MW Connect™

Understanding and Implementing Interoperability

How Open Standards Provide Pathways from Top to Bottom in Wireless Networked Lighting Controls

background

Often considered a ‘holy grail’ by many in the lighting industry, interoperability suffers from the same challenges as many other technical terms—it means different things to different people. So, what exactly is interoperability? And why has it been so sought after for so many years?

In general, non-technical terms, interoperability is the notion that different devices—programmable LED drivers, sensors, emergency units—will work seamlessly together, one can simply ‘plug’ devices together and ‘play’ them. As for the ‘why’, interoperability offers numerous benefits, providing greater design and installation flexibility at the time of initial installation as well as into the future. In addition, this also offers greater customer choice.

Let’s take a closer look at what this actually requires from a lighting controls perspective. There are different levels of interoperability, each of which this paper will explore in detail later. These levels include:

Device level
How different devices (i.e., driver, sensor) will physically fit together, regardless of manufacturer. For instance, the way a sensor or controller fits into a lighting fixture involves the form factor of the devices as well as how one device attaches to another.

Intra-network level
How different devices communicate with each other on the same network, whether that be wireless-wireless, wired-wireless or wired-wired.

Network-network and cloud interoperability
How different networks communicate with each other, across multiple building systems and third-party networks or clouds. This is frequently considered to be integration, rather than ‘pure’ interoperability, as different building systems (i.e., Building Management Systems (BMS) or access control systems) use significantly different protocols and communication between them generally requires a gateway or other bridging device.

Currently in North America, networked lighting controls (NLC) account for a small percentage of installed controls. In its 2022 Solid-State Lighting R&D Opportunities report, the US Department of Energy Office of Energy Efficiency and Renewable Energy estimated that less than one percent of all luminaires in the US were 'connected lighting.'[1] More recently, the DesignLights Consortium has offered estimates of market penetration of NLCs as being in the five-10 percent range for commercial buildings[2]. The opportunity in energy savings alone is vast, with savings estimates averaging near 50%.[3] Add in additional savings from integration with other building systems, such as HVAC, and the estimates are even higher.

Non-energy benefits may be even more significant, however, and this is where the value of interoperability for wireless NLC is most pronounced. With the ability to design and deploy a custom solution from a range of best-in-breed components, customers can bring much-needed flexibility to their budgets as well as to their planning timelines. No longer does a controls project need to be completed in a specific timeframe; project phases can be accommodated over a single budget cycle or multiple cycles without sacrificing functionality.

Furthermore, this flexibility in timing, design and deployment is particularly valuable in retrofit situations, where owners/operators of small or midsize facilities face rising energy costs while struggling with a lack of technical expertise or capital funding for costly lighting and controls upgrades. More than half of the commercial buildings in the US were built between 1960-1999; only 25% were built after 2000.4 And many of these buildings are modestly sized; according to the 2018 CBECS, 71% of commercial space in the US consisted of facilities 10,000 ft2 or less. The versatility inherent in interoperability provides a toolkit of solutions for a range of building budgets and vintages.

The emergence of building performance standards (BPS) for existing buildings may also present an opportunity for deploying more wireless NLC. Focused on improving energy performance in existing buildings, BPS set long-term performance targets for buildings without specific rigorous prescriptive requirements for achieving those targets. Using a flexible NLC solution bundled with a lighting upgrade can help building owners/operators comply with these standards.

Exploring the Layers of Interoperability

Device level interoperability

At this mechanical interface level, interoperability means that different devices will physically fit together, regardless of manufacturer. For instance, the way a sensor or controller fits into a lighting fixture involves the form factor of the devices as well as how one device attaches to another. Two of the most common standards for mechanical interoperability are those from the Zhaga Consortium, a global lighting industry consortium that develops and promotes standards for LED lighting components, and those from NEMA, the National Electrical Manufacturers Association, a US-based trade association that develops standards for various types of electrical equipment, including LED-based luminaires. (See illustration below.)

The Zhaga standards focus on defining standardized interfaces for LED lighting components, such as control modules and other components. Book18 describes a smart interface between outdoor luminaires and sensing/ communication nodes, specifying power and communication aspects in addition to the mechanical fit and electrical pins.5 Book 20 defines a smart interface between an indoor LED luminaire and a sensing/ communication node.6

NEMA Standards focus on defining specific product characteristics. For instance, NEMA LS 20000-2021 provides recommended mechanical shapes and minimum keep-out area dimensions for indoor luminaires to interface with luminaire integrated control devices7, while ANSI C136 provides standards for roadway and area lighting equipment.

