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Edge mixed networking (EMN) technical requirements for smart buildings

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Contents

Foreword

This document is drafted in accordance with the provisions of GB/T 1.1-2020 "Guidelines for Standardization - Part 1: Structure and Drafting Rules for Standardization Documents".

This document is under the jurisdiction of SILA.

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Introduction

This document, led by Shanghai Pudong Intelligent Lighting Association (SILA) and Elites Intelligent Technology (Suzhou) Co., Ltd., aims to standardize the application technical requirements of Edge Mixed Networking (EMN) in intelligent buildings, to promote the in-depth application of IoT technology in the field of intelligent buildings.

Based on swarm intelligence technology, EMN provides innovative solutions for issues such as multi-physical layer communication, AI self-learning and automated configuration, and device interconnection. EMN establishes unified control interface standards, enabling centralized management and control of various IoT devices and edge computing platforms, simplifying operational processes, and improving system automation and intelligence. EMN provides guidelines for system optimization and maintenance, ensuring that the edge mixed networking system can adapt to different operating environments and conditions, achieving self-adjustment and fault recovery to maintain system stability and efficiency.

This document clarifies the technical content of the communication layer and application layer for DALI, PLC, and BLE, and establishes standardized communication interfaces to achieve seamless connection between different devices and systems, as well as efficient collaboration between networks. This technical specification clarifies the application reference for scenario-based self-learning functions, promoting the popularization of edge mixed networking technology in various smart building scenarios; it also provides a reference for the formulation of other national, local, and industry standards in the future.

The issuing organization of this document reminds that the declaration of compliance with this document may involve the use of the following 2 patents related to this document.

Patent application numbers and their titles are as follows:

No.	Patent Application No.	Patent Title
1	CN 202211311766.2	A Method for Clustering and Networking in Large-Scale Wireless Sensor Networks
2	CN 202411463800.7	Method and Apparatus for Generating Deployment Location Maps Based on IoT Lighting System

The issuing organization of this document takes no position regarding the authenticity, validity, and scope of these patents.

The patent holder has committed to the issuing organization of this document that they are willing to negotiate patent licensing with any applicant under reasonable and non-discriminatory terms and conditions. The declaration of the patent holder has been filed with the issuing organization of this document. Relevant information can be obtained through the following contact:

Patent Holder: Elites Intelligent Technology (Suzhou) Co., Ltd.

Address: Room 2205, Building 1, Tongji Technology Plaza, No. 2 Hushan Road, Changshu High-Tech Industrial Development Zone.

Please note that apart from the above patents, certain content of this document may still involve other patents. The issuing body of this document does not undertake the responsibility of identifying patents.

Edge mixed networking (EMN) technical requirements for smart buildings

1 Scope

This document defines the architecture of the communication layer, the functional requirements of the application layer, and the implementation requirements for scenario-based self-learning functions for Edge Mixed Networking (EMN) in smart buildings.

This document applies to the design, production, installation, commissioning, and use of EMN systems and related equipment in smart buildings.

2 Normative References

This document has no normative references.

3 Terms and Definitions

The following terms and definitions apply to this document.

3.1

node

A connection point or a communication endpoint in a communication network; typically, a device is a node.

3.2

network

The maximum control scope of an EMN network, composed of multiple nodes.

3.3

unit

The next level of control scope under the EMN network. Each node must belong to one and only one unit.

3.4

group

An optional auxiliary control scope for EMN nodes, similar to a tag; a node can belong to multiple groups.

3.5

instruction

A request for data or a control message in lighting control protocols.

3.6

physical layer

Creates, maintains, and dismantles the physical links required for data transmission, providing mechanical, electronic, functional, and procedural characteristics.

3.7

communication layer

The protocol layer for communication message format and transmission.

3.8

application layer

Strongly related to usage scenarios, used to define business and functional specifications, etc.

3.9

state

A set of parameters that a node can maintain operation with at a certain moment.

3.10
mode
A collection of multiple states and transition parameters arranged in a predetermined logical sequence.

3.11
scene
One mode or several modes pre-stored internally in the device.

4 Abbreviations

The following abbreviations apply to this document.

AD: Analog-Digital

BLE: Bluetooth Low Energy

DALI: Digital Addressable Lighting Interface

EMN: Edge Mixed Networking

IO: Input Output

PHY: Physical Layer

PLC: Powerline Communication

PWM: Pulse Width Modulation

UART: Universal Asynchronous Receiver/Transmitter

Sub-GHz: Refers to frequency bands or related technologies below 1 Gigahertz (Sub-Gigahertz)

LAN: Local Area Network

WI-FI: A technology that allows electronic devices to connect to a wireless LAN (Wireless Fidelity)

DTU: Data Transfer Unit, a device specifically designed to convert serial port data to IP data or IP data to serial port data to achieve remote data transmission.

