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SIoT Project

# BLUETOOTH MESH

# What is Bluetooth mesh technology?

## Bluetooth® Classic

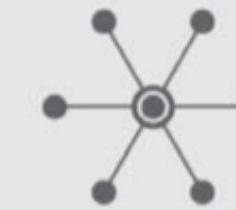
### Solution Areas



AUDIO STREAMING

DATA TRANSFER

### Device Communication



POINT-TO-POINT

### Basic Rate/ Enhanced Data Rate Radio



## Bluetooth® Low Energy

### Solution Areas



AUDIO STREAMING  
(COMING)



DATA TRANSFER



LOCATION SERVICES



DEVICE NETWORKS

### Device Communication



POINT-TO-POINT

BROADCAST

MESH

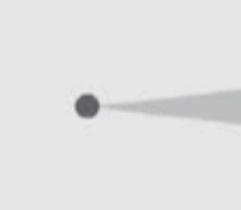
### Device Positioning



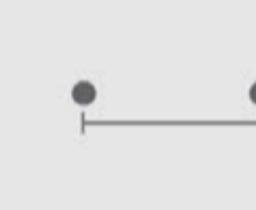
PRESENCE



PROXIMITY



DIRECTION



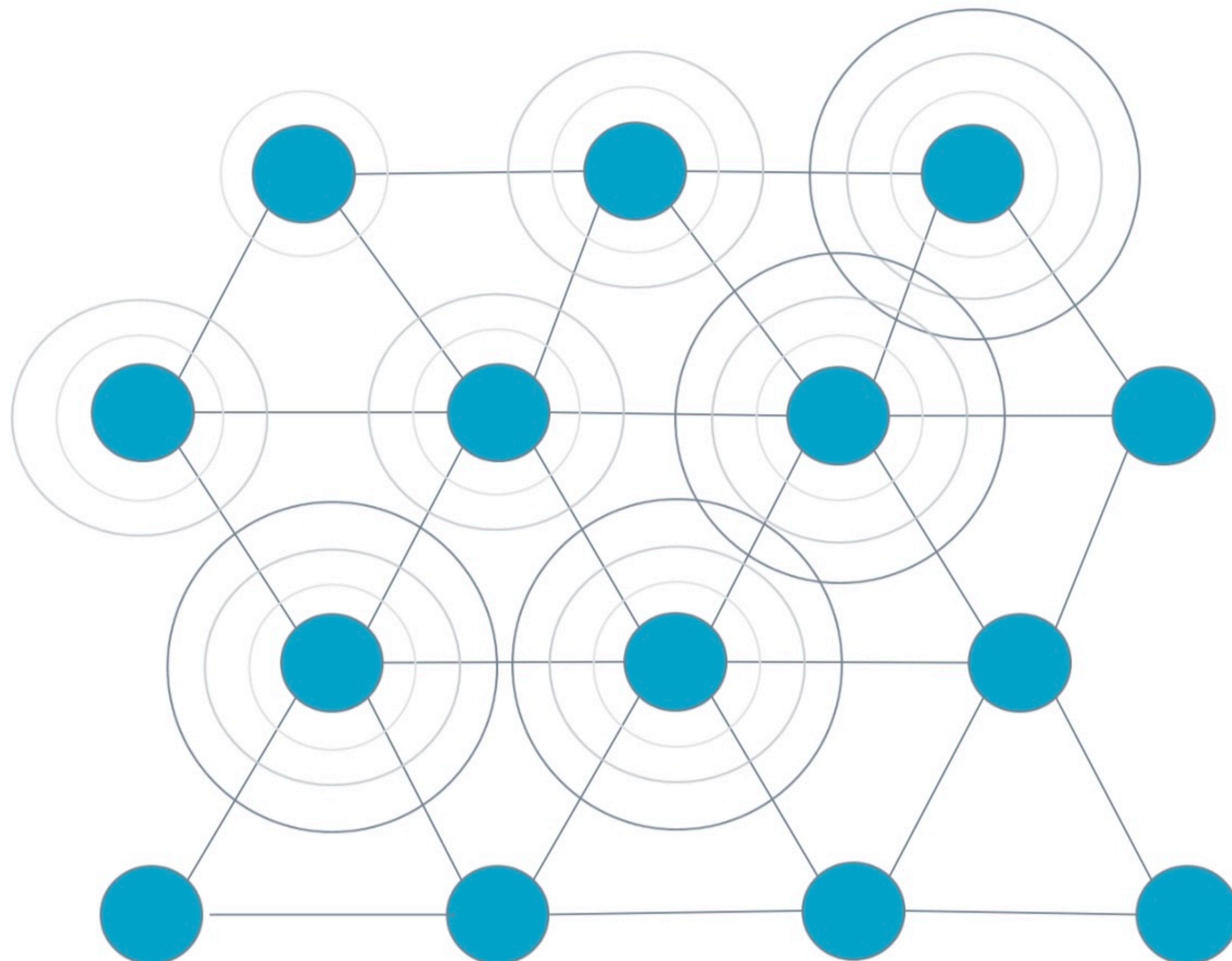
DISTANCE  
(COMING)

### Low Energy Radio



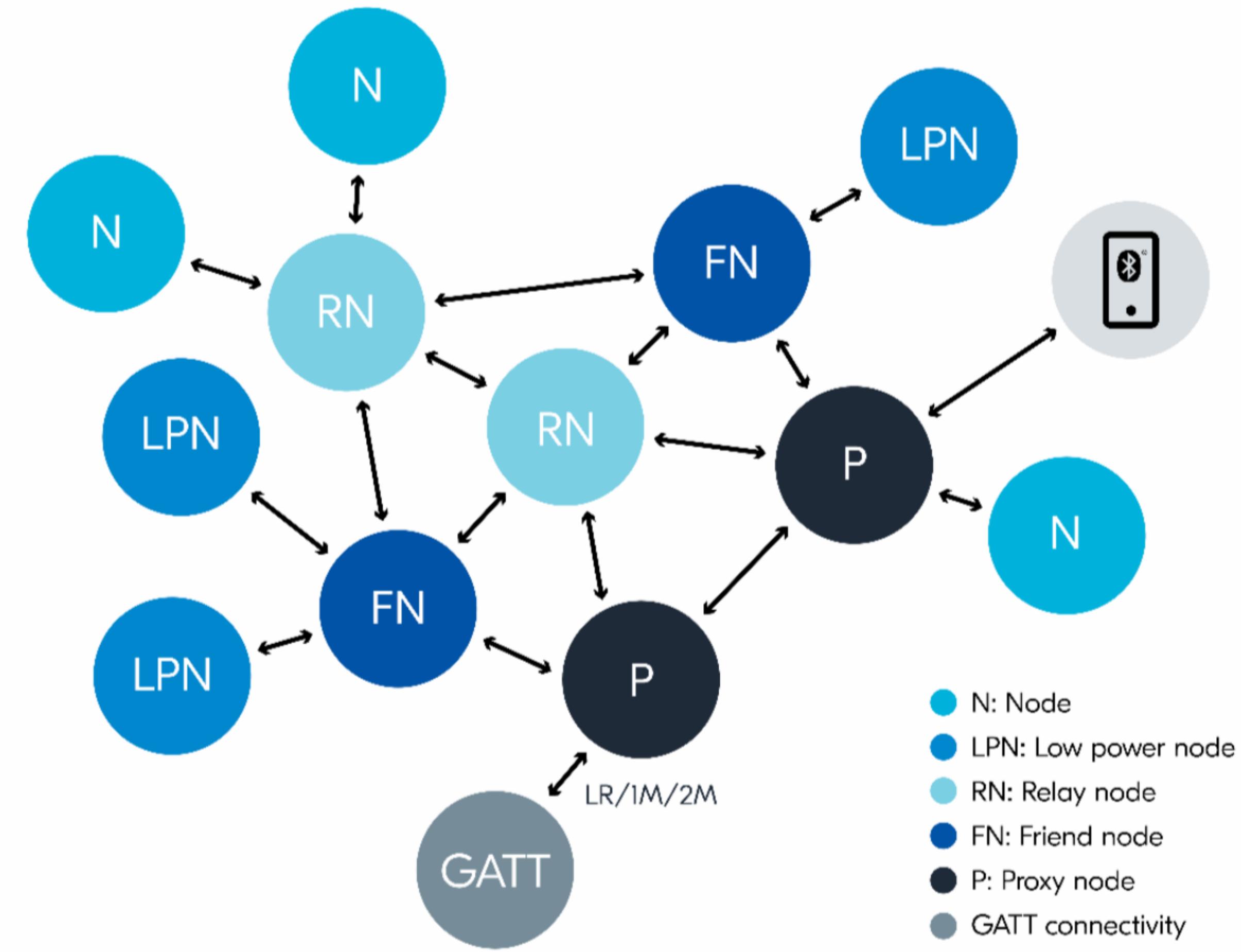
(Source: Bluetooth SIG)

# From point-to-point to mesh



- Based on Bluetooth LE
- Network technology
- Many-to-many communication
- Whole building coverage
- Managed flooding

