Whitepaper

Helvar

Connecting Controls – an overview on connectivity technologies in lighting control.

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Introduction

Lighting technology has advanced more rapidly in the last few years than at any other time in its history. The development of LEDs has brought about significant reduction in the energy consumption of lighting (herein reviewed in context of commercial real estate); the revelations around human centric lighting, based on the premise that light has a significant impact on well-being of all living creatures, has opened new use cases for lighting, and the introduction of lighting controls has been key to adding new levels of comfort to the built environment.

Most recently, the inclusion of artificial intelligence in the form of self-learning solutions, that refine and improve performance while in operation, has seen the birth of Lighting Intelligence. Helvar is at the very forefront of all these developments.

With these rapid advancements in lighting technology came developments in the infrastructure of lighting, i.e. connectivity between controls & luminaires, and consequently we are seeing the appearance of wireless lighting control systems in commercial real estate. In the near future we believe that wireless lighting control systems will further complement wired lighting control systems, providing hybrid connectivity solutions that offer superior quality of service, security and interoperability.

With wireless infrastructure options it is important to differentiate systems of connected objects (e.g. luminaires, sensors, etc.) from networked objects. For example, a connected luminaire can be defined as a single device accessible through a control interface such as a mobile app, often connected to a central hub. It offers a one-to-one control similar to that often seen in smart home lighting solutions. In contrast, networked luminaires can communicate with each other whilst being controlled through a mobile app or similar user interfaces.

Some Lighting Intelligence systems like ActiveAhead from Helvar allow direct interaction with the whole network through one luminaire; others require a gateway interface or router to accomplish the control. Networked devices that are able to communicate directly with each other are crucial to applying the intelligence dynamically to the system 'at the edge'.

Lighting Intelligence with networked devices will form a key part of hybrid connectivity solutions that Helvar sees as the future of lighting control.

CONNECTIVITY TECHNOLOGIES

Examples of wired technologies:

DALI

DALI is the true standard for professional digital lighting and lighting control. Digital Addressable Lighting Interface (DALI) is a trademark for the technical standard IEC 62386. It is for network-based systems that control lighting in building automation. The underlying technology was established by a consortium of lighting equipment manufacturers (including Helvar) in the late 1990s as a successor for 0-10 V lighting control systems.

DALI is described as a protocol for communications and control of lighting equipment. This includes Control Gears (ballasts, LED drivers, emergency devices, colour control, switching devices etc.) that have DALI interfaces. The controller can monitor and control each gear by means of a bi-directional data exchange. The DALI protocol permits devices to be individually addressed and it also allows multiple devices to be addressed simultaneously via multicast and broadcast messages.

Each device is assigned a unique address in the numeric range 0 to 63, making it possible to connect up to 64 devices to a DALI network. Addresses may be arbitrarily assigned and devices need not be mapped to contiguous addresses (gaps may exist in the address map). DALI networks can be easily extended beyond 64 devices by the use of specialist products such as Helvar's DALI Routers. Data is transferred between the controller and devices by means of an asynchronous, half-duplex, serial protocol over a two-wire bus, with a fixed data transfer rate of 1200 bit/s.

A single pair of wires makes up the bus used for communication to all devices on a DALI network. The network can be arranged in a bus or star topology, or a combination of these. DALI is not classified as SELV (Separated Extra Low Voltage) and therefore its wiring may be run next to mains cables or within a multi-core cable that includes mains power. Data is transmitted using Manchester encoding and has a high signal to noise ratio which enables reliable communications in the presence of significant electrical noise.

A DALI network requires a power supply to operate. The supply and data are carried on the same pair of wires to peripherals that require it, such as motion detectors. A separate power supply can be used, although some manufacturers provide DALI Routers with an integrated power supply.
The next version of DALI has been released. DALI 2 expands from Control Gears to support also Control Devices.

