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Designers Lighting Forum

Applying wireless technologies to connected lighting as a catalyst for the Internet of Things (IoT)

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March 14 2018

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Learning Objectives

At the end of the this course, participants will be able to:

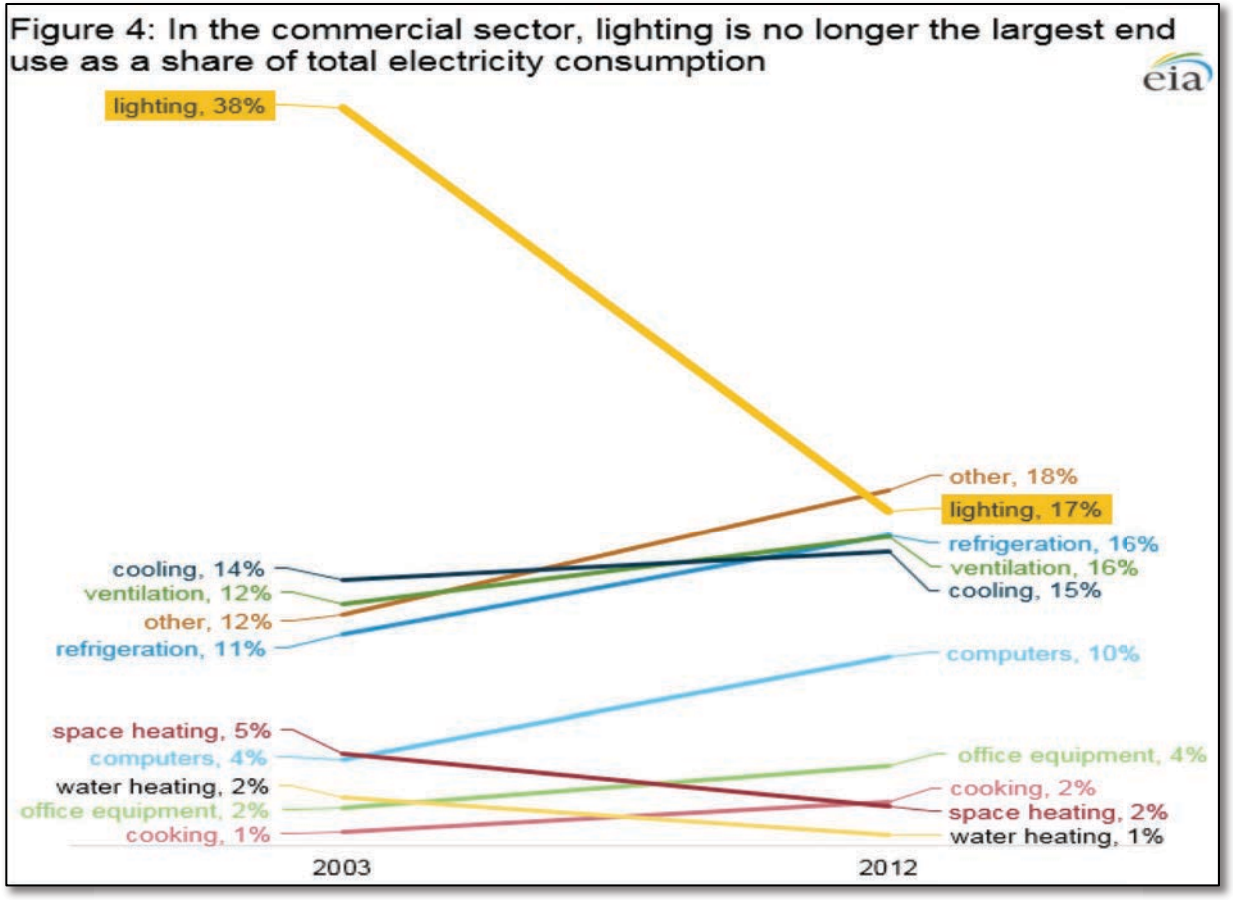
1. Participants will gain an understanding of how the quest to reduce energy waste has driven the evolution of lighting and control approaches towards a connected wireless platform, including the benefits of implementing wireless lighting controls to provide occupant flexibility and space comfort.
2. Participants will gain an understanding of the different types of standardized wireless controls technologies and learn important basic cyber security best practices to ensure that wireless control operation is safely and securely installed.
3. Participants will gain an understanding of when and why it is necessary to involve Information Technology (I.T.) personnel to address building safety and security concerns.
4. Through examination of industry trends, participants will gain an understanding of how connected lighting is being used in the implementation of the Internet of Things (IoT) and will learn important criteria to assist in future-proofing system selections provides building occupant health, safety and welfare.

Learning objective 1

Participants will gain an understanding of how the quest to reduce energy waste has driven the evolution of lighting and control approaches towards a connected wireless platform, including the benefits of implementing wireless lighting controls to provide occupant flexibility and space comfort.

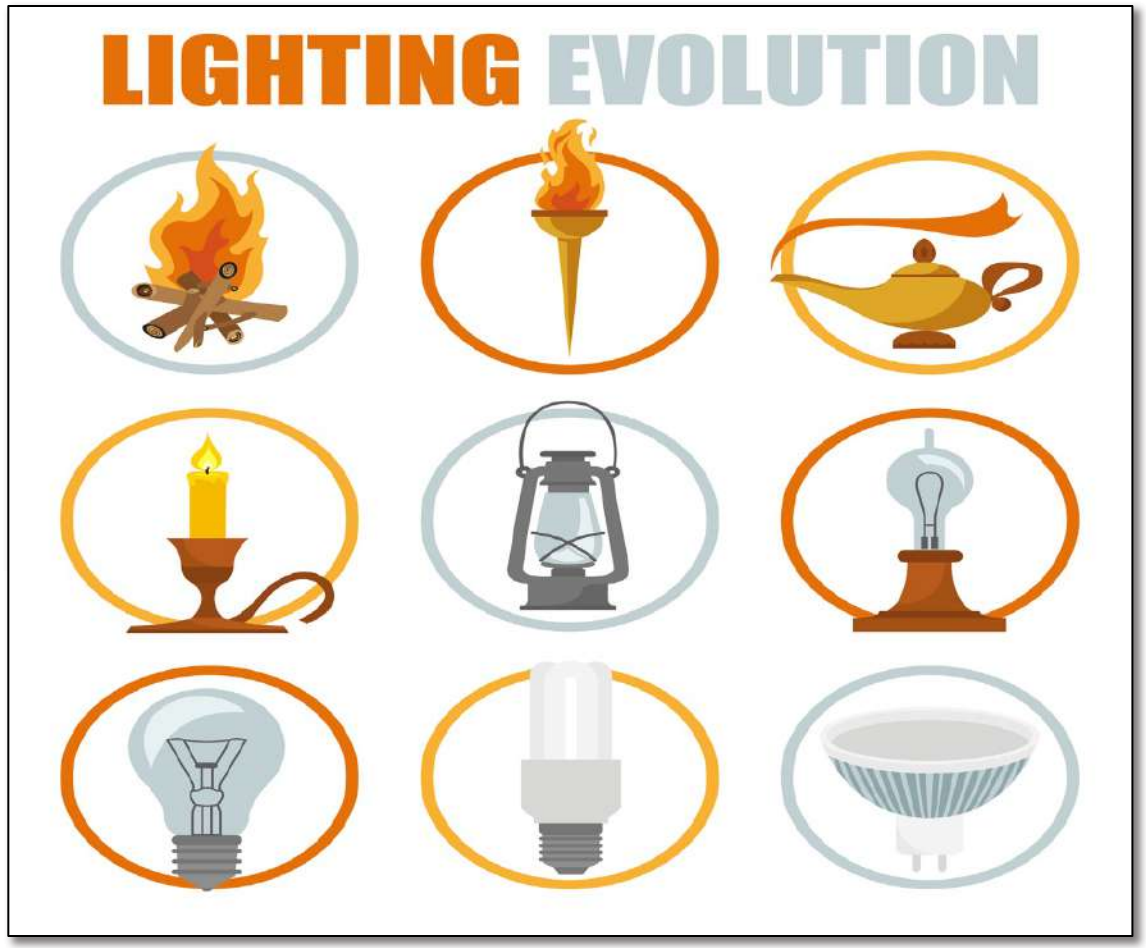
Lighting control progress

Advances in lighting technology and controls have reduced the electricity used to run lighting in commercial spaces from 38% to 17% over the last decade



– Energy Information Administration, "Trends in Lighting in Commercial Buildings," May 17, 2017

Lighting and control evolution



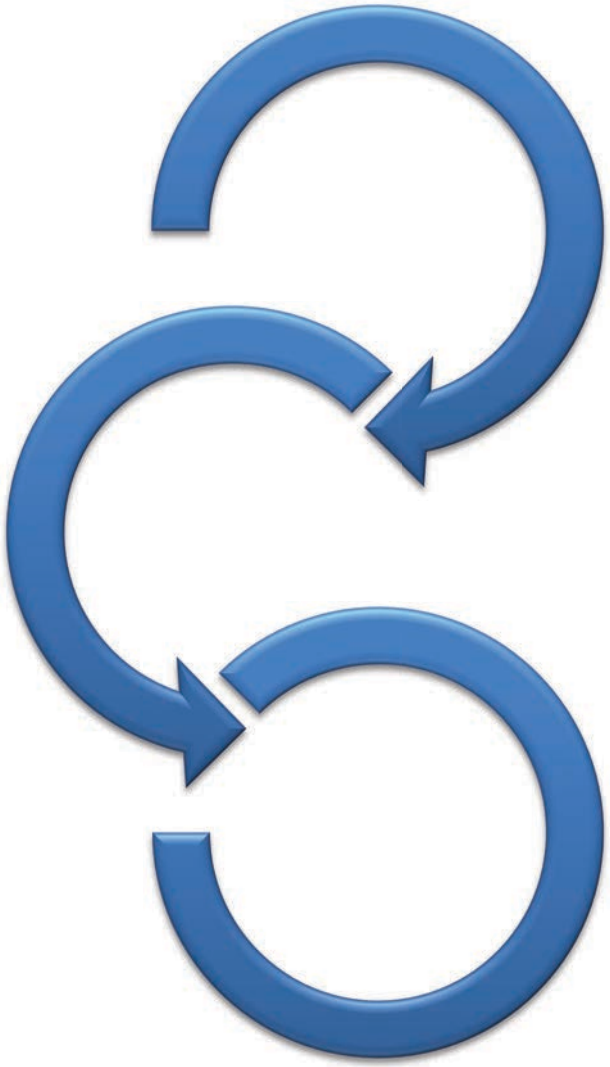
Efficient lighting technologies continue to reduce electricity use and operational cost

