

Evaluating Smart Home Protocol Options from a User's Perspective

Is there one smart home protocol to rule them all?

By Devanjan Sikdar



In recent years, smart home technology has transformed the way consumers interact with their living spaces, offering unprecedented convenience, security, and efficiency. However, the myriad connectivity options available—ranging from Wi-Fi, Bluetooth, Zigbee, Z-Wave, and proprietary standards to emerging protocols like Thread, Matter, and Amazon Sidewalk—present a complex decision-making landscape for developers and users alike.

This paper evaluates these smart home protocols from a user's perspective, focusing on key factors, including ease of setup, reliability, interoperability, cost, and security.

Through a comprehensive review of current wireless technologies, user feedback, and real-world performance data, this paper seeks to demystify the connectivity choices and provide clear guidance for developers looking to build or expand their smart home product offerings. By highlighting the strengths and weaknesses of each option, the paper intends to empower developers to make informed decisions that align with their specific product needs, maximizing effort and return.





Introduction to Smart Home Wireless Protocols

Smart home devices are becoming more popular and affordable, but there is still a confusing array of different wireless technologies that enable them to communicate with each other and with your smartphone or voice assistant. These technologies are protocols or standards, and they have different features, benefits, and drawbacks. Some of the most common are Wi-Fi, Thread, Matter, Zigbee, Amazon Sidewalk, Z-Wave, Bluetooth, and proprietary. Here's a comparison of these smart home technologies to help you decide which suits your needs and preferences.

Wi-Fi

Wi-Fi is the most widely used and familiar technology for connecting smart home devices. It uses the same wireless network that you use for your laptop, tablet, or phone, and it offers high-speed data transfer and wide coverage. Wi-Fi is compatible with most smart home devices and platforms, such as Amazon Alexa, Google Assistant, Apple HomeKit, and Samsung SmartThings, just to name a few. Wi-Fi operates on the 2.4 GHz and 5 GHz frequency bands and can support data rates up to several gigabits per second.

Advantages	Disadvantages
High data rate and bandwidth, suitable for streaming video and audio	High Peak power requirement – Requires batteries capable of supplying hundreds of mA of peak current
Ubiquitous and compatible with many devices and platforms	Prone to interference and congestion from other Wi-Fi devices and networks
Easy to set up and use with existing infrastructure and standards	Limited range and coverage, especially in large or multi-story buildings
Supports cloud and remote access and control	Wi-Fi is widely used and familiar, making it a common target for hackers. The extensive use of Wi-Fi means that vulnerabilities are more likely to be discovered and exploited



Use Cases

Line-powered devices and battery-powered devices (rechargeable or higher capacity primary cell batteries, i.e., alkaline):

- Smart speakers, smart displays, smart TVs, and smart cameras
- Smart thermostats, smart locks, and smart doorbells
- Smart plugs, smart switches, and smart bulbs

Wi-Fi Mesh Use Cases:

Wi-Fi Mesh can improve the connectivity and functionality of smart home devices, including those located outdoors. This includes devices like security cameras and lighting.

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Thread

Thread is a low-power, mesh-based wireless protocol based on 802.15.4. It uses the same frequency band as Wi-Fi, but it creates a separate and dedicated low-power mesh network. Thread devices use robust mesh networking to cover homes and even commercial buildings. Thread does not define an application layer, so manufacturers need to develop their own or may be able to support an existing ecosystem like Apple HomeKit.

Advantages	Disadvantages
Consumes less power than Wi-Fi, which means that battery-operated devices can last longer	Low data rate and bandwidth, unsuitable for streaming video and audio
Maintains a stable and robust connection, as it can automatically adjust to changes in the network topology or environment	Dependent on a border router or gateway device for internet and cloud access
Supports a large number of devices, and devices can act as routers that extend the network range. Like Matter it supports IP	Limited availability and adoption of devices and products. Thread only defines the layers up to the network layers and does not define the application layer. Developers would need to create their own application layer or use an application layer that supports Thread natively like Matter, KNX and Dali+



Use Cases

Line-powered devices and battery-powered devices (primary cell and coin cell batteries):

- Smart sensors, such as motion, temperature, humidity, and light sensors
- Smart switches, smart plugs, smart lights
- Smart locks

Beyond the Door Thread Applications:

- Sensor networks, Asset tracking, and Control systems
- Garden/Backyard automation, Pool monitoring, and Outdoor lighting

