DALI-2:
The global standard for smart, digital, lighting control in the IoT era

Scott Wade – Technical & Certification Manager – DiiA
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22nd May 2019, LIGHTFAIR, Philadelphia

Digital Illumination Interface Alliance

DALI 2

Agenda

- DALI & DiiA overview, key facts & benefits, comparison with 0-10V (Scott Wade, DiiA)
- Q&A
- New DiiA specifications – smart luminaires (Ronald Tol, Signify/DiiA)
- Proposed American National Standard For Lighting Systems – Digital Interface with Auxiliary Power (Michael S. O'Boyle, Signify/ANSI)
- An End User's Perspective to Using DALI for Outdoor Lighting (Kevin Fitzmaurice, Georgia Power)
- Q & A

DALI & DiiA

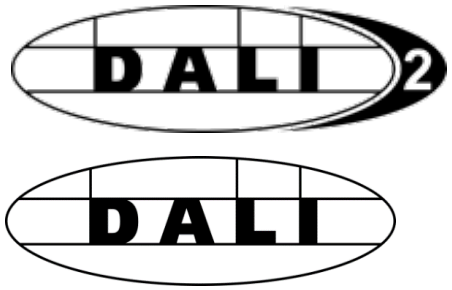
Digital **A**ddressable **L**ighting **I**nterface

- **World-wide standard** for lighting control communications
- Technically managed in the open standard **IEC 62386**
- Driven by Digital Illumination Interface Alliance (DiiA)
- Ensures **interoperability** through **testing, certification** and **registration** with **trademark** use
- **Control, configuration & querying** of devices over a 2-wire bus
- **Individual, group & broadcast addressing** to any DALI device
- DALI and DALI-2 trademarks owned by Digital Illumination Interface Alliance

Membership (May 2019)

- **170+ members** world-wide

- Membership allows DALI trademark use:
  - **435 DALI-2** certified products
  - **1048 DALI version-1** registered products



- **Membership types:**
  - **Regular**
  - **Associate**
  - **Community registration** – for luminaire makers

Membership benefits

	ASSOCIATE MEMBER	REGULAR MEMBER	COMMUNITY (note 2)
Access to DiiA test sequences	X	X	
Certification of DALI-2 products, use of DALI-2 logo on certified products	X	X	
Use of logos (DALI-2, DALI version-1) on luminaires containing DALI devices from DiiA members	X	X	X
Use of DALI version-1 logo on products other than luminaires	X	X	
Use of DiiA logo and DALI version-1 logo for marketing materials	X	X	X
Access to members-only website	X	X	
Participation in General Assembly meetings	X	X	
Receive membership communication	X	X	X
Access to draft deliverables (test sequences, specifications)		X	
Approval of final deliverables		X	
Participation and voting in working groups. Contribute to DiiA roadmap and development of test specifications.		X	
Participation in interoperability events (Plugfests)		X	
Eligible for Board of Directors membership		X	

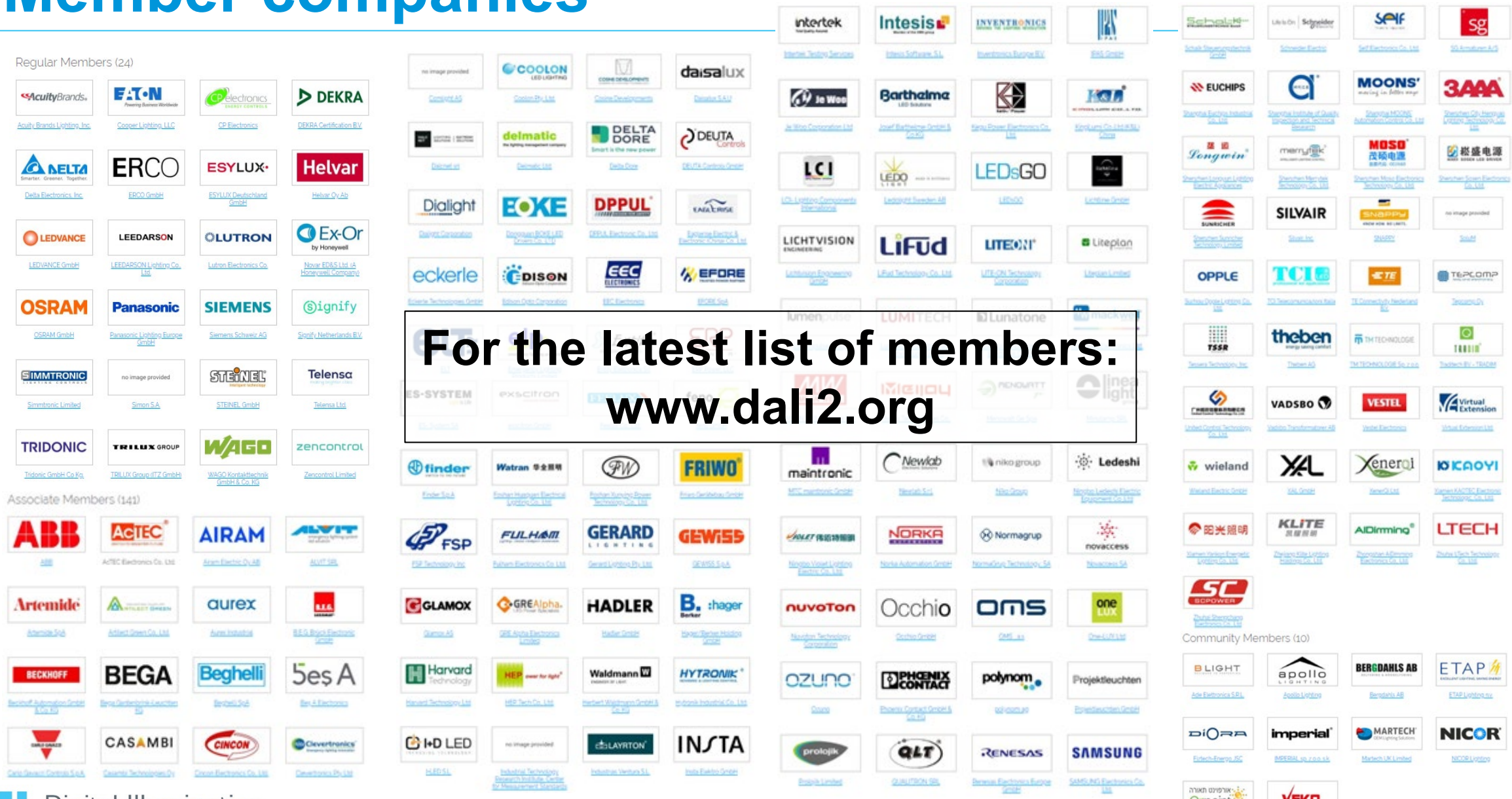
DiiA booth:
5921

Hall F

Membership benefits:

www.dali2.org/membership/benefits.html

Member companies



For the latest list of members: www.dali2.org

DALI – key facts & benefits

- **Technical limits**
  - max. 64+64 addresses per DALI subnet
  - max. 300 m cabling (between furthest-apart devices)
  - max. 250 mA bus power supply