Lighting control evolution

Energy codes continue to drive control strategy implementation with the ultimate goal of supporting the push towards “Net Zero” building designs

– National Institute of Building Sciences, www.wbdg.org

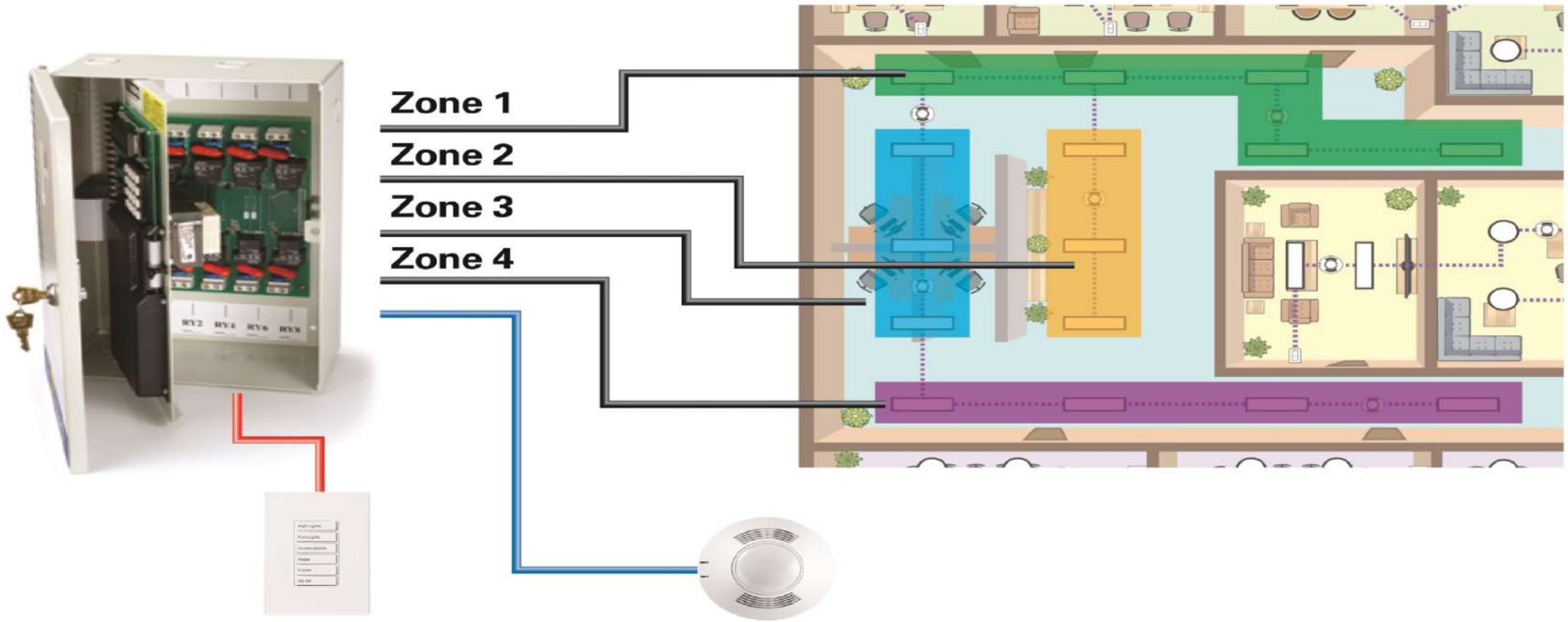
Evolution of control approaches



- Hardwired zoned based
- Hardwired addressable
- Wireless

Control approaches

Traditional hardwired controls require layout of circuits into fixed or dedicated control lighting zones



Control approaches

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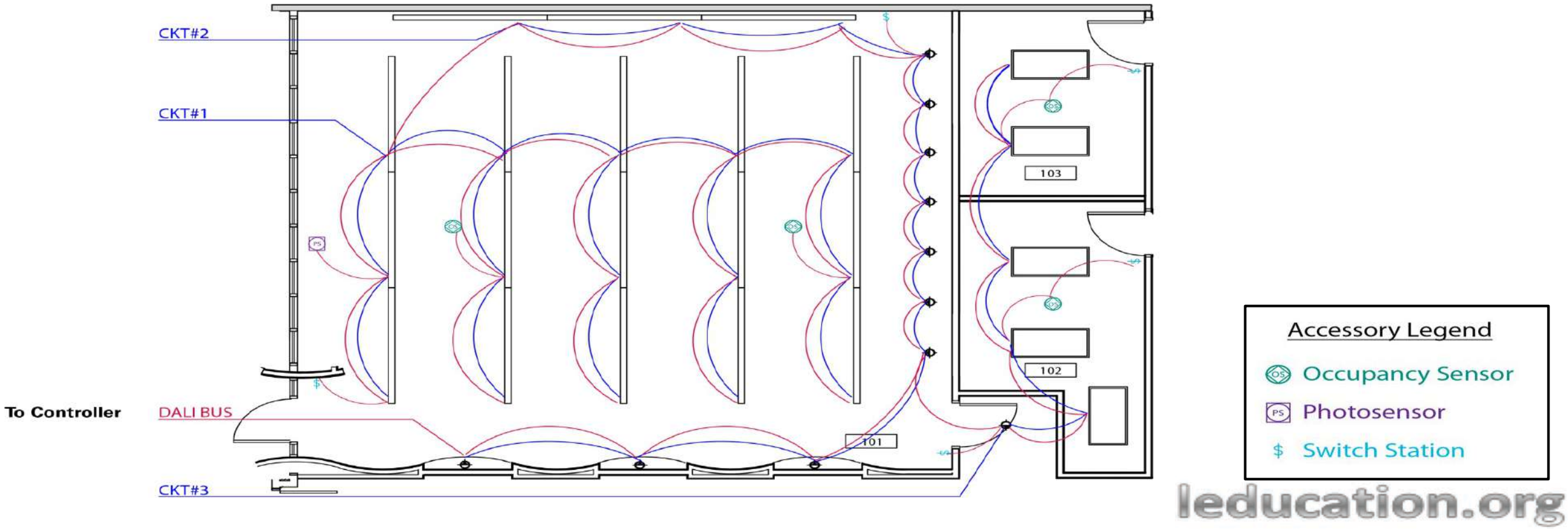
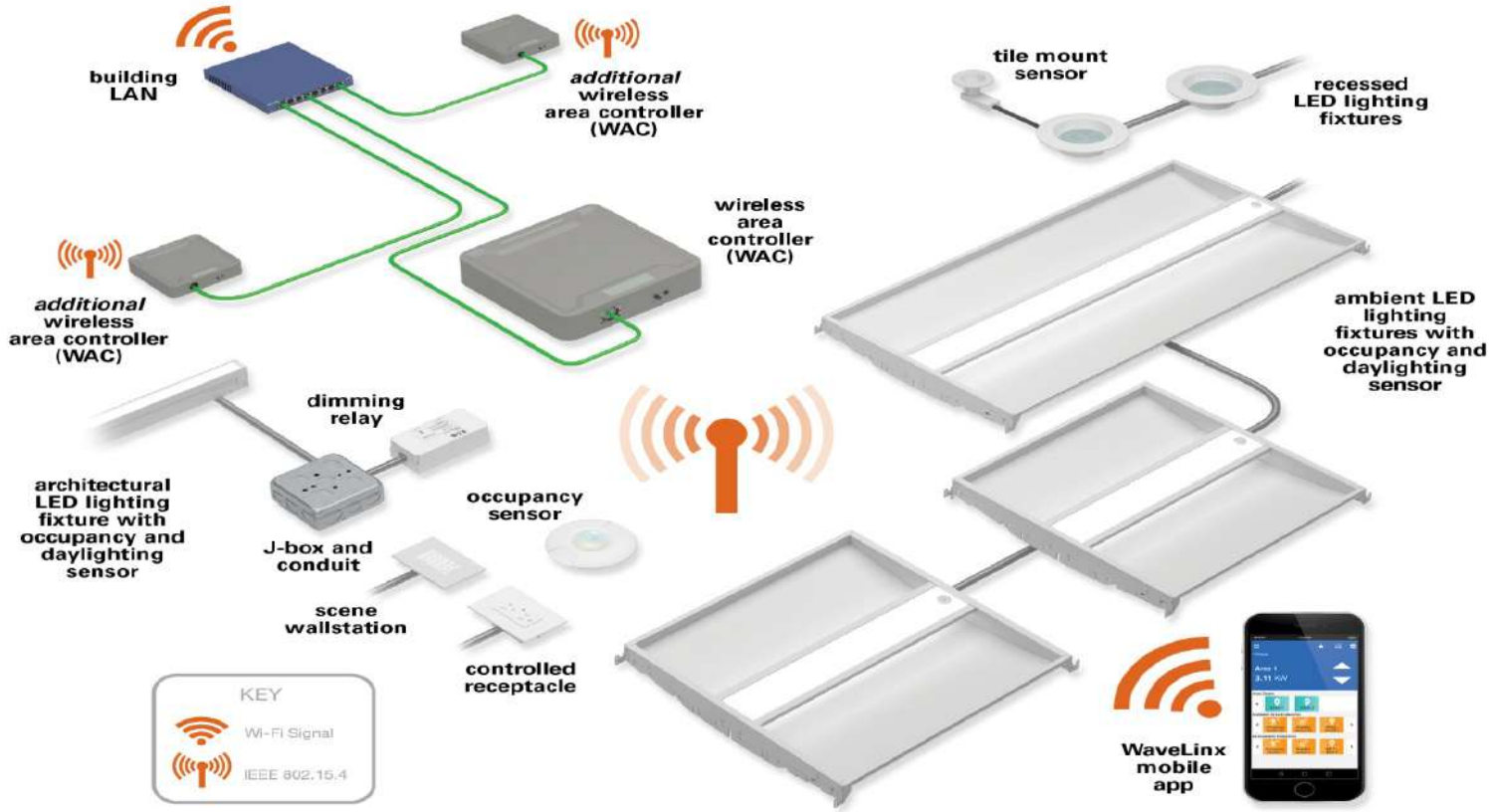


Control approaches

Wireless mini-sensors factory installed in light fixtures offer simplified installation while maintaining the flexibility of granular control

