PHILIPS

Smart Buildings

The future of enterprise office lighting

Connected lighting and the Internet of Things

Technology by

CISCO

A joint Philips Lighting and Cisco white paper

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Derek Wright
Global Head of Office Systems,
Philips Lighting

Emmanuel Frimout
Chief Indoor Systems Architect,
Philips Lighting

Luis Suau
Technical Leader,
Industries Product Group, Cisco

Akshay Thakur
Global Business Development Manager,
Industries Product Group, Cisco

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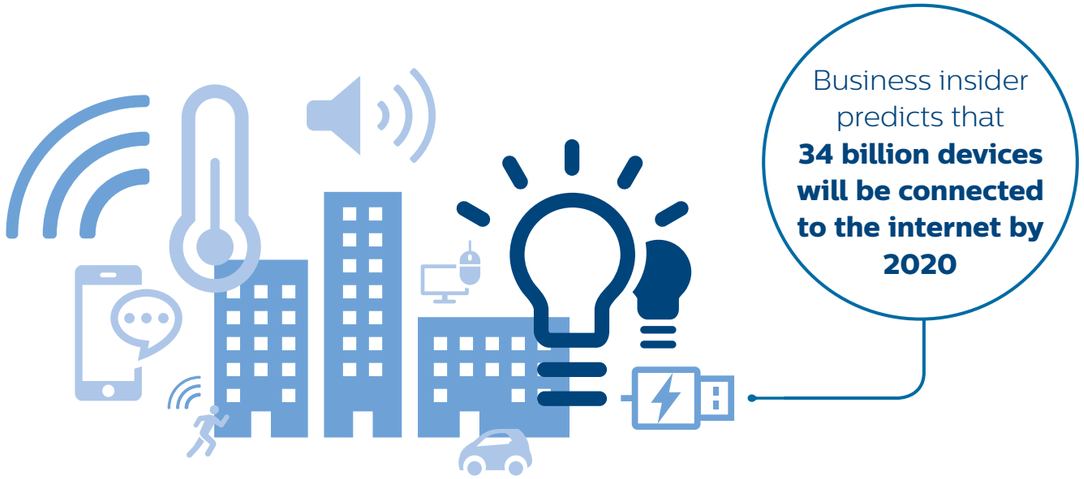
I. The Internet of Things, connected lighting, and workplace transformation

The Internet of Things has been called the next industrial revolution, and it is changing the way businesses, governments, and consumers interact with the physical world. IoT is also making its entry into the traditional enterprise workplace, driving a major transformation and shift towards the workplace of the future – the smart workspace.

"A smart workspace leverages the growing digitalization of physical objects brought about by the Internet of Things (IoT) to deliver new ways of working, sharing information and collaborating," writes leading research and advisory firm Gartner. "Programmability of physical environments enables smart workspaces to contextually work with mobile devices, software applications… and smart machines to improve workforce efficiency and effectiveness. Any location where people work can be a smart workspace." [1]



The IoT and smart lighting

The IoT describes a wide range of approaches to enabling digital devices with data gathering and communications capabilities, and connecting them by networks to computing systems. By blending the physical and digital realms, the IoT is transforming the way we relate to our environment, to each other, and to information, and is revolutionizing the way we live, work, travel, heal, and relax.

Data — and communications-enabled smart devices range from thermostats to energy meters to tractors to wearables for monitoring personal fitness and vital signs. Any digital device that can collect or share meaningful data about itself, its usage, and the environment in which it's embedded is a candidate for participation in the IoT. When connected, LED luminaires become smart devices that can also participate in the IoT.

This white paper describes how Philips Lighting and Cisco are collaborating to bring together LED-based connected lighting systems and IT networks. The resulting smart system not only illuminates, but also serves as a pathway for data and services to create new value in energy savings, building efficiency, space optimization, and employee productivity and well-being in modern offices.

