U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Control System Interoperability: Can We Talk?

DOE SSL Market Development Workshop

November 13, 2014

Michael Poplawski

Pacific Northwest National Laboratory

Welcome to Michigan

Michigan State University

College | Grad School | Online Programs | Global | All Rankings | Jobs and

- Overview
- Photos
- Map
- Ranking Indicators
- Applying
- Academic Life
- Student Life
- Campus Safety
- Campus Services
- Cost and Financial Aid

U.S. News College Compass

- Expanded Profiles for 1,800 Schools
- SAT Scores and GPAs
- Save Schools, Compare and Take Notes

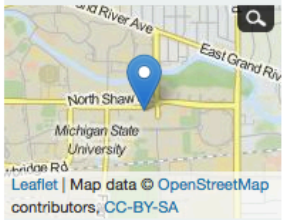
Learn More

#85 Tie National Universities

Summary

Michigan State University is a public institution that was founded in 1855. It has a total undergraduate enrollment of 37,988, its setting is suburban, and the campus size is 5,192 acres. It utilizes a semester-based academic calendar. Michigan State University's ranking in the 2015 edition of Best Colleges is National Universities, 85. Its in-state tuition and fees are $13,200 (2014-15); out-of-state tuition and fees are $34,980 (2014-15).

2015 Quick Stats



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East Lansing, MI 48824
Phone: (517) 355-1855

2014-2015 Tuition & Fees
$13,200 in-state
$34,980 out-of-state

Students
37,988 enrolled
50% male / 50% female

University of Michigan--Ann Arbor

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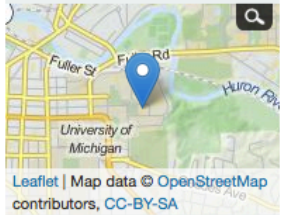
#29 National Universities

Summary

University of Michigan--Ann Arbor is a public institution that was founded in 1817. It has a total undergraduate enrollment of 28,283, its setting is urban, and the campus size is 3,245 acres. It utilizes a trimester-based academic calendar. University of Michigan--Ann Arbor's ranking in the 2015 edition of Best Colleges is National Universities, 29. Its in-state tuition and fees are $13,977 (2014-15); out-of-state tuition and fees are $41,811 (2014-15).

2015 Quick Stats



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500 S. State St.
Ann Arbor, MI 48109
Phone: (734) 764-1817

2014-2015 Tuition & Fees
$13,977 in-state
$41,811 out-of-state

Students
28,283 enrolled
51% male / 49% female

http://colleges.usnews.rankingsandreviews.com/best-colleges/michigan-state-2290
http://colleges.usnews.rankingsandreviews.com/best-colleges/university-of-michigan-9092

Objectives

- Discuss some Terminology
- Review some examples of how Interoperability is achieved
- Understand the Standards development process
- Learn about the recent efforts of a some Industry Consortiums developing interoperability specifications
- Enable better Conversations

Key points

- There are many possible types, or levels of interoperability.
- Rarely does one “protocol” define and deliver full “application-level” interoperability.
- Interoperability can, and should be (carefully) specified.

- Not all specifications are similar, even if their purposes appear to be similar.
- Specifications are developed for different purposes, by different types of bodies, and using different processes.
- No specification is perfect.

System terminology

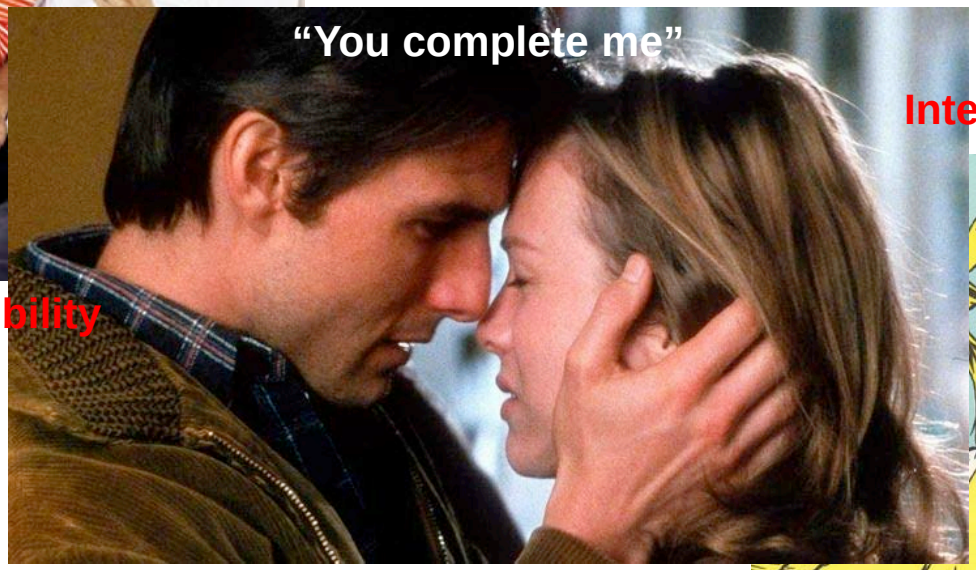
- Compatibility: Two devices (or a device and a system) are compatible if they can coexist in a system (or in the same physical environment) – that is, operate without corrupting, interfering with, or hindering the operation of the other entity.

- Interoperability: Two devices (or a device and a system) are interoperable if they can both work together to operate as intended, typically facilitated by an ability to share a common defined set of information.

- Interchangeability: Two devices are interchangeable if they can be physically exchanged for each other, and provide a defined level of identical operation in a system without additional configuration.

