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Designers Light Forum

IoT Connected Lighting: A Design Guide

Jered Widmer, IALD,
Paula Ziegenbein, LC, Assoc IALD,
Ardra Paige Zinkon, CLD, IALD

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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 Analyze goals and objectives for the use of connected light systems and develop a Sequence of Operations for the Owner.

#2 Explore required components for a connected light system and how to integrate them with the design team.

#3 Investigate strategies for teamwork on connected light projects.

#4 Identify key players and roles in an IoT connected project.

IES Design Guide
IoT Connected Lighting Systems

- What is IoT
- IoT Use Applications
- IoT Ecosystem
- IoT in the Lighting Design Process
- IoT Considerations

Illuminating Engineering Society

What is IoT?

- Key components of an IoT ecosystem include:
  - (1) physical objects
  - (2) device data
  - (3) a networked infrastructure

- IoT enables the synthesis of device data into meaningful insights capable of both informing stakeholders and producing more favorable outcomes

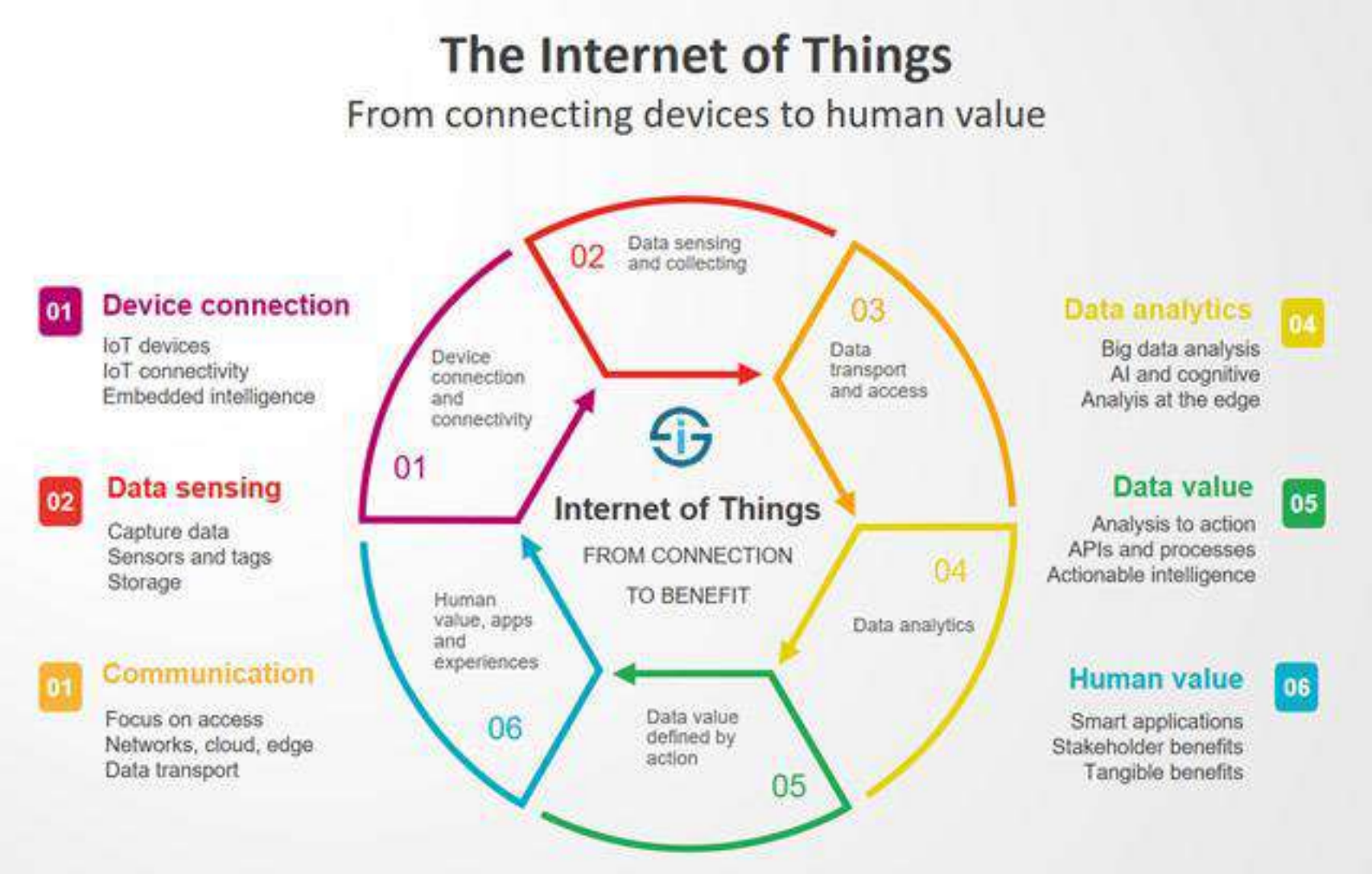
What is IoT?

Connected People

INTERNET

Connected Things

What is IoT?


The Internet of Things
From connecting devices to human value
01 Device connection
IoT devices
IoT connectivity
Embedded intelligence
02 Data sensing
Capture data
Sensors and tags
Storage
01 Communication
Focus on access
Networks, cloud, edge
Data transport
02 Data sensing and collecting
03 Data transport and access
04 Data analytics
05 Data value defined by action
06 Human value, apps and experiences
01 Device connection and connectivity
Internet of Things
FROM CONNECTION
TO BENEFIT
Data analytics
04
Big data analysis
AI and cognitive
Analyis at the edge
Data value
05
Analysis to action
APIs and processes
Actionable intelligence
Human value
06
Smart applications
Stakeholder benefits
Tangible benefits

What is Lighting's role in IoT?

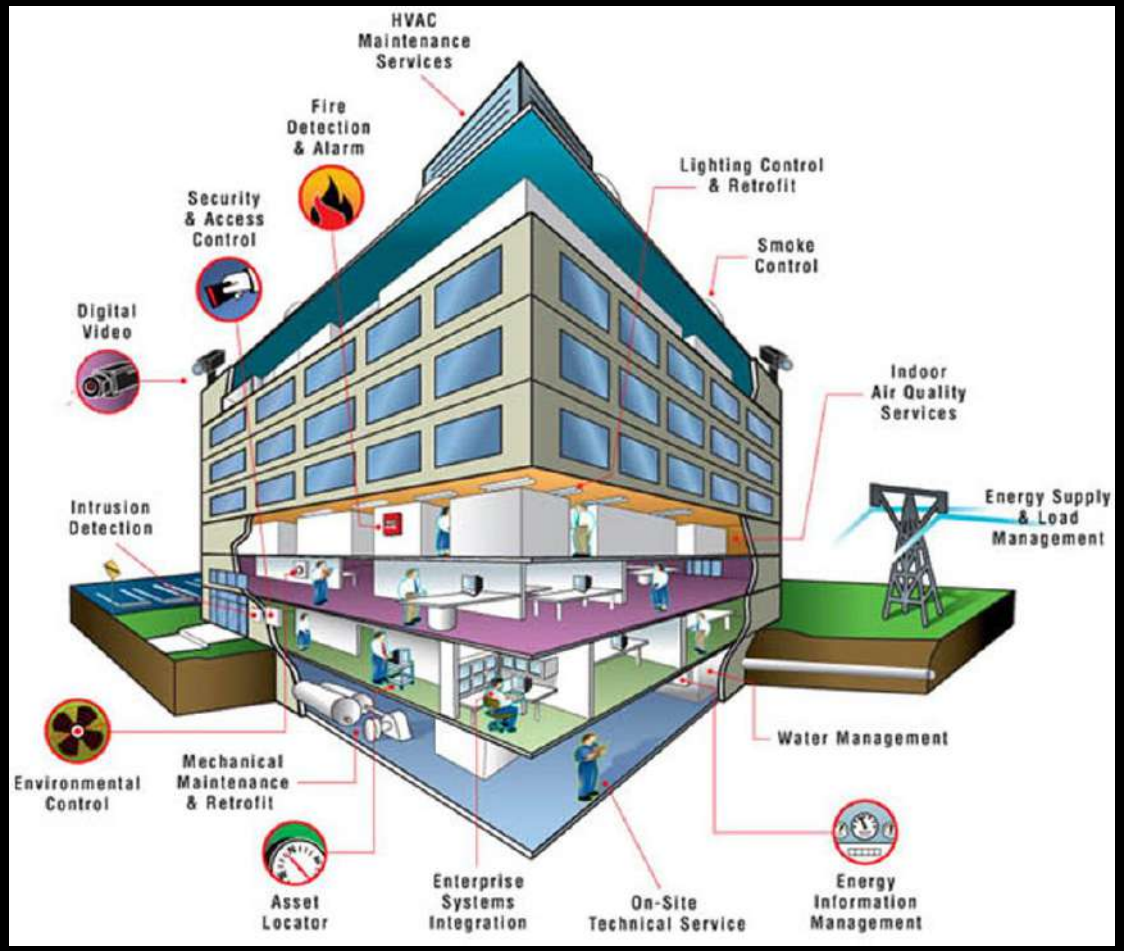
From a Broader Industry Perspective:

- Lights serve as the central nervous system for data collection – a regular layout/grid indoors and outdoors
- Lights are interconnected with power and sometimes dedicated data lines to facilitate 3rd party communication
- Lights can accommodate onboard sensors and antennas

Lighting and Data

“Buildings and other structures, such as HVAC and lighting systems, are the fifth-largest generators of data connected to the Internet of Things (IoT) in facilities management”.

IFMA Boston Chapter: The Internet of Things & the Workplace



Smart VS. IoT

Smart Building

A smart building means unlike things (lighting, HVAC) are connected and can interact.

Example: Occupant turns on lights in Conference Room A, Ceiling Sensor notes occupancy, HVAC kicks on.

Smart VS. IoT

IoT Connected Building

An IoT Building means unlike things (lighting and HVAC) are connected and can interact **AND** there is Data Collection, Analysis and Human Experience.

Example: Lighting/Sensors indicates nobody uses Conference Room B, HVAC Sensor indicates temperature is 10 degrees less than Conference Room A. HVAC adjusts temperature. Occupants change their behavior and both rooms are utilized.

What is Lighting's role in IoT?

Back to a Lighting Designer's Perspective:

- ***If*** lights simply serve as power delivery system for a network of sensors that perform non-lighting related outcomes, ***then*** how does lighting quality fit into this model?

IoT Applications and Market Sectors

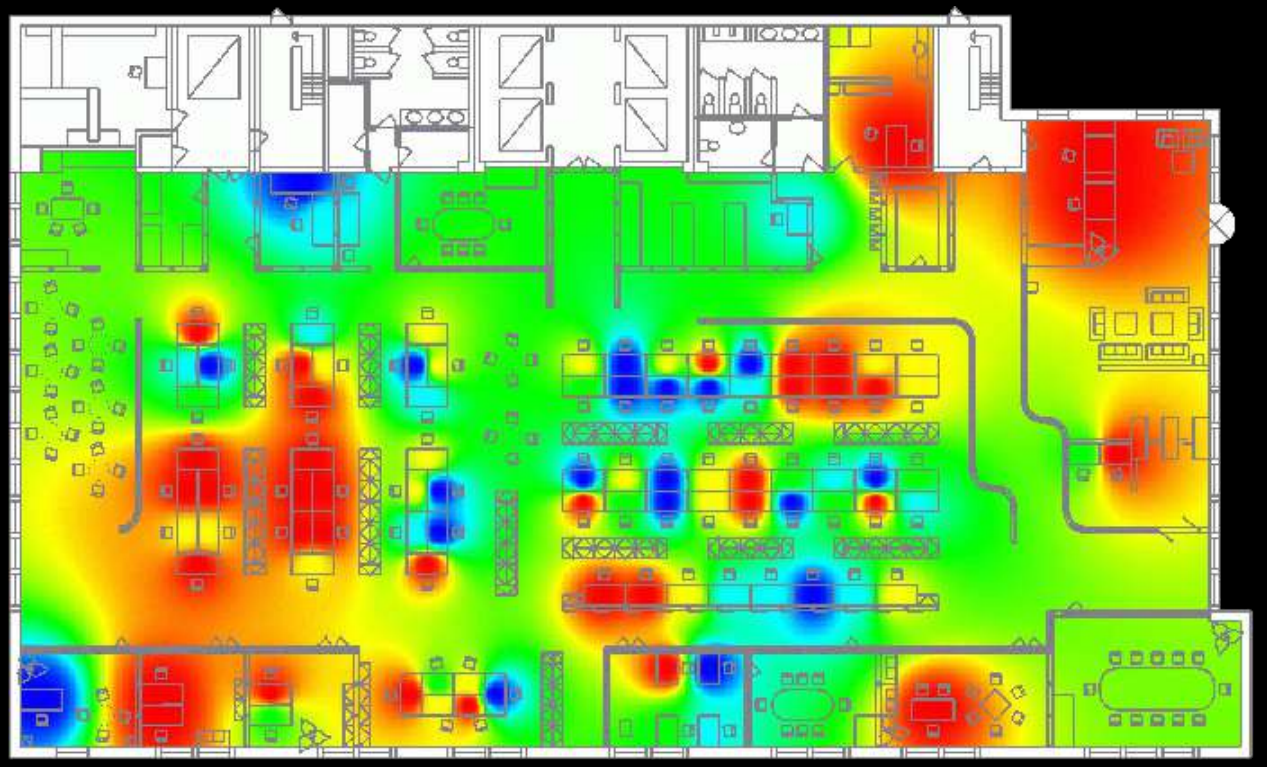
Application Terminology

Applications which involve **occupancy** and **location** include:

- Space Utilization
- Indoor Positioning
- Personal Environmental Control
- Asset/Occupant Tracking