# Bluetooth mesh roles



# Bluetooth mesh is designed to be:

Reliable



Multipath  
transmission  
Gateway independent

Scalable



Large node-count  
Covering large  
areas

Secure



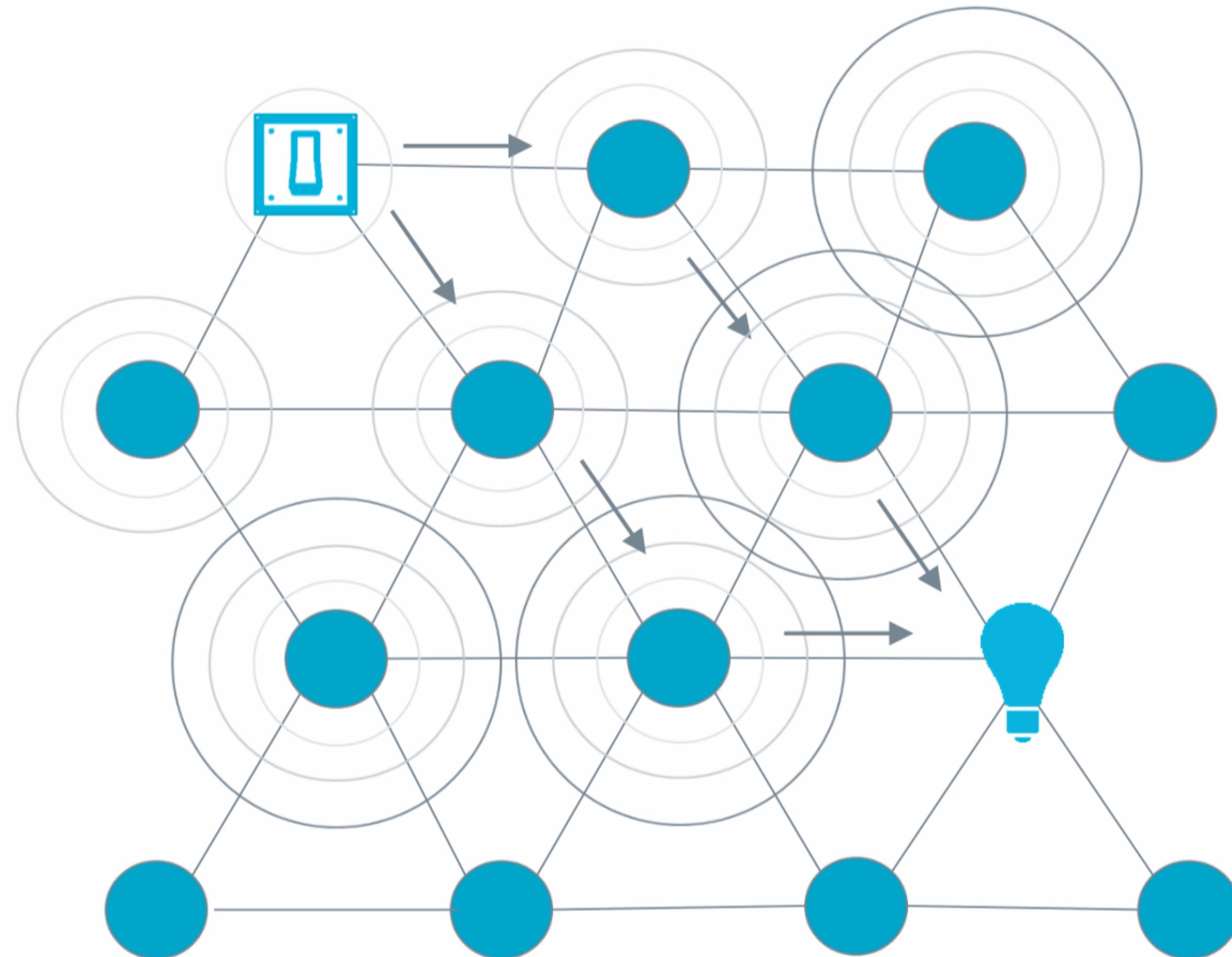
Built-in security  
Multi-level encryption  
Privacy

Fast



Responsive - low  
latency  
Multicast based  
(Does not mean  
high bandwidth)

# Multi-hop and multi-path



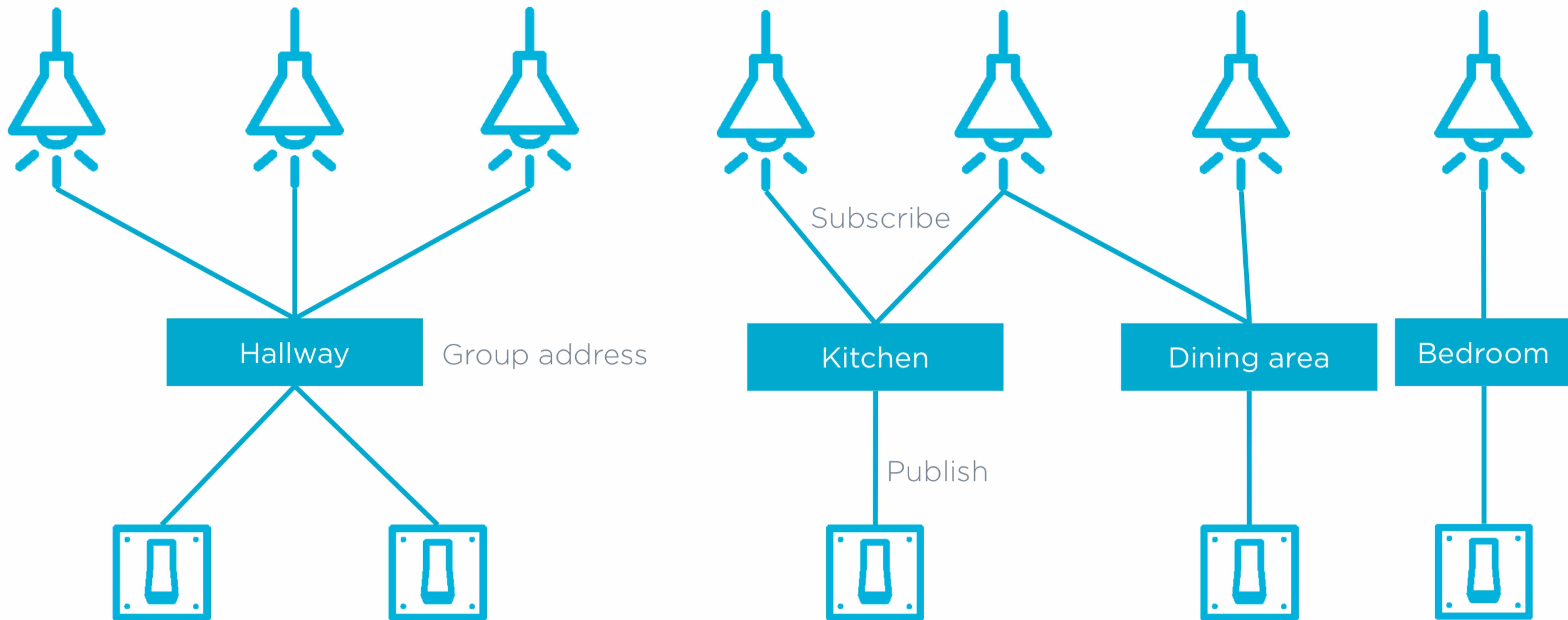
## Multi-hop (message relay)

- Extends range beyond RF
- Near unlimited range
- Avoid physical obstacles

## Multi-path

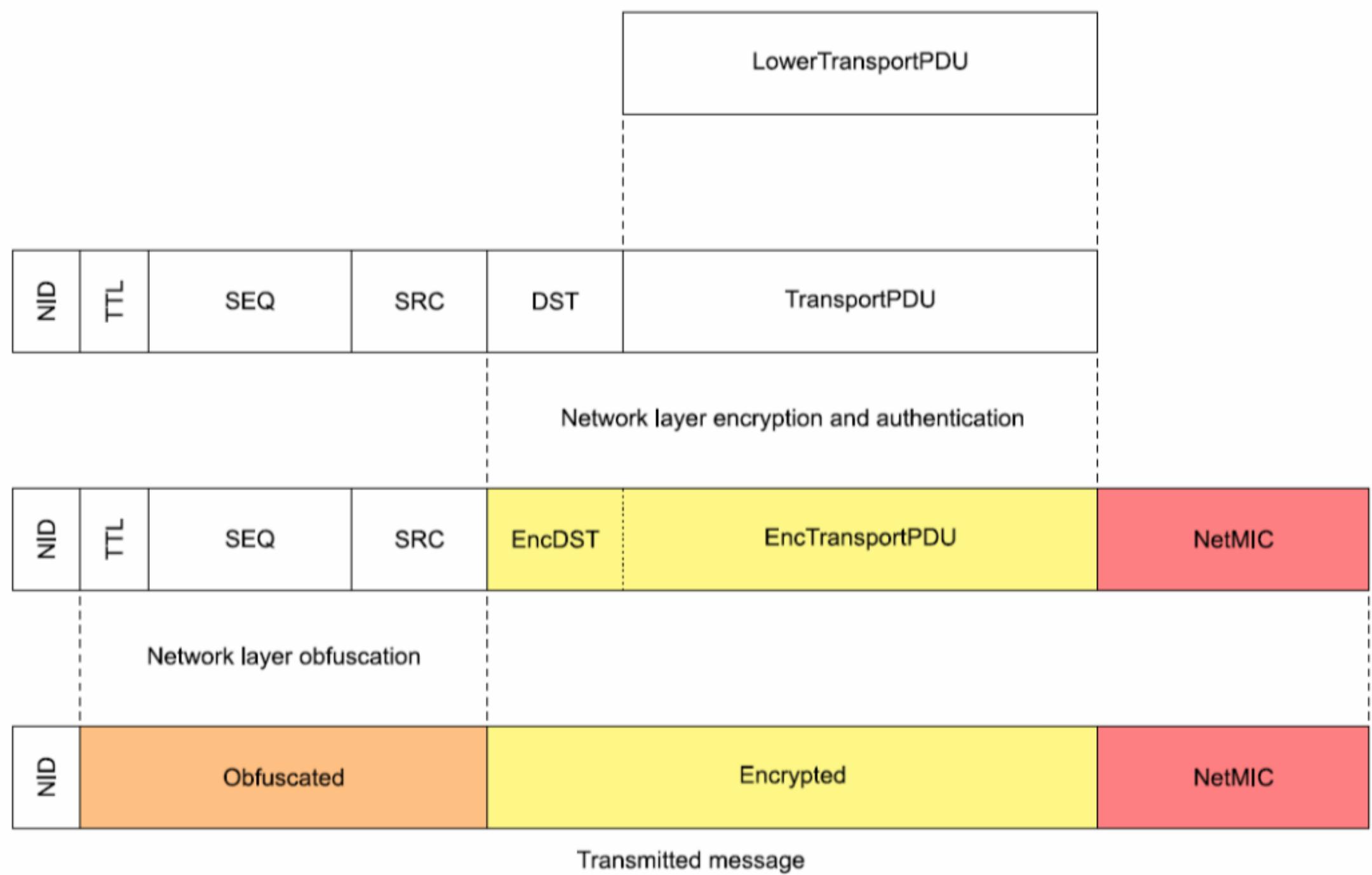
- Increases reliability
- Creates redundancy
- Ideal for multiple receivers