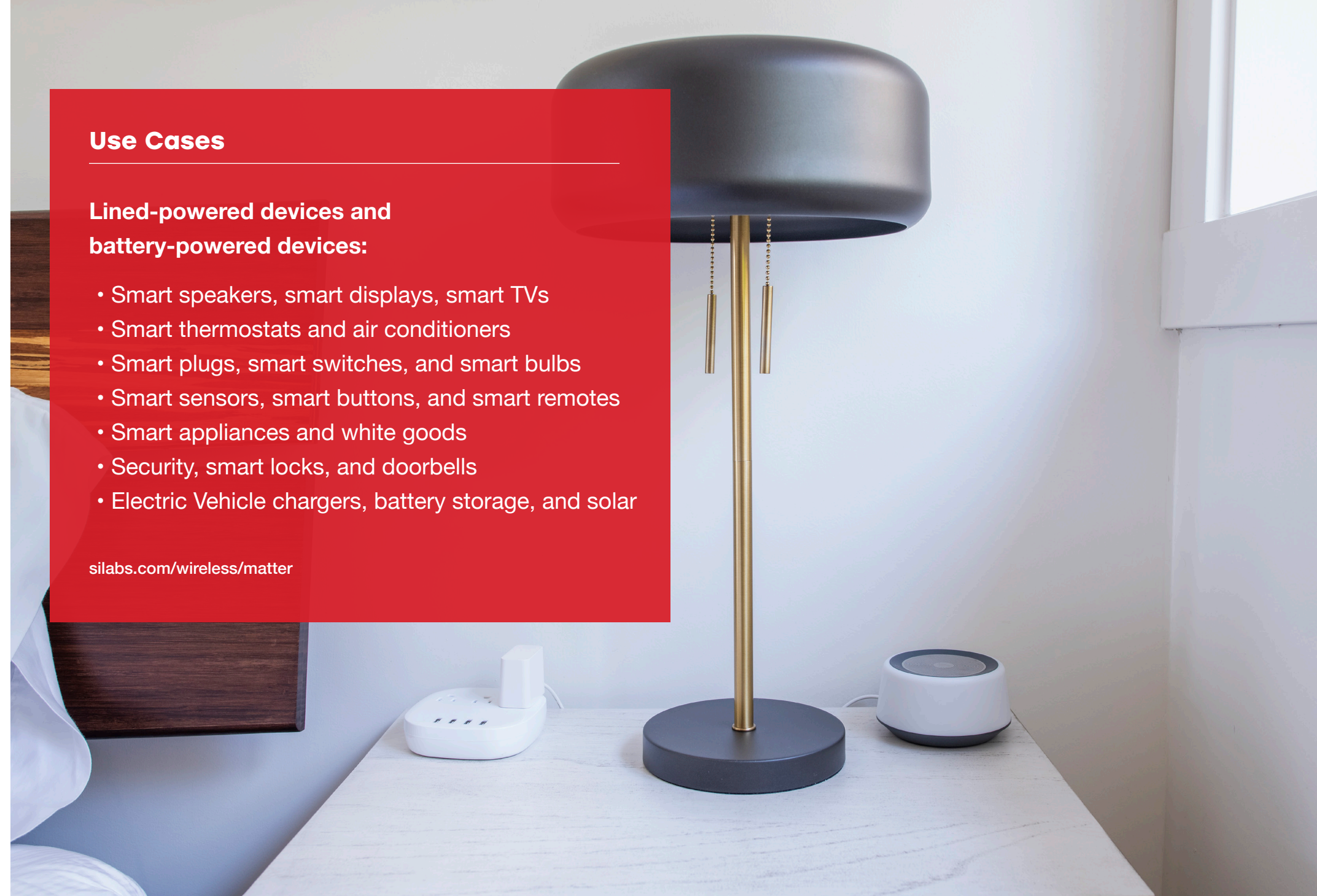
silabs.com/wireless/thread

Matter

Matter is a smart home protocol released in 2022 by the Connectivity Standards Alliance (CSA), a group of companies that includes Amazon, Apple, Google, Samsung, Silicon Labs, and many others. Matter aims to create a universal and interoperable standard for smart home devices, regardless of the brand, platform, or technology.