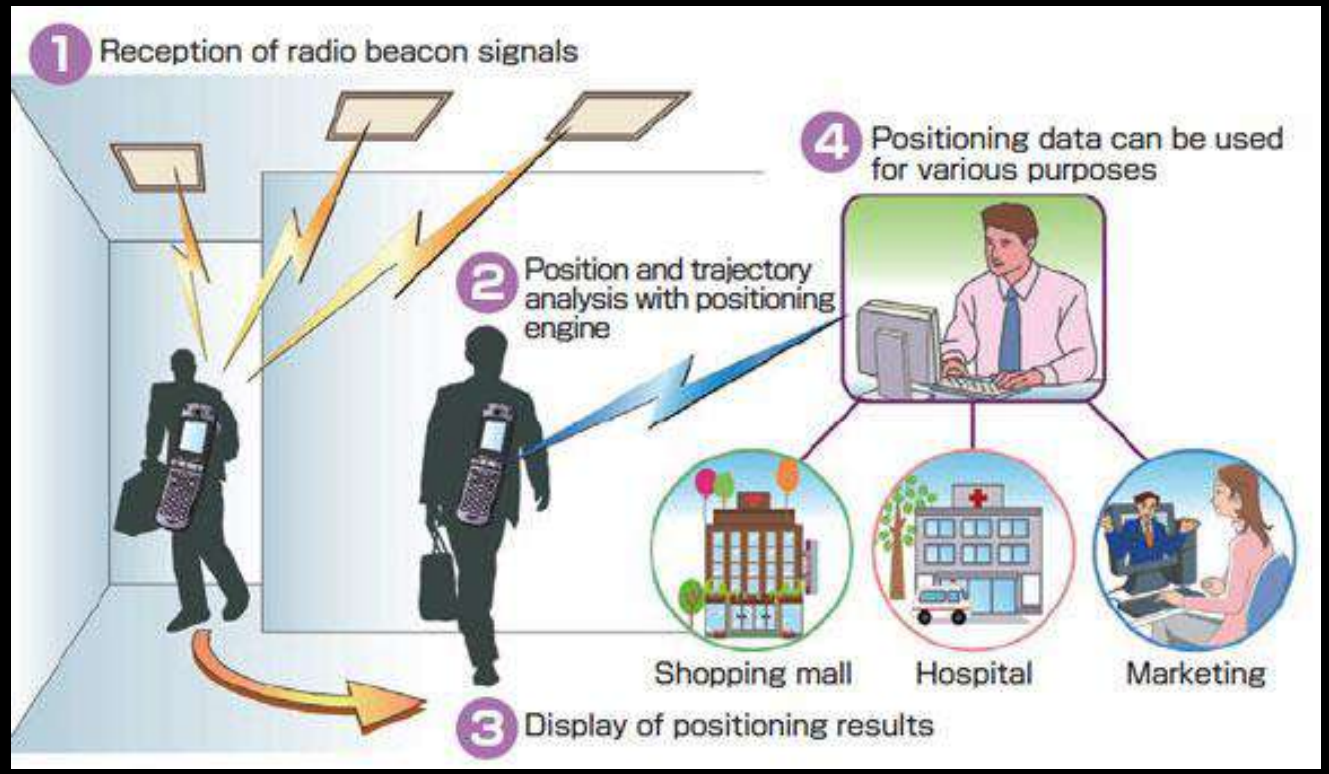
Space Utilization

- Heat mapping communicates space utilization
- Improves headcount accuracy and uncovers important details about the actual purpose and priority of space.



Indoor Positioning

- Provides occupants of a space the ability to determine their real-time location
- Indoor GPS
- Occupants typically interact with IPS technology via an enabled application operating on a smartphone or internet-connected portable electronic device.



Personal Environmental Control

- Provides the ability to control the immediate space, often resulting in energy savings as well as higher occupant satisfaction
- Combined with IPS & personal data, it can provide an automatic response to specific individuals and automatically sync to their preferred settings

Asset or Occupant Tracking

- Tracks the location of physical portable objects/assets
- Largely enabled through the use of radio frequency transmissions (i.e. RFID or Bluetooth)

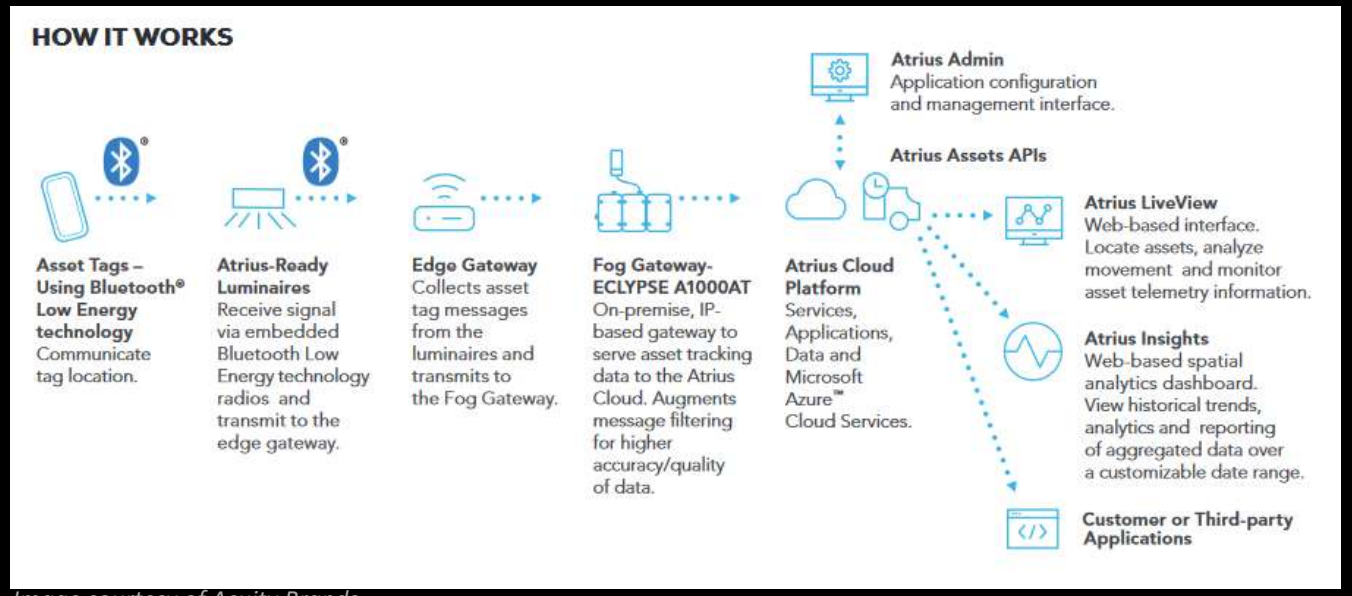


Image courtesy of Acuity Brands

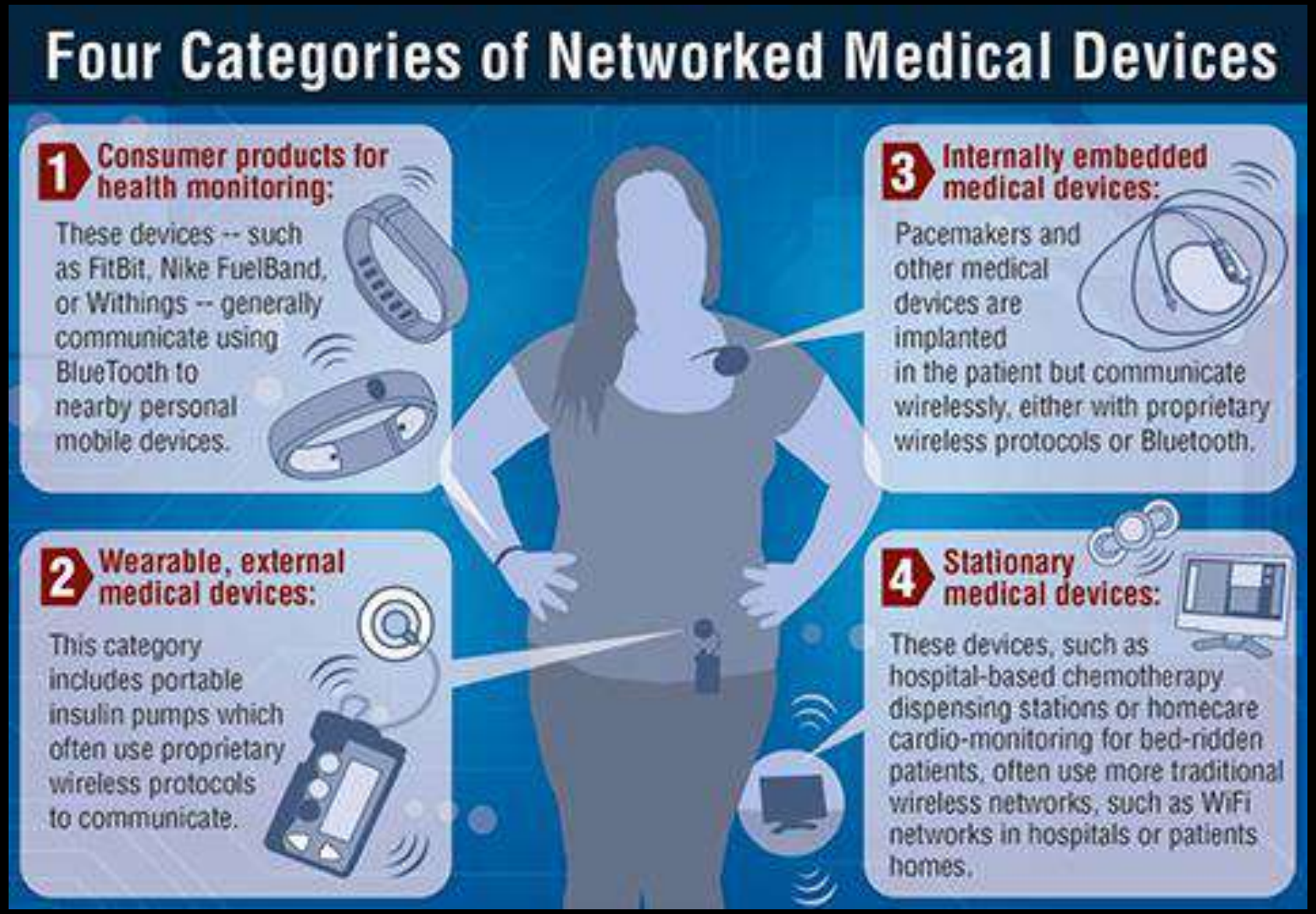
Market Sectors

- Healthcare
- Transportation
- Hospitality
- Retail
- Office
- Education
- Industrial
- Smart City

IoT in Healthcare

- Execute enhanced lighting system for Circadian lighting & CCT control
- Inventory & locate Assets (gurney/wheelchairs/crash carts)
- Monitor/Track patients
- Integrate with devices like “fitbit” to track sleep/wake cycles, heartrate & steps in recovery

IoT in Healthcare



IoT in Transportation

- Inventory & locate Assets (wheelchairs)
- Enhance security coverage for DHS
- Automatic Re-booking
- Passenger updates for wait-time for Security
- Track employees and luggage
- Analyze traffic flow to reallocate assets & improve efficiency

IoT in Transportation

IoT in Hospitality/Hotels
(for Ownership)

- Coordinate Housekeeping staff
- Save energy on lighting & HVAC loads
- Analysis guest habits, booking trends & rates
- Track maintenance needs more effectively

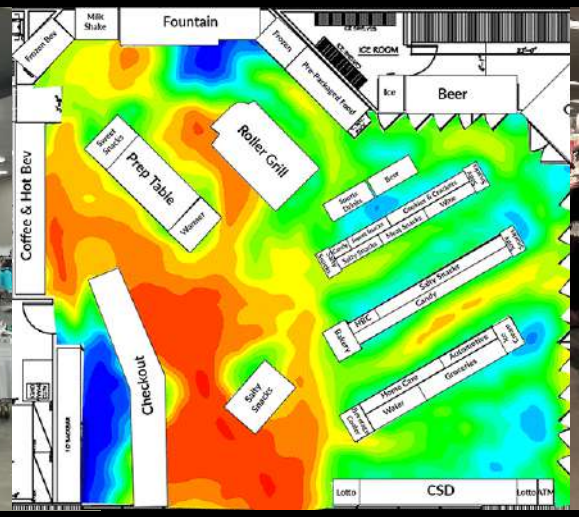
IoT in Hospitality/Hotels
(for Guests)

- Access room with Phone as key card
- Set/control lights and AC in room
- Control TV via phone
- Change digital artwork in room based on profile



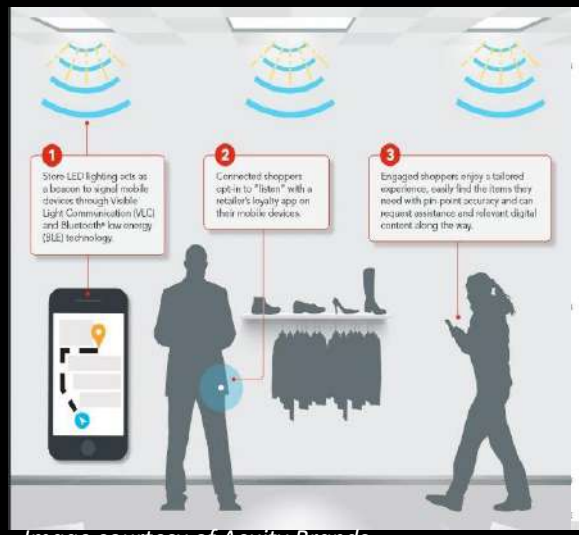
IoT in Retail
(for Retailer)

- Track customer purchases/recommend product
- Analyze customer traffic & adjust staffing
- Monitor trends & better organize store design
- Prioritize displays by controlling light intensity



IoT in Retail
(for Consumer)

- Find products faster
- Get notified of sales/specials
- Check out without the checkout
- Optimize shopping schedule based on traffic



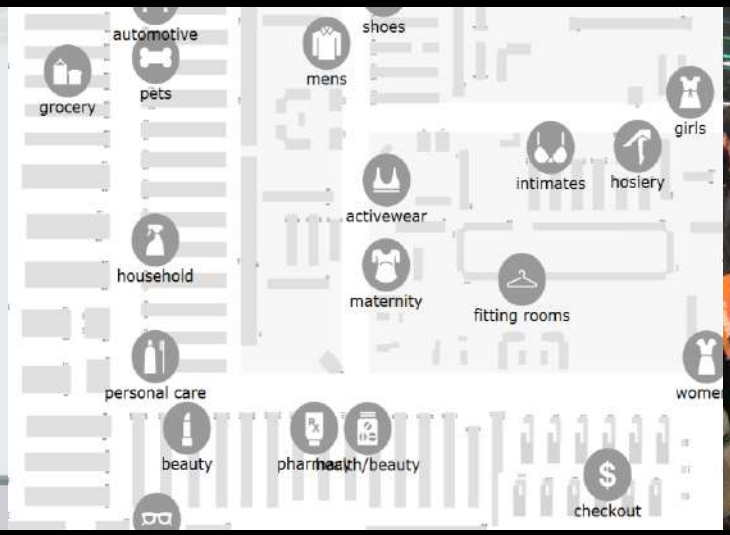
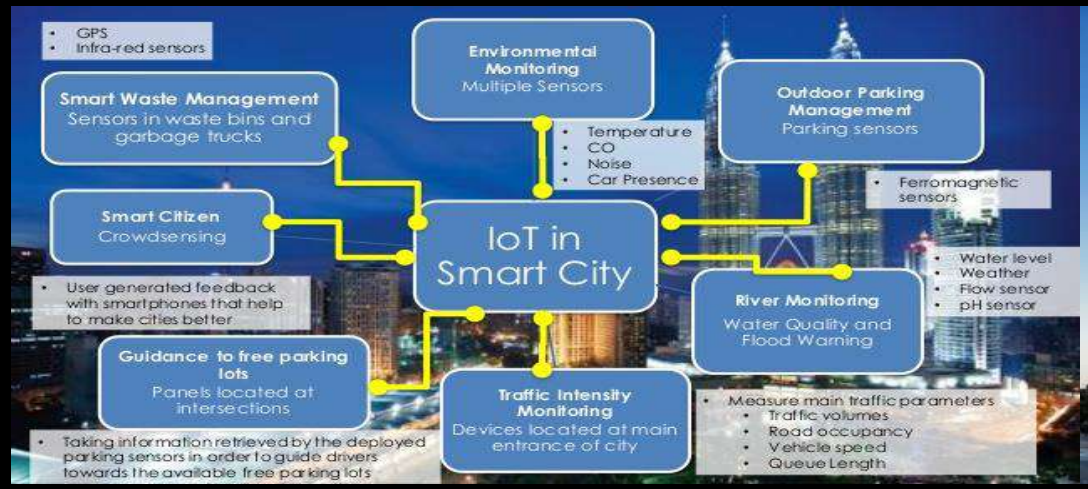


