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MSH-102: Bluetooth Mesh for Lighting Applications

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14 September 2021



The Market Drivers



The Drivers for Smart Wireless Lighting

BEING SMART



Energy Savings

40% of building's energy budget is lighting; save 30+% in costs using sensor driven control.



Productivity and Wellness

Color and brightness tuning to create more comfortable space; Boost productivity



Regulation

Must in states like California, US (Title 24)

ADVANTAGES OF WIRELESS LIGHTING



Simplified Installation

Avoids cabling for switches & sensors, App/App-less provisioning speeds up deployment



Value Added Services

Deploy location services for convenience, asset tracking; collect data for preventive maintenance; sensor data for better space utilization and lighting plans

Bluetooth Mesh – The Advantages



Smart Phone Connectivity

Ubiquitous and easy connectivity.



Optional Gateway

No single point of failure



Scalability

Few to a few thousand nodes



Extendibility & Flexibility

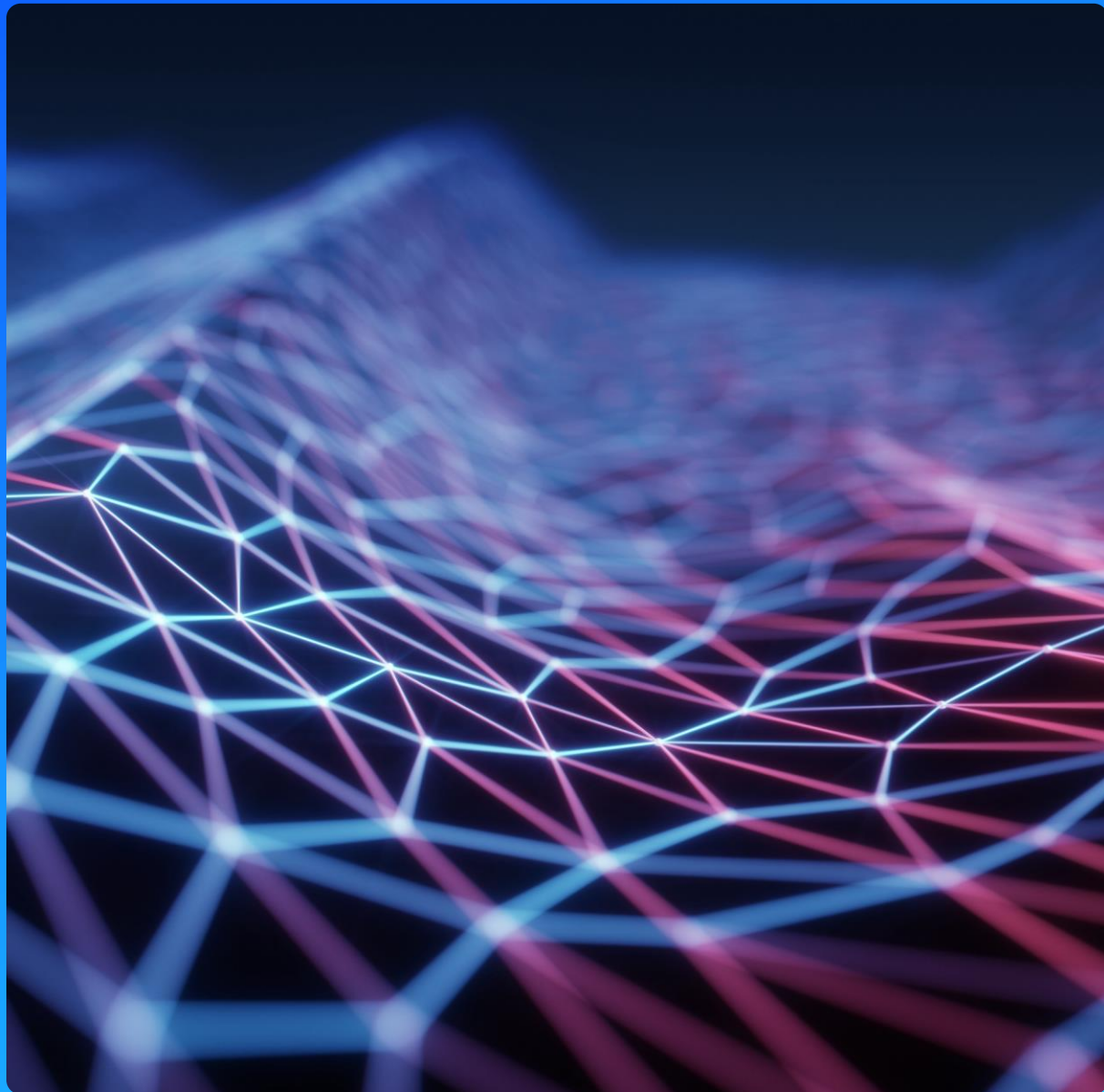
Easy to add nodes, partition based on space, reconfigure based on user preference