A useful distinction is sometimes made between the Industrial Internet of Things (IIoT) and the IoT. As Bill Schmarzo, CTO of Dell EMC Services, explains, the IIoT "refers to all the devices, sensors, and software… that use network resources to communicate with a remote application infrastructure in order to monitor and control the machine or the surrounding environment." The IoT, on the other hand, "can be thought of as the application layer" on top of the IIoT. "The IoT refers to the potential life — or business-changing applications that the realization of the Industrial Internet will bring," Schmarzo writes. [2]

Connected lighting systems embrace aspects of both the IIoT and the IoT. On the IIoT side, connected luminaires can report data on their own status and operations, and the system can be commissioned to automatically respond to changing conditions or issues as they arise. Data about the lighting system collected over time supports energy and cost optimization efforts. When outfitted with sensors and communications to gather and share data in the illuminated environment, connected lighting systems support all kinds of IoT-enabled capabilities, from space optimization to wayfinding to smart resource scheduling to personalization and productivity applications for employees.

According to a 2015 report by the McKinsey Global Institute (MGI), "the Internet of Things has a total potential economic impact of $3.9 trillion to $11.1 trillion per year in 2025… equivalent to about 11% of the world economy." MGI estimates a total economic impact of $70 billion to $150 billion in 2025 in the office setting, including impacts from activity monitoring, organizational redesign, energy monitoring, and other applications. [3] Connected lighting systems serve as enablers for all of these applications. *Business Insider* predicts that 34 billion devices will be connected to the Internet by 2020 — in other words, "four devices on average for every human on Earth." [4]

The global lighting market is also producing some noteworthy numbers. The $112 billion global lighting market will continue to grow at 3% percent annually, with global revenues topping $130 billion in 2020, according to a report by the Boston Consulting Group (BCG). BCG predicts that 80% of professional luminaires sold will be LED-based. BCG also sees connected lighting systems growing in popularity, in part because they allow significant energy cost savings — another 40% on top of the sizable savings generated by LED technology alone. [5]

Trends driving
the growth of the IoT

Two forces — digitization and networking — have rapidly expanded the universe of opportunities created by the modern computer and the IoT. In lighting, digitization drove the first shift in lighting, from incandescent and fluorescent to solid state (LED). Networking is now driving the second shift in lighting, the emergence of connected LED lighting systems, which can serve as enabling platforms for IoT applications in workplaces and elsewhere.

Several enabling technologies have now become mature enough for systems designers and integrators to create and deploy effective IoT applications in real-world applications. These include:

- **IoT hardware commoditization**
  Reflecting the trend that has helped make personal computers and smartphones ubiquitous, the hardware and devices that support IoT systems are rapidly becoming commodities, lowering barriers for adoption.
- **Ubiquitous wireless coverage at low cost**
  Cellular coverage is well established in most regions of the world. According to OpenSignal, 93 of 95 countries that they studied had 3G or better signal availability more than half the time, with many countries offering 3G or better signal availability more than 90% of the time. Wi-Fi is available almost everywhere, to end-users, and because it uses unlicensed spectrum, no carrier fees accrue. [6]
- **Growth of Big Data and data analytics**
  As Forbes reported in 2015, "more data has been created in the past two years than in the entire history of the human race." [7] According to the *Cisco Global Cloud Index*, data derived from IoT systems will reach 247 exabytes (approximately 247 billion gigabytes) by 2020, representing 27% of data stored in data centers. [8] But less than 1% of this data has been analyzed. Unsurprisingly, data analytics is expected to be one of the fastest-growing IoT applications.
- **Emergence of an IoT ecosystem**
  System and application development is supported by an emerging network of related businesses, including hardware/software developers and vendors, systems integrators, researchers, architects, city planners, facility managers, and a growing community of commercial and consumer users. Industry advisors believe that "digital business ecosystems and platforms are fast becoming the go-to business model for the digital economy." [9]
- **Early successes**
  IoT applications are already resulting in real-world successes — in healthcare and smart cities, for example. [10]

Trends driving
IoT adoption in workplaces

The IoT offers wide-ranging applications in a number of settings, both indoors and outdoors, both consumer and commercial. The workplace is an important setting for the IoT — one of the nine main settings where the IoT creates value today, according to the McKinsey Global Institute. [11]

Traditional lean workspace design is becoming a thing of the past. Contemporary office workplace concepts favor flexibility in design, automation of facilities management, new work styles and preferences, and the ability for workers to interact with the workspace in new ways.