Image courtesy of Acuity Brands

IoT in Smart Cities

- Monitor & optimize traffic
- Monitor & optimize parking
- Monitor/report crime
- Monitor/report air quality
- Provide city-wide WiFi
- Control light pollution

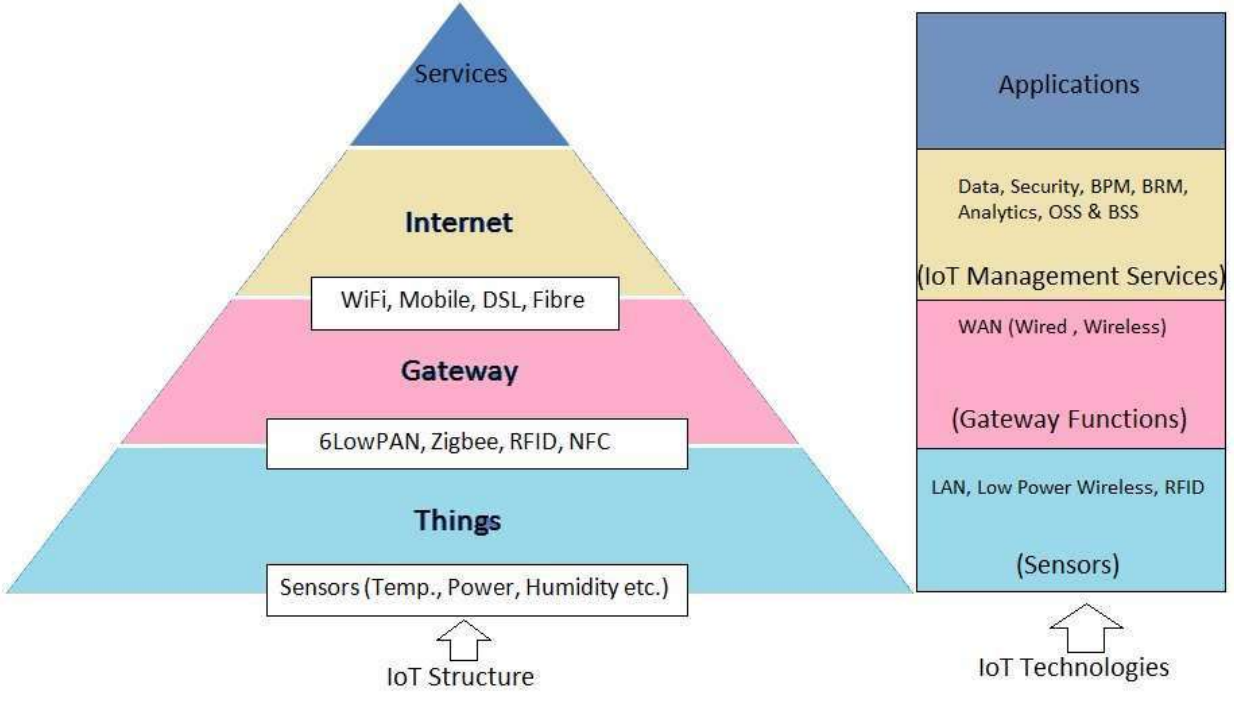


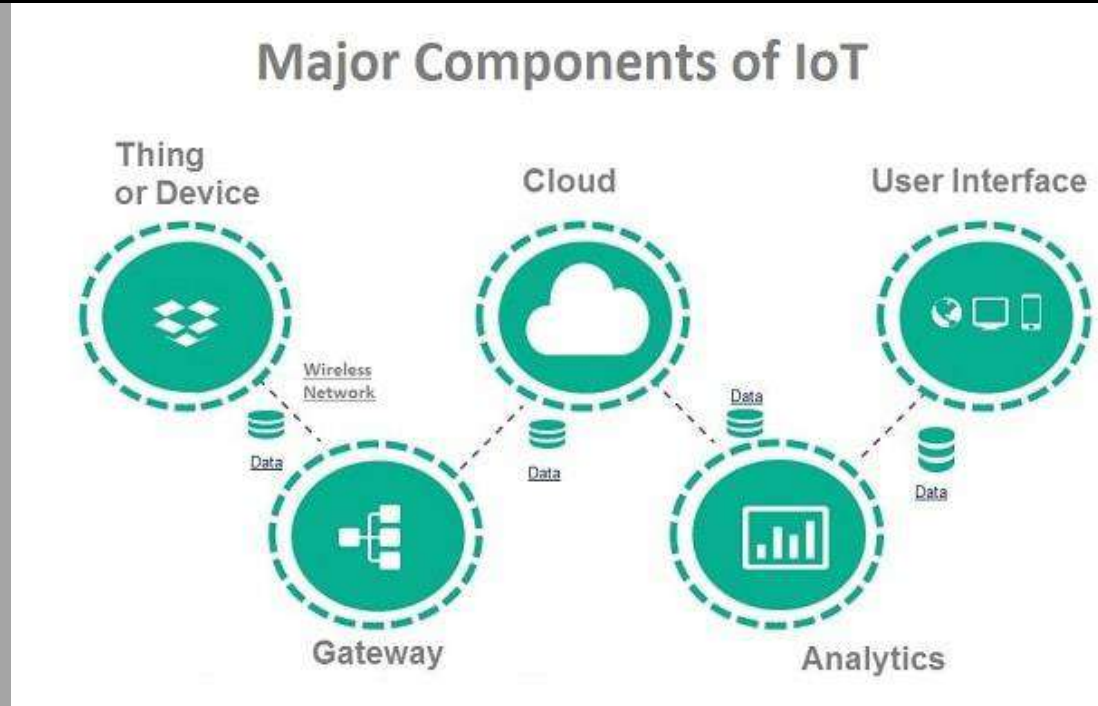
IoT Ecosystem

IoT Ecosystem

System Hardware
Sensors
Gateway
Interface
Data Storage

Software
Component Level
Analytics





IoT Ecosystem - Sensors

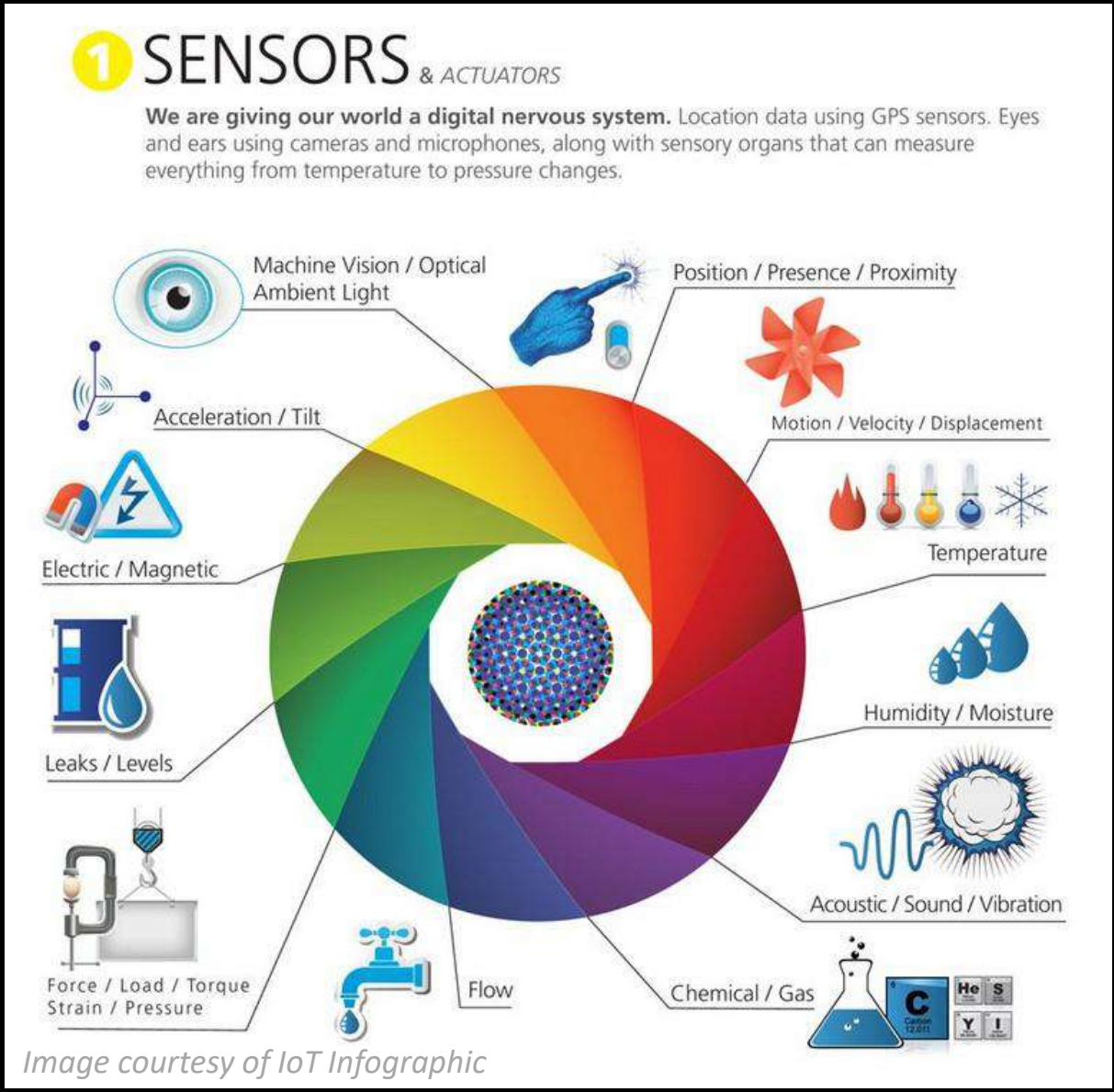


Image courtesy of IoT Infographic

Wireless Standards

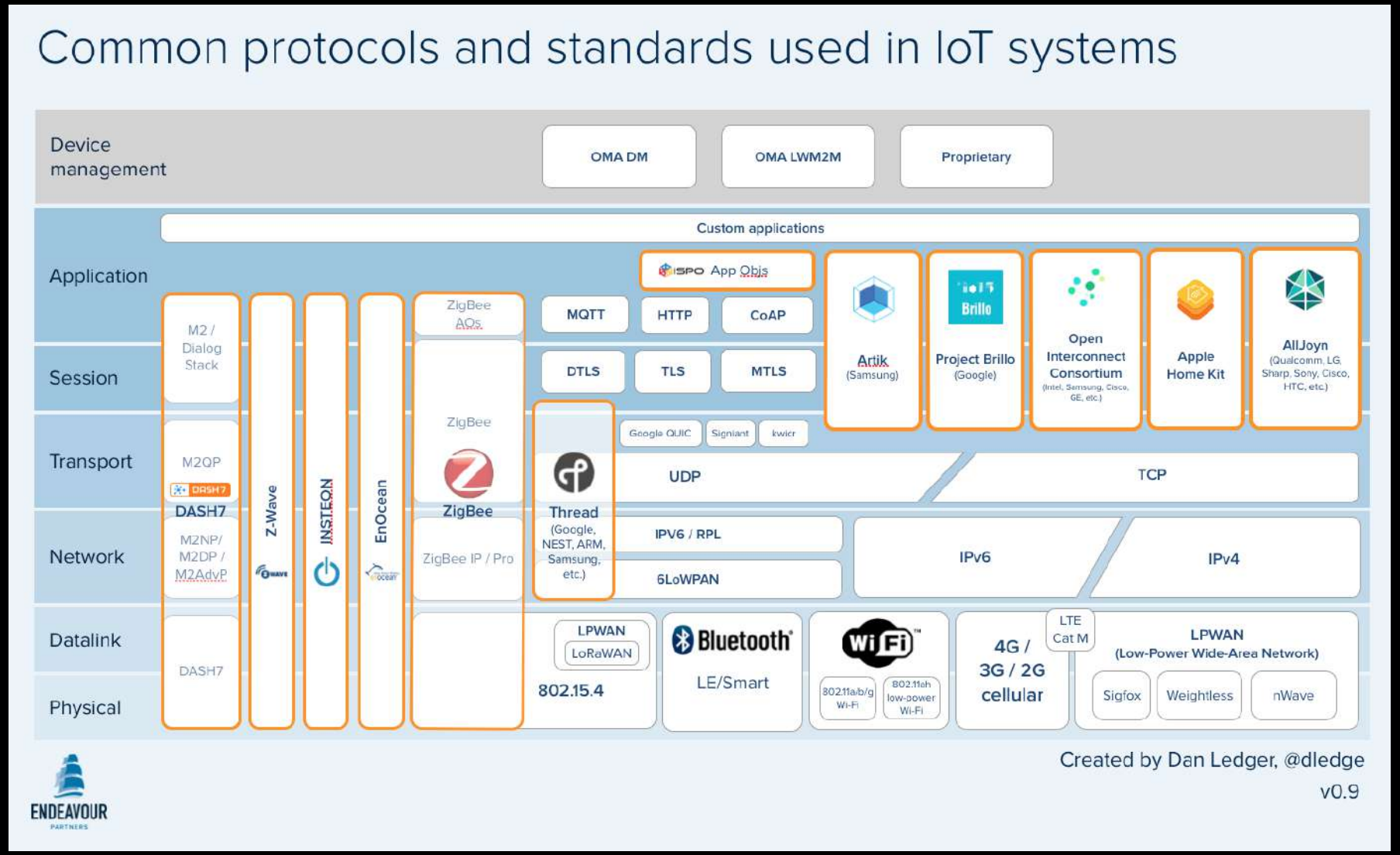
Commonly applied in lighting

ZigBee Alliance	**IEEE 802.15.4**
Wifi	**IEEE 802.11x**
Bluetooth®	**IEEE 802.15.1**