Luminaire with integrated wireless mini-sensor



Control approach comparison

Traditional	Wireless
Control based on wired zone	Granularity of control down to individual fixture
Occupant customized control limited to fixed zone	Occupant customized personal control
Limited ability for sharing of data	Data sharing is simplified due to system design
Future changes require expensive rewiring and reconfiguration	Future changes may only require reprogramming

Cost of control approaches

Los Angeles: 10 year life cycle cost summary

	Localized control	Conventional relay panel	Conventional dimming panel	Hardwired addressable	Wireless dimming
	BASELINE				
Total equipment & installation Cost	100%	158%	174%	126%	97%
Total commissioning cost	100%	145%	171%	310%	258%
Total annual energy cost	100%	92%	81%	63%	60%
Net present cost (LCC at 10 years)	100%	115%	114%	89%	76%

— Clanton & Associates, "Wireless Lighting Control: A Life Cycle Cost Evaluation of Multiple Lighting Control Strategies," 2011

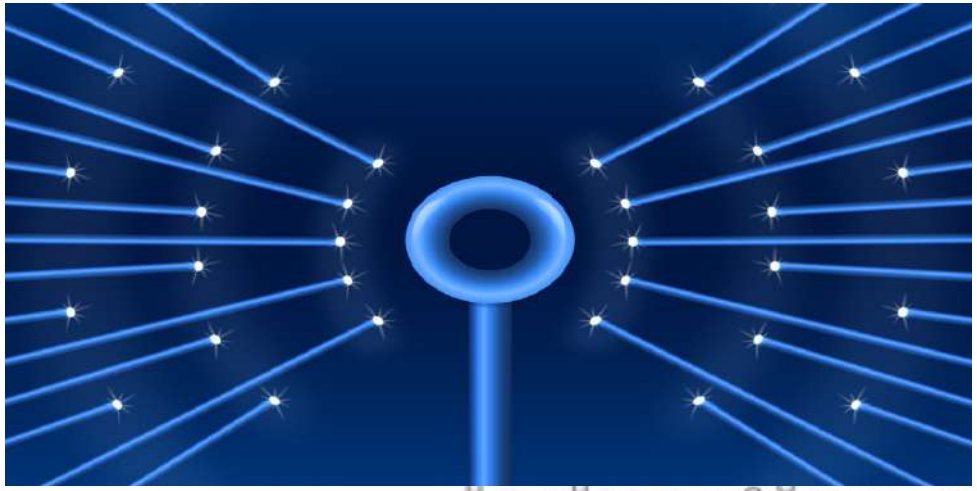
Additional Recent Factors

Learning objective 2

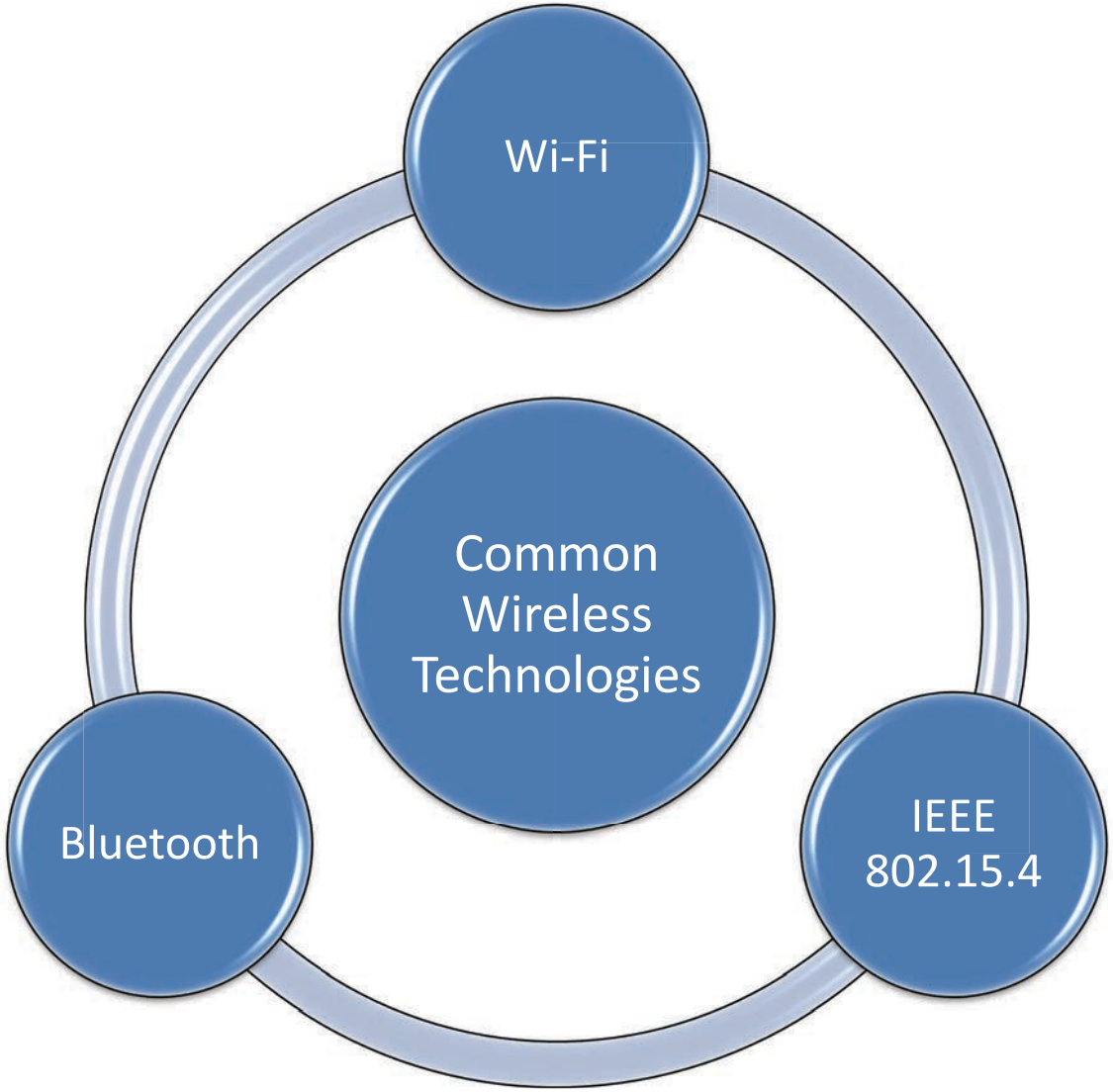
Participants will gain an understanding of the different types of standardized wireless controls technologies and learn important basic cyber security best practices to ensure that wireless control operation is safely and securely installed.

The wireless challenge

Goal: To meet and exceed wired connectivity capabilities delivering signals reliably and quickly via RF transmissions through the air



Wireless technologies



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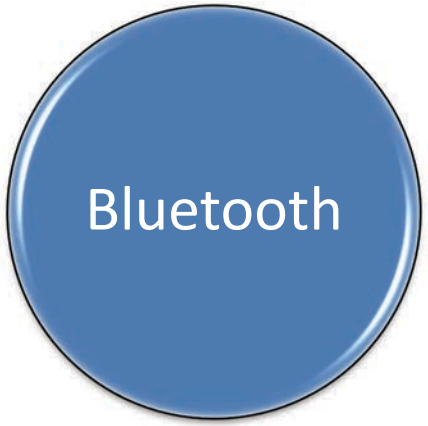
Wireless technologies

- Short for “Wireless Fidelity”
- Trademark of the Wi-Fi Alliance
- Brand name for products using the IEEE 802.11 family of standards
- Commonly used for “wireless local area networks” (WLAN)
- Typically operates at 2.4GHz and 5GHz

Wireless technologies

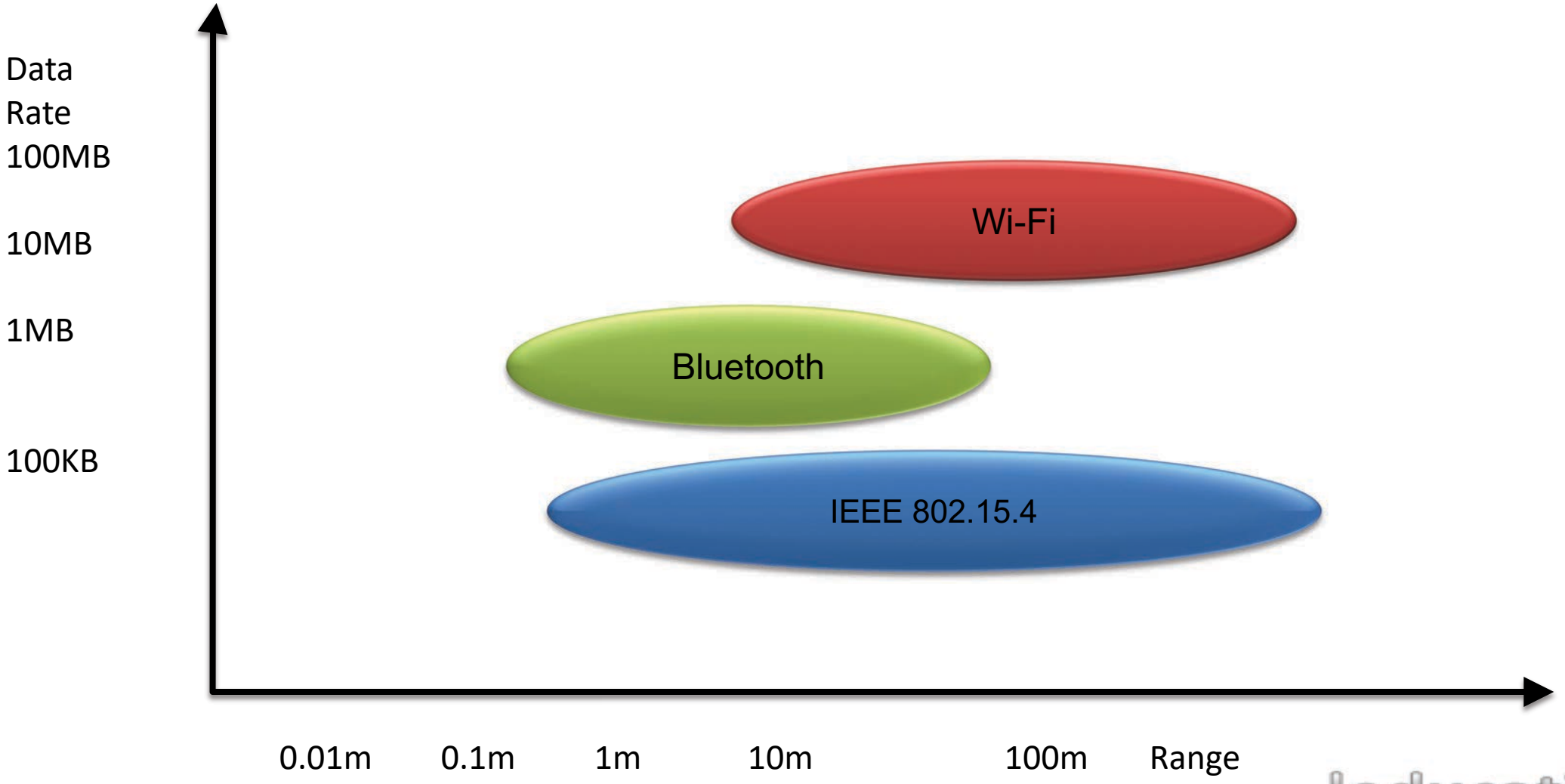


- Standard IEEE 802.15.1 now under control of Bluetooth SIG
- Design goal
  - Short range for cable replacement
  - Low cost
  - Low power
  - Small size
  - For mobile devices
- Wireless Personal Area Networks (WPAN)
- Operates at 2.4GHz