- **Digital benefits**
  - Robust communication
  - Addressing: individual (64+64), groups (16/32) and broadcast (all)
  - Flexible: Simple operation “out-of-box”, or changes can be made via software
  - Two-way communication (feedback)

- **Cabling benefits**
  - Standard 2-core cable (1.5 mm^2)
  - Polarity-free & free wiring topology
  - DALI power and data on same pair of wires

DALI – key facts – basic types of devices

Currently, the standard describes **three basic types** of devices:

- **Control gear**
  - These are normally directly connected to the lamp, providing it with power

- **Control devices** (two basic types – see following slides)
  - Application controllers
  - Input devices

Download the *DALI Quick Start Guide*:
www.dali2.org/downloads

- **Bus power supplies**
  - Provide typically 16 V, up to 250 mA to power the bus.

DALI – key facts – control devices

- Control devices (IEC 62386-103) are new to the DALI-2 standard. There are two types:

- **Application controllers**
  - The “brains” of the system.
  - Use information from any source, make decisions and can send commands to the control gear.

- **Input devices**
  - Fairly simple devices that provide information to the system.
  - Examples include push-buttons, sliders, occupancy sensors, and light sensors.

Control devices – Application controllers

- **Can be very simple devices, or could be complex gateways interfacing with other systems**

- **Single-masters: Only one can be used on the DALI bus**
  - Often these only support control gear, but may also be able to poll input devices.

- **Multi-masters: Follow the rules for shared use of the DALI bus**
  - Often they support both the polled and event driven methods of obtaining information from input devices.
  - The DiiA product database describes the supported features: www.dali2.org/products

Control devices – input devices

- **Currently four types:**
  - 301 Push-buttons
  - 302 Absolute input devices (switches, sliders)
  - 303 Occupancy sensors
  - 304 Light sensors

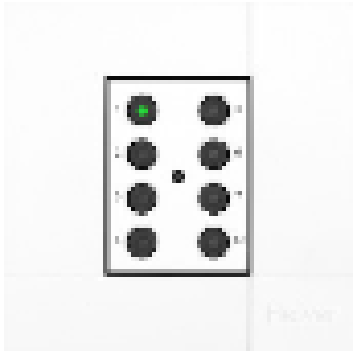
- Up to 32 of these “instances” can be in the same product (using one address)
  - An example is a sensor consisting of an occupancy sensor (303) and a light sensor (304):

- Operation can be event driven, or polled, or periodic transmission.

- Optional “feedback” feature can be used to control LED indicators on each instance, for example on push-buttons.

Control devices – input devices

- **Input device 301: Push-buttons**
  - Events can be sent on:
    - Press
    - Release
    - Short press
    - Long press
    - Double press
    - Button stuck



- **Input device 302: Absolute input devices**
  - Simple on/off switches, or multi-position switches
  - Digital inputs
  - Analog inputs
  - Slider or rotary controls

Control devices – input devices

- **Input device 303: Occupancy sensors**
  - Movement or presence type sensors catered for.
  - Events can be triggered on state change to: occupied, vacant, movement, no movement.

- **Input device 304: Light sensors**
  - Measures illuminance level
  - Programmable hysteresis to minimise bus traffic
  - Optional periodic events reporting the illuminance level

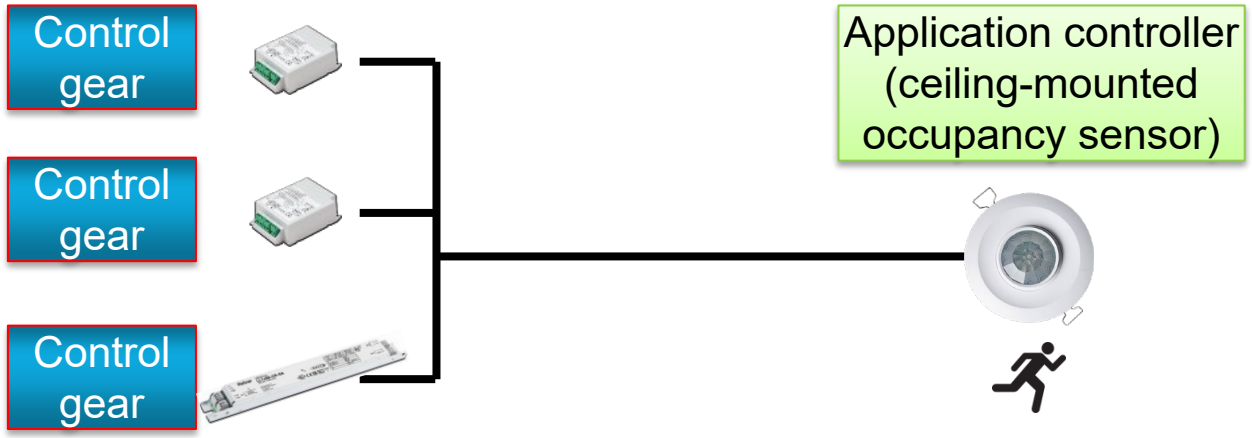
System example – Out-of-box system operation

- **Products are wired together**, and work in a similar way to 0-10V systems, without needing any programing.
- Often called a **“broadcast” system** because commands are simply broadcast to all devices.
- Addresses, scenes, groups and other **configuration is not required.**
- Bus wiring can be used to divide the operation into groups of lights, in the same way as with 0-10V.

- There are still advantages over 0-10V:
  - multiple controls can be used; controls can co-operate; push-button feedback LEDs; controls can be powered from the bus; programing can be done later if required…

- The following example demonstrates this:

System example – Out-of-box system operation



- Control gear
- Application controller (control device)

Note:

- A bus power supply is required, either separate or integrated with an existing device.
- More than one application controller is allowed.

