Wireless Connectivity Technology Selection Guide

Introduction

Selecting the right wireless connectivity technology is a critical design decision from the beginning. This determines the protocol interoperability, distance, robustness and the use-cases for your application. This selection guide will walk you through several key decision requirements starting with the table below as a high-level summary of various wireless connectivity technologies.

Features & specifications	Bluetooth® Classic	Bluetooth Low Energy	Bluetooth Mesh	Zigbee	Thread	Wi-Fi®	Wireless M-BUS	MIOTY	Amazon Sidewalk	WI-SUN® FAN 1.0	Proprietary Sub-1 GHz / 2.4 GHz
Range	Up to 100 m	Up to 200 m or 400 m w LR	Up to 200m(1)	Up to 200 m(1)	Up to 200 m	Up to 200 m	Several km of network coverage	Several km of network coverage	Varies based on the number of participating bridges	Several km of network coverage	Up to 1600 m
Frequency	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz	2.4 GHz 5 GHz	Sub-1 GHz	Sub-1 GHz	Sub-1 GHz and BLE: 2.4 GHz	Sub-1 GHz	Sub-1 GHz 2.4G Hz
PHY throughput	Up to 3 Mbps	Up to 2 Mbps	Up to 1 Mbps	Up to 250 Kbps	Up to 250 Kbps	Up to 100 Mbps	C,S, & T-Mode: 32 Kbps - 100 Kbps N-Mode: 2.4 to 19.2 Kbps"	400 Bps	FSK – 50 Kbps *(more data rates coming later)* BLE – 2 Mbps, 1 Mbps, 500 Kbps and 125 Kbps	50 - 200 Kbps	500 Kbps (Sub-1) 2 Mbps (2.4 GHz)
Network type	Peer-to-peer (P2P), Star	Peer-to-peer (P2P), Star, Broadcast	Mesh	Mesh	Mesh	Star (AP-STA modes), Mesh, Peer-to-peer (Wi-Fi Direct)	Star	Star	Star	Mesh	Peer-to-peer (P2P), Star, Mesh
Battery type	Single-AA	Coin-cell	Coin-cell	Coin-cell & energy harvesting	Coin-cell	Double-AA	Lithium batteries (ultra-low power)	Coin-cell	Coin-cell	Currently not intended for battery operated nodes	Coin-cell

Notes: (LR) Long Range - Requires the use of wireless power amplifiers and proper antenna setup. (1) For a single-hop.

Technology	Considerations
Bluetooth Classic	**Advantages of Bluetooth Classic:** • **Network type**	Bluetooth Classic is designed for short range applications, and supports network types such as peer-2-peer (P2P) and star network topologies. • **Throughput**	Bluetooth Classic is designed for high data throughput applications such as audio streaming, with data rates of up to 3 Mbps. • **Target application**	Audio streaming through wireless headsets, speakers and sound bars. **Potential disadvantages of Bluetooth Classic:** • **Power consumption**	Bluetooth Classic is not optimized for low power applications. **To get started with your Bluetooth Classic application, visit** www.ti.com/product/CC2564C