Advantages	Disadvantages
Supports multiple wireless technologies and protocols, enabling flexibility and versatility	Low data rate and bandwidth, unsuitable for streaming video and audio
Supports IP-based communication and interoperability with other devices and platforms. Enables common certification and logo for interoperability	May face initial challenges and interoperability issues between vendors and different Ecosystems
Supports high security and encryption with public key infrastructure and device authentication. Also Supported by existing Ecosystems and products in the field from companies like Google, Apple, Amazon and Samsung	Adoption uncertainty

Matter over Wi-Fi and Matter over Thread address different device types depending on key requirements in areas such as throughput, range, and battery life. The below image provides guidance on which wireless technology (Matter over Wi-Fi or Matter over Thread) applies to various devices and applications.

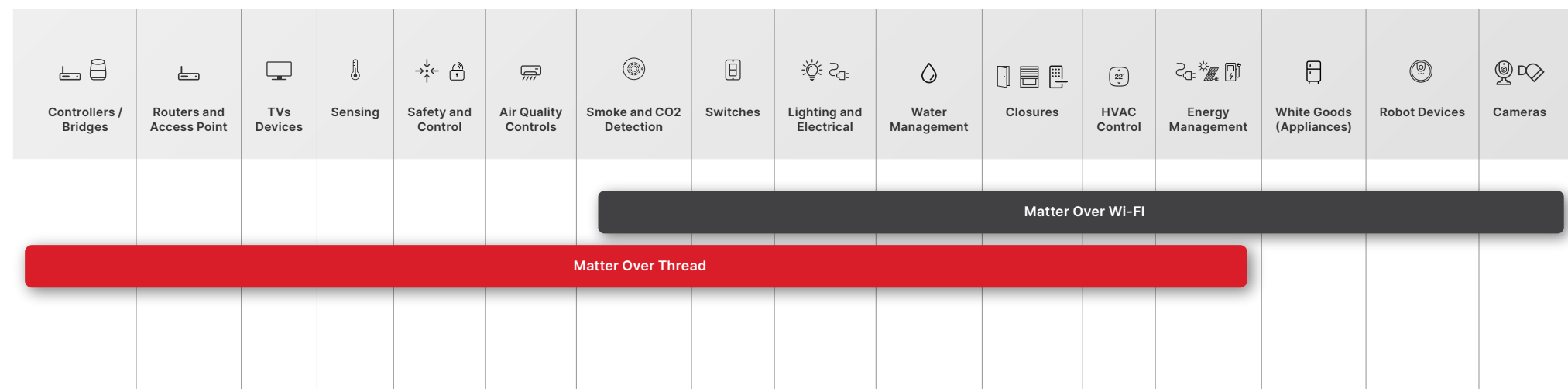


Use Cases

Lined-powered devices and battery-powered devices:

- Smart speakers, smart displays, smart TVs
- Smart thermostats and air conditioners
- Smart plugs, smart switches, and smart bulbs
- Smart sensors, smart buttons, and smart remotes
- Smart appliances and white goods
- Security, smart locks, and doorbells
- Electric Vehicle chargers, battery storage, and solar

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Zigbee

Zigbee is one of the most established smart home protocols used by many popular brands, including Philips Hue, Ikea, and Honeywell. It's also a low-power mesh-based protocol that operates on the same frequency band as Wi-Fi, but it uses a different modulation and coding scheme. Zigbee devices can form a network of hundreds of nodes and can communicate with each other or with a central hub or coordinator. Zigbee is directly supported around the globe by key smart home ecosystems, including Amazon, Samsung, and Tuya as well as many internet service providers.

Advantages	Disadvantages
Consumes very little power, which means that battery-operated devices can last for years	Routers for mesh networking need to be line-powered (this is typical for any mesh network)
Supports a variety of device types and has a large based on available products	Not suitable for high-speed data transmission, like voice and video
Zigbee mesh networking combined with high output power and sensitivity provides good coverage in the home and beyond the front door	Zigbee does require a hub/gateway. Certain ecosystem devices and device makers have this native



Use Cases

Lined-powered device and battery-powered devices (coin cell batteries):

- Smart sensors, such as motion, temperature, humidity, and light sensors
- Smart switches, smart buttons, smart plugs and smart lighting
- Smart locks
- Smart meters

Large building and beyond-the-door Zigbee applications:

- Sensor networks, asset tracking, and control systems
- Outdoor sensors, pool monitoring, and outdoor lighting

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Amazon Sidewalk

Amazon launched Sidewalk in 2021, a smart home protocol that enables shared wireless networks connecting IoT devices in homes, beyond the front door, neighborhood, and city. It's a long-range and low-bandwidth protocol that uses 900 MHz (Long Range) and 2.4 GHz Bluetooth LE to connect smart home devices and extend their network coverage. Amazon Sidewalk uses two modulation techniques to transmit data over the 900 MHz band: frequency-shift keying (FSK) and chirp spread spectrum (CSS).

