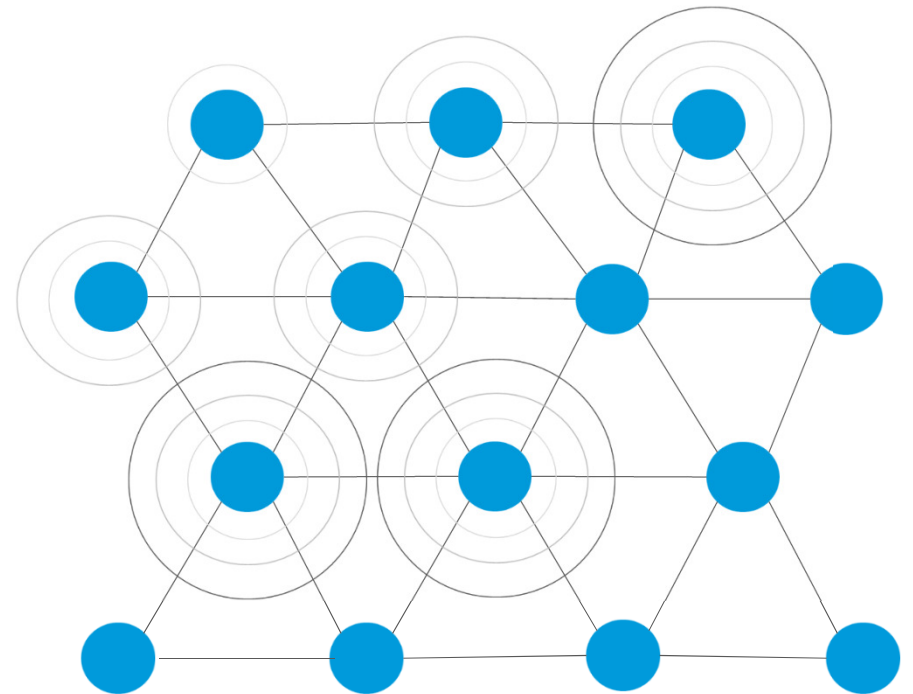# Expanding Bluetooth mesh for low power applications

Bluetooth World 2018

Bluetooth Mesh

- Managed flooding.

- Relaying messages.

- Radio needs to be always active on both relay and non-relay nodes.

- Current consumption for sole radio in range of 10mA.

=>Most nodes are main-powered

Low power applications

- Bluetooth Mesh initially customized for lighting control applications.
    - Power supply might not be a problem
    - Large number of plugged-in nodes works as backbone for mesh
- But the demand for low power mesh operation is high:
    - Energy harvesting light switch
    - Environment monitoring
    - Low energy indoor positioning
- Other applications requiring low power operation

Advantages of going low power

- Cutting the cables, including the power cable.
- Reducing or eliminating maintenance.
- Placing devices at harder to reach locations.
- Reducing size and cost.
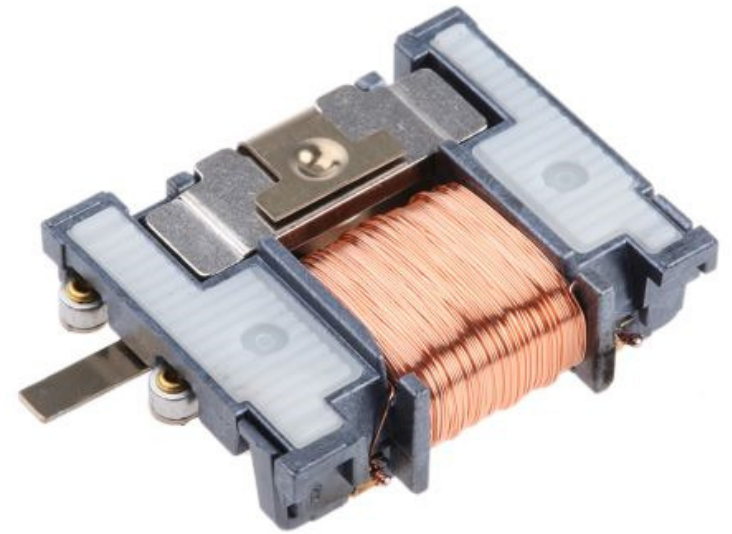
Low power requirements

Running mesh on small battery or on energy harvesting supply requires:

- Able to suspend the radio and enter deep sleep mode.

- Able to send few bytes of data over a period of time without receiving or relaying other messages.