# Group addressing and publish/subscribe

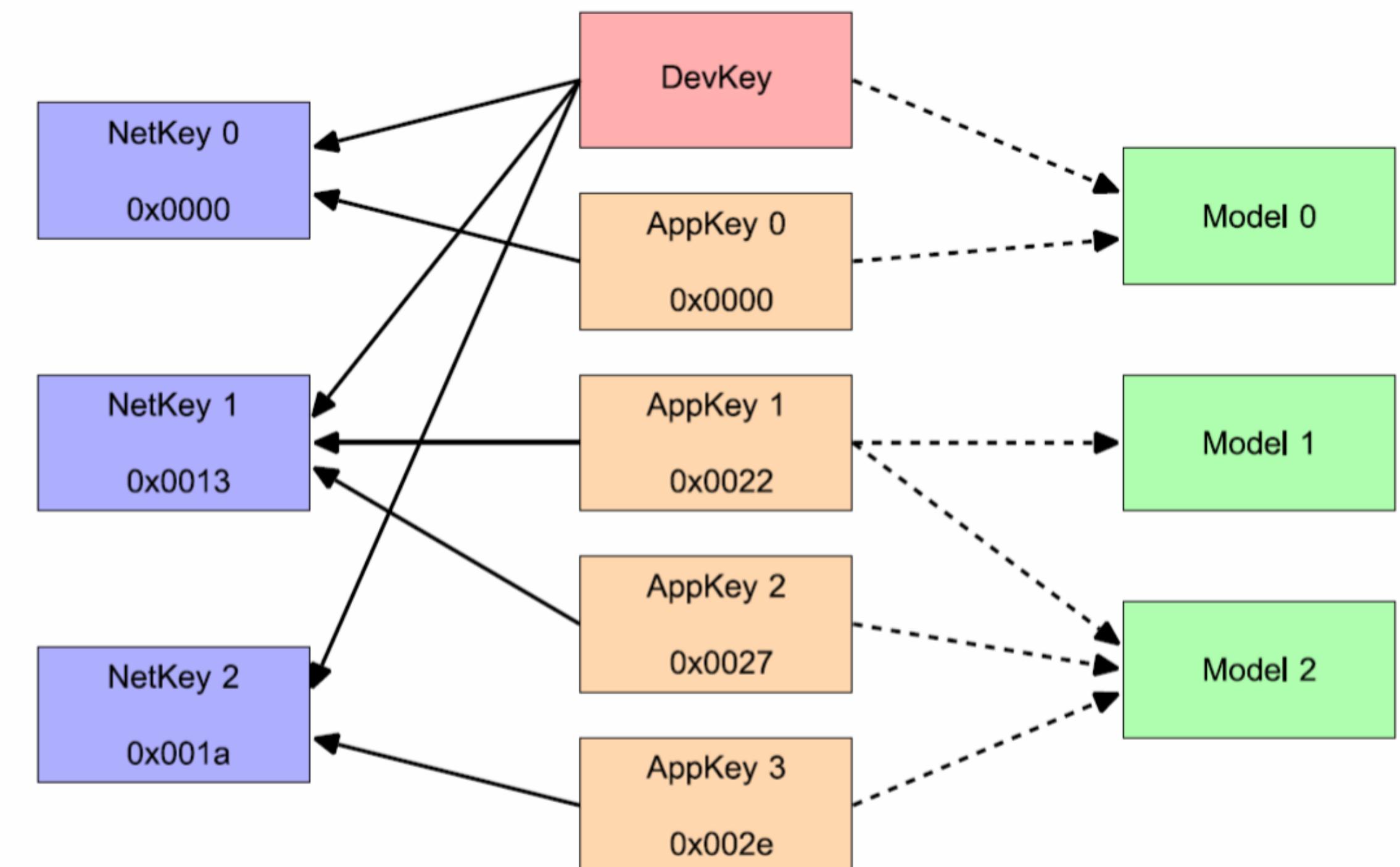


# Bluetooth mesh has built-in security

PDU structure



Encryption keys



# Industrial grade security



Delta panel light, first smart lighting  
product to receive UL IoT security rating

## Industry grade security

- Multi-level encryption
- Privacy

## Protected from the ground up

- Brute-force attack
- Replay attack
- Man-in-the-middle attack
- Trash-can attack

Continuous improvement on security

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# HOW MANY NODES CAN YOU HAVE IN A BLUETOOTH MESH NETWORK?

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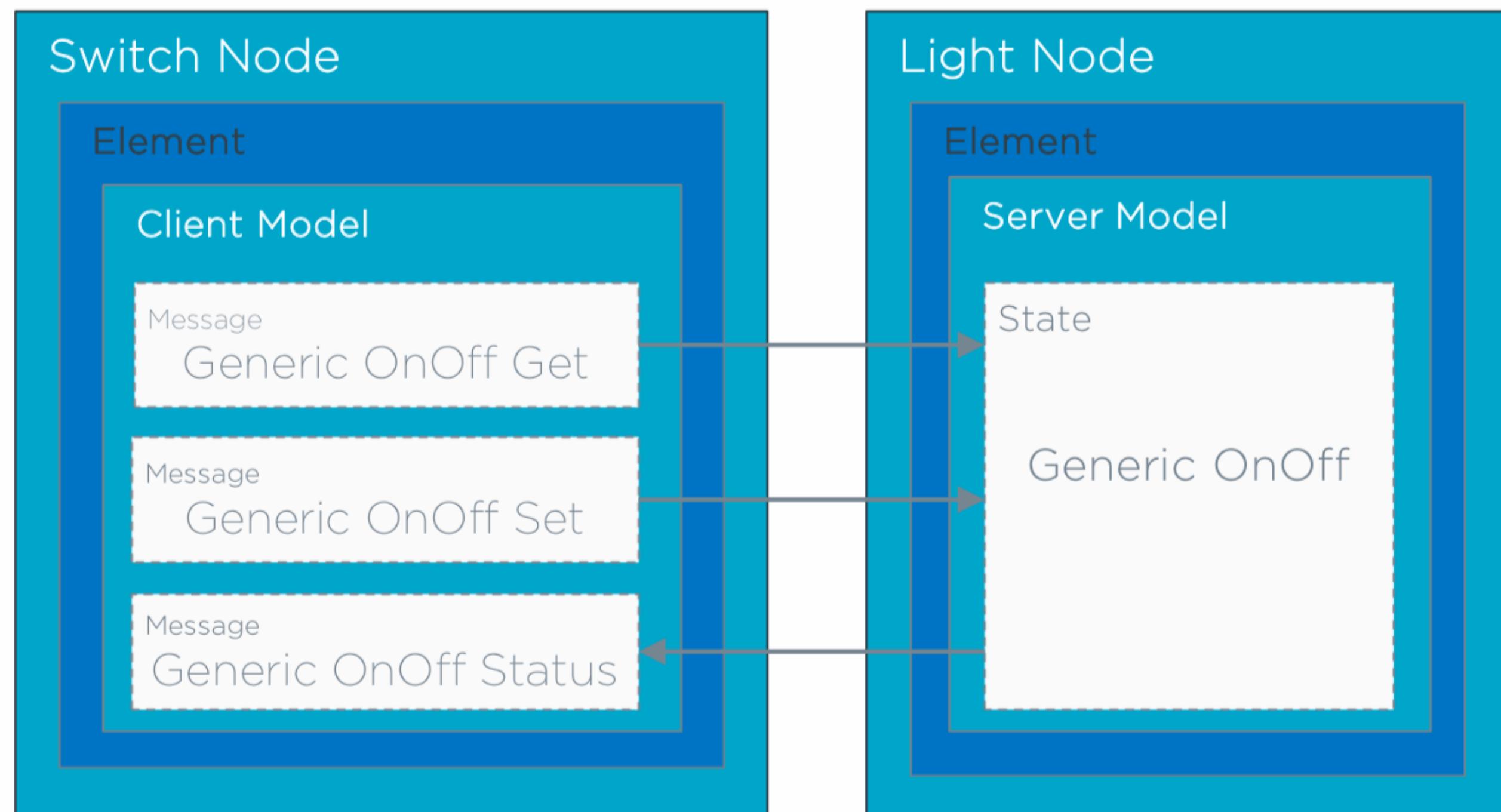
# Largest Bluetooth mesh lighting network

- 3685 mesh nodes
  - Expanded to 3923
- Light controllers with PIR/ALS sensors
- 17 floor office building in Minnesota
- Project by EMC, Silvair, and McWong International
- Runs on nRF52832!