Amazon Sidewalk uses FSK for medium-range communication between Amazon Sidewalk Bridge devices, such as Echo or Ring, and Amazon Sidewalk-enabled devices. CSS can provide a longer range than FSK but much lower data rates. By using FSK and CSS, Amazon Sidewalk can create a reliable and secure wireless network that covers a large area and supports a variety of low-power devices.

Advantages

Improves the connectivity and functionality of smart home devices, especially those located outdoors or far from the router, such as security cameras, smart lights, or pet trackers

Because it's a shared network, users can access Amazon Sidewalk without having actual infrastructure devices

Disadvantages

Consumes some of your internet bandwidth and power. Can have limited compatibility and availability, as it only works with certain devices and is currently limited to the US region

It can raise some concerns about data sharing and privacy

Use Cases

In the Home (Bluetooth LE):

- Tracking
- Theft Prevention
- Access Control
- Home Automation

Beyond the Front Door (Sub-GHz FSK):

- Outdoor Lighting
- Water Mitigation and Control

Beyond the Fence (Sub-GHz FSK and CSS):

- Park Management
- Environmental Management
- Building and Campus Management
- Airports

silabs.com/amazon-sidewalk





Z-Wave

Z-Wave is a low-power, mesh network protocol that operates on the 800-900 MHz frequency band. It is developed by the Z-Wave Alliance, which includes over 300 companies that produce Z-Wave-compatible devices. Z-Wave is widely used in smart home devices, especially for security, sensing, and climate control.

Designed to be reliable, scalable, and secure, Z-Wave uses a mesh network topology. This means that each device can act as a repeater and extend the range of the network. It also uses encryption and device authentication to prevent unauthorized access and hacking. A Z-Wave network can handle a maximum of 232 devices (nodes), including the primary controller.

Z-Wave Long Range (LR) provides higher output power for North America and supports more devices in a single network, up to 4,000 nodes, allowing users to add more smart home features and functionalities to their homes. This also enables multi-dwelling property managers to cover a building or complex on a single network.

Advantages	Disadvantages
Can avoid interference and congestion from other Wi-Fi devices, as it uses a different frequency band (868 MHz or 908 MHz, depending on the region)	Z-Wave devices operate in the sub-GHz band, which varies regionally. This means products are specific to regions and require vendors to have region-specific products based on regulatory approvals
Ensures a high level of compatibility and interoperability, as it follows a standardized and certified protocol that is maintained by the Z-Wave Alliance	Z-Wave devices have a maximum data rate of 100 kbps, which is sufficient for simple commands and status updates but not for streaming audio or video. grows
Z-Wave LR can extend the ranger to hundreds of meters, allowing for reliable communication beyond the fence for applications like gate openers and irrigation, as well as multi-dwelling units	While Z-Wave is backward compatible to standard Z-Wave, it does require a Long Range compatible hub for extended range

Use Cases

Z-Wave In Home - Lined powered device and battery-powered devices (coin cell batteries)

- Smart sensors, such as motion, temperature, humidity, and light sensors
- Smart switches, smart plug
- Smart locks, smart doorbells, and smart security systems

Z-Wave LR – Lined powered device and battery-powered device:

- Z-Wave LR enables wireless connectivity for sensors, door locks, and lighting without the need for repeaters or extenders. It can cover larger areas like gardens, driveways, or backyards, and provide more reliable communication in harsh weather conditions.