At this level, the greatest benefit for interoperability is speed of installation, particularly with outdoor lighting. Because the standards enable ‘click on’ installation with minimal or no wiring, contractors can retrofit a project devoting only a couple minutes per fixture. The customer also benefits from the possibility of phasing in advanced controls more conveniently over a large project if funding is a concern. By selecting an open standard approach, the customer can order different luminaires over time without concerns about control compatibility.

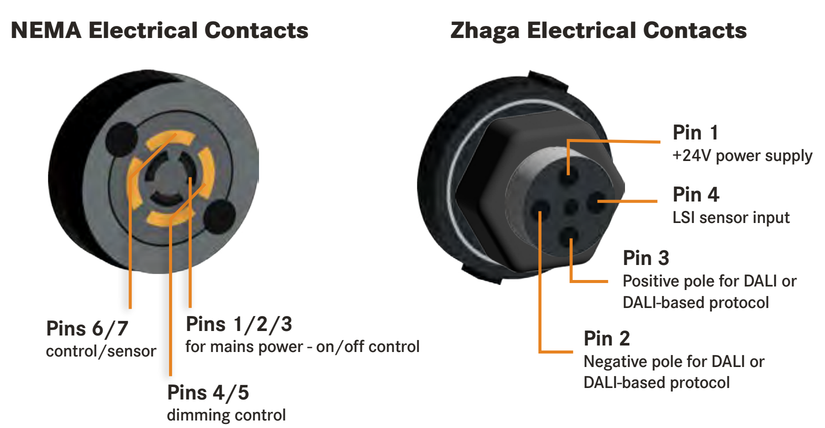


Figure 1: Comparison of NEMA and Zhaga mechanical interface standards

Intra-luminaire interoperability

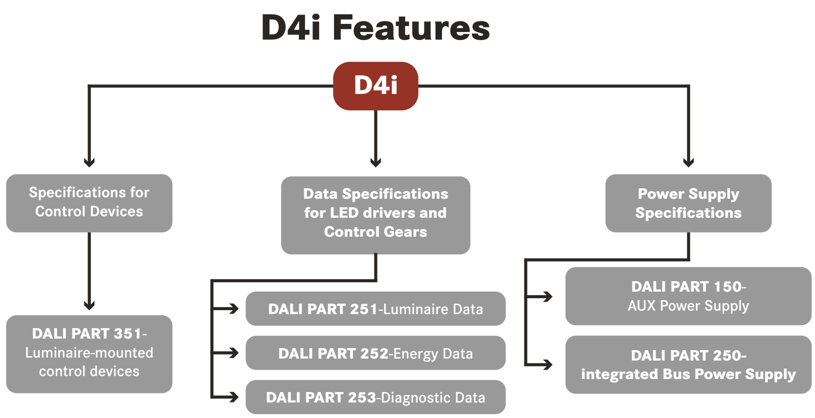


Figure 2: DALI D4i features

Inside the luminaire, in addition to the standardized mechanical interface described above, an open standard communication interface enables free-flowing communication between the components within a luminaire, such as drivers and embedded control devices. The DALI D4i standard, an extension of DALI-2, establishes specific criteria for data and power transmission between devices inside the luminaire. While DALI-2 standardizes the interface for intra-luminaire communication; D4i standardizes the feature set of the LED driver. This provides a way to extract data from components inside the luminaire such as energy or occupancy monitoring. PoE provides standardized data communications and power supply to components within a luminaire via Ethernet cable.

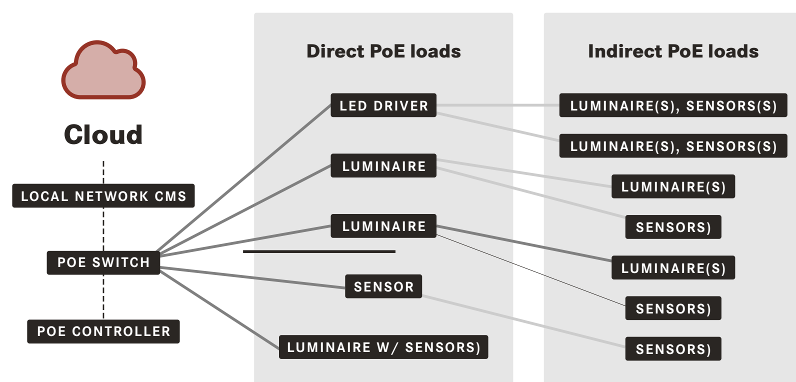


Figure 3. Visualization of how PoE works. Image credit: US DOE PoE Lighting System Energy Reporting Study Part 1, February 2017

The greatest benefit from this level of interoperability, available from a full stack standard,* is the ability of a user to extract valuable data from inside the luminaire, such as energy reporting or occupancy monitoring without the need for intermediate gateways or translators. Because of the open standard inside the luminaire, the customer can scale more easily in the future as well as broadcast future functionality updates to the intra-luminaire components.