Example of operation:

- Movement triggers the sensor
- Sensor may automatically broadcast several commands:
  - **`DTR0 (2)`** [Data transfer register = 2]
  - **`SET FADE TIME (`*`DTR0`*`)`** [Set fade time to 1s]
  - **`DAPC (254)`** [Go to 100%]
- All lights react together by going to 100%.

System example - Commissioned (programed) system

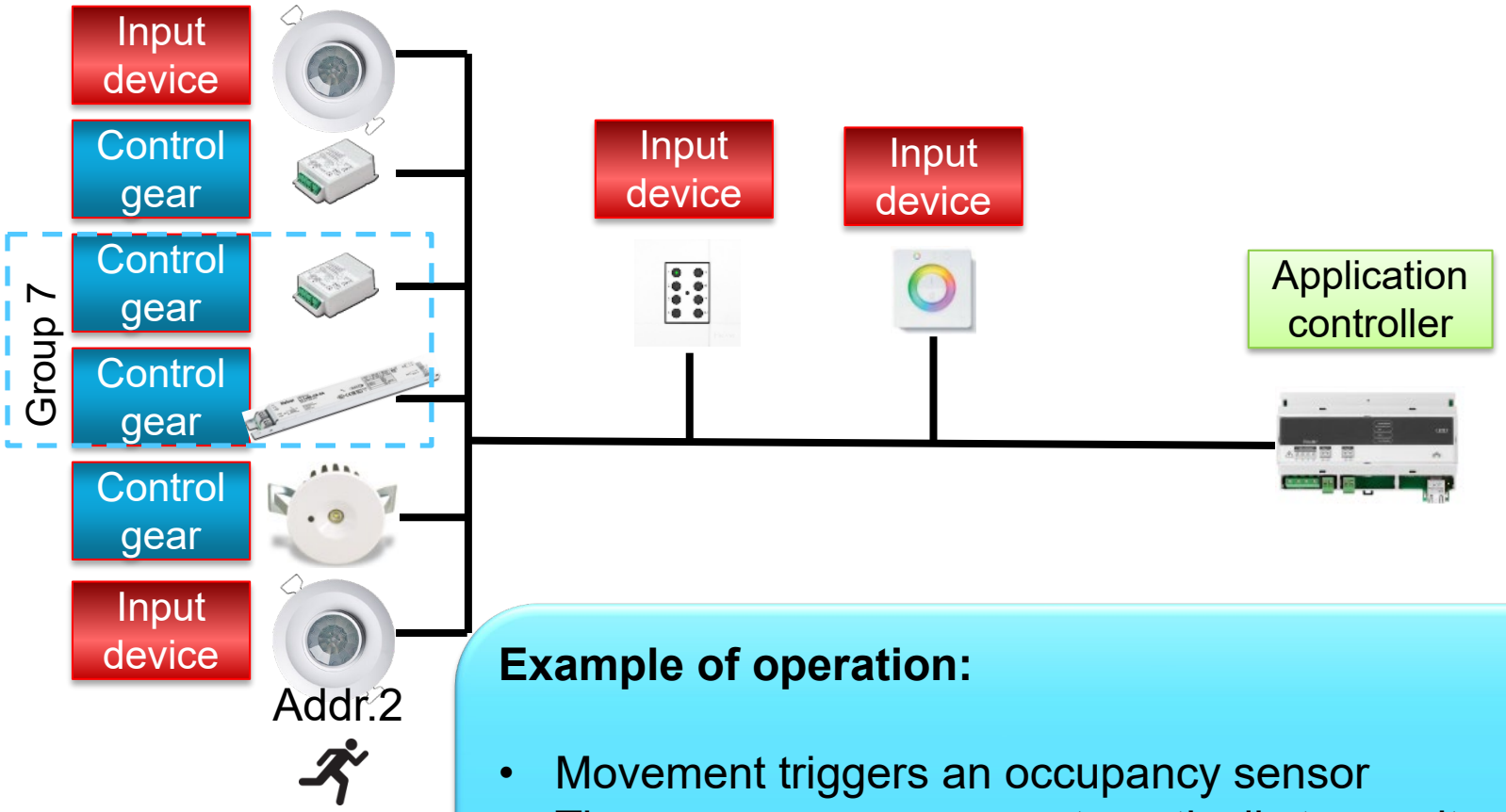
- **Products are wired together on the same DALI bus** (no need to divide the bus wiring).

- A **tool** is used to set-up the system.
  - Laptops, tablets, phones, IR handsets, LCD touch-panels or even wall-mounted push-buttons are examples of programing tools.

- Main commissioning (programing) steps are:
  - Assign **addresses**
  - **Group** the devices
  - Set-up scenes, fade-times and other parameters as required.

- The following example demonstrates this:

System example - Commissioned (programed) system



- Control gear
- Input devices (control devices)
- Application controller (control device)

Note:

- Systems can contain more than one application controller.
- A bus power supply is required, either separate or integrated with an existing device.

Example of operation:

- Movement triggers an occupancy sensor
- The occupancy sensor automatically transmits a notification:
  <address 2><instance 3> **`INPUT NOTIFICATION (0x009)`** [Movement detected]
- Application controller receives this, and decides to recall scene 5 in the group 7 lights:
  <group 7> **`GO TO SCENE 5`** [Change level according to scene 5]
- All lights in group 7 fade to the pre-programed levels in scene 5.

Comparison with 0-10V (1-10V)

- **Wiring**
  - 0-10V: uses a **2-wire connection**, with thicker cables required for longer runs, to avoid voltage drop affecting the light output. Daisy-chain, star, tree and combinations allowed.
  - DALI: also use a **2-wire bus**, but polarity insensitive. Daisy-chain, star, tree and combinations allowed.
- **Bus power**
  - 0-10V: Drivers provide between 10µA and 2mA.
  - DALI: Up to 250mA allowed on DALI bus. Drivers consume 2mA max. Devices can be bus-powered.
- **Signal**
  - 0-10V: The voltage represents the light output, although the dimming curve is not standardised. (ANSI C137.1)
- Other
  - 0-10V: some manufacturers of control gear provide a non-standardised way to indicate a lamp has failed: the current sourcing in the control gear is turned off. Can be useful with a single driver.
  - DALI: **Configuration** can be changed in the control gear, for example fade time, groups and scenes. Information can also be **queried**, for example output level, lamp failure, emergency test status.
  - DALI: **Individual** devices **or groups** can be addressed/configured/controlled/queried.
  - DALI: Multiple points of control are allowed.

