Texas Instruments

MARIE HERNES and BHARGAVI NISARGA

WIRELESS MESH NETWORKING

EXTEND YOUR WIRELESS CONNECTIVITY WITH MESH TECHNOLOGIES: WI-SUN®, BLUETOOTH® MESH

Agenda

- Mesh network basics
- Wi-SUN®
  - Highlights
  - Applications
  - TI Wi-SUN software and hardware

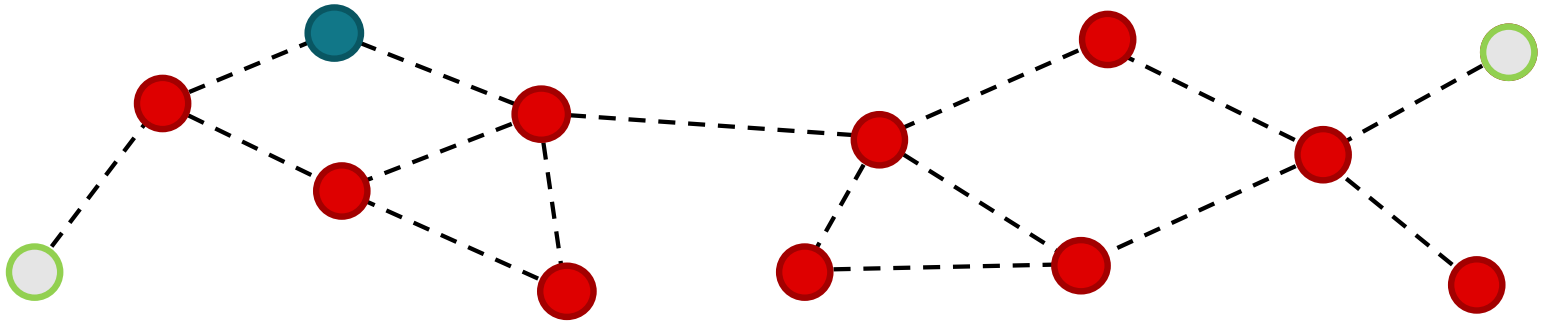
Speaker: Marie Hernes
Applications manager, TI Sub-1 GHz Connectivity

- *Bluetooth*® Mesh
  - Highlights
  - Applications
  - TI Bluetooth Mesh solution
- Summary

Speaker: Bhargavi Nisarga
Systems engineer, TI 2.4 Ghz Connectivity

Mesh | Network Basics

- Mesh Network: Network where devices may interconnect
  - **Router**: Device capable of connecting to other devices in the mesh network and can provide upward and downward packet forwarding. A new device should be able to join through any router.
  - **Border router/Gateway**: Device that provides outside connectivity.
  - **End node/leaf**: Node which is only capable of connecting to one peer device. Some protocols allow end nodes to be sleepy.



Mesh | Network Basics

- **Routing network**: Messages are sent according to a routing table
- **Flooding network**: All messages are sent through all connections in the network and assumed to reach their destination
- **Number of hops/jumps**: How many devices a message passes through before it reaches its destination

Mesh | Network Basics

- **Broadcast**: Message sent from one device to all devices in the network.
- **Unicast**: Message sent from one device to a single destination device.
- **Frequency hopping**: In a mesh network, it is not necessary for all nodes to be on the same channel all the time. Each node can have its own channel hopping schedule. However, when two nodes need to communicate, they need to be on the same channel.
- **Dwell time**: How long a device stays on a given channel and is available for communication.
- **Cost information**: In a frequency hopping mesh network, the fewest amount of hops may not represent the lowest cost route.