Several major trends are now driving the transformation of the traditional office space. These include:

- **Globalization**
  Teams and workers are more frequently distributed across multiple geographical locations.
- **Changing demographics**
  Millennials — who now make up the largest workforce constituency in the US, [12] and are expected to form 50% of the global workforce by 2020 [13] — bring a more intimate and in-depth engagement with mobile apps, social networking, and virtual tools.
- **New social technologies**
  Business assets continue to migrate to the cloud, virtualizing workers' access to information, applications, services, and each other.
- **New management approaches**
  Key objectives include sustainability, the integration of IT with building services and connected devices, employee productivity and comfort, and an increasing reliance on sensor data and analytics to streamline operations.
- **Rise of freelance and other independent work**
  Enabled by new social technologies and other forms of reliable, remote connectivity, freelance, contract, and temporary work is on the rise, especially in the US, the UK, and the EU. [14]
- **Flexible workspaces to enable work-life blending**
  Younger generations in today's workforce demand flexible workspaces for work-life balance and integration. Employers must deploy IoT capabilities to support flexible workspaces and working styles to stay competitive. [15]

Office designs are becoming more agile and adaptable, with different kinds of spaces for collaboration, brainstorming, and solo work. Following a service model, offices will need to adjust to changing teams, needs, topics, and tasks, rather than providing fixed, single-purpose physical spaces. Office spaces are also changing to accommodate shifting demographics and worker preferences. Conventional lean office spaces with fixed desks and basic services are rapidly becoming a thing of the past. By 2040, according to a report published by CBRE, workers will become workplace consumers or "digeratis," who are "totally in control of where, how and when they work." [16]

To attract and retain top talent, therefore, companies are increasingly shifting away from hierarchical structures and traditional long-term working arrangements in favor of employment contracts that support flexible working times and an emerging range of radical working patterns. At the same time, real estate developers increasingly focus on offering adaptive, agile facilities that prioritize employee needs and respond to their constantly evolving demands. These facilities fluidly integrate new technologies to foster collaboration and co-creation, enhance employee comfort and productivity, keep remote workers connected to company culture, and support sustainable business practices.

The trend toward measurement of all aspects of employee and office life will also have a significant and increasing impact on how future offices function. The "quantified self" movement is becoming more mainstream, as smartphones and other wearables track employee location, motion, velocity, and interactions. Organizations are already starting to use this data for performance and process management, health tracking, recruiting, and improved personal services, subject to the appropriate privacy laws and consent of employees. Indeed, data security, data governance, and privacy issues will become more important as IoT applications become more pervasive.

IoT adoption in the workplace can deliver several significant benefits to both the users (employees, visitors) and managers (property owners, corporate tenants) of workplaces. These include:

- Human productivity
- Organization redesign
- Workspace optimization
- Human well-being
- Sustainability and carbon mitigation
- Energy and cost efficiency
- Branding

The role of LED and connected lighting in the IoT

Lighting is everywhere that people go within an office. By digitizing lighting with LED technology and connecting LED luminaires together into a system, lighting can serve as a grid (backbone) that is able to easily host IoT applications throughout a workspace.

In a connected lighting system, every luminaire or light point has a unique IP address to enable two-way data communications over a building's IT network. Connected lighting is a natural carrier for the IoT in workplaces since it makes use of electrical, lighting, IT, and communications networks already in place.

In addition to pure lighting capabilities, most connected lighting fixtures offer plug-in sensor capabilities, making the application possibilities almost endless. When outfitted with sensors, a connected lighting system can continuously capture anonymous data on room occupancy and other properties, allowing facility managers to gain actionable insight into occupancy and activities in the illuminated space. These insights in turn support space optimization, energy and operational efficiency, and employee comfort and well-being.

When Wi-Fi is part of the network, connected lighting systems have the potential to deliver a range of location-based services (LBS) and user applications to people in the illuminated environment. These services could vary from first-level localization and wayfinding, intelligent resourcing of conference rooms and workspaces in open-plan offices, and workspace personalization to enhance comfort, productivity, and a sense of ownership of the space.