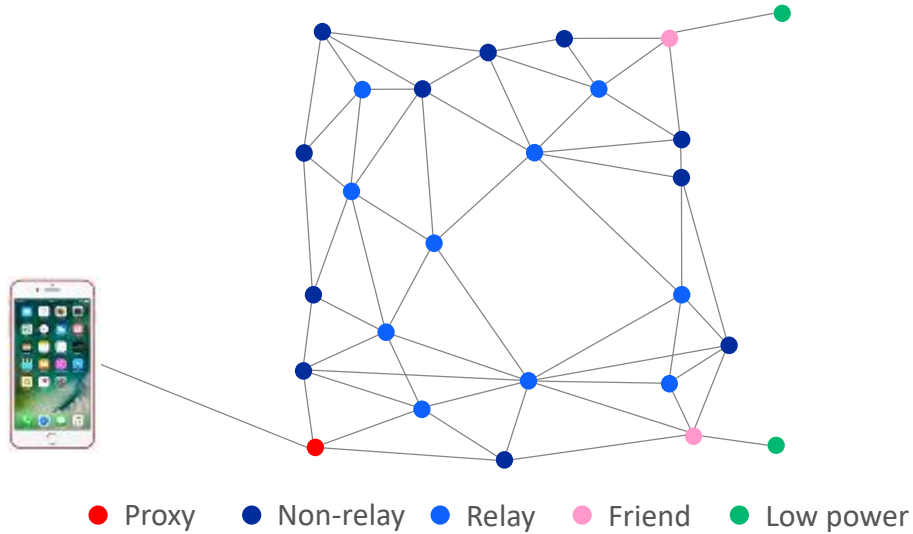
Value Added service

Easy to piggyback data transmission on already existing network

Bluetooth Mesh Fundamentals



Bluetooth Mesh Nodes and Features



	Relay	Proxy	Low power	Friend
Send messages	Yes	Yes	Yes (limited)	Yes
Receive messages	Yes	Yes	Yes	Yes
Relay messages	Yes	Yes	No	Yes
GATT bearer	Yes/No	Yes	Yes/No	Yes/No
Battery operated	Typically no	Typically no	Yes	Typically no
Cache messages	No	No	No	Yes

- **Relay:** Relays messages within a Bluetooth mesh network
- **Low power Node:** Polls friends at intervals for configuration changes etc; can sleep up to 4 days
- **Friend:** Caches messages for low power nodes while they sleep
- **Proxy:** Connects GATT and Bluetooth mesh worlds

Bluetooth Mesh – Network Architecture

Models	Function specific behaviors, states, state bindings, messages etc
Foundation Models	Models for configuration and mgmt. of a mesh network
Access Layer	Format for app. data, defining and controlling encryption, verify data for the network
Upper Transport	Encryption, decryption & authentication of application data
Lower Transport	Segmentation and re-assembly
Network Layer	Defines message address types and network message formats for PDUs
Bearer Layer	Advertisement – Uses adv/scan, most popular GATT – For devices that don't support Adv
Bluetooth Low Energy	Base transport