Wi-SUN®: Standards Based Sub-1 GHz mesh

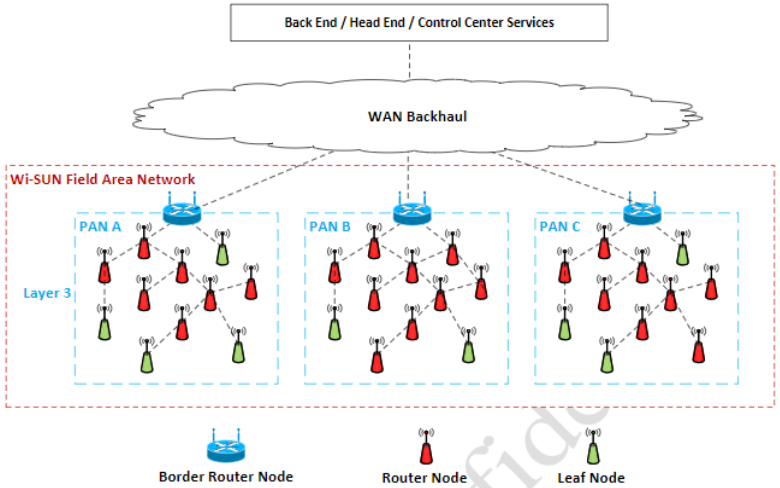
TI Sub-1 GHz connectivity

Marie Hernes

Wi-SUN | Overview

Wi-SUN target applications

- Smart utilities / smart grid
  - Advanced meter reading
- Smart city
  - Connected Street Lights
  - Smart traffic lights



Key features of Wi-SUN

- Open standards-based solutions
  - IEEE 802.15.4g wireless standard
  - Wi-SUN field area network (FAN)
- Robust and resilient wireless connectivity
  - Long range with Sub-1Ghz RF
  - Mesh network topology
  - Frequency hopping
- Support for Global frequency bands
- IPv6 protocol suite
- Standards-based, multi-layer security
- Certified products
- Multi-vendor interoperable solutions

Wi-SUN FAN 1.0 | Highlights

- IPv6 Based Network → Easier Integration with cloud and other network management services
- IEEE 802.1x Certificate based authentication → Improved network security
- Frequency hopping-based MAC → Robust network performance
- Mesh based topology → Self-healing network
- Worldwide region support → FSK Based PHY (50 kbps to 200 kbps) meeting regional requirements

Wi-SUN FAN | Example applications

Image source: Wi-SUN Alliance

TI Wi-SUN | Implementation

- Fully spec compliant
- Optimized stack with low memory foot print
- Multi data rate support
- Layer 3 based routing
- Scalable to several 100s of nodes
- Integrated on-chip NV usage for enhanced security
- TI-RTOS integration

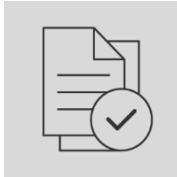
TI Wi-SUN Solution

HARDWARE

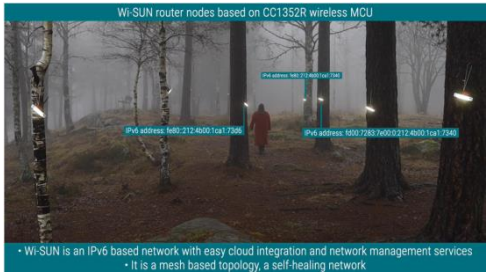
- Scalable silicon portfolio to support mesh nodes with needed memory, IOs, integrated PA,..
  - TI Wi-SUN Products
- Fully certified modules

- Evaluation Boards
  - CC13x2 LaunchPad development kits

SOFTWARE



- Platform software scalability
- Request information about the software TI provides for WI-SUN projects.



Wi-SUN® connected lights demo for smart cities

IDE, APPS

IDE Support:

- Code Composer Studio (CCS)

Extending Wireless Connectivity With *Bluetooth*® mesh

TI 2.4GHz Connectivity

Bhargavi Nisarga

Bluetooth Mesh | Not a new radio

Bluetooth Mesh technology enables wireless communication in a mesh network topology over multiple hops; thus extending range of the wireless connectivity.

Bluetooth Mesh is not a new radio. It's a new network topology.

Bluetooth LE | Technology

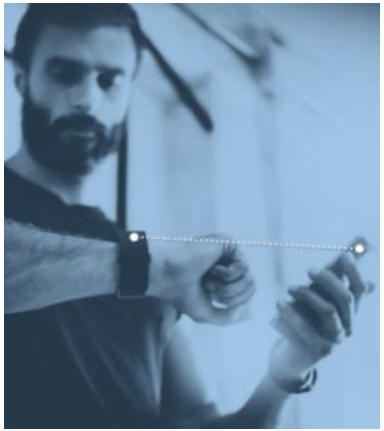
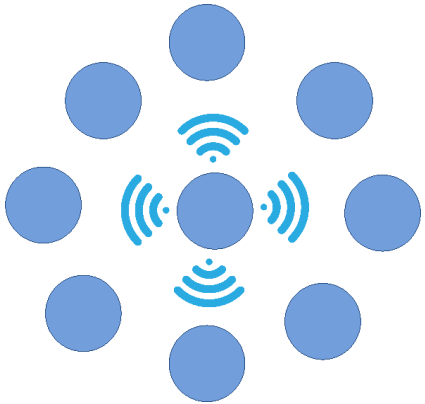
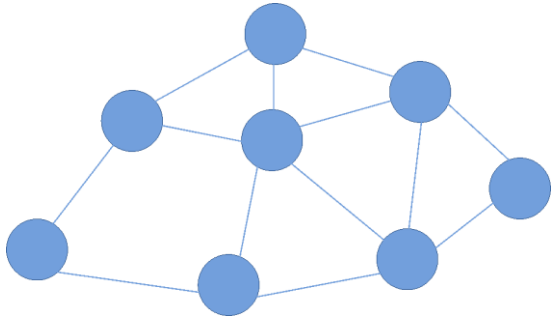