Visible light communications (VLC) uses the native modulation of the LED light beam itself to encode data that can be received by a smartphone camera, opening up new and exciting possibilities in the way we send and receive information. With a location-based system that leverages VLC, an enterprise does not have to invest in additional infrastructure to house, power, and maintain location beacons for indoor positioning. VLC provides very accurate location information. In some applications that Philips Lighting has helped to develop for retail stores, VLC has achieved location accuracy of 30 cm or better — more than sufficient for location services in office spaces, which may require room — or desk-level accuracy.

When tied into a common IP backbone, lighting can integrate more readily with other building services, such as HVAC and scheduling, to enable unprecedented levels of building performance monitoring and operational efficiency. The network convergence of building subsystems enables integration at the IP layer, eliminating the need for intermediary gateway devices to bridge between protocols.

II. The Philips Lighting and Cisco alliance

To take advantage of the extraordinary opportunities afforded by the convergence of connected lighting and the IoT, Philips Lighting and Cisco have entered into a global vertical strategic alliance focused on creating new value in building energy savings, building space efficiency, and workforce/user experience. The alliance allows customers to leverage state-of-the-art, best-of-breed technologies, applications, and system designs in the lighting and IT industries.

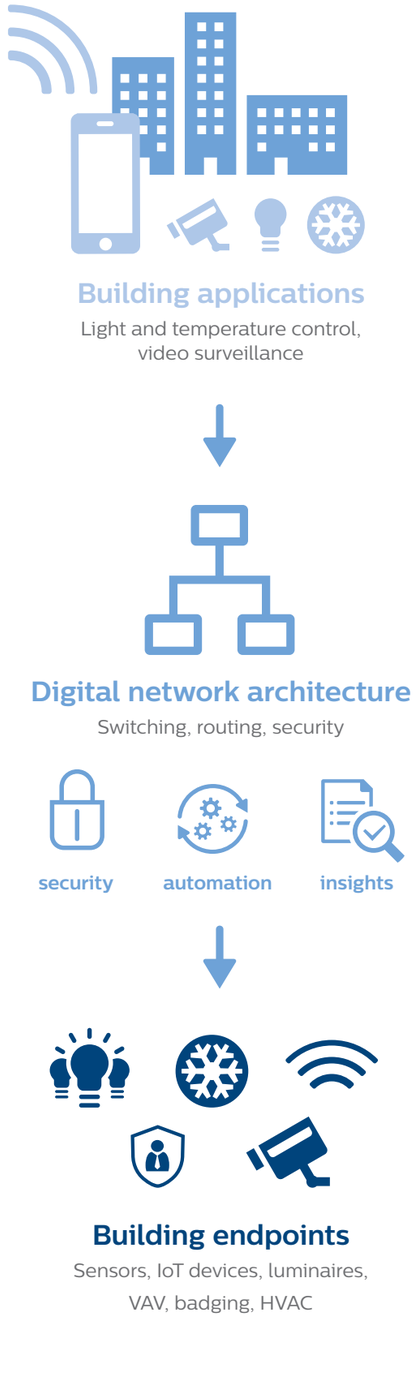
LED luminaires from Philips Lighting — equipped with VLC and a rich array of sensors, and monitored and managed via robust software dashboards and applications — can be connected, powered, and secured using Cisco Digital Building Series and Catalyst network switches. When connected, the lighting serves as a pathway for information, enabling the creation of new services that go beyond illumination.

The lighting market is rapidly shifting to LED-based lighting. LED luminaires offer highly energy-efficient operation (typically reducing energy consumption for lighting by 75%+), and a far longer useful life than traditional luminaires. Due to their lower power requirements, LED luminaires can be powered by standard Power-over-Ethernet 802.3at (PoE+) and Cisco's Universal Power Over Ethernet (UPOE). With PoE and UPOE, every light fixture is directly networked, receiving control and power over a single network cable.