- Can communicate with the network immediately after wakeup.

How Bluetooth Mesh supports low power

Low Power node

Friend node

Friend node

Low Power node
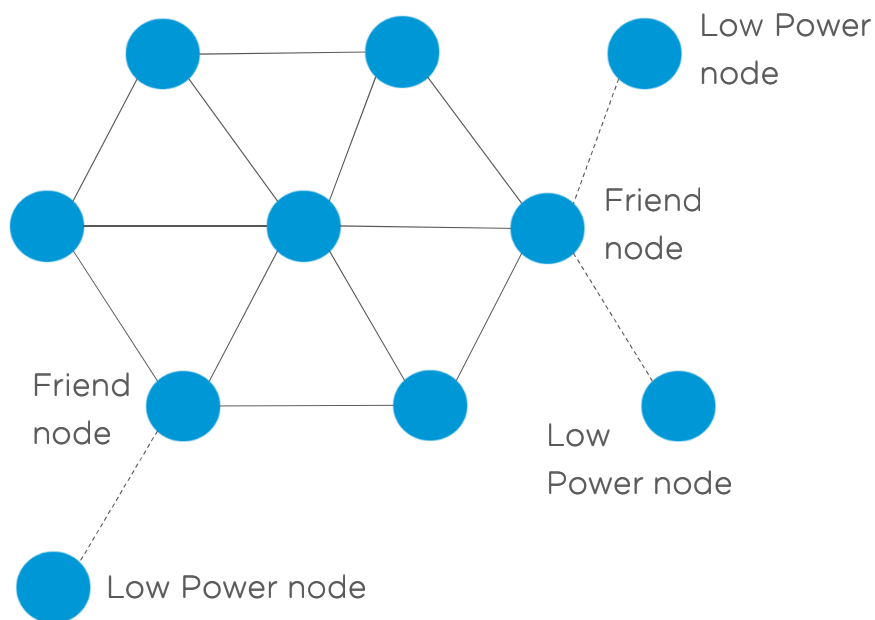
Low Power node

- Low Power (LP) feature and Friend feature are built-in in Mesh.

- Friend nodes cache messages for LP nodes.

- LP nodes sleep and wake up to poll messages from Friend nodes.

- Friendship must be established in advance.

Building a friendship
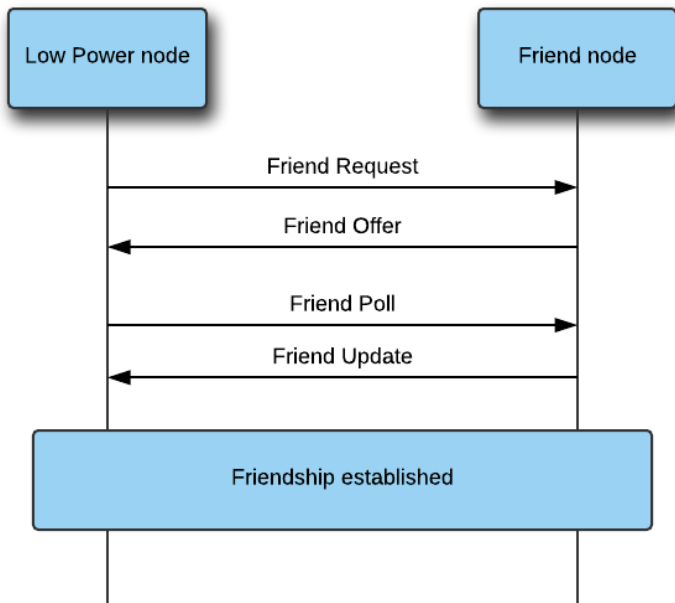
- LP nodes send Friend Requests to **all** neighbor nodes.
- LP nodes can have only one Friend node at a time.
- Friend nodes can have multiple LP nodes.

Friendship

- Friendship will be terminated if LP nodes are inactive for longer than the Poll Timeout period.

- LP nodes provides a Friend Subscription List so Friend nodes know which packets to cache.

