WHITE PAPER

SMART CONNECTIONS

Why Power over Ethernet is the Ideal Infrastructure for Smart Buildings

creating connections for life

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Executive Summary

Neither building data nor building automation is new. What sets smart buildings apart is their ability to integrate and combine data from multiple sources, delivering a more detailed and effective view of how a building is used, and enabling decisions to be better informed.

There are many factors helping drive interest in smart building technology: increased acceptance of new ways of working, climate change concerns, rising energy costs, and increased understanding of the relationship between indoor environments and occupant health. Add to that, an explosion in availability of IoT devices has suddenly enabled better functionality to be delivered cheaply and easily. Today, with a huge range of sensors, devices, platforms and integrations on the market, a building, workspace, facility or campus can be made “smart” in precisely the ways that are required by the owner or occupants.

The heart of what makes a building “smart” is data: what data is collected, how it’s collated, and what systems or processes can be automated as a result of it. From lights that change tone to suit the time of day to meeting rooms that mark themselves as available when empty, smart buildings rely on constant connectivity to an array of sensors and to controllable devices. This connectivity needs to be fast and reliable – when data is being continuously assessed and responses need to be made in real time, breaks in connection can interrupt the system’s ability to take effective action.

PoE (Power over Ethernet) is a technology that expands the potential for long-established Ethernet connectivity by enabling it to supply power along the same cables that carry data. It provides safe, low-voltage DC power, ideal for IoT sensors and devices, alongside the high performance data transport capability needed for smart buildings to communicate with all their components. Flexible, cost-effective and future-ready, PoE is the natural fit for smart building applications.

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We spend 90% of our time within buildings, whether that's at home, school, work or for leisure or recreation time.

Arcadis: The business case for intelligent buildings [13]

Established technology, future-ready

Ethernet is so ubiquitous today, it's hard to imagine a world without it. Invented in 1973 and standardized in 1980, Ethernet has come to dominate the market for data connectivity. It originally began life on coaxial cable but by the 90s it had shifted from coaxial cable to copper twisted-pair due to reduced costs and easier install. Since then it has continued to evolve, delivering improved bandwidth and a variety of options for protecting against crosstalk and EMI. As the Internet Protocol is commonly carried over Ethernet, it's considered one of the backbone technologies of the Internet.

Early innovations to transmit power and data over the same cabling were developed by Cisco to support WLAN access points and VoIP phones, but the first IEEE Standards were released in 2003[1]. The original IEEE 802.3af-2003 standard provided up to 15.4W of DC power (12.95W minimum delivered) on each port. The latest standards, IEEE 802.3bt-2018, also known as PoE++ or 4PPoE, introduces two new power types: up to 51W delivered (Type 3) and up to 71.3W delivered (Type 4) at Powered Devices. The potential for these higher-powered connections has not yet been fully explored, especially as the power requirements for many devices has continued to decrease.

Building automation was also developed in the 1980s[2]. Often running on Ethernet networks, Building Information Modelling tools (BIM) were the first software systems able to collate and model data about a building. The generic BACnet standard enabled different building automation systems to communicate with one another. But the big leap came at the end of the 1990s, with the development of the Internet of Things. At the time it was difficult to predict the impact this would have on the world, especially since there were limits to the number of unique devices the current internet protocol (IPv4) could support. In 2012 the major Internet service providers and web companies addressed this by moving to IPv6 – offering an almost unlimited number of available IP addresses[3]. This meant building sensors, devices and pieces of equipment could be individually connected without complication. It's predicted that there will be 27.1 billion IoT connected devices by 2025[4].

The rise of smart building technology has been enabled by Ethernet and, more recently, Power over Ethernet infrastructure. While the idea of smart buildings has been around for some time, it is only recently that the technology has been able to deliver. It's fair to assume that technology will continue to evolve and develop into areas we cannot currently imagine.

Refined and enhanced over decades, PoE's longevity points to many of its benefits: ease of use, safety, flexibility and familiarity.

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Low barrier to entry

The adoption of new technologies typically follows a pattern. Early versions are expensive, complicated and prone to bugs, and early adopters are tech enthusiasts keen to get in on the ground floor. The majority of potential customers will wait for the early issues to be resolved and for costs to fall before making serious investigations.

But these problems do not exist with PoE. Firstly, although there are continual ongoing improvements, the technology itself is not new. The vast majority of organizations around the world already utilize some form of infrastructure based on twisted-pair cabling – it is familiar to many professions, not just those specializing in IT. Secondly, PoE-based infrastructures can be altered and expanded relatively easily. It's entirely possible to build out a smart building installation gradually, spreading the costs over time or offsetting costs against savings.