Image source: Bluetooth SIG

Point to Point (1:1)	Broadcast (1:m)	Mesh (m:m)
Data Transfer	Localized Information	Large Device Network
Connection Oriented Communication	Connection-less Communication	Multiple Bluetooth LE Radio Nodes
Sports & Fitness devices, Health & Wellness devices, Peripherals & Accessories	Point of interest beacons, Item finding beacons, Way finding beacons	Building automation, Wireless sensor networks, Asset tracking
Radio range dependent on RF sensitivity and Transmit output power		Range extension with mesh relay nodes

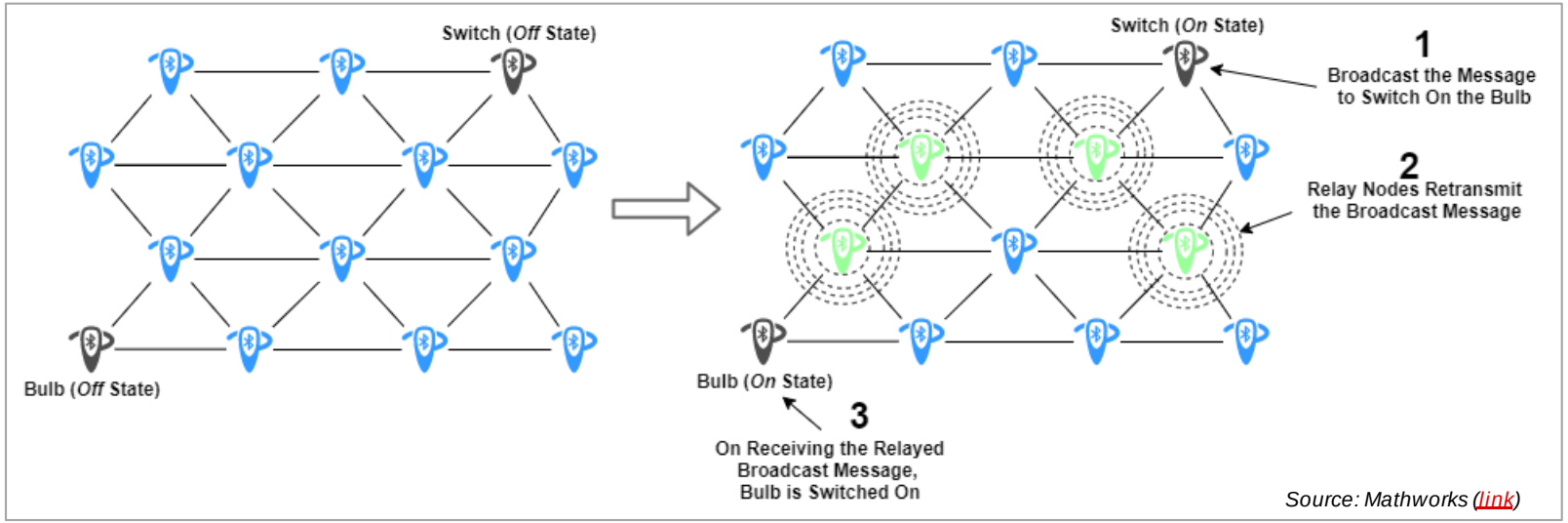
Bluetooth Mesh | Based on Bluetooth LE





Point to Point	Broadcast	Mesh
GATT bearer for Bluetooth Mesh Proxy role	Advertising bearer for all other Bluetooth Mesh roles	Mesh is based on observer and broadcaster roles
GATT connection for legacy Bluetooth LE devices	Advertisement and Scanning	Mesh devices have assigned addresses & shared keys