** A full stack standard is one that provides standardization for the device/application layer in addition to defining the transport/communication layer(s).*

Network Interoperability

Across the control network, the open standards approach involves the way devices communicate, whether they communicate wirelessly between themselves, are physically wired together for communication, or some combination of both. Common wireless standards include:

Bluetooth NLC
Bluetooth® NLC (Networked Lighting Control) is a full-stack standard for wireless lighting control, providing standardization from the radio through to the device layer, providing a set of device profiles that standardize the control of smart lights, sensors and control interfaces.

Zigbee
Zigbee is an IEEE 802.15.4-based specification for high-level communication protocols used to create personal area networks with small, low-power digital radios. The specification is full stack, but there may be private vendor extensions or modifications that make full interoperability challenging.

Matter/Thread
Thread, a low-power, low-bandwidth, full stack mesh networking protocol that uses the 802.15.4 radio technology, is specifically developed to improve connectivity between products, using a mesh network, so devices communicate with each other without the need for a central hub. Matter is an application layer that runs on Thread.

WiFi
WiFi is a family of wireless network protocols based on the IEEE 802.11 family of standards, commonly used for local area networking of devices and Internet access, allowing nearby digital devices to exchange data by radio waves.

LoRa
The LoRaWAN® specification is a Low Power, Wide Area (LPWA) networking specification designed to wirelessly connect battery operated ‘things’ to the internet in regional, national or global networks.

Multi-Network Interoperability/Integration

Finally, there's the way multiple networks of devices communicate, for example, how a building management system (BMS) integrates with a lighting/control system, or the way a lighting system communicates with an external system, such as an electricity provider for demand response. The most common approaches include:

Application Programming Interface (API)
An API is essentially a mechanism for two or more computer programs or components to communicate with each other. These can be proprietary or open (Project Haystack and Brick are examples of the latter). This approach is typically used to 'bridge' systems where data from one can be used in the other. A common example is the integration of lighting control data and systems with HVAC data and systems.

OpenADR
OpenADR is an open, highly secure, two-way information exchange model that standardizes the messaging format used for automated demand response so that dynamic signals can be exchanged between electricity providers and building control systems.

BACnet/Modbus
BACnet and Modbus are communication protocols for building automation and control (BAC) networks, developed for communication between building systems such as heating, ventilating, and air-conditioning control (HVAC), lighting control, access control, and fire detection systems and their associated equipment.

KNX
KNX is an open standard for commercial and residential building automation, to provide two-way communication between building systems such as lighting, window coverings, HVAC, security systems, energy management, and more.

Stacking/Layering Tiers of Interoperability

Layering different levels or types of interoperability can bring different benefits depending on the use case or the project objectives. Let's take a look at how this can work from the stakeholder's perspective, progressing through the lifecycle of a project and the different stakeholders involved at each stage.

Designers

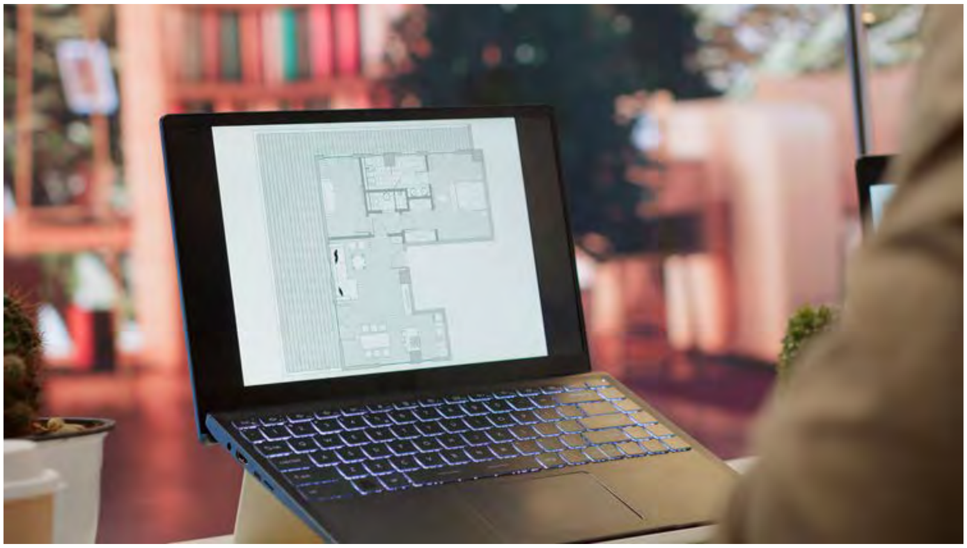
At the earliest stages of a project, the designer (whether lighting designer, controls designer, or collaboration) along with the project owner, will be most familiar with the project goals, and will be tasked with ensuring those goals are met in the design documents. For instance, a retrofit office project may have three primary goals: the ability to reconfigure space depending on tenant needs, providing tunable white capabilities for occupants; and providing capabilities for integrating the existing HVAC system with the lighting control to provide occupant-responsive temperature control.