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Bluetooth LE

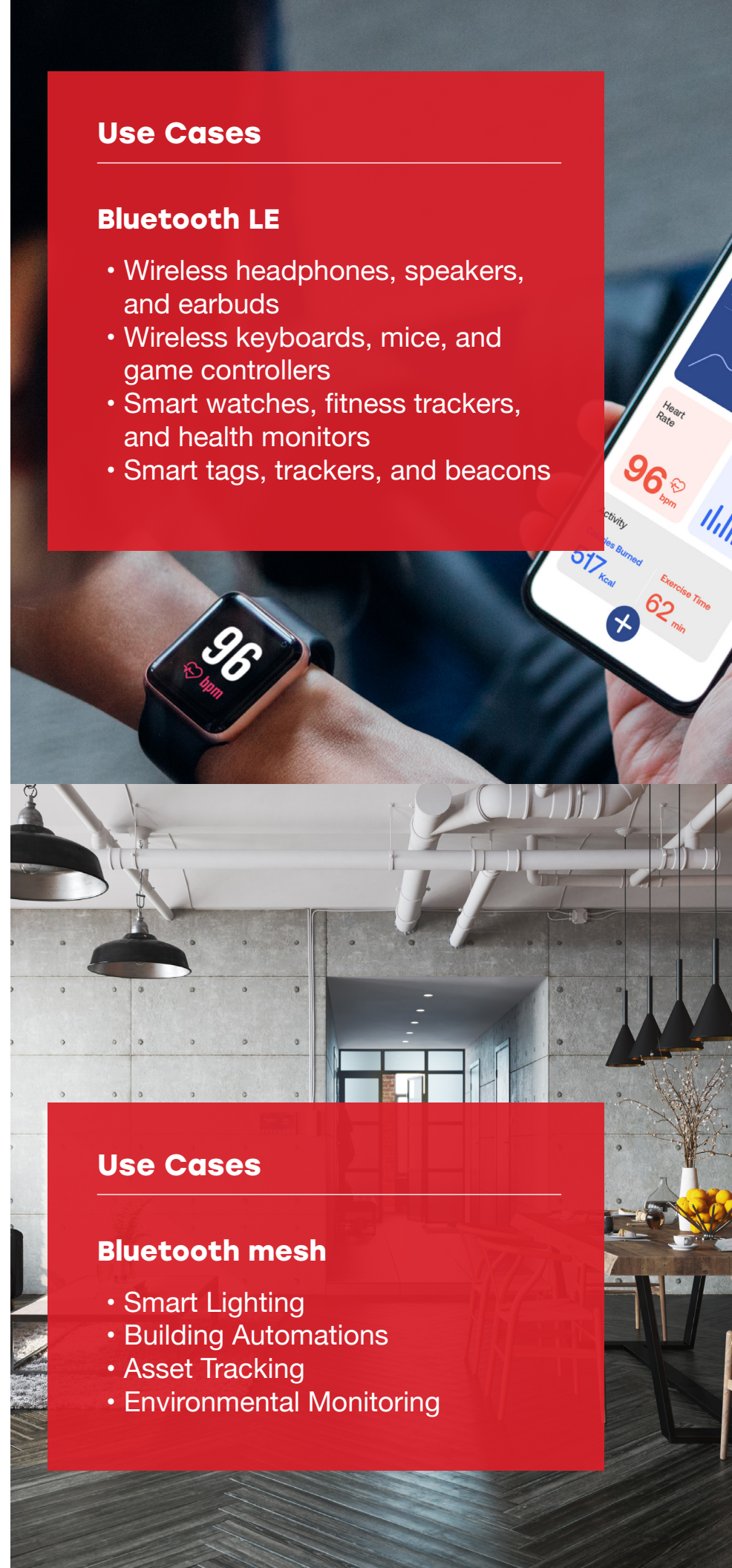
Bluetooth LE is another common and familiar technology predominately used for connecting devices to phones. It uses the same frequency band as Wi-Fi, but it has a shorter range and a lower data rate. Bluetooth devices can communicate with each other or with a smartphone or tablet, and they can form a network of up to seven devices, called a piconet. Typical smart home devices are locks and lighting that use the phone for in-home control. Bluetooth requires a hub for control outside of the home.

Advantages	Disadvantages
Easy to set up and use, as you only need to pair your devices with your smartphone or tablet. It is widely available and supported, as most smartphones, tablets, laptops, and smart home devices have Bluetooth capabilities	More targeted towards connectivity through phones and not for larger smart home applications
Supports location estimation to locate and track	Limited range

Use Cases

Bluetooth LE

- Wireless headphones, speakers, and earbuds
- Wireless keyboards, mice, and game controllers
- Smart watches, fitness trackers, and health monitors
- Smart tags, trackers, and beacons



Use Cases

Bluetooth mesh

- Smart Lighting
- Building Automations
- Asset Tracking
- Environmental Monitoring

Bluetooth mesh

Bluetooth mesh is a network topology that allows Bluetooth devices to relay messages to each other, forming a mesh network and overcoming the range limitations of Bluetooth LE. This means that Bluetooth devices can communicate with each other without relying on a central hub or router, can cover a larger area, and can support more devices. Bluetooth mesh also offers features such as self-healing, scalability, security, and low power consumption.