Wireless technologies

- Standard IEEE 802.15.4 published 2003
- Design goal
  - Low power consumption
  - Simple design
  - Few costs
- Low Rate Wireless Personal Area Networks (LR WPAN)
- 900 MHz or 2.4GHz (more common)

Wireless technologies



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Wireless frequency

FM Radio

88.0 – 108.0 MHz

(licensed)

315/433 MHz

315/433.050 - 434.790

(unlicensed)

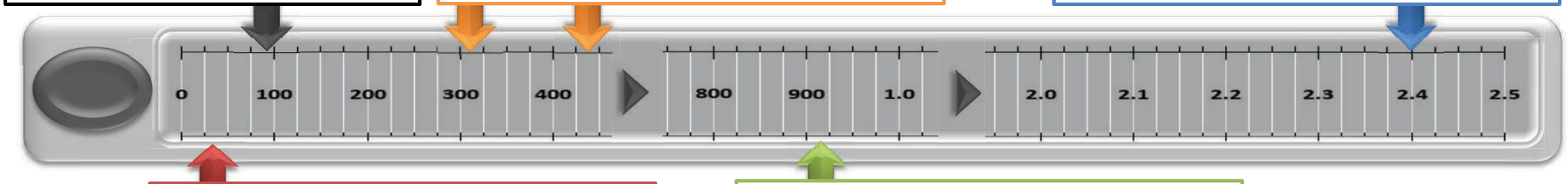
- security systems
- wireless thermometers
- garage door openers
- RFID
- proprietary control systems

2.4 GHz

2.400 - 2.500

(unlicensed)

- data networks
- personal area networks
- 802.11 Wi-Fi
- 802.15.4/Zigbee/ 6LoWPAN
- Bluetooth



27 MHz

26.957 – 27.283

(unlicensed)

- CB radio
- R/C hobby controls
- A/V remote controls

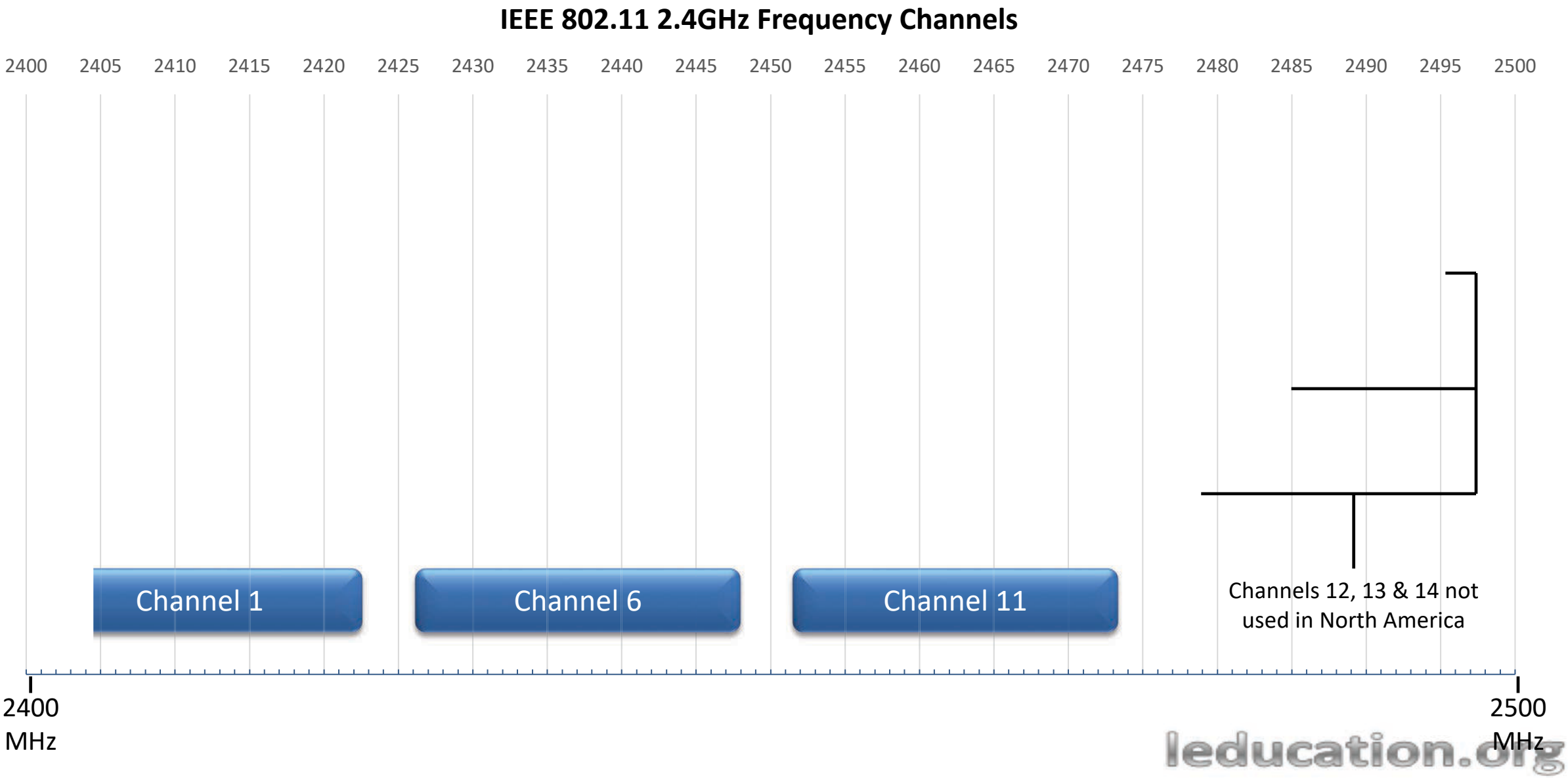
915 MHz

902.000 - 928.000

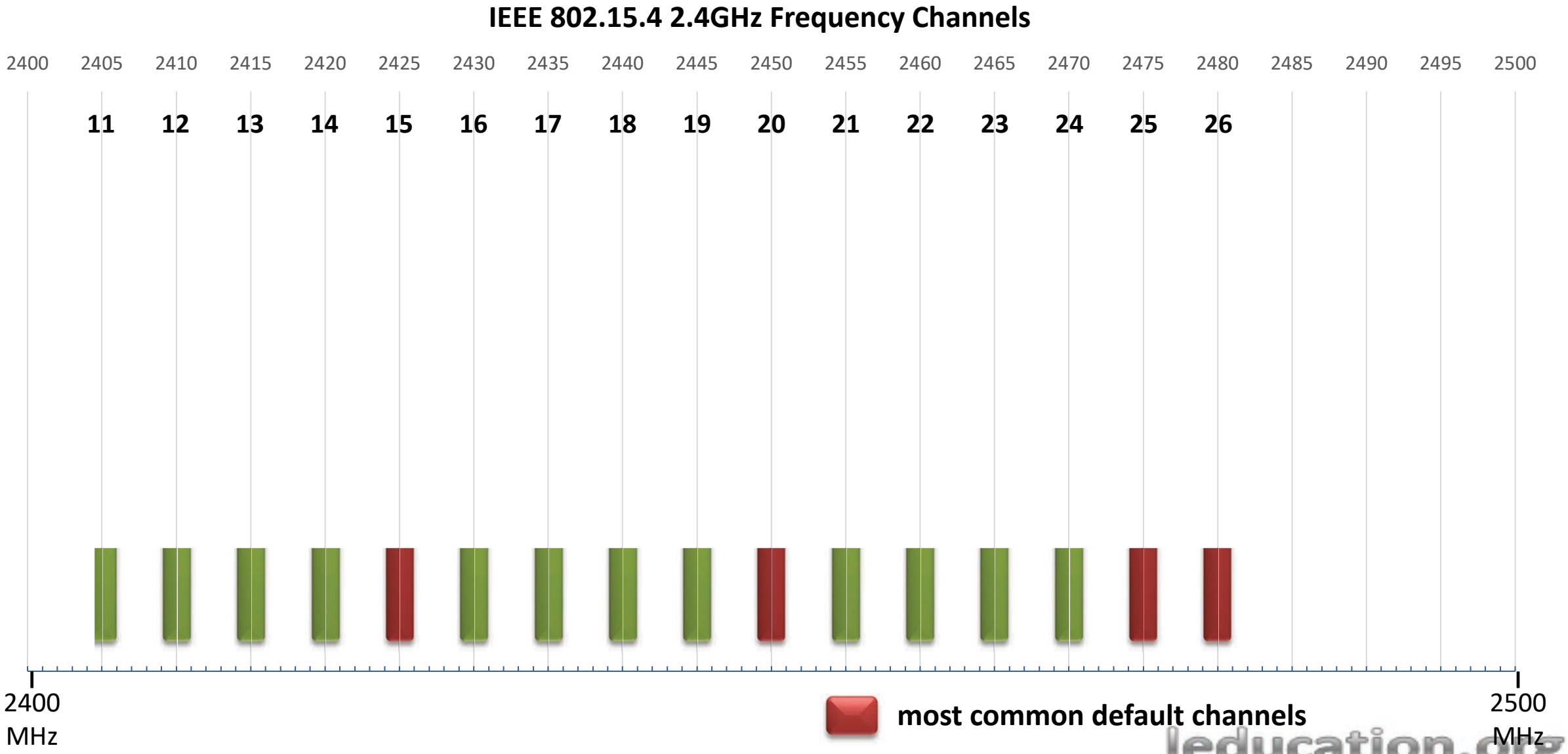
(unlicensed)