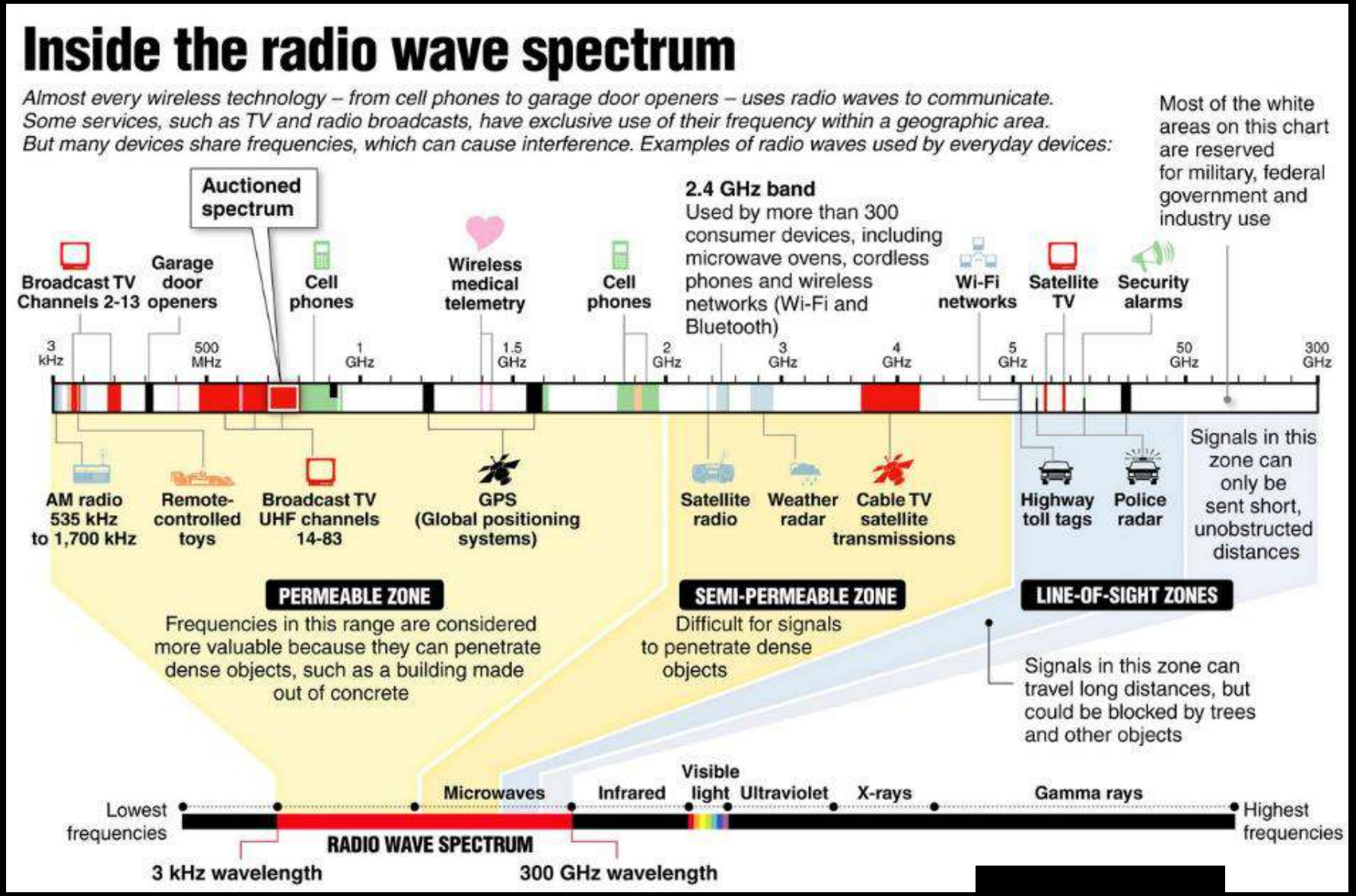
IoT Ecosystem - Communication Protocols

Wired
- Powerline
- PoE

Wireless
- Bluetooth
- Zigbee
- Wifi



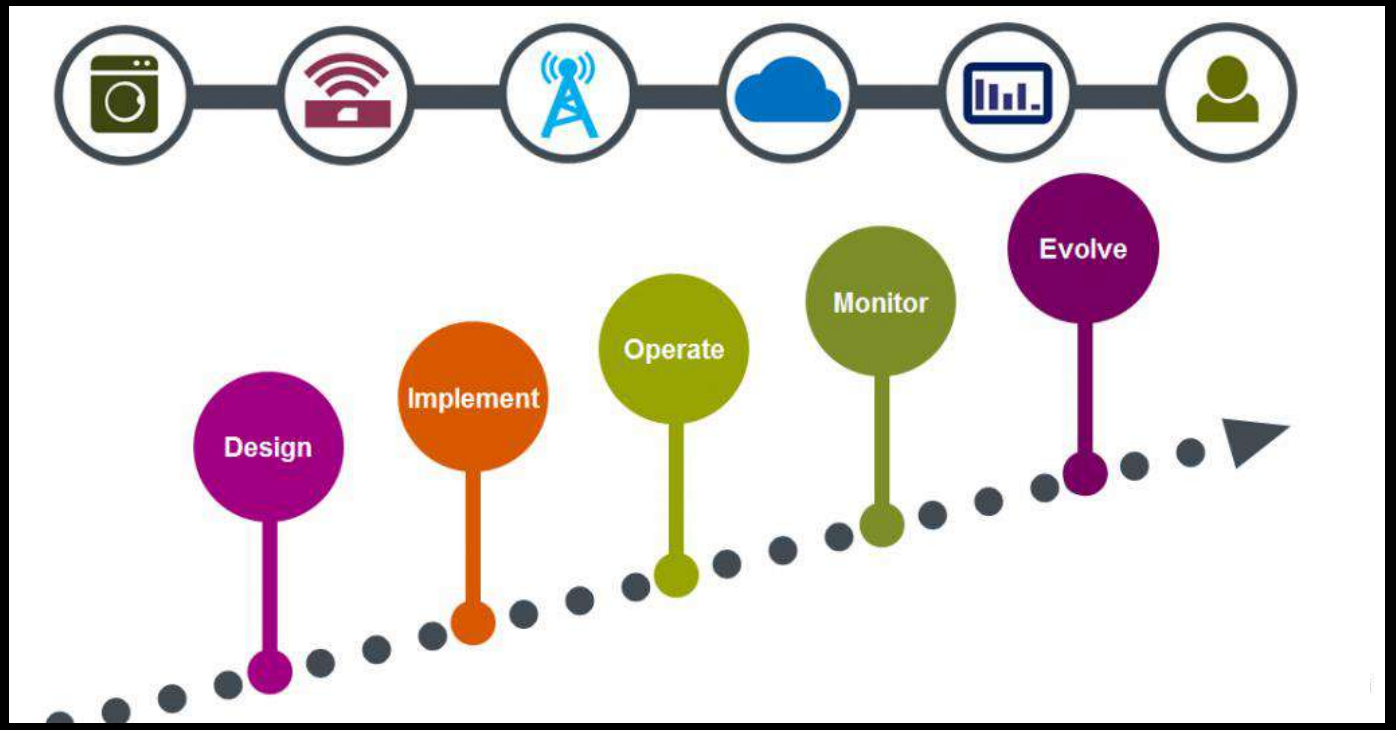
Wireless


Inside the radio wave spectrum
Almost every wireless technology – from cell phones to garage door openers – uses radio waves to communicate. Some services, such as TV and radio broadcasts, have exclusive use of their frequency within a geographic area. But many devices share frequencies, which can cause interference. Examples of radio waves used by everyday devices:
Most of the white areas on this chart are reserved for military, federal government and industry use
Auctioned spectrum
2.4 GHz band
Used by more than 300 consumer devices, including microwave ovens, cordless phones and wireless networks (Wi-Fi and Bluetooth)
Broadcast TV Channels 2-13
Garage door openers
Cell phones
Wireless medical telemetry
Cell phones
Wi-Fi networks
Satellite TV
Security alarms
3 kHz
500 MHz
1 GHz
1.5 GHz
2 GHz
3 GHz
4 GHz
5 GHz
50 GHz
300 GHz
AM radio 535 kHz to 1,700 kHz
Remote-controlled toys
Broadcast TV UHF channels 14-83
GPS (Global positioning systems)
Satellite radio
Weather radar
Cable TV satellite transmissions
Highway toll tags
Police radar
Signals in this zone can only be sent short, unobstructed distances
PERMEABLE ZONE
Frequencies in this range are considered more valuable because they can penetrate dense objects, such as a building made out of concrete
SEMI-PERMEABLE ZONE
Difficult for signals to penetrate dense objects
LINE-OF-SIGHT ZONES
Signals in this zone can travel long distances, but could be blocked by trees and other objects
Lowest frequencies
Microwaves
Infrared
Visible light
Ultraviolet
X-rays
Gamma rays
Highest frequencies
RADIO WAVE SPECTRUM
3 kHz wavelength
300 GHz wavelength

IoT in the Design Process

Planning an IoT Project

Much of the value of IoT lies in the information that you can capture. That information can allow you to improve processes and be more efficient, understand your customer and provide a better experience, enable entirely new business models, and much more.



Planning an IoT Project

- What data do I need?
- Where should that data come from? How?
- After I get the data, what do I need to do to transform it? Do I need to combine it with data from other sources?
- What other devices, processes, and people would need the new transformed data?
- What's the best way to deliver this transformed data?
- What processes, technology, policies, & organizations need to change with this data?

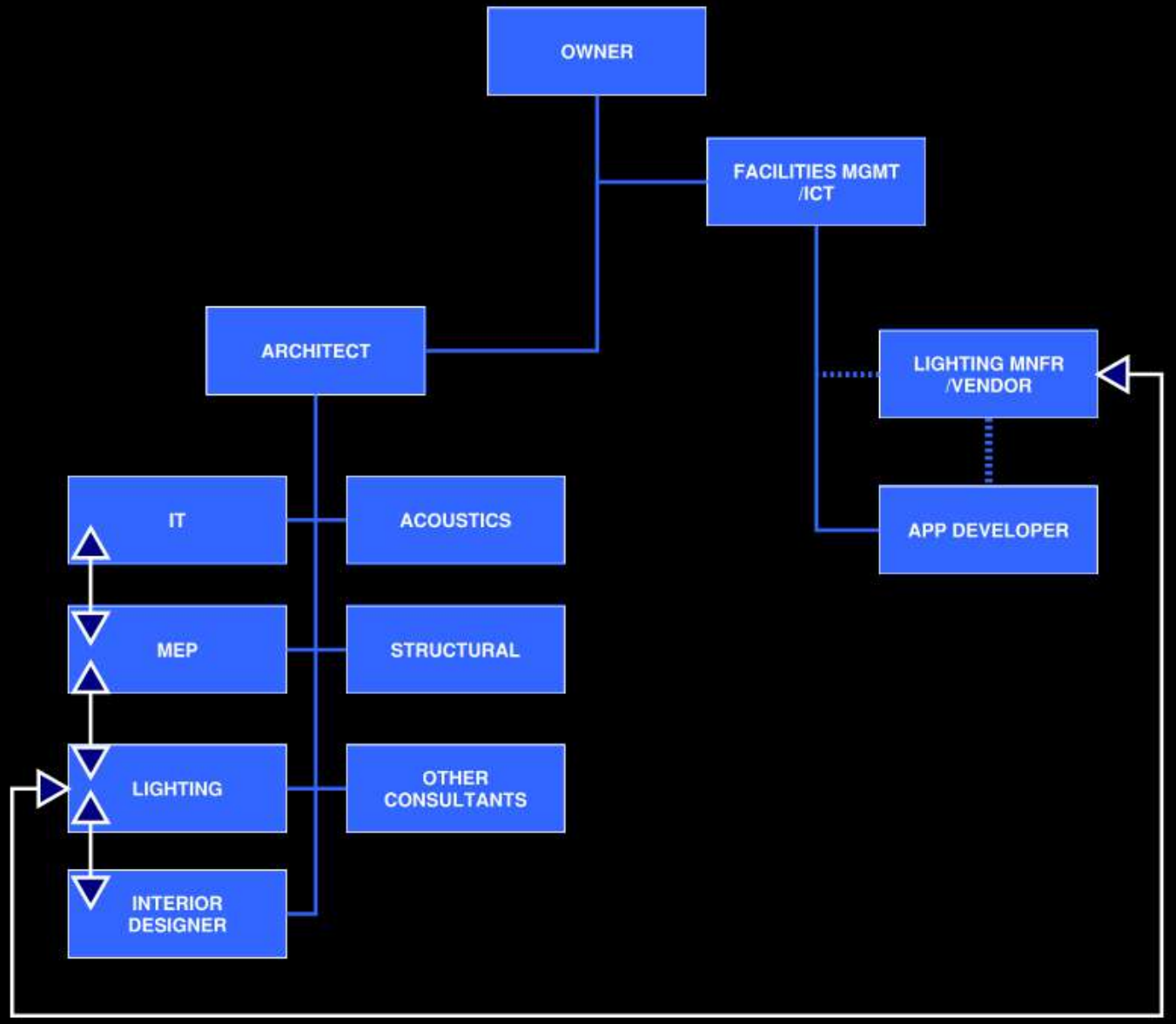
Design Team Roles

Client / User groups

- Owner
- Facilities Management/ICT
- Occupant

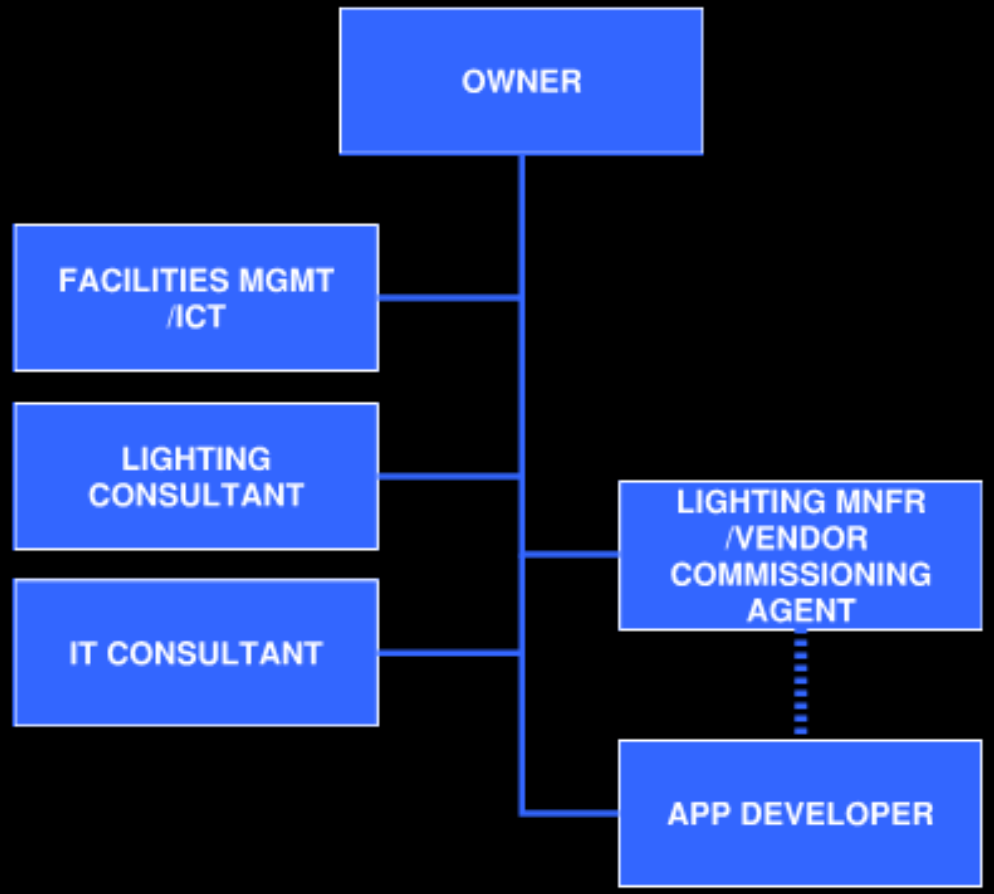
Design Team

- Architecture
- Lighting Consultant
- Acoustics Consultant
- ICT/IT Consultant
- Sustainability Consultant
- MEP Consultant
- App Developer
- Vendor/ Commissioning Agent