Advantages	Disadvantages
Self-healing, rerouting messages through other devices if one fails or goes out of range, ensuring uninterrupted operation and reliable message delivery	Uses a repeating mesh, so they don't scale as well as routing mesh networks. Bluetooth mesh 1.1 introduced Direct Forwarding, which helps reduce traffic
Supports a large number of nodes to meet the needs of large-scale and complex IoT applications	Large networks require careful planning and configuration to reduce delays and latency
Has a feature to standardize interface with phones, which have native Bluetooth support. That's an advantage over 15.4 mesh technologies	

Proprietary

Proprietary wireless technologies can operate on different frequency bands, such as sub-GHz or 2.4 GHz, and can support different data rates and bandwidths, depending on the vendor or manufacturer. Proprietary wireless devices can form different network topologies, such as star, tree, or mesh, depending on the vendor or manufacturer. Proprietary networks require their own hub or gateway and don't have direct connections to ecosystems. These devices can be enabled to work with ecosystems, such as Google Nest and Apple HomeKit through Actions or Skills.

Advantages	Disadvantages
Offers a unique or exclusive feature or functionality not available in other protocols	May limit the compatibility and choice of smart home devices, as you may not be able to mix and match products from different brands or platforms
Ensures a high level of quality and performance, as they are optimized and customized for their own devices	Can have increased costs compared to standard-based technologies
Provides better customer service and support, as they have a direct and dedicated relationship with their users	Pose a risk of obsolescence or discontinuation, as they may not be updated or supported by their manufacturers or platforms

Use Cases

- Proprietary smart sensors, smart buttons, and smart remotes
- Proprietary smart locks, smart doorbells, and smart security systems

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Smart Home Protocol Comparison Conclusion

As you can see, there is no single or best smart home protocol or standard, as each one has its own strengths and weaknesses, and they may suit different needs and preferences. Table 1 shows the summary of all protocols.

By comparing and evaluating the following factors, you can find the best smart home protocol or standard for your smart home.

amazon sidewalk

Bluetooth®

matter

Proprietary

THREAD

WiFi

zigbee

ZWAVE®

Which smart home wireless protocol should you use?

- Wi-Fi's ubiquity and compatibility with many devices make it a versatile and scalable option, but it also comes with a potential threat of getting hacked. Wi-Fi is a great technology for devices that need high bandwidth or are line-powered. Appliances, lighting, smart plugs, etc.
- For compatibility and interoperability of smart home devices with your existing or preferred platform, Matter is recommended. Regional adoption may affect this. Matter does have the most adoption across global ecosystems, but device types, etc., are still ramping.
- Z-Wave technology is a strong contender for smart home technology that requires extended range and coverage. Z-Wave operates on a sub-GHz frequency band, which allows for a mesh network where each device can act as a router or repeater to extend the network's range and coverage.
- Amazon Sidewalk can also be considered due to sub-GHz support that provides longer range.
- Zigbee is highlighted for its low-power and low-data-rate wireless technology designed for applications that require long battery life, network reliability, and security. Zigbee devices can form a mesh network to extend the range and coverage, which also contributes to efficient power usage.

- While considering power consumption, Zigbee, Matter over Thread, and Z-Wave can all provide years of battery life for sensors on coin cells. Wi-Fi is a viable option for devices that can run on larger primary cell (think alkaline) batteries but is not the best for sensors due to the small size and small battery requirements.
- When it comes to scaling, most technologies will scale to a larger enough number of devices for a home.
- While considering the cost and complexity, Wi-Fi has the broadest install base and has that advantage, but it can be difficult to set up, especially for devices that don't have a any type of a user interface.
- Technologies like Zigbee, Z-Wave and Amazon Sidewalk are very easy to commission on to the network but will require a hub that supports them. Matter does have an advantage as it simplifies commissioning for Wi-Fi and can support Matter over Thread for devices that Wi-Fi are not the optimal technology choice.
- Proprietary protocols can be optimized for performance, providing faster response times and more reliable connections. This is particularly important for applications that require real-time data transmission, such as security systems or home automation.
- Bluetooth Mesh can be a great choice when you don't require a central hub for communicating between devices.

Based on the application requirements and device type, you may see more than one smart home protocol that is being used. Refer to Table 2 for the Smart Home Protocol Selector Guide.

Wi-Fi is a great technology for devices that need high bandwidth or are line-powered. Appliances, lighting, smart plugs, etc. Zigbee, Z-Wave, and Matter over thread are good for devices that need long battery life (measured in years) or need to run on coin cells. Wi-Fi can be an option for devices that can run on multiple alkaline batteries (we mainly see this in Smart Locks), but they do provide less battery life than Zigbee, Z