- LP nodes can communicate with other nodes when in normal operation if needed.
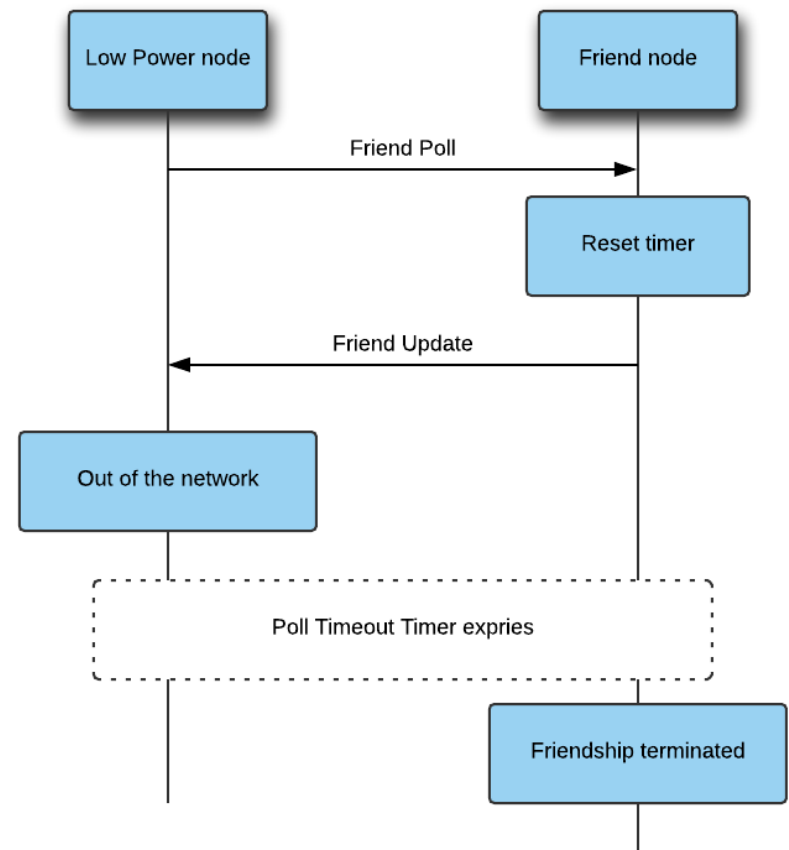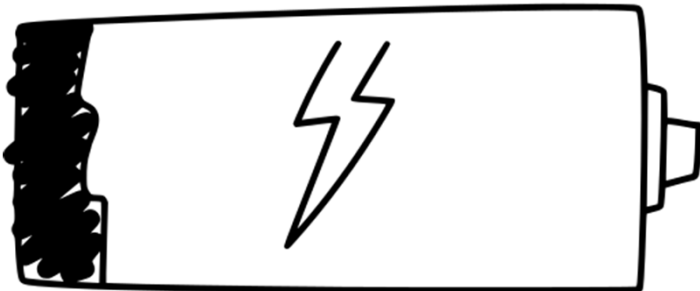
How low power ?

- LP nodes can sleep as long as needed, but should wake up at least once every 96 hours to update IV index.

- When polling data from Friend node, the LP node only needs to listen during the Receive Window.

- Communication encrypted using the Friendship credential to further reduce power consumption.
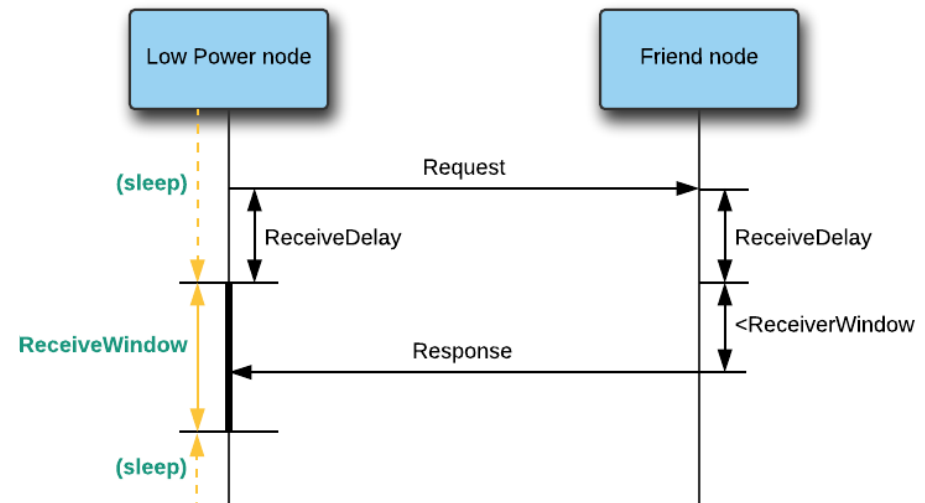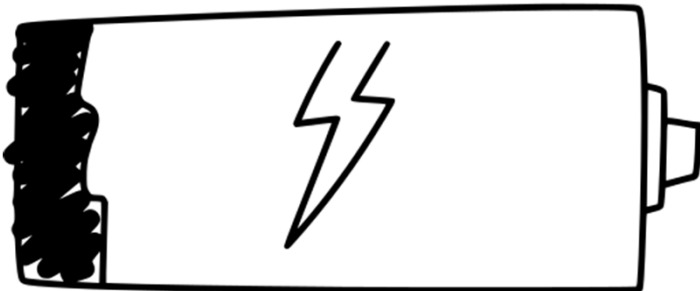
What if Friendship is not an option ?