Compatibility, Interoperability, Interchangeability

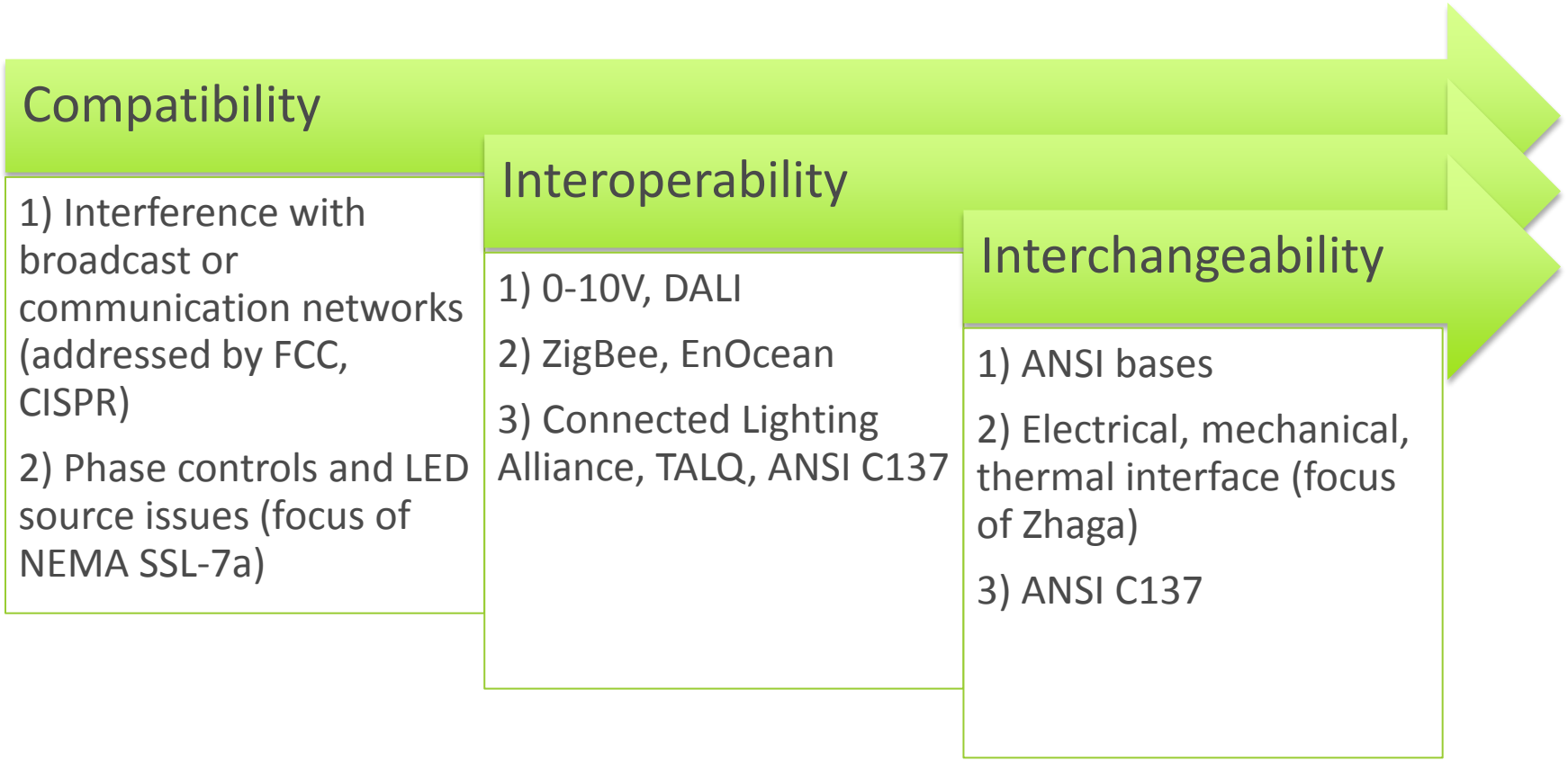
Compatibility



Interoperability

Interchangeability

Lighting system evolution



Focus on interoperability

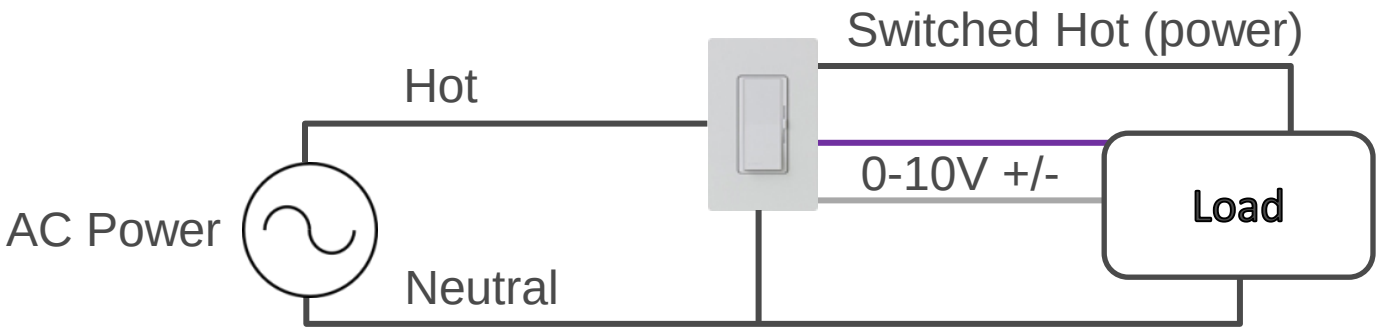
- Facilitates ability to integrate best-of-breed components (e.g. controllers, sensors, software) into a system
- Facilitates ability to modify and improve an existing system as you learn what you (really) need/want
- Helps manage risk of component, manufacturer obsolescence
- Facilitates the sharing of data
  - Devices share data they generate
  - Devices can use data generated elsewhere
  - For adaptive lighting
  - For non-energy benefits
- Sharing of application data requires a common application definition (sometimes referred to as functional profile) … or an up-to-date "translator"

Some interoperability specifications & standards

- 0-10V
- DALI
- ZigBee
- Zhaga
- EnOcean
- Insteon
- Ledotron

0-10V overview

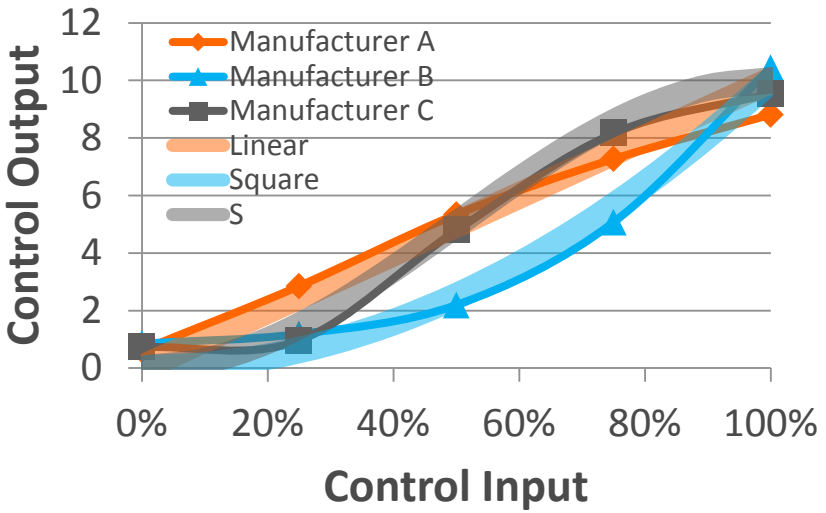
- Separate AC power and control
- Analog, one-way communication
- Actually two “standards”
  - ANSI E1.3, originally developed by the Entertainment Services and Technology Association (ESTA) in 1997 for theatrical equipment
  - IEC 60929, originally released in 1992 for linear fluorescent systems
- Requires two low-voltage differential wires per control channel, which carry a low-speed signal, directly connected between each control and load
- Impossible to assign individual control devices (dimmers, sensors) to one or many light sources without added wiring