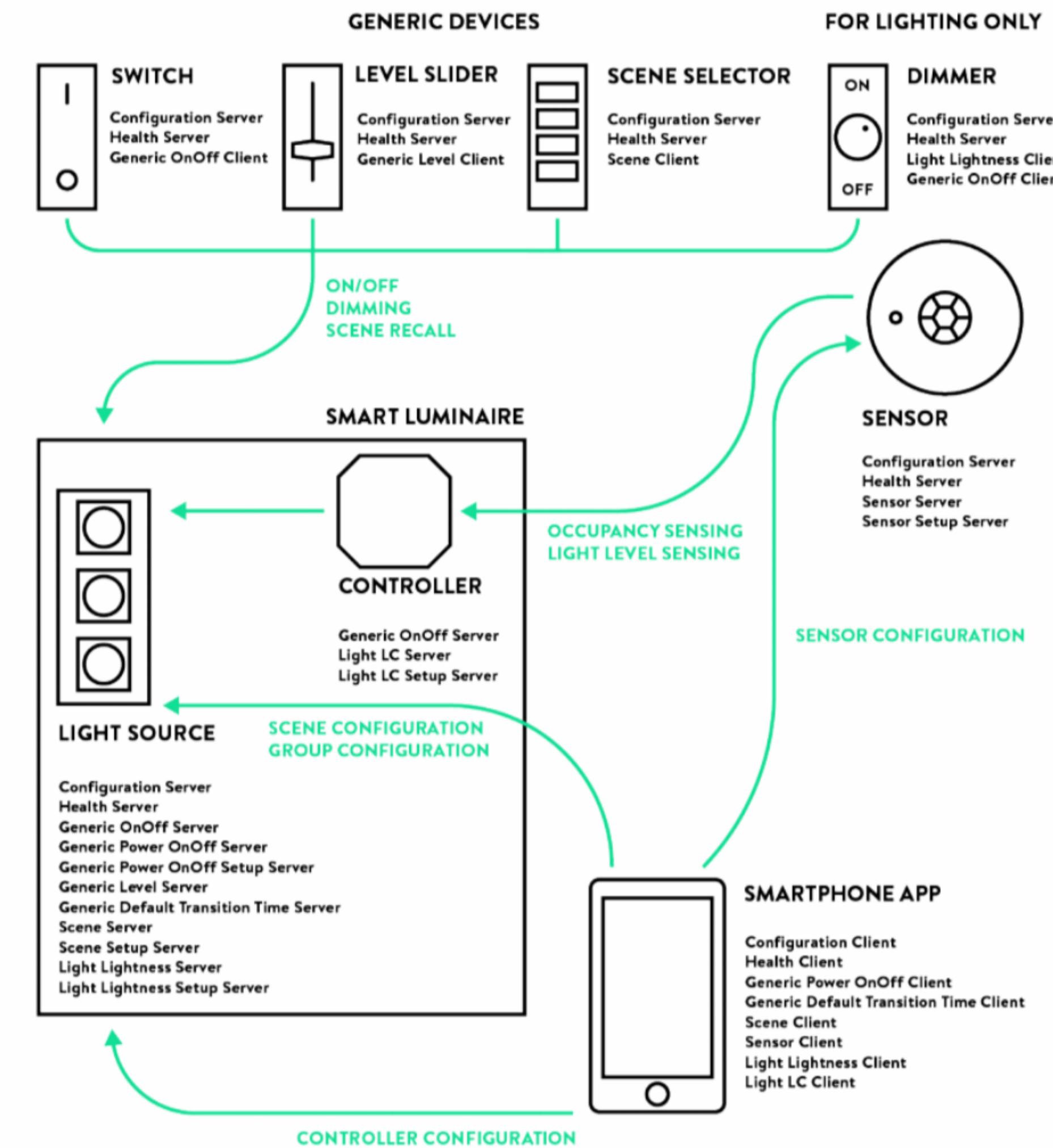
(Source: Silvair)

# Bluetooth mesh models

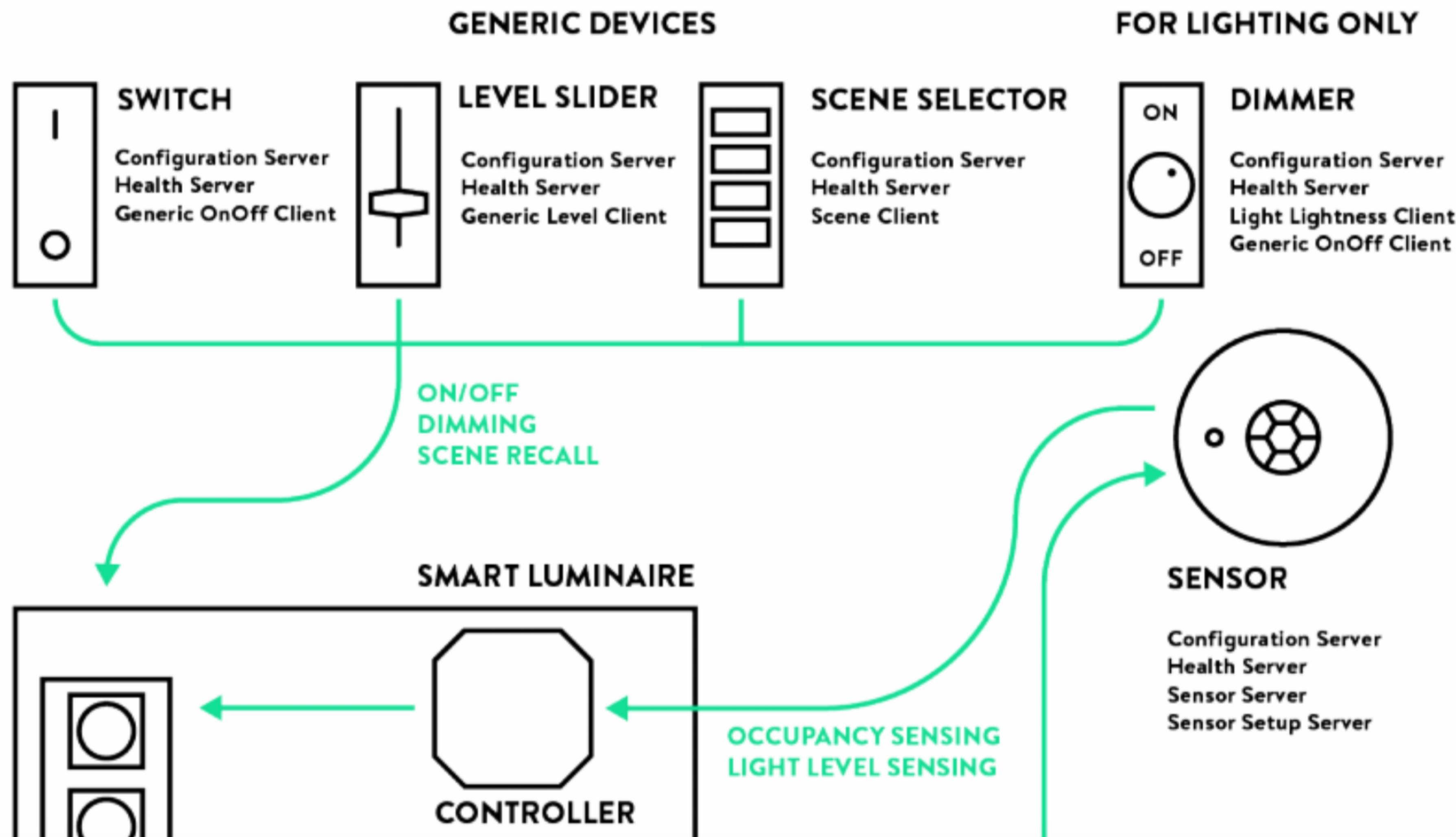


- Application layer concepts
- Light weight, backwards compatible
- Models defined for:
  - Generic features
  - Sensors
  - Time and Scenes
  - Lighting