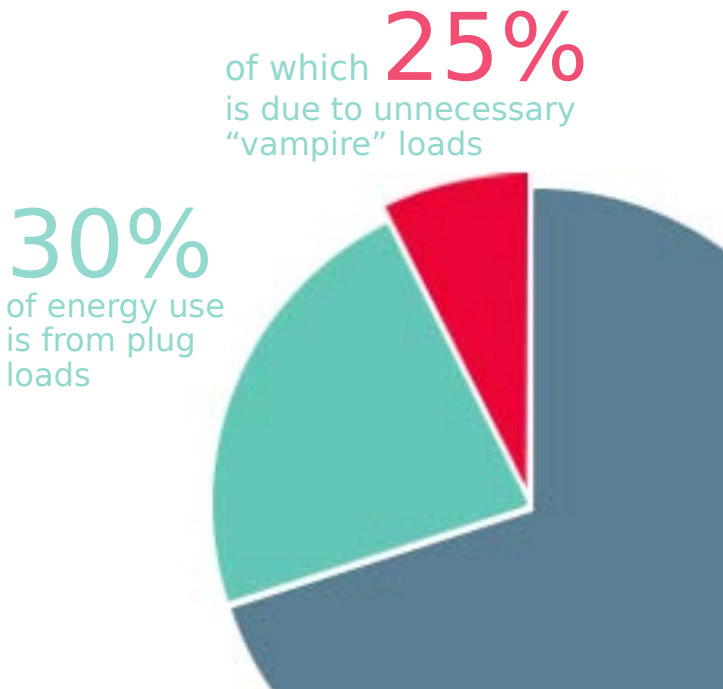
PoE lighting is an area where the technology found early application, as it quickly delivers significant and measurable cost savings. PoE lighting typically uses LED bulbs, which offer many benefits to traditional incandescent and fluorescent technologies: the bulbs have a long usable life, are usually made of recyclable materials, they generate minimal heat, and require much less power. LEDs naturally require DC power, so when retrofitted into an existing mains-powered system the power must be converted from AC. PoE naturally supplies DC power, so no energy is wasted and there is no extra heat generated.

With power and data simultaneously provided by PoE, smart lighting systems can automatically control the fixtures, ensuring ideal conditions for occupants and maximizing cost savings. By controlling lights in response to occupancy and lighting levels, artificial lighting requirements can be reduced by up to 80%[5] and fully integrated smart lighting systems can save up to 90%[6]. Control systems can also automatically adjust the color tone ("temperature") of the light to match natural daylight, helping to improve the wellbeing and productivity of occupants: one study found a 20% improvement in student achievement when daylighting was implemented[7].

Implementing PoE lighting can quickly deliver significant cost savings. Irrespective of the luminaire type, implementing advanced lighting controls can deliver 44% energy savings with a payback of less than five years[8]. Energy efficiency grants or financing options[9] may be available to enable organizations to offset the upfront costs against the long-term costs savings.

Implementing plug load control can also generate quick savings. In a typical commercial building, around 30% of the energy use is down to plug loads. Of this, around 25% is wasted "vampire" loads – devices that draw power even when not in use[10].

Plug energy draw is typically difficult to measure and even more difficult to control. While energy use overall may be under the remit of facilities management in theory, in practice different departments may be responsible for the equipment



The ability to migrate lighting controls to IP-based infrastructure makes lighting a key IoT building asset that can be controlled synergistically along with other building functions.

Giovanni Frezza, Molex [14]

they use with no overall oversight - think data centers managed by IT, or cooking equipment managed by the kitchen.

Plug load devices enable a smart building to record granular, real-time data on energy use, and to centrally control plug individually or by zone. These devices are self-powered, making them easy to install. Energy-wasteful equipment like microwaves, printers and AV systems can be turned off overnight or when rooms become unoccupied, instantly generating savings. A growing number of energy codes now require plug load control, using the term "automatic receptacle control.[11]

Alternatively, cost savings can be re-invested into building out smart building functionality. Data from the lighting system sensors – for example occupancy and light levels – can be analyzed to understand how facilities are used, to optimize how they are laid out and scheduled, and to understand what other smart building functionality might be beneficial. Many other possible automations – for example room scheduling, beacons, emergency lighting and plug load control - are all likely to utilize the same data that the lighting system already provides.

Cost effective installation

PoE is cost effective to install and modify. Much of this is due to the fact it delivers low voltage power.

The IEC defines several categories for Extra-Low Voltage. Even 4PPoE, delivering up to 90W, falls into this category. However it's important to realise that even though 90W could theoretically cause a shock, there is little chance of this occurring from a PoE connected cable or device. Power is not constantly running through a PoE cable as it is with a typical AC cable. A "handshake" procedure between the Power Sourcing Equipment at one end and the Powered Device at the other ensures the correct amount of power is delivered, when it is required. If there is no handshake, no power is supplied. As well as protecting devices against overpowering / underpowering, it also protects against harm.