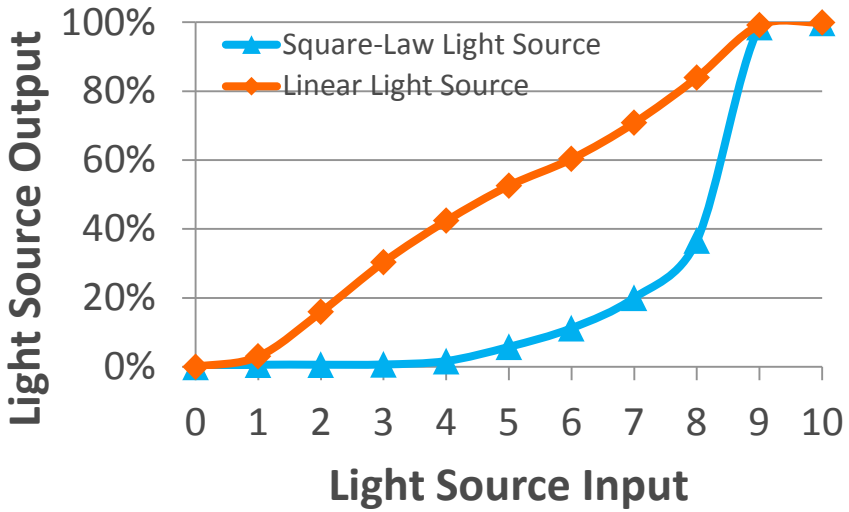


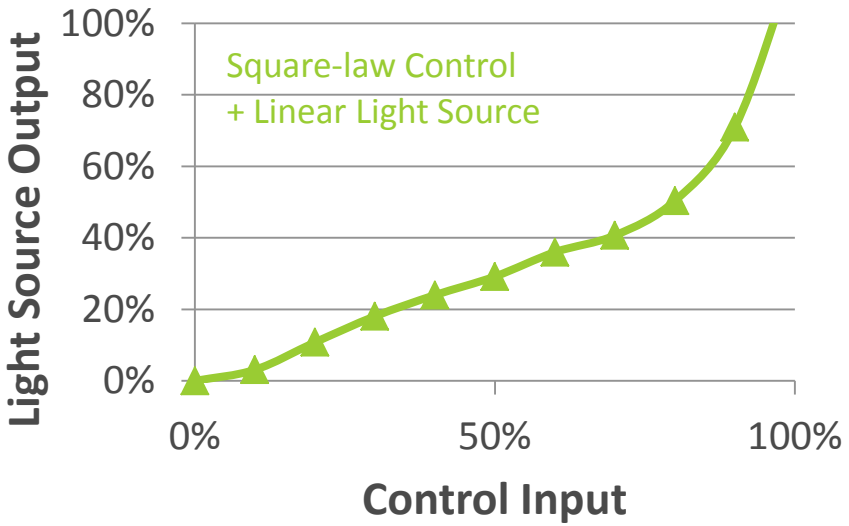
0-10V features and challenges

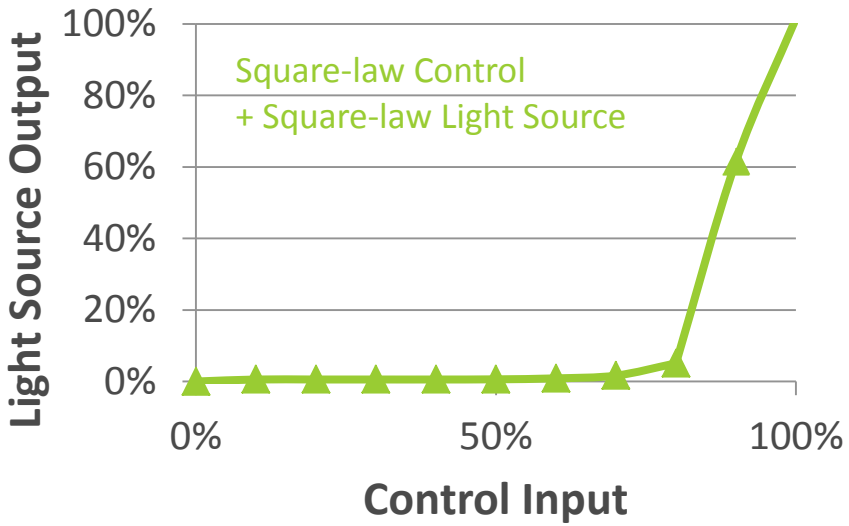
- Features
  - Cost-effective control
  - Control zones can be run separate from power zones
  - Few interoperability problems when all components comply with same “standard”
- Challenges
  - Typically (not always) requires line-voltage switching
  - Costly wiring requirements
  - Long wire runs can affect performance (e.g. dimming range, accuracy)
  - “Standards” do not specify whether controls signals should be run as UL Class 1 or Class 2
  - Unknowing use of components complying with different “standards” results in interoperability problems
  - Limited definition of application requirements