Common misconceptions

- DALI is a **European standard**.
  - **No!** IEC 62386 is a world-wide standard. DiiA member companies operate throughout most regions.
- DALI **devices are more expensive**.
  - Sometimes true, but the situation reversed in Europe as the DALI volume increased above the 1-10V volumes.
- DALI is **difficult** to program (e.g. laptops needed, 2-man job, difficult to replace faulty products).
  - Out-of-box operation, with no programing, gives at least the level of operation obtained from 0-10V.
  - Programing, if required, varies between manufacturers.
- Products are **not available**
  - The choice is increasing. Additionally, some companies may already have implemented DALI in their products without stating they use DALI communications.
- The drivers and controls need to be on **separate buses**
  - No – they are designed to allow connection to the same DALI bus. Look for the DALI-2 logo on the products.
- DALI is **expensive to install**
  - No – it is likely to be lower cost than 0-10V installations due to requiring less wiring
  - This makes the installation simpler and offers more robust communication.

Major changes from DALI version-1 to DALI-2

- **Improved interoperability!**
  - **Control gear:**
    - Clearer specifications: timing, fading, power-on and start-up
    - New: extended fade times (0.1s to 16min), bus-powered, Continuous Up/Down commands
  - **Control devices:**
    - New to the DALI-2 standard (DALI version-1 is only control gear)
  - **Bus power supplies:**
    - Clearer specifications
    - Tests added
    - Can be DALI-2 certified
- **Increased testing**
- **DALI-2 certification!**

See a comparison and download the technical note on the DiiA website:

www.dali2.org/dali/comparison.html

Testing

- Products can be tested by the member company, or sent to an accredited test-house:
  - For **self-testing**, the following are required:
    - ProbitLab2 test platform
    - Official test-sequence software (downloaded from DiiA account)
    - Oscilloscope, voltage/current/resistance meter
    - Light meter (for testing of control gear and some control devices)
  - **Accredited test-houses** are listed on the website: www.dali2.org/testing/test-houses.html

- **Products that can be tested:**
  - Control gear of various types, with LED drivers being the most popular.
  - Control devices: application controllers, and the recently added input devices.
  - Bus power supplies (and integrated bus power supplies)

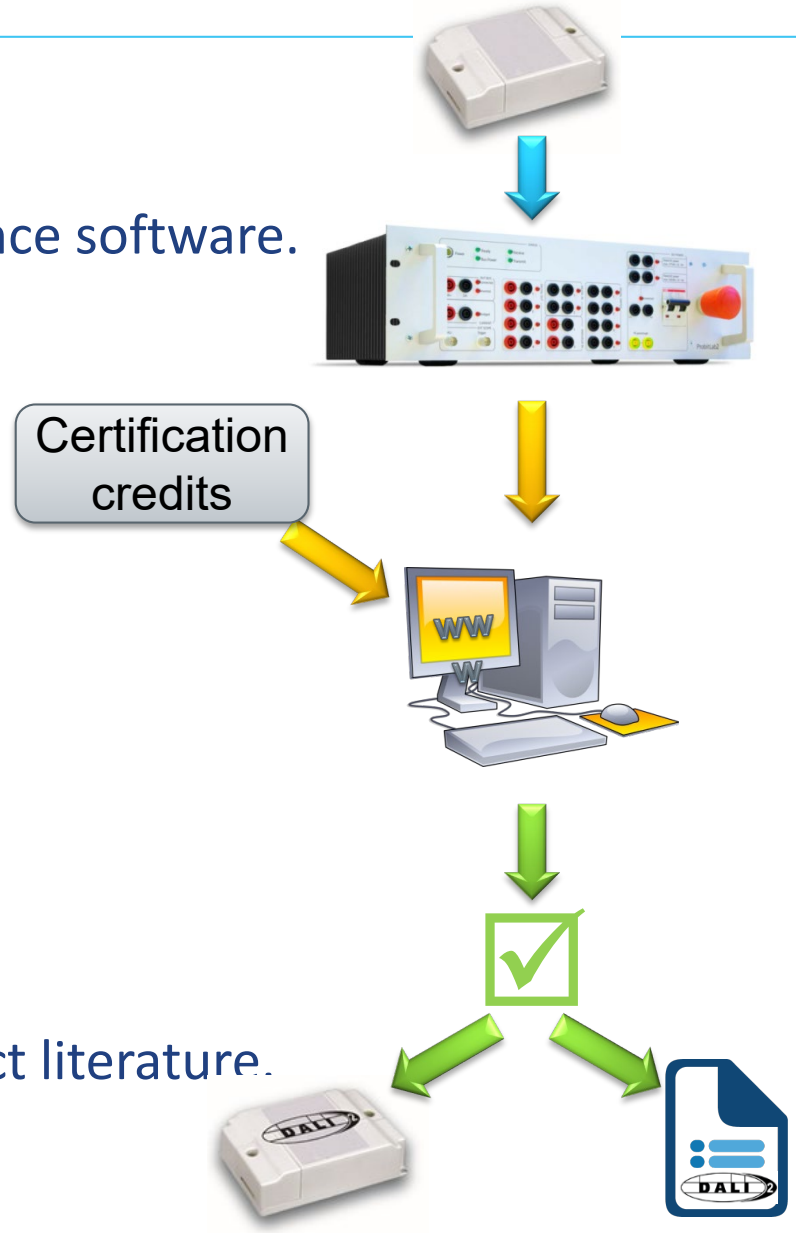
DALI-2 Certification

- **Test the product**
  - Self-tested using the approved tester and the official test sequence software.
  - Alternatively: use a DiiA accredited test-house.

- **Submit product information and test results**
  - This is done through the member's DiiA website account.

- **Verification by DiiA**
  - Test results and product information is checked.

- **Trademark use:**
  - The DALI-2 trademark may be applied to the product and product literature.
  - The product is automatically included in the public database.