- telemetry/meters
- older cordless and baby monitors
- video
- 802.15.4/Zigbee
- EnOcean and Z-Wave
- 802.11ah Wi-Fi HaLow

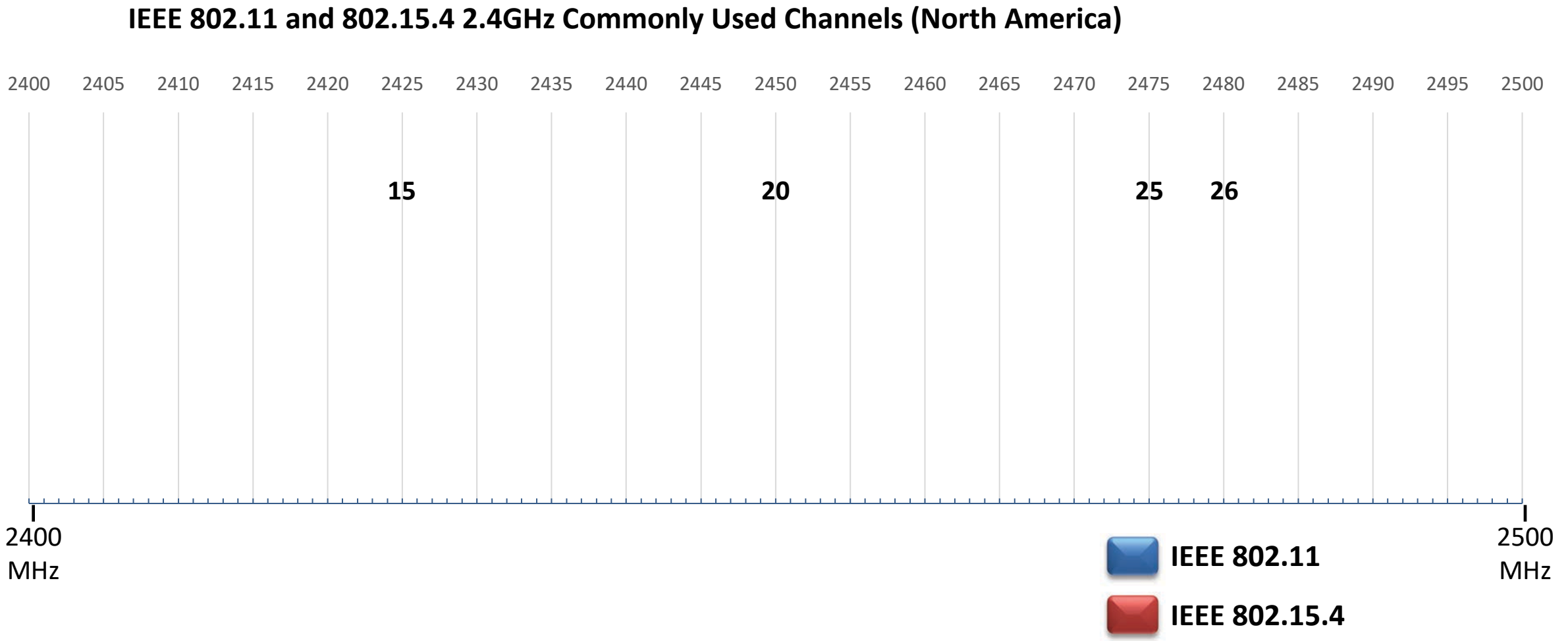
Wireless channels



Wireless channels

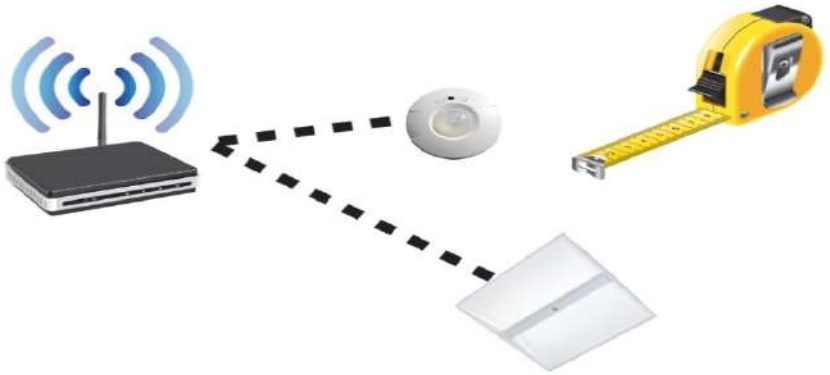


Wireless channels

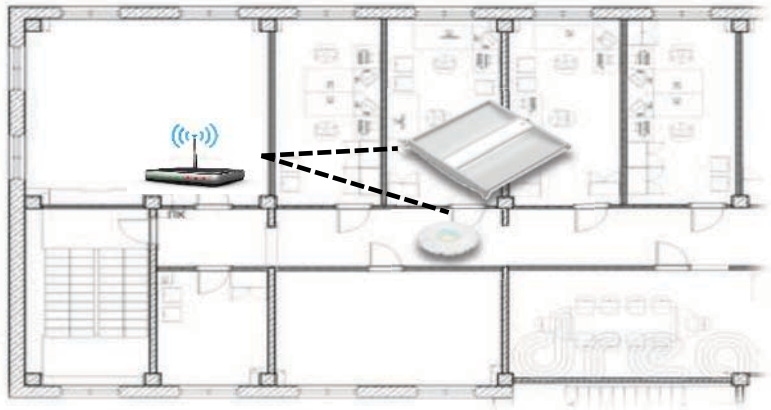


Potential causes of signal disruption

Range and distance



Obstacles



Proximity to other transmitters

Quantity of devices

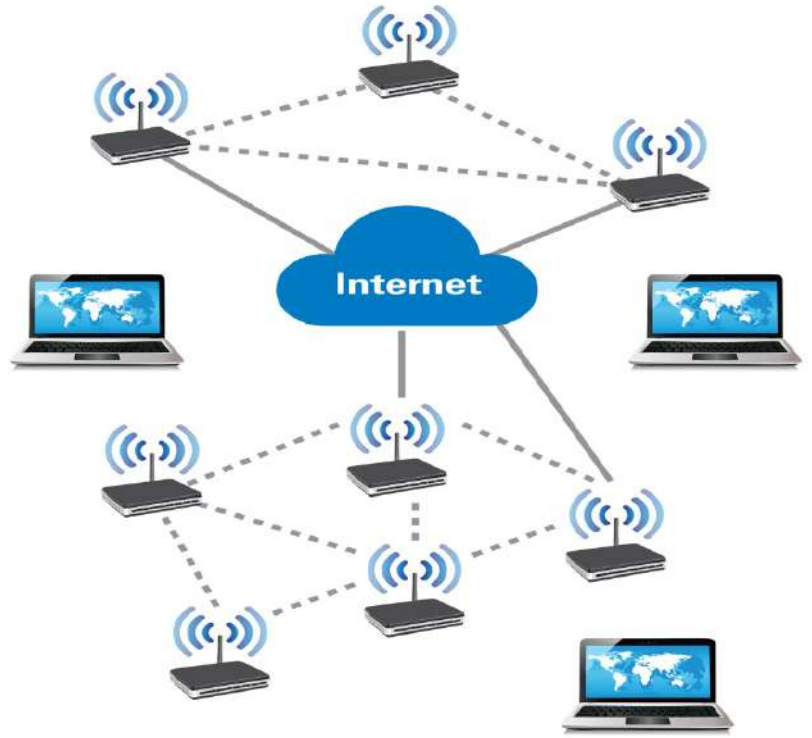
Wireless communications

IEEE 802.11 wireless communications

Point-to-multipoint
(access point)

Point-to-point
(ad hoc)

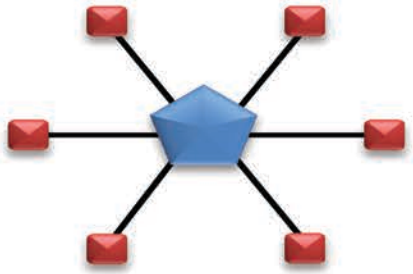
Multipoint-to-multipoint
(mesh)



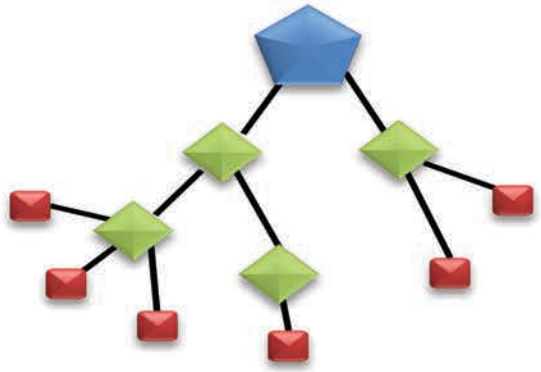
Wireless communications

IEEE 802.15.4 wireless connection topologies

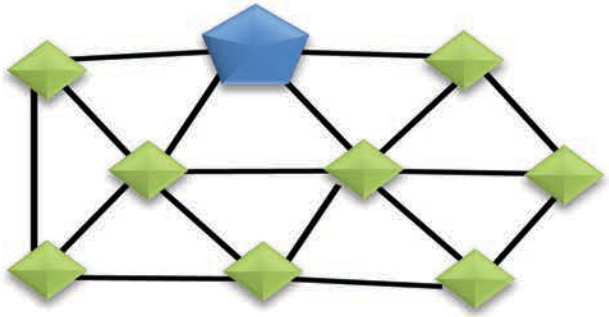
Star



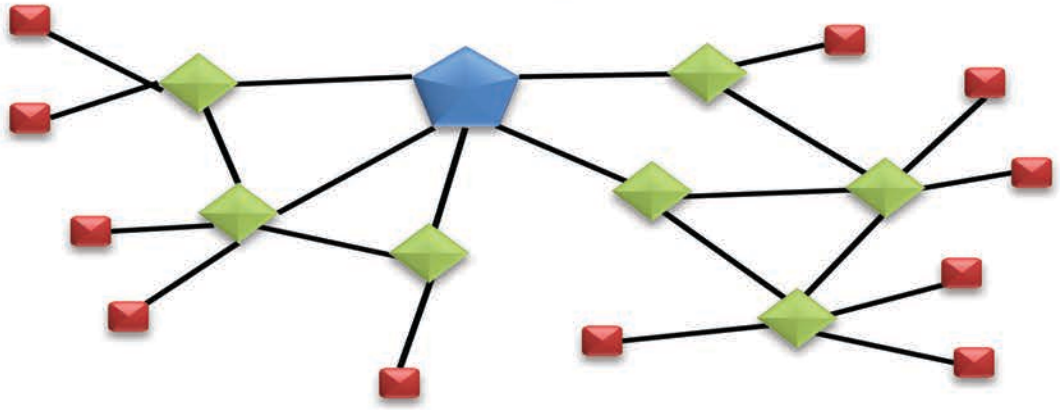
Tree



Mesh



Cluster



Wireless design questions

1. What wireless technology is the control system utilizing?
2. Are there other wireless technologies being used in the same space? If so, what are they?
3. If using the same frequency bands, what channels do the wireless systems use? Are they auto-sensing or do they allow assignment to specific channels?
4. What is the expected range of the wireless technology from the manufacturer's perspective? Has a wireless layout been done for the project that accounts not only for the placement of the devices but also allows for layout contingent on wall locations and materials to ensure best signal strength across the signal range?
5. What are the locations of Wi-Fi access points or other transmitters in proximity to the control system transmitters? Are they far enough away to prevent potential interference and placed in a location ideal for signal transmission (not the electrical room)?
6. What quantity of devices does the system support?
7. What is the wireless connection topology? If a device goes offline, what is the behavior? Does this meet the requirements of the project?
8. How are devices moved or replaced for maintenance?

Learning objective #3

Participants will gain an understanding of when and why it is necessary to involve Information Technology (I.T.) personnel to address building safety and security concerns.

Wireless controls and I.T.

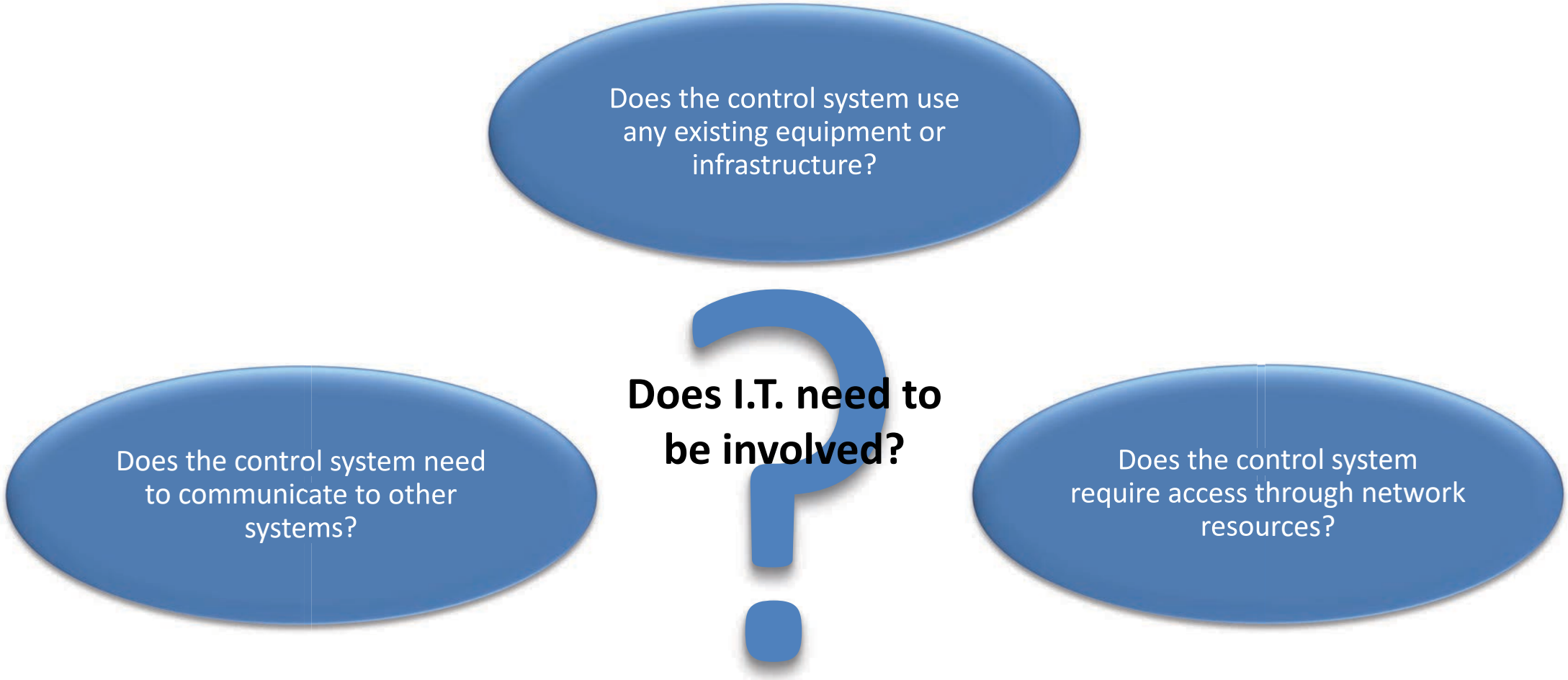
- Operational Technology -
  “the hardware and software dedicated to detecting or causing changes in physical processes through direct monitoring and/or control of physical devices”
  – Wikipedia

- Information Technology:
  “the technology involving the development, maintenance, and use of computer systems, software, and networks for the processing and distribution of data”
  – Merriam-Webster

Operational Technology (O.T.)

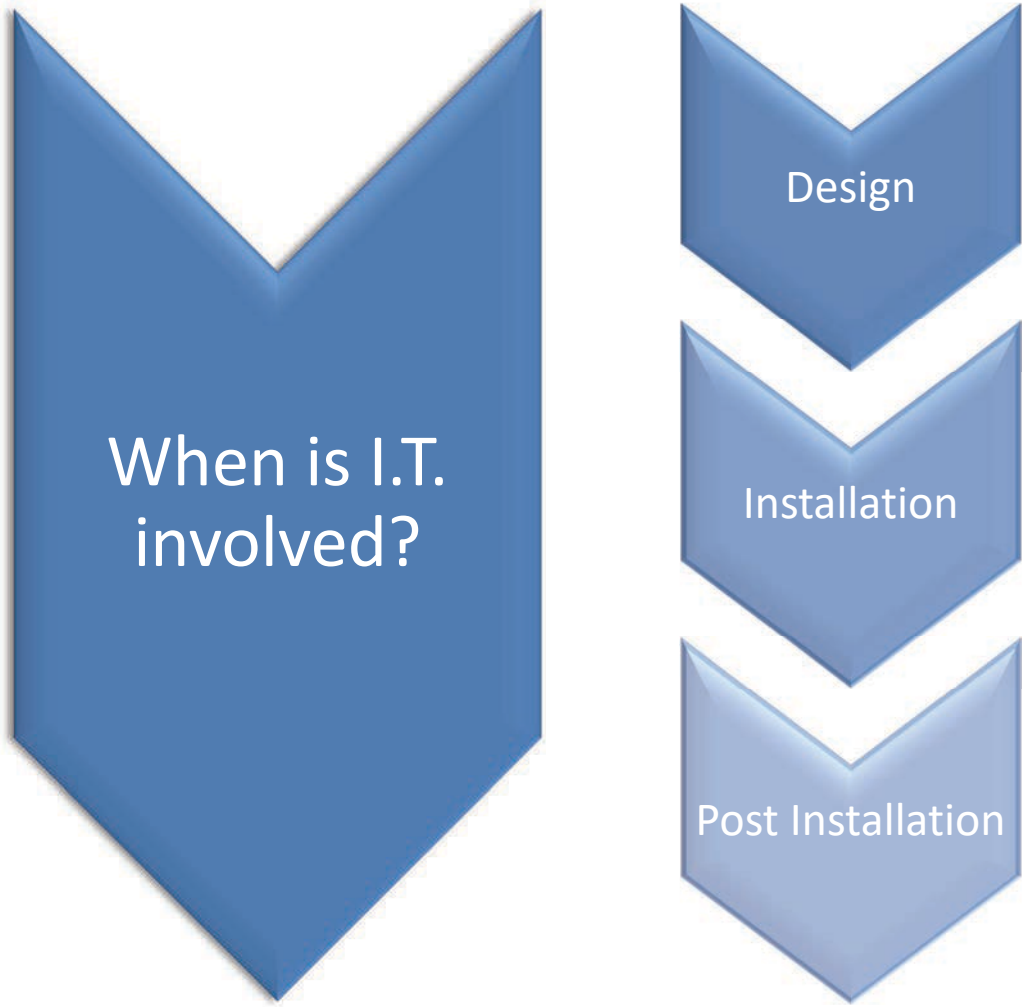
Information Technology (I.T.)

Wireless controls and I.T.



If any answer is YES then I.T. should be involved!

Wireless controls and I.T.



- Access requirements
- Hardware and cabling

- Can the control system temporarily operate separately from the I.T. network?
- Can commissioning occur prior to I.T. infrastructure being complete?

- Access requirements
- Security

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Addressing security concerns

“Security through obscurity” is a thing of the past

Addressing security concerns

How do you address security concerns?

Manufacturer A

We follow industry best practices by restricting physical access, restricting customer access through password protection per NIST recommended practices, AES encryption, secure HTTPS and WPA2 protocols, and segment our network to reduce risk.

Manufacturer B

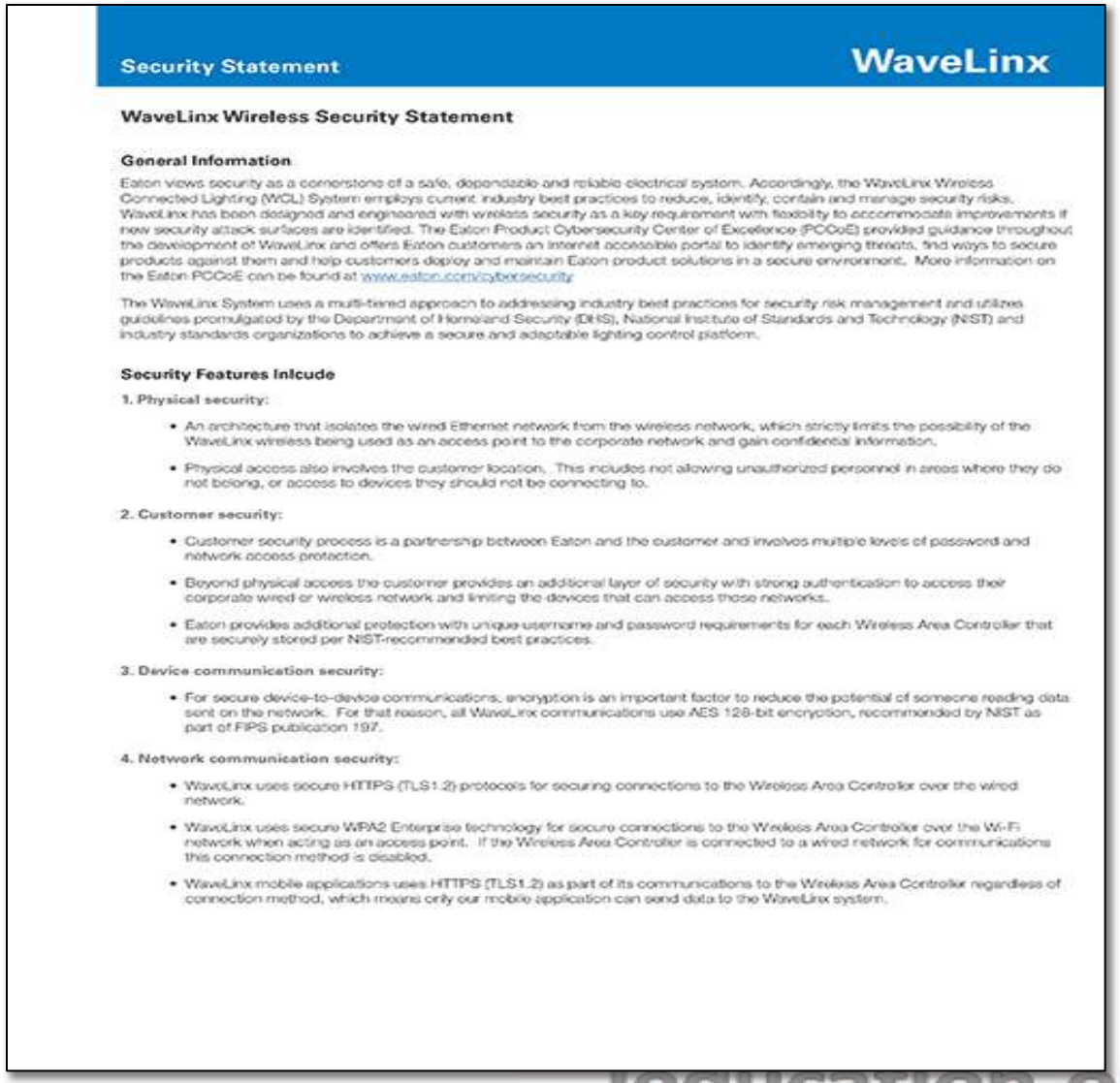
Hmmm. We haven't really thought about that. Is it really necessary?

Security measures are necessary!

Addressing security concerns

Documents should identify:

- Basic network architecture
- Hardware and wiring configuration
- Address configuration
- Required ports
- PC/server requirements
- Protocols
- Access requirements
- User name and password management
- Additional security measures or certifications
  - UL 2900 Standard



Security Statement — WaveLinx

WaveLinx Wireless Security Statement

General Information

Eaton views security as a cornerstone of a safe, dependable and reliable electrical system. Accordingly, the WaveLinx Wireless Connected Lighting (WCL) System employs current industry best practices to reduce, identify, contain and manage security risks. WaveLinx has been designed and engineered with wireless security as a key requirement with flexibility to accommodate improvements if new security attack surfaces are identified. The Eaton Product Cybersecurity Center of Excellence (PCCoE) provided guidance throughout the development of WaveLinx and offers Eaton customers an Internet accessible portal to identify emerging threats, find ways to secure products against them and help customers deploy and maintain Eaton product solutions in a secure environment. More information on the Eaton PCCoE can be found at www.eaton.com/cybersecurity

The WaveLinx System uses a multi-tiered approach to addressing industry best practices for security risk management and utilizes guidelines promulgated by the Department of Homeland Security (DHS), National Institute of Standards and Technology (NIST) and industry standards organizations to achieve a secure and adaptable lighting control platform.

Security Features Inlcude

1. Physical security:
   - An architecture that isolates the wired Ethernet network from the wireless network, which strictly limits the possibility of the WaveLinx wireless being used as an access point to the corporate network and gain confidential information.
   - Physical access also involves the customer location. This includes not allowing unauthorized personnel in areas where they do not belong, or access to devices they should not be connecting to.
2. Customer security:
   - Customer security process is a partnership between Eaton and the customer and involves multiple levels of password and network access protection.
   - Beyond physical access the customer provides an additional layer of security with strong authentication to access their corporate wired or wireless network and limiting the devices that can access those networks.
   - Eaton provides additional protection with unique username and password requirements for each Wireless Area Controller that are securely stored per NIST-recommended best practices.
3. Device communication security:
   - For secure device-to-device communications, encryption is an important factor to reduce the potential of someone reading data sent on the network. For that reason, all WaveLinx communications use AES 128-bit encryption, recommended by NIST as part of FIPS publication 197.
4. Network communication security:
   - WaveLinx uses secure HTTPS (TLS1.2) protocols for securing connections to the Wireless Area Controller over the wired network.
   - WaveLinx uses secure WPA2 Enterprise technology for secure connections to the Wireless Area Controller over the Wi-Fi network when acting as an access point. If the Wireless Area Controller is connected to a wired network for communications this connection method is disabled.
   - WaveLinx mobile applications uses HTTPS (TLS1.2) as part of its communications to the Wireless Area Controller regardless of connection method, which means only our mobile application can send data to the WaveLinx system.

Security resources

Additional cybersecurity resources:

- NIST: National Institute of Standards and Technology - https://www.nist.gov/cyberframework
- US-CERT: Department of Homeland Security United States Computer Emergency Readiness Team https://www.us-cert.gov/
- Manufacturer sponsored cybersecurity web pages

Learning objective #4

Through examination of industry trends, participants will gain an understanding of how connected lighting is being used in the implementation of the Internet of Things (IoT) and will learn important criteria to assist in future-proofing system selections provides building occupant health, safety and welfare.

Connected lighting

Connected lighting - lighting equipment that has integrated intelligence and control and that allows bi-directional data communication

- Connected LEDs could have a potential of up to $17 billion annual energy savings by the year 2035
  - Department of Energy – DOE SSL Program Goal
- Intelligence in a single building system may generate 5% to 20% savings in energy for that system while a multisystem approach can result in 30% to 50% in savings building wide
  - Architectural Lighting
- Interconnectivity and ability of sensors to report on conditions is seen as a “game changing” trend in Net Zero building design
  - Continental Automated Buildings Association (CABA)

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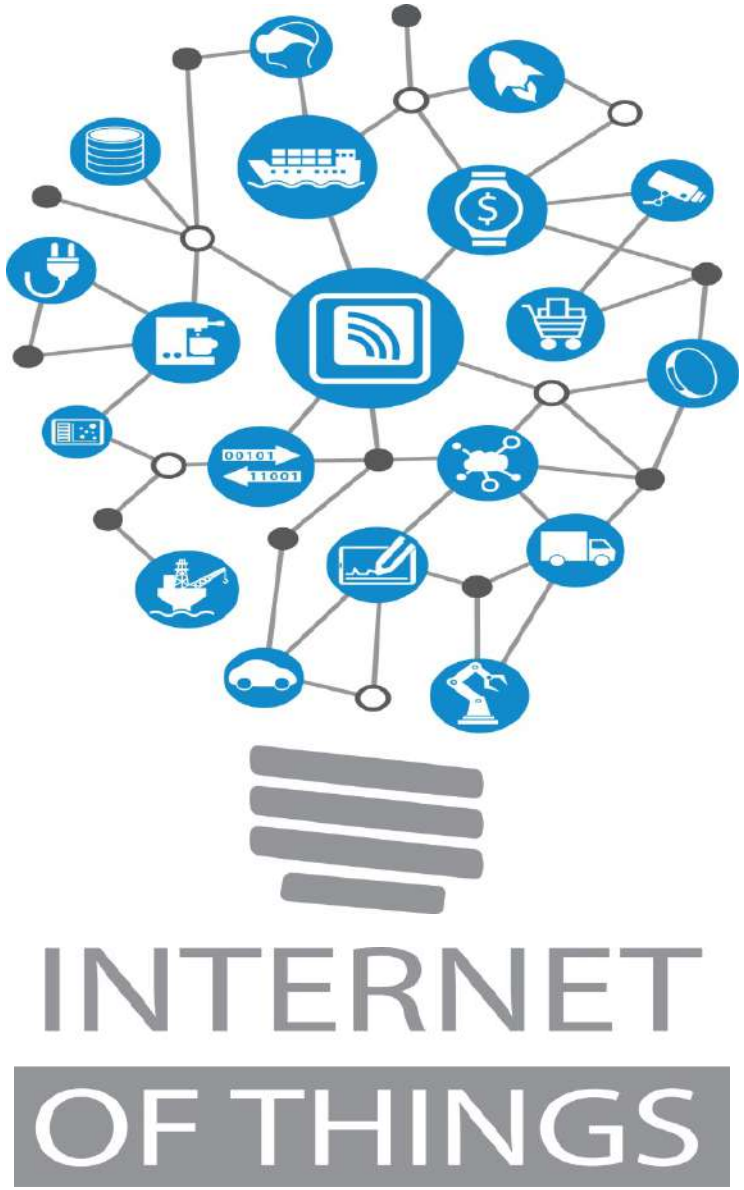
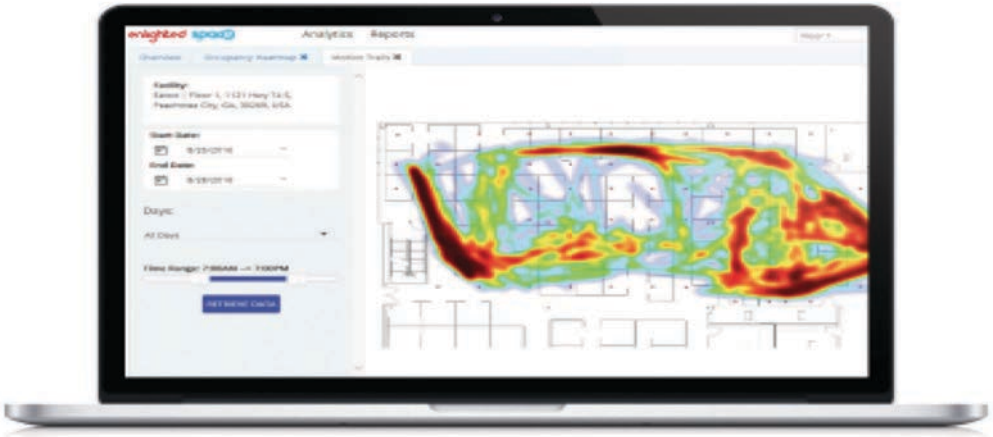
What is the IoT?



- The IoT is “literally a network of internet connected objects that are able to collect and exchange data using embedded sensors”
  - The Business Insider
- Collaborations and communications of the IoT have been “hitherto unknown and unimagined”
  - Telecommunication Standardization Sector (ITU-T)
- The IoT has “a total potential economic impact of $3.9 trillion to $11.1 trillion per year in 2025” an estimated value of “about 11 percent of the world economy”
  - McKinsey Global Institute

Current IoT uses



Facilities managers use data to analyze and make informed decisions to maximizing the use of real-estate while minimizing the use of energy

- Hot desk strategy management
- Wayfinding
- Customized user based control
- Demand driven lighting, heating and cooling

Current IoT uses

Facilities may use lighting based IoT for asset tracking

- Reducing time lost in tracking down equipment and people
- Reduce equipment loss
- Identifying bottlenecks in processes
- Streamlining distribution routes

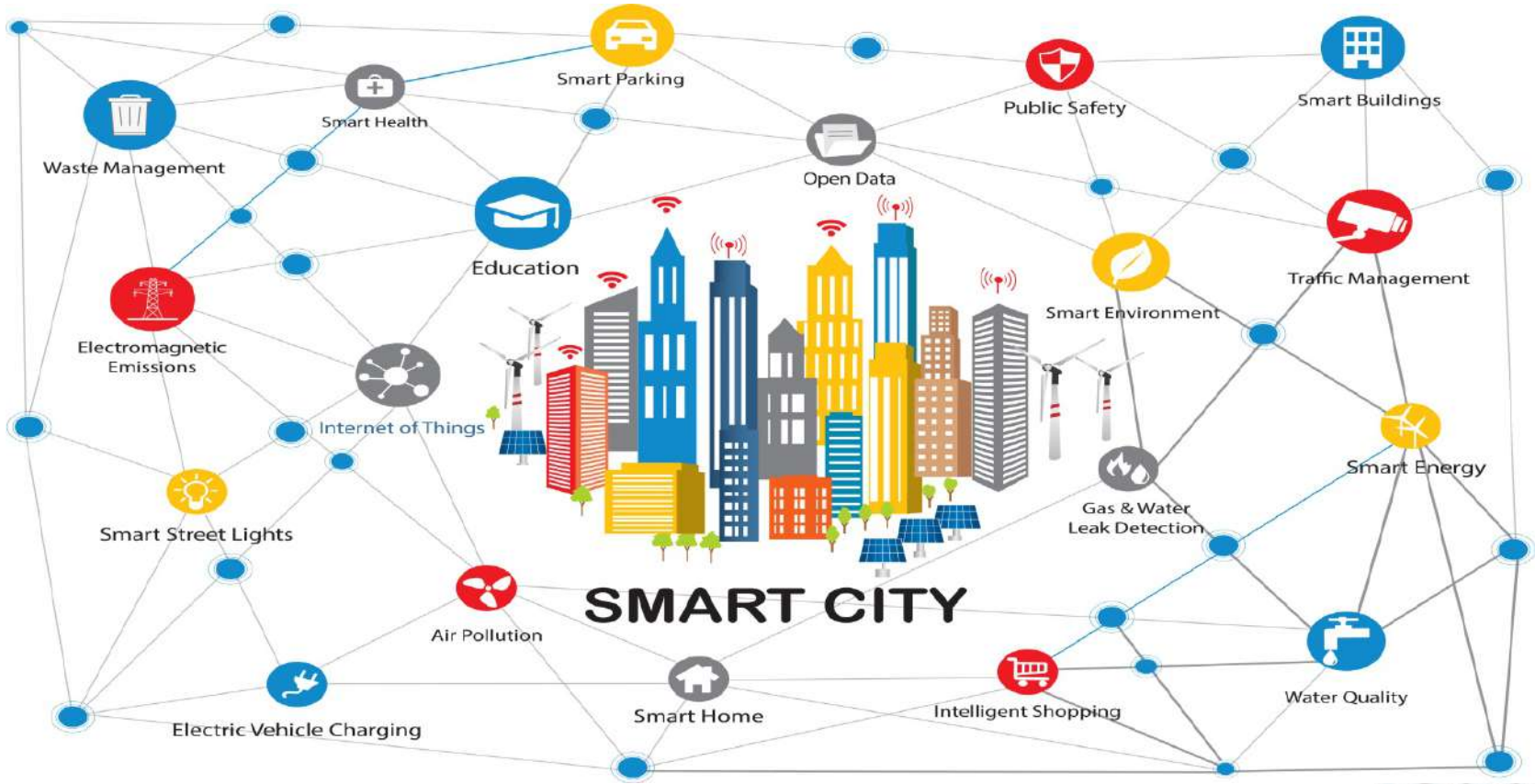
Current IoT uses

Retail facilities use lighting based IoT to gather marketing data, improve efficiency and streamline customer experiences

- Display feedback
- Smart shopping lists
- Wayfinding
- Smart shelves

Current IoT uses

Smart city implementation maximizes resource use for energy consumption, waste management, traffic and parking, lighting, safety, and security.



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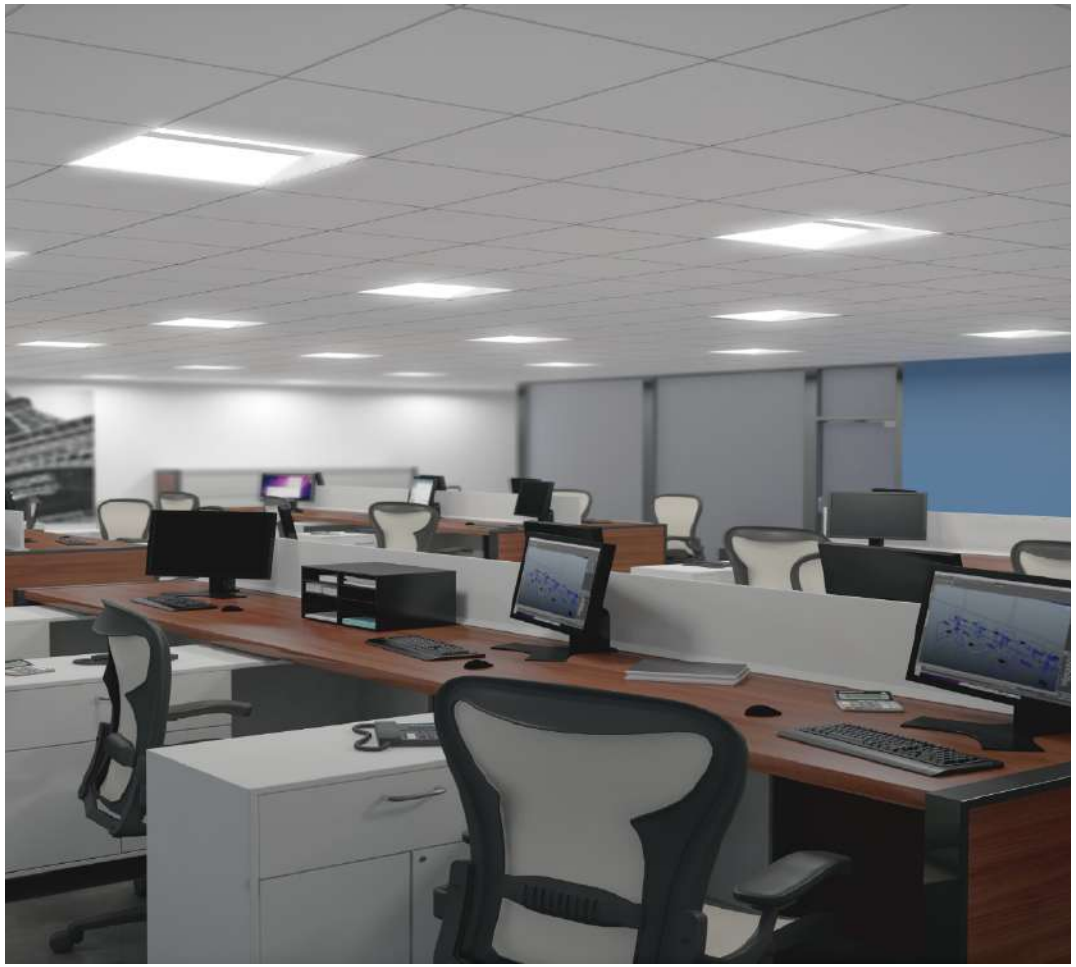
IoT challenges

Hurdles to widespread IoT acceptance

- Device cost
- Device location, connection and power
- Device communications and security
- Format and amount of data to process, analyze and report

Connected lighting IoT solution



A properly designed connected lighting system allows facility managers to solve higher complexity problems by leveraging the physical real-estate of the luminaire through integrated controls, sensors and data communications

Connected lighting IoT solution

Cost of IoT already paid for by purchase and installation of the connected lighting system

Provides methods of data storage, collection and communication

Density of lighting placement is ideal for sensor data collection and communication

Use of standard technologies and best practices addresses “future-proof” and security concerns

Intelligence is continuously powered by lighting circuit removing need for batteries

Lighting placement grid pattern creates a reliable mesh communications network

Considerations for future-proofing

- Standardized platforms and current technology
- Multi-functionality of sensor and technologies
- Data sharing capability and security
- Update path for firmware and software
- Security methods and path for updates
- Reputable manufacturer

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Applying wireless technologies to connected lighting as a catalyst for the Internet of Things (IoT)

(AWT)

Questions ?

Thank You for Attending!

This concludes the American Institute of Architects Continuing Education Systems Program

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Resources

- Adler, Laura. (2016, February 18). How Smart City Barcelona Brought the Internet of Things to Life. Retrieved from http://datasmart.ash.harvard.edu/news/article/how-smart-city-barcelona-brought-the-internet-of-things-to-life-789
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