

6.6 Bluetooth and the Internet of Things (IoT)

Bluetooth Mesh Networking in Detail

Bluetooth Mesh is a software-based networking solution that runs on top of the BLE physical radio. It is designed to support large-scale, many-to-many device communication, making it ideal for smart buildings and industrial IoT.

Key concepts of a Mesh network include:

- **Nodes:** Any device on the mesh network is a node. Nodes can transmit, receive, and relay messages. This relaying capability (called **managed flooding**) is what allows the network to cover a very large area.
- **Provisioning:** The process of securely adding a new device to the mesh network.
- **Models:** Models define the fundamental behaviors of a node. For example, a light bulb might implement a "Generic OnOff Server" model, while a wall switch might implement a "Generic OnOff Client" model.
- **Publish-Subscribe (Pub/Sub):** Mesh uses a pub/sub messaging system. Instead of sending a message to a specific device address, a node publishes a message to a group address (e.g., "First Floor Lights"). All nodes that have subscribed to that address will receive and process the message. This is highly efficient for controlling large groups of devices simultaneously.

The architecture is highly reliable because there is no single point of failure; if one node goes down, messages can automatically find an alternative path through other nodes.

Periodic Advertising with Responses (PAwR)

Introduced in Bluetooth 5.4, **Periodic Advertising with Responses (PAwR)** is a new communication mode designed for large-scale, one-to-many IoT applications that require low-power, bidirectional communication without forming a connection.

How It Works:

A central device (a **broadcaster**) sends out small, time-synchronized advertising packets on a predictable schedule. The thousands of listening devices (**observers**) are synchronized to this schedule and only wake up for a brief moment to listen for a relevant packet. This saves an enormous amount of power.

Crucially, after each broadcast event, there are dedicated time slots where the observers can send back a small response. This enables bidirectional communication for acknowledgements, sensor data, or status updates.

Use Case: Electronic Shelf Labels (ESL)

The primary and first officially adopted profile for PAwR is **Electronic Shelf Labels (ESL)**. In a retail environment, a single gateway can control and update prices on tens of thousands of e-paper labels throughout the store.

- **Price Update:** The gateway broadcasts price update information. Only the specific ESLs targeted in the broadcast will wake up, receive the new price, and update their display.
- **Acknowledgement:** The ESL can then send a small response back to the gateway in its designated response slot, confirming that the price was successfully updated.
- **Battery Life:** Because the labels are not maintaining a constant connection and only wake for milliseconds at a time, they can run for 5-10 years on a single coin-cell battery.

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