Koolmesh System Overview

Revision History

Date	Version	Description
March 2025	V1	First release

Introduction

This document is a useful asset for specifiers, solution partners, and end users involved in lighting control design. It doesn't aim to substitute essential statutory, mandatory, or recommended design documents but to supplement them.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

Wireless Mesh Solution

How does it work?

Koolmesh is an advanced lighting control solution that capitalizes on the power of Bluetooth® Mesh technology, which is built upon the foundation of Bluetooth® Low Energy.

Bluetooth® Low Energy, being the most prevalent and dependable low - power radio technology present in all contemporary devices, acts as the fundamental communication bridge. It enables seamless interaction between a mobile phone or other control devices and the Koolmesh network. Once the connection is established via BLE, the Bluetooth Mesh technology takes over to ensure secure, encrypted device - to - device wireless communication within the lighting network.

In the context of Bluetooth Mesh's operation, Koolmesh's technology is designed to be highly adaptable. It can be smoothly integrated into a diverse array of components such as fixtures, LED drivers, LED modules, switches, sensors, and various control modules. Each of these components, when integrated with Koolmesh, becomes a node within the Bluetooth Mesh network. Based on the mesh network's multi - hop and self - healing characteristics, data can be transmitted across multiple nodes.

Koolmesh technology constructs a mesh network where the intelligence of the system is replicated across every node. In a Bluetooth Mesh network, each node not only receives and transmits data but also has the ability to route information for other nodes. This distributed intelligence, facilitated by BLE - based communication, creates a resilient system with no single point of failure. If one node malfunctions, the network can automatically re - route data through alternative paths, ensuring continuous and reliable operation of the lighting control system. This design not only results in an ideal solution that is easy to install and highly functional but also minimizes the need for additional hardware and reduces deployment costs, offering a cost - effective and efficient approach for lighting control systems.

How Koolmesh differentiates from other wireless solutions

Koolmesh, powered by Bluetooth® Mesh technology, stands out from other wireless solutions due to features below:

Ease of deployment

With Bluetooth® technology native in 100 percent of smartphones and tablets, installers can use commissioning apps that communicate directly with nodes on a Bluetooth® Mesh network, eliminating the need for specialized engineering expertise or internet and cloud platforms to support installation and operation of the system. In addition, a remote provisioning feature makes adding new devices or changing existing devices even easier.

Reliable & scalable performance

Bluetooth® Mesh Networking was specifically designed with large-scale wireless network deployments in mind. Three key features help separate Bluetooth® Mesh Networking from other wireless networking technologies and provide the resiliency needed by installers, building managers, and end users in commercial and industrial installations.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

- Control systems based on Bluetooth® Mesh Networking do not require centralized controllers, as intelligence is distributed to all end devices. A decentralized control architecture enables systems to achieve significantly greater scale, reliability, and performance, at lower costs.
- A unique publish/subscribe message addressing approach significantly lowers messaging traffic on the network, leading to greater network scale and performance.
- Bluetooth® Mesh Networking offers multiple options for message relay. Managed Flood provides reliable, multi-path messaging over multiple hops. Directed Forwarding increases scalability and can improve messaging efficiency in the most complex, large-scale mesh networks.

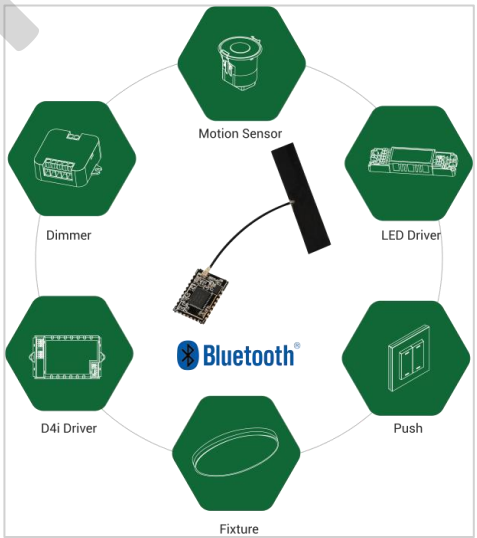
Interoperability with other standards

Koolmesh supports key standards that have a significant market presence. Some of the standards that Koolmesh devices are compatible with today are:

• DALI (including DT6 and DT8), DALI-2 and D4i
• EnOcean kinetic switches
• 0-10V &1-10V
• PWM controllable LED strips
• Relay input & output
• Shelly energy metering
• RGBW
• Trailing edge dimming

Hardware Overview

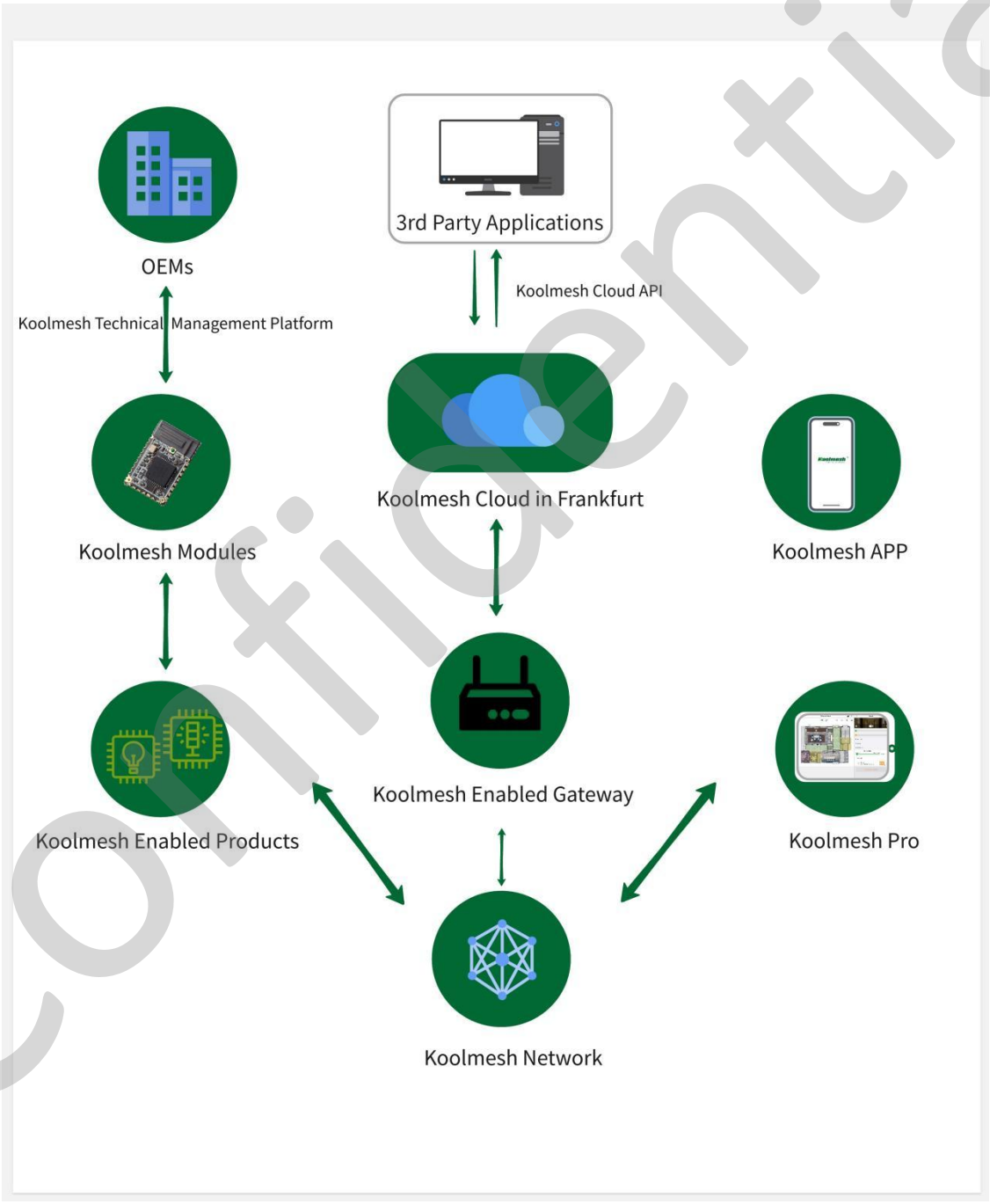
Koolmesh's hardware products mainly include KMB series Bluetooth modules. The main Bluetooth modules currently used are KMB02/KMB03.Based upon Nordic Semiconductor's nRF52840 / nRF54L15 SoC, both modules offer low energy consumption, great memory for Flash & RAM, and support the latest Bluetooth® 5. Specification to offer long-range and high throughput modes. Through Koolemsh technology, these modules can be integrated into a wide range of components, including fixtures, LED drivers, LED modules, switches, sensors, and various control modules.



Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

Building on the capabilities of Koolmesh's hardware products, the Koolmesh Technical Management Platform brings a wealth of advantages. It simplifies the integration process and cuts down on costs while enhancing functionality. With this platform, you can easily oversee and update firmware across installations worldwide.

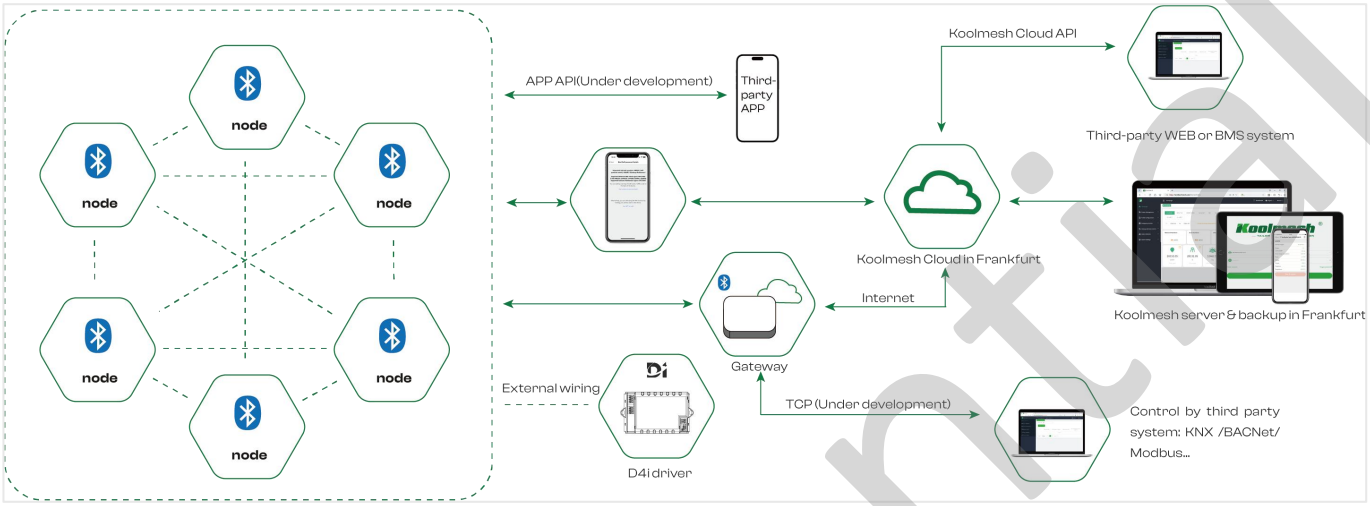
Regardless of the product architecture, whether it's switches, sensors, or drivers, the platform allows for seamless adaptation without the need to re-engineer the core hardware. You can define hardware - specific parameters like PIN assignments and voltage ranges. In just a few minutes, you can generate customized firmware packages tailored to your unique requirements.



Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

System Architecture

The Koolmesh system supports collaborative work among iOS smartphones, Android smartphones, iPads, web platform, and other third-party systems.



Network

In the Koolmesh system, there are concepts of projects and networks. A project generally refers to a site for actual application, and different areas within the site can be divided into different networks as needed. In the Koolmesh system, after creating the project and network, add Koolmesh enabled devices to the network, and a Bluetooth mesh network is built.

The Koolmesh system is powerful and can accommodate countless networks under one project, and the number of nodes in a single network can reach thousands. In general, we recommend configuring 200 Bluetooth nodes and 400 receivers for each network, but the actual number of nodes needs to be flexibly determined based on the specific application installation environment.

In addition, Koolmesh also supports the collaborative management of multiple networks with the help of gateways(Multi-network gateway synchronous control),which greatly improves management efficiency and convenience, and provides strong support for system integrators to achieve diversified and large-scale deployment in different scenarios.

For more information about Koolmesh projects and networks, please refer to the Koolmesh APP User Manual and other related documents.

Gateway

The gateway plays a very important role in the Koolmesh system.

By using a gateway, it is possible to access and control Koolmesh networks remotely or interface Building Management Systems and other third-party services (via a Cloud API). It also allows for network monitoring.

There are several gateway options from Koolmesh:

• **Koolmesh Enabled Gateway**: The Koolmesh Enabled Gateway is a device enabling users to control and receive data from their network remotely over the internet. The device has Ethernet and WiFi connections available for the internet. It should be powered and within Bluetooth range of the network for which it is acting as a gateway.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

• **Smartphone or tablet**: A device that is permanently powered can also simulate a gateway from the Koolmesh app. It must be within Bluetooth range of the network for which it is acting as a gateway, and have an internet connection. The Koolmesh app must be continuously activated and when simulating the gateway,users need to stay in this page and not quit.

• **BMS Gateway:**Koomesh BMS Gateway as a type of edge device,is like an intelligent bridge, connecting the Bluetooth lighting system and the Building Management System (BMS), building an efficient data channel, and realizing collaboration between the two. With it, the device status, energy consumption and other data of the Bluetooth lighting system can be accurately transmitted to the BMS in real time; the BMS can also send instructions to the Bluetooth lighting system through the gateway according to the preset logic to realize intelligent dimming and scene switching, so that lighting management and environmental control can work together to improve the building's intelligence level and energy efficiency.

Koolmesh API - interfacing 3rd party systems and solutions

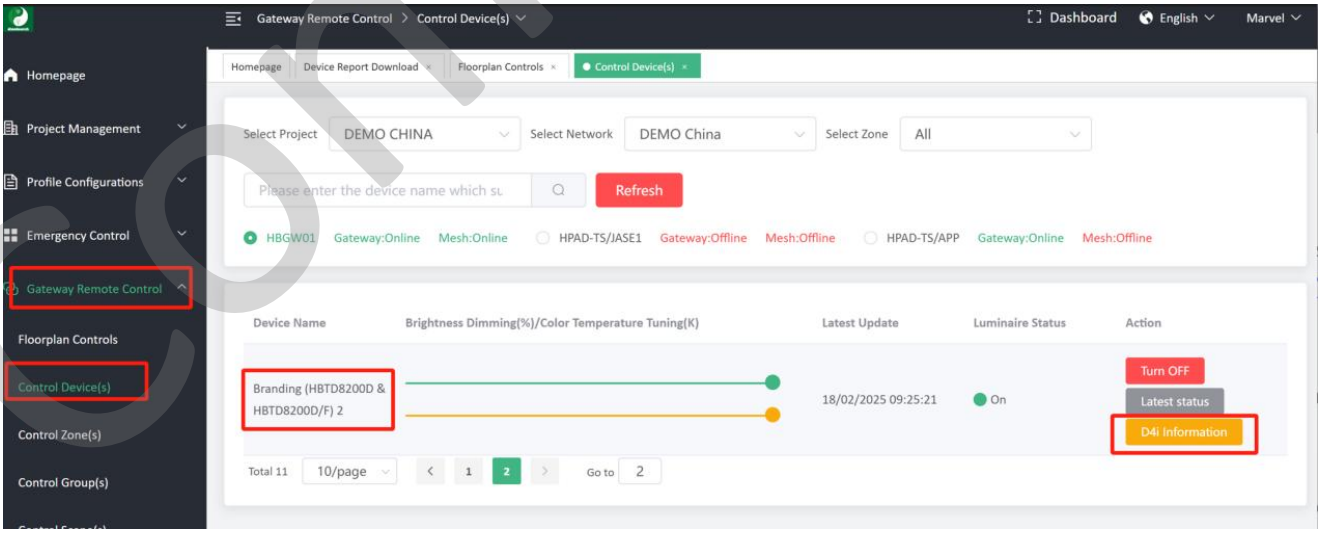
Third - party systems can obtain data from the Koolmesh system through the Koolmesh Cloud API.

An API (Application Programming Interface) is a set of routines, protocols, and tools to enable custom software applications to be built. Koolmesh 's API allows developers to connect to a Koolmesh system. It specifies the "building blocks" and defines what interactions are permitted. A software programmer can use the API building blocks to develop custom software applications, such as different user interfaces.Koolmesh also supports Cloud API,allow users to integrate data into their own platforms as needed.

D4i related data extraction

D4i is an extension of the DALI-2 certification program. D4i LED drivers have a mandatory set of features related to power supply requirements and smart-data capabilities. Such drivers inside the luminaire have the capability to store and report a wide range of luminaire, energy and diagnostics data in a standardized format; which can then be used for performance monitoring, asset management, predictive maintenance and many other tasks.

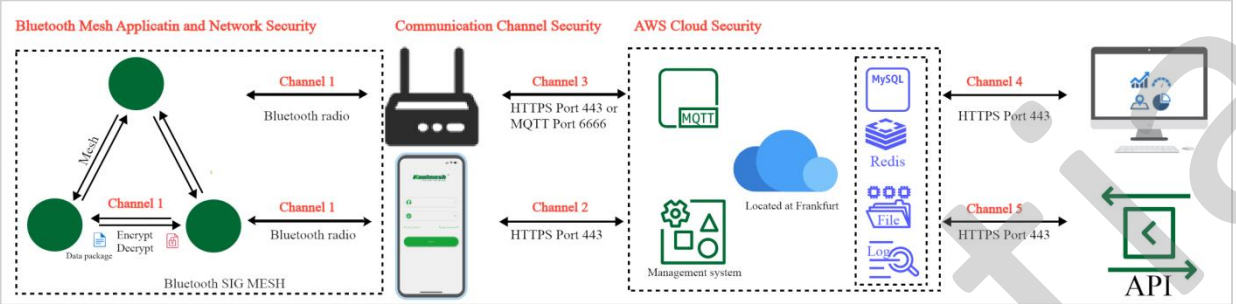
In a Koolmesh network, D4i related data can be extracted and communicated for monitoring and management purposes,for example,the energy related data will be displayed on the energy consumption statistics on Koolmesh IoT platform.



Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

Security

There are three levels of security in Koolmesh system, they are Bluetooth MESH Application and Network Security, Communication Channel Security, AWS Cloud Security.



Bluetooth MESH Application and Network Security

1. Bluetooth Mesh Protocol

Encrypting and authenticating messages at the upper transport layer and network layer is designed to secure communications within the mesh network against eavesdroppers and malicious attacks. Each layer maintains distinct keys to allow separation between application and network entities.

All messages are encrypted and authenticated using two types of keys. One key type is for the network layer communication, such that all communication within a mesh network would use the same network key. The other key type is for application data. Separating the keys for networking and applications allows sensitive access messages (e.g., for access control to a building) to be separated from non-sensitive access messages (e.g., for lighting). There are no unencrypted or unauthenticated messages within a mesh network.

The BLE SIG 5.0 Standard covers requirements for this, including

- Encryption and Authentication

All Bluetooth mesh messages are encrypted and authenticated

- Separation of Concerns

Network security, application security, and device security are addressed independently

- Area Isolation

A Bluetooth mesh network can be divided into subnets, each cryptographically distinct and secure from the others

- Key Refresh

Security keys can be changed during the life of the Bluetooth mesh network via a Key Refresh procedure

- Message Obfuscation

Message obfuscation makes it difficult to track messages sent within the network and, as such, provides a privacy mechanism to make it difficult to track nodes

- Replay Attack Protection

Bluetooth mesh security protects the network against replay attacks

- Trashcan Attack Protection

Nodes can be removed from the network securely, in a way which prevents trashcan attacks

- Secure Device Provisioning

The process by which devices are added to the Bluetooth mesh network to become nodes is a secure process.

More details,please refer to the link below:

https://www.bluetooth.com/blog/bluetooth-mesh-security-overview/ or refer to Mesh Profile / Specification Revision: v1.0.1 2.3.9 Security.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

2. Over the Air (OTA) update

The Koolmesh system is fully compliant with the SIG 5.0 standard in the Bluetooth layer. The SIG 5.0 Standard ensures continual monitoring of potential security threats. Therefore if a potential threat is detected against the current SIG 5.0 protocol, the protocol will be updated, and Koolmesh will follow this, and update our protocol immediately. If required, an applicable update can be implemented to an existing network system, via an "Over the Air" (OTA) upgrade by the manager for the site network. All OTA updates for the firmware are protected by the Koolmesh protocol, and only the Koolmesh App or Koolmesh enabled gateway can gain access to the Koolmesh firmware server to request an update. All firmware is encrypted on both the application side and network side. Every time the user requests a update via the App, it will send the user's token and sign to the server to authorize access. When the authorization is approved, the server will send out the encrypted updates through the internet to the App. The App will again check the sign and token, before decrypting the update and installing it on the device.

3. Account ownership, Project, Network, Permission Management and Authorization Levels of installation

In the Koolmesh system, there are three account identities or "levels" for a single mesh network:

• Installer;
• Admin;
• Sub-user;

Admin:

This identity / level has full access to the network, including the ability to add or delete installers to the network; add or delete sub-users; and give the sub-users different layer permissions of network functions. One mesh project /network will only have one Admin level account but can have many installers or sub-users. If the Admin does not want to manage the project /network anymore, they can transfer the ownership to another user by creating a unique QR code (with encrypted key as previously mentioned). Once the project or network is transferred, it will vanish from the Admin's account. Admin can manage the sub-user's permission levels,e.g. Only open control access to the sub-user, but do not allow them to change sensor's commissioned settings or scene setting. These permissions can be set in the Koolmesh App PERMISSION SETTINGS when clicking "Add sub user".

Installer:

This identity / level is intended to commission the network, so it has full access to the network, and is responsible for managing the network, which includes adding or removing nodes from the network; changing mesh settings or single devices settings and conducting OTA upgrades (usually conducted during commissioning phase). If the Installer who created the mesh network does not transfer the network to any other Admin level user, this Installer can add a new Installer to this network. The installer can also add sub user,which has the same process as for Admin.

When the Installer adds a new installer account to this network, the App will generate a QR code and an encrypted, randomized key (remains open and valid for 24 hour). Therefore, the new installer can utilize the Koolmesh App to scan this QR code or input the encrypted randomized key, thereby gaining access to the same network. All the authorization process is done within the Koolmesh App.

After the installer has finished the commissioning on site, they can "transfer" the ownership of the network to the Admin account, there is "transfer" available. They will need to enter their account password generating a QR code and complete this process. After the "ownership transfer" is completed, this network will disappear from the installer's account, and will appear on the Admin's account instead.

Sub-User:

Managed by the Admin/installer level user, the Sub User identity / level does not usually have the full access and permissions to the network. This level cannot transfer or add Installers. Again, this identity can be authorized by the Admin/installer level to have different layer permissions,e.g. only permit on/off control of the luminaires.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

All the authorization processes are protected by the Koolmesh protocol, and all the encryption keys are generated randomly, and are unrepeated (as detailed above). All the account data is encrypted and saved, with backup on the cloud servers.

Communication Channel Security

There are several communication channels throughout the Koolmesh system, including

Channel 1 Node and node, node and mobile phone or gateway

Channel 2 Mobile phone and Cloud

Channel 3 Gateway and Cloud

Channel 4 Cloud and Web platform

Channel 5 Cloud and Open API

All these channels are secured by the below ways (except channel one; channel one is secured by the Bluetooth MESH).

- 8 changeable passwords

A combination of uppercase and lowercase letters, numbers, and special characters

- AES 256 symmetric-key encryption cipher

All the Koolmesh node data packages can be only encrypted or decrypted by the Koolmesh App or the Koolmesh enabled gateway. There are no other methods, third - party equipment or software that handle the mesh data packages. All the data formats and encryption methods are bespoke to the Koolmesh system, and are not used or shared with any third - party. Koolmesh has two very important elements that protect the data when it is being transferred to the cloud server:

- **Element 1: "Token":**

As the user logs in, they will provide user authentication information (such as account and password details) to the server. After authentication, the server returns a "Token" to the client's account. When the user sends or requests information again, this token is attached to it. If the token is received and verified, the data will be returned.

- **Element 2: Message signature ("sign"):**

This uses ASCII code and takes the first "Token" element as input. Then, it uses MD5 ("fingerprint file") encryption to generate a secondary "sign" signature; and then every time you "call" the system for user information after logging in, the system uses both the "Token" and "Sign" parameters for authentication.

- CBC (Cipher Block Chaining) / PKCS5Padding

AWS Cloud Security

Koolmesh cloud services are hosted on the Amazon Web Services which are located at Frankfurt. Cloud security at AWS is the highest priority. For more details, please refer to the link below:
https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/ec2-security.html

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

APP Feature Overview

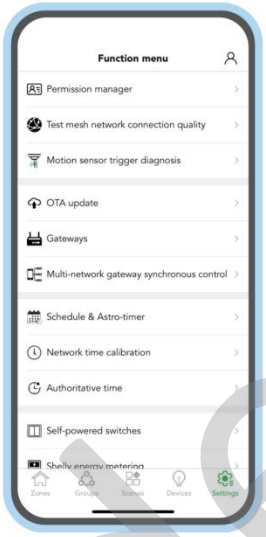
The Koolmesh app serves multiple roles in a Koolmesh lighting control solution: it acts as a user interface, commissioning tool, diagnosis and troubleshooting tool,management and maintenance tool and also emergency test tool. It is compatible with both iOS and Android devices and can be downloaded for free from the Google Play Store and Apple App Store.

Commissioning

- Zone / Group
- Motion sensor
- Daylight sensor
- Luminaires
- Scenes (Animation & time-based scene)
- Schedule & Astro-timer
- Push switches / Self-powered switches
- Floorplan & Staircase function
- Gateway / Central control screen
- Bulk commissioning
- Off-line commissioning
- RGBW function
- Shelly energy metering
- Multi-meter

Expansion

- Emergency



Diagnosis and Troubleshooting

- Device network relations
- Test mesh network connection quality
- Motion sensor trigger diagnosis
- Motion sensor range test
- Check schedule

Management and Maintenance

- Alert for excess lux / temperature / humidity
- Alert for overheating / overvoltage..protection
- Gateway offline notification
- Emergency failure notification
- Permission manager
- Report generation
- Mesh OTA
- One-key device replacement
- Third-party system(e.g. BMS)

More information about app functions please refer to the Koolmesh APP User Manual and video tutorials.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

Wireless Emergency Lighting

Koolmesh solution for emergency lighting provides:

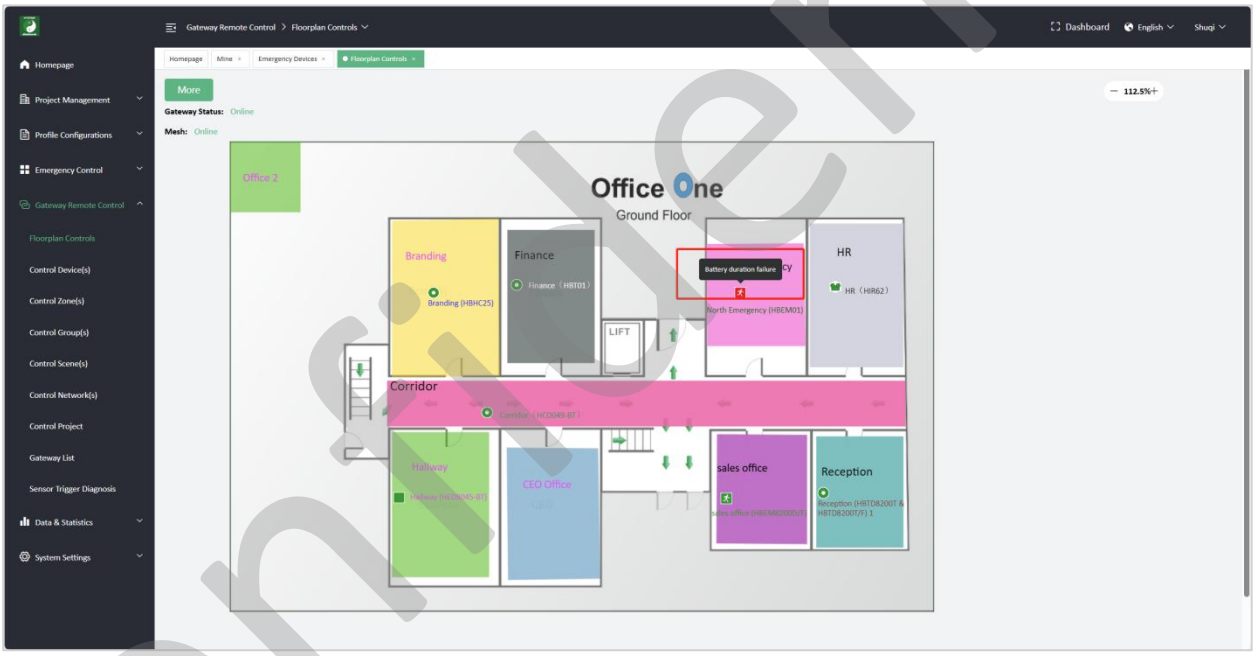
• **Automatic test**:The system supports automatic test scheduling. Users can set the time for automatic function test and duration test in the Koolmesh app or Koolmesh IoT platform .

• **Manual test**: Users can manually trigger the function test and duration test through the Koolmesh app or push switch.

• **Group test:**Users can create different emergency test groups and set different test times by groups to avoid the situation where emergency lighting cannot be provided when an emergency occurs during the test.

• **System default configuration file:**Users can use the system default configuration files to quickly set up emergency lighting device,users can also copy parameters from an existing emergency device or add a new profile according to their needs.

• **Real-time monitoring:**Based on Mesh technology,Koolmesh system can monitor the status of emergency lighting device in real time,both on Koolmesh app and Koolmesh IoT platform, detect and deal with potential problems in a timely manner.



• **Data Collection and Reporting:**Test results can be collected through mobile applications or gateways , and detailed reports can be generated on the web for users to view and manage.

• **Email notification:**Notifications include Self-test results/Emergency failure notification and Self-test scheduling advance notice,which can help users better manage the emergency lighting devices.

More details about Koolmesh Emergency system please refer to Koolmesh Emergency Lighting Control Introduction and Emergency User Manual.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/

Project Reference

Rotterdam logistic warehouse - advanced lighting control - 80% energy savings

Less Energy undertook an ambitious project for a logistics warehouse in Rotterdam, aiming to develop an advanced lighting system that maximized energy efficiency while offering precise and adaptable control tailored to the space's specific needs.Partnering with Hytronik, a Koolmesh - based solution was implemented, transforming the warehouse's operations.

Koolmesh Solution

- Split the warehouse into 28 control zones, each programmed for specific lighting needs.
- Centralized control was achieved via the Koolmesh App. It simplified setup (including batch - programming sensors), allowed parameter customization (like light levels and hold times), and provided remote access for real - time adjustments and monitoring.

Results

- Automated, zoned lighting streamlined daily operations, optimizing lighting for different activities and improving efficiency.
- The lighting adjusted based on occupancy and natural light, reducing risks and creating a safe work environment.
- Advanced controls eliminated unnecessary activations and technical failures, ensuring consistent, accurate lighting.
- The 28 - zone division customized lighting for each area, enhancing spatial efficiency and optimizing energy use.
- The solution balanced operational efficiency and environmental responsibility, setting a new standard in the logistics industry.
- The system's scalability allowed for easy adaptation to future expansions, ensuring a good return on investment.
- The Koolmesh platform provided remote access and customization, simplifying operation for managers.

Address: Unit3, Tallow Way, Irlam, Manchester, M44 6RJ, United Kingdom
Tel: +44 (0) 1992 504 111
Email: info@koolmesh.com
Website: https://www.koolmesh.com/