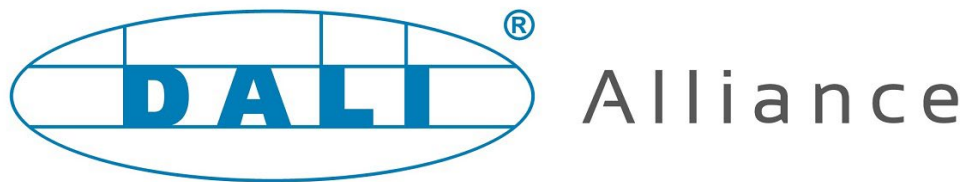


State-of-the art, energy-efficient lighting control systems with D4i-enabled luminaires

DALI Alliance seminar, Lightfair 2023



Speakers

Sree Venkit

- System Architect for Connected Lighting, **Signify**

Kevin Fitzmaurice, LC

- Principal Engineer,
Lighting and Smart Services, **Georgia Power**

Michael Davidson

- System Architect, **Synapse Wireless**

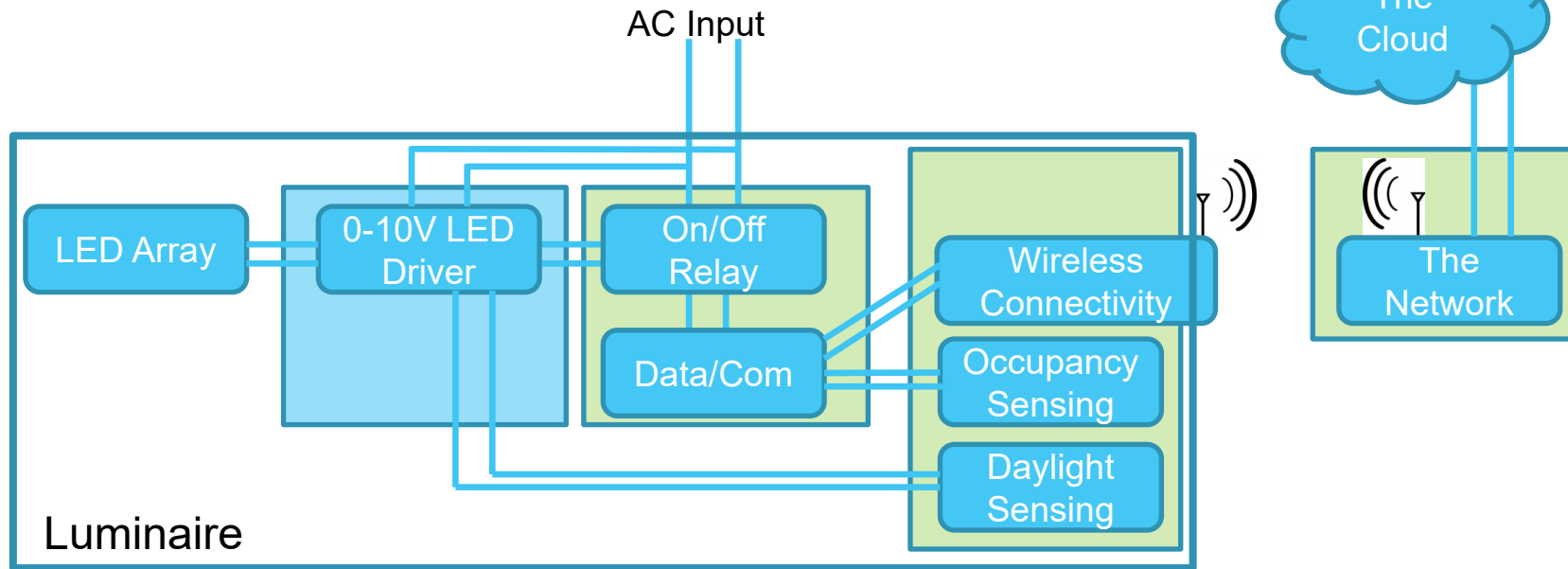


What is “Connected Lighting”?

Smart lighting fixtures will drive enhanced energy saving and make Lighting a key driver in the “Internet of Things”

- **Lighting is everywhere where people are**
- **Focus will gradually shift from energy savings to data insights leading to new uses:**
 - Occupancy/space management
 - Building automation / control (HVAC, security, elevators)
 - Retail engagement
- **Lighting provides an opportunity for human centric data collection**
 - Luminaires become the collecting points for local information.....data nodes.....Luminaire OEMs uniquely positioned to be the carrier

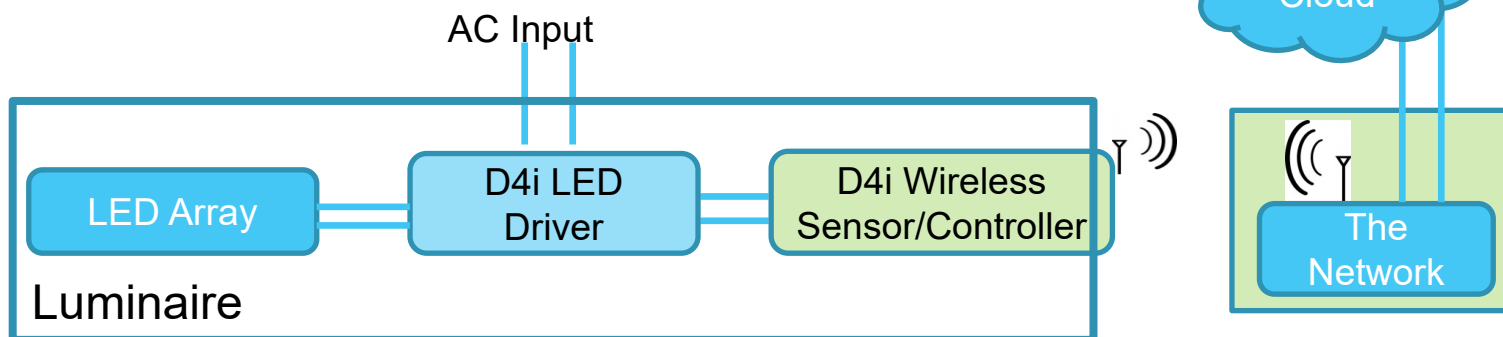
Connected Luminaire Architecture:



Analog 0-10V:

- Complex with many components
- Limited standardization
- No data capability from LED driver
- Reduced reliability - AC mains connection to multiple components

0-10V Dim2OFF with Aux is in between, but still no data from LED driver.



Digital D4i:

- Simple with few components
- Standardized connection for power and digital data from LED driver
- High reliability – AC mains to the LED driver only

D4i – Overview

- D4i is a certification program for interoperable DALI devices that enable smart, connected luminaires
 - D4i is an extension of DALI-2 certification
- D4i components have a compulsory set of features
 - Based on power-supply and data specifications from DiiA
- All D4i LED drivers provide luminaire, energy & diagnostics data
- D4i enables intra-luminaire DALI
 - Other D4i implementations are also permitted
- D4i luminaires are smart and IoT-ready
 - D4i simplifies addition of sensors and communication devices (NLCs) to luminaires
- D4i enables plug-and-play interoperability when combined with a connector system
 - e.g. Zhaga Book 18 & 20 or NEMA/ANSI C136.41



Benefit Summary – D4i Drivers vs 0-10V



Benefit	Driver Feature	Feature Description	0-10V	0-10V Dim2OFF w/Aux	D4i
Ease of maintenance and Asset Management	Asset management via DALI scenes	Use limited space in DALI scenes for unique vendor code and manual lookup tables to correlate to specific fixture			✓
	Asset management via MB1	Standardized method for storing vendor specific information in the driver; No lookup table required.			✓
	Memory Banks with Diagnostics Data	Data such as voltages, surges, currents and thermals made available back through NLC for analysis			✓
Ensure/monitor energy savings	Memory Banks with Power/Energy metering Data	Measured power and energy data. Supports DLC NLC QPL listing and thus qualify for utility rebates.			✓
High reliability	Integrated switching, and Low Voltage power supply	Eliminates mains protection and relay. No need for separate low voltage supply for the NLC.		✓	✓
Easy integration	Built-in DALI Bus Power Supply	Simple two wire connection from the driver to the NLC node to supply power and data			✓
System interoperability assurance	D4i Certification program	Testing assures DALI communication protocol robustness and D4i specified power and data availability to NLC.			✓

DiiA Specifications – Published



- The following specifications can be downloaded from the [DiiA website](#)

Specification	Name	Version	Certification?
Power supply specifications			
DALI Part 150	AUX Power Supply	v1.1, Oct 2019	✓
DALI Part 250	Integrated Bus Power Supply	v1.1, Oct 2019	✓
Data specifications for LED drivers & other control gear			
DALI Part 251	Luminaire Data	v1.1, Oct 2019	✓
DALI Part 252	Energy Data	v1.1, Oct 2019	✓
DALI Part 253	Diagnostics Data	v1.1, Oct 2019	✓
Specifications for control devices			
DiiA Part 351	Luminaire-mounted Control Devices	v1.0, Oct 2019	✓

Specification of state-of-the-art lighting control system:

- Automatic control of light levels based on presence detection
- Co-ordinated control of lighting for zones and groups to optimize comfort and energy savings
- Ability to override light levels with schedules and other external factors such as weather, events etc.
- Ability to remotely monitor energy usage at a granular level on a continuous basis.
- Ability to adapt the LED driver, sensor and other control settings of the luminaire to optimize customer experience and energy savings.
- Ability to monitor the health of luminaires on a continuous basis to anticipate maintenance needs and, also entertain requests for extended warranty.
- Ability to provide the replacement parts information readily and quickly to replace failed parts and minimize disruption towards customers.

High level selection: Luminaire & lighting control system

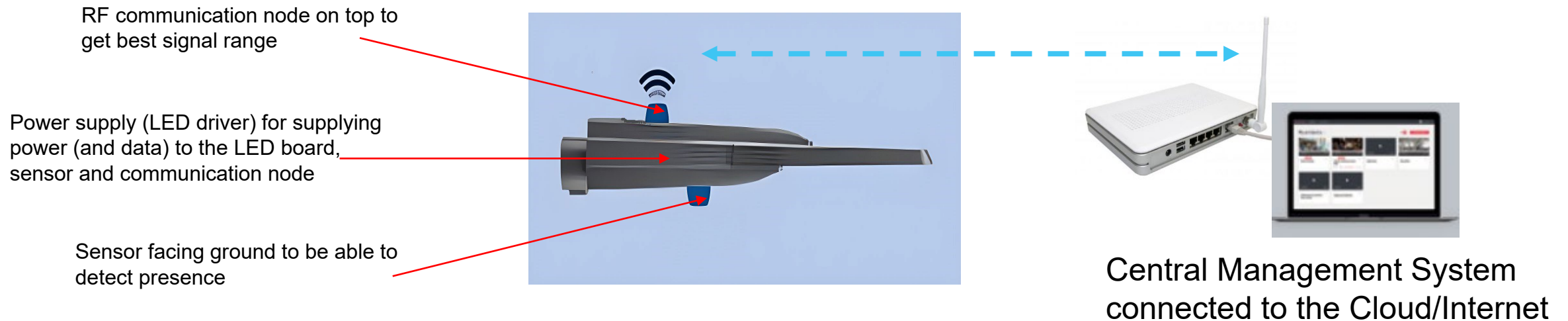
Automatic control of light levels based on **presence detection**

- Luminaire should have the capability to **integrate sensors**

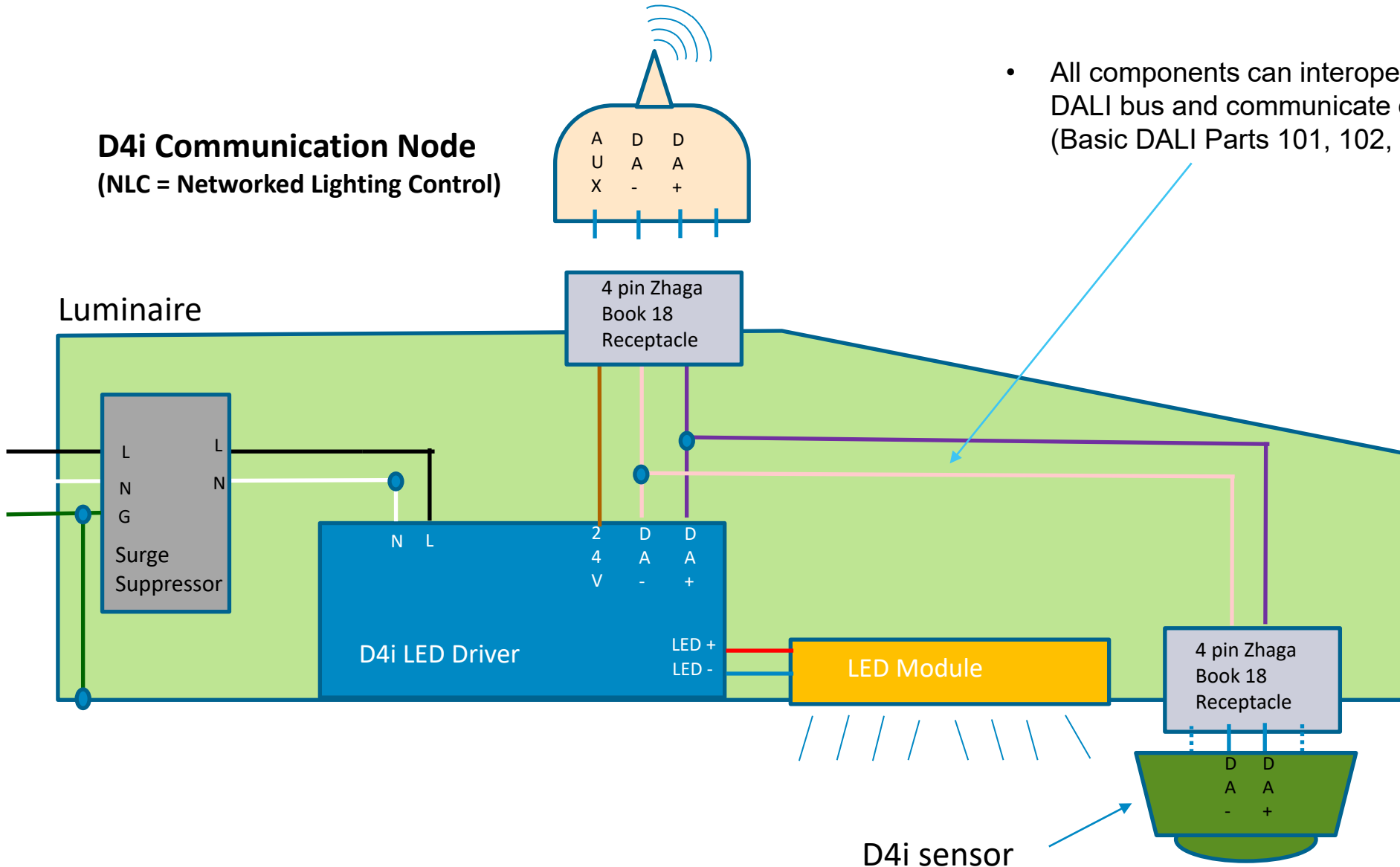
Co-ordinated control of lighting for zones and groups to optimize comfort and energy savings

Ability to override light levels with **schedules and other external factors such as weather**, events etc

- Luminaire should have the capability to integrate a **communication device**
- **Central Management System (CMS)** capable of handling group level control and internet connectivity



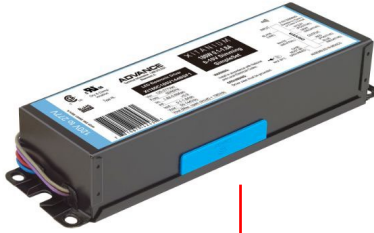
Luminaire components & wiring:



- All components can interoperate on the DALI bus and communicate digital data (Basic DALI Parts 101, 102, 103)

LED driver & sensor on the luminaire

D4i LED Driver
(Parts 101, 102, 207
250, 251, 252, 253)

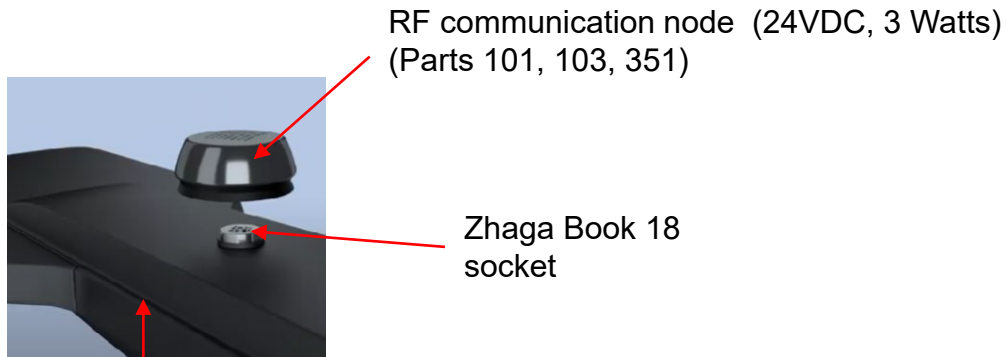


D4i Motion Sensor
(Parts 101, 103, 303, 351)

- Automatic control of light levels based on **presence detection**

- D4i certified LED driver provides compatible LV bus power supply to the sensor (Part 250)
- D4i certified sensor works with the bus power supply from the driver (Part 351)
- D4i certified sensor provides presence data on the DALI bus (Part 303)

LED driver & communication node on the luminaire

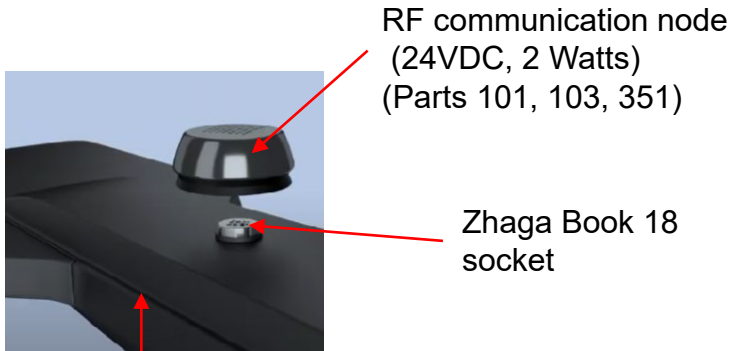


D4i LED Driver
(Parts 101, 102, 207
150, 250, 251, 252, 253)

- Ability to adapt the LED driver, sensor and other control settings of the luminaire to optimize customer experience and energy savings.

- D4i certified LED driver provides compatible power supply to the communication node (Part 150 - 24VDC, 3W).
- D4i certified communication node works with the 24V, 3W power supply from the driver (Part 351, Type A)
- D4i certified communication node acts as a master application controller to communicate with and control the LED driver and sensor (Part 351)

LED Driver & Communication node on the luminaire



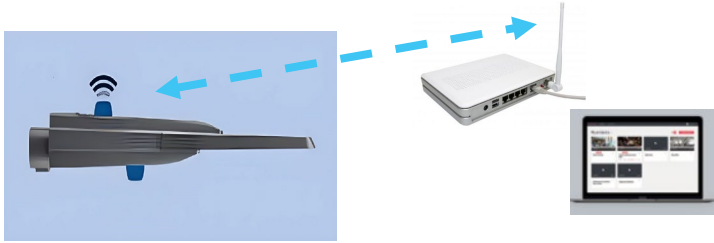
- Ability to remotely **monitor energy** usage at a granular level on a continuous basis..
- Ability to **monitor the health of luminaires** on a continuous basis to anticipate maintenance needs and, also entertain requests for extended warranty.
- Ability **to provide the replacement parts information** readily and quickly to replace failed parts and minimize disruption towards customers.



D4i LED Driver
(Parts 101, 102, 207
150, 250, 251, 252, 253)

- D4i certified LED driver provides energy data to the communication node (Part 252)
- D4i certified LED driver provides diagnostic data (fault codes, temperature...) to the communication node (Part 253)
- D4i certified LED driver provides asset management (luminaire model# and associated details) to the communication node (Part 251)

Luminaire & CMS



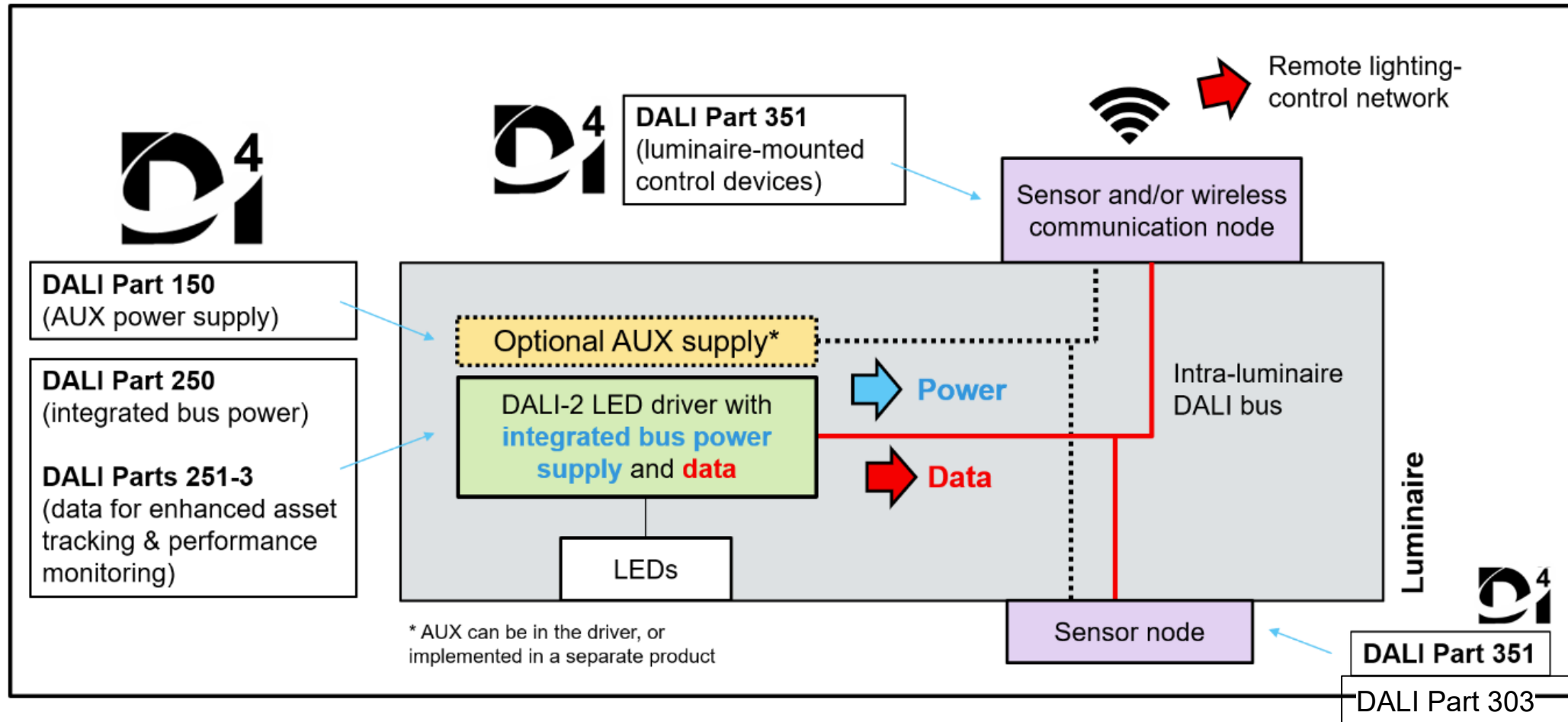
CMS

connected to the
Cloud/Internet

- Automatic control of light levels based on **presence detection**
- **Co-ordinated control of lighting for zones and groups** to optimize comfort and energy savings
- **Ability to override light levels with schedules** and other external factors such as weather, events etc.
- Ability to **remotely monitor energy usage** at a granular level on a continuous basis.
- Ability to **adapt the LED driver, sensor and other control** settings of the luminaire to optimize customer experience and energy savings.
- Ability to **monitor the health of luminaires** on a continuous basis to anticipate maintenance needs and, also entertain requests for extended warranty.
- Ability to provide the **replacement parts information readily and quickly** to replace failed parts and minimize disruption towards customers.

- CMS communicates with the internet to obtain external data (eg. weather, events) and send notifications (eg. email)
- CMS communicates via the communication node to the sensor to read the presence signal and, also adapt sensor settings to optimize performance (Sensor Parts 303, 351)
- CMS communicates to the LED driver via the communication node to control driver settings and the light level (Driver Part 207)
- CMS communicates to the LED driver via the communication node to continuously monitor asset, energy and diagnostic data (Driver Parts 251, 252, 253)

Summary – Luminaire with all D4i components



Asset Management and Energy Reporting

Real Life Examples

Kevin Fitzmaurice – Principal of Smart Services – Georgia Power

LightFair 2023

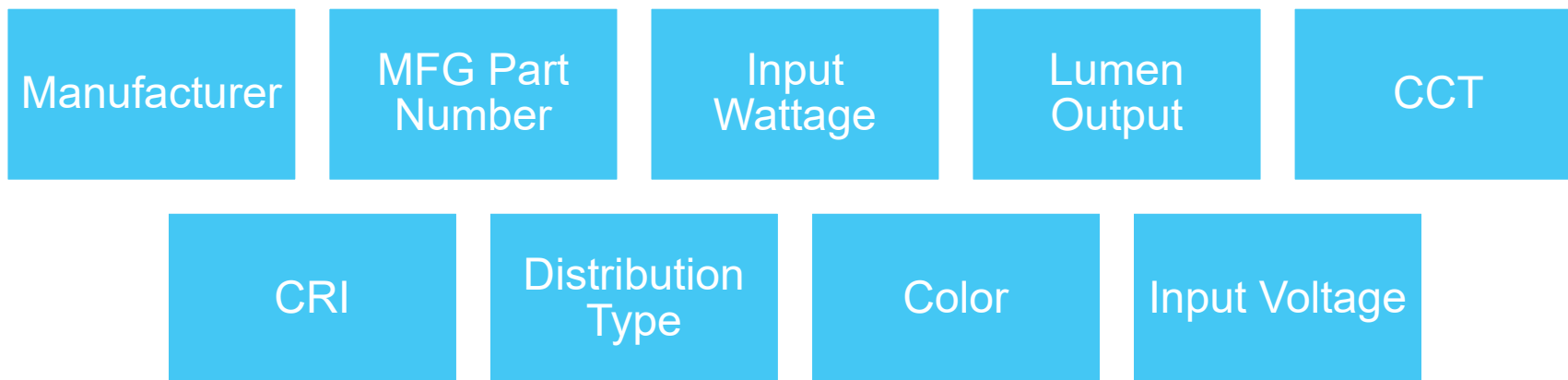
Asset Management and Energy Reporting

Luminaire Asset Data retrieval from DALI Drivers

Data can be retrieved via lookup codes in older DALI version 1 drivers without Memory Bank 1 (MB1)

Data can be retrieved from MB1 using the ANSI C137.4 format in newer style DALI drivers (e.g., D4i, DALI-2, DALI with MB1)

Examples of data:



Asset Management and Energy Reporting

Luminaire Asset Data from DALI Drivers using Scene Data

Luminaire Asset Data from Lookup Tables

SCENE 11	SCENE 12	SCENE 13	LOOKUP_CODE	MFG_PART_NUMBER	STYLE	WATTAGE	SOURCE	LUMENS	CCT	DIST_TYPE	COLOR	VOLTAGE
04	00	00	0000	ERL10C7E140AGRAYLR005	Evolve	51	LED	5090	4000K	II	Gray	120-277
04	00	01	0001	ERL10E3E140AGRAYLR005	Evolve	91	LED	8610	4000K	II	Gray	120-277
04	00	02	0002	ERS10J2G1640AGRAY097	Evolve	161	LED	14085	4000K	III	Gray	120-277
04	00	03	0003	ERL10C7E140ADKBZLR005	Evolve	51	LED	5090	4000K	II	Bronze	120-277
04	00	04	0004	ERL10E3E140ADKBZLR005	Evolve	91	LED	8610	4000K	II	Bronze	120-277
04	00	05	0005	ERS10J2G1640ADKBZ097	Evolve	161	LED	14085	4000K	III	Bronze	120-277
04	00	06	0006	ERS2027G1X40AGRAY033	Evolve	274	LED	27400	4000K	III	Gray	120-277

Asset Management and Energy Reporting

Luminaire Asset Data from DALI Drivers with MB1

- Specification for DALI-2/D4i memory bank 1 extension (DALI part 251)
- Luminaire's DALI driver shall support the programming and storage of applicable information
- OEM information shall be encoded by the luminaire manufacturer
- This requires the NLC and CMS partner to be able to access the data
- Table 5 is derived from DiiA Specification DALI Part 251 and sourced by permission from Digital Illumination Interface Alliance (DiiA)

Address	Description	Default value (factory)	RESET value ^a	Memory type
0x00	Address of last addressable memory location; Range [0x77,0xFE]	factory burn-in	No change	ROM
0x01	Version of the memory bank	0x01	No change	ROM
0x02	Lock byte Lockable bytes in the memory bank shall be read-only while the lock byte has a value different from 0x55.	0xFF	0xFF ^c	RAM-RW
[0x03, 0x08]	Luminaire manufacturer GTIN with manufacturer specific prefix to derive manufacturer name	0xFF	No change	NVM-RW (protectable) ^e
[0x09, 0x10]	Luminaire identification number	0xFF	No change	NVM-RW (protectable) ^e
0x11	Content Format ID ^a (MSB)	0x00	No change	NVM-RW (protectable) ^e
0x12	Content Format ID ^a (LSB)	0x03	No change	NVM-RW (protectable) ^e
0x13	Luminaire year of manufacture [YY] Range 0-99, MASK = unknown	0xFF	No change	NVM-RW (protectable) ^e
0x14	Luminaire week of manufacture [WW] Range 1-53, MASK = unknown	0xFF	No change	NVM-RW (protectable) ^e
0x15	Nominal Input Power [W] (MSB)	0xFF	No change	NVM-RW (protectable) ^e
0x16	Nominal Input Power [W] (LSB); Range 0-65535, MASK = unknown	0xFF	No change	NVM-RW (protectable) ^e
0x17	Input Power at minimum dim level [W] (MSB)	0xFF	No change	NVM-RW (protectable) ^e
0x18	Input Power at minimum dim level [W] (LSB); Range 0-65535, MASK = unknown	0xFF	No change	NVM-RW (protectable) ^e
0x19	Nominal Minimum AC mains voltage [V] (MSB)	0xFF	No change	NVM-RW (protectable) ^e
0x1A	Nominal Minimum AC mains voltage [V] (LSB); Range 90-480, MASK = unknown	0xFF	No change	NVM-RW (protectable) ^e
0x1B	Nominal Maximum AC mains voltage [V] (MSB)	0xFF	No change	NVM-RW (protectable) ^e
0x1C	Nominal Maximum AC mains voltage [V] (LSB); Range 90-480, MASK = unknown	0xFF	No change	NVM-RW (protectable) ^e
0x1D	Nominal light output [Lm] (MSB)	0xFF	No change	NVM-RW (protectable) ^e
0x1E	Nominal light output [Lm]	0xFF	No change	NVM-RW (protectable) ^e
0x1F	Nominal light output [Lm] (LSB); Range 0-16777215, MASK = unknown		0xFF No change	NVM-RW (protectable) ^e
0x20	CRI; Range 0-100, MASK = unknown		0xFF No change	NVM-RW (protectable) ^e
0x21	CCT [K] (MSB)		0xFF No change	NVM-RW (protectable) ^e
0x22	CCT [K] (LSB); Range 0-17000; MASK = unknown; MASK - 1 = Part 209 implemented		0xFF No change	NVM-RW (protectable) ^e

Address	Description	Default value (factory)	RESET value ^a	Memory type
0x23	Light Distribution Type; 0 = not specified; 1 = Type I; 2 = Type II; 3 = Type III; 4 = Type IV; 5 = Type V; 6-254 = available for additional types MASK = unknown According to IES RP-8, Roadway Lighting; Annex E, Classification of Luminaire Distribution		0xFF	No change NVM-RW (protectable) ^e
[0x24, 0x3B]	Housing finish color [24 ascii characters string, first char at 0x24] ^d Range 32-126 (ascii printing characters only)		0x00	No change NVM-RW (protectable) ^e
[0x3C, 0x77]	Luminaire identification [60 ascii characters string, first char at 0x3C] ^d Range 32-126 (ascii printing characters only)		0x00	No change NVM-RW (protectable) ^e
[0x78, 0xFE]	Reserved for future use			
0xFF	Reserved – not implemented		Answer NO	No change n.a.

^a Must be set to 0x0003 when this format is used.
^b Reset value after "RESET MEMORY BANK."
^c Also used as power-on value.
^d Null terminated if shorter than the specified length.
^e This field is write protectable as specified in DiiA Specification 251.

Note 1: Description provided with the LSB of a multi-byte field applies for the entire field.
 Note 2: References to mains voltages are 50/60 Hz AC mains power.
 Note 3: Manufacturer ratings in this table are not inclusive of tolerances and are for general comparison only.
 Note 4: Formatting and display of information in this table, including GTIN and Luminaire Identification Number, are outside the scope of this standard but are typically displayed to a user as decimal numbers.

Asset Management and Energy Reporting

Energy Reporting – DALI Part 252

The D4i LED driver can report operational data including

- Active energy/power
- Apparent energy/power
- Load-side energy/power

Asset Management and Energy Reporting

Energy Reporting – DALI Part 252

Use Cases

- Adaptive lighting and scheduled dimming
- Input data for monitoring and control systems
- Submetering for cost allocation or billing

Benefits

- Energy Savings
- Compliance
- Sustainability
- Improved Operations