Security in Bluetooth Mesh



Security is mandatory

All messages are encrypted and authenticated



Dynamic Keys

Security keys can be changed over the life of the network



Protection Against Replay Attacks

Using Sequence number and IV Index



Addition and Removal of Nodes

Secure process, prevents trash can attack

SEPARATION OF CONCERNS



Network Key

Must have, enables a node to be part of network; each subnet has own NetKey

Application Key

Associated with only one NetKey; Isolates different applications in the same network

Device Key

Each device has a unique one, known only to the provisioner

Silicon Labs' Solutions









The Hardware Portfolio

SoC

Target applications	General purpose Bluetooth LE and mesh	Mains powered Bluetooth LE and mesh	Lowest power Bluetooth LE, Direction Finding and Bluetooth mesh LPNs
SoC	Series 1 – B/MG13	Series 2 - B/MG21	Series 2 - B/MG22
Bluetooth features	5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)	5.1 and mesh 1.0 (1M, 2M, LE Coded PHYs and AE)	5.2 and Bluetooth mesh LPN (1M, 2M, LE Coded PHYs, AE and AoA/D)
Security	Hardware Crypto , TRNG	TRNG, Enhanced Crypto, Secure Boot & Debug, Secure Vault	TRNG, Enhanced Crypto, Secure Boot & Debug
TX / RX (1M, GFSK)	+19 dBm / -95.8 dBm	+20 dBm / -97.5 dBm	+6 dBm / -99 dBm
TX Current (0 dBm)	10.5 mA	10.5 mA	4.1 mA 7.4 mA (6 dBm)
RX Current (1M, GFSK)	9.5 mA	8.8mA	3.6 mA
Flash (kB)	512	Up to 1024	Up to 512
RAM (kB)	64	Up to 96	32
Packages (mm)	7x7 QFN48, 5x5 QFN32	4x4 QFN32 (20x GPIO)	5x5 QFN40 (26x GPIO) 4x4 QFN32, TQFN32 (18x GPIO)

Modules

	 B/MGM13P	 B/MGM13S	 B/MGM210P	 B/MGM210L	 B/MGM220P	 B/MGM220S
Antenna	Built-in or U.FL	Built-in or RF pin	Built-in or RF pin	Built-in	Built-in	Built-in or RF pin
GPIO	25	30	20	12	24,25	25
Dimensions W x L x H (mm)	13.0 x 15.0 x 2.2	6.5 x 6.5 x 1.4	13.0 x 15.0 x 2.2	13.0 x 15.0 x 2.2	13.0 x 15.0 x 2.2	6 x 6 x 1.3
Certifications	BT, CE, FCC, ISED, Japan, S-Korea and Taiwan	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea	BT, CE, FCC, ISED, Japan & S-Korea