- Shouldn't rely on one single solution
- Friend feature is not a mandatory feature for Mesh, and not all vendors will support this.
- There are a limited amount of caches a Friend node can provide.
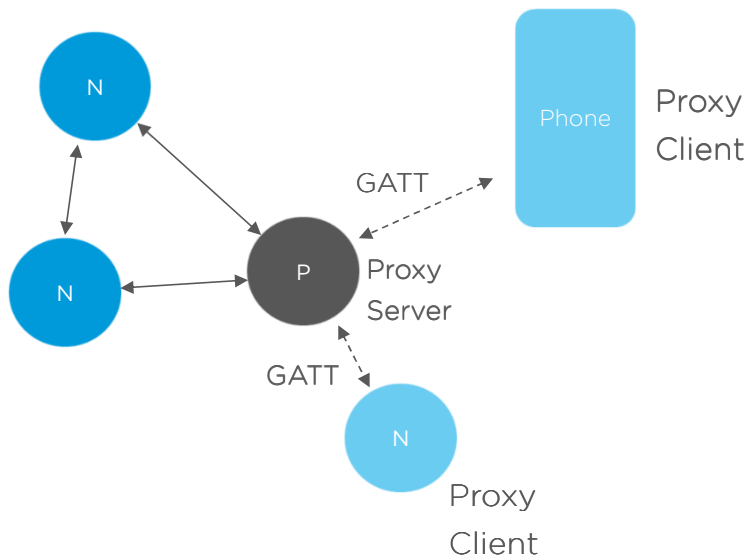- If there is no friend around?

What if Friendship is not an option ?

Alternative solutions:

- GATT bearer proxy
- Proprietary proxy
- Low duty cycle

GATT proxy

- Allows devices that do not support the ADV bearer to participate in the mesh network via GATT bearer (BLE connection)
- The main use case is to let mobile phones join the Mesh network, but it can be used for low power GATT clients.