Building services and systems are becoming increasingly reliant on network connectivity and security. [17] Because of its simplicity and cost-effectiveness, PoE use has increased not only in the IT domain but also in the building systems domain. [18] Enterprises are increasingly motivated to converge separate building systems into a single secure network infrastructure, with wins in flexibility, efficiency, and performance. [19]

The alliance between worldwide connected lighting leader Philips Lighting and worldwide IT and networking leader Cisco is a logical starting point for driving the smart workspace forward. Cisco's Digital Building Solutions connect different building services, offering the ability to collect usage data and analytics for space optimization. As the most mature technology in the building space, LED-based connected lighting from Philips Lighting leads the digital building transformation. Cisco is taking network innovation to the next level with the Catalyst® Digital Building Series, the industry's first purpose-built switch designed specifically for smart buildings. Digital Building Series switches power and connect disparate building subsystems such as lighting, HVAC, sensors, AV, and security onto a single low-voltage IP network. By bringing together LED-based connected lighting systems from Philips Lighting and Cisco's Digital Building Series, the strategic vertical alliance between Philips Lighting and Cisco addresses a global office market estimated to be worth €1 billion. [20]

Image: Pentagon offices, Helsinki, Finland



Yesterday, Voice-over-IP... today, Light-over-IP

Building management systems and lighting control networks often reside in their own silos of the building environment. There may be integration points into the building management system, but there is usually no convergence with the existing IP Infrastructure and processes. The emergence of network-powered lighting is leading the convergence onto a single IP infrastructure and enabling other building systems to communicate natively over IP.

Telephony has followed a similar path. As recently as 18 years ago, telephony was a technology silo completely independent of the IP network and infrastructure silo. The advent of Voice-over-IP (VoIP) and PoE drove the convergence of the telephony and network infrastructures, enabling a wealth of new services and integrated collaboration opportunities. New technologies continue to emerge in this space even now, enhancing and improving daily work and ease of use.

A similar trend — at least as far as the underlying infrastructure is concerned — is already in progress in the building space, with many technologies able to connect over IP. In addition, building management systems typically offer functionality for integration with external systems. Connected LED-based lighting systems represent a new opportunity for convergence with IP and PoE network infrastructures already in place in virtually all professional buildings.

Connected lighting instrumentation

The confluence of LED efficacy, Power-over-Ethernet (PoE), and the Internet of Things is driving the consolidation of lighting systems onto a single low-voltage PoE network.

The convergence of building automation applications on a unified IP network still allows for a clear separation of concerns for the different application verticals on the network. Philips connected lighting systems exploit broad application configurability, supporting well-established lighting application behaviors in a highly robust, scalable, and distributed manner. Application integration is achieved by effectively deploying the appropriate data (sensor, status, energy) and control interfaces without requiring point-to-point assigned logical connections.

The flat and unified Cisco IP infrastructure can be extended with new value-added features, and can extend lighting applications across multiple physical networks (for example, by integrating wireless components).

Among other benefits, a converged IP infrastructure enables per-device energy management and analytics, as well as the ability to integrate multiple applications and building control systems. The network architecture calls for standard production Cisco Catalyst® PoE+, and/or UPOE switches, depending on the power requirements of the fixtures in a particular application.

The opportunity for property owners and developers

Property owners and developers can realize specific benefits from connected office lighting systems:

More services and capabilities for tenants and facility managers, and a better experience for the users of the illuminated space

A building that gives tenants and facility managers granular insight into usage for cost optimization — energy, HVAC, and building usage

Zoning to more easily manage system performance and costs per tenant

Full compliance with green building standards (LEED, BREEAM)

Lighting systems that are software upgradeable, with easy integration into BMS or other verticals

Lighting network can be used to host sensor networks and as a means to integrate multiple building services

The evolution of **PoE for lighting**

As businesses increasingly converge workspace resources, services, and devices onto IP network infrastructures, PoE becomes ever more widely deployed technologies as a means of powering networked devices. PoE offers the following primary benefits:

- **High availability** for power with no electrical wiring to luminaires, guaranteeing uninterrupted service — a requirement for critical applications
- **Faster deployment** of new networking infrastructures for end-user access by eliminating the need for a power outlet for every endpoint
- In combination with Energy-Efficient Ethernet (EEE), helps meet **corporate sustainability** mandates while **lowering energy costs**

Industry standard PoE+ can deliver up to 30W per switch port. Cisco UPOE leapfrogs the industry to provide 60W per switch port, allowing a much wider range of device support and enabling new deployment options in next-generation workspaces. Philips Lighting and Cisco both participate in 802.3bt standards efforts to ensure UPOE compliance.