A Complete Solution for Mesh Network Development

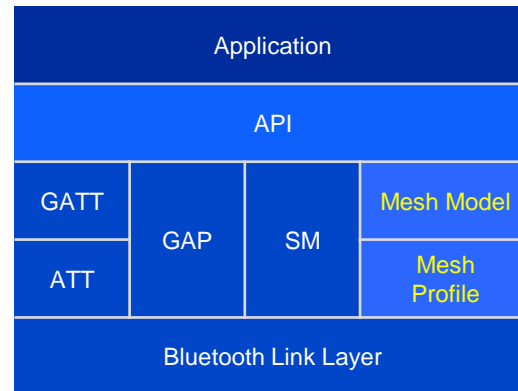


DEV KITS

Multiple physical interfaces to support advanced development and debugging

UART, Ethernet, USB

LCD, LED, buttons



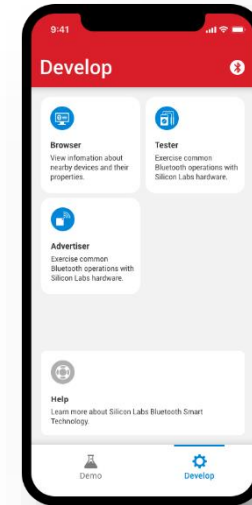
STACK SOFTWARE

In-house developed stack

Mesh v1.0.1 qualified*

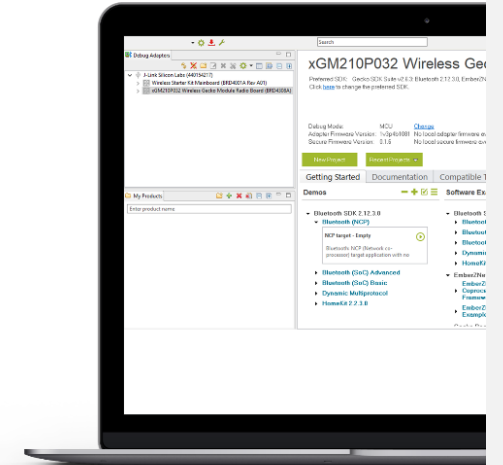
Support for all features and bearers

All security features supported



MOBILE APPLICATIONS

Bluetooth Mesh ADK and Reference applications and source code for iOS and Android



DEVELOPMENT TOOLS

Simplicity Studio with sample apps (light & switch)