5 Communication Layer

5.1 SILA-EMN Node Structure

5.1.1 Communication System Structure

The node structure (as shown in Figure 1) includes:

a) SILA-EMN Standard Node;

b) SILA-EMN Gateway Node.

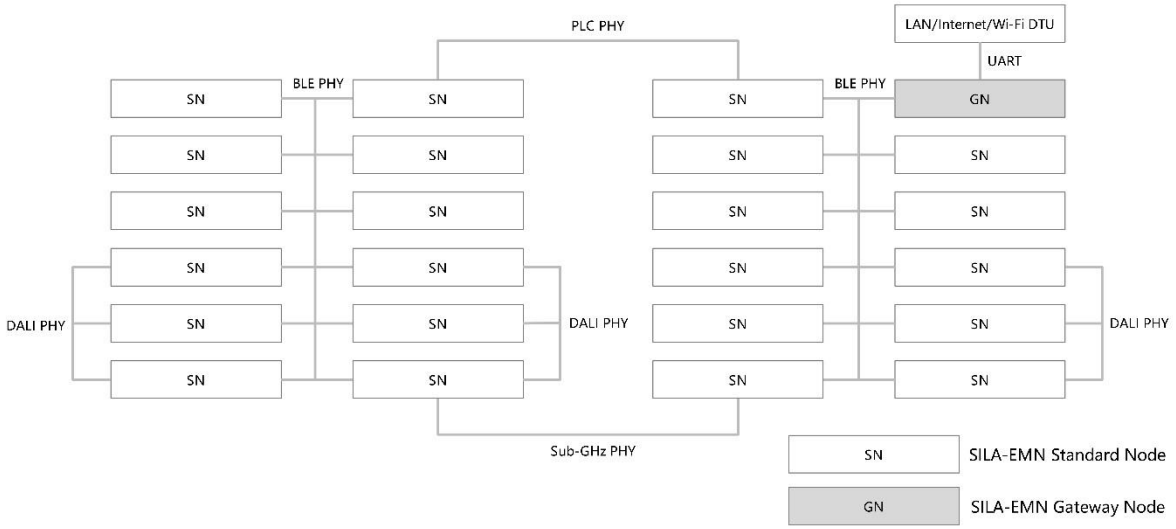

Figure 1 SILA-EMN Network System Diagram

5. 1. 2 SILA-EMN Standard Node

Standard nodes must have the BLE PHY; other physical layers are optional, as shown in Figure 2:

a) A single-mode standard node has only the BLE PHY physical layer.

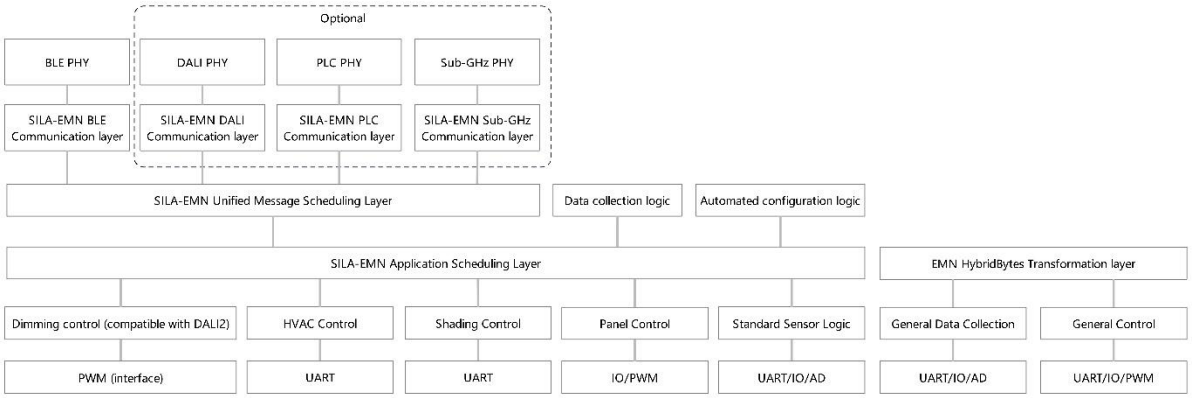

Figure 2 SILA-EMN Standard Node System Diagram

b) A multi-mode standard node must have the BLE PHY physical layer, and other physical layers can be selected from PLC, DALI, Sub-GHz, either one or a combination of several.

5. 1. 3 SILA-EMN Gateway Node

A conversion node that interfaces with upper-level systems to achieve data collection and remote command distribution, as shown in Figure 3.

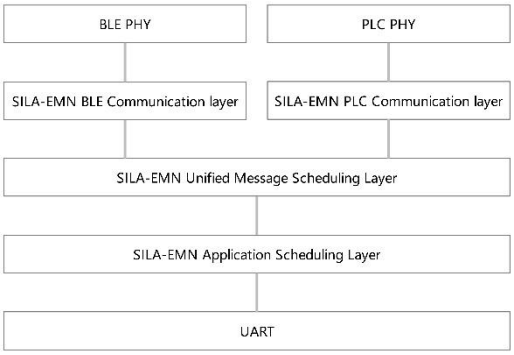

Figure 3 SILA-EMN Gateway Node System Diagram

5.2 Hierarchical Division

5.2.1 Network

4-byte length, the largest EMN network concept, representing the maximum unit manageable in a single operation. However, nodes from different networks can also communicate under specific protocols.

5.2.2 Unit

2-byte length, range 256 ~ 65534, so one network supports a maximum of 65279 units (as it shares the address field with groups, it starts from 256). Equivalent to the device address concept in DALI, DALI device addresses 0-63 correspond to EMN unit addresses 256 ~ 319. Each node must and can only belong to one unit. Multiple nodes are allowed to belong to the same unit.

5.2.3 Group

1-byte length, range 0 ~ 255, equivalent to the group concept in DALI. Each node can belong to 0 ~ 32 groups, so a device can belong to no group.

5.2.4 Device/Node

6-byte globally unique address, each node has a unique and non-repeating address. Equivalent to a MAC address. This concept cannot be used in the DALI bus.

5.3 Communication Layer Message Structure Standard

5.3.1 SILA-EMN BLE/PLC Message Format

Refer to the EMN4.0 standard format.

5.3.2 SILA-EMN DALI Message Format

Refer to the DALI2 standard format.

5.4 Message Classification

5.4.1 Batch Write Message (Broadcast Instruction)

A downlink instruction without response, broadcast to all nodes within the same network, usually initiated by a gateway or downloader, used for functions such as:

a) Batch mode switching;

b) Batch scene switching;

c) Batch parameter setting.

5.4.2 Single Node Message (Single Instruction)

An instruction that can communicate with a single node, supporting both non-response and response modes, usually initiated by a gateway or downloader, used for functions such as:

a) EMN debugging instructions;

b) DALI debugging instructions;

c) PLC debugging instructions;

d) Single device data/parameter reading.

5.4.3 Cluster Message (Cluster Instruction)

Instructions locally initiated within the network, usually initiated by nodes themselves, used for:

a) Sensor status synchronization;

b) Position self-learning calculation;

c) Batch data and status reporting;

d) Configuration-free post-sales calculation.

5.5 Security Mechanism

AES 128-bit encryption, with an independent key for each network, which can be set. Certain special instructions are allowed to be used unencrypted to maintain minimal maintenance requirements. Cluster instructions use an unpublished independent key and cannot be set.

5.6 Cross-Communication Layer Scheduling

5.6.1 BLE-PLC Scheduling

Adopts the basic communication scheduling mechanism of EMN. Adds an exclusive data uplink channel for the PLC communication layer.

5.6.2 BLE-DALI Scheduling

Refers to the DALI general command set IEC 62386—102, should include:

a) DALI dimming instruction: Converted to EMN constant-on instruction to control devices within the same scope (unit or group);

b) EMN mode instruction: When an EMN node experiences a brightness change, it will automatically send a DALI instruction;

c) DALI scene instruction: Converted to EMN scene instruction;

d) EMN scene instruction: Converted to DALI scene instruction.

Note: Scenes configured via DALI will only support constant-on. Among multiple EMN nodes on the same DALI network, one node will be automatically selected to send the DALI control signal.

6 Application Layer

6.1 Standard Actuator

6.1.1 Operating State Data Format

Maximum 4 bytes, representing the parameters that can be maintained for operation at a certain moment.

6.1.2 State Type

6.1.2.1 Operating State Type

See Table 1 for operating state types.

Table 1 Operating State Types

Type Name	Type ID	Data Format
Dimming Only	0x01	Bytes 0-1: Brightness (0-65535)
Dimming and Color Temperature	0x02	Byte 0: Brightness (0-255) Byte 1: Color Temperature (0-255)
Thermostat	0x21	Byte 0: 6-bit temperature (0-63), 1-bit temperature reference (0: thermostat, 1: designated sensor), 1-bit temperature compensation function (0: off, 1: on) Byte 1: 1-bit thermostat switch (0: off, 1: on), 3-bit operating mode, 3-bit fan speed, 1-bit panel lock (0: panel locked, 1: manual control allowed)
Curtain	0x41	Byte 0: Travel 0 Byte 1: Travel 1 Byte 2: Travel 2 Byte 3: 1-bit open/close status (0: fully closed, 1: fully open)

6.1.2.2 Curtain Control Commands

See Table 2 for curtain control commands.

Table 2 Curtain Control Commands

Attribute Name	Variable Format	Unit	Variable Value and Meaning
Curtain Type	1 Byte	—	0 Double curtain 1 Left curtain 2 Right curtain
Motor Control	1 Byte	—	0 Close 1 Pause 2 Open
Motor Status	1 Byte	—	0 Closing 1 Pausing 2 Opening
Current Position	1 Byte	Percentage	0～100 step 1 0% fully open 100% fully closed
Set Position	1 Byte	Percentage	0～100 step 1 0% fully open 100% fully closed
Motor Reverse	Bool	—	—
Operating Speed	1 Byte	—	0 Low speed 1 Medium speed 2 High speed

6.1.3 Sensor Control Mode

The mode includes three states: Occupied State, Unoccupied State, Sleep State.

Each node can specify the relationship between the DALI message address field and the state.

The state transition follows a fixed sequence: Occupied State → Unoccupied State → Sleep State.

6.1.4 Scene

Scene numbers 0-127, a total of 128 scenes. Each scene stores a complete set of sensor control modes in the device, maximum 15 bytes.

6.1.5 Other Parameters

Can be configured via parameter setting instructions.

6.1.6 Basic Data Structure for Automated Archiving

The SILA-EMN system should periodically report an array of this structure. See Table 3 for the basic data structure for automated archiving.

Table 3 Basic Data Structure for Automated Archiving

Field Name	Field Type	Remarks
Device Address	String	—
Network Address	String	—
Device Type	Byte	—
Auto-generated	Bool	True：Auto-generated False：Manually recorded
First Network Join Time	DateTime	—
Last Online Time	DateTime	—
X Coordinate	Int	—
Y Coordinate	Int	—
Belonging Floor	String	—
Belonging Group Address	Int[]	—
Unit Address	Int	—
Local Network Access	Byte	Bit0: BLE PHY Bit1: DALI Bit2: PLC Bit3: Sub-GHz
Comprehensive Networking Strength Score	Int	-
DALI Link ID	Int	0 indicates not in any DALI link; devices on the same DALI link will use the same ID
Maximum Power	Float	The maximum power the device itself can achieve, e.g., power at 100% brightness, -1 indicates invalid
Minimum Power	Float	The minimum power the device itself can achieve, e.g., power at 0% brightness, -1 indicates invalid
Name	String	Name given to the device during on-site recording
Group Name	String	Name of the group
Unit Name	String	Name of the unit

6.2 Standard Sensor

Supports the following information output:

a) Motion/Presence detection;;

b) Motion/Presence detection;;

c) Motion/Presence detection;

6.3 Standard Panel

a) Supports the following information output:

1) Short press;
2) Multiple short presses;
3) Long press;
4) Release.

b) Can support the following information input:
1) Backlight brightness value;
2) Emphasis key (backlight color change).

6.4 General Input/General Output

Logically bound to the standard format via EMN HybridBytes.

Can communicate with the following interfaces via an EMN gateway equipped with EMN HybridBytes:

a) Third-party PLC interface;
b) KNX；
c) RS485/RS232/UART；
d) Modbus；
e) IO；
f) Third-party PLC interface.

6.5 Standard Debugging Interface

6.5.1 EMN Debugging

Follows the EMN4.0 debugging interface standard, including the following basic content:

a) Device discovery;
b) Device relationship with nearby devices;
c) Basic parameter configuration;
d) Zoning archive configuration；
e) Operating parameter configuration；
f) Scene parameter configuration；
g) Naming；
h) Single device naming/ unit naming/ group naming/ network naming.

6.5.2 DALI Debugging

Supports wireless-to-DALI debugging instructions, including:

a) Allows wireless configuration, including device address and group address;
b) Identifies DALI line relationships and DALI communication reachability status via wireless communication;
c) Allows using the EMN4.0 map generation mechanism for rapid address assignment of DALI devices.

6.5.3 Sub-GHz Debugging

Supports Sub-GHz wireless physical layer and BLE physical layer forming a dual-physical layer module.

6.6 Data Acquisition

6.6.1 Data Packet Registration Mechanism

Data that needs to be collected using the cluster intelligence network must be registered on the node, including the following information:

a) Data interval in minutes, 1 byte;

b) Priority, 1 byte;

c) Data ID, 2 bytes;

d) Subsequently, data must be pushed to the node at the agreed interval, with each data packet length being 2 bytes.

6.6.2 Data Packet Push Logic

The gateway will irregularly push a collection of data packets, including:

a) Data source device address;

b) Data start time;

c) Number of data packets;

d) Data packet collection.

7 Scenario-based Self-Learning Function

7.1 General Self-Learning Function

7.1.1 Automatic Networking

Obtain detailed information of the entire network on any node, including node addresses, groups, and states.

7.1.2 Configuration-free After-sales Service

No configuration required; after replacing a faulty product, the newly installed device will automatically complete configuration migration.

7.2 Flowing Public Spaces / Bus Terminals / Warehouses

7.2.1 Path Linkage Learning

Luminaires autonomously learn movement paths in the space and automatically complete the configuration of linkage relationships between sensors and luminaires.

7.2.2 Radar Sensor Fault Learning

The system autonomously detects radar faults and shields faulty radar signals.

7.3 Office Spaces

7.3.1 Radar Sensor Fault Learning

The system autonomously detects radar faults and shields faulty radar signals.

7.3.2 Thermostat Return Air Vent Position Learning

The thermostat autonomously learns the position of the associated air conditioning return air vent.

7.4 Hotel Rooms / Classrooms

7.4.1 Commissioning-free Deployment of Default Scheme

After device installation, no configuration is needed; devices can automatically group according to spatial distribution and operate according to the default scheme.

7.4.2 Rapid Replication of Operating Schemes

After modifying the operating scheme in a single space, other similar spaces will proactively replicate the new operating scheme.

7.4.3 Default Scheme Examples

Can include the following functions:

a) Sleep Aid Function: For guests who need lights on to sleep in unfamiliar environments, pressing a button to start sleep aid mode adjusts the preset light strip to 5% brightness and turns off after 1 hour;

b) Blind Touch Function: Hotel rooms are public environments, and guests are unfamiliar with smart panels. When getting up at night, blindly touching any button defaults to the night light function, avoiding accidentally turning on curtains or all lights, which could disturb the guest's sleep quality;

c) Night Light Function 1: After sleep mode or sleep aid mode, blindly touching any button defaults to the night light function, turning on the preset light strip to 5% brightness and optionally linking to dimly light the bathroom;

d) Night Light Function 2: When someone approaches the sensing radar after switching to sleep mode/sleep assistance mode, a hand close to the smart switch panel is recognized by the system as activating the night wake-up function, adjusting the preset light strip to 5% brightness, and can also slightly activate the bathroom light；

e) Room Temperature Care: The smart thermostat panel in the guest room can be set to intelligently adjust the temperature, slowly increasing the temperature by 1 degree every half hour after 00:00 until it reaches 22°C, providing customer care for those in need.

7.5 Industrial Plants

7.5.1 Path Linkage Learning

Luminaires autonomously learn movement paths in the space, automatically complete the configuration of linkage relationships between sensors and luminaires, and autonomously learn flowing areas/non-flowing areas to achieve independent configuration of operating parameters for flowing areas/non-flowing areas.

7.5.2 Radar Sensor Fault Learning

The system autonomously detects radar faults and shields faulty radar signals.

7.6 Sub-GHz Application

Primarily used for networking medium-to-large power devices with medium spacing, such as industrial and mining lights, floodlights, street lights, and courtyard lights, or to improve connection quality in indoor applications, enhancing the adaptability of SILA-EMN in different scenarios.

References

[1] IEC 62386—102 Digital addressable lighting interface – Part 102: General requirements – Control gear.

[2] Elites Intelligent Technology (Suzhou) Co., Ltd. A Method for Clustering and Networking in Large-Scale Wireless Sensor Networks: 202211311766.2[P]. 2023-01-31.

[3] Elites Intelligent Technology (Suzhou) Co., Ltd. Method and Apparatus for Generating Deployment Location Maps Based on IoT Lighting System: 202411463800.7[P]. 2024-11-22.