Bluetooth Mesh | In action



Managed flooding mechanisms:

- Optional relay node capability
- Time To Live (TTL)
- Message Cache
- Heartbeats

Robust network reliability:

- **Multipath delivery:** Messages can arrive at their destination via multiple paths through the network
- Message transmission over **three advertising channels**, one at a time

Bluetooth Mesh | Highlights

Industrial-Grade Solution

RELIABILITY
- Self-healing, multipath delivery with no single point of failure

SCALABILITY
- Support 10's-100's nodes with industrial level messaging performance

SECURITY
- Mandatory security at mesh network and application levels

End-user accessibility:
- Mesh nodes accessible by smart devices without a gateway
- Flexibility with device provisioning and configuration

Proven, Global Interoperability

FULL STACK SOLUTION
- All levels of network technology fully specified
- SIG specified functional models provides improved vendor interoperability

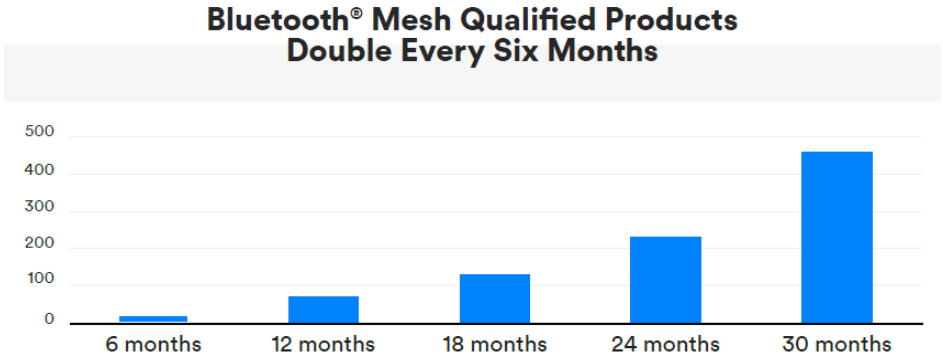
TOOLS AND PROCESS
- Qualification to ensure Global Multi-vendor Interoperability

Mature Technology

GLOBAL BRAND AWARENESS

MATURE ECOSYSTEM
- Create products and services with faster time to market

Bluetooth Mesh | Market adoption



Source: Bluetooth Market Update, 2020; Bluetooth SIG Qualification Program

- Bluetooth mesh specification was first released in July 2017
- Product qualifications have doubled every six months for the last two years with no signs of slowing down
- By enabling secure, reliable large device networks in areas with dense deployments, Bluetooth mesh is well suited for industrial applications.

Automation Systems —Bluetooth technology enables the automation of a building's essential systems, including HVAC (heating, ventilation, and air conditioning), lighting, and security to harness energy savings, lower operating costs, and improve the life span of a building's core systems.

Control Systems — Bluetooth mesh networking is quickly being adopted as the wireless communications platform of choice in a number of control systems, including advanced lighting solutions for smart building and smart industry markets.

Monitoring Systems — Bluetooth wireless sensor networks (WSN) monitor environmental factors to improve employee productivity, lower operating costs, or reduce unplanned downtime of production equipment.

Source: Bluetooth Market Update, 2020

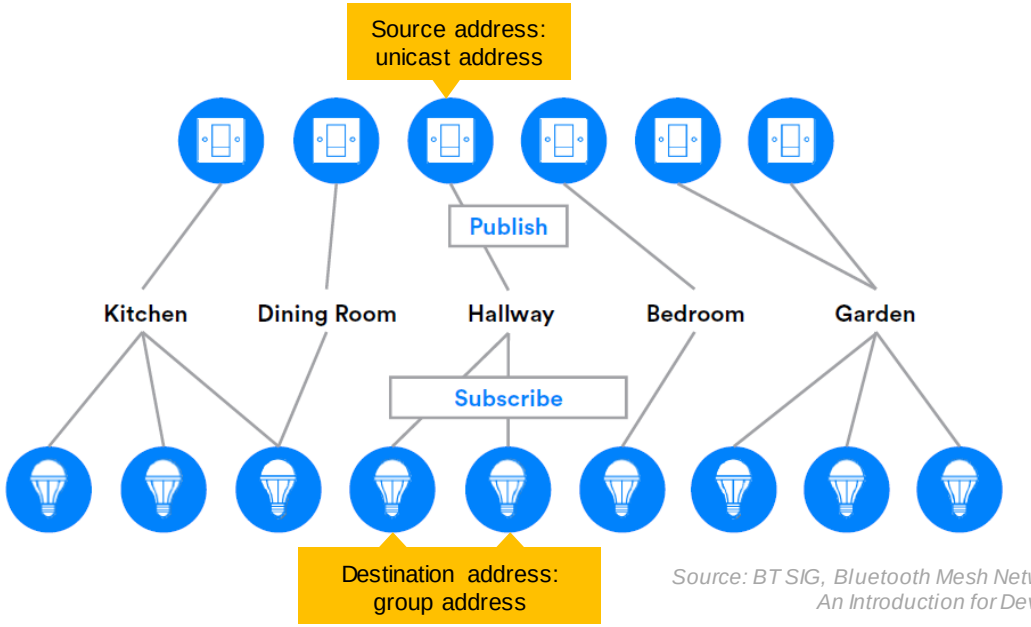
Bluetooth Mesh Application | Group control