Mesh configurator

Network analyzer

Energy Profiler

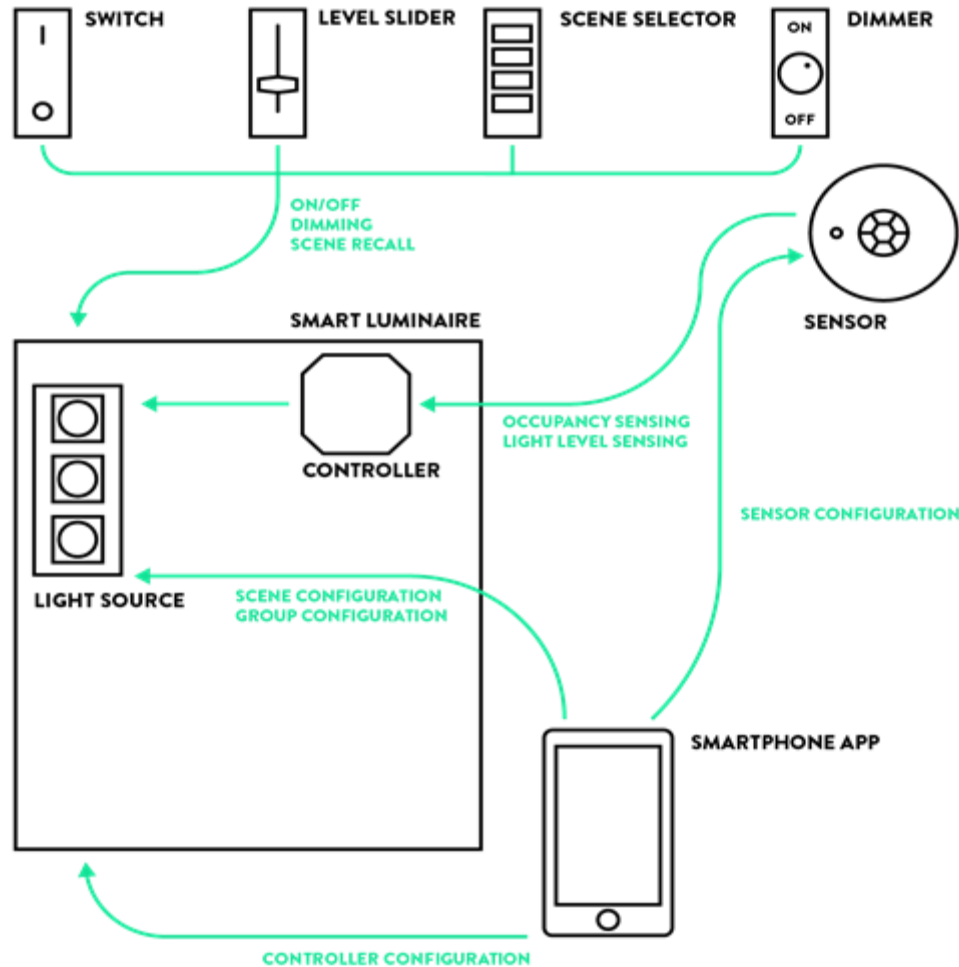
Supported Bluetooth Mesh Models

Model Group	Model	Stack/APIs	Example app(s)	iOS APIs	iOS reference app	Android APIs	Android reference app
Vendor	Any vendor model	✓		✓		✓	
Generic	OnOff	✓	✓	✓	✓	✓	✓
	Level	✓	✓	✓	✓	✓	✓
	Default Transition Time	✓	✓	✓		✓	
	Power OnOff	✓	✓	✓		✓	
	Power Level	✓		✓			
	Battery	✓		✓		✓	
	Location	✓		✓			
	Admin property	✓		✓			
	Manufacturer property	✓		✓			
	User property	✓		✓			
	Client property	✓		✓			
Property	✓		✓				
Lighting	Lightness	✓	✓	✓	✓	✓	✓
	CTL	✓	✓	✓	✓	✓	✓
	LC	✓	✓	✓	✓	✓	✓
	HSL	✓					
Sensors	Sensor	✓	✓	✓		✓	
Time and Scenes	Scene	✓	✓	✓	✓	✓	✓
	Time	✓	✓	✓	✓	✓	✓
	Scheduler	✓	✓	✓	✓	✓	✓

Lighting Network – Devices, Roles & Models



Components of a Wireless Lighting Solution



- **Lighting controls (mains or battery power)**
 - On/Off switches
 - Dimmers
 - Scene selectors
- **Sensors (mains or battery power)**
 - Occupancy
 - Ambient Light Level
- **Light sources and controllers**
 - Controlled by lighting controls and/or sensors
- **Optional smart phone app or gateway**
 - Provisioning and configuration
 - Device control
 - Life cycle management (OTA, removing devices etc.)
 - Value added services

Light Sources / Luminaires



- Each luminaire is a node in the mesh n/w, can have multiple elements
- Can be single or multiple lights
- Can be combined with sensors (occupancy) and controllers
- Generally act as Relay at min, can also act as Proxy and Friend.

Scenario	Models Used	Publish / Subscribe
On/Off	Generic OnOff Server	Subscribe
Light Level Control	Generic Power OnOff Server Generic Power OnOff Setup Server Generic Level Server Light Lightness Server Light Lightness Setup Server	Subscribe
Transition	Generic Default Transition Time Server	
Scene	Scene Setup Server Scene Server	
Sensor driven functionality	Light LC Server	Subscribe
Controller	Light LC Server Light LC Setup Server Light Lightness Server Light Lightness Setup Server	Subscribe

Key h/w and s/w to consider

BG21

BGM210P

BGM210L

“Light” sample application.

Controls



- Switches / Dimmers / Scene selectors are examples of lighting controllers.
- Functionality will depend on the capabilities.
- Controls can be either mains powered or battery powered.
- Mains powered devices typically act as relays, battery powered are LPNs

Scenario	Models Used	Publish / Subscribe
On/Off	Generic OnOff Client	Publish
Light Level Control	Generic OnOff Client Generic Level Client Light Lightness Client	Publish
Transition	Generic Default Transition Time Client	
Scene	Scene Client	Publish
Sensor driven functionality		
Controller		

Key h/w and s/w to consider

BG21

BGM210P

BG22

BGM220P

BGM220S

“Switch” sample application.

Sensors



- Occupancy sensors and ambient light sensors are the most common used in the lighting systems.
- Sensors can be either mains powered or battery powered.

Scenario	Models Used	Publish / Subscribe
On/Off		
Light Level Control		
Transition		
Scene		
Sensor driven functionality	Sensor Server Sensor Setup Server	Publish
Controller		

Key h/w and s/w to consider

BG22

BGM220P

BGM220S

“Switch” sample application.

Summary

- **Significant drivers for moving to Wireless Smart Lighting: Lower Cost, Better Convenience and Higher Productivity**
- **Bluetooth Mesh offers many advantages: Smart phone connectivity, gateway less, scalability and Value-added services deployment**
- **Silicon Labs has comprehensive solution of ICs, Modules, Software Stack and tools to efficiently address this lighting market**