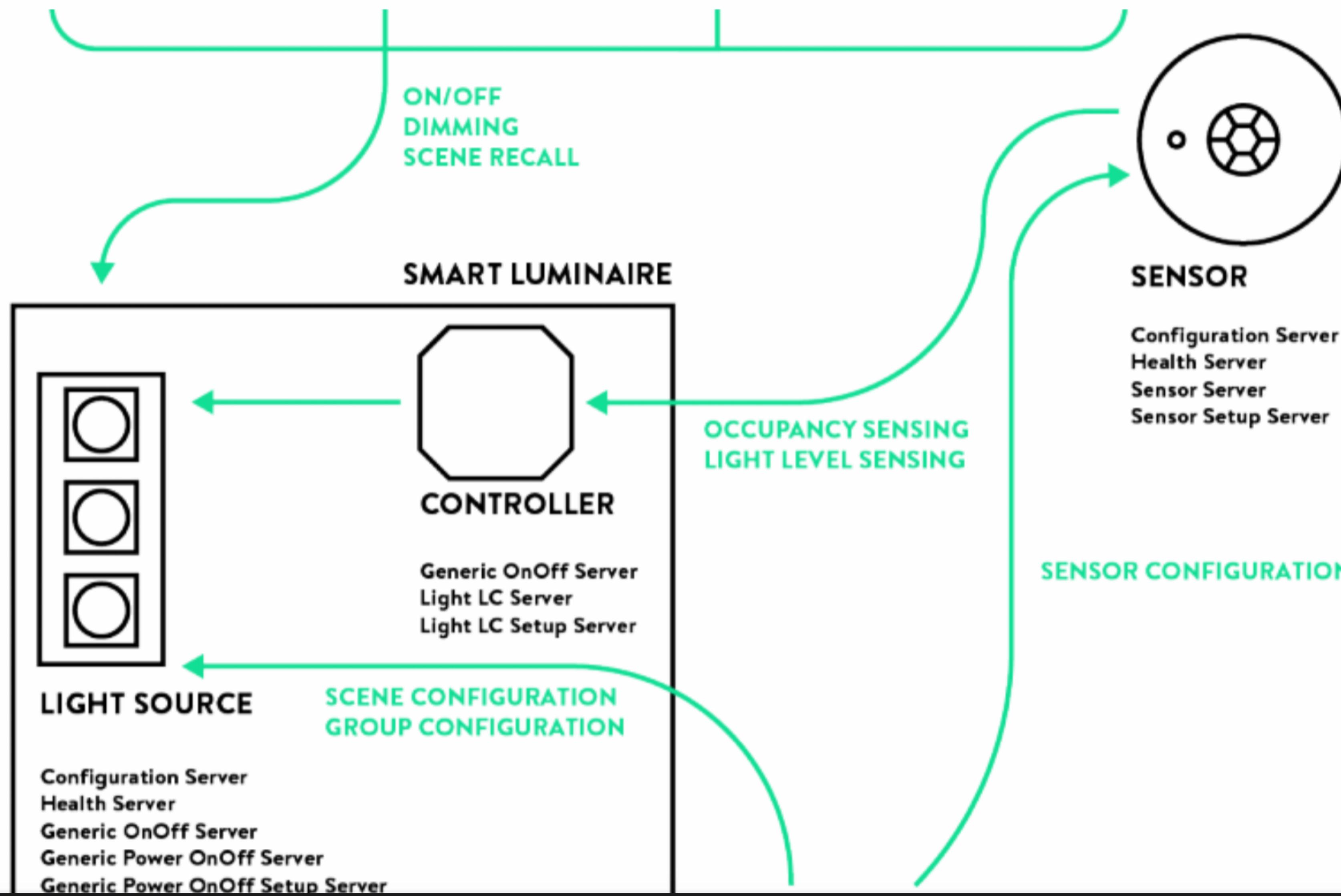
# Models used in a lighting control system



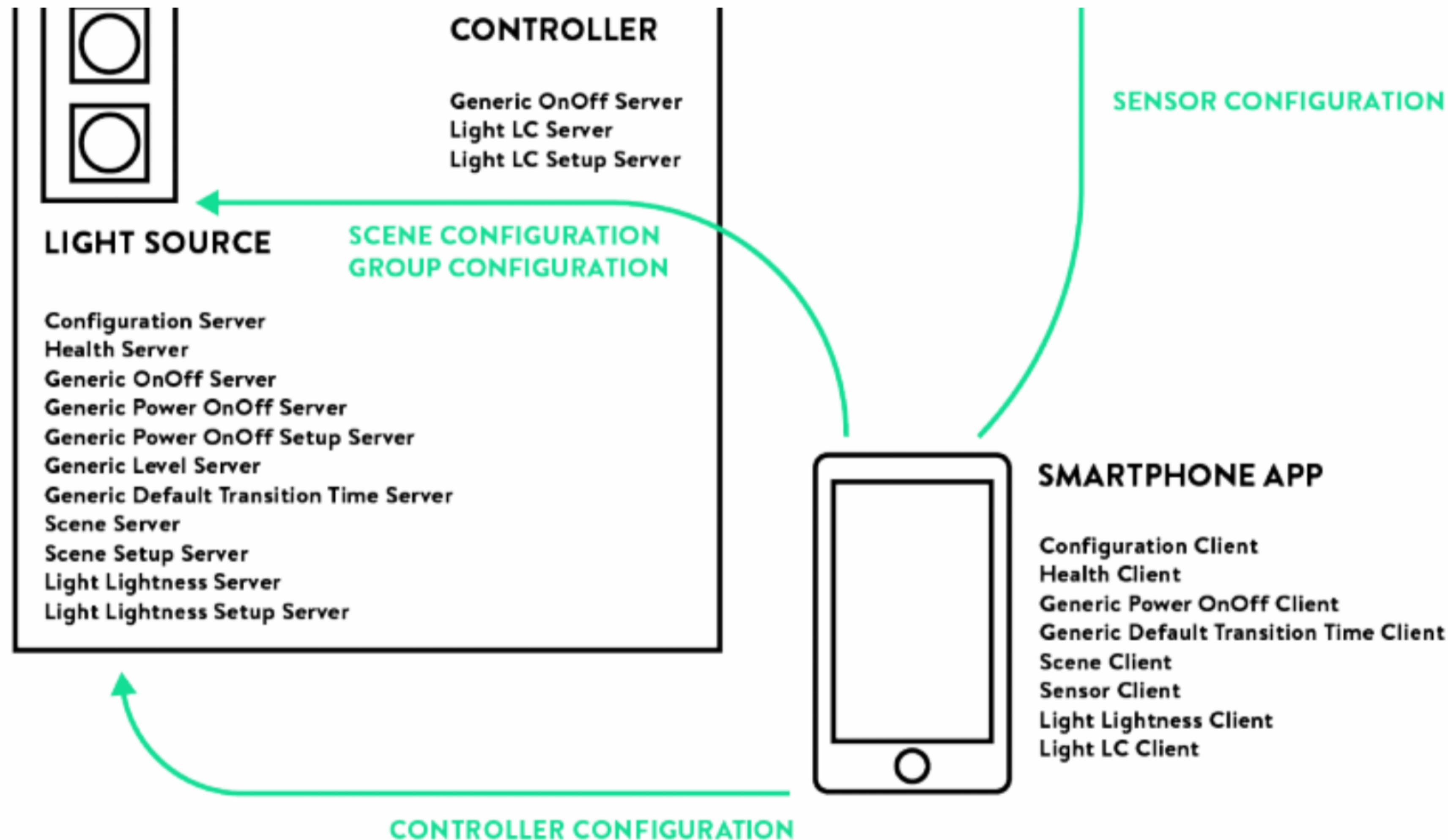
# Models used in a lighting control system