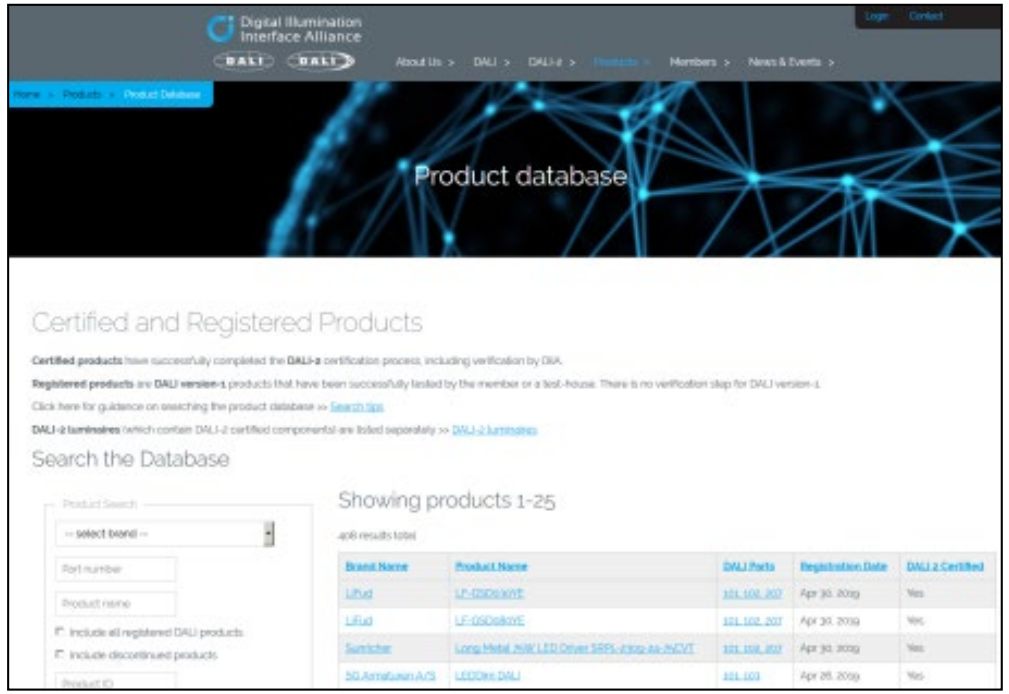


Product database (public)

- **Lists all DALI-2 certified products, as well as DALI version-1 registered products**
- **Used for two main purposes:**
  - Check if a product that shows the DALI-2 (or DALI) Trademark is really certified (or registered)
  - Find and select suitable products for an installation.
- **If a product isn't listed, it isn't certified.**

Product database:

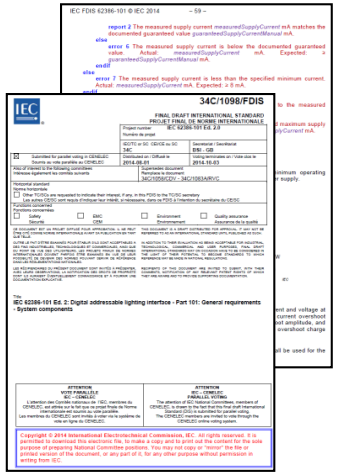
http://www.dali2.org/products



IEC 62386 Parts

- **Many existing IEC 62386 parts for:**
  - Control gear
  - Control devices
  - Bus power supplies

- **Several IEC parts are in progress**



IEC 62386 standard

Red text = DALI-2 versions published

Part 101: General requirements – System components

Part 102: General requirements – Control gear	Part 104: General requirements – Wireless and alternative wired systems **In progress**	Part 103: General requirements – Control devices
Parts 2xx: Particular requirements for control gear	Part 105: General requirements – Firmware update **In progress**	*Parts 3xx: Particular requirements for control / input devices*
Published: **Part 201: Fluorescent lamps** Part 202: Self-contained emergency lighting Part 203: Discharge lamps (excluding fluorescent lamps) Part 204: Low voltage halogen lamps Part 205: Supply voltage controller for incandescent lamps Part 206: Conversion from digital signal into DC voltage **Part 207: LED modules** Part 208: Switching function Part 209: Colour control	**Published:** **Part 216: Load referencing** **Part 217: Thermal gear protection** **Part 218: Dimming curve selection** **Part 220: Centrally-supplied DC emergency operation** **Part 221: Load shedding** **Part 222: Thermal lamp protection** **Part 224: Integrated light source** **In progress:** Part 219: Power measurement Part 223: Light-output compensation over lifetime Part 225: Colour Tc Part 226: Colour xy	**Published:** **Part 301: Push buttons** **Part 302: Absolute input devices** **Part 303: Occupancy sensors** **Part 304: Light sensors** **Part 332: Input control devices - Feedback** **Part 333: Manual configuration** **In progress:** Part 307: Relative input devices **Future part:** Part 305: Colour sensor
For Parts 207, 209 and others, DiiA adapts DALI version-1 test specifications for use with DALI-2.		

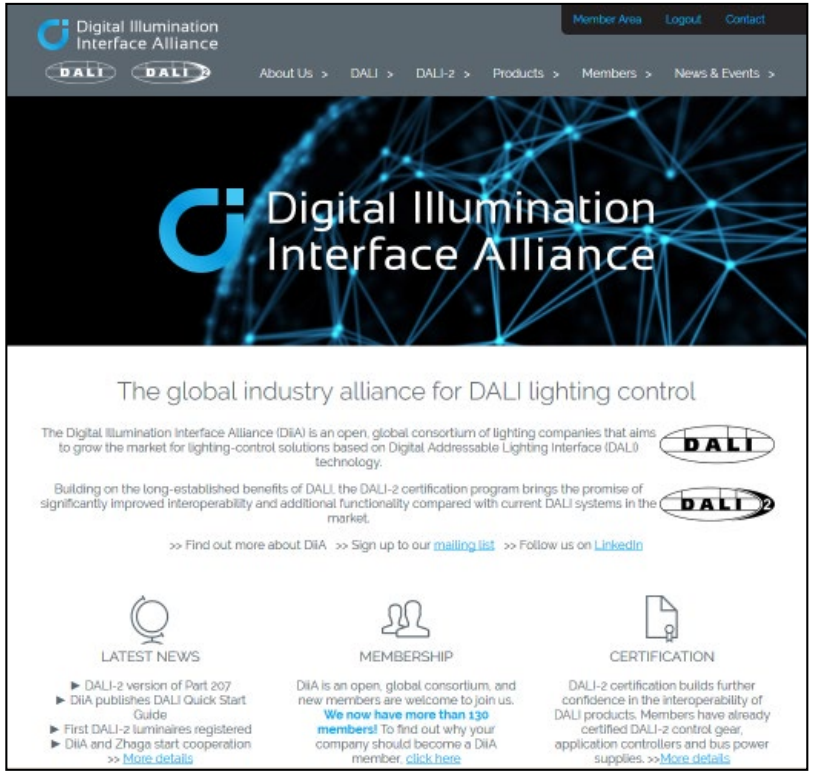
Updated: Dec 2018

For latest information, see:

www.dali2.org/dali/standards.html

Further information

- **See the DiiA website:**
  - Download the ***DALI Quick Start Guide:***
    http://www.dali2.org/downloads/
  - **Product database:**
    http://www.dali2.org/products
  - **Membership benefits:**
    http://www.dali2.org/membership/benefits.html
  - **Contact us:**
    info@digitalilluminationinterface.org



Questions?