Technology	Considerations
Bluetooth Low Energy	**Advantages of Bluetooth Low Energy:** • **Network type**	Bluetooth Low Energy is designed for short range applications supporting peer-2-peer (P2P), star and broadcaster roles. Bluetooth Low Energy can be found in applications like health monitors, personal electronics, asset trackers and many more. Bluetooth is an excellent wireless technology medium that quickly establishes a connection and exchange data between two devices like smart car access. • **Power consumption**	Bluetooth Low Energy is designed for ultra-low power wireless communications and is capable of operating for years on a single coin-cell battery. The protocol is designed to be lightweight with the flexibility of tweaking various communication interval parameters like broadcasting at a 1-second interval. • **Throughput**	The Bluetooth 4 Low Energy and newer version standard data rate is 1 Mbps, which is sufficient for most types of communication. However, Bluetooth 5 Low Energy now also supports up to 2 Mbps for transferring data quicker. • **Wireless robustness**	Bluetooth Low Energy uses the 2.4-GHz wireless band, which is shared with other wireless technologies such as Wi-Fi, Zigbee, and Thread. To mitigate collisions in this crowded frequency band, Bluetooth uses frequency hopping to find an open channel before communicating. • **Security**	To learn more about security in Bluetooth networks, read: Understanding Security Features of SimpleLink™ Bluetooth® Low Energy CC13x2 and CC26x2 Wireless MCUs • **Target applications**	Wireless keyboards, heart rate monitors, blood pressure monitors, smart car access and many more. Bluetooth Low Energy is the most widely used wireless technology as it is commonly found in every smartphone or tablets. **Potential disadvantages of Bluetooth low energy:** • **Range**	Bluetooth is not designed for applications requiring long-range connections. Bluetooth would require a gateway bridge to connect to an IP network. **To get started with your Bluetooth low energy application, visit** www.ti.com/ble
Technology	**Considerations**
Bluetooth Mesh	**Advantages of Bluetooth Mesh:** • **Network type**	Built upon existing Bluetooth Low Energy technology, Bluetooth mesh extends the range of wireless communication in a mesh network over multiple hops, helping extend range of the wireless connectivity. Supports small to large networks up to 100 nodes with industrial level messaging performance while providing a self-healing, multi-path network with no single point of failure. One device connects and communicates with another device, establishing a 1:1 relationship. Inside the network a devices can have 1:1 relationships with multiple devices creating the hub mesh network. • **Power consumption**	Just like Bluetooth Low Energy, Bluetooth Mesh is designed for ultra-low power wireless communication and is capable of operating for years on a single-coin-cell battery. The device can remain in standby longer as intervals between radio-on times can be longer. • **Example application**	Lighting, HVAC, wireless sensor networks, data collection and many more. **Potential disadvantages of Bluetooth low energy:** • **Throughput**	Bluetooth Mesh is not designed for high data throughput. It's a low latency application. For any high data throughput, it's recommended to use Bluetooth Low Energy. **To get started with your Bluetooth Mesh application, visit** www.ti.com/bluetoothmesh

Technology	Considerations
Zigbee	**Advantages of Zigbee:** • **Network type**	Zigbee technology is a mesh based protocol that allows a network to grow as your application needs. It supports self-forming and self-healing mesh. There are four different Zigbee roles; Coordinators, Routers, End Devices and Green Power Devices. Zigbee is primarily found in building and home automation. • **Power consumption**	Zigbee is a low-power wireless communication enabling long battery life in end applications. To achieve this energy consumption, the end device periodically wakes up to send data and reenters low power mode as soon as possible. Zigbee Green Power Devices can even enable battery-less applications like energy harvesting using solar panels. • **Wireless robustness**	Zigbee is a wireless stack based on IEEE 802.15.4 (as the physical and MAC layer). The Zigbee application is capable of selecting a specific channel to communicate on with up to 16-channels. Zigbee is self-healing, and can identify a broken node in the network and reroute as necessary to preserve the network. • **Range**	Typical range of a Zigbee application is up to 200 m line-of-sight with one-hop distance. However, Zigbee can achieve long range through its mesh network capability by daisy-chaining multiple Zigbee routers in the network. • **Security**	To learn more about security in Zigbee networks, read: Understanding Security Features for SimpleLink™ Zigbee CC13x2 and CC26x2 Wireless MCUs • **Target applications**	You can find Zigbee networks in various home automation controls like a wireless light switch, thermostat and many more. Zigbee Certification guarantees interoperability with Zigbee Certified products from other vendors as well. **Potential disadvantages of Zigbee:** • **Network type**	Zigbee does not provide an easy way to connect to the cloud. Connecting to an IP network would require a gateway and address translation layer. • **Throughput**	Zigbee is not designed for high data rate transfer. It is designed to be a low data rate application with a maximum throughput of 250 Kbps. Discover new wireless technologies such as Zigbee SubGHz which combines proven, secure, reliable low-power Zigbee with ultra-long range communication. **To get started with your Zigbee application, visit** www.ti.com/zigbee
Technology	**Considerations**
Thread	**Advantages of Thread:** • **Network Type**	Thread is designed for the connected home using mesh to an IP-based network. It is designed primarily for building automation to control lighting, thermostats and other product. Thread self-heals and self-forms, meaning that it automatically promotes or demotes nodes to ensure there is no single-point of failure in the network. In addition, Thread works with any IPv6 gateway thus making it easy to commission new devices to the network. • **Power consumption**	Thread is designed to operate in low-power sensing applications, and connecting your sensors to the IPv6 network. Thread End Devices can sleep for an extended period of time, thus extending battery life. • **Range**	Thread range is typically up to 200 m line-of-sight for a single-hop. Thread is a mesh network capable of up to 32 hops to extend range. • **Security**	Inter-device communication is secured by default using AES-128. Commissioning uses standard DTLS with ECJ-PAKE. • **Target Applications**	You can find Thread networks being used in various home automation devices like light bulbs, electronic locks and many more. Thread is also designed to be controlled through any Thread certified devices. It can easily integrate with any existing application framework. **Potential disadvantages of Thread:** • **Throughput**	IPv6-based networks have the possibility for high-overhead, so the 250 Kbps throughput of Thread may be less adequate for existing IPv6 deployments. • **Application agnostic**	Thread does not prescribe an interoperable application framework; while Thread certifies network interoperability, application framework interoperability is not guaranteed. **To get started with your Thread application, visit** www.ti.com/thread