0-10V dimming control performance



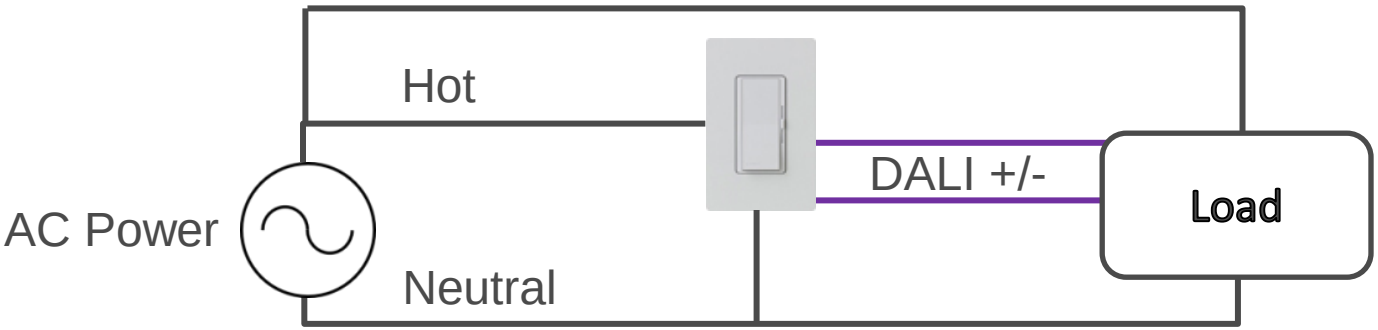






DALI overview

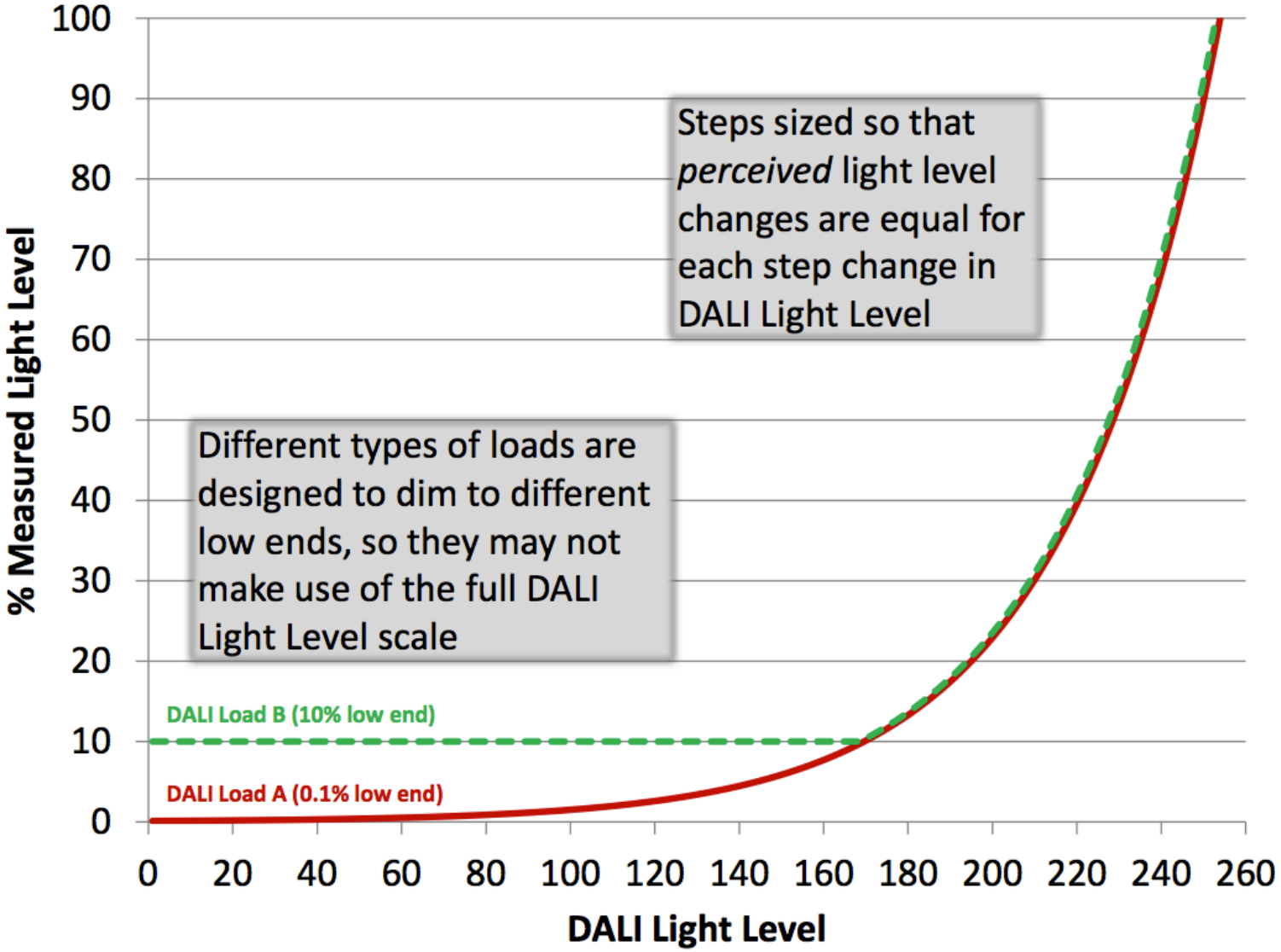
- Digital, two-way communication
- Originally developed in 1990's as part of IEC 60929 for linear fluorescent systems
  - Recently removed, expanded and turned into IEC 62386
- Requires two low-voltage differential wires which carry a low-speed signal, daisy chained across one or more devices
- Easy to assign individual control devices (dimmers, sensors) to one or many light sources without added wiring