Agenda

- DALI & DiiA overview, key facts & benefits, comparison with 0-10V (Scott Wade, DiiA)
- Q&A
- New DiiA specifications – smart luminaires (Ronald Tol, Signify/DiiA)
- Proposed American National Standard For Lighting Systems – Digital Interface with Auxiliary Power (Michael S. O'Boyle, Signify/ANSI)
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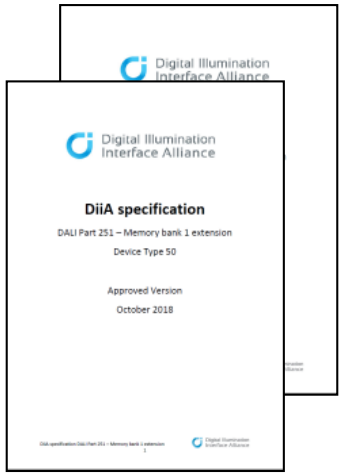
- Q & A

New DiiA Specifications

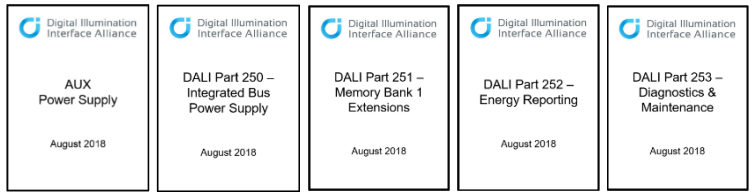
- **DiiA has developed several new specifications**
  - For use in smart luminaires, and products attached to smart luminaires

- **Specifications (www.dali2.org/specifications/download.html):**
  - DiiA part 250 – Integrated Bus Power supply
  - DiiA part 251 – Memory Bank 1 Extension (Luminaire Data)
  - DiiA part 252 – Energy Reporting
  - DiiA part 253 – Diagnostics and Maintenance
  - DiiA AUX – Auxiliary Power Supply
  - DiiA part 351 – Luminaire mounted control devices (under development)



- **Collaborations with:**
  - IEC TC34/WG11 on IEC62386, Zhaga and ANSI C137
  - It is expected these 5 new specifications will be included in IEC 62386

D4i specifications for intra-luminaire DALI



AUX power supply spec.

DALI Part 250 (integrated bus power supply)

DALI Parts 251-3 (operational & diagnostic data)

Remote lighting-control network

Communication node / sensor

Intra-luminaire DALI bus

AUX supply*

DALI-2 LED driver with **integrated bus power supply** and **data**

Power

Data

LEDs

Luminaire

DALI sensor node

* Auxiliary (AUX) power supply can be in a driver, or implemented in a separate product.

New DiiA Specifications – Applications

A primary application for these new specifications is outdoor lighting, such as streetlights

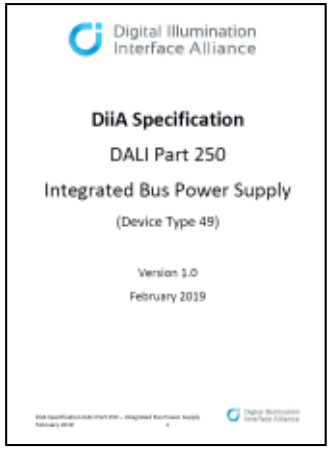
- Each streetlight can be a single DALI system
- A sensor or wireless communications module is often connected to the DALI bus
- DiiA-Zhaga collaboration is standardising:
  - the connector/receptacles (Zhaga book 18),
  - the use of DALI for communications, and
  - the bus and auxiliary power supplies.
- Through participation in ANSI C137.4:
  - Power supplies, asset management
  - Reference to ‘NEMA’ socket

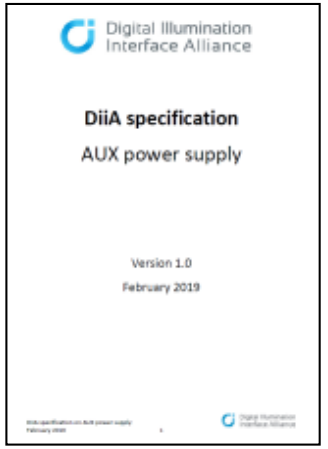
Some reasons that DALI was chosen:

- Industry standard
- Specifically for lighting control
- Direct connection to control gear
- Standardised dimming curve
- Bi-directional communication

Integrated bus power supply and AUX power supply

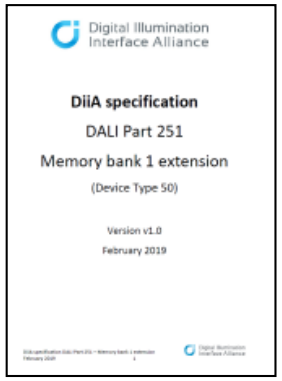
- **DiiA Part 250 – Integrated DALI bus power supply:**
  - Provides at least 50mA on the DALI bus
  - Useful to power sensors or other control devices
  - **Memory bank 201**:
    - Allows the **guaranteed** and **maximum** currents to be read
    - Allows the bus power supply to be enabled/disabled
- **AUX power supply**
  - 24V DC auxiliary power supply
  - Can be used by sensors or communication modules attached to the luminaire
  - 3W average power
  - 6W peak power
    - Supports city-wide wireless communications requiring high peak transmission power