Technology	Considerations
Wi-Fi	**Advantages of Wi-Fi:** • **Network Type**	Wi-Fi has the ability to support star connections (stations with central access point), Peer-to-peer connections (Wi-Fi direct) and mesh networks. Wi-Fi is commonplace in most home and enterprise environments, allowing products with this technology to very quickly connect to existing infrastructures. • **Wireless Robustness**	Wi-Fi supports operation in the 2.4 GHz and 5 GHz bands, enabling flexibility of Wi-Fi products to decide which band they'd like to support. Wi-Fi's ability to operate in the 5 GHz band enables products to benefit from less congested channels to improve performance. Additionally, advanced PHY modulation schemes enable Wi-Fi to send data quickly, reducing the time on the air and chance of collisions. • **Security**	Wi-Fi has an active ecosystem that constantly evolves its security to keep it up to date and robust against hackers. Wi-Fi data can be encrypted before being transmitted by using the latest WPA3 personal and enterprise level encryption. Wi-Fi also has multiple layers of security because of its native IP like TLS. Our products meet some of the highest level of security with FIPS 140-2 validation. To learn more about security in Wi-Fi networks, read: Understanding security features for SimpleLink Wi-Fi CC32xx MCUs • **Throughput**	The Wi-Fi protocol is designed to be scalable to support a variety of application throughput requirements ranging from edge nodes to gateways. It enables fast over-the-air (OTA) updates and typical IoT/edge node devices with throughputs up to 100Mbps utilizing MIMO(Multiple Input Multiple Output). • **Power Consumption**	Power Consumption	The Wi-Fi protocol is flexible and allows very low average power consumption while connected to the network for battery-operated applications. It is also the most power efficient per bits of data transfer. • **Target Applications**	Wi-Fi is commonly used in consumer, industrial and enterprise applications to enable wireless connections between devices and the cloud. Wi-Fi can be found in products for smart buildings such as video surveillance, HVAC, access controls; for healthcare such as patient monitors, medical equipment; for grid infrastructure such as smart meters, solar/ renewable energy, EV charging; and many more smart products that need connection to the internet and remote monitoring. Note that Wi-Fi is one of the most widely used wireless communication standard between devices to the Internet. **Potential disadvantages of Wi-Fi:** • **Power consumption**	The Wi-Fi network include overhead of additional transmissions/receive cycles in addition to application requirements to maintain Wi-Fi connections. Calibration and TX/RX currents can be higher than other technologies making Wi-Fi solutions rely on AA batteries and have higher peak current draw. • **Range**	5 GHz transmissions have reduced range due to the increased path loss of transmitting at higher frequencies. This also reduces its ability to penetrate solid surfaces like walls or ceilings in a home. **To get started with your Wi-Fi application, visit** www.ti.com/wifi
Technology	**Considerations**
Proprietary 2.4 GHz	**Advantages of proprietary 2.4 GHz:** • **Network Type**	A proprietary 2.4-GHz network allows you the flexibility to tailor your wireless application layer protocol with the flexibility of designing peer-to-peer, mesh or star network configuration. 2.4 GHz operates on a license free band around the world which means you can deploy your application at a lower cost. • **Power consumption**	Proprietary solutions allow the best potential power optimization, as you are not limited in how you can customize the timing and duration of data transfer. • **Throughput**	There could be higher effective data transfer rate than most wireless standards, as you could optimize the communication overhead that is typically associated with wireless protocols. • **Target Applications**	Great for custom wireless protocol applications and interoperability with legacy 2.4-GHz wireless protocol application. **Potential disadvantages of proprietary 2.4 GHz:** • **Standards**	Proprietary 2.4 GHz is chosen to enable custom protocols that do differ from existing standards. You would have to define the application layer protocol when communicating between different peers. Proprietary 2.4-GHz protocols would not be interoperable with devices using any other wireless standard. • **Range**	2.4-GHz networks do not generally offer the longest range (see Proprietary Sub-1 GHz for long range proprietary networks). However, there are options to select wireless devices with Power Amplifiers (PA) to extend your application range by pairing them with proper external antennas. **To get started with your Wi-Fi application, visit** www.ti.com/wireless