Through the alliance with Cisco, Philips Lighting now offers highly efficient UPOE-compatible LED-based connected luminaires designed for use in professional environments. Because they are connected to the IP network and managed by, these UPOE-compatible luminaires can provide highly granular information on their own status, usage, and health. They can be extended with embedded sensors for monitoring properties of the illuminated space — such as occupancy, light level. Sensors are modular and replaceable, enabling upgrades for more extensive sensing in the future. UPOE-compatible luminaires from Philips Lighting can also incorporate VLC.

IPv6 affords advantages over IPv4, especially in systems with large numbers of PoE luminaires and other addressable devices, as it supports an almost infinite number of addresses, enabling each luminaire and device to be individually monitored and controlled.

Component and architecture overview

In a connected lighting architecture, intelligent PoE-enabled luminaires with embedded sensors are connected to a building's LAN, along with other IP devices for lighting and other building applications.

Because it is high-bandwidth, the PoE network enables rich data collection. Every luminaire is a source of sensor, energy, usage, and maintenance data. A central lighting monitoring and management platform supports the day-to-day operations of the lighting system. The platform continually collects and analyzes operational data to ensure that performance levels are maintained. System managers can make changes to the system configuration and lighting behaviors to regularly refine and improve the efficiency of the building.

The data collected from the system can be used for higher-level building and energy management purposes. The building server also links building verticals and supports smart energy management applications such as demand response. The lighting system commissioner can configure the desired energy reduction modes.

Area topology for efficient DC power distribution

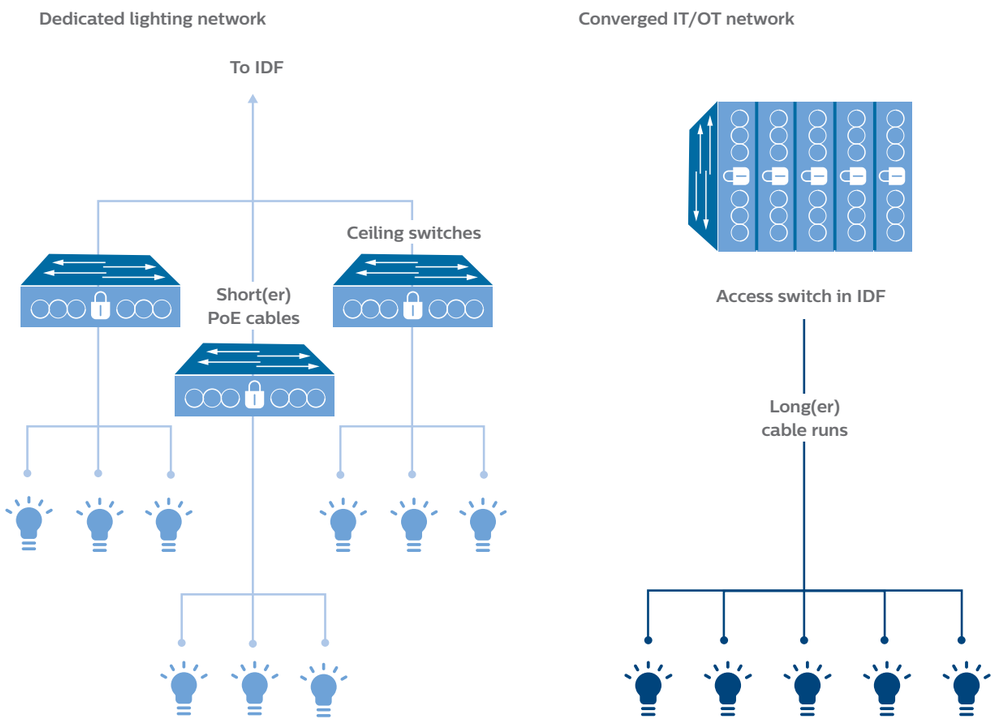
The recommended PoE network topology is segmented and secured, with reliable, long-lifetime, fan-less Cisco Digital Building switches distributed throughout the building. This allows for the use of very cost-efficient off-the-shelf Cat 5E/6/6A cables between switches and fixtures, while maintaining optimal energy efficiency. Though the recommended topology is a segmented (distributed) topology, a centralized topology as commonly implemented by IT departments is also supported when using higher power (UPOE) switches and fixtures. Hybrid topologies (a combination of segmented and centralized) are also possible.