Design Team Roles

Design Team Roles
(during CA and Commissioning)



Proposal Phase

- Confirm the overall intended goal of the IoT solution for the project scope
- Confirm that the solution requires or is intended to use the lighting infrastructure
- Understand your role in the commissioning process and the expectations from the client
- When IoT is not identified in the RFP but you feel it could play a role, include clear exclusionary language regarding IoT integrated with the lighting system

Schematic Design

IoT Modified Scope of Service

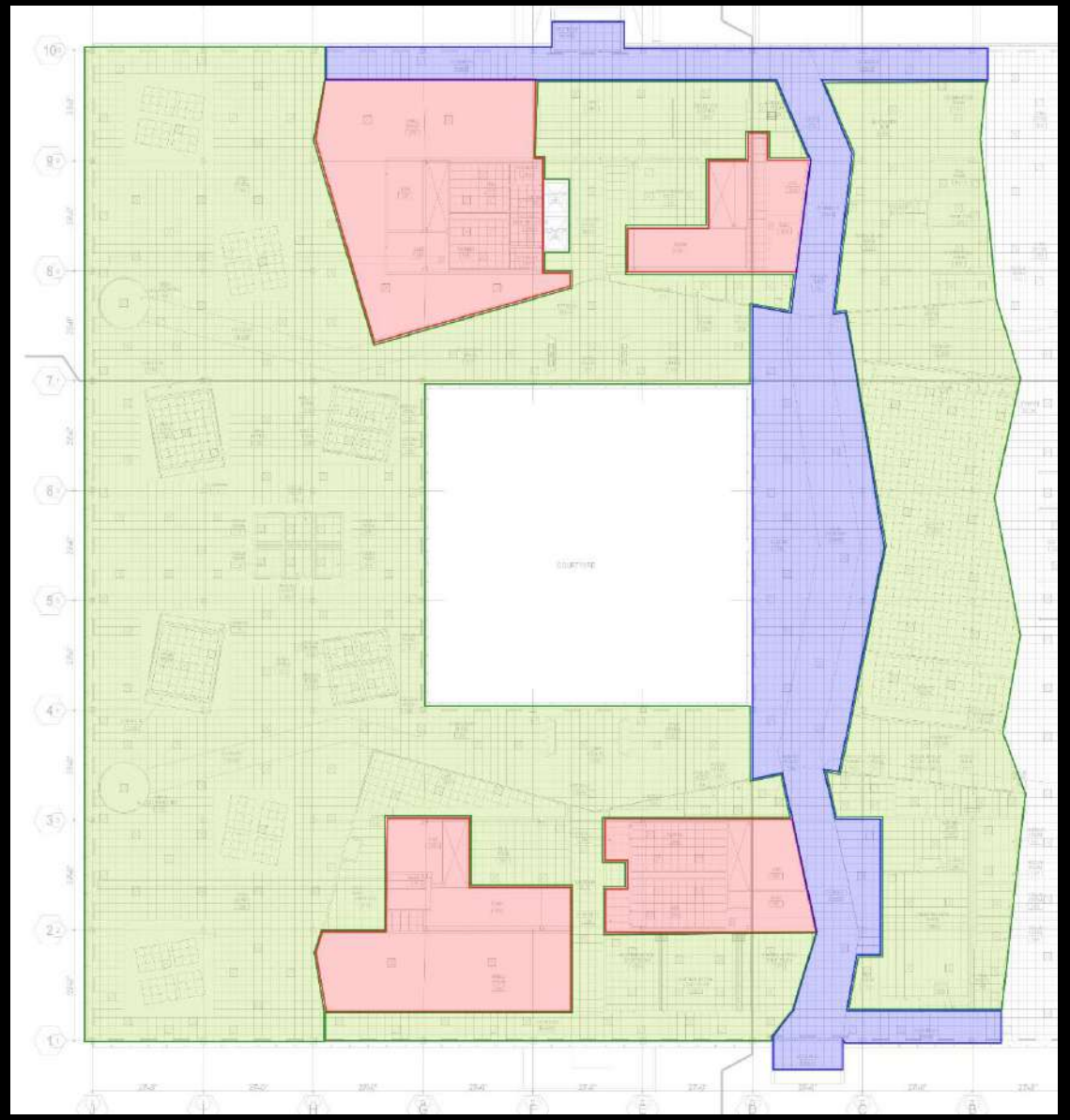
- Conferences with ownership to discuss expectations from sensor network
- Preliminary analysis of sensor types to achieve intended outcomes and compatibility with third party lighting equipment
- A Basis of Design that includes sensor network coverage expectations & overview of general system components

Schematic Design

NO TRACKING REQUIRED

LOW ACCURACY TRACKING REQUIRED

HIGH ACCURACY TRACKING REQUIRED



Design Development

IoT Modified Scope of Service

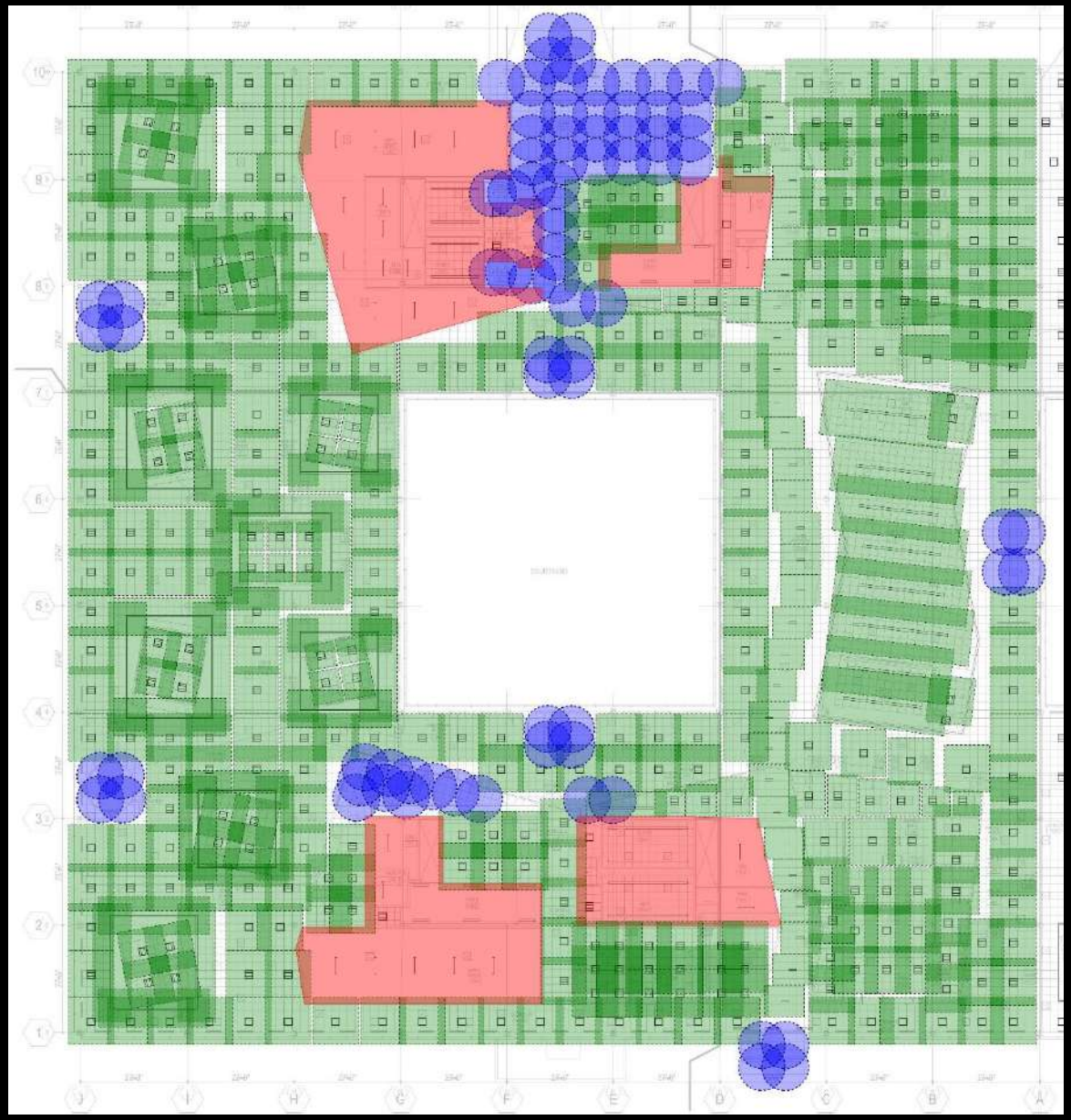
- Conferences to review expected sensor outcomes and impact to architectural design – identify priorities
- Confirm preliminary sensor types with design team and clarify limitations/range of coverage
- Coordinate sensors with proposed lighting equipment; includes coordination with anticipated vendor(s)
- Layout of lighting and sensors
- Preliminary specification of lighting system & controls with sensor integration
- Preliminary sequence of operations