Technology	Considerations
Proprietary Sub-1 GHz with 15.4 Stack	**Advantages of proprietary Sub-1 GHz:** • **Network Type**	A proprietary Sub-1 GHz network allows you the flexibility to tailor your wireless application layer protocol with the flexibility of designing peer-to-peer, mesh, or star network configurations. • **Wireless Robustness**	Sub-1 GHz is also typically less crowded than the 2.4-GHz band, thus offering much more robust wireless communication. However, the Sub-1 GHz spectrum band (typically 300 MHz to 900 MHz) varies by geographical region and the licensing of frequency band needs to be taken into considering when designing products for worldwide deployments. Some countries have specific frequency band within Sub-1 GHz that license free. For example, 915 MHz is a license free band in United States but not worldwide. • **Power consumption**	Proprietary solutions allow the best potential power optimization, as you are not limited in how you can customize the timing and duration of data transfer. • **Range**	Sub-1 GHz frequency band can travel significantly longer distances due to its longer carrier wave, allowing it to penetrate through walls. However, the longer the distance, the lower the data rate may need to be as data losses come into play. Additionally, there are options of using Power Amplifiers (PA) to extend your application range by pairing them with proper external antennas. • **Target Applications**	Great for applications that require long range communication like metering, smoke detectors or temperature sensors for buildings and industrial applications. **Potential disadvantages of proprietary Sub-1 GHz:** • **Standards**	There is currently no widely accepted wireless standard in the Sub-1 GHz frequency band. In a proprietary network, you would have to define the application layer protocol when communicating between different peers. • **Throughput**	Sub-1 GHz data throughputs could range from 5 Kbps to 500 Kbps, thus effectively lower than higher frequency data transfer like 2.4 GHz. The lower the frequency, the lower the data bandwidth that one could transfer because of the frequency bandwidth. **To get started with your Proprietary Sub-1 GHz application, visit** www.ti.com/sub1ghz
Technology	**Considerations**
Amazon Sidewalk	**Advantages of Amazon Sidewalk:** • **Overview**	Amazon Sidewalk is a shared network that helps products like Amazon Echo devices, Ring security, outdoor lights and motion sensors work better at home and beyond the front door. When enabled, Sidewalk can unlock unique benefits for your end-product, support other Sidewalk devices in the community and even open the door to new innovations like locating items connected to Sidewalk. • **Network type**	Amazon Sidewalk is a star network designed to connect devices conveniently beyond the front door. • **Power consumption**	The transceivers and wireless MCUs used in the end nodes deploy the same low power technology that is used in flow meters, allowing nodes to run years powered by AAA batteries. • **Throughput**	FSK – 50 Kbps, Bluetooth Low Energy 2 Mbps, 1 Mbps, 500 Kbps, 125 Kbps. Data rates may evolve and TI transceivers and wireless MCUS support a wide range of data rates. • **Wireless Robustness**	TI solutions for Sidewalk uses Sub-1 GHz band and Bluetooth Low Energy. Sub-1 GHz is also typically less crowded than the 2.4-GHz band, thus offering much more robust wireless communication. Some countries have specific frequency band within Sub-1 GHz that license free. For example, 915 MHz is a license free band in United States but not worldwide. • **Range**	Sidewalk allows end nodes to be connected to neighbors Sidewalk bridges using a small portion of its bandwidth, meaning that while there are Sidewalk bridges in the range of the end node, it will always be connected. • **Security**	There are different levels of security to protect customer data and privacy. More details can be found in this Amazon white paper. • **Target applications**	Applications are unlimited. Smart Home, Moisture Sensors, Garage Door Lock, Leak and Temperature Sensors, Pets Tracker, Home Security and so on. **Potential disadvantages of Amazon Sidewalk:** • **Global support** |Today Sidewalk is focused on the Americas ISM bands. **To get started with your Amazon Sidewalk application, visit** www.ti.com/amazonsidewalk