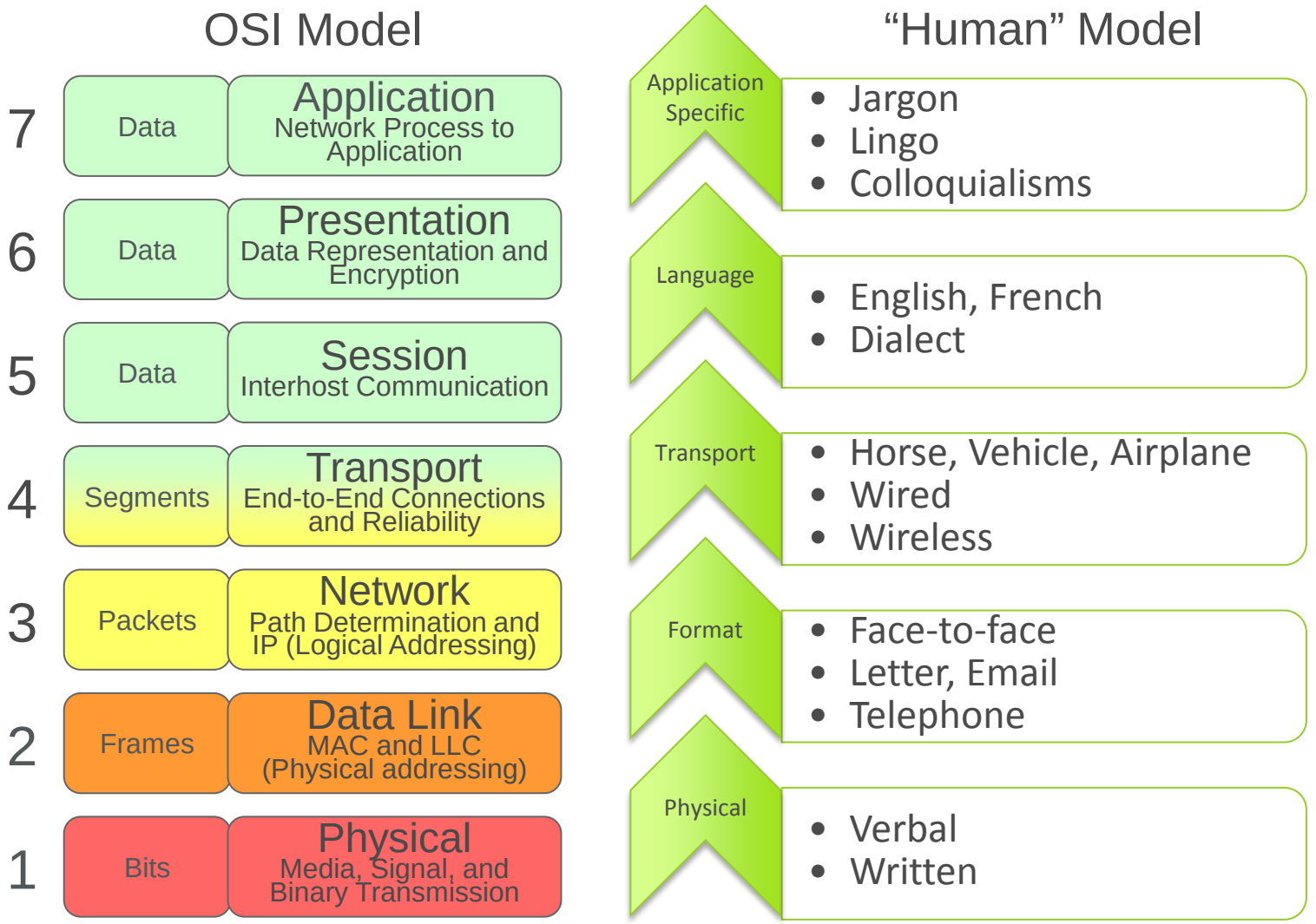
DALI features and challenges

- Features
  - Single interface for Electronic Control Gears and Electronic Control Devices
  - Addressing of up to 64 individual components per DALI link, at data rates of 1200 bits/second
  - Allows control and status reporting of wide variety of ballasts, dimmers, sensors
  - Presumes that control signal is run as UL Class 1 (with AC)
- Challenges
  - Addressing of up to 64 individual components per DALI link, at data rates of only 1200 bits/second
  - Many manufacturers have “proprietary” extensions, resulting in interoperability problems with components from other manufactures
  - Typically time-consuming and complex commissioning
  - Some manufacturers run control signal as UL Class 2