RBC WaterPark Place, Toronto, Canada

Two network deployment models

Distributed 'switches in ceiling'
Energy efficient, shorter cables

Centralized 'switches in wiring closet'



Route to implementation

Although each luminaire in a connected lighting system is powered by network cabling, instead of by separate proprietary cabling, the general look-and-feel of lighting control doesn't dramatically change. Buildings, areas, zones, scenes, and shows still serve as the common language of control, while interfaces with other applications add new capabilities.

An organization that wants to deploy a connected lighting system in their workspace should begin by talking to Philips Lighting to determine whether the enterprise is ready for the new connected lighting solution. If the enterprise is ready, Philips Lighting recommends a complete system, along with APIs for integration, to deliver the lighting experiences, performance targets, and connected applications that the business desires. Philips Lighting fully supports planning, commissioning, rollout, and operations.

On the infrastructure side, the requirement for Cat5E/6/6A or higher cabling and network design and architecture represents a major change in implementation. Every light fixture requires a power/data cable that can be no longer than 100 m (about 328 ft). This enforces a segment topology with several network and power distribution points for which mechanical engineers, electrical engineers, low-voltage contractors, and IT, whether internal or external, will have to plan accordingly.

Because new cabling is required, green-field deployments in large enterprises, schools, and hospitals represent an obvious sweet spot for connected lighting implementations. Deep renovations are also strong possibilities.

Philips Lighting + Cisco joint validated design

By leveraging two strong company portfolios of products and services, as well as the ability to deliver on truly global basis, the Philips Lighting + Cisco alliance establishes a true end-to-end solution and one-stop-shop for connected lighting.

Joint validated designs (JVDs), tested and documented by both Cisco and Philips Lighting, provide the foundation for connected lighting system designs based on the most common use cases or current engineering priorities for lighting systems connected with Cisco IT networks. The JVDs incorporate a broad set of technologies, features, and applications to address customer needs. Each JVD is comprehensively tested and documented by Cisco and Philips Lighting engineers to ensure faster, more reliable, more secure and fully predictable and replicable deployment.

JVDs are informed by both the Cisco Validated Design program (CVD) and the tested validated design (TVD) process at Philips Lighting. CVDs provide the foundation for systems design based on common use cases or current engineering system priorities. They incorporate a broad set of technologies, features, and applications to address customer needs. Each one has been comprehensively tested and documented by Cisco engineers to ensure faster, more reliable, and fully predictable deployment. TVD is a professional test and validation process conducted by Philips Lighting to foster adherence to specifications, integrity, interoperability, and security of connected lighting systems. Philips Lighting implements this system test and validation program for each architecture that is released to the market, and the test may be repeated when there is any change in system configuration.

System-level tests and validations are performed on integrated systems, with all components in interaction, from the initial installation to day-to-day operations. Results of these test and validation programs are documented for continued system improvement processes. Philips Lighting also uses tests to optimize the performance of its Systems and Service Centers and installation partners, to ensure that systems delivered to customers operate as expected, with the ultimate goal of maximum end-user satisfaction.

III. RBC WaterPark Place A proof point

Canadian builder EllisDon designed and built RBC WaterPark Place III in Toronto, Canada, which opened in 2015 as one of the smartest and most connected buildings in the Americas. As a tenant, Cisco rents four floors from building owners Oxford Properties Group. A connected lighting system from Philips Lighting creates a cutting-edge workspace ` with clear visibility on operations for facilities managers. The goal was to install a system that would optimize building performance and allow employees to achieve maximum comfort at their desks.

The Philips connected lighting system at WaterPark Place integrates seamlessly with Cisco's PoE IT architecture. The connected luminaires are a portal to data, energy savings, sustainability, and personal comfort. They merge with the building's IT network and are uniquely identified by IP address, allowing them to be individually monitored, managed, and controlled.

Each light point sends and receives data, allowing managers to track occupancy patterns, changes in temperature, and more while employees can personalize the lighting in their workspaces. Overall, the system offers maximum visibility and better control, and reduces energy consumption in the office spaces.