A direct benefit is that PoE does not need to be handled by electrical professionals. In many regions, this immediately results in a significant cost reduction to the cost of installation. It also eliminates the need for the additional safety precautions, insulation and conduits required of high voltage power.

Ethernet itself is familiar to many types of professionals, including those involved in facilities and IT. While the introduction of power to the infrastructure does involve new network devices and rules, it's entirely possible for in-house departments to manage moves, adds and changes. Small changes like relocating a light fitting, upgrading a sensor, or taking out devices when a room is repurposed can be carried out with a minimum of disruption.

Additional considerations for PoE

PoE does have some additional design considerations above a typical Ethernet installation. Transmitting power on the network inevitably generates heat, and unless properly managed this heat buildup can affect the transmission of

Right now we have the opportunity to digitize real estate. This isn't just about putting sensory components into a building. It's about – how do we fundamentally re-platform a building?

Bob Cicero, Cisco, discussing Cisco's Penn One project[15]

both power and data, impact air conditioning requirements, and ultimately – in serious cases – cause physical damage to network components.

Managing this heat buildup is primarily a case of good planning. Issues present themselves when cables are run in bundles, in-ceiling or under-floor, without adequate spacing or air circulation. Choosing thicker cable (a lower AWG) or cable with shielding can also help manage heat.

Easy to install into hard-to-reach locations

Many sensors and devices will be installed in easy-to-access locations in dry, temperature controlled, offices and corridors. But monitoring only the easily accessible locations can potentially leaves gaps in your smart building intelligence.

The flexibility of PoE means it's relatively easy to install devices in many places that would otherwise be hard to reach or hard to safely service: high ceilings, outdoors, on rooftop antennae. There are many different IP-rated cables, connectors and outlets available to ensure the products have the right protection for the environment they will be installed in. Industrial PoE products are available that are specifically designed for the extreme conditions commonly experienced in in manufacturing and material handling environments.

It's also easy to integrate completely wireless devices into a PoE network. Using a wireless gateway enables the network to "talk to" unwired sensors and devices such as kinetic-powered switches, light-powered sensors and mains-powered plug monitors. Wireless sensors can be effortlessly positioned and re-positioned. Wireless access points (WAPs) are themselves commonly connected and powered by PoE.

Flexible and upgradable

If collecting data is the first element of a smart building, and automation is the second, the third is optimization: using the data gathered to make larger analyses and more significant changes.

As information is collated and trends identified, the business, the building and the technology infrastructure should be able to explore new strategies and ideas. Over time the business itself is likely to change, and new smart building technologies will become available – from better versions of existing devices to entirely new devices offering different functionality. A system that is complicated or expensive to update or maintain

is effectively locking businesses in to a model that will become increasingly unfit for purpose. If changes to the business or its operating landscape cannot be reflected by updating the smart building installation, then it will gradually become obsolete.

For example, imagine an office where occupancy data has identified both bottlenecks and underutilized spaces that can be addressed by simply moving furniture. Changing layout is likely to require repositioning lights and sensors to reflect the newly redrawn spaces. A room that is repurposed into a meeting room might require additional controls for AV equipment and occupancy beacons. A room repurposed into storage might not need light and temperature sensors as it is no longer necessary to fine-control environmental conditions on a minute-to-minute basis.

With a PoE-based smart building system, these changes can be made relatively quickly and potentially by in-house teams, enabling occupants to move into the new spaces with a minimum of disruption.

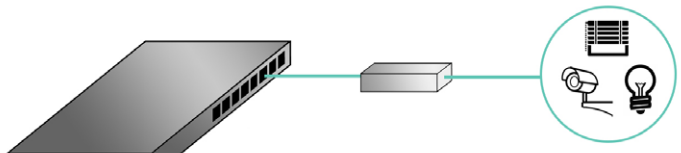
PoE is also designed with safeguards to protect both the devices on the network and the network itself. When a powered device (PD) is connected to a network with PoE power, there is a negotiation that takes place between the PD and the power supply. The network will detect if the device needs power, and how much power is needed. If, for example, a non-powered device is connected, the network will not supply power. If a device stops working, or turns off, the network will not "force" power into it. This also makes it safe to add different types of device to the same network.

The latest high-power PoE, IEEE 802.3bt Type 4, can supply up to 71W (delivered), while Power over HDBase-T can deliver up to 100W[12], but many devices require far less than that. As PoE automatically delivers the amount of power required, it's possible to have a mix of lower and higher power devices on the same network.