Design Development

NO TRACKING INFRASTRUCTURE

LOW ACCURACY BLUETOOTH TRACKING

HIGH ACCURACY VLC+BT TRACKING

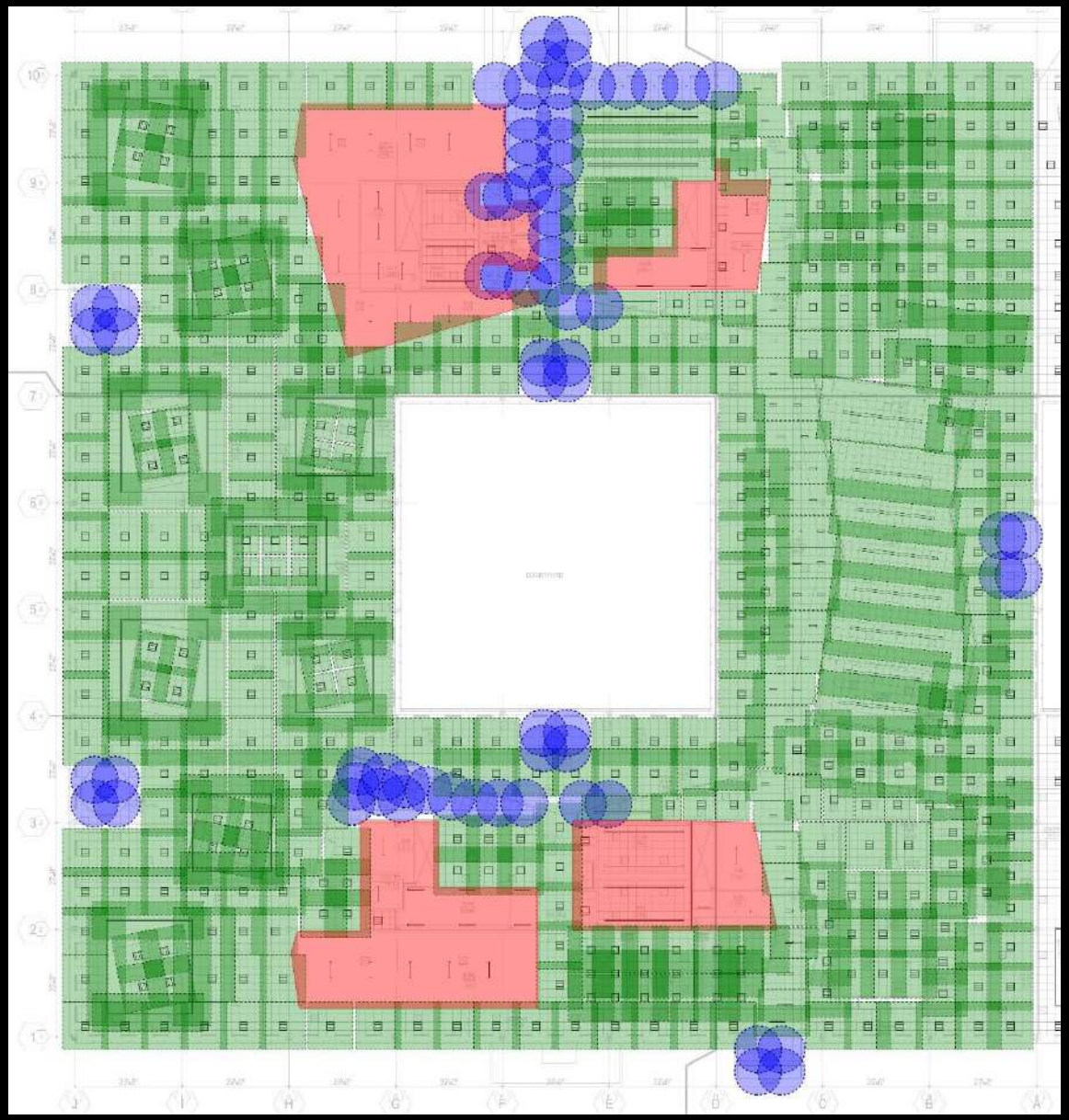


Design Development

NO TRACKING INFRASTRUCTURE

LOW ACCURACY BLUETOOTH TRACKING

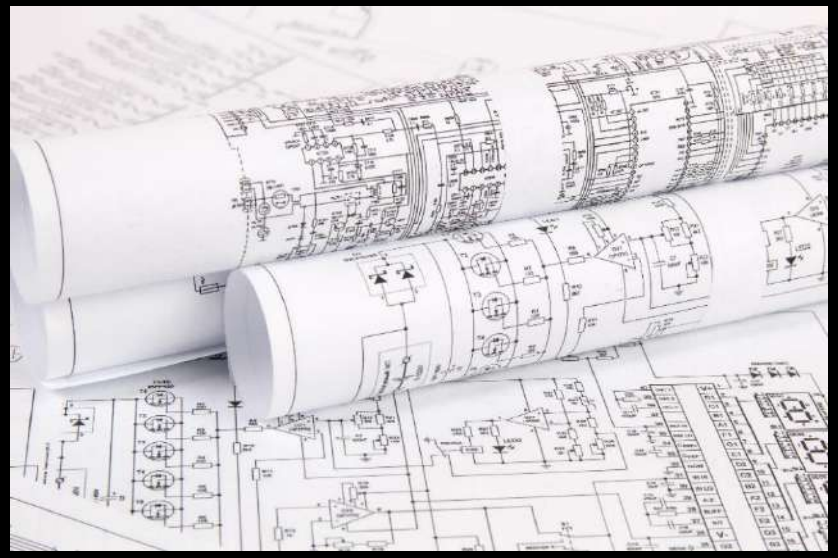
HIGH ACCURACY VLC+BT TRACKING



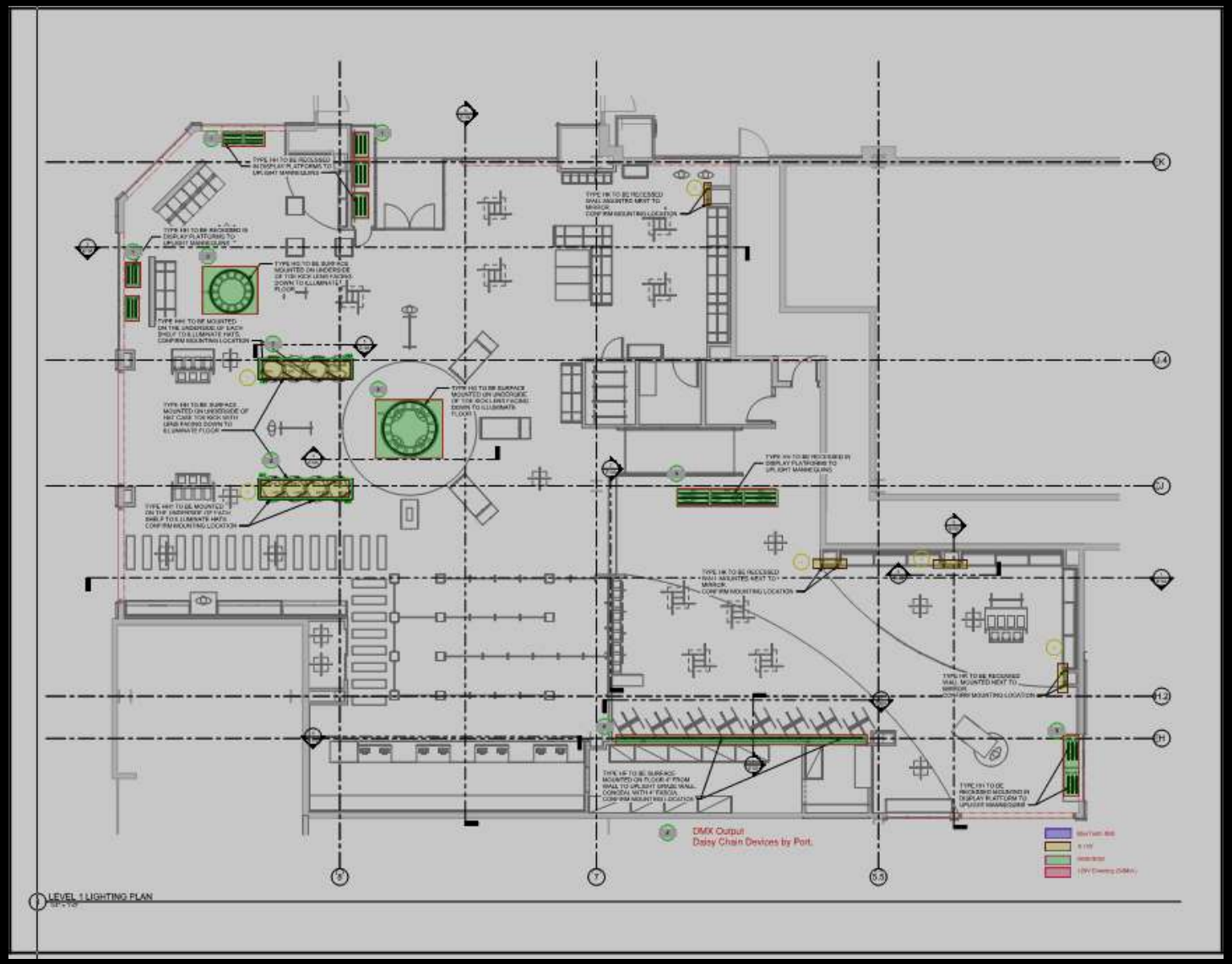
Construction Documents

IoT Modified Scope of Service

- Prepare final control network specifications
- Supplemental conferences & coordination with IT & MEP consultants
- QA review of final lighting documentation for conformance with sensor requirements (coverage/spacing, height, power, locations, etc)
- Incorporate commissioning requirements & responsible contractors in bid documentation



IoT Eco-system – Example Documentation



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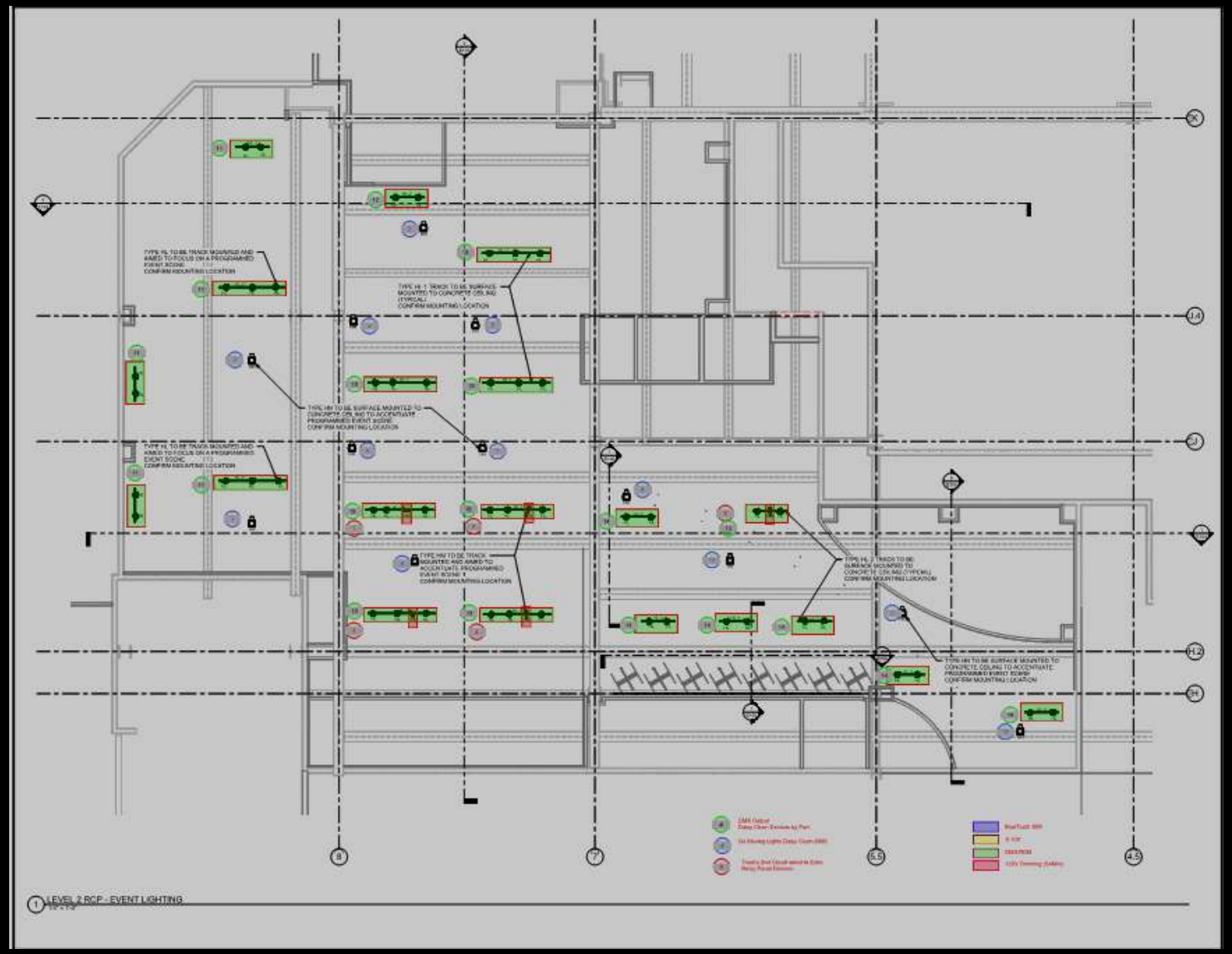

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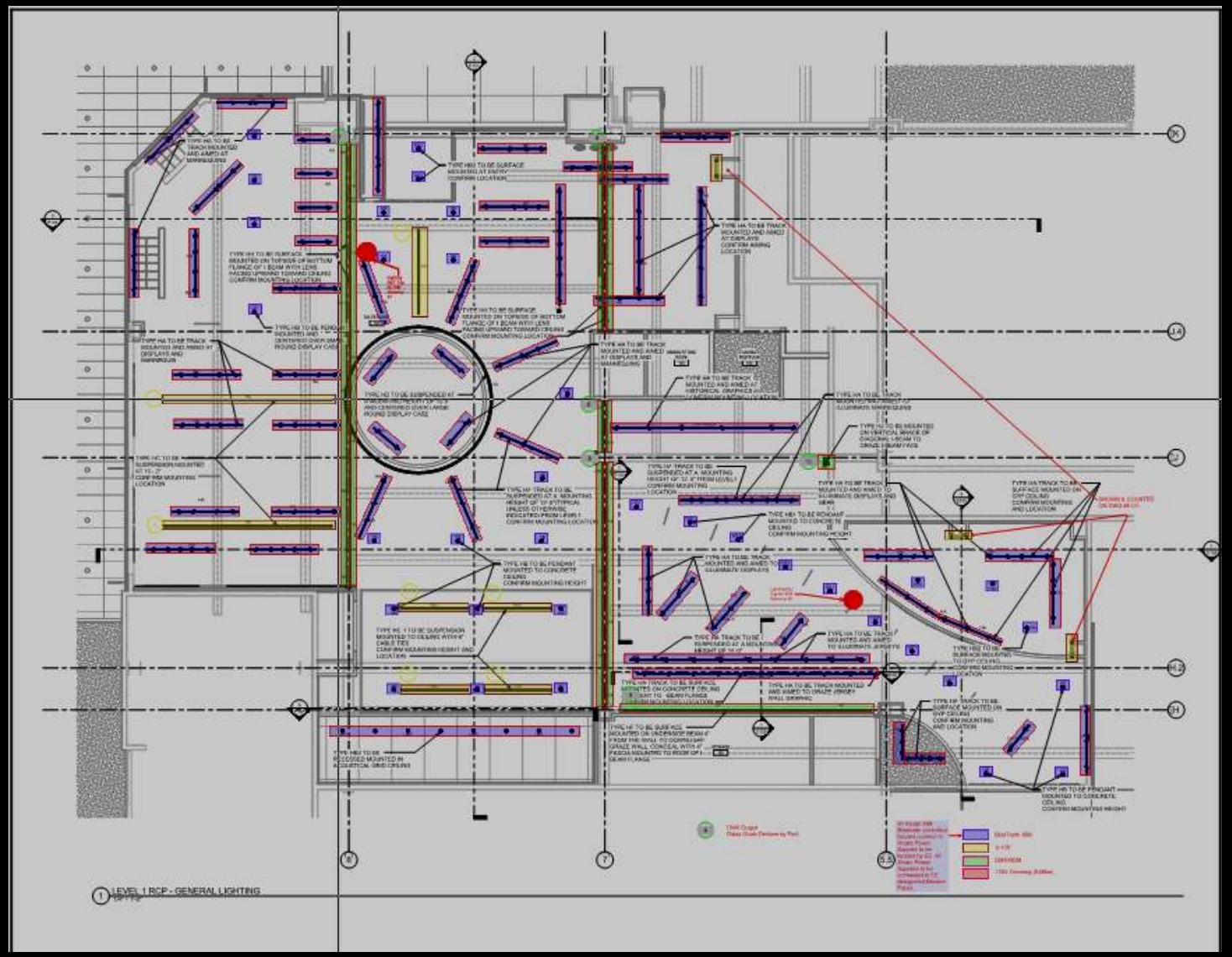