Building automation – lighting control, equipment control (tools, desks)

With publish-subscribe messaging model, a node can publish messages to a **unicast or multicast address**

Area isolation within mesh network is enabled by **subnets**:

- By using different network (subnet) keys, the mesh network can be securely partitioned
- Conserves energy by limiting relaying messages within subnets.



Source: BT SIG, Bluetooth Mesh Networking / An Introduction for Developers

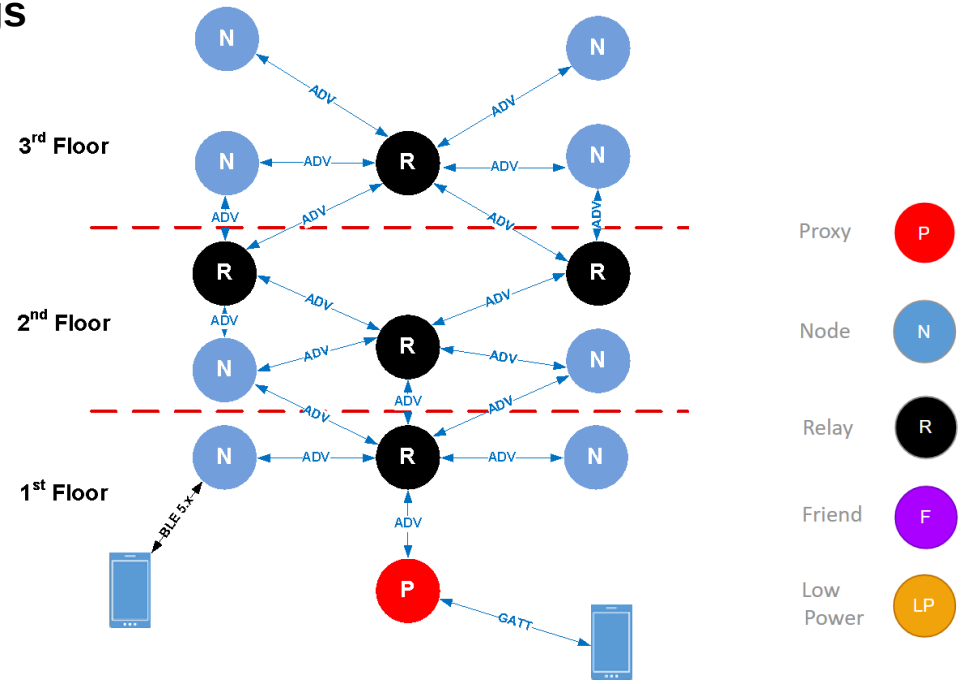
Bluetooth Mesh Application | Data collection

Smart grid: e-meter reading in buildings

Data collection from different nodes in the mesh network via mesh proxy node

- **Unicast addressing** used to sequentially gather data from different nodes in the mesh network
- **GATT proxy** enables smart device access to the mesh network with no additional gateway
- **Overall latency** for data collection dependent on multiple factors including #hops, payload size, collisions.

