Connectivity Protocols for Smart Lighting Systems

Introduction

Lighting control systems are crucial to implementing energy-efficient systems by automatically turning on or off lights based on occupancy, adjusting lighting levels based on ambient conditions and by streamlining management capabilities. Some studies estimate that lighting control systems save close to 40% of energy consumption and this is the biggest driver for the increasing adoption of control systems in commercial settings (Figure 1).

Strategy	Definition	Examples	Average Savings
Occupancy	Adjustment of light levels according to the presence of occupants.	Occupancy sensors, time clocks, Energy management system	24%
Personal Tuning	Adjustment of individual light levels by occupants according to their personal preferences;applies,for example ,to private offices,workstation specific lighting in open-plan offices, and classrooms.	Dimmers,wireless on- off switches, bi-level switches , computer based controls, preset scene selection	31%
Daylight Harvesting	Adjustment of light levels automatically in response to presence of natural light.	Photosensors, time clocks	28%
Institutional Tuning	(1) Adjustment of light levels, through commisioning and technology to meet location specific needs or building policies (2) Provision of switches or controls for areas or groups of occupants; examples of the former include high end trim dimming (also known as ballast tuning or reduction of ballast factor), task tuning ,and lumen maintanance.	Dimmable ballasts, on-off or dimmer switches for non personal lighting	36%
Multiple Strategies	**Any combination of the above**		**38%**

Figure 1: Average Energy Savings by Employing Lighting Control Systems with Sensors[1]

Further, the emergence of the Internet of Things (IoT) and new possibilities with sensors and wireless connectivity is changing the lighting landscape. The new value in integrating data from sensors and transmitting it to the cloud for analysis and insights is gaining traction and presenting new opportunities and new services. This era of connected lighting has also resulted in several network protocols designed for specific purposes and environments. This article summarizes the current and emerging protocol landscape for lighting control systems.

Lighting Control Protocols Landscape

Many wired and wireless protocols are available today and OEMs must consider several factors before deciding the optimal protocol that suits the needs of the end application. Wired protocols offer reliable performance and greater control. However, the cost of wiring and installation can be high especially in commercial settings. In recent times, low-cost wireless connectivity protocols like ZigBee, Bluetooth LE, and Wi-Fi have shown potential to reduce costs to provide scalable options. The figure below features the popular lighting protocols.

Wired

Wired Digital Control

- **DALI**: Digital Addressable Lighting Interface non-proprietary protocol. Most popular wired standard, and successor of 0-10V lighting control systems
- **DMX**: Serial, unidirectional protocol that is commonly used to control stage lighting and special effects
- **Power Line Communications**: Existing powerlines are used for communication and are popular for outdoor street lighting and in industrial settings
- **Power over Ethernet**: Data and power are received over a standard Ethernet cable

Analog Control 0-10V: Earliest and simplest lighting control system. However, it requires one dedicated wire per control channel resulting in high cabling and installation costs

Wireless

Wireless Digital Control

- **ZigBee:** Based on 802.15.4, supports point-to –point, star, tree and mesh architecture
- **Bluetooth LE**: Low-energy protocol used in a variety of point-to-point consumer applications
- **Wi-Fi:** Based on IEEE802.11 MAC and PHY specifications. High data rate, star topology
- **6LoWPAN:** Based on 802.15.4, supports star and mesh topologies, large addressing space, allowing many devices to be connected to route-able IPv6 address
- **EnOcean:** Energy harvesting wireless technology for building and home automation
- **Li-Fi:** Point-to-point. Li-Fi transmits data using light with the help of LED bulbs
- **Thread:** Emerging standard, Based on 6LoWPAN, supports mesh topology

Figure 2: Popular Lighting Protocols

The choice of protocol is driven by considering several factors:

1. The size of installation – How many end-points must be connected and the requirement for central control. For large installations, wired protocols can greatly increase the complexity of the network and cost of wiring and installation.
2. Interoperability with other devices and systems – Are the lights expected to be interoperable with other devices in the network (thermostats, etc.). Does the protocol provide flexibility for future upgrades?

3. The range of communication – What is the maximum range of communication required. While both wired and wireless protocols are subject to transmission losses, special allowances for environmental related losses (noise, interference, obstacles such as walls and barriers) should be made for wireless protocols.
4. Scalability of the network – Building systems that meet current requirements while providing the capability for future enhancements is a key. Protocols that easily allow adding or removing lights from the network should be considered.
5. Security requirements – Hackers already proved that breaching a light to gain access to the entire network is possible. Securing the network and endpoints is especially critical in today's connected environments.
6. Device management requirements – Protocols offer local (Bluetooth) or remote (IP-based such as Wi-Fi or Thread) management capabilities.
7. Cost of installation and maintenance - Upfront investments and ongoing costs for maintenance and repair should be included in the total cost of ownership calculations

Survey of Protocol Usage – Current and Future

Figure 3 shows survey results on lighting protocol usage in 2016. Open protocols are preferred to proprietary technologies and DALI is the predominant communication technology used. Wireless is still in its early stages of adoption but is increasingly considered as the future. Primary advantages are the elimination of wiring and the ability to drive more monitoring and control points. The most common wireless technologies for Lighting include ZigBee, Bluetooth, Wi-Fi, and EnOcean.