Technology	Considerations
Matter (Connected home over IP (CHIP))	**Advantages of Matter (Connected home over IP (CHIP)):** • **Network type**	Matter (Project CHIP) is an application framework designed to run over multiple IP-based wireless technologies like Thread or Wi-Fi and uses Bluetooth Low Energy for easy provisioning. It is designed to interoperate with various existing home or building automation ecosystem like smart speakers or sensors and connect to the world wide web. • **Power consumption, throughput, range, wireless robustness**	This depends on the underlying IP-based wireless technology being used. • **Security**	Each device requires authentication and device attestation to ensure devices has not been tampered. • **Examples applications**	Door lock, thermostat, temperature sensors, light switch and many more connected home automation devices **Potential disadvantages of Matter:** • **Device requirement**	High memory requirement **To get started with your Matter application, visit** www.ti.com/matter
Technology	**Considerations**
MIOTY	**Advantages of MIOTY:** • **Overview**	MIOTY technology is a new low-power wide-area network (LPWAN) solution, and is a true standardized technology based on ETSI 103 357. MIOTY achieves long range with Sub-1 GHz communication, and offers robust networks due to its innovative telegram splitting. Telegram splitting also makes MIOTY capable of scaling to thousands of devices on a single base station. Target applications are ultra-low power sensor devices, such as metering and environmental/industrial monitoring. • **Network**	MIOTY is a star network with +10,000 nodes. • **Power consumption**	MIOTY is used in ultra-low power applications. With mioty you can achieve up to 15+ years battery lifetime. • **Throughput**	MIOTY has very low data rates at 400 Bps with a long communication range. • **Range**	MIOTY excels at long range, with 5 kilometers in an urban environment, and up to 15 kilometers in rural areas. • **Examples applications**	MIOTY is perfect for applications where low data rates are sufficient. In the smart grid sector, flow (gas and water) meters are a good example of this. Asset tracking is another application that aligns well with MIOTY. A rapidly growing market is smart agriculture. This includes applications such as environmental and soil monitors, farm asset tracking, and irrigation controls. **Potential disadvantages of MIOTY:** • **Throughput**	MIOTY is not geared towards applications that require higher throughput such as e-meters. **To get started with your MIOTY application, visit** www.ti.com/MIOTY