GATT proxy connection establishment

- Proxy Clients can be either central or peripheral

- Sleep latency can be used on the peripheral

- Proxy Clients register a black/whitelist filter with the Proxy Server to filter out messages to be forwarded.
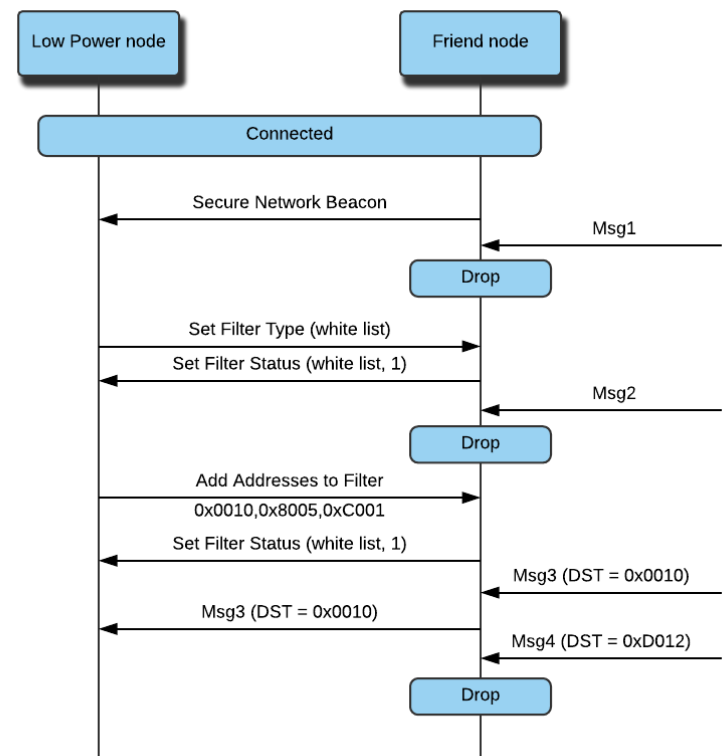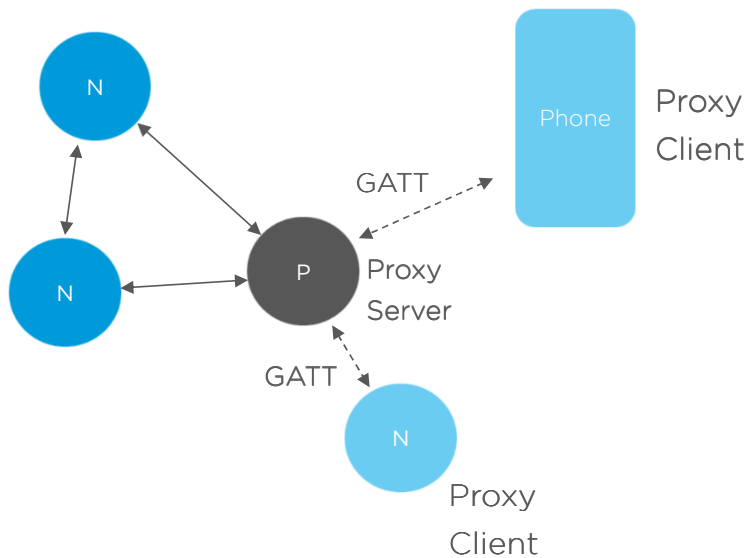
GATT proxy pros & cons
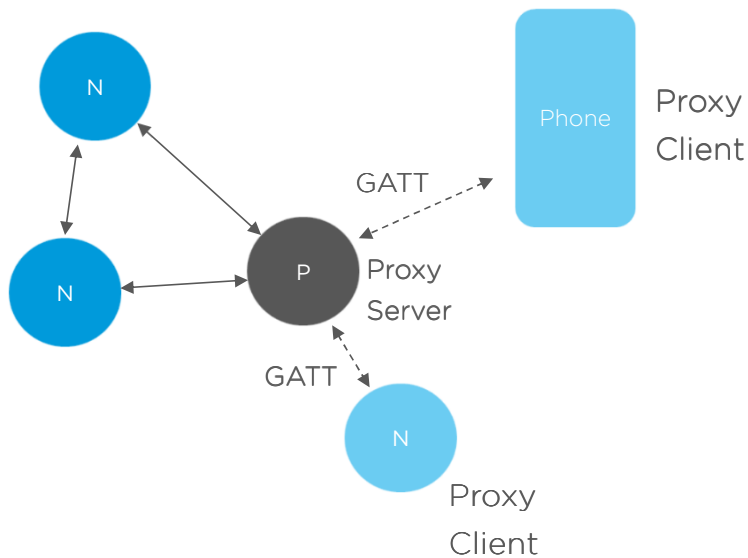
Pros:

- Has relatively short latency compared to Friendship and other solutions.

- Same power consumption as a Bluetooth Low Energy node.

- Data is encrypted with the same key as normal ADV bearer messages.

- Nodes can switch to normal mesh operation if needed.
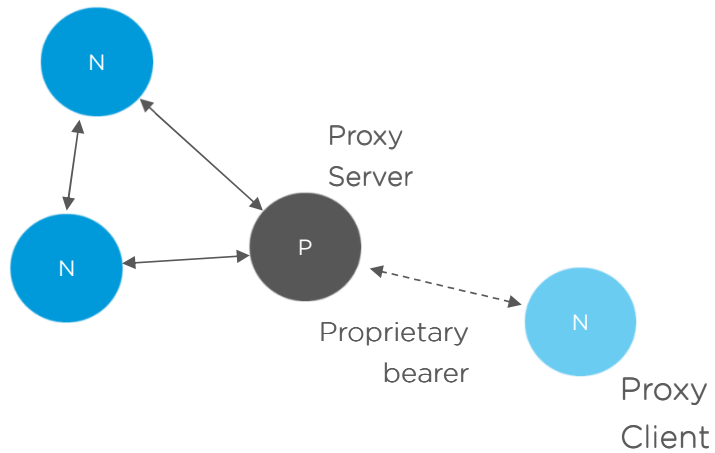
GATT proxy pros & cons

Cons:

- No cache mechanism, nodes can't really enter deep sleep for a long time.

- Mesh bandwidth on the Proxy Server node is reduced because of the radio occupation for Proxy links.

=> A more complex solution is to combine Proxy Server with LP feature.