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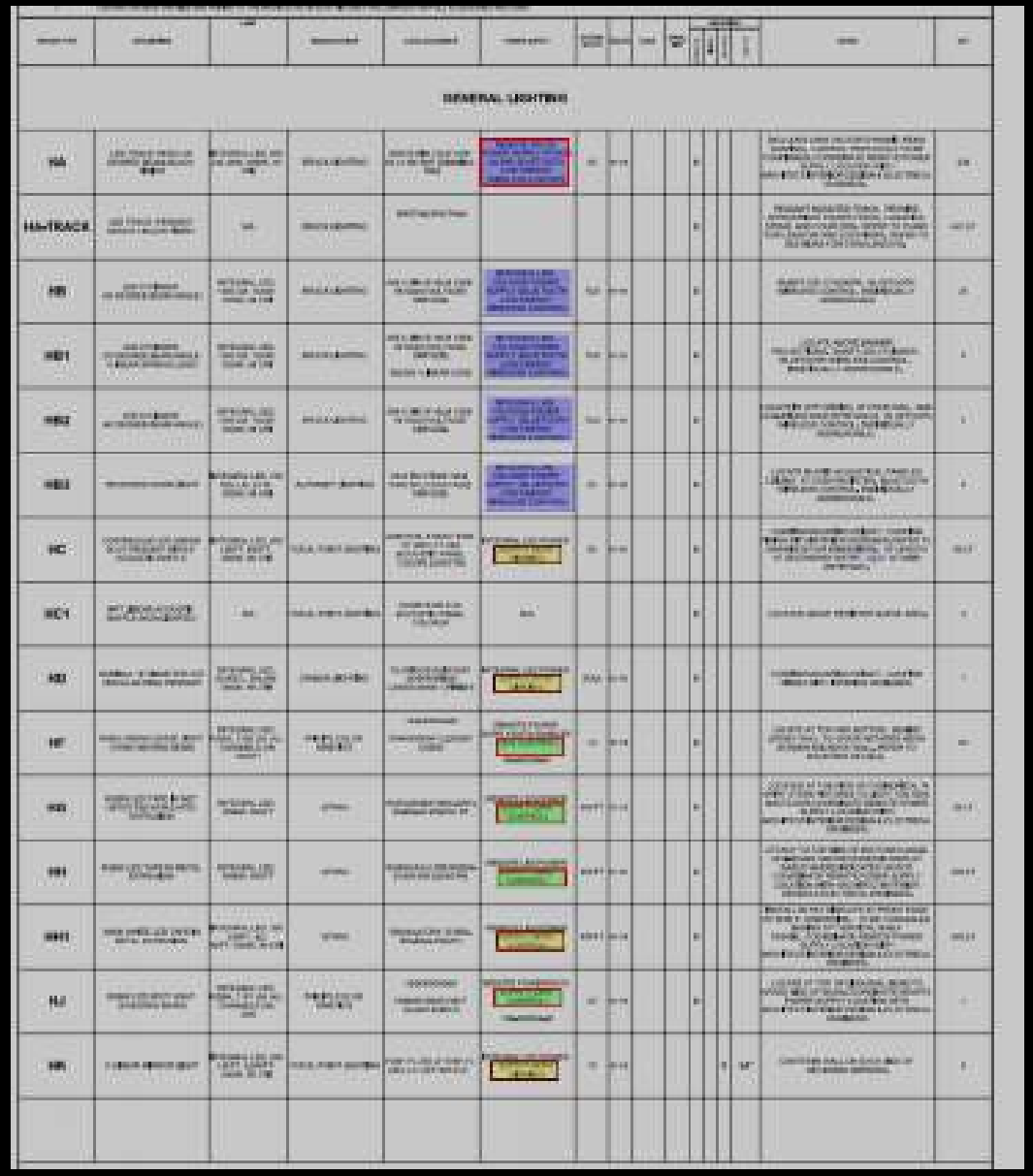

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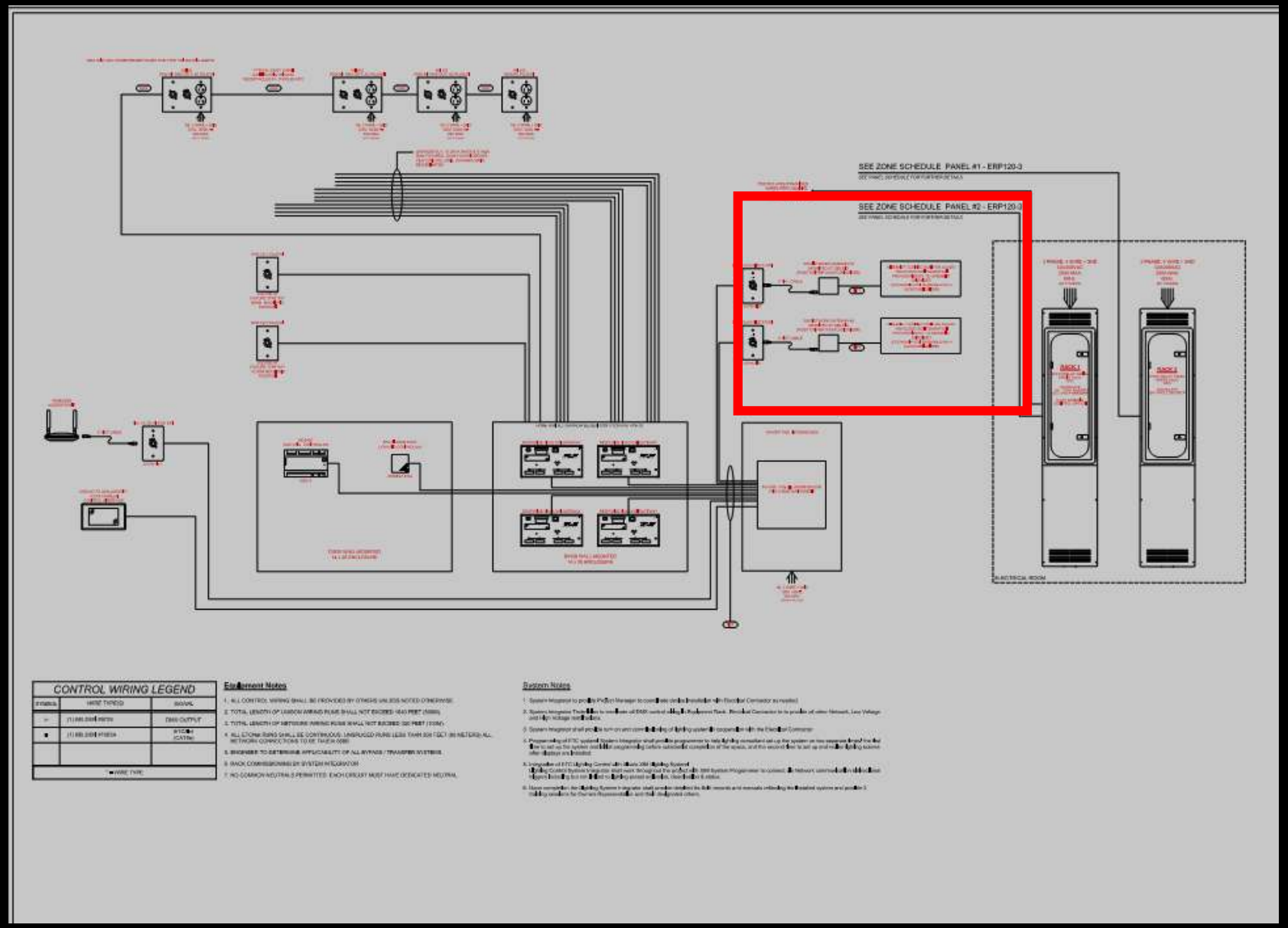

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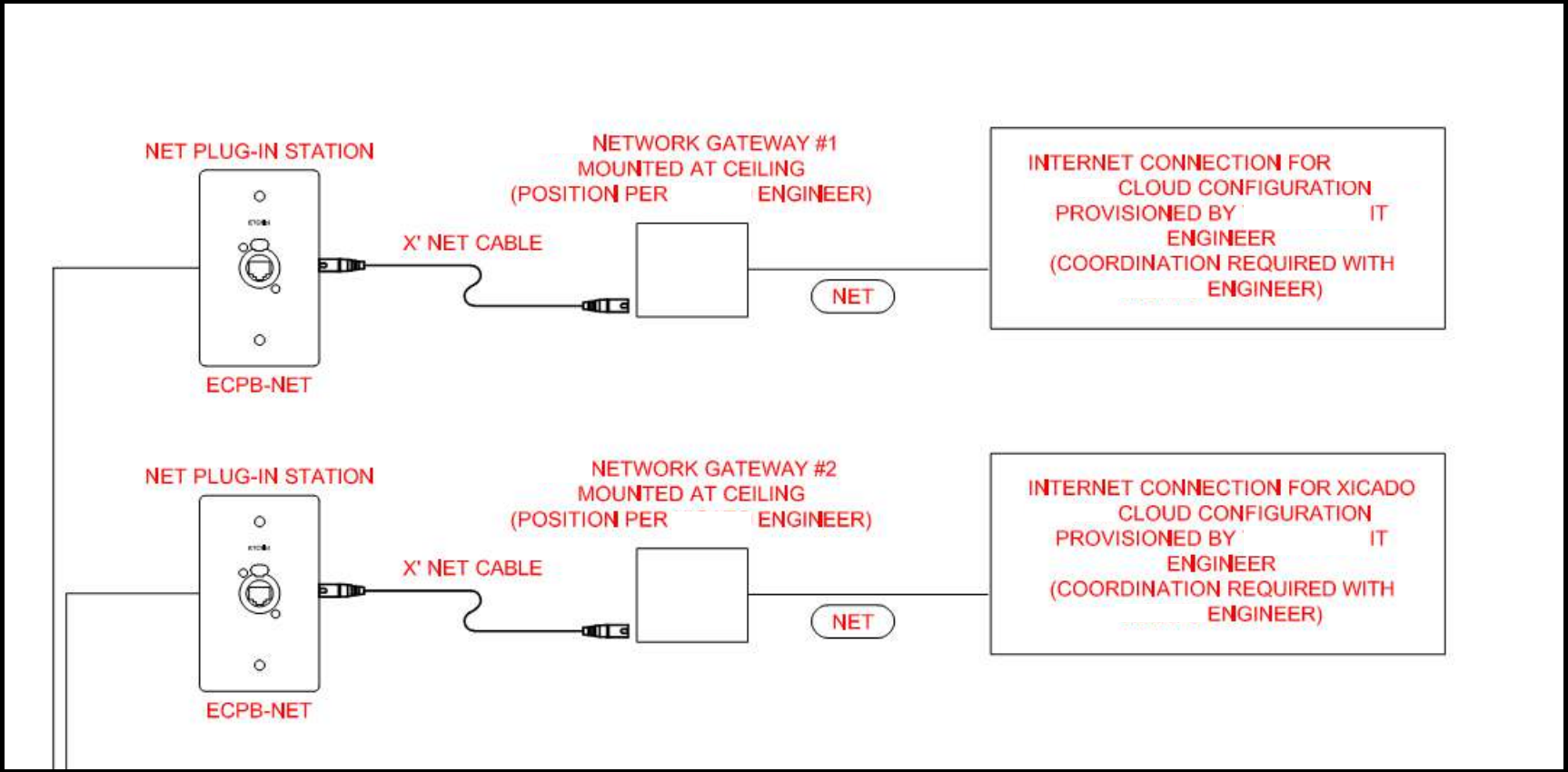


Construction Administration

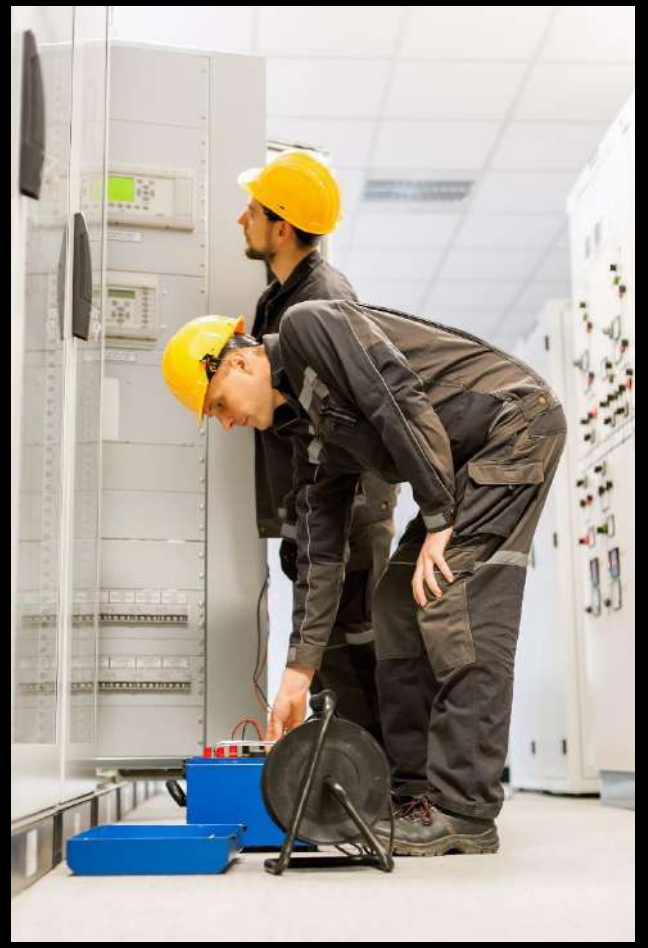
IoT Modified Scope of Service

- Submittal coordination between consultants; confirming luminaire submittals and sensor selections are aligned with other approved infrastructure submittals
- Coordination review of submittals with facilities management/ICT coordinator and contractor

Commissioning

IoT Modified Scope of Service

- Integrated commissioning process involving vendors, ownership IT/facilities representative, IT consultant, app developer and lighting consultant



Considerations

Considerations

Security Considerations

- 8.4 billion devices currently in use
- 24 billion anticipated in the next 2 years
- No existing government regulation of the IoT

Attacks have already occurred utilizing millions of IoT connected devices (DVR's, baby monitors, printers).

FUN FACT

"By 2020, more than 25% of identified attacks in enterprises will involve the IoT, although the IoT will account for less than 10% of IT security budgets."