# Models used in a lighting control system

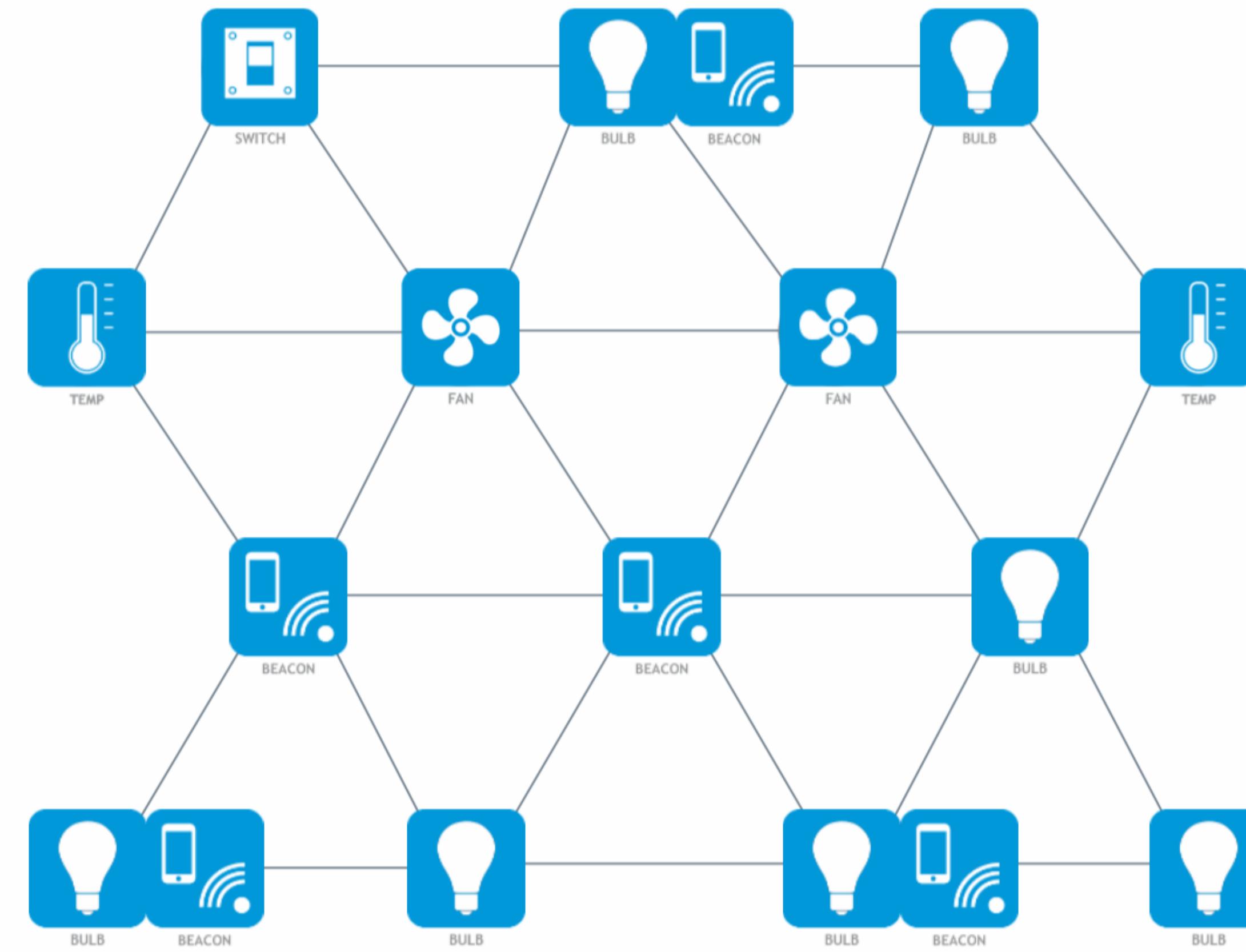


# Models used in a lighting control system



# From smart light to smart building

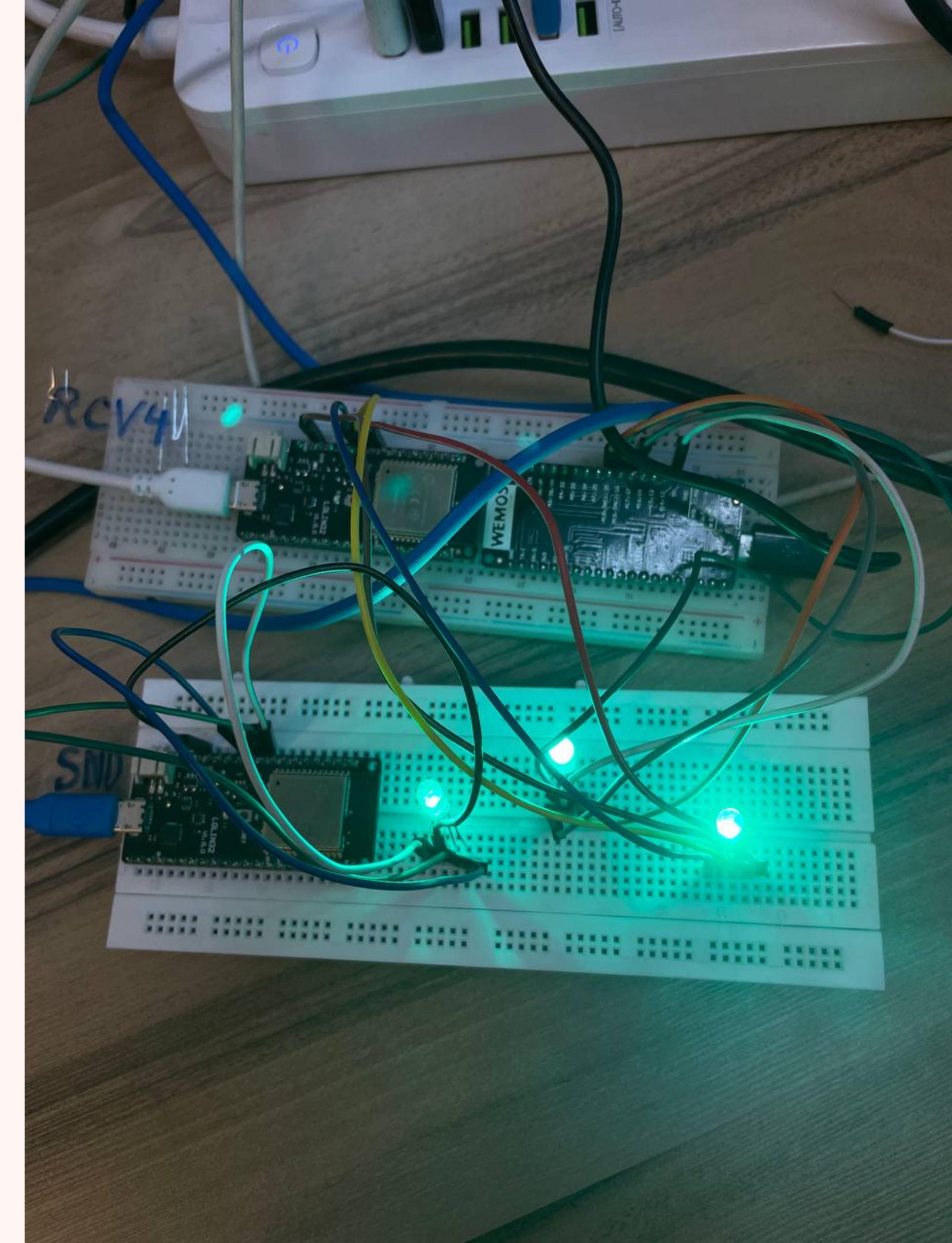
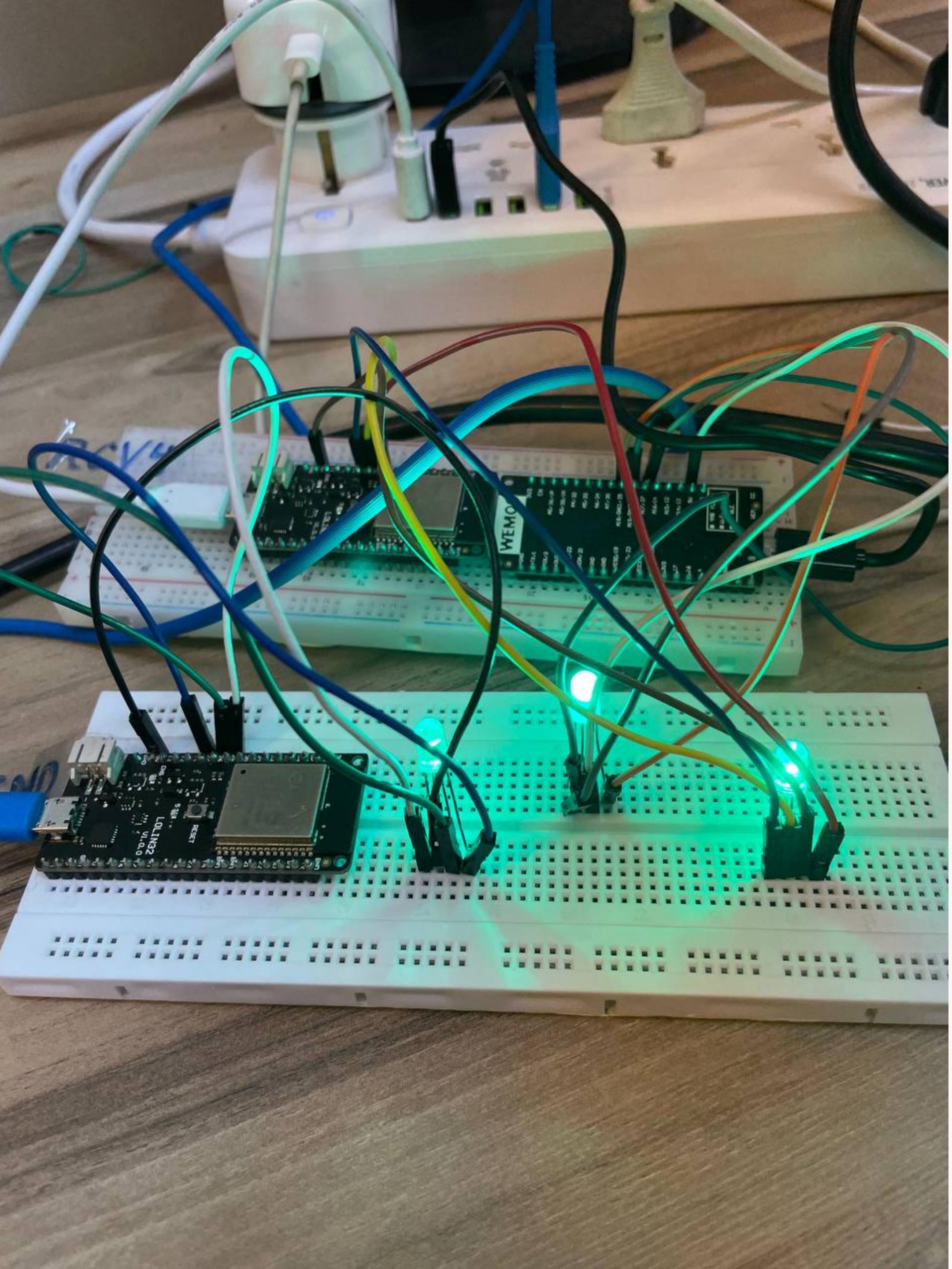
- Asset tracking
  - Beacon management
  - Occupancy control
  - Predictive maintenance
  - HVAC
  - Emergency lighting
  - Building automation



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# **GETTING STARTED WITH ESP-BLE-MESH**

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4:16

4:17

4:17

4:17

4:17

4:17

Abort Provision Cancel Menu Next Application Keys Select None St

## Device Capabilities

Name: ESP-BLE-MESH >

PROVISIONING DATA

Unicast Address: 0x0003 >

Network Key: Primary Network Key >

DEVICE CAPABILITIES

Elements Count: 3

Supported Algorithms: BTM ECDH P256 CMAC AES128 AES CCM

Public Key Type: None

OOB Types: None

Output OOB Size: 0

Supported Output OOB Actions: None

Input OOB Size: 0

Supported Input OOB Actions: None

## Configuration

Quick Configuration

Configure the node with just few clicks.

Bind Application Keys

Subscribe

Set Publication

## Application Keys

Select Application Keys to bind to Models.

APPLICATION KEYS

App Key 1 (Primary Network Key) ✓

New Application Key (Bound to Primary Network Key)

If necessary, selected keys will be added automatically.

## Models

Select Models to bind the Application Keys to.