New parts for Control Devices are currently being written, including push buttons, presence detectors and light sensors. With DALI 2 there are also improvements of reliability and interoperability, compared to the original standard. DALI 2 adds new features, and sets the basis for the future incorporation of input devices. One key features is the additional separate address space for Control Devices. DALI 2 is backwards compatible with the original standard so it is possible to mix DALI 2 control gears with existing DALI gears.

DALI 2 has a new certification and logo licensing process introduced. This means that no DALI 2 marked products can be put on the market without having the test results approved by DiiA (Digital Interface Illumination Alliance). The DiiA is a new organisation who is running and administrating this process. DiiA is an industry driven non-profit organisation which promotes and supports the use of DALI and is driving further development of the DALI standard.

Power over Ethernet (PoE)

POE consisting of set standards and non-standard technologies that have been developed over the years for transmitting DC power over a twisted pair of data cables. The standardisation has taken place in several waves: the original IEEE 802.3af standard was developed in the early years of the last decade.

The standards main driving force was providing voice-over-Internet Protocol (VOIP) phones, cameras, WiFi, base stations and other low-power devices that needed high data communication capabilities and relatively low power. PoE lighting systems are controlled and powered through a data cable connected from a central hub to the luminaire. The IP connectivity that a PoE system offers has the potential to be a major disruption to the traditional lighting control industry.

However, there are limitations in the PoE standard, such as the voltage limitation to 48V DC and the voltage losses in cabling that is reducing the practical distance between the Hub and control gears to a few meters. This issue can be partially solved by using thicker cabling, but the cost of such a PoE cable, which both transfers data and powers luminaires as well as all other devices in the network in a feasible way, is still well beyond the budget of most commercial application projects.

Also, PoE is a DC-based power architecture and therefore radically different to the current AC systems. We expect the adoption to be lead from 'native' DC environments, for example, battery-powered constructions.

Wireless technologies

A number of the most widely available wireless connectivity technologies, such as 3G, 4G, Zigbee, Wi-Fi and Bluetooth® low energy (BLE), will be familiar to many from mobile phone usage, smart home or other commercial solutions.

A common network topology of many connectivity technologies has been a star configuration around a hub, such as a gateway controller or router with a communication distance of up to 50 metres and operating on a 2.4 GHz frequency. ZigBee, in contrast to Wi-Fi, is developed to enable a mesh network topology, yet it is still centrally controlled by a hub. The presence of a central hub is integral to the smooth operation of a network but also allows for Single Point of Failure issues, because if the hub fails then the network can cease to function.

Connectivity technologies such as BLE, Wi-Fi and ZigBee can also be vulnerable to interference. Even though they operate on different channels, the possibility of interference cannot be completely eliminated. However, these technologies do offer high levels of interoperability, especially Wi-Fi, due to significant progress in standardisation.

Mobile communication networks also offer connectivity technologies that may eventually be used in commercial property applications. Currently, available networks are in the 4th Generation (4G), offering superior speed and bandwidth capabilities. However, 4G also requires relatively high processing power and energy consumption.

With 5G, powerful cellular networks building on existing 4G technology are moving into buildings to offer very high bandwidth and location context as well as being able to operate as a seamless Internet of Things (IoT) network, potentially replacing some wireless technologies in many applications. While the technical benefits are clear, 5G will not be commercially available for some time, and the specifications and standards to which it will operate are still not finalised. It is expected that the commercial roll-out of 5G networks will take place from 2020 onwards.

Bluetooth®, another connectivity technology, is commonly used throughout residential and commercial applications. Bluetooth® Low Energy (BLE), also called Bluetooth® Smart, developed originally by Nokia and released in 2010, also operates on 2.4 GHz yet with a maximum range of approximately 10 metres. The low energy functionality of BLE means that devices require very little additional power to connect to the network, and can run on small coin-cell batteries or energy-harvesting devices. Through BLE technology, users can connect to a network of Bluetooth® enabled devices with a smart phone or tablet, which in turn can communicate to those they are directly connected with. With nearly three billion devices shipping annually, Bluetooth® is the wireless technology of choice for developers, product manufacturers, and consumers worldwide.