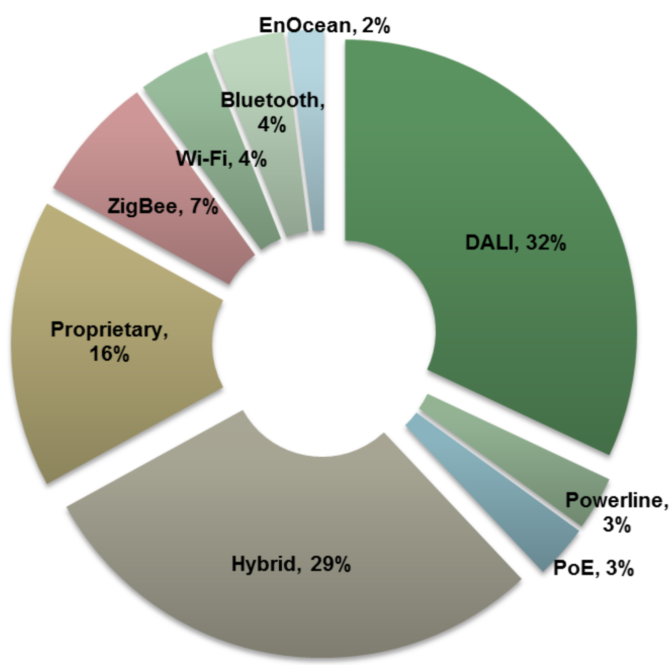

Figure 3: Lighting Protocol Usage in 2016

(Source: Strategies Unlimited)

Lighting Technologies for the Future

An in-depth lighting market wide study conducted in 2015 revealed the communication protocol preferences over the next three years (Figure 4). Key takeaways from the study include

1. DALI not seen as a dominant protocol in the future. While it's hard to predict the pace of transition, the growth in wireless technologies will probably dominate DALI-based installations
2. The trend towards wireless, especially in indoor applications - Wireless lighting control is gaining traction in indoor professional lighting and commercial markets. Wi-Fi, ZigBee, and Bluetooth will be the primary contenders.
3. Hybrid solutions implementing two or more protocols will also gain traction in critical applications. In addition, having interoperability capabilities with multiple devices will help future-proof existing solutions
4. Powerline communication is the leading contender for connecting industrial-based lighting solutions. Wireless technologies

Note that the survey conducted did not include Thread as an option. In April 2016, The Connected Lighting Alliance (TCLA), the primary advocate of wireless lighting connectivity, announced that it is collaborating with the Thread Group on an open protocol solution for the network-layer in indoor professional lighting applications. Thread's advantages of IP addressability, robust security, easy commissioning and management, and no single point-of-failure make it an attractive option for the next generation of lighting solutions.

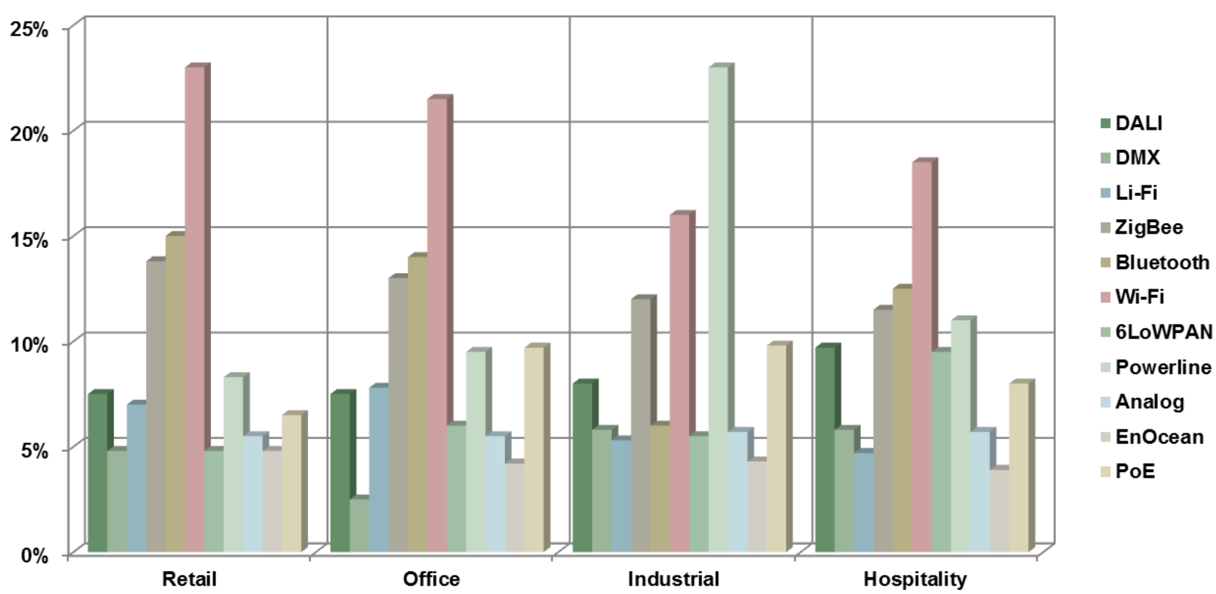

Figure 4: Connectivity Protocol Usage in the Next 3-5 Years

(Source: Strategies Unlimited)

Summary

Connected lighting systems bring new opportunities for energy and cost savings, especially in commercial environments that control a large network of lights. Low-cost sensing, wireless connectivity, and readily available cloud-based solutions have changed the landscape and made it ripe with disruption opportunities. Driving innovation in this environment involves making decisions around business models, go-to-market approach and technology choices.

The existing and emerging connectivity protocols aim to drive greater adoption of connected solutions. Decisions around connectivity should be driven by current and future trends – easy to install, manage, control and service; scalable; reliable; and low total cost of ownership. Arrow Lighting has the technical know-how, broad supplier offering, and value-added services to help OEMs adopt new technologies and compete effectively.

References

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3. ZigBee, Bluetooth, and Wi-Fi the Top Most Rated Lighting Communications Technologies to Win-Out in the next 3 years
4. Top Lighting and LED Trends for 2015

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