DALI … as specified by IEC-62386 Parts 201,202,…210



There are many possible levels of interoperability



http://en.wikipedia.org/wiki/OSI_model

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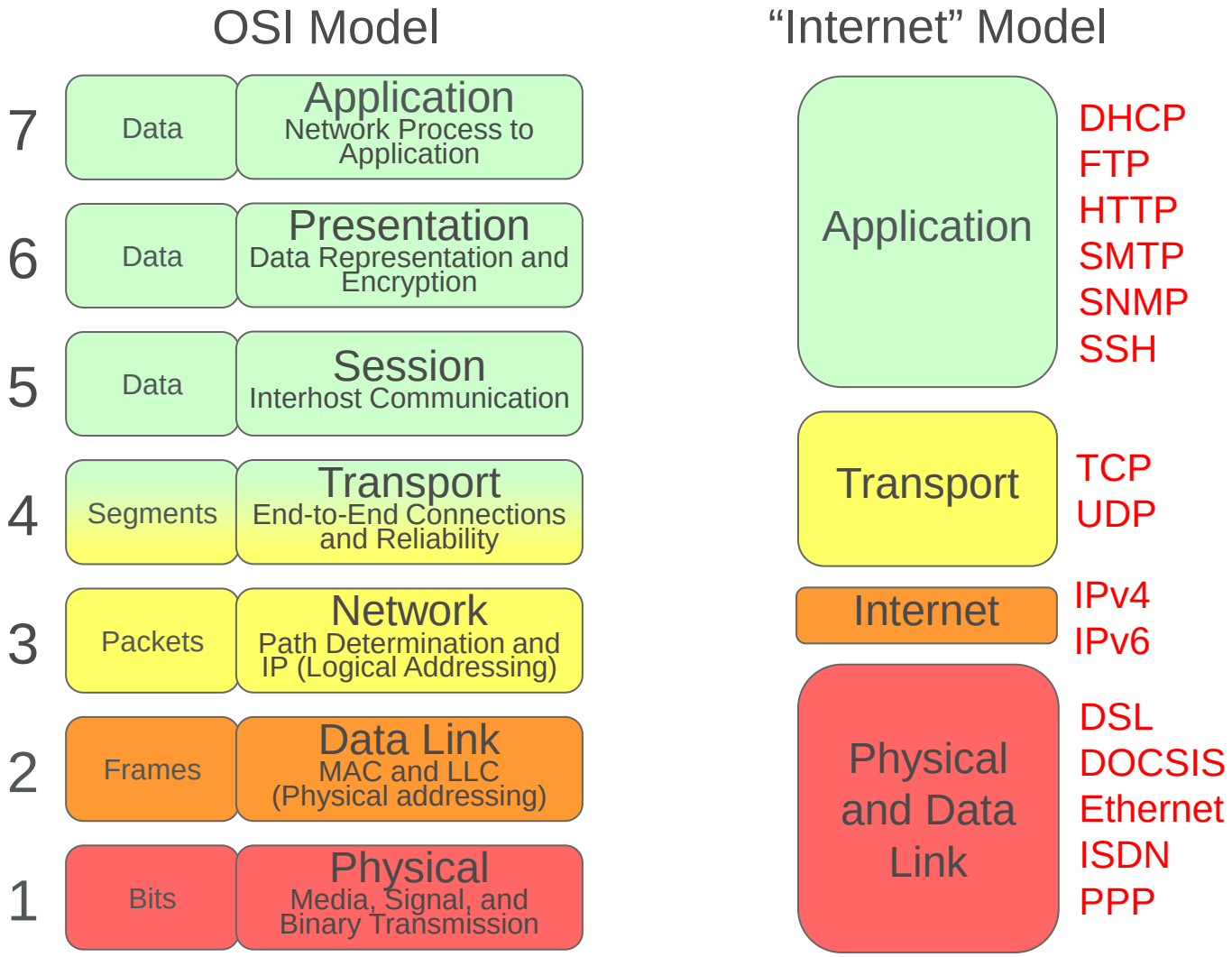
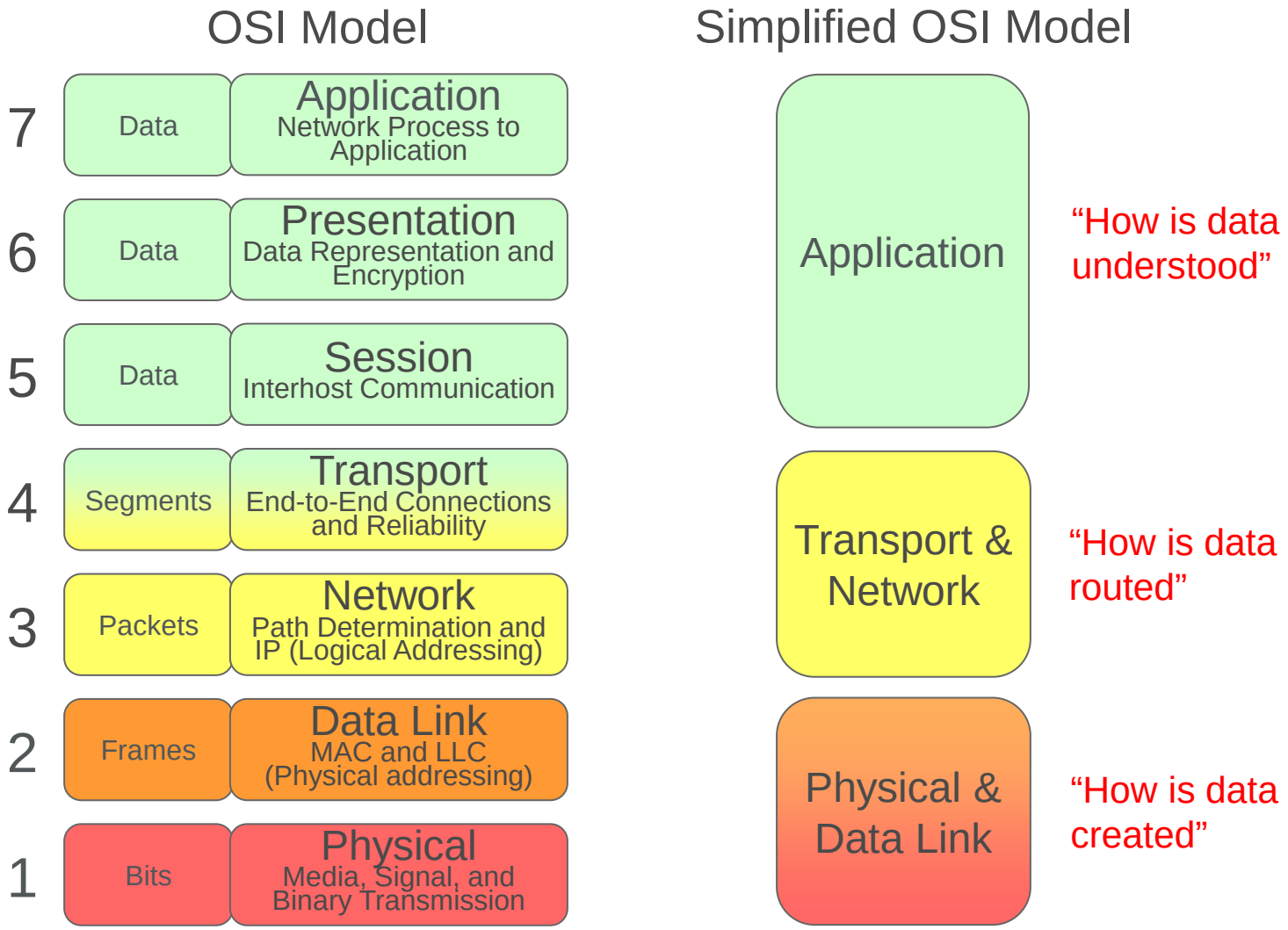


There are many possible levels of interoperability



Some more interoperability specifications & standards

- 0-10V
- DALI
- ZigBee
- Zhaga
- EnOcean
- Insteon
- Ledotron

- Connected Lighting Alliance
- TALQ Consortium
- ANSI C137 “Lighting Systems”