Technology	Considerations
Wi-SUN®	**Advantages of Wi-SUN:** • **Overview**	Wi-SUN® is a standards-based mesh network with frequency hopping. The Wi-SUN Alliance has more than 300 members from 46 countries, with 100M+ devices deployed world-wide. Wi-SUN supports IPv6 protocol suite and standards based multi-layer security. The standard supports multiple data rates and frequency bands to meet different regulatory requirements world-wide. Applications include smart grid and smart city applications, with certified products enabling multi-vendor interoperability. • **Network type**	Wi-SUN is a mesh network where a single border router typically supports 100s of nodes. Multiple border routers can be deployed with the same network name but different PAN ID or different network names can be configured to scale network to 1000s of nodes. Multiple border routers can also increase overall network robustness. • **Range**	Typical Wi-SUN networks will cover up to a few square km of urban area with 5 - 10 hops. The Wi-SUN 1.0 standard allows up to 24 hops (or levels). • **Power Consumption**	All nodes in a Wi-SUN 1.0 network are routers and not intended for battery operation. Future versions of the standard intend to support battery operated devices as well. • **Security**	Wi-SUN FAN 1.0 supports best-in-class network security based on IEEE 802.1x specification. It uses public key infrastructure with x.509 certificates, and each device on the Wi-SUN network is expected to have its own unique certificate. Device identity certificates can be obtained either from a Wi-SUN Alliance approved third-party Certificate Authority (CA) or a manufacturer CA can be used. • **Example applications**	The largest installed base of Wi-SUN products is in Smart Metering, but Smart City applications such as Street Lighting is gaining traction. Wi-SUN is a good fit for any Smart City application that demands long RF transmission range, good level of security and high number of nodes. **Potential disadvantages of Wi-SUN:** • **Power consumption**	The Wi-SUN FAN 1.0 standard only supports routers that are always on, which is a challenge for battery operated devices. A future goal of the standard is also to support sleeping nodes running on batteries. • **Security**	Wi-SUN FAN 1.0 requires use of security certificates, which adds overhead in an application where high level of security is not required. **To get started with your Wi-SUN application, visit** www.ti.com/wisun
Technology	**Considerations**
Wireless M-Bus	**Advantages of Wireless M-Bus:** • **Overview**	Wireless M-Bus (wM-Bus) is the only European standard for wireless meter reading. Widely adopted by major metering companies across the continent, if there is a wireless meter or heat cost allocator currently installed in Europe, chances are it's using this standard. It has already been deployed for +15 years in several European countries. wM-Bus is based on European standard (EN) 13757-4, covering the specification of communication between meters and data collectors, also known as gateways. • **Network**	wM-Bus is a star network (LPWAN) of up to 1,000 nodes. This is meant to cover neighborhoods and cities for meter reading. • **Power consumption**	wM-Bus was designed with ultra low-power in mind. Due to the nature of metering designs, most wM-Bus devices run on lithium batteries. • **Throughput**	wM-Bus stack supports various throughputs, and these are defined by different modes. Stationary (S) mode is appropriate for meters that only need to only send data a few times a day. Frequent transmit (T) mode is applicable when sending greater amounts of data per day. Compact (C) mode can handle even higher data rates. These three modes operate on 868MHz. C,S, & T-Mode support 32 Kbps to 100 Kbps. If you don't need a high data rate, but your network is spread over a wide area, then the solution is a narrowband network on 169MHz. N-Mode, sometimes called Narrowband mode, supports 2.4 to 19.2 Kbps. • **Range**	wM-Bus provides several kilometers of network coverage. • **Examples applications**	wM-Bus was designed for the wireless metering market. Wireless meters include electricity, gas, and water meters. wM-Bus is also frequently used in heat cost allocators. **Potential disadvantages of wM-Bus:** • **Global support**	Right now, wM-Bus is mostly deployed in European countries, so if you aren't in Europe it might not be common to your area. **To get started with your wM-Bus application, visit** www.ti.com/wmbus

Choosing a wireless connectivity technology for your application use case can be challenging and this guide provides the initial specs that should be considered. That's why TI offers devices that support all of the above protocols and makes it easy to reuse and re-purpose application code as your requirements change. To get started on your next wireless connectivity project, visit www.ti.com/wireless to learn more on each specific wireless technology.

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