Bluetooth now comes in three delicious flavours.

- **BR/EDR**
  - point-to-point: 1:1

- **Low Energy (LE)**
  - broadcast: 1:m

- **Mesh**
  - many to many: m:m
relationship between Bluetooth technologies

RADIO

 Bluetooth BR/EDR

Bluetooth mesh networking

Bluetooth Low Energy

NETWORKING
Bluetooth Mesh Networks
multi-hop, multi-path, multicast
Bluetooth Mesh

Node Network Roles
Messages get sent to other nodes that are in direct radio range of the publishing node.

Some nodes can act as “relays” however.

Relays retransmit messages so that they can travel further, in a number of “hops”.

R = Relay function on
Low Power Nodes (LPNs) are highly power constrained.

To avoid the need to operate at a high(er) duty cycle to receive messages from the mesh, an LPN works with a Friend.

Friend nodes store messages addressed to LPNs they are friends with and forward them when the LPN occasionally polls.
friend nodes and low power nodes

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“set temperature thresholds”
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“do you have any messages for me?”

To: Sensor
“set temperature thresholds”
friend nodes and low power nodes

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To: Friend
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STORED MESSAGE(S)
Bluetooth low energy devices like smartphones can communicate with a mesh network via a proxy node.
proxy nodes

Bluetooth low energy devices like smartphones can communicate with a mesh network via a proxy node

mesh monitoring and control applications
Bluetooth Mesh

Communication and Interaction
messages and state

nodes communicate with each other by sending messages

nodes have state values which reflect their condition (e.g. ON or OFF)

access messages operate on state values

SET - change of state
GET - retrieve state value
STATUS - notify current state
ACK vs UNACK
messages and state

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- **SET** - change of state
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- **ACK vs UNACK**
the publish/subscribe communication model

- Kitchen
- Dining Room
- Hallway
- Bedroom
- Garden

Publish

Subscribe
node composition

A node consists of an arrangement of elements, models, and states. Each element has its own address.

Note: A model is sometimes owned by multiple elements.
models

- Define node functionality
- Define states, messages, state transitions and behaviors
- Client, server, and control types
- Generics such as onoff client and server
- Lighting, sensors, scenes, & time
node composition

single node
3 elements
multiple models and states

node

elements
0x0100
0x0101
0x0102

models

generic onoff server
light lightness server

states

generic onoff

light lightness actual
light lightness last
light lightness range
Bluetooth Mesh

Security
devices and network membership

Bluetooth mesh networks are secure

only members of the same network can talk to each other

a security process called **provisioning** makes a device a member of a network
devices and network membership

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only members of the same network can talk to each other

a security process called **provisioning** makes a device a member of a network

*Device* is now a *node* on the network
Bluetooth mesh: Security

- Mandatory, cannot be reduced
- Encryption and authentication
- Separate security for network and each application
- Area isolation
- Message obfuscation
- Protection from replay and trashcan attacks
- Secure device provisioning
network key (*netkey*)
- **origin:** provisioning
- **use:** derivation of other keys

encryption key
- **origin:** derived from netkey using the k2 function
- **use:** secures data at the network layer

privacy key
- **origin:** derived from netkey using the k2 function
- **use:** obfuscation of network header information

application key (*appkey*)
- **origin:** created by the config. client and provided to nodes after provisioning
- **use:** secures application data at the upper transport layer

device key (*devkey*)
- **origin:** established during provisioning
- **use:** secures communication between the config. client and individual node

appkey is bound to a netkey

devkey is bound to all netkeys known to a node

bound to one or more models.

ref: mesh profile 1.0 section 2.3.9.1
Bluetooth mesh

Anatomy of a smart lighting system
Switch Models

Generic On/Off Client

Light Models

Generic On/Off Server

Sensor Models
Switch Models
- Generic On/Off Client

Light Models
- Generic On/Off Server
- Light Lightness Server
- Light HSL Server
- Light LC Server

Sensor Models
- Sensor Server
Bluetooth Mesh

Video Demonstration
Bluetooth Mesh

What next?
Bluetooth Mesh Networking - An Introduction for Developers

This in-depth introduction for developers examines Bluetooth mesh's system architecture, security mechanisms, and unique message publication and delivery.

LEARN MORE

Bluetooth Mesh Models - A Technical Overview

In this detailed technical paper, Martin Woolley provides a guided tour of the Bluetooth...

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https://www.bluetooth.com/bluetooth-resources/?types=paper&categories=&tags=mesh
Bluetooth SIG Resources - hands-on education

An Introduction to Bluetooth Mesh Networking
Learn the theory and practice of Bluetooth mesh device firmware development, and develop a working mesh network.

LEARN MORE

An Introduction to the Bluetooth Mesh Proxy Function
Learn how to create applications for smartphones and other platforms which can monitor and control nodes in a Bluetooth mesh network.

LEARN MORE

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questions?

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