ELEMENT 1

Configuration Server (Bluetooth SIG) ✓

Generic OnOff Server (Bluetooth SIG)

ELEMENT 2

Generic OnOff Server (Bluetooth SIG)

ELEMENT 3

Generic OnOff Server (Bluetooth SIG)

4:17

81 4:05

85 4:06

85 4:06

85

Cancel

Done

# Configuration

Configuration complete

00:00

Add App Key 1  
Success

Bind App Key 1 to Generic OnOff Server  
Success

Bind App Key 1 to Generic OnOff Server  
Success

Bind App Key 1 to Generic OnOff Server  
Success

## Network



### ESP-BLE-MESH1

Address: 0x0003  
Company: Espressif Systems (Shanghai) Co., Ltd.  
Elements: 3  
Models: 4



### ESP-BLE-MESH2

Address: 0x0006  
Company: Espressif Systems (Shanghai) Co., Ltd.  
Elements: 3  
Models: 4



### ESP-BLE-MESH3

Address: 0x0009  
Company: Espressif Systems (Shanghai) Co., Ltd.  
Elements: 3  
Models: 4

## THIS PROVISIONER



### iPhone

Address: 0x0001  
Company: Apple, Inc.  
Elements: 2  
Models: 23

+

&lt; Network

ESP-BLE-MESH1

Configure

&lt; Element

Generic OnOff Server

Edit

Default TTL

7

SUBSCRIPTIONS

All Nodes

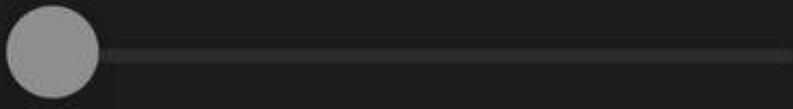
Subscribe

CONTROL

Default Transition Time and Delay



Default



Immediate

Network Keys

1

Application Keys

1

Scenes

Not supported

ELEMENTS

Element 1

2 models

Element 2

1 models

Element 3

1 models

STATUS

Current

ON

Target

N/A

Company Identifier

0x02E5 - Espressif Systems (Shanghai) Co., Ltd.