Concurrent Bluetooth LE and Bluetooth mesh operation to enable legacy LE connection use-cases

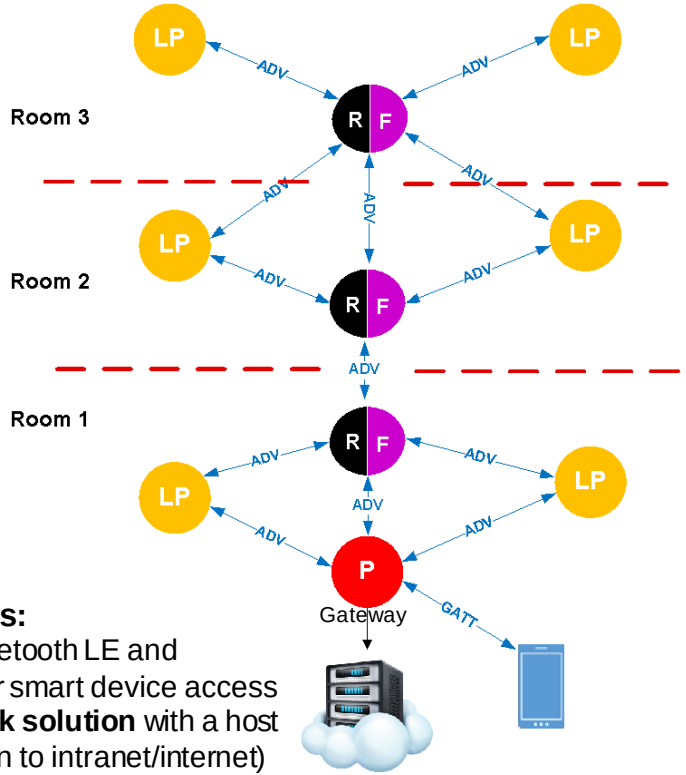


E.g. Technician collecting e-meter readings from multiple meters in a building

Bluetooth Mesh Application | Monitoring systems

Building, Factory Automation: Monitoring, Sensor systems

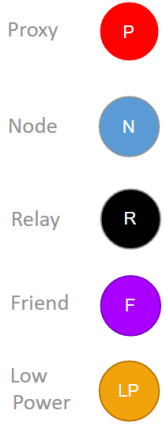
- *Predictive maintenance: monitor equipment operation, health status to extend equipment durability, reduce unplanned downtime, etc.*



Wireless sensors operate as low power nodes *- transmit sensor data at regular intervals to proxy/ gateway or when sensor crosses threshold value.*

Proxy, gateway node features:

- GATT proxy or concurrent Bluetooth LE and Bluetooth mesh connection for smart device access
- Support for **2-chip mesh stack solution** with a host processor (gateway connection to intranet/internet)



TI Bluetooth Mesh Solution

Bluetooth Mesh demo

HARDWARE

SimpleLink™ Bluetooth® Low Energy
Texas Instruments

- **Scalable silicon portfolio** to support mesh nodes with needed memory, IOs, integrated PA,..
  - TI Bluetooth Mesh Products
- Fully certified modules

- Evaluation Boards
  - CC26x2/CC13x2 LaunchPad development kit
  - LPSTK-CC1352R (LaunchPad SensorTag kit)

SOFTWARE

- **Platform software scalability**
- Bluetooth SIG qualified and easy to use stacks (link) Mesh profile QDID
- Concurrent Bluetooth LE and Bluetooth mesh operation
- Stack support for 1-chip (SoC) and 2-chip (with host) architecture

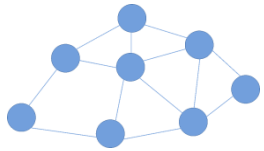
- Resource explorer documentation
- Mesh sample examples

IDE, APPS

IDE Support:
- Code Composer Studio (CCS)
- IAR Embedded Workbench

Bluetooth Mesh Provisioner, Configuration Client:
- Mobile app and ADK for Android and iOS
- BlueZ (Linux)

Wi-SUN, Bluetooth Mesh | In Summary



- Ultimately, the choice of wireless mesh technology to use for a deployment depends on several factors.
  - Wi-SUN is a Sub-1Ghz based mesh protocol optimal for long range connectivity with secure, reliable and open standards based communication **over large geographic areas**.
  - Bluetooth mesh is operated in 2.4GHz frequency band, uses Bluetooth LE radio over multi-hops to enable secure, scalable and reliable **large device networks in dense deployments**.
- No matter which mesh technology is needed, TI shall support a full featured hardware and software solution.

Application Considerations
Frequency Band
Interoperability
Routing & Reliability
Network scalability
One-hop range
Latency & Throughput
Security
Support for battery operated nodes
Cloud connection
Smart device connection
Provisioning

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