Bluetooth® Low Energy (BLE) has made little impact in the commercial lighting market as a connectivity protocol because peer-to-peer communication between luminaires is essential to an intelligent lighting system. BLE network can only broadcast one message to all devices on the network; however, this weakness is removed now that a BLE mesh network has been introduced. We are expecting the 1.0 standard as well as several independent implementations to emerge during 2017. BLE mesh networks are similar to a BLE network, yet are not limited by its broadcast-only functionality. They enable smart-phones and tablets to control multiple devices that are connected to

the same network, and the devices themselves can communicate with each other. This is particularly important in lighting control applications because it can ensure seamless dimming and rising of light levels when sensors detect presence.

One crucial advantage that BLE mesh networks hold over comparable technologies is that there is no Single Point of Failure. There is no central hub and even if one device, such as a luminaire, fails then the others can continue to operate and communicate with each other whilst responding to controls.

Helvar, along with a number of other manufacturers, has developed lighting control that uses a BLE mesh network.

Devices, such as luminaires, with integrated BLE mesh technology are much easier to install, requiring no additional wiring, a genuine "plug-and-play" solution. Many "smart" lighting systems enable individual luminaire control through mobile apps, so that individual devices can be configured differently through intuitive mobile and desktop apps. Mesh networks also allow whole lighting systems to be controlled through one device as the commands can be passed automatically throughout the network of devices.

These lighting control solutions can generate significant value by gathering a wide variety of data through sensors and relaying it to a cloud-based portal, accessible through mobile applications or a web-based interface. Building managers can analyse this data to implement a wide range of business benefits, including improving energy performance and optimising space utilisation.
Each of the above technologies has limitations and benefits. There is currently no single wireless technology that can entirely replace wired lighting control solutions. At Helvar we believe that in the near to medium future the best solution is a hybrid connectivity solution of BLE mesh networks and wired DALI-based control systems. Hybrid connectivity solutions can offer the reliability, quality of service and interoperability that a solely wireless solution cannot yet compete with.

Hybrid Connectivity Solutions build on DALI and BLE MESH network technology
The appearance of BLE mesh networks show the possible progression from centralised lighting control solutions that are run by control devices such as lighting routers mounted on racks, to decentralised automated systems which, once set up, do not require any further interaction from a control interface due to its self-learning lighting intelligence. However, it needs to be highlighted that such systems are not suitable for all lighting application cases. The more complex the task the more important wired solutions become – that's why at Helvar we believe that in many application cases a hybrid connectivity solution is the best solution.

Interoperability

In a conventional wired lighting control system, the infrastructure that delivers the power and control commands, for example instructing the luminaire to dim or raise light levels, to the luminaire is a dedicated cable.

The DALI protocol ensures that these commands are standardised across the industry, so that two compliant devices supplied by different manufacturers are interoperable. DALI-connected lighting systems can also gather small amounts of data and use the cable infrastructure to convey this intelligence back to a central hub; however, one of the limitations of DALI-connected lighting systems is that the rate at which data can be collected is limited by the bandwidth of a DALI network.

Bluetooth®, the communication infrastructure which BLE mesh networks are built on, is a standardised protocol. One of the major advantages of a BLE mesh network is that it has the bandwidth capacity to collect much more data and relay this intelligence back to a cloud or app-based portal to analyse e.g. lighting energy consumption and presence in different areas of a property.

This processed data put into an intelligent logic can generate real value for business owners, it is what lighting designers should focus on when delivering a future-proof lighting control solution. However, the control that tells the luminaires how to operate is yet to be standardised, so lighting control solutions that communicate via a Bluetooth® infrastructure are currently using proprietary commands and are unable to communicate with each other to provide truly seamless lighting control.