Source: Leading the IoT – Gartner Insights on How to Lead in a Connected World

IFMA Boston Chapter: The Internet of Things & the Workplace

Security Considerations

Making Moves

Initiatives, committees or standards regarding cybersecurity and connected products include:

American National Standards Institute (ANSI)

- Publications in partnership with the Internet Security Alliance (ISA)
- Standards resources
- Conformity assessment activities

National Electrical Manufacturers Association (NEMA)

Cybersecurity Council

- Identifies standards, best practices and liability limitations related to cybersecurity for the electrical grid
- Identifies guidelines that electrical equipment and medical imaging manufacturers can implement during product development to minimize the possibility that bugs, malware, viruses or other exploits can be used to negatively impact product operation
- Supports cybersecurity information sharing legislation in Congress

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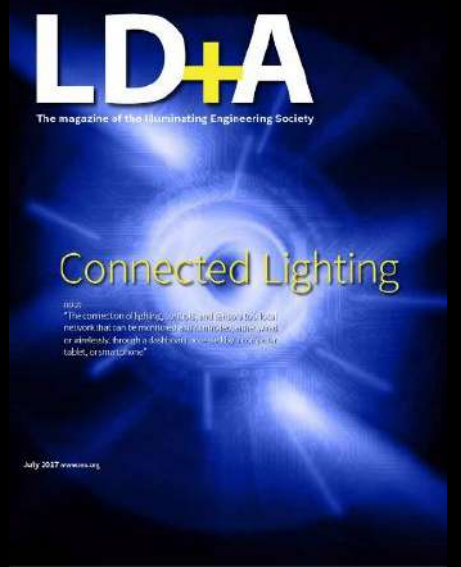

Security Considerations

Underwriters Laboratories (UL) Cybersecurity Assurance Program

- **UL 2900:** Series of standards to offer testable cybersecurity criteria for network-connectable products and systems

National Institute of Standards and Technology (NIST)

- **SP 800, Computer Security (December 1990-present):** NIST's primary mode of publishing computer/cyber/information security guidelines, recommendations and reference materials
- **SP 1800, NIST Cybersecurity Practice Guides (2015-present):** A new subseries targets specific cybersecurity challenges in the public and private sectors; practical, user-friendly guides to facilitate adoption of standards-based approaches to cybersecurity

Department of Energy (DOE)

- **Connected Lighting Systems Initiative:** Targets energy reporting, interoperability, system configuration complexity, cybersecurity, key new features and stakeholder collaboration
- **Collaboration** with UL to develop standardized test methods

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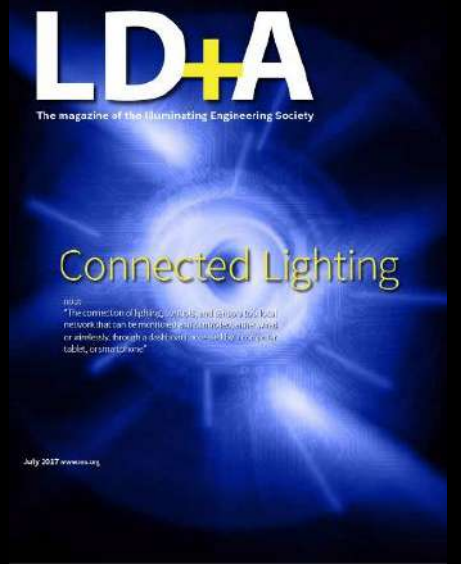
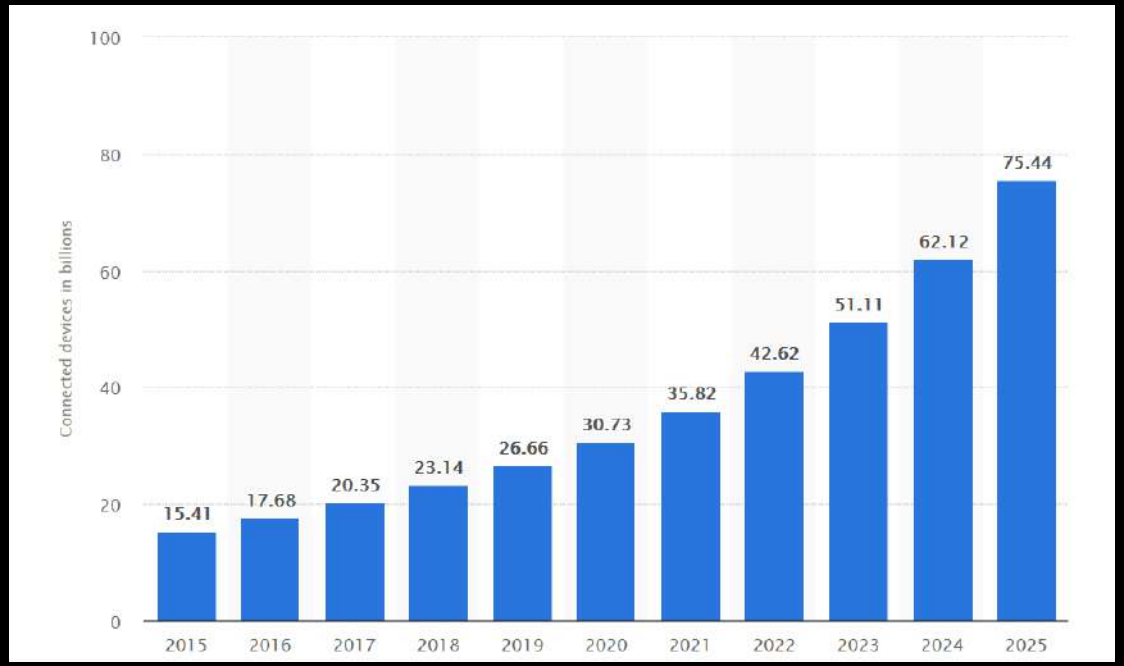


Connectivity Considerations

- Current systems are centralized
- This model is sufficient for current IoT ecosystems
- When networks grow to join billions and hundreds of billions of devices, centralized systems will turn into a bottleneck.
- Systems will require huge investments and spending in maintaining new systems

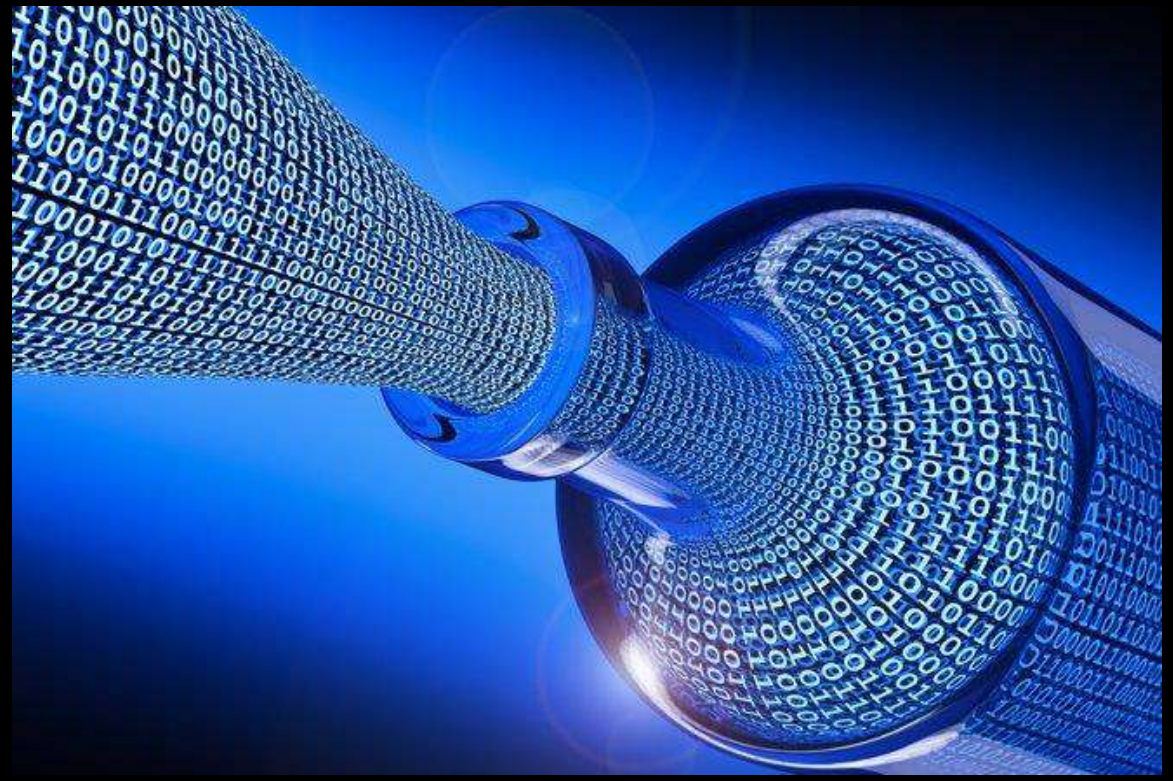
Installed base of connected devices from 2015 to 2025 expected to be 75 billion



Three Major Challenges Facing IoT: IEEE, March 14, 2017

Connectivity Considerations

- The future of IoT will very much have to depend on decentralizing IoT networks.
- This model will have its own set of challenges, especially from a security perspective



Three Major Challenges Facing IoT: IEEE, March 14, 2017

Compatibility Considerations

- IoT is growing – more competition
- Non-unified services & lack of standardized protocols
- Obsolete technologies

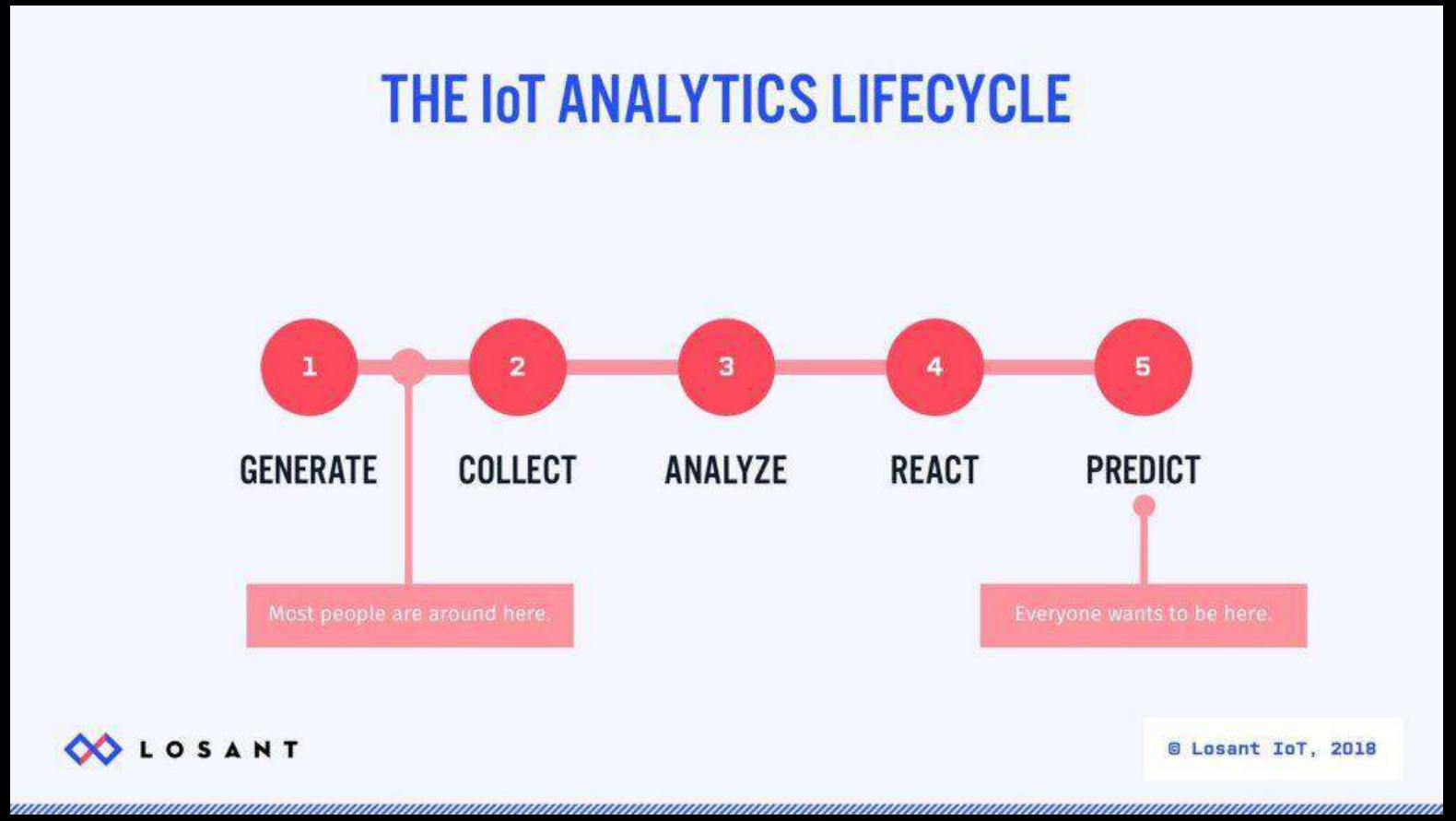
Three Major Challenges Facing IoT: IEEE, March 14, 2017

Standards Considerations

- Regulatory standards for data markets are missing
- Lack of transparency about data usage
- Need for clear guidelines on the retention, use, and security of the data

Three Major Challenges Facing IoT: IEEE, March 14, 2017

Intelligent Analysis Considerations



"The last stage in IoT implementation is extracting insights from data for analysis, where analysis is driven by *cognitive technologies* and the accompanying models that facilitate the use"

Three Major Challenges Facing IoT: IEEE, March 14, 2017

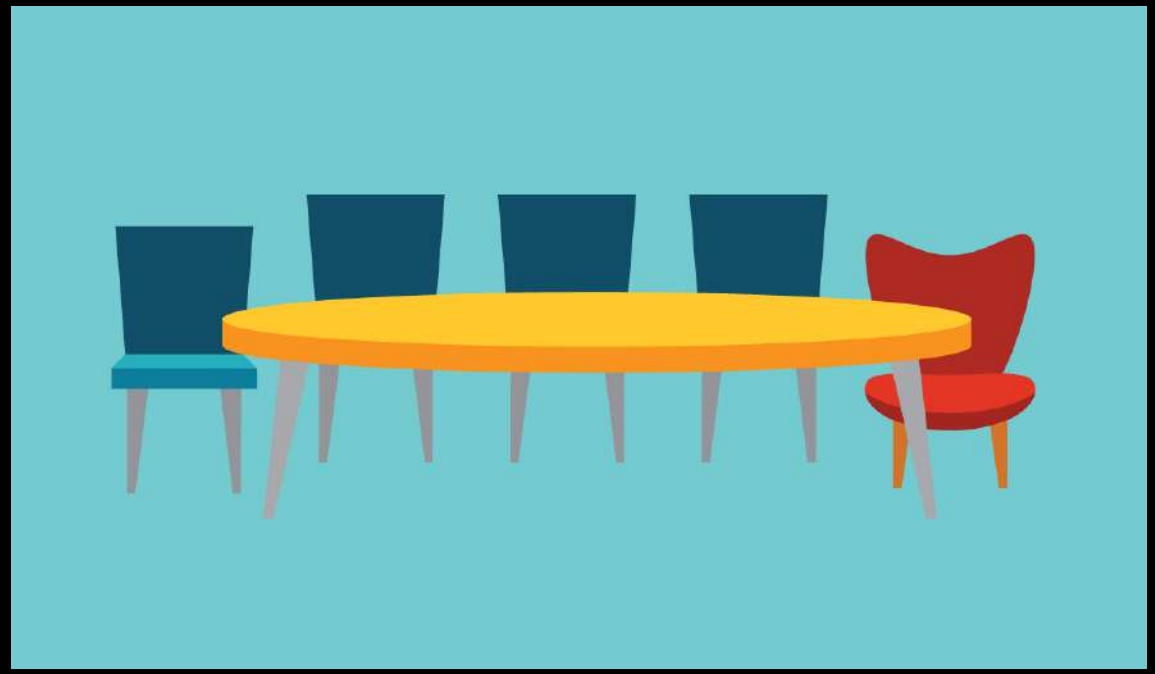
Emergency Considerations

Specific PoE Challenges

- Emergency PoE battery operated fixtures need to be developed or UPS system must be provided in IT rooms.
- Emergency PoE LV wiring must be run separately from normal PoE LV wiring

Lighting Considerations

The Challenge for the Lighting Industry today is making sure we have a seat at the table in and that lighting quality doesn't falter due to the opportunity and availability of connectivity.




QUESTIONS
ANSWERS

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