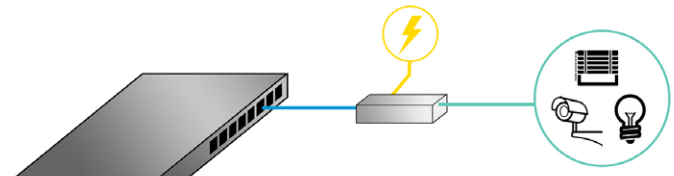
Older PoE networks and Ethernet networks can also be easily upgraded. By adding in a power injector, a section of network can be upgraded from one power level to another, or even from unpowered Ethernet to PoE. Legacy and low-powered devices like IP cameras can be connected and powered using a PoE splitter.

This flexibility ensures the implementation is adaptable and cost effective: it's not necessary to over-specify or try to predict future requirements up front, both of which are usually costly. Upgrades do not require a rip-and-replace of the entire network. PoE ensures you can install only what you know you need at that time, and upgrade and expand as requirements or possibilities come to light.

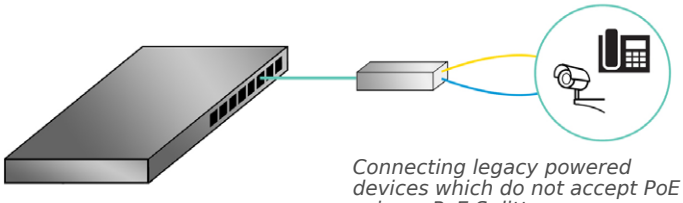
Types of PoE Connection



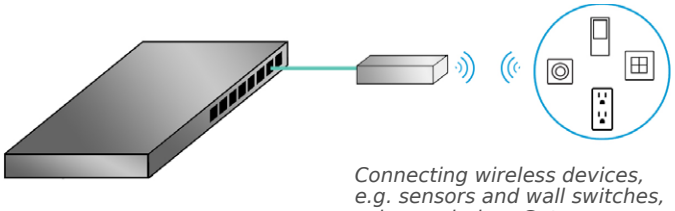
Standard PoE connection providing both power and data over a single cable



Introducing power onto a non-powered Ethernet link using a PoE Injector



Connecting legacy powered devices which do not accept PoE using a PoE Splitter



Connecting wireless devices, e.g. sensors and wall switches, using a wireless Gateway

Integrate multiple systems on a single platform

Many building automation tools are already in use across the market, but typically they control only one system or set of systems. What elevates a smart building is the ability to integrate the information and control of multiple systems into a single dynamic platform, where information can be analyzed holistically.

IP convergence has already brought telephony, computing and AV onto the same infrastructure. Converging building automation onto the same platform is a logical step. With so many data networks built around this infrastructure and so many devices already available, it's highly likely that future developments will also center around it.

PoE also continues to evolve. With IEEE 802.3bt, PoE has the potential to power a much wider range of devices. Large screen TVs, Electronic Point of Sales, window blinds, and even mechanical stand-sit desks can be powered from a single cable connection. With increasing numbers of systems only requiring low voltage, PoE is becoming a viable options for applications that were previously not considered under the scope of IT.

Utilizing an Ethernet based power delivery infrastructure also has the benefit of instantly enabling easy monitoring of the network itself. In most traditional buildings it is difficult to get information on where the power is going and the status of the network hardware. With PoE it's possible to get real-time, granular data on energy use and the performance of devices, equipment and the network itself. The network becomes another source of intelligence, helping inform how assets are used and identifying potential avenues for optimization.

The immediate, practical benefit of integration is that the work of facilities and IT teams is streamlined. Multiple systems can be managed from a single pane of glass, data can be shared across systems, and alerts and notifications can enable greater proactivity and efficiency. Longer term, the building itself stops being merely a space and becomes a platform for business intelligence and occupant satisfaction.

Conclusion

The potential for smart buildings to improve the performance of buildings and businesses is only just starting to be explored. The spaces in which we work have the power to significantly impact some of the key considerations of our time, from climate change and energy concerns to working patterns and occupant health.

Optimization is a journey, not a one-off exercise. Change is inevitable, as practices evolve and technological innovation presents new opportunity. To support this evolution smart buildings also need to be able to evolve. The infrastructure needs to be both familiar and future-ready, reliable but also adaptable. Cost effective, safe, and scalable, Power over Ethernet provides all the benefits needed to transform real estate into an intelligence-generating platform, supporting both today and tomorrow's requirements.

About Molex

Molex is a global electronics leader committed to making our world a better, more-connected place. With presence in more than 40 countries, Molex enables transformative technology innovation in the automotive, data center, industrial automation, healthcare, 5G, cloud and consumer device industries.

Molex Connected Enterprise Solutions offers a broad portfolio of data connectivity products and solutions including PowerCat Power over Ethernet, Lightband fiber optics, data center solutions, and the CoreSync smart building solution. Trusted by leading organizations worldwide, our products are designed to be used and re-used, delivering reliable high performance every time.

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