Proprietary proxy

N

Proxy
Server

P

N

Proprietary
bearer

N

Proxy
Client

- Custom proxy protocol, e.g. using BLE Advertising packets.

- Can be customized for very low power devices, such as energy harvesting applications.

- Devices just need enough energy to send a few RF packets.

Proprietary proxy pros & cons

Proxy Server

Proprietary bearer

Proxy Client
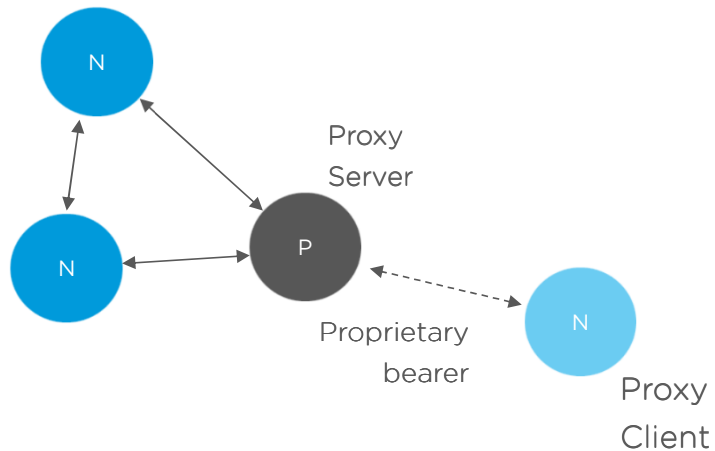
Pros:

- Very low energy consumption.
- Low power nodes can be very simple.
- Can pair to multiple Proxy nodes.

Cons:

- Proprietary protocol.
- No native mesh encryption.
- Can't be reached when sleeping.
- Can't talk directly to other mesh nodes.

Low duty cycle node

- A node should receive at least one packet per 96 hours to catch up with IV Update process.

- A node, inactive for more than 96 hours, needs to be able to scan for at least 5 seconds for Secure Network Beacon to recover IV Index.

- Nodes inactive for more than 48 weeks need to be re-provisioned.

Mesh time

Sleep time
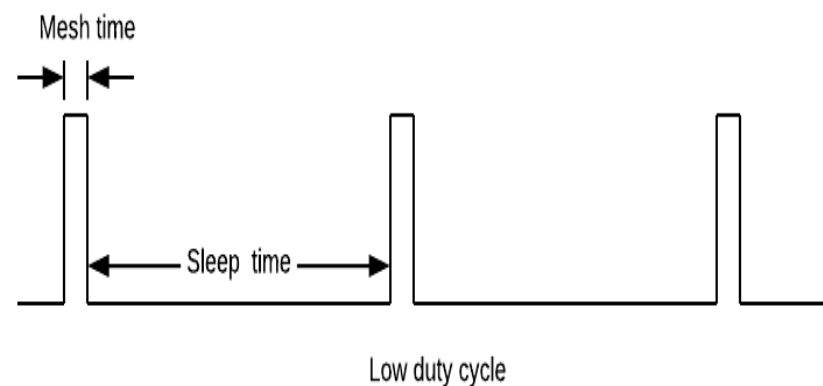
Low duty cycle

Low duty cycle node
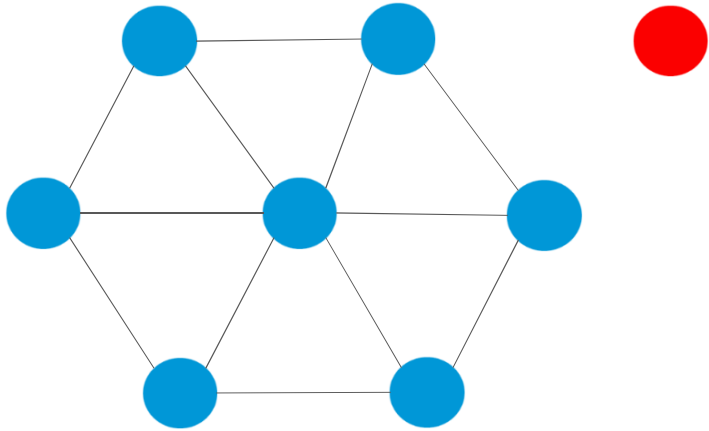
Pros:

- Uses native ADV bearer.

- Easy to implement.

- Doesn't require proxy nodes.

Cons:

- Can take multiple of seconds to get back to the network.

- No message cache.

- Can have very long latency.

Q&A

Expanding Bluetooth mesh for low power applications