The Bluetooth® Smart mesh Working Group has, since 2015, been developing a standardised meshing protocol to integrate into BLE, so that any manufacturers' BLE mesh network device can operate on the same network. A statement on this standardised protocol is expected from the Bluetooth® Special Interest Group during 2017.

A possible avenue of development may be the establishment of a wireless DALI network, so that a standardised set of commands can be issued through the BLE mesh network's communication infrastructure.

This would mean technology from all manufacturers could operate together seamlessly, removing the necessity for proprietary commands and ensuring seamless communication between different connectivity technologies. An initiative in this direction has already been submitted to IEC and a working group has been established to take this further.

The standardised BLE mesh control protocol will create the interoperability that is essential for a comprehensive lighting control solution. To provide a cohesive and uniform lighting system, solutions created by different manufacturers must be able to understand the same commands and carry out the same function. Interoperability is crucial in lighting, as so often a wide range

of luminaires and control technology is used for different purposes, particularly on larger projects.

Until the control standardisation proceeds further, there is a need to use proprietary commands over a Bluetooth® infrastructure. This makes the case for a hybrid connectivity solution for lighting control even stronger.

The wired DALI network can provide lighting control to larger open-plan areas for example, a commercial office building. The wireless connectivity technology can be used in dedicated areas such as meeting rooms and stairways. Proprietary commands, such as those used on a BLE mesh network, can be translated by a wired DALI network to enable the two connectivity technologies to work seamlessly alongside each other, so that a BLE mesh network can operate as part of a hybrid lighting control solution.

This is the ideal solution for lighting control, particularly in commercial applications, because it provides the lighting intelligence that many building owners expect now, as well as the quality of service that a wired DALI network is expected to provide.

Bluetooth®

Quality of Service

Lighting is an essential service in commercial and residential property. It is crucial that it does not fail, and is always operating as it should be. This includes the system always being able to provide acceptable response times to users with no perceivable lag.

With a hybrid connectivity solution, having the option of using both wired and wireless connections where appropriately, offers not only improved interoperability, but a significantly more reliable system that delivers a much improved quality of service.

Wireless technology has developed rapidly in recent years but it may be some time until a solely wireless control solution is able to provide the same reliability of service in real life that wired solutions can.

We know that our customers want a lighting control solution that provides a seamless, high quality service. It is therefore essential that we view connectivity technology, in both wired and wireless form, as the enabler of lighting intelligence and be agnostic about how we deliver this intelligence.

BLE mesh networks currently provide advanced, value-generating functionality when combined with a wired DALI network, and we believe that in the near-future this hybrid connectivity system provides the most reliable, high quality and secure lighting solution.

Security

Security is always a key concern when introducing wireless technology into a commercial environment. Reputable manufacturers and developers of BLE mesh networks build in strong security protocols and encryption to ensure that data transferred over Bluetooth® remains secure, and that unauthorised users cannot take control of the lighting system without permission.

Bluetooth® has a limited range which means that BLE mesh networks are only accessible when a person is physically located very near them. Any person attempting to interfere with a BLE mesh network would also have to be inside the building, where physical security measures should stop any unwanted intruders.

Wired lighting control systems have, by their very nature, the benefit of additional physical security, because access to a wired network is required before any harm can be done. This is more difficult as it means the unauthorised user would have to be inside the building and physically connected to the network, and most commercial properties would have other security measures to prevent this. This additional physical security of a wire DALI network underlines the value of a hybrid lighting control solution.

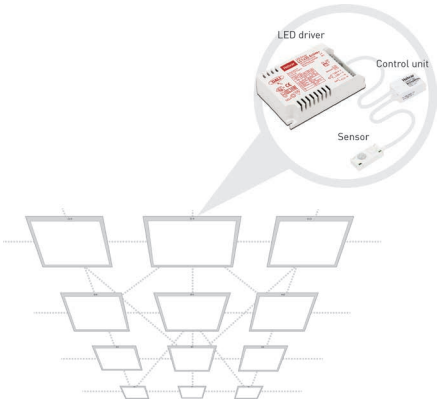
When any new technology is introduced to the market, education is always essential to ensure that it is designed, installed and used safely and correctly. The lighting industry has a responsibility to educate its customers when using wireless connectivity solutions and to establish best practices so that unauthorised users cannot interfere with the system, and that the data generated from the lighting intelligence remains secure.