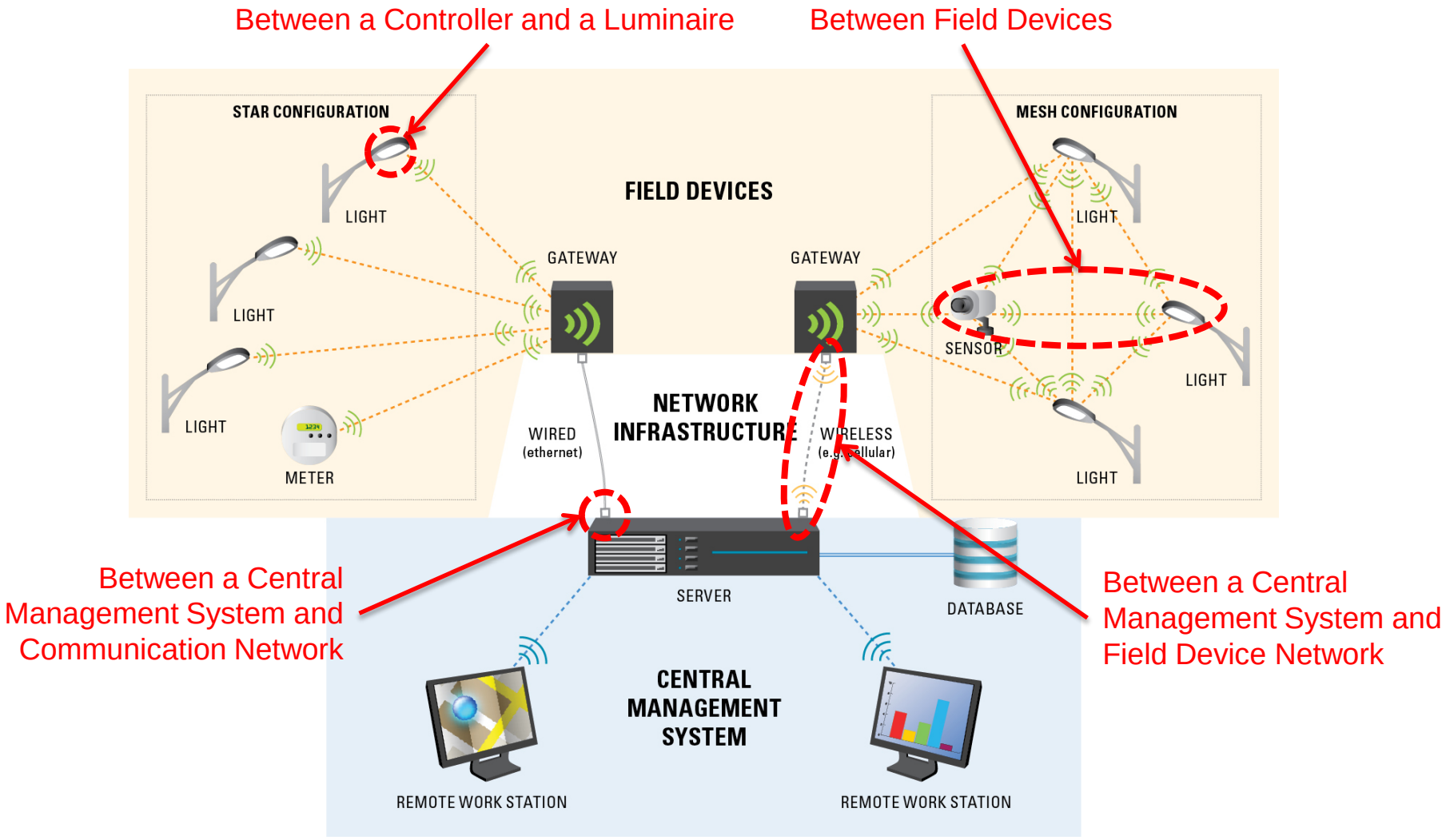
- LonMark
- ZigBee Alliance NAN
- Wi-SUN
- NTCIP
- 3GPP (LTE, LTE-Advanced, LTE-Direct)
- AllSeen Alliance

There are many possible levels of interoperability

Facilitating interoperability…

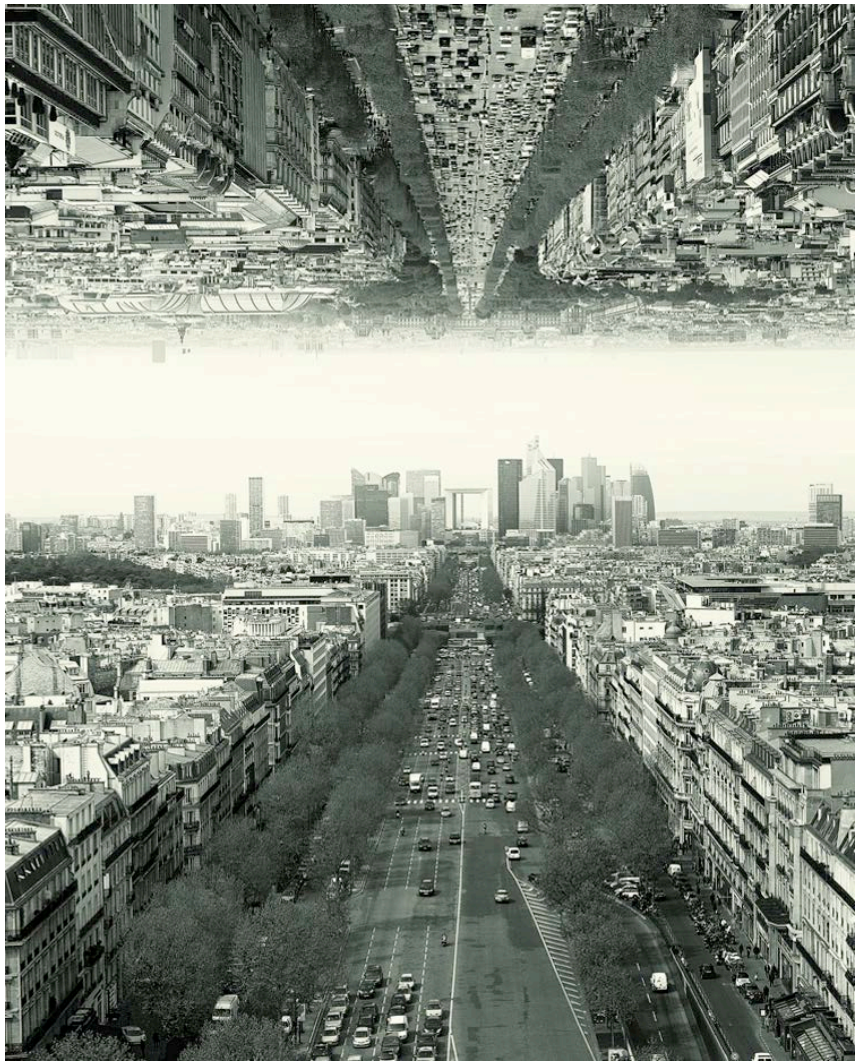
- Gateways, drivers, schemas serve as bridges between devices and systems, providing or translating across one or more interoperability layers (physical/data link, network/transport, application)
- Protocol changes (e.g. bug fixes, feature additions) require updating the translator
- Some changes happen more frequently than others
- Some changes are easier to update than others (e.g. firmware, driver, software)
- Deeper levels of device-to-device interoperability (i.e. fewer translators) can deliver greater system flexibility and performance, but require broader, deeper adoption of specifications/standards

There are many possible levels of interoperability

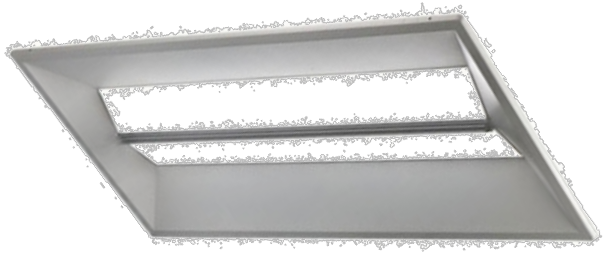


Changes are coming…

- Drive for interconnected systems
- Likely not one lighting, building protocol
- Likely not one master command center
- Building, lighting systems look more like IT systems
- Devices and systems that connect to communication networks, exchange data, and make intelligent decisions



Changes are coming…



Specifications & standards

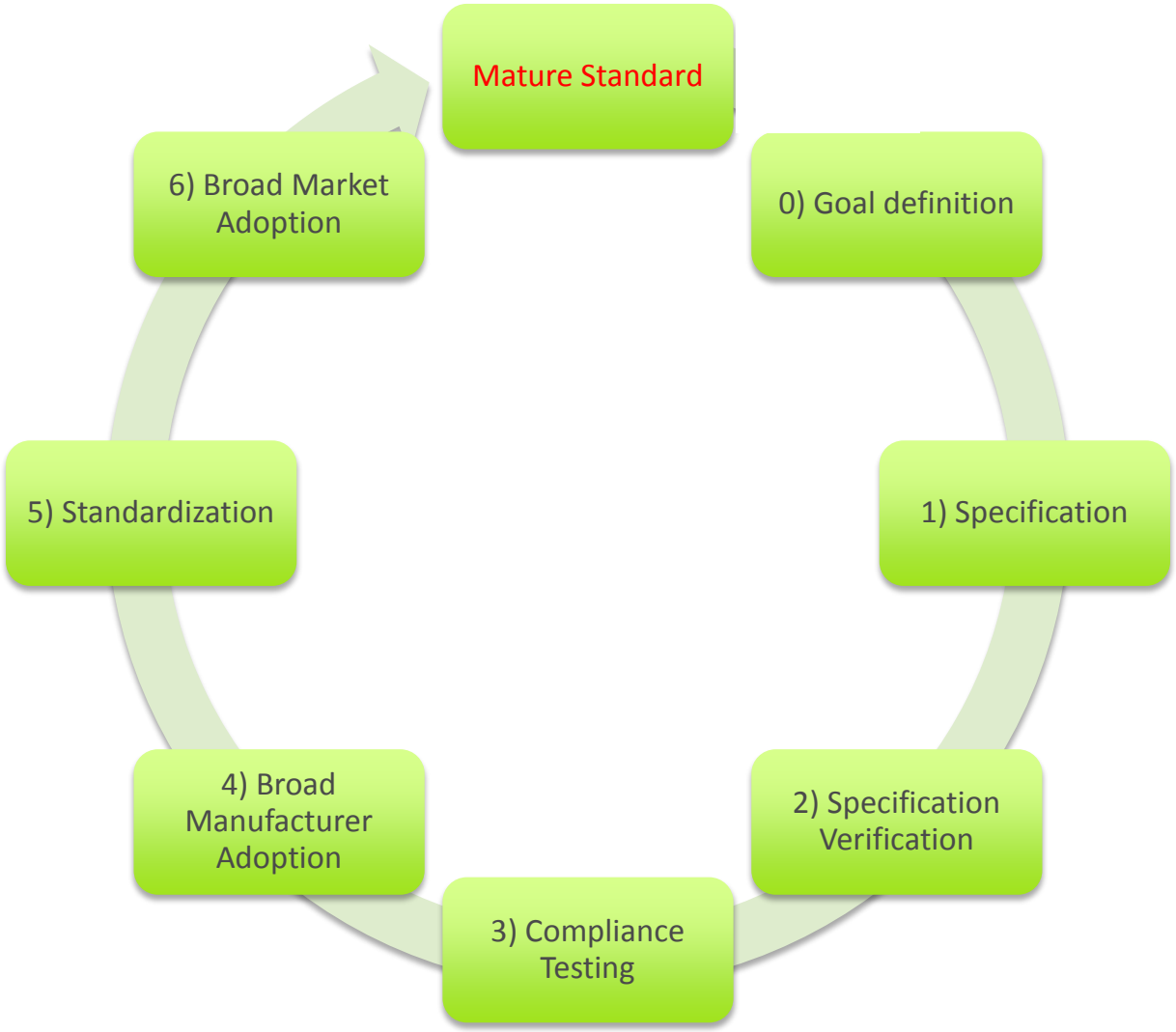
Goals

- Improve compatibility?
- Ensure interoperability?
  - At what levels(s)?
  - For what features?
- Ensure interchangeability?
  - At what levels(s)?
  - For what features?

Characteristics

- Open?
- Licensed?
- Fee?
- Compliance testing?

Standard development process



(Overly) simple interoperability questions to ask

- What data communication aspects does the specification address? How data is physically created? How it is routed? How it is understood?
- What application-level features and/or performance does the specification guarantee (if any)? Does the specification contain functional profiles? For what types of devices?
- How is compliance with an interoperable specification verified, reported?
- How mature is the specification? Is is open? Licensed? Is there a fee? What is the fee used for? Has it been standardized?
- What other devices/systems or device/system vendors does your product work together with? What “translators” are required? Where do those “translators” physically reside in the system? How are they updated?

Introduction to TCLA and TALQ

- Industry consortiums
- Driven by lighting end-product manufacturers (i.e. lamp, luminaires, controllers, software – rather than sub-components)
- Focused on interoperability
- Managed compliance testing and reporting

Lighting system performance is a function of …

Capability

And…

Compatibility
Interoperability
Interchangeability

Greater interoperability promises to …

- Increase adoption
- Increase user satisfaction
- Facilitate the deployment of an energy-saving platform (multi-phase, not limited to initial install choices)
- Leverage crowd-source development (software, use cases)
- Reduced incremental cost (software vs. hardware)
- Communicate measured performance (hours-of-use, energy)
  - Simplified utility programs
  - Decouple increased energy savings from new hardware, installation

Recommendations

- Let go of the past (experiences, approaches)
- Leverage new industry (lighting and non-lighting) specification development
- Figure out how to specify interoperability based on your needs
- Demand managed compliance testing
- Don’t add to the confusion
- Promote, facilitate ecosystem that streamlines the path to mature standards
- Be patient during (and contribute to!) the maturity process

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Questions?

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