In a project like this, the designer will first design network interoperability, to capture the first two goals, and then layer on multiple network interoperability to capture the third goal, HVAC integration.

By including network interoperability, the designer will be able to choose from a range of component devices, perhaps selecting tunable white devices from one manufacturer to achieve the second goal while selecting occupancy sensors from another manufacturer because the feature set is preferred. By layering on multi-network interoperability, the designer can then leverage the occupancy sensors to incorporate temperature control via thermostat in primary project goals. This can improve energy performance significantly, with increased savings ranging from 17-24%.

Installer

Interoperability benefits to the installer occur at the initial installation as well as any future upgrades, additions or replacements. Device level interoperability will streamline the initial installation significantly; for example, an outdoor controls project using either the Zhaga or NEMA connection standards will reduce the amount of time needed to install control devices on luminaires. Typically, an installer will only need to attach the control device and twist to secure before moving on to the next luminaire. Similarly, if a replacement is needed in the same application, the replacement can be done without removing or opening the luminaire. Network level interoperability layered on benefits the installer as well. Consider the same outdoor controls project, consisting of phases installed over a period of months or even years. The installer can utilize any compatible control device, regardless of manufacturer, in subsequent phases or as replacement devices in the original phase. This can reduce the needed inventory the installer must carry as well as reduce service calls, as the installer can maintain a modest supply on the truck for faster response time.



Owner/operator

Interoperability benefits to the owner/operator occur at every stage of the project. Stacking device and network interoperability ensures the owner's financial investment will be safeguarded both at the initial installation phase as well as throughout the lifecycle of the project. Initially, the device interoperability means that installation costs will be reduced, while network interoperability ensures that future expansions or replacements will be achieved in a cost-effective manner. Layering additional interoperability, such as multi-network, offers additional energy savings by enabling integration of occupant-responsive control over both lighting and HVAC systems. Similarly, providing OpenADR or API functionality can offer a portfolio owner/operator additional opportunities to manage energy performance or integration with other buildings systems such as shading or smart glass.

Consider a property management firm with a portfolio of commercial office properties in the Southwest and southern California. Leveraging all the layers of interoperability will enable the management team to maintain a real time view of each property's lighting system for predictive maintenance. Scheduling service calls for device or driver failure will be streamlined and simplified, since the service crew can choose from the available compliant device, rather than having to order specific proprietary items. Similarly, the central management team can coordinate upgrades or expansions of multiple properties to pre-commission luminaires from a single factory location and reduce installation time accordingly.

Occupants

Occupants are the ultimate beneficiary of the investment in interoperability, as they are not directly involved in the design or build phases of the project. Their productivity, ability to adjust lighting and temperature controls more easily and intuitively, are the direct result of the connectivity gained through interoperable design and performance. A 2018 survey of 7,000 Staples employees revealed that 80% of the respondents said that having good lighting in an office was essential. One-third said they would be happier at work if they had better lighting.[8]

conclusion

The benefits of interoperability are numerous:

- Flexibility in choosing network components, including luminaires, drivers, control devices
- Flexibility for the future in adjusting NLC performance to meet changing needs
- Simplified scalability for multi-phase projects or budget-conscious applications
- Effective insight into network operation for predictive maintenance, energy reporting, occupancy monitoring, demand response and more
- Integration between building systems like lighting, HVAC, access control and more
- Enhanced energy performance energy savings
- Improved occupant satisfaction and productivity

While many of these benefits can be realized from intentionally including interoperability into a project design and execution, this paper demonstrates that these benefits increase exponentially when a project team layers tiers of interoperability. Starting with foundational device interoperability ensuring swifter installations; adding network interoperability captures the forward-looking flexibility that owners and operators find vital. Adding multi-network interoperability achieves the full range of benefits possible.

It's becoming easier than ever to ensure all the stakeholders can realize some or all of the benefits described above. Industry consortiums like Bluetooth, Zhaga, and DALI Alliance continue to certify growing numbers of products that comply with open standards. Educational offerings—either in person at conferences and workshops or online via education platforms—make it easier than ever to gain an understanding of the principles of interoperability and how to incorporate it into an NLC project. The future of interoperability continues to expand and the future of interoperability continues to expand and the marketplace as a whole will benefit.

resources

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endnotes

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