With an expected annual energy savings of 177,000 kWh and annual cost savings of 50% in the 110,000 sq ft (10,220 sq m) office space, the system is set to provide payback within three years. In November 2015, WaterPark Place was awarded a CoreNet REmmy Innovative Workplace Award. The REmmys recognize projects that raise the bar for real estate in Canada, bringing innovation and sustainability to the workplace. [21]

IV. For more information...

Philips Lighting systems
http://www.lighting.philips.com/main/systems

Cisco Digital Building Solutions
http://www.cisco.com/c/en/us/solutions/workforce-experience/digital-building/index.html

Philips Lighting / Cisco alliance
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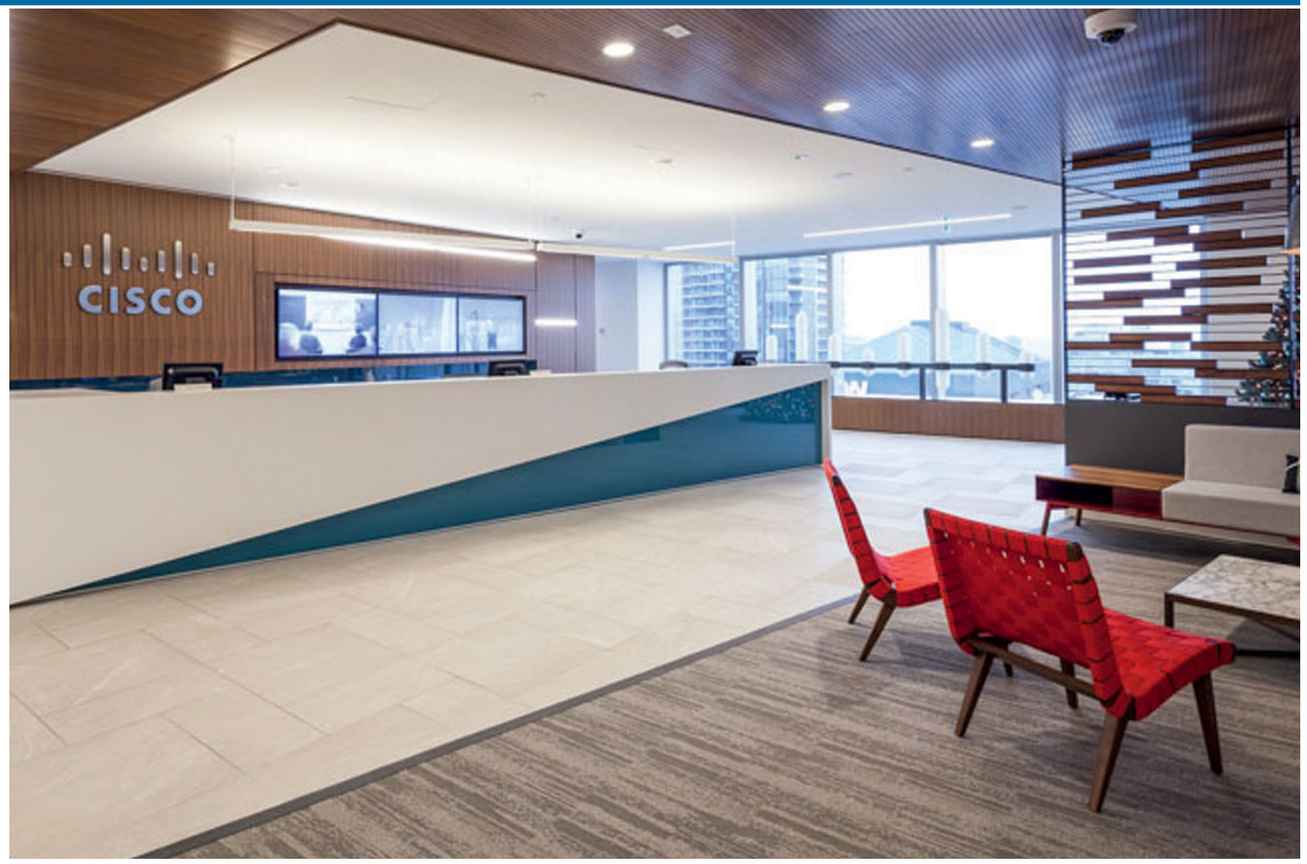

Image: Cisco offices, Toronto, Canada

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