Example applications for hybrid connectivity solutions with Helvar's ActiveAhead

One of the applications where wireless lighting controls can have the biggest impact is the commercial office space. A typical office building may have several hallways, a number of staircases, meeting rooms, open plan office space and breakout areas, as well as other areas. In each scenario the lighting requirement is different.

In circulation areas such as hallways and staircases, simply dimming the lighting when there is nobody present can create significant energy savings by ensuring that light is not wasted. This can be achieved by wireless lighting control, and a BLE mesh network can provide a seamless solution that always delivers the right light in the right place at the right time.

Helvar's ActiveAhead solution has been specifically designed take advantage of the latest BLE mesh network technology, and is ideal for areas such as corridors and stairwells. From the moment they are installed, luminaires with integrated ActiveAhead technology operate autonomously so there is no need for commissioning, connecting to each other through the mesh network.



This enables them to communicate with each other automatically, dimming or raising light levels when reacting to motion or ambient light.

The system can therefore generate significant energy savings by ensuring that luminaires are only operating when necessary and to required light levels. Users can change the customised parameters of the ActiveAhead solution, using a mobile app, for example if they want certain luminaires to work in a group, to dim more/faster or always remain on.

ActiveAhead's ground-breaking and patented algorithm learns the behaviour of people in their environment through sensors integrated into luminaires, detecting both presence and ambient light. It then uses this information to predict where people will be going to provide the appropriate lighting conditions. The algorithm is constantly learning, able to adapt instantly to changing conditions and always keep the lighting at the ideal level.

In open plan office space, meeting rooms or breakout areas, a more complex lighting control solution may be required. Users may want to adjust the colour temperature or intensity of the lighting, or programme a daily schedule where the lit environment changes over time.

This may require a sophisticated wired DALI network, which, through translatable commands, can operate seamlessly alongside the wireless BLE mesh network installed in other areas of the building. A hybrid lighting control solution is the best option to deliver the quality of service, through this interoperability, that customers require for advanced and reliable lighting control in commercial real estate.

An example of how wireless and wired lighting control solutions can work together can be seen as a person approaches a meeting room. The luminaires in the corridor outside know, through BLE mesh network connectivity, that the person is approaching the meeting room so can command the luminaire closest to the door, which is also connected to the mesh network, to turn on.

Once the person is inside the room that Bluetooth® connected luminaire can, through a command that can be translated by the wired DALI network in the room, alert the other luminaires of the person's presence. Those luminaires can then turn on and adjust to a pre-defined scene-setting or other mode if required.

We can see here how a hybrid solution of wired and wireless connectivity technologies can work together to provide a seamless lighting control system, with superior interoperability, reliability and quality of service.

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Summary

We believe that the future of lighting connectivity may lie in hybrid connectivity solutions, IP-controlled, wired or on Bluetooth® low energy mesh network wireless technology. However, the wireless technology currently available on the market cannot support a solely wireless lighting system in complex and professional applications.

To generate significant value in commercial applications and provide the very best service to its customers, the lighting industry will adopt a hybrid connectivity solution of wired and wireless technology. This can combine the advanced, autonomous, data-gathering lighting intelligence through wireless technology with a reliable, standardised wired lighting control system like DALI to provide a seamless, robust, secure and high quality lighting control solution.

About the Authors:

Lars Hellström and Tommi Raivisto joined the lighting industry less than 18 months ago with a long-term background in mobile/wireless technology, IT & digital service industry and on the premise to contribute to the rapid change in a fascinating industry.

Lars is heading Marketing and Business Development at Helvar, while Tommi signs as Chief Digital Officer and head of R&D.