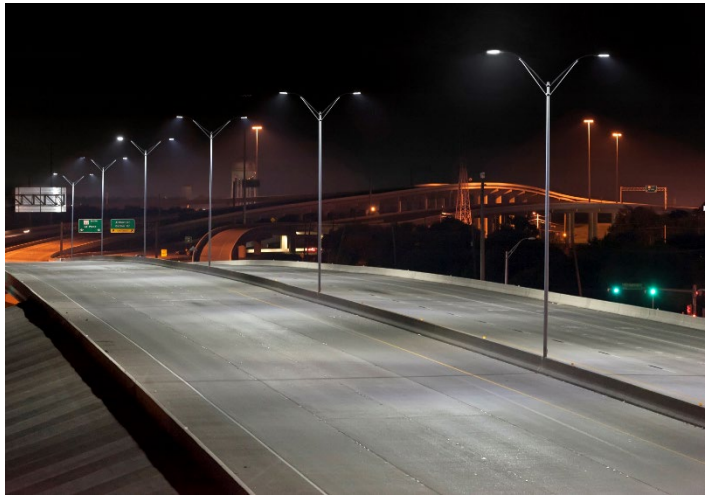




DiiA part 251 – Memory bank 1 extension

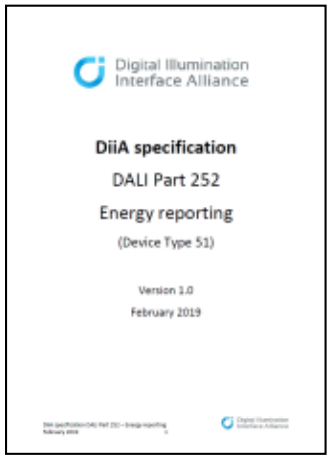
- **Memory bank 1 includes luminaire information such as:**
  - GTIN
  - date of manufacture
  - nominal input power
  - power at minimum dimming level
  - supply voltage range
  - nominal light output
  - CRI
  - CCT
  - light distribution type
  - luminaire colour
  - luminaire description
- **Useful for asset management applications**





DiiA part 252 – Energy Reporting

- **Memory bank 202:**
  - **Active** energy and power
- **Memory bank 203 (optional):**
  - **Apparent** energy and power
- **Memory bank 204 (optional):**
  - **Load-side** energy and power


Digital Illumination Interface Alliance

DiiA specification

DALI Part 252

Energy reporting

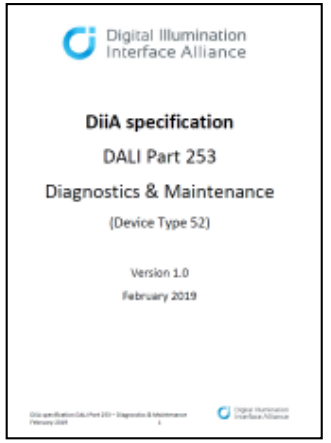
(Device Type 51)

Version 1.0

February 2019

DiiA part 253 – Diagnostics and Maintenance

- **Memory bank 205 – Control gear diagnostic and maintenance information:**
  - Operating time, start counter, external supply voltage, external supply frequency, power factor, overall failure condition, overall failure counter, external supply under-voltage & counter, external supply over-voltage & counter, output power limitation & counter, thermal derating & counter, thermal shutdown & counter, temperature, output current %.



- **Memory bank 206 – Light source diagnostics and maintenance information:**
  - Start counters, on-time counters, voltage, current, overall failure condition & counter, short-circuit & counter, open-circuit & counter, thermal derating & counter, thermal shutdown & counter, temperature.

- **Memory bank 207 – Luminaire maintenance data:**
  - Luminaire lifetime, control gear reference temperature, rated light-source starts.

Photo: Georgia Power / Buildings magazine

DiiA part 351 – Luminaire mounted control devices

- **Draft specification nearing completion**
- **Allows two types of control devices: Type A and B**
  - Maximum of one type-A and one type-B control device can be connected.

- **Examples**
  - Type A: an outdoor luminaire controller with city-wide wireless communications
  - Type B: a light or occupancy sensor

New trademarks

- **New wordmark (‘D4i’) and new logo:**

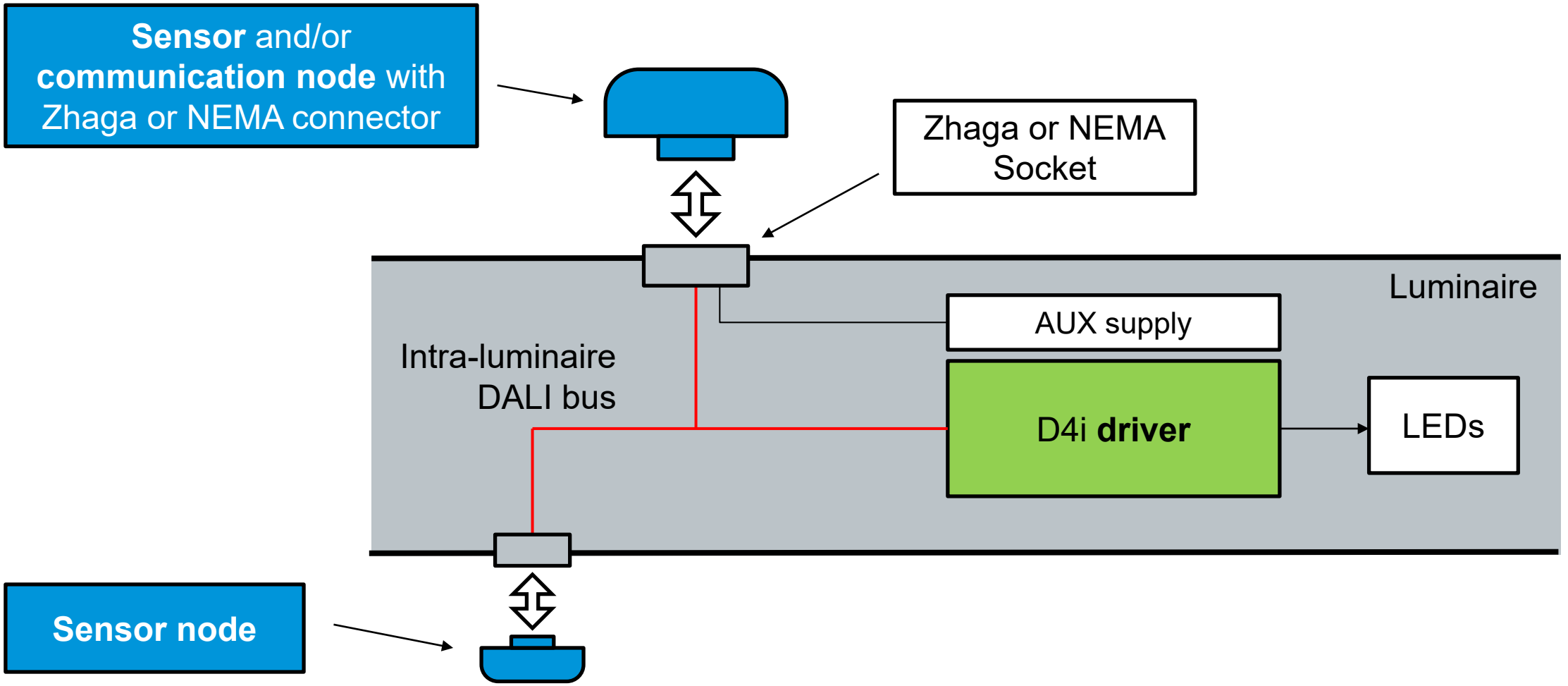
- Used on drivers, control devices and luminaires to indicate **D4i certification**

- **D4i Certification of drivers:**
  - Parts 207 and 250-253 implemented. Part 250 bus power supply default state: “enabled”.

- **D4i Certification of control devices:**
  - Part 351 implemented

- **D4i use on luminaires:**
  - All drivers are certified for D4i.
  - Only include control devices meeting the DALI-2 and D4i requirements.
  - At most one type A and one type B control device as per Part 351.

Streetlight with sockets for nodes



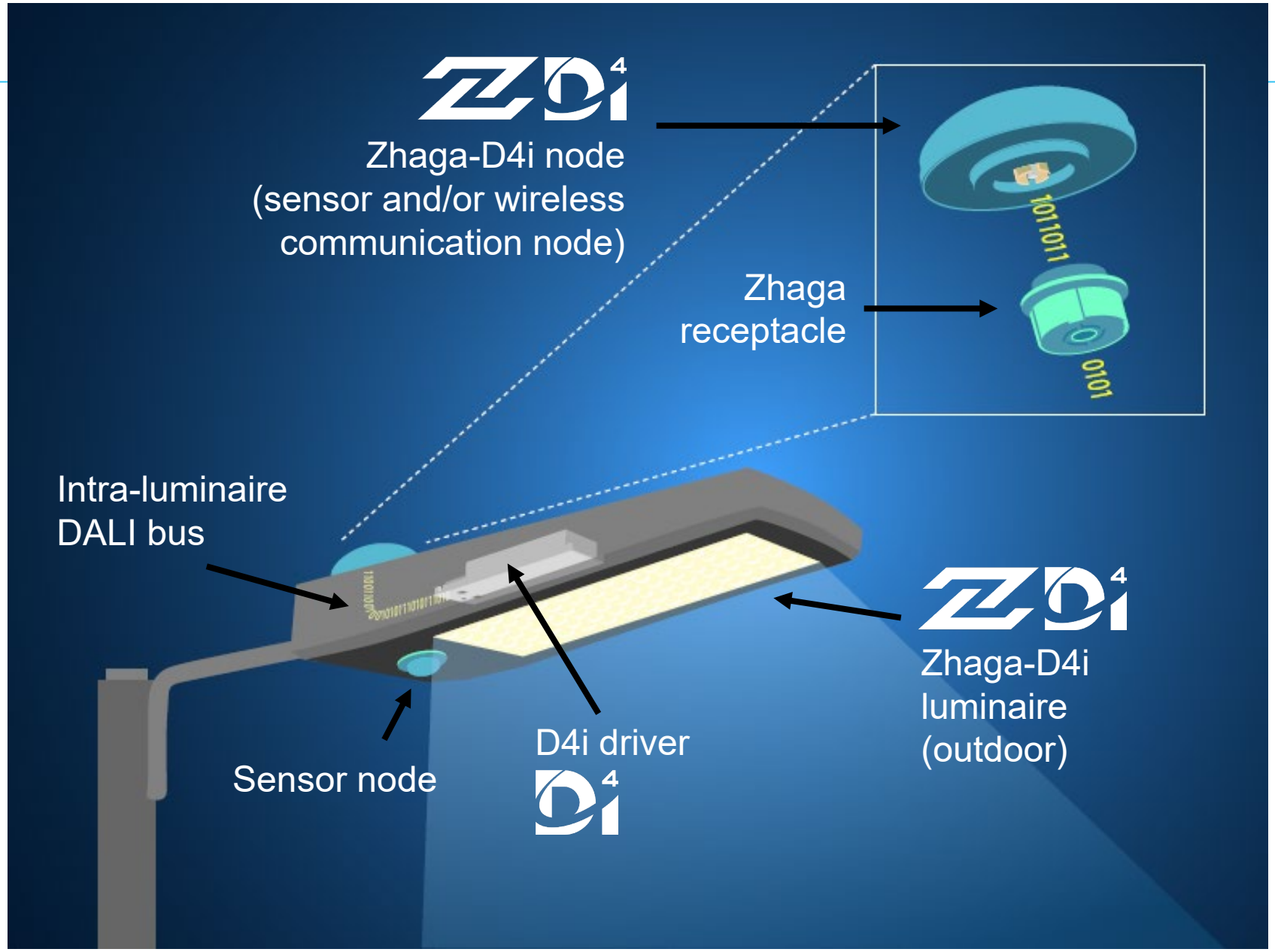
Benefits

- **Easy to add or upgrade sensors and/or communication nodes:**
  - Enables future-proof luminaires that can keep pace with rapid developments in digital networking and sensing technology.
- **Intra-luminaire DALI-2 bus:**
  - Enables bi-directional interaction between sensors and/or communication nodes and LED drivers using the well-established and standardized DALI protocol.
- **D4i drivers are smart:**
  - Able to report operational and diagnostic data to an external network, and can provide inventory-related information about the luminaires.
- **IoT connectivity:**
  - With a suitable wireless communication node, the luminaire is able to interact with an external lighting-control network, and to participate in the IoT.

Co-operation with Zhaga

- **Zhaga-D4i certification: A joint program from Zhaga and DiiA**
  - Certification for interoperable luminaires and sensors and/or communication nodes
- **Based on complementary specifications from Zhaga and DiiA**
  - Zhaga **Book 18** plus **D4i** specifications from DiiA
- **Product certification enables use of**  **on outdoor luminaires, sensors and communication nodes.**
  - Logo indicates multi-vendor **product interoperability**
- **Initial focus on outdoor lighting**
  - Indoor solutions will also be developed

Zhaga – D4i


Zhaga-D4i node
(sensor and/or wireless
communication node)
Zhaga
receptacle
1011011
0101
Intra-luminaire
DALI bus
Sensor node
D4i driver
Zhaga-D4i
luminaire
(outdoor)

Scope of Zhaga–D4i certification

Zhaga-D4i **Node**[1]		Dual Zhaga-D4i logos	Granted by Zhaga
Zhaga-D4i **Luminaire**[2]		Dual Zhaga-D4i logos	
D4i **Driver**		D4i logo	Granted by DiiA as part of D4i certification

[1] Zhaga-D4i Node = D4i certified sensor and/or communication node with a Zhaga Book 18 plug
[2] Zhaga-D4i Luminaire = has a powered Zhaga Book 18 socket and contains a D4i driver