Product Identifier

0x0000

Read



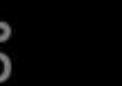
Local Node



Network



Groups



Proxy



Settings



Local Node



Network



Groups



Proxy



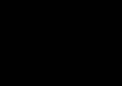
Settings



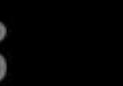
Local Node



Network



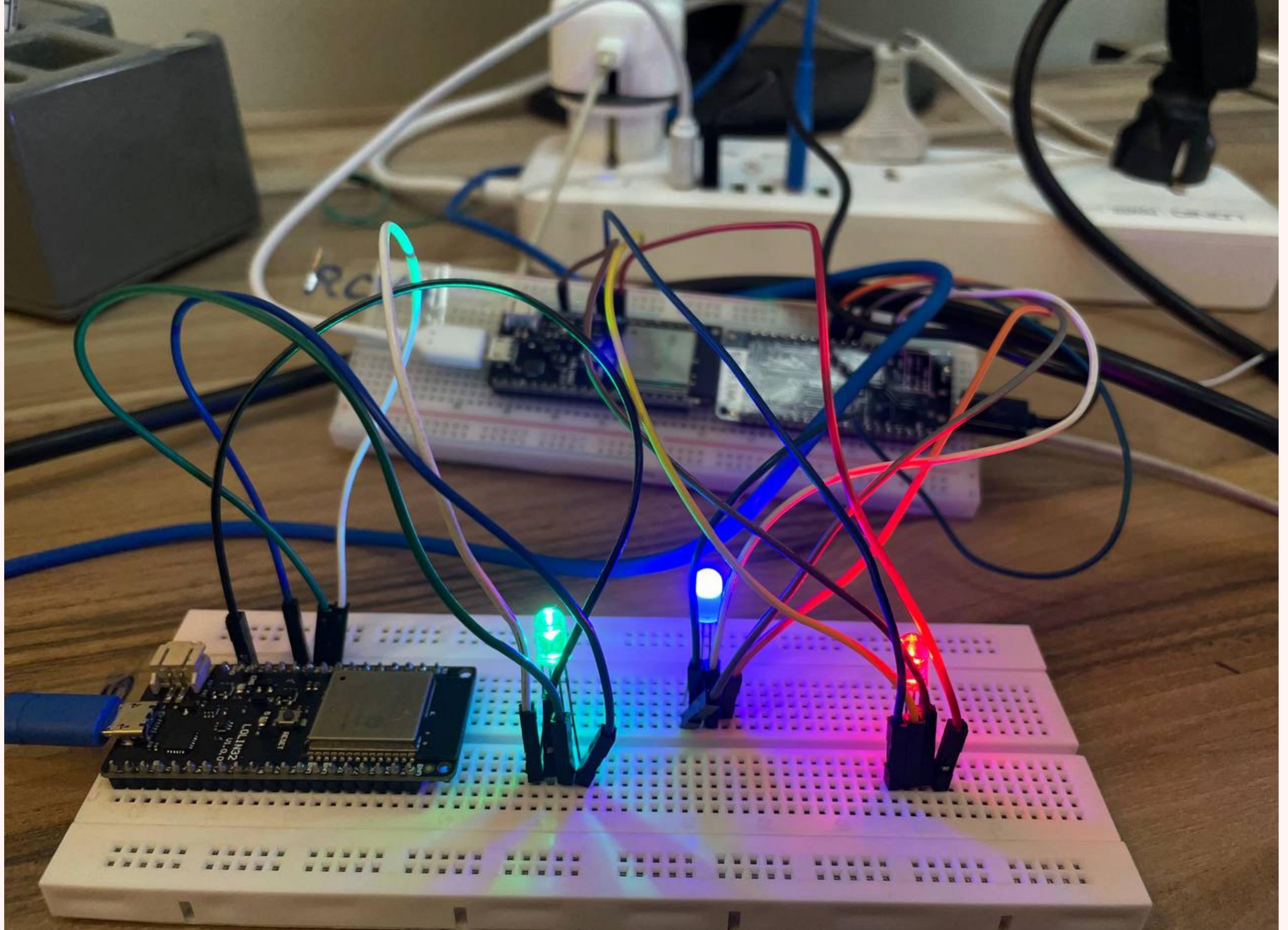
Groups



Proxy

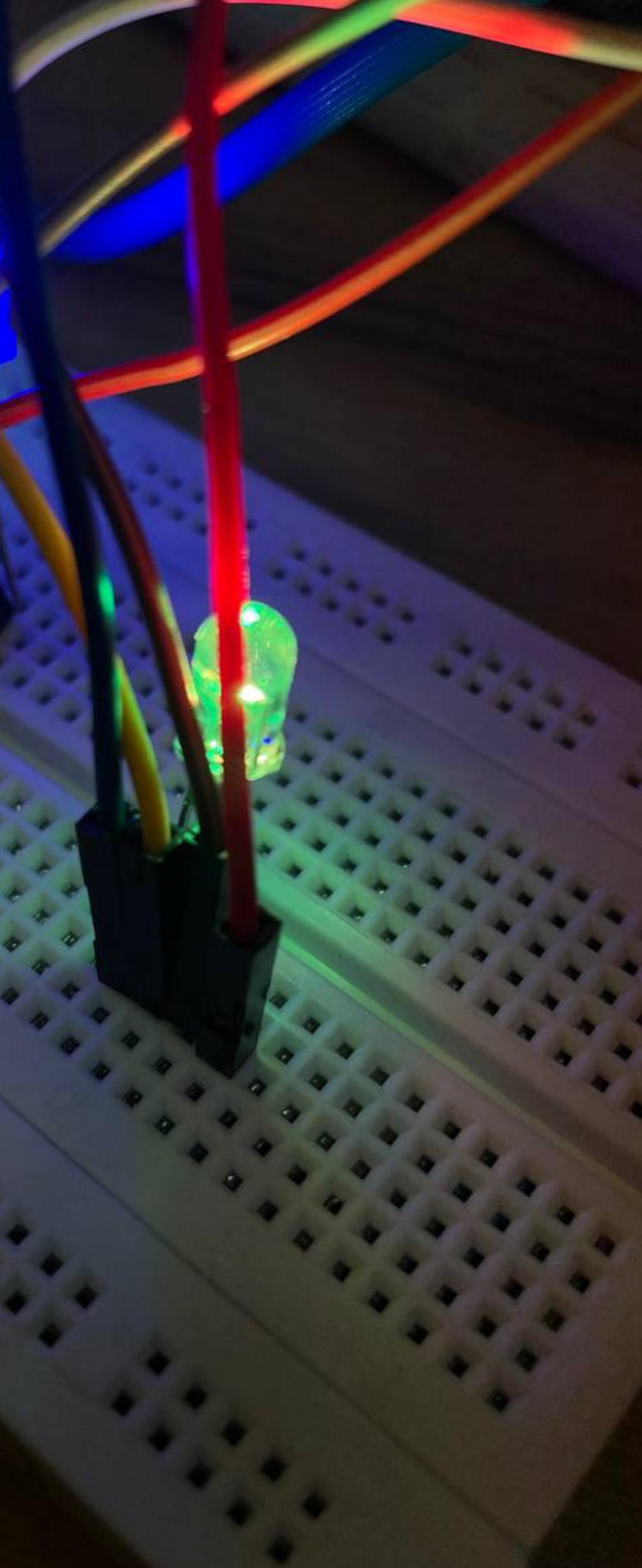
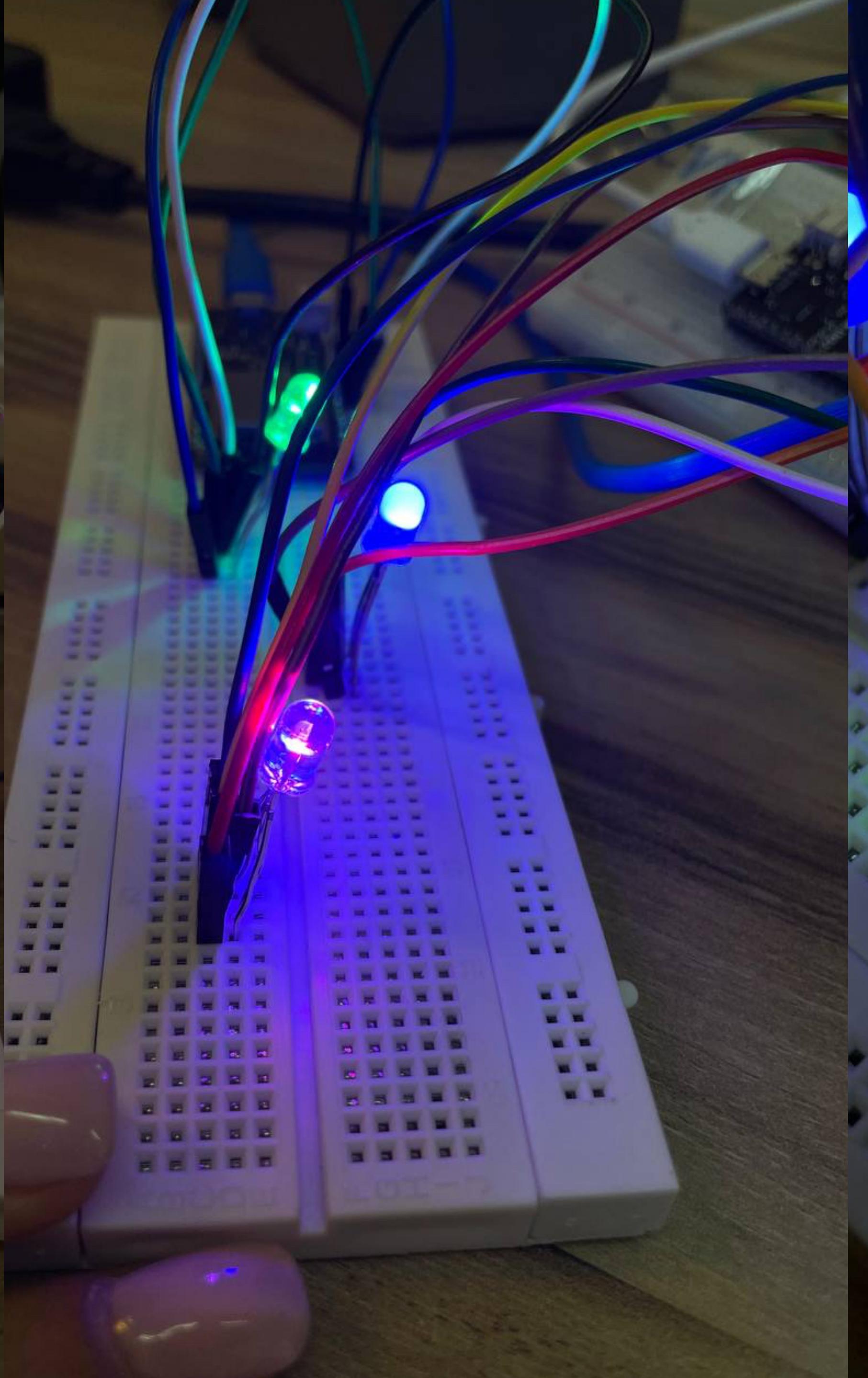
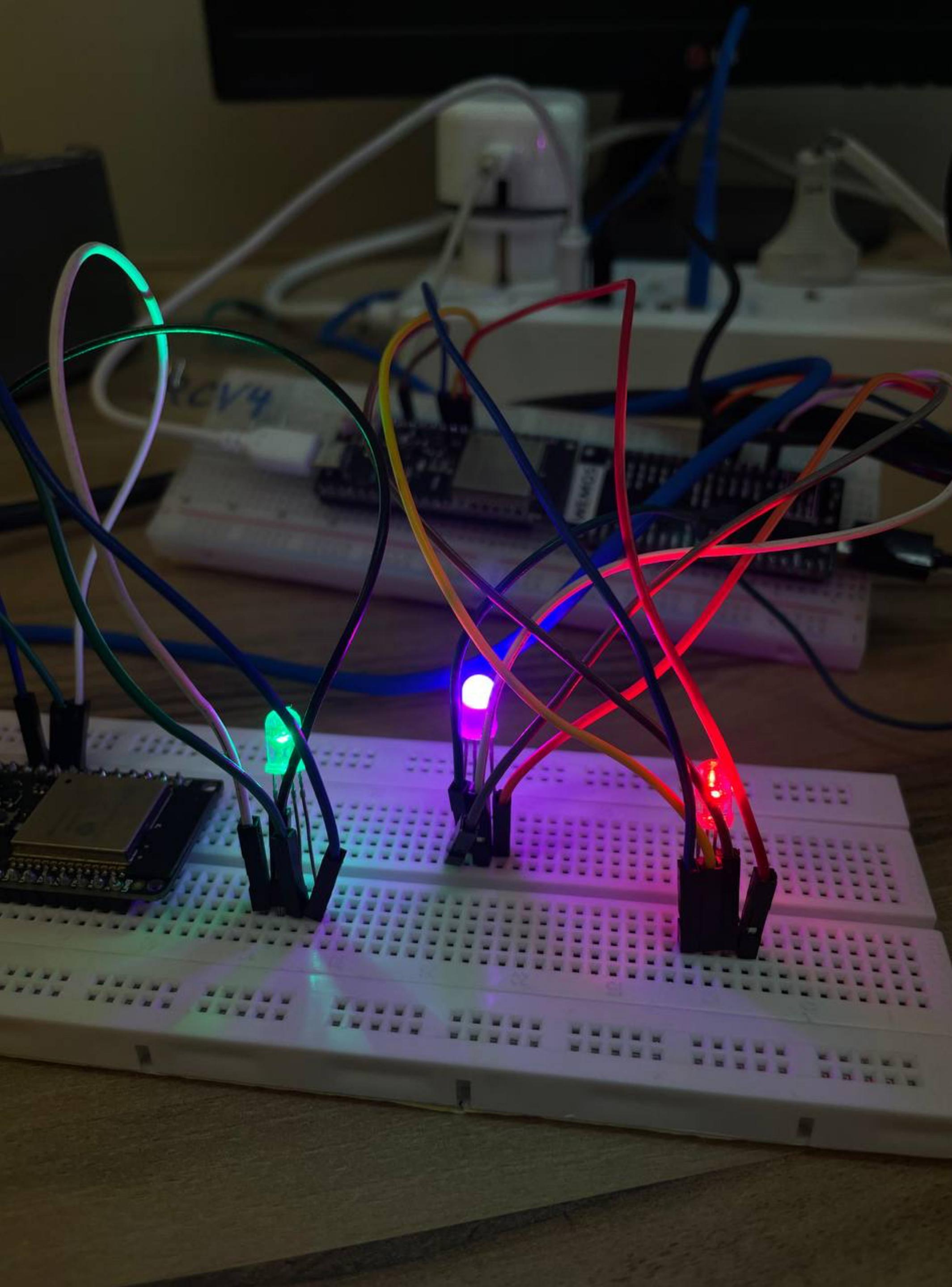


Settings



ESP-IDF 5.1 CMD - "C:\Espressif\idf\_cmd\_init.bat" esp-idf-0e2582fd252b057fc2c285b273065d53 - python.exe "C:\Espressif\frameworks\esp-idf-v5.1.2\tools\idf.py" monitor

I (198808) EXAMPLE: onoff 0x00  
W (198808) BOARD: led red is already off  
I (200208) EXAMPLE: event 0x00, opcode 0x8203, src 0x0001, dst 0x0003  
I (200208) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_STATE\_CHANGE\_EVT  
I (200218) EXAMPLE: onoff 0x01  
I (201538) EXAMPLE: event 0x00, opcode 0x8203, src 0x0001, dst 0x0003  
I (201538) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_STATE\_CHANGE\_EVT  
I (201538) EXAMPLE: onoff 0x00  
I (203298) EXAMPLE: event 0x00, opcode 0x8203, src 0x0001, dst 0x0003  
I (203308) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_STATE\_CHANGE\_EVT  
I (203308) EXAMPLE: onoff 0x01  
I (208218) EXAMPLE: event 0x00, opcode 0x8203, src 0x0001, dst 0x0003  
I (208218) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_STATE\_CHANGE\_EVT  
I (208228) EXAMPLE: onoff 0x00  
I (210558) EXAMPLE: event 0x00, opcode 0x8203, src 0x0001, dst 0x0003  
I (210558) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_STATE\_CHANGE\_EVT  
I (210568) EXAMPLE: onoff 0x01  
I (227688) EXAMPLE: event 0x01, opcode 0x8201, src 0x0001, dst 0x0004  
I (227698) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_GET\_MSG\_EVT  
I (227698) EXAMPLE: onoff 0x00  
I (229888) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0004  
I (229888) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (229888) EXAMPLE: onoff 0x00, tid 0x86  
W (229888) BOARD: led green is already off  
I (231828) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0004  
I (231838) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (231838) EXAMPLE: onoff 0x01, tid 0x87  
I (234318) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0004  
I (234328) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (234328) EXAMPLE: onoff 0x01, tid 0x88  
W (234328) BOARD: led green is already on  
I (237888) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0004  
I (237898) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (237898) EXAMPLE: onoff 0x00, tid 0x89  
I (240468) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0004  
I (240478) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (240478) EXAMPLE: onoff 0x00, tid 0x8a  
W (240478) BOARD: led green is already off  
I (250798) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0005  
I (250798) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (250798) EXAMPLE: onoff 0x01, tid 0xa2  
I (251938) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0005  
I (251938) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (251938) EXAMPLE: onoff 0x00, tid 0xa3  
I (253198) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0005  
I (253198) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT  
I (253198) EXAMPLE: onoff 0x00, tid 0xa4  
W (253198) BOARD: led blue is already off  
I (255598) EXAMPLE: event 0x02, opcode 0x8203, src 0x0001, dst 0x0005  
I (255598) EXAMPLE: ESP\_BLE\_MESH\_GENERIC\_SERVER\_RECV\_SET\_MSG\_EVT



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**THANKS FOR YOUR ATTENTION**

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