

Designers Lighting Forum

What's so smart about Smart Lighting Control Systems?

Anne D. Cheney, LC, LEED AP, MIES, DLF
Melanie Freundlich Lighting Design

March 13, 2018 5:00-6:00PM



WHAT'S SO SMART ABOUT SMART LIGHTING CONTROL SYSTEMS?



Anne Cheney, LC, LEED AP, MIES, DLF

Senior Project Manager/Lighting Designer, Melanie Freundlich Lighting Design



Credit(s) earned on completion of this course will be reported to **AIA CES** for AIA members. Certificates of Completion for both AIA members and non-AIA members are available upon request.

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material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

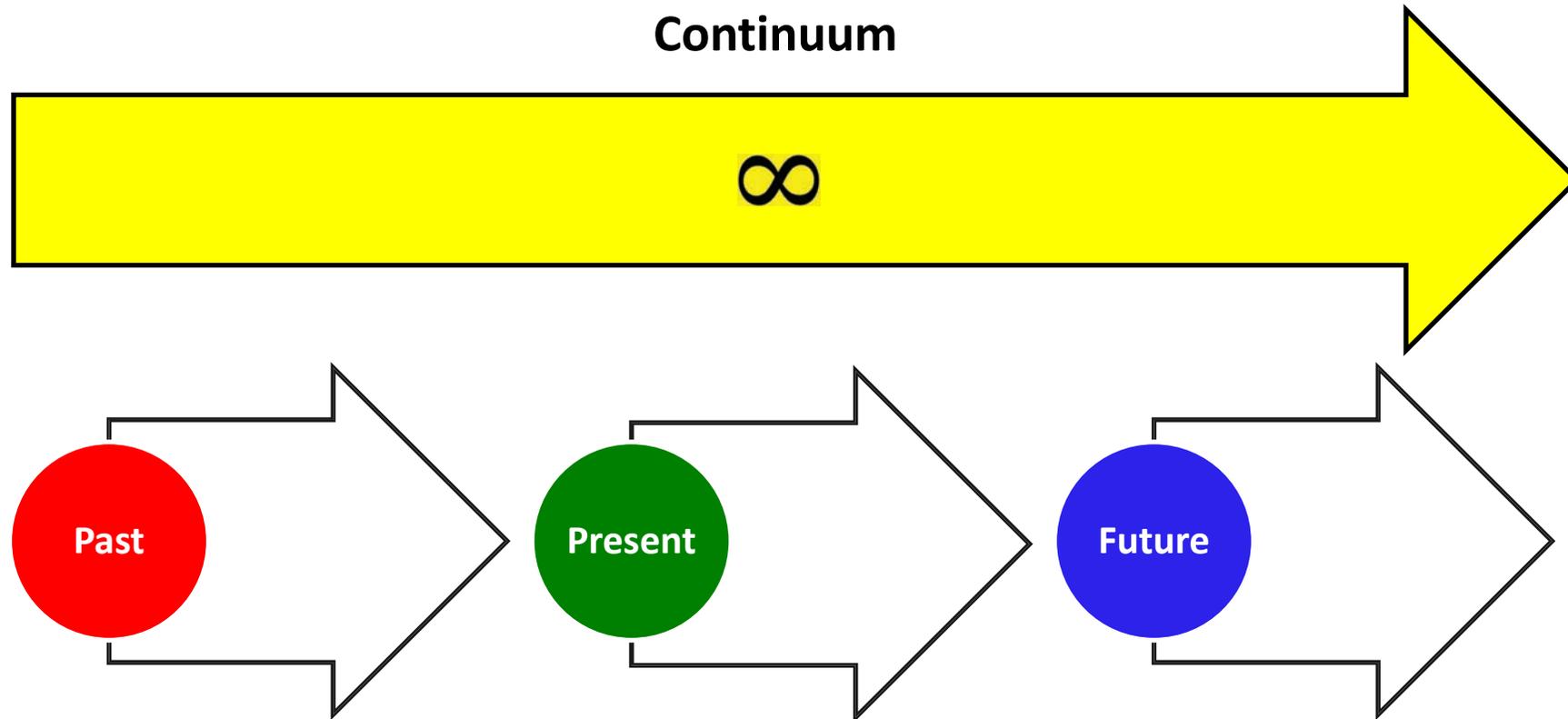


Learning Objectives

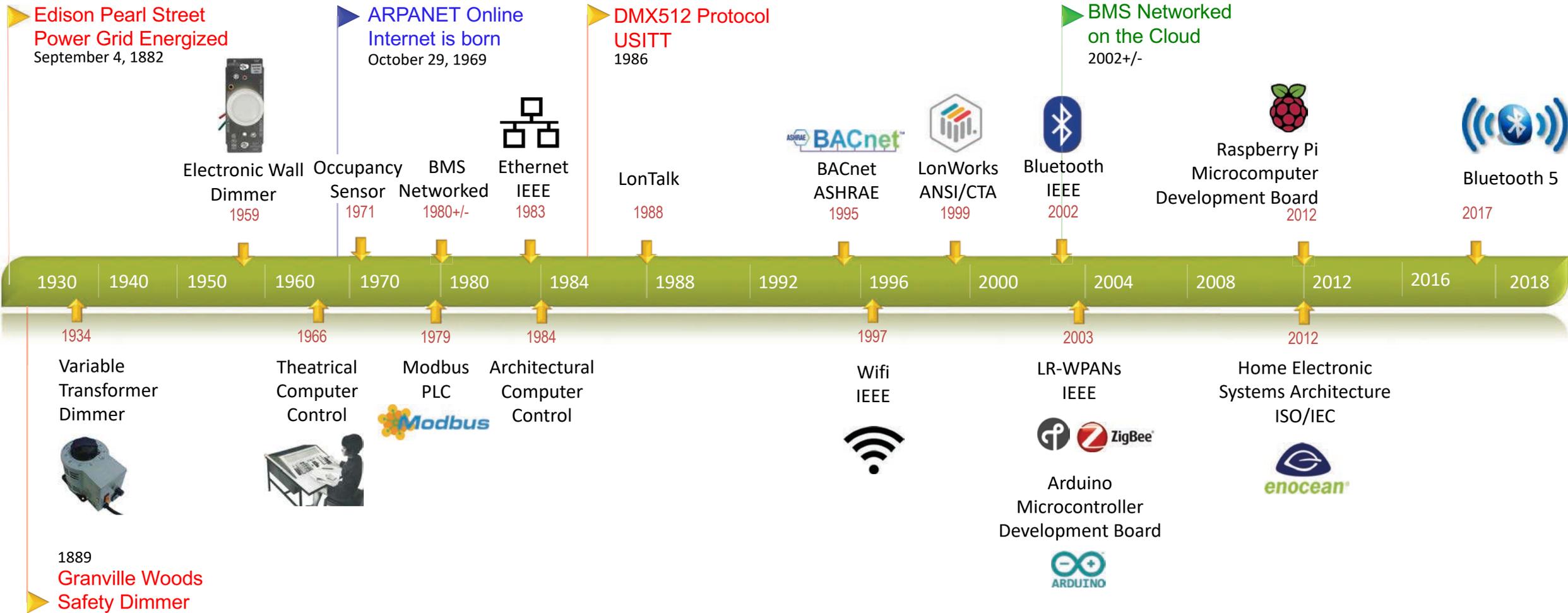
At the end of the this course, participants will be able to:

1. Understand - The basic parts of a smart control system, and how to describe the "smart" technologies utilized.
2. Compare - Wired and wireless smart lighting control systems.
3. Identify - Reference Standards for components of a smart lighting control system.
4. Consider - Security of wireless and cloud connected control systems.
5. Describe - Wired and wireless networked microprocessor driven sensors and controls that are connected to the internet.

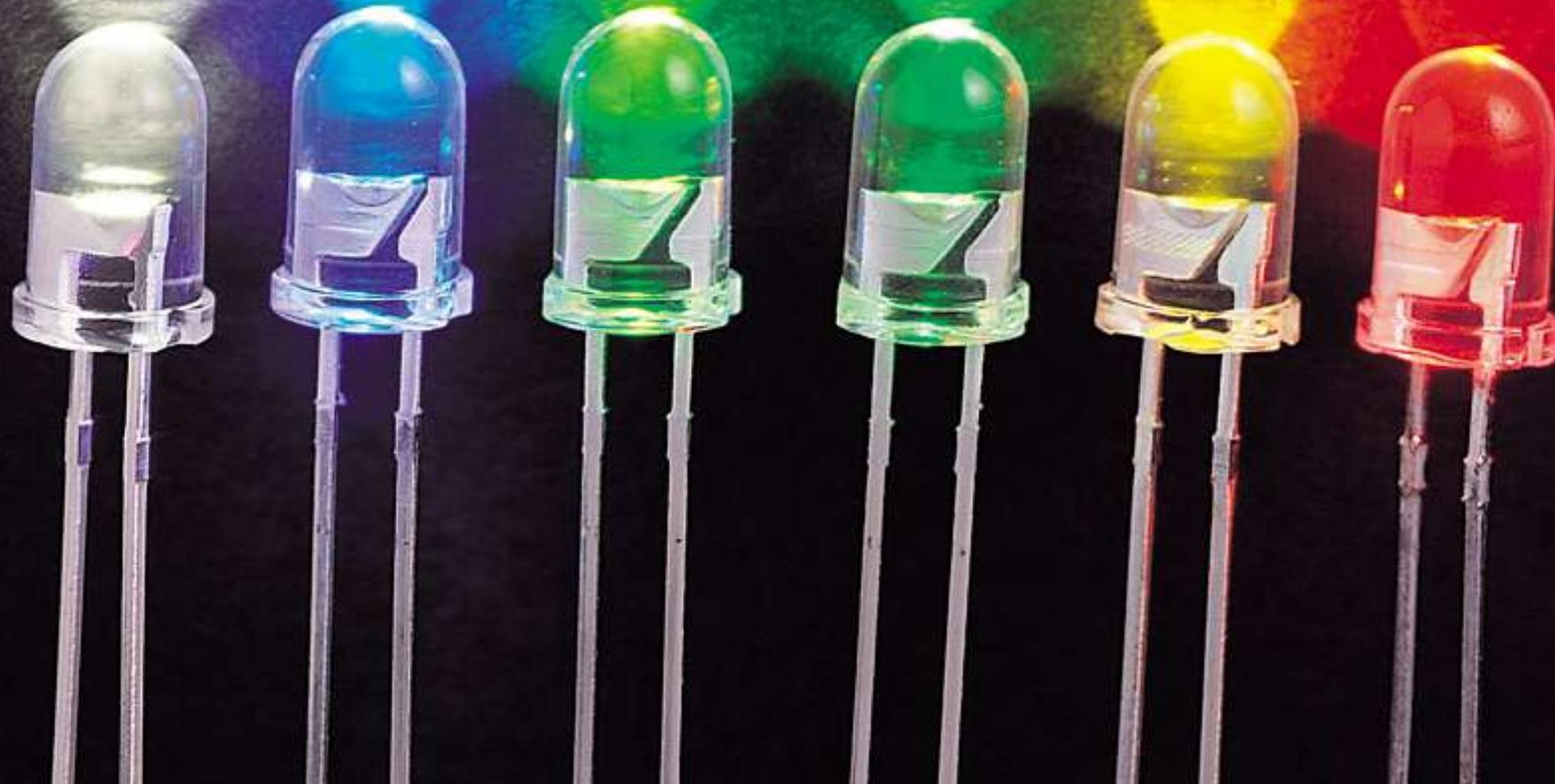
Smart Lighting Controls Systems



Smart Lighting Controls Systems

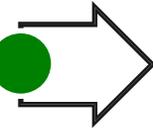


For the past decade, LEDs have been *the* disruptive technology in the lighting industry

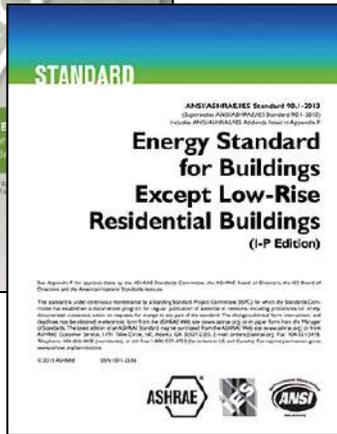
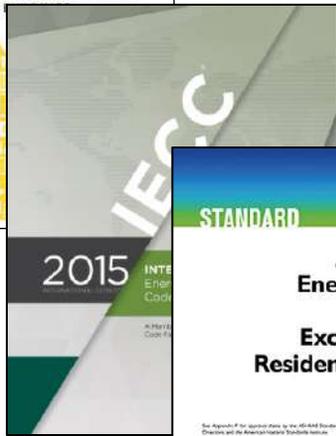
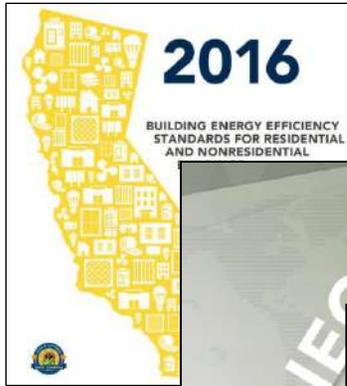




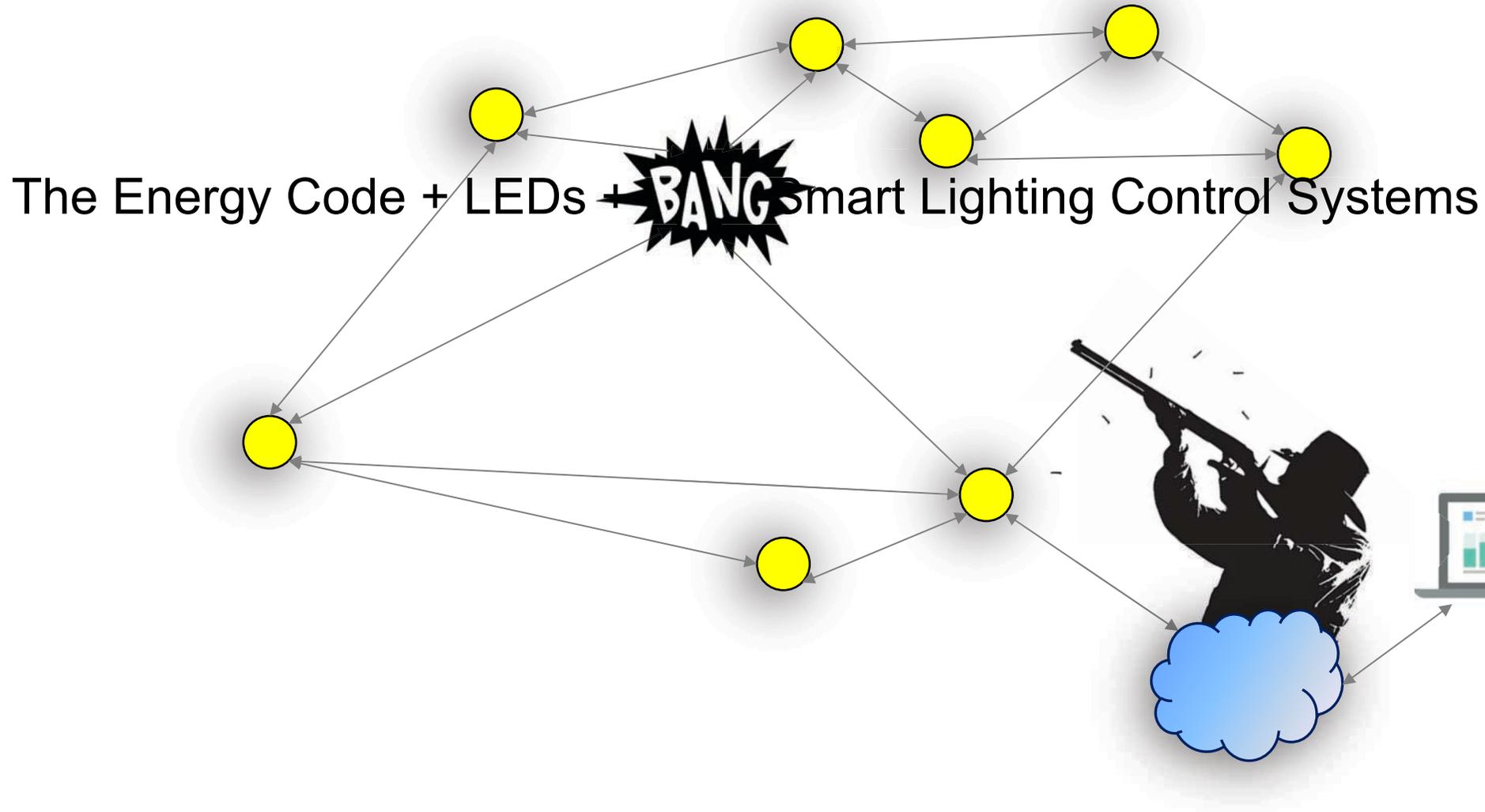
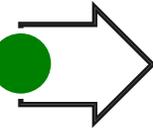
Smart lighting control systems are the new *Wild West*



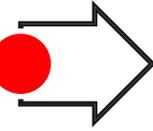
The Energy Code + LEDs +  = Smart Lighting Control Systems



Smart lighting control systems are the new *Wild West*



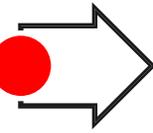
Smart lighting control systems are the new *Wild West*



Lighting Controls – old technology

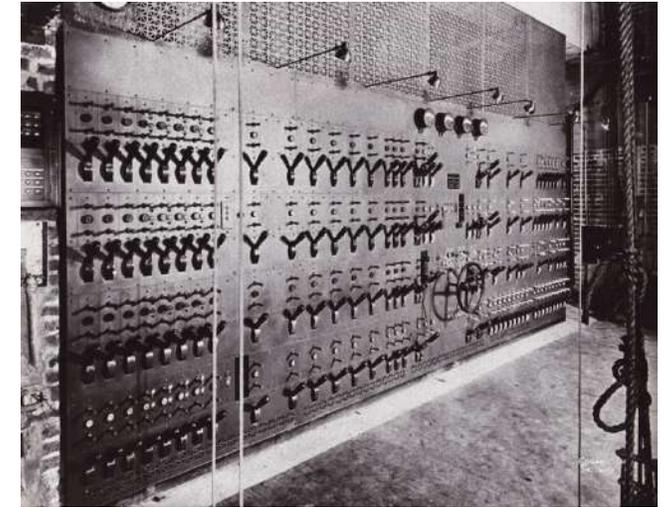
1. Analog Controls
2. Computer Controls
3. Digital and Analog Converters
4. Computer Lighting Control System
5. Occupancy Sensor
6. Daylight Sensor
7. Time Clock Control

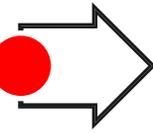




Lighting Controls – old technology

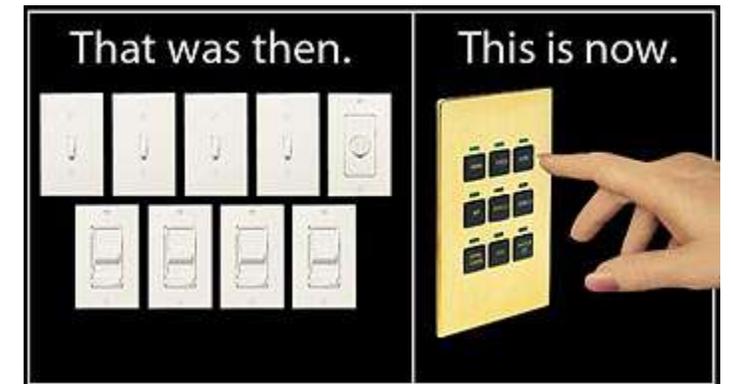
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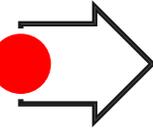




Lighting Controls – old technology

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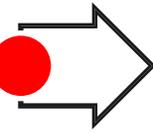


Lighting Controls – old technology

1. Analog
2. Computer Controls
3. Digital to Analog Converters
4. Computer Lighting Control System
5. Occupancy Sensor
6. Daylight Sensor
7. Time Clock Control



"BLACK BOX"



Lighting Controls – old technology

1. Analog
2. Computer Controls
3. Digital and Analog Converters
4. Computer Lighting Control System
 - Circuit, Dimmer, Channel/Zone
3. Occupancy Sensor
4. Daylight Sensor
5. Time Clock Control

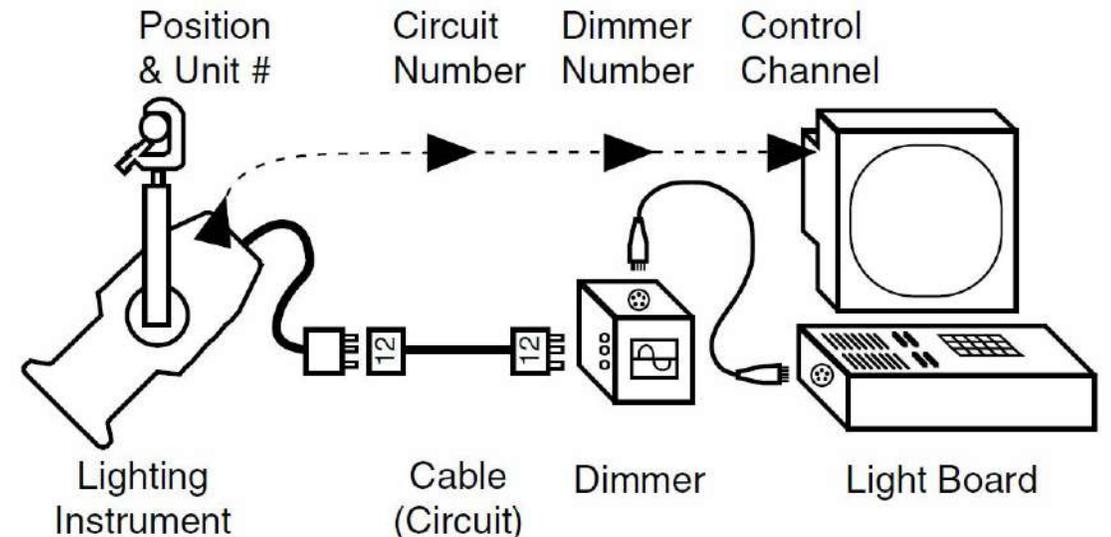
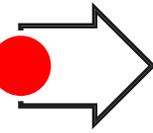


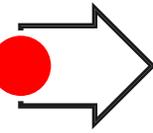
Image from: *A Practical Guide to Stage Lighting* by Steven Louis Shelley



Lighting Controls – old technology

1. Analog
2. Digital and Analog Converters
3. Computer Controls
4. Computer Lighting Control System
5. Occupancy Sensor: PIR/Ultrasonic
6. Daylight Sensor
7. Time Clock Control

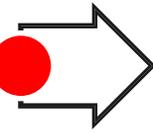




Lighting Controls – old technology

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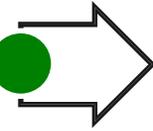




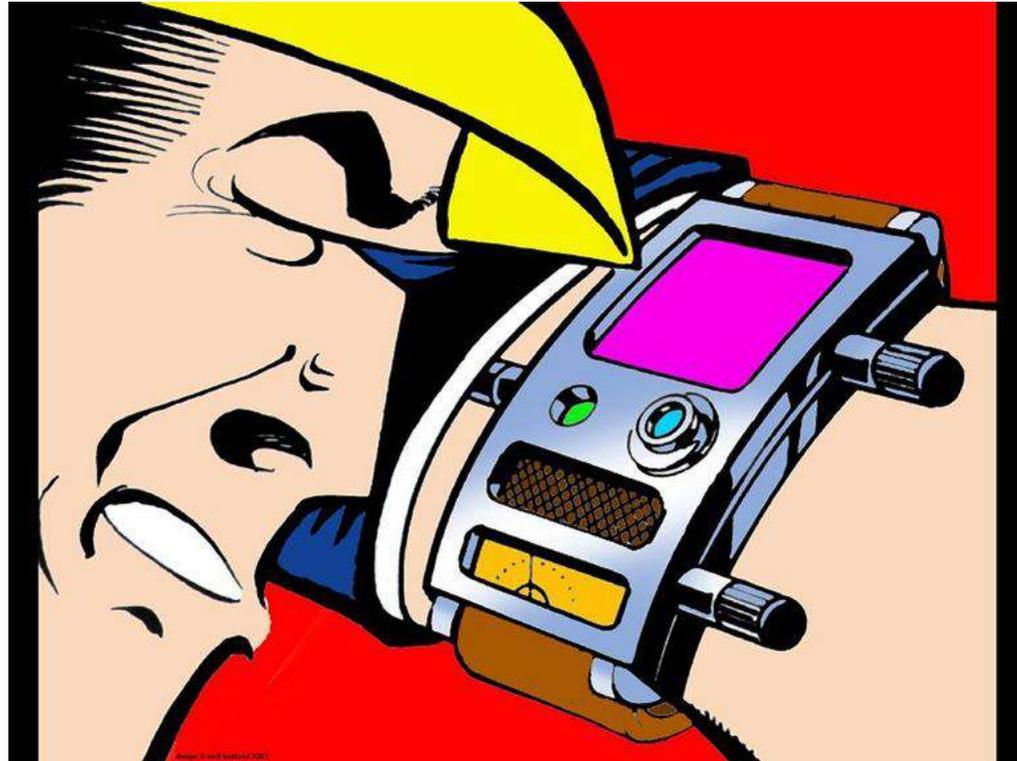
Lighting Controls – old technology

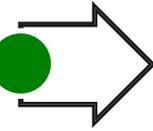
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Smart Lighting Controls – Welcome to the Future





Smart Lighting Controls – Welcome to the Future

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Renewable Energy
BUILDING TECHNOLOGIES OFFICE

INTERNATIONAL ASSOCIATION OF LIGHTING DESIGNERS

IALD



Next Generation

LUMINAIRES

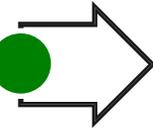


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Smart Lighting Controls – Welcome to the Future

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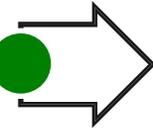


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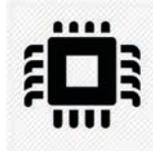
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Lighting Controls – New Technology

1. Microprocessor controlled



2. Networked – wired and wireless



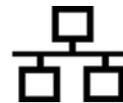
3. Plug-and-Play



4. Interoperable



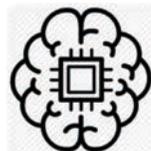
5. Connectable to the Internet

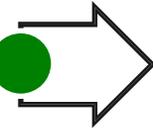


6. Analytics



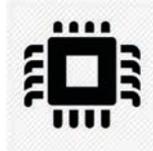
7. Artificial Intelligence





Lighting Controls – New Technology

1. Microprocessor controlled
2. Networked – wired and wireless
3. Plug-and-Play
4. Interoperable
5. Connectable to the Internet
6. Analytics
7. Artificial Intelligence



```

if allowed(request.querystring("startFolder"),session("username")) then
  dim filename : filename = request.querystring("filename")
  dim objFile : Set objFile = objFSO.GetFile(getPath(null,filename))
  dim currentAttr : currentAttr = objFile.Attributes
  if request("Submit") = "Save" then
    if request("attr") <> "" then objFile.Attributes = cint(request("attr"))
    set objFile = nothing
    response.write( filename & " has been saved")
  else if request("Submit") = "Cancel" then
  else
    response.write("<form class='msgbox' method='post'></h2>"&vbCrLf)
    response.write("<input type='text' value='&filename&'>"&vbCrLf)
    response.write("<input name='action' type='hidden' value='false'>"&vbCrLf)
    response.write("<input name='startFolder' type='hidden' value='&request("startFolder")&'>"&vbCrLf)
    response.write("<input name='attr' type='radio' value='0'>"&vbCrLf)
    if (currentAttr AND 0) = 0 or currentAttr="" then response.write(" checked='checked'")
    response.write(" /> None<br />"&vbCrLf)
    response.write("<input name='attr' type='radio' value='1'>"&vbCrLf)
    if (currentAttr AND 1) = 1 then response.write(" checked='checked'")
    response.write(" /> ReadOnly<br />"&vbCrLf)
    response.write("<input name='attr' type='radio' value='2'>"&vbCrLf)
    if (currentAttr AND 2) = 2 then response.write(" checked='checked'")
    response.write(" /> Hidden<br />"&vbCrLf)
    response.write("<input name='attr' type='radio' value='32'>"&vbCrLf)
  end if
end if
    
```

IF

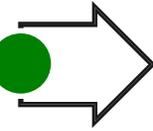
(THIS)

END

THEN

(THAT)

END



Lighting Controls – New Technology

1. Microprocessor controlled

2. Networked – wired and wireless



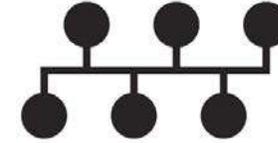
3. Plug-and-Play

4. Interoperable

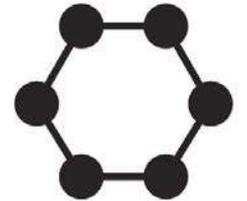
5. Connectable to the Internet

6. Analytics

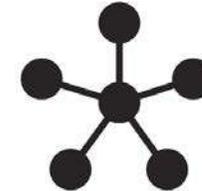
7. Artificial Intelligence



Bus



Ring



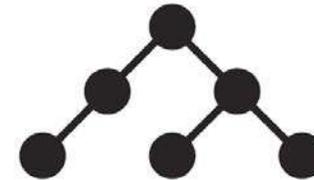
Star



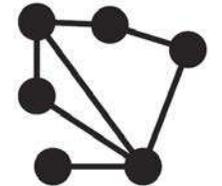
Fully Connected (Mesh)



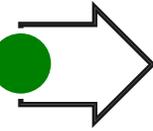
Daisy Chain



Tree

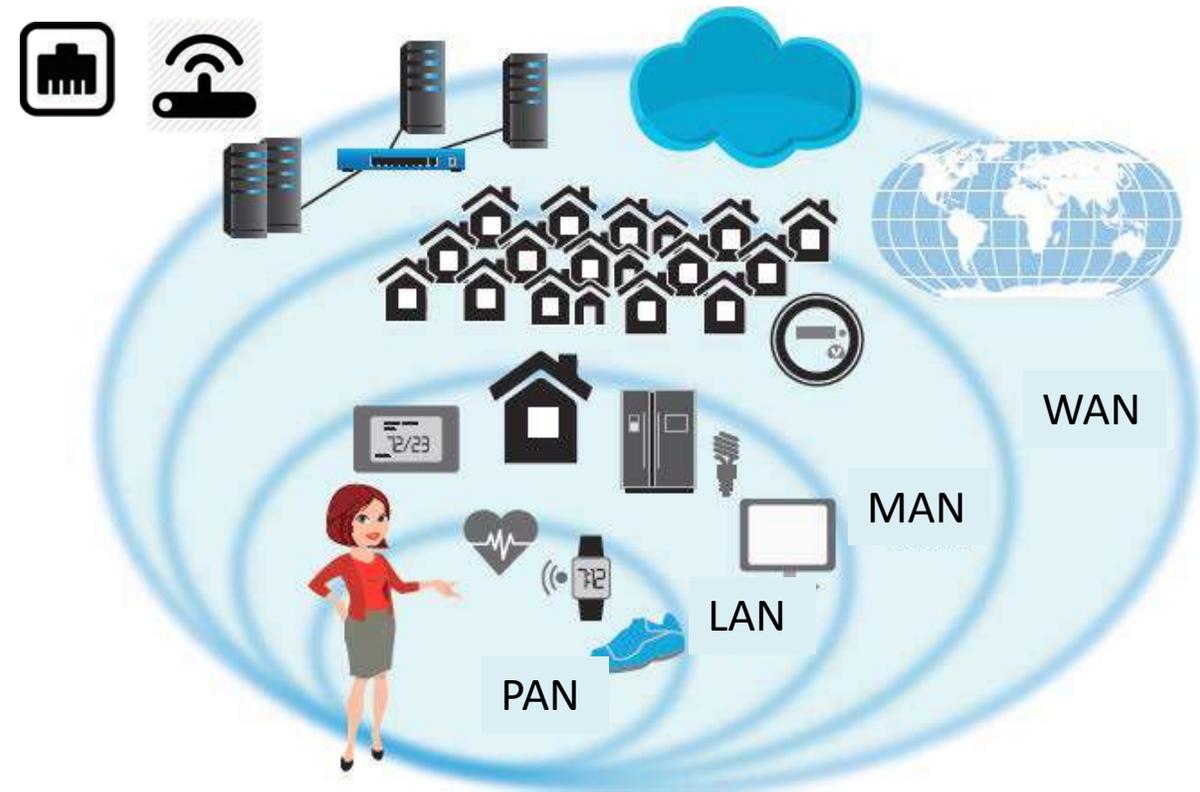


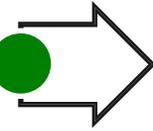
Mesh



Lighting Controls – New Technology

1. Microprocessor controlled
2. Networked – wired and wireless
3. Plug-and-Play
4. Interoperable
5. Connectable to the Internet
6. Analytics
7. Artificial Intelligence





Lighting Controls – New Technology

1. Microprocessor controlled
2. Networked – wired and wireless
3. **Plug-and-Play** 
4. Interoperable
5. Connectable to the Internet
6. Analytics
7. Artificial Intelligence

PLUG & PLAY

Transform your garden in 3 easy steps

★★★★★
feefo

STEP 1 Choose your lights

3 x 20W = 60W + 3 x 20W = 60W = 120W

STEP 2 Choose your cables

You now need to pick a main cable, the number of lights you've chosen and your planned layout will determine its length, and the number of connectors that you'll need.

10M Main Cable with 4 Connectors

4 Metres Plug

2 Metres Connector

15M Main Cable with 6 Connectors

4 Metres Plug

2 Metres Connector

STEP 3 Choose the right transformer

The total wattage consumed by the lights you've chosen in Step 1 will determine the right transformer for your system.

150W Correct Wattage



Optional Extras

'Dusk to Dawn' Sensor with Timer	Motion Sensor	Remote Control and Receiver	Additional Receiver
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Extension cables & 3 way connector

The number of extension cables and cable connectors that you'll need will depend on the number of lights you've chosen, and the layout of the lights in your design.

10M Extension Cable



6M Extension Cable



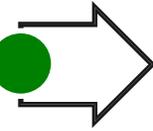
3 Way Connector



Position your chosen lights, connect them together and plug the transformer into the mains... then sit back and enjoy your garden. It's that simple.

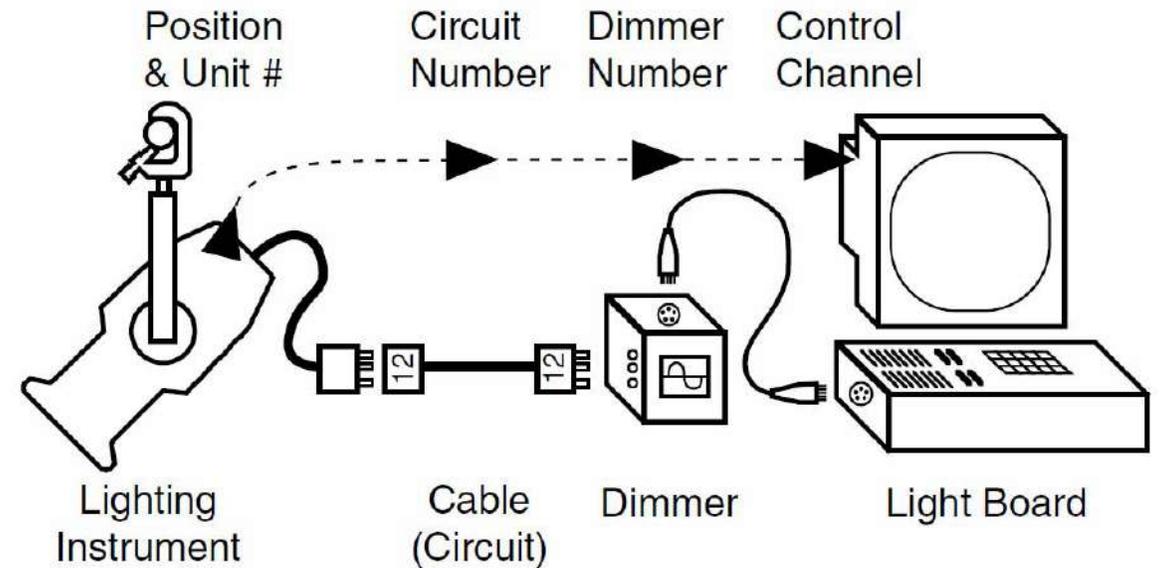

No electrician required

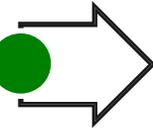
No need for an electrician • Quick & easy to install • Low voltage • Endless combinations



Lighting Controls – New Technology

1. Microprocessor controlled
2. Networked – wired and wireless
3. Plug-and-Play 
4. Interoperable
5. Connectable to the Internet
6. Analytics
7. Artificial Intelligence

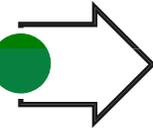




Lighting Controls – New Technology

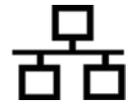
1. Microprocessor controlled
 2. Networked – wired and wireless
 3. Plug-and-Play
 4. **Interoperable**
 - Network Protocols
1. Connectable to the Internet
 2. Analytics
 3. Artificial Intelligence

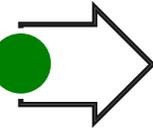




Lighting Controls – New Technology

1. Microprocessor controlled
2. Networked – wired and wireless
3. Plug-and-Play
4. Interoperable
5. Connectable to the Internet
6. Analytics
7. Artificial Intelligence

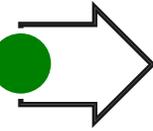




Lighting Controls – New Technology

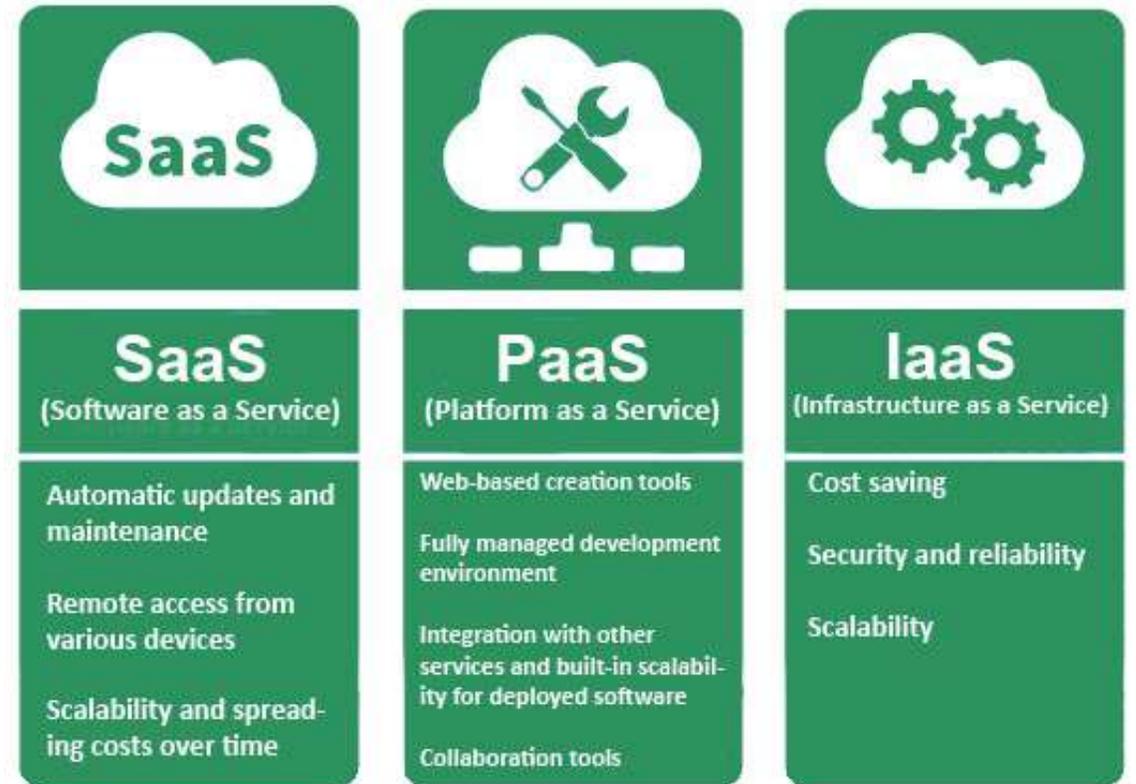
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7. Artificial Intelligence

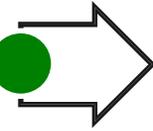




Lighting Controls – New Technology

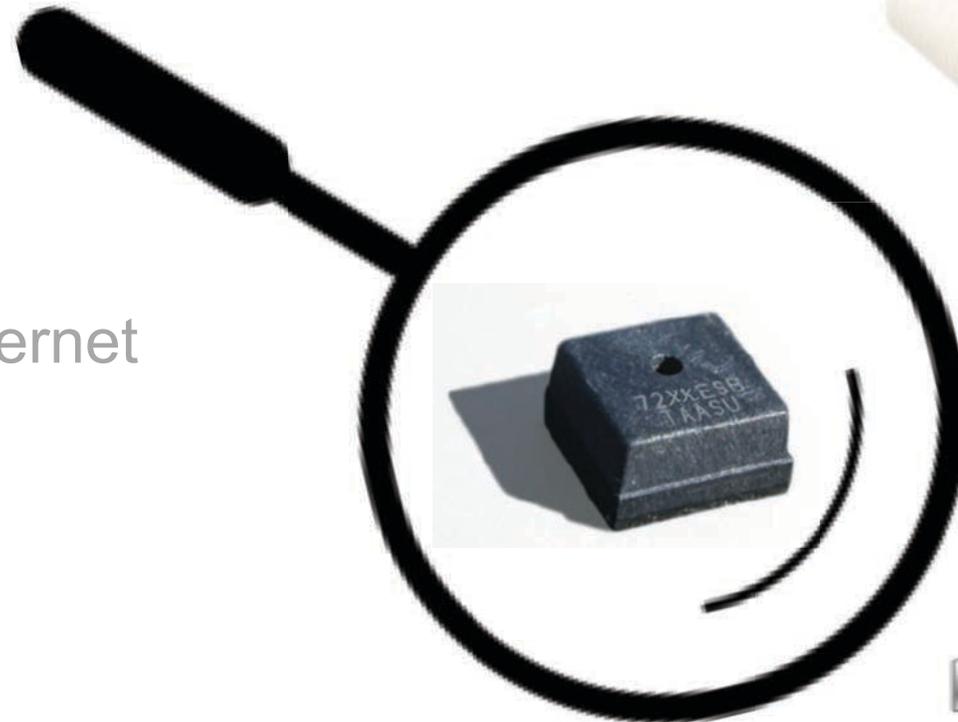
1. Microprocessor controlled
2. Networked – wired and wireless
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4. Interoperable
5. Connectable to the Internet
6. Analytics 
 - Services
7. Artificial Intelligence

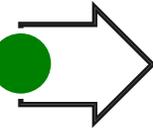




Lighting Controls – New Technology

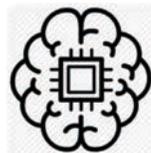
1. Microprocessor controlled
2. Networked – wired and wireless
3. Plug-and-Play
4. Interoperable
5. Connectable to the Internet
6. Analytics
 - Sensors
7. Artificial Intelligence





Lighting Controls – New Technology

1. Plug-and-Play
2. Microprocessor controlled
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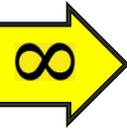


Building Controls – the continuum

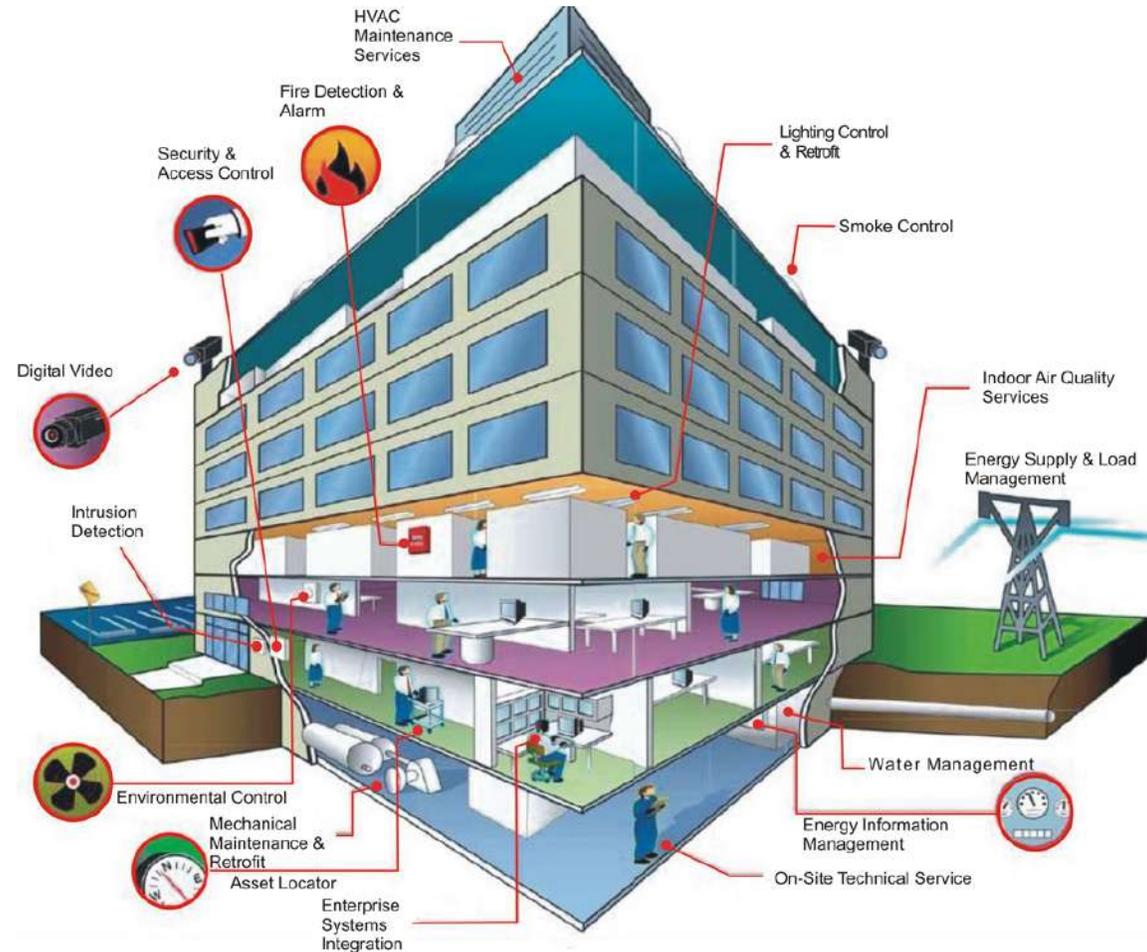
Building Management System (BMS)

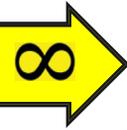
- Illumination (lighting) control
- Electric power control
- Heating, ventilation and air-conditioning (HVAC)
- Security and observation
- Access control
- Fire alarm system
- Lifts, elevators etc.
- Plumbing
- Closed-circuit television (CCTV)
- Other engineering systems
- Control Panel
- PA system
- Alarm Monitor
- Security Automation



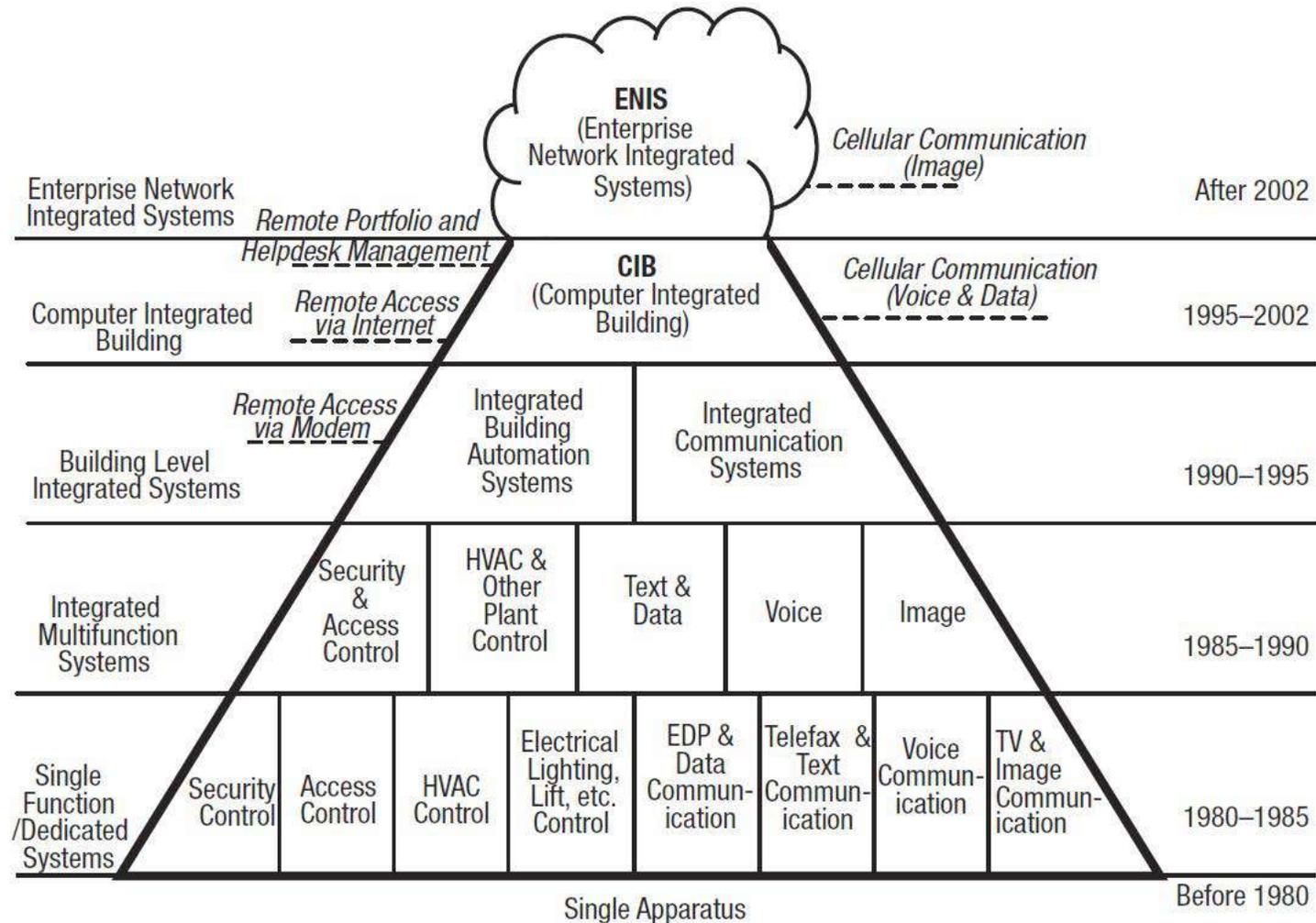


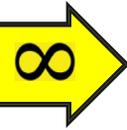
Building Management Systems (BMS) – the continuum





Building Management Systems (BMS) – the continuum



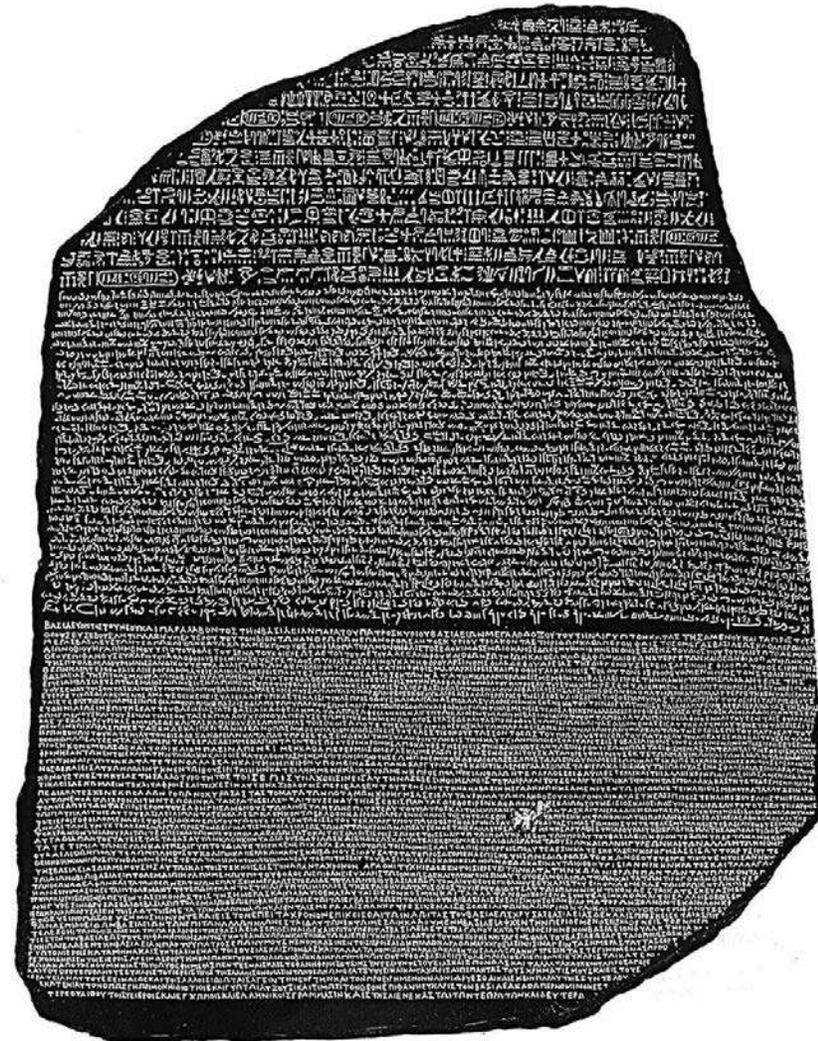


Building Management Systems (BMS) – the continuum

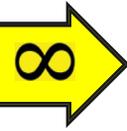


Pieter Bruegel the Elder – The Tower of Babel

Building Management Systems (BMS) – the continuum

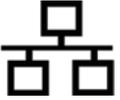


Rosetta Stone – British Museum



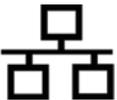
Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

1. Ethernet 
2. Wifi 
3. Bluetooth 

Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

- 1. Ethernet 
- 2. Wifi
- 3. Bluetooth



Cat5e



Cat6



Cat6a



Cat7

Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

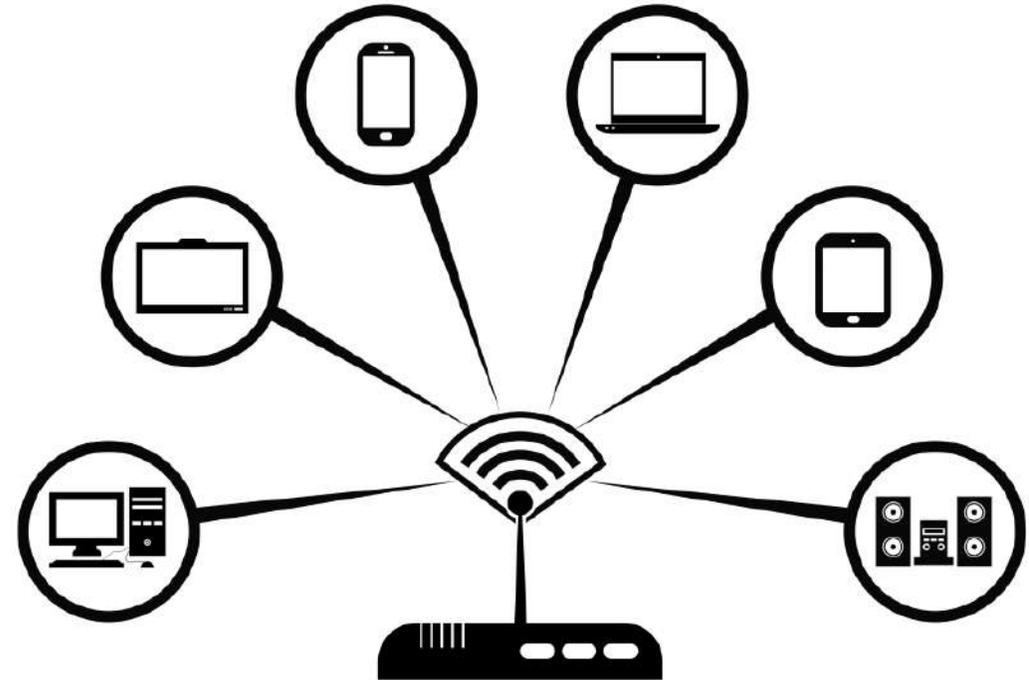
1. Ethernet

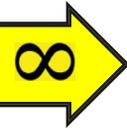
2. Wifi

3. Bluetooth



IEEE
802.11





Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

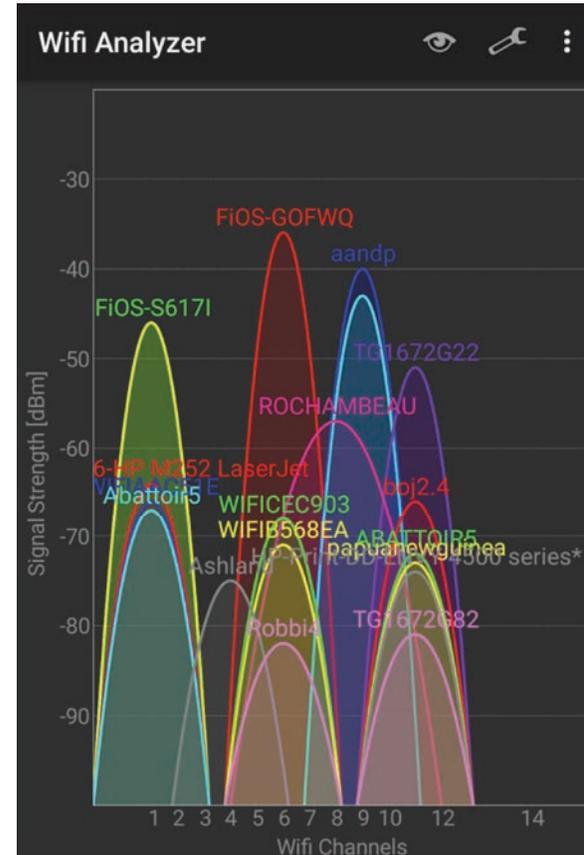
1. Ethernet

2. Wifi



IEEE
802.11

3. Bluetooth



Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

1. Ethernet

2. Wifi

3. Bluetooth 

• Short-wavelength UHF

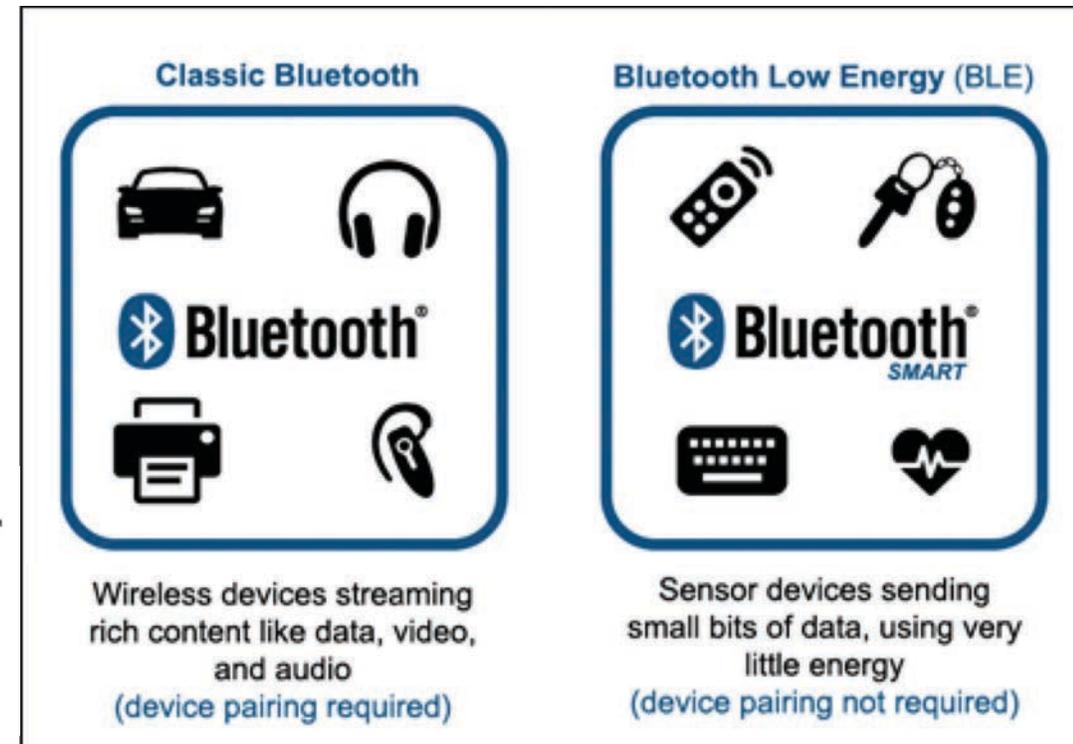


Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

1. Ethernet
2. Wifi
3. Bluetooth

- Bluetooth Low Energy (BLE)



Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

1. Ethernet
2. Wifi
3. Bluetooth 

The emerging benefits of  **Bluetooth™ 5**

Bluetooth 5 with mesh networking can technically support an **unlimited number of devices on a network**.

The range of **Bluetooth 5** is up to four times that of its predecessors, meaning you can cover larger areas using fewer devices. And with mesh **network topology enabling every device to connect to every other device**, network sizes are technically limitless.

Bluetooth 5 can deliver up to **10 years' service** from a single cell battery.

Bluetooth beacons will be greatly improved by **Bluetooth 5**, giving assets the ability to **transmit longer messages at higher data rates over greater distances**.

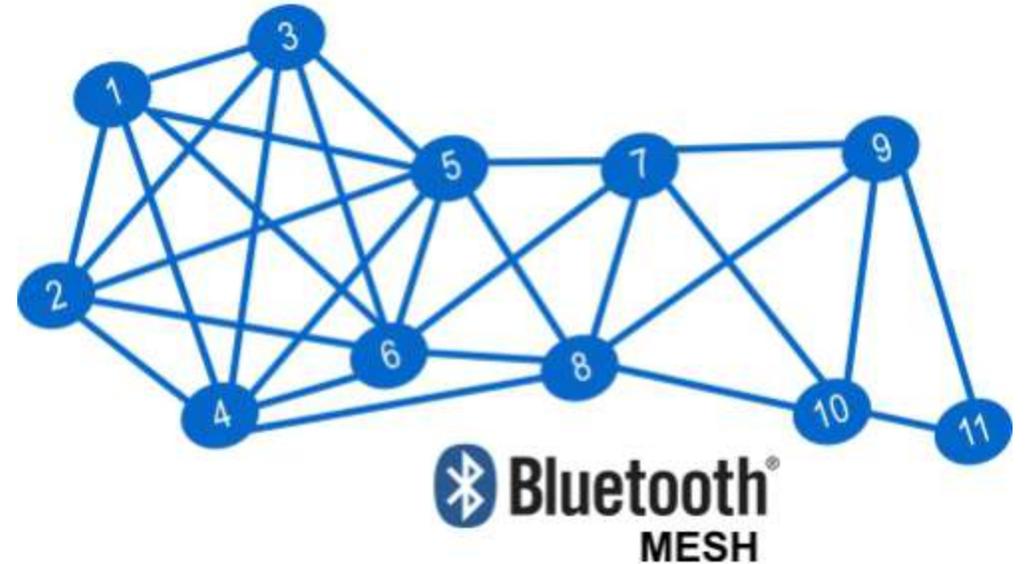
Thanks to techniques such as channel hopping and slot availability masks, **Bluetooth 5 has better interoperability and coexistence with other wireless technologies**.

Building Controls – Standards

NETWORKING STANDARDS THAT ARE NOT BUILDING CONTROLS SPECIFIC:

1. Ethernet
2. Wifi
3. Bluetooth

- **M2M** – Machine to Machine communications (bi-directional communications)



Building Controls – Standards

Building Management System (BMS) Network Protocols
[also know as Building Automated Systems (BAS)]

1. Building Automation Control Network (BACnet)
 ASHRAE/ANSI Standard 135 (1995)

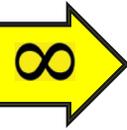


2. Local Operating Network (LonWorks)
 ANSI/CEA-709.1-B (1999)



1. Modbus
 This is an unpublished protocol that requires the use of a proprietary programmable logic controller (PLC)



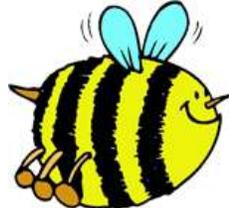


Building Controls – Standards

- 0-10VDC
- BACnet
- DALI
- DeviceNet
- EnOcean
- INSTEON
- KNX
- LonWorks
- Modbus
- oBIX
- Thread
- VSCP
- xAP
- X10
- Z-Wave
- ZigBee



0-10VDC



VSCP
Very Simple Control Protocol

INSTEON



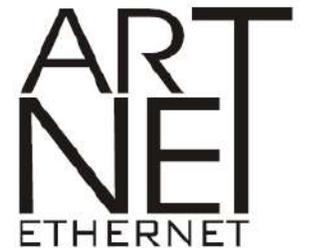
oBIX

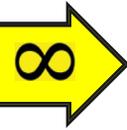


Building Controls – Standards

THEATRICAL CONTROL NETWORK STANDARDS

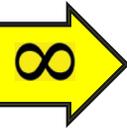
1. **DMX512**
(Digital Multiplex with 512 pieces of information)
2. **DMX512-A**
3. **RDM**
(Remote Device Management)
4. **ACN**
(Architecture for Control Networks)
5. **Art-Net**



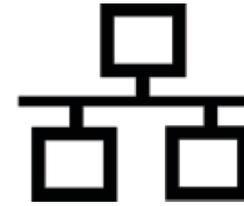


Lighting Controls – new standards

1. **ASHRAE** - American Society of Heating, Refrigerating and Air-Conditioning Engineers
2. **ANSI** - American National Standards Institute
3. **NIST** - National Institute of Standards and Technology
4. **IES** - Illuminating Engineering Society
5. **IEEE** - Institute of Electrical and Electronics Engineers
6. **CTA** - Consumer Technology Association (formerly CEA)
7. **USITT** - United States Institute for Theatre Technology
8. **ESTA** - Entertainment Services and Technology Association
9. **ISO** - International Organization for Standardization
10. **IEC** - International Electrotechnical Commission
11. **ETSI** - European Telecommunications Standards Institute
12. **OASIS** - Organization for the Advancement of Structured Information Standards
13. **EIA** - The U.S. Energy Information Administration



Lighting Controls – new standards

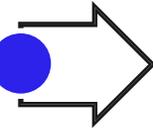


1. ASHRAE
2. ANSI
3. NIST
4. IES
- 5. IEEE**
6. CTA
7. USITT
8. ESTA
9. ISO
10. IEC
11. ETSI
12. OASIS
13. EIA

IEEE 802.3-2015

Ethernet is a family of computer networking technologies commonly used in area networks. The protocol was introduced in 1980 as a proprietary system and standardized as IEEE802.3 in 1983.

Ethernet has mostly replaced competing wired LAN technologies.

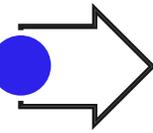


Lighting Controls – Security Standards

ANSI C137 – Lighting Systems standards

NIST recommends a multi-tiered approach to security which includes:

1. An architecture that isolates the wired Ethernet network from the wireless network.
2. A distributed security architecture with each hub having its own unique keys that would limit any potential breach to only a small area of the system.
3. Multiple levels of password protection (Wi-Fi network and the hubs themselves), with built-in rules that force the user to enter a strong password.
4. Best practices including salting and SCrypt for securely storing usernames and passwords
5. AES 128-bit encryption for network communications
6. HTTPS (TLS 1.2) protocol for securing connections to the hub over the wired network
7. WPA2 technology for securing connections to the hub over the Wi-Fi network



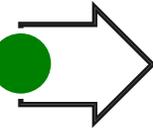
Lighting Controls – Security Technology

Blockchain:
ISO/TC 307
Security with a
scalability
challenge.

CryptoKitties

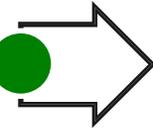
New tech can
have surprising
problems. A
lesson for first
adopters.





Lighting Controls – What am I looking at?





Lighting Controls – What am I looking at?

How to figure out what type of control system you are looking at?

If there are no wires going in/out of the sensor, switch or dimmer, it could be:

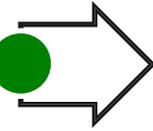
Blue Tooth Low Energy (BLE)

WiFi

ZigBee

Or another wireless standard



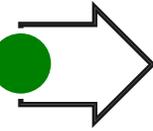


Lighting Controls – What am I looking at?

How to figure out what type of control system you are looking at?

If there are Ethernet in and out ports on a sensor, switch or dimmer – then it probably Ethernet protocol, but it may be DMX512 with RDM or ArtNet





Lighting Controls – What am I looking at?

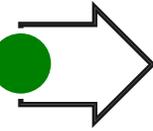
How to figure out what type of control system you are looking at?

There may be a Bluetooth, wifi or infrared (IR) wireless programming interface to a wired control system.



Or, you might have a wireless network of devices that have a wireless to Ethernet hub so it can plug into your computer or a BACnet system.



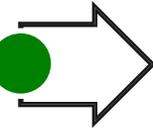


Lighting Controls – What am I looking at?

How to figure out what type of control system you are looking at?

Look at the literature and research the system you are considering. There are a lot of ways to combine protocols and control capabilities. Without looking at the literature, you won't really know what is going on under the hood.

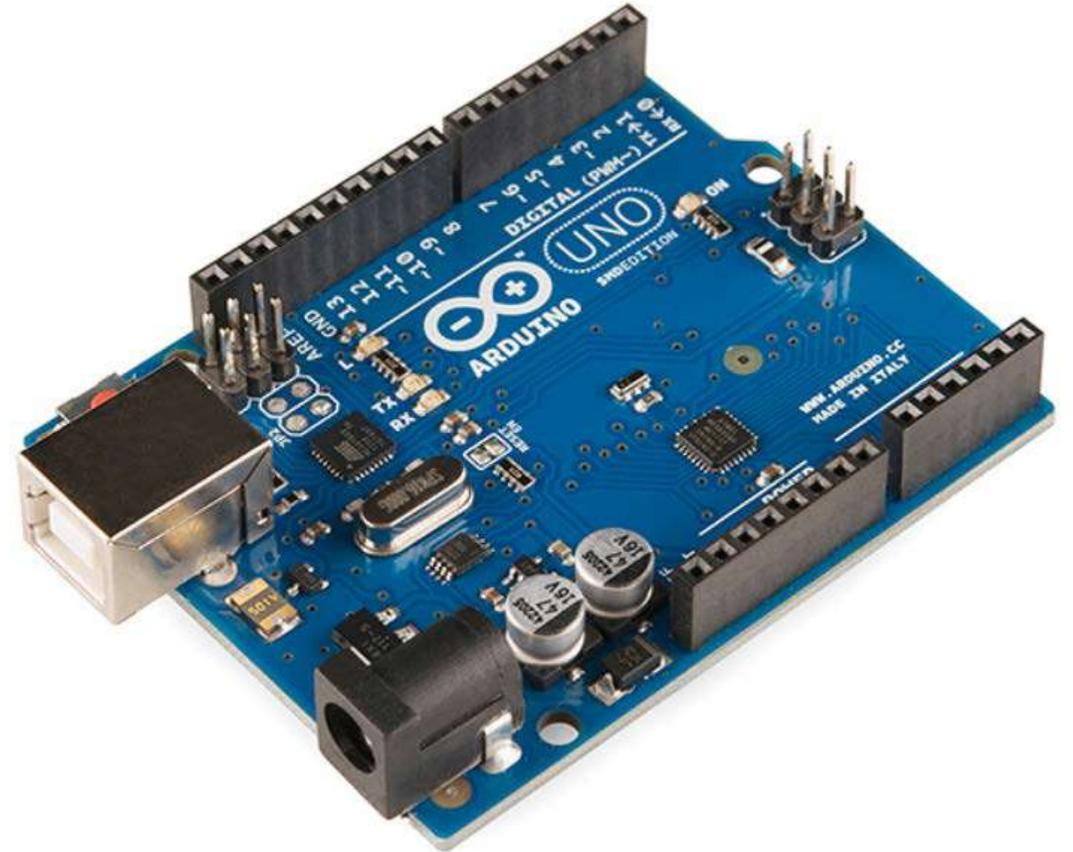
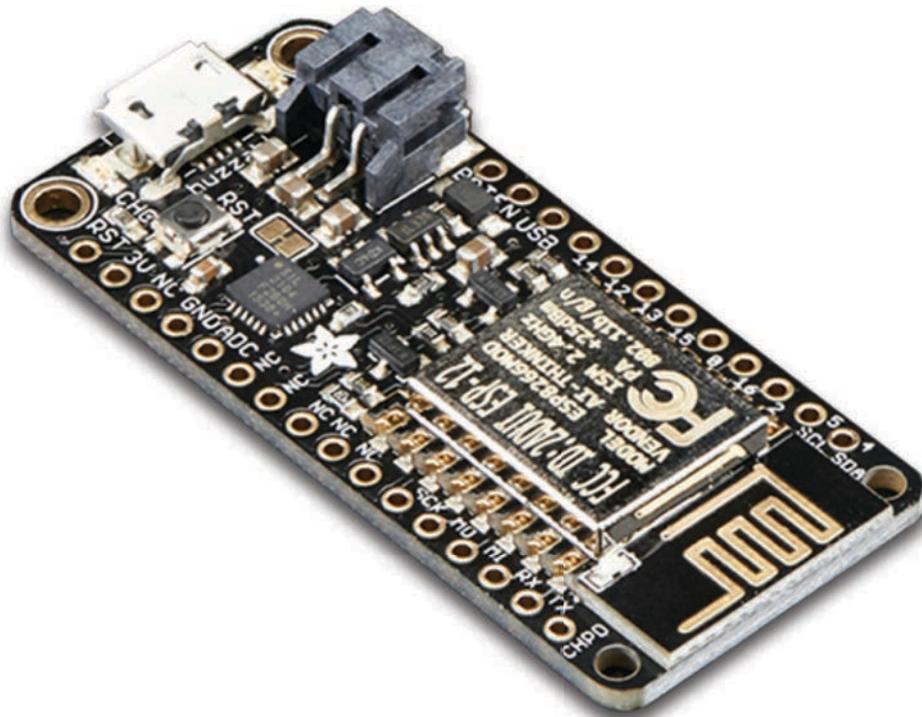
There are no “equal” control manufacturers anymore. There are equal performance specifications based on code requirements and client use. And then there is the challenge of finding multiple manufacturers who meet your specs.

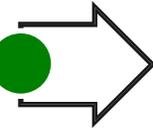


Lighting Controls – DIY

Programmable development boards:

- microcontroller
- microcomputer

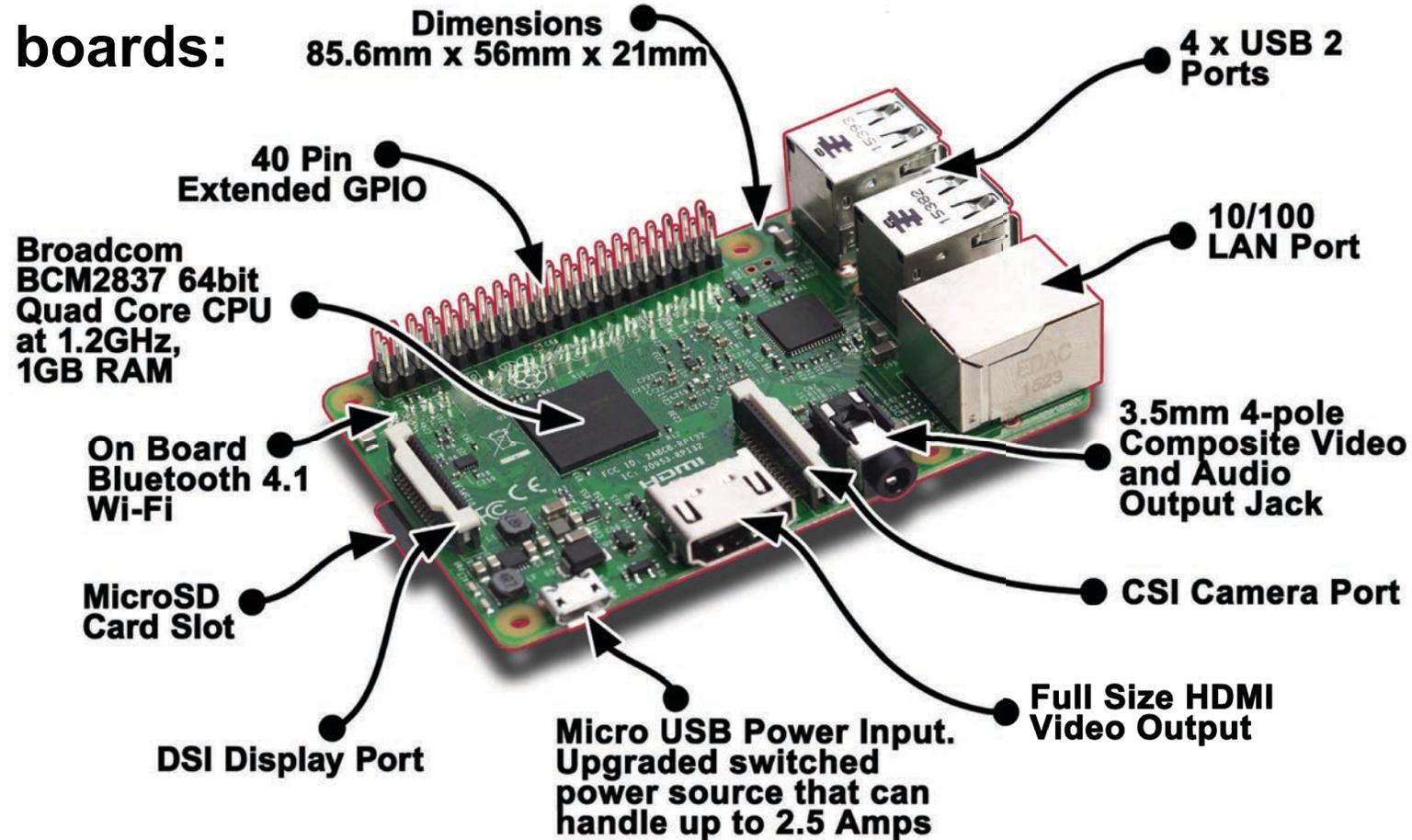


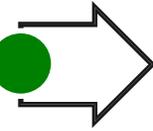


Lighting Controls – DIY

Programmable development boards:

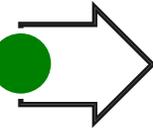
- microcontroller
- microcomputer





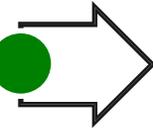
Lighting Controls – DIY

1. Microprocessor development boards are used inside a lot of new IoT products.
2. You can make your own IoT smart lighting control system using these boards – if you really want to.
3. DIY designers are making cool stuff that can do things.



Lighting Controls – DIY





Lighting Controls – DIY







Lighting Controls – A Fist Full of Dollars?



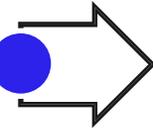
Lighting Controls – The Good The Bad and the Ugly?

Lighting Controls – Is Big Brother watching you?





Lighting Controls – A Fist Full of Dollars?



Lighting Controls – evolving technology

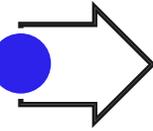
IoT Retail Lighting System

Sensor chip that clips onto luminaires.

Control system measures

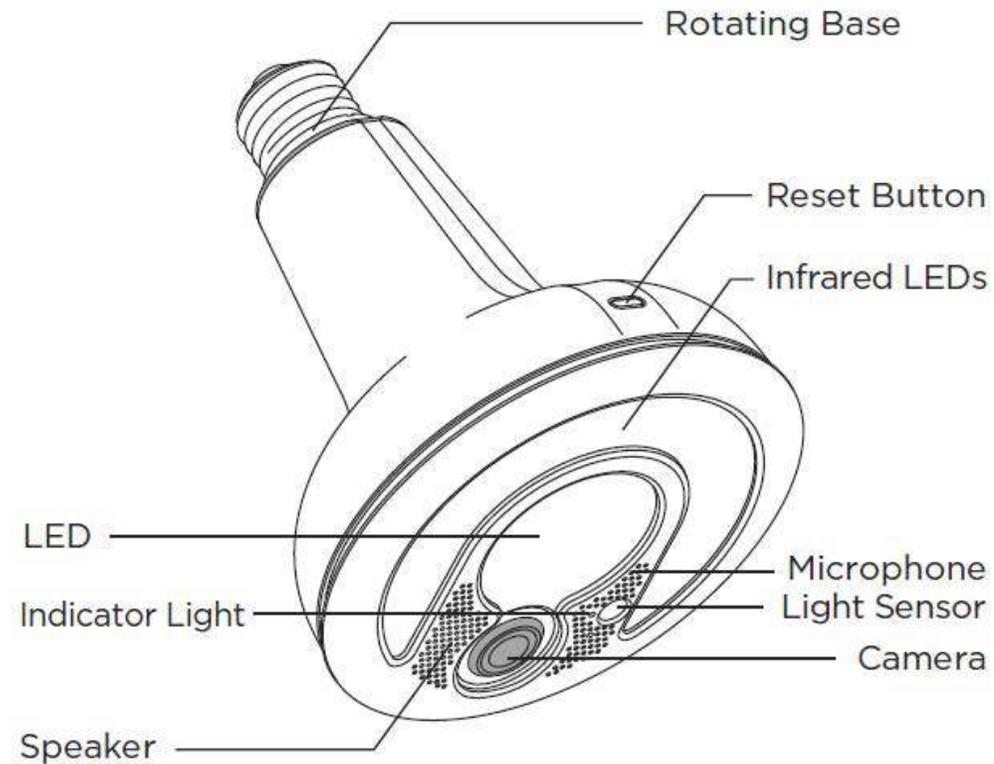
- Ambient light levels
- Color temperature
- Occupancy
- Motion tracking
- Volume tracking
- Direction tracking

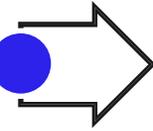




Lighting Controls – evolving technology

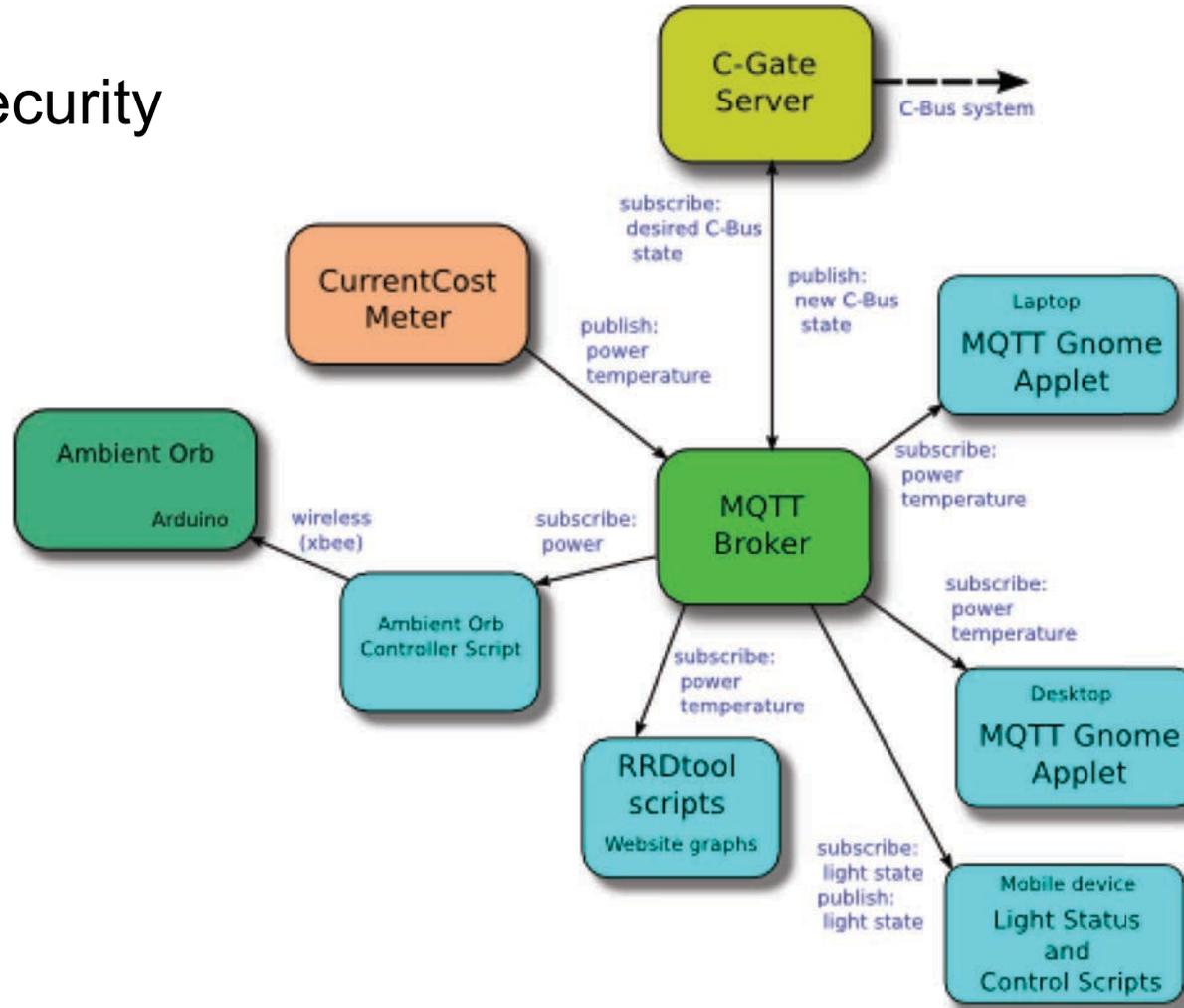
Smart Home Systems – Smart Lamps

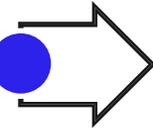




Lighting Controls – evolving technology

IoT Devices – Security

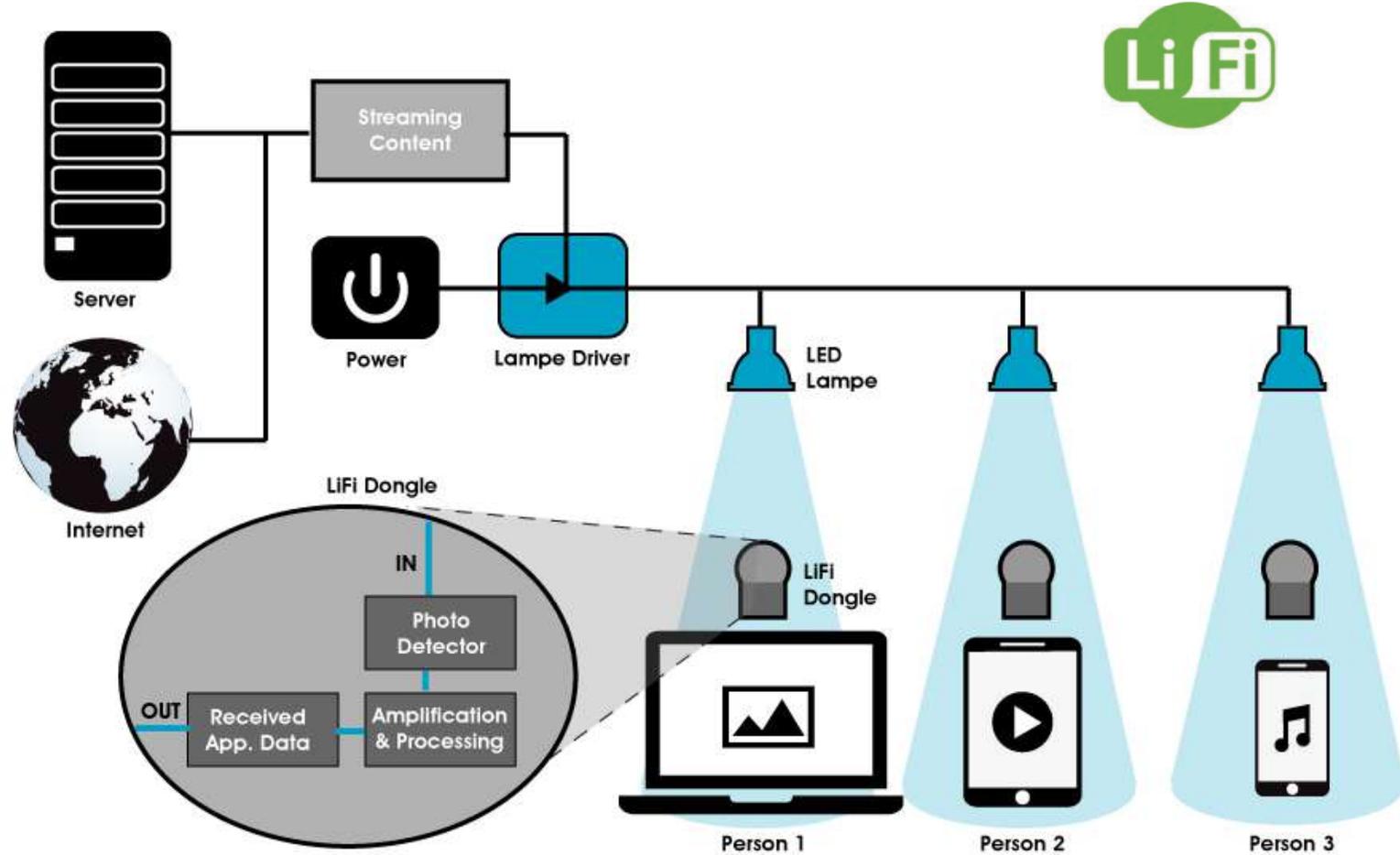


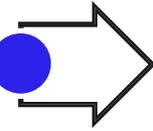


Lighting Controls – evolving technology

IoT Network: LiFi
 LiFi is a Visible Light Communications (VLC) system that uses LEDs for data transmission and 100 times faster than standard Wifi.

LiFi does not transmit through walls, and requires lights to be on to transmit data.





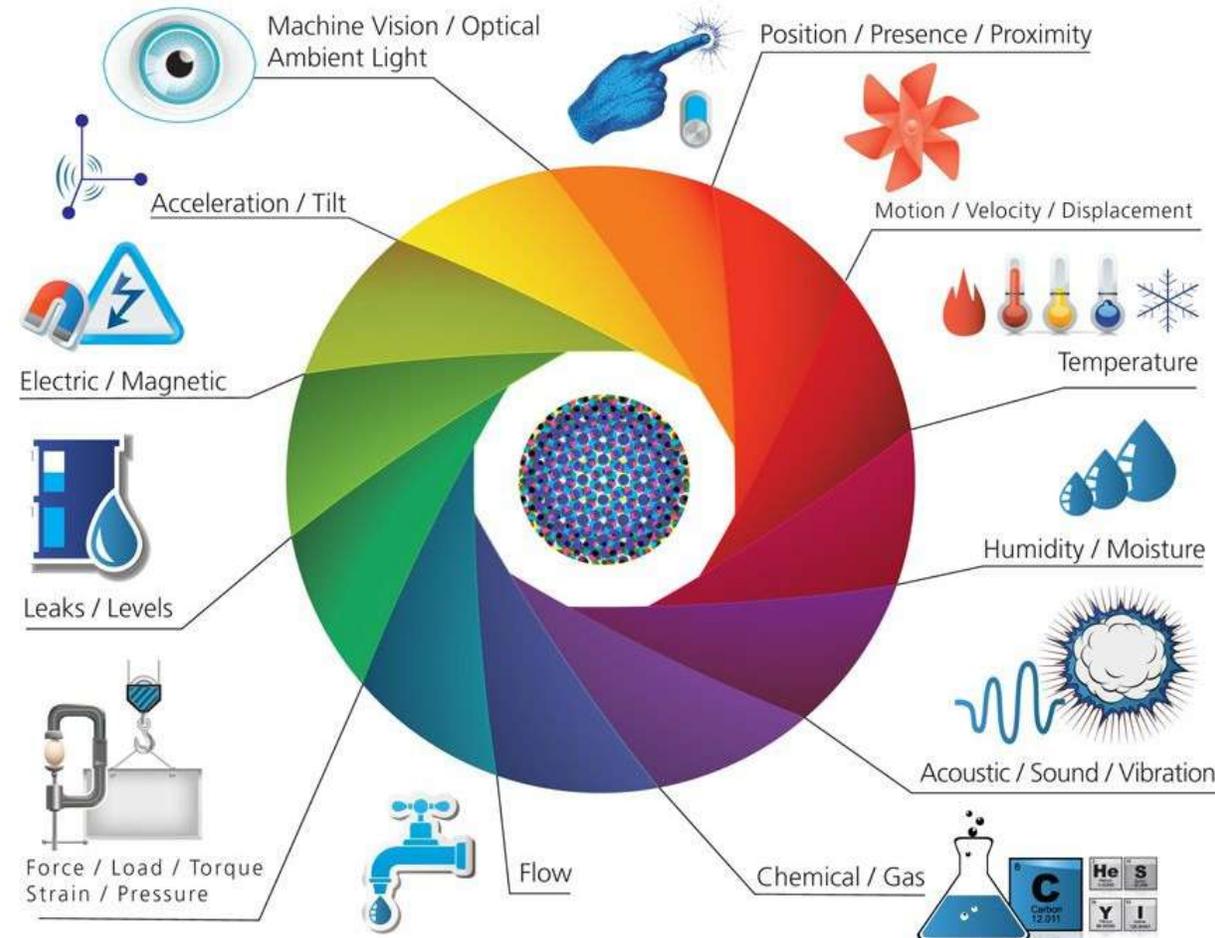
Lighting Controls – evolving technology

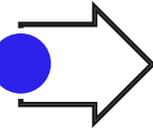
IoT Smart Cities: Data Collection

- Light
- Sound
- Vibration
- Movement
- Motion
- Proximity
- Temperature
- Moisture
- Chemical/Gas

IoT Smart Cities: Data Distribution

3G, 5G, Ethernet, Bluetooth, Wifi...



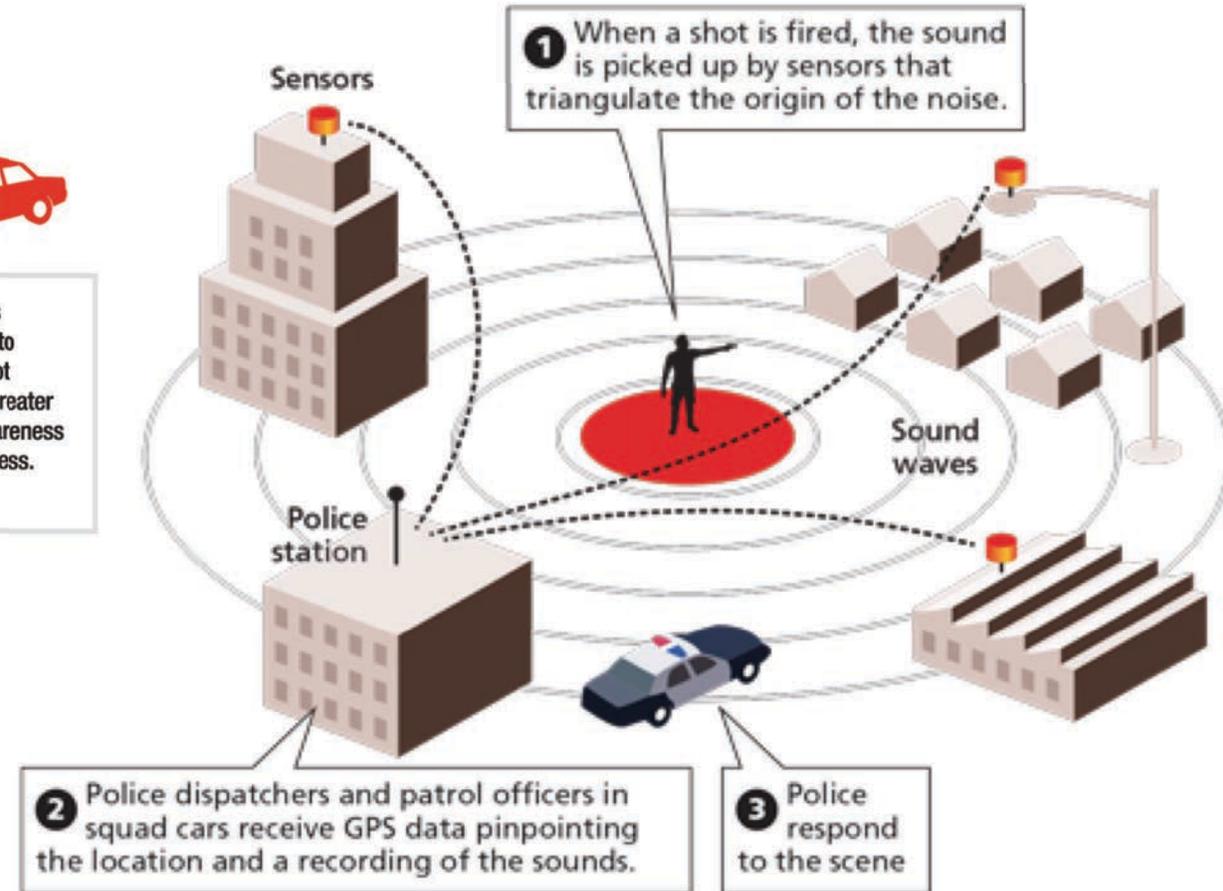


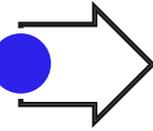
Lighting Controls – evolving technology

IoT Smart Cities: Security



<p>A gun is fired; the sound of an explosion radiates.</p>	<p>Multiple ShotSpotter sensors throughout coverage area trigger.</p>	<p>Location of gunfire is pinpointed within seconds and ShotSpotter gunfire and acoustic experts review and qualify the data.</p>	<p>Qualified Alert quickly sent to dispatch center, PSAP and mobile units for immediate dispatch.</p>	<p>Within minutes officers arrive to precise gunshot location with greater situational awareness and preparedness.</p>
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Lighting Controls – evolving technology

IoT Smart Cities: Funding

Fig. 5A

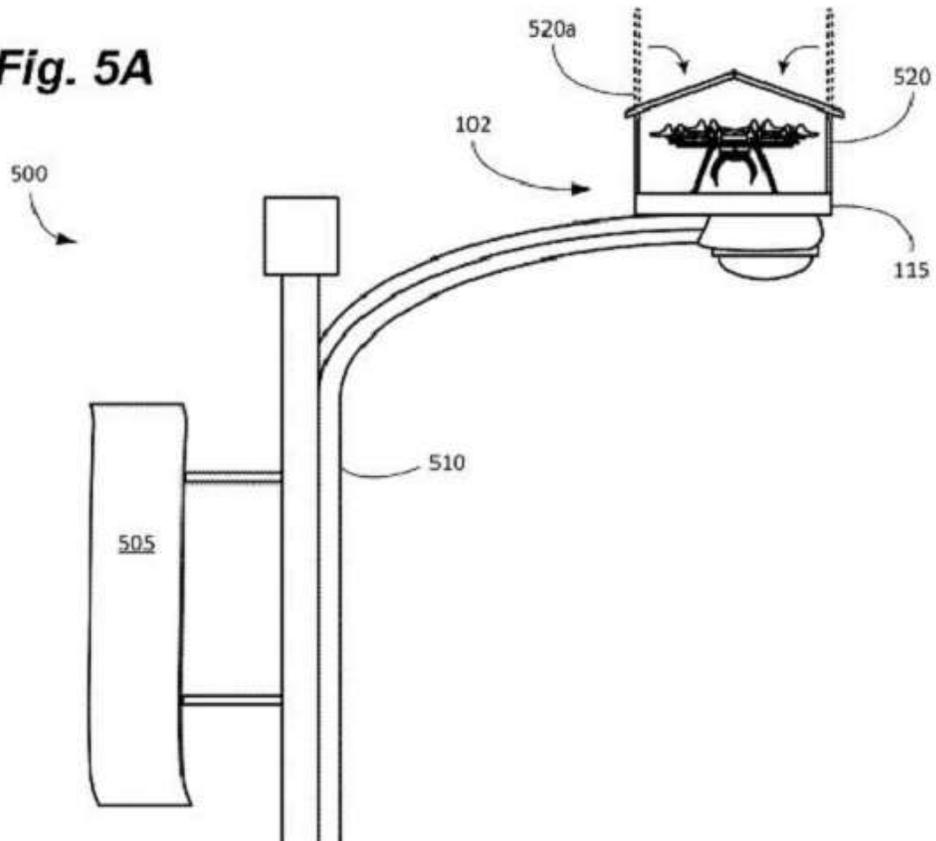
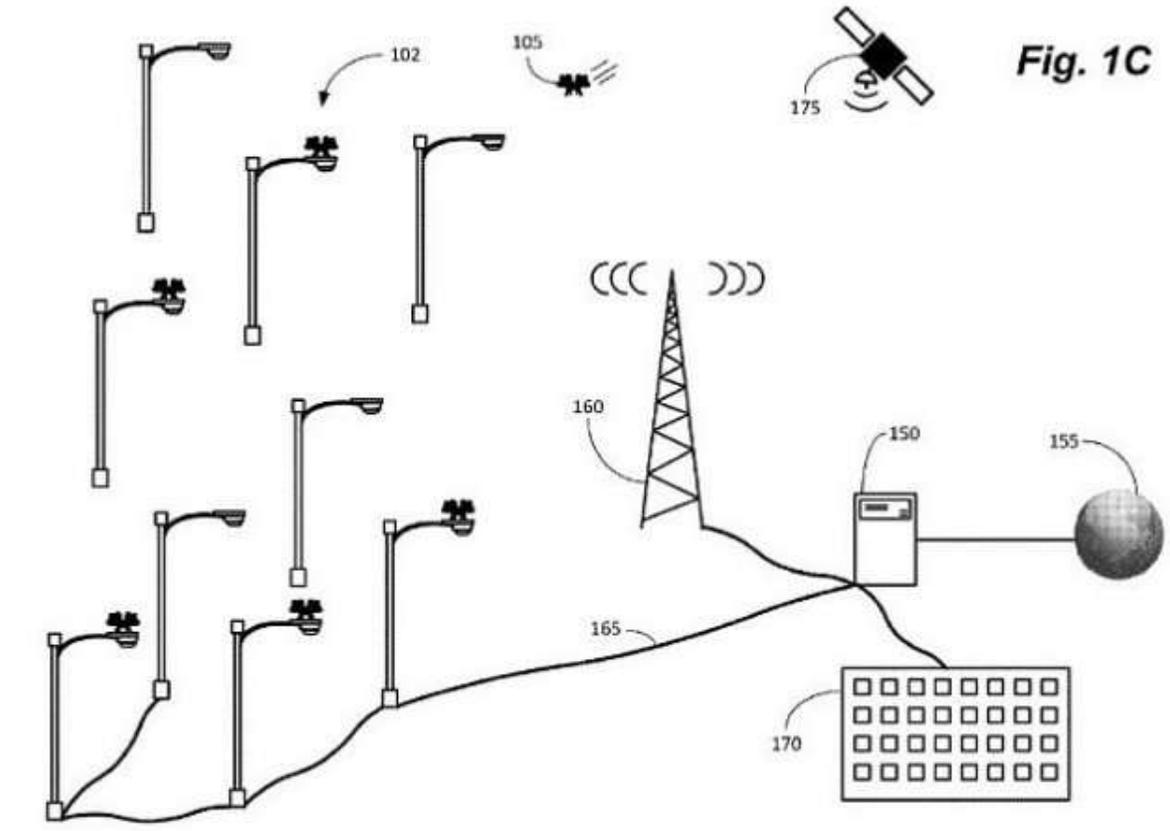


Fig. 1C



© U.S. Patent



Are smart lighting controls a disruptive technology???



What can we predict and how can we inform?



USE [AND] TO SELECT MORE THAN ONE DIMMER OR CHANNEL IN A SINGLE STATEMENT.
EX: [CHAN] [1] [AND] [5] [AND] [8] [FULL]



USE [AT] TO ENTER AN INTENSITY FOR A SELECTED DIMMER OR CHANNEL.
EX: [CHAN] [1] [AND] [4] [AT] [45]



USE AUTO FADER [BACK] TO INITIATE A 3 SECOND FADE TO THE PREVIOUS CUE, AND BACK UP THE CUE SHEET.



USE [BLACK OUT] TO PRODUCE A FULL STAGE BLACKOUT. PRESS [BLACK OUT] A SECOND TIME TO RESTORE STAGE LIGHTS.



USE [BLIND] TO CREATE OR MODIFY CUES WITHOUT AFFECTING STAGE LEVELS.
EX: [BLIND] [CUE] [1] [CHAN] [1] [FULL] [REC]



USE [CHAN] TO SELECT A CHANNEL OR GROUP OF CHANNELS.
EX: [CHAN] [1] [THRU] [5] [FULL]



USE [CLEAR] TO CLEAR THE CURRENT KEYPAD ENTRY. PRESS TWICE TO CLEAR ALL ENTRIES.
EX: [CHAN] [5] [CLEAR] [8]



USE AUTO FADER [CLEAR] TO CLEAR A FADER PAIR OF ANY CUES WHICH HAVE BEEN ASSIGNED TO IT.



USE [CUE] TO SELECT A CUE NUMBER.
EX: [CUE] [156.1]



USE THE DECIMAL POINT [.] TO SELECT DECIMAL CUE NUMBERS (.1 - .9) OR 1/10 SECOND FADE TIMES.
EX: [TIME] [.] [5] [ENTER]



USE [DELAY] TO SELECT A DELAY TIME BETWEEN LINKED CUES.
EX: [LINK] [2] [DELAY] [5]



USE [DIM] TO SELECT A DIMMER OR GROUP OF DIMMERS IN SOFTPATCH.
EX: [DIM] [1] [THRU] [5]



USE [ENTER] TO ADVANCE THE OPERATOR PROMPT OR TERMINATE/VERIFY SELECTED CONSOLE FUNCTIONS.
EX: [REC] [ENTER]



USE [FULL] TO ENTER AN INTENSITY OF 100% FOR A DIMMER OR CHANNEL.
EX: [CHAN] [1] [THRU] [10] [FULL]



USE AUTO FADER [GO] TO EXECUTE THE SELECTED CUE IN AN AUTO FADER.
EX: [CUE] [1] [GO]



PRESS [HELP] AND THEN ANY BUTTON TO RECEIVE A BRIEF DESCRIPTION OF THE BUTTON'S FUNCTION.
EX: [HELP] [CHAN]



USE FADER [HOLD] TO INTERRUPT A FADE. PRESS [GO] TO RESUME, [HOLD] TO STOP.
EX: [CUE] [1] [GO] [HOLD] [HOLD]



USE KEYPAD NUMBER (0 - 9) TO ENTER NUMERICAL SELECTIONS.



USE [LINK] TO TRIGGER A CUE FROM ANOTHER.
EX: [CUE] [1] [LINK] [2]



USE THE MINUS [-] TO DECREMENT THE SELECTED NUMBER BY ONE UNIT.
EX: [CUE] [4] [-] = CUE 3



USE [PATCH] TO ASSIGN DIMMERS TO CHANNELS AT LEVELS (00%-100%).
EX: [PATCH] [1] [ENTER] [5] [ENTER] [80]



USE THE PLUS [+] TO INCREMENT THE SELECTED NUMBER BY ONE UNIT.
EX: [TIME] [10] [+] [+] = TIME 12



USE [REC] TO SAVE ALL CUE OR SOFTPATCH INFORMATION IN CONSOLE MEMORY.
EX: [CUE] [1] [CHAN] [5] [FULL] [REC] [ENTER]



USE [REMAIN DIM] TO CLEAR NON-SELECTED CHANNELS. USE [REMAIN DIM] TO RECORD A CUE WITHOUT TRACKING.
EX: [CHAN] [1] [THRU] [10] [REMAIN DIM]



USE [SET UP] TO SELECT PRINT, DISK, OR CUSTOMIZATION FUNCTIONS.
EX: [SET UP] [4] [ENTER]



USE [STAGE] TO CREATE, MODIFY OR EXECUTE CUES ON STAGE.
EX: [STAGE] [CHAN] [1] [AT] [50]



USE [THRU] TO SELECT A CONTINUOUS GROUP OF DIMMERS OR CHANNELS.
EX: [CHAN] [1] [THRU] [5] [AND] [7]



USE [TIME] TO SELECT UPFADE AND DOWNFADE TIMES FOR CUES.
EX: [TIME] [5] [ENTER] [10]

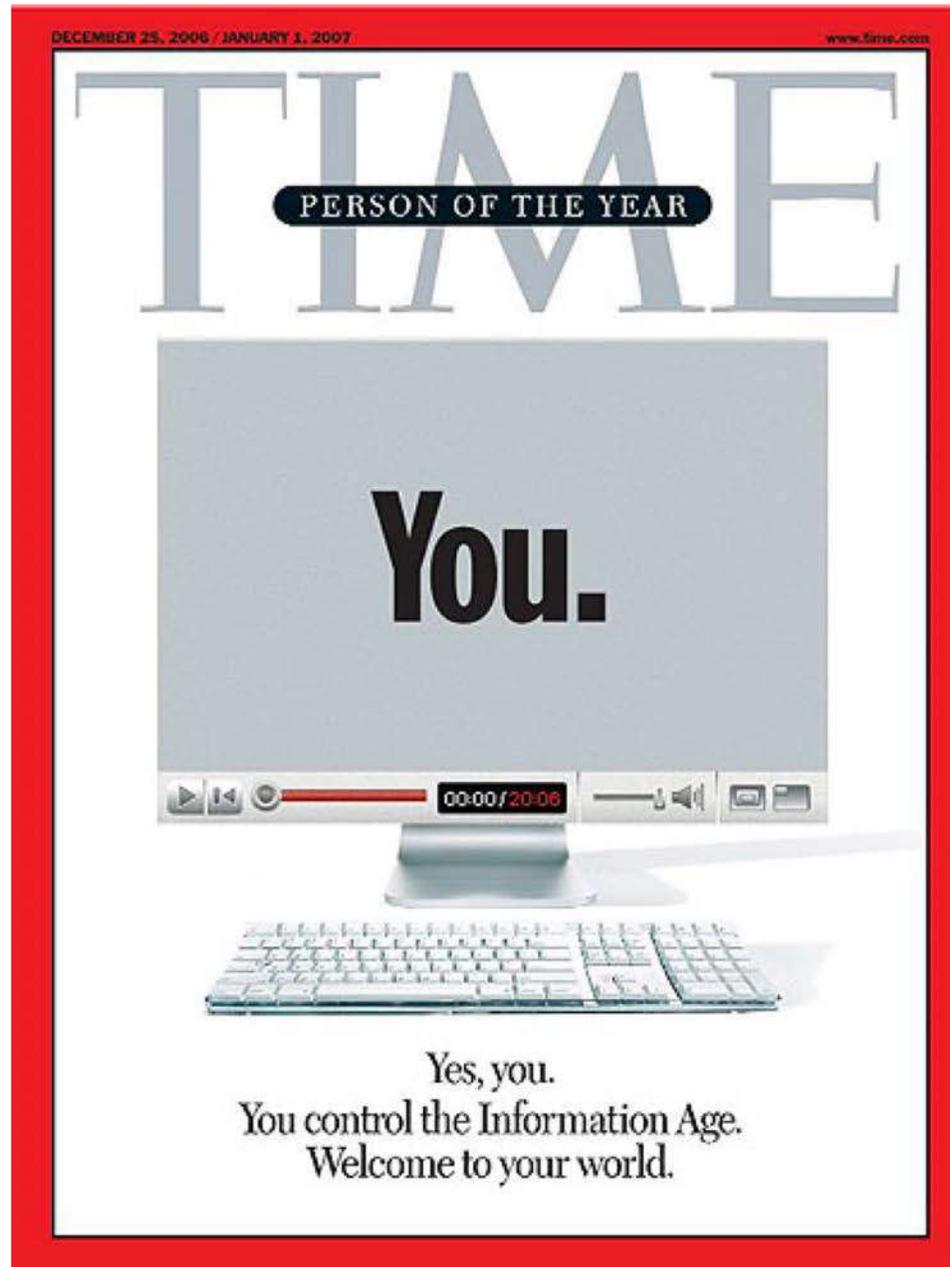


Image: Time Magazine cover December 25, 2006

This concludes The American Institute of Architects Continuing
Education Systems Course





Lighting Control Links

- NEMA Lighting Controls Terminology: <https://www.nema.org/Standards/Pages/Lighting-Controls-Terminology.aspx>
- Technical Standards Program/ESTA documents page with ANSI theatrical controls standards including DMX512: http://tsp.esta.org/tsp/documents/published_docs.php
- 2017 LEDucation talk with Energy Code control requirements explained for NYC/IECC and ASHRAE compliance paths: <https://www.slideshare.net/LEDucationNYC/your-energy-code-questions-answered-by-adam-kroll-and-marty-salzberg>
- Lighting Controls Association – free lighting control education modules: <http://aboutlightingcontrols.org/EducationExpress/>
- Wikipedia – Lighting Control System: https://en.wikipedia.org/wiki/Lighting_control_system
- IoT and Security: <http://luxreview.com/webinar/242/iot-and-security>
- David DiLaura presents A History of Disruptive Technologies in Lighting: <https://vimeo.com/41036311>
- IES Lighting Control Protocols Technical Memorandum: <https://www.ies.org/store/technical-memoranda/lighting-control-protocols/>
- IoT Ready Alliance: <http://www.iot-ready.org/>
- TALQ consortium for a smart outdoor lighting protocol: <http://www.talq-consortium.org/>
- US Department of Energy (DOE) connected lighting systems: <https://energy.gov/eere/ssl/connected-lighting-systems>
- ANSI Lighting Systems Committee: <https://www.nema.org/Technical/Pages/ANSI-C137-Lighting-Systems-Committee.aspx>
- The Smart City Revolution: Where's It All Going? World Economics Forum: <https://www.youtube.com/watch?v=mXtpdby9JSQ>
- Smart City Vision, San Jose CA: <https://www.sanjoseca.gov/index.aspx?nid=5289>
- Reading list for the MIT Ethics and the Law on the Electronic Frontier course: <https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-805-ethics-and-the-law-on-the-electronic-frontier-fall-2005/readings/>
- Harold Haas Li-Fi Ted Talk: https://www.ted.com/talks/harald_haas_a_breakthrough_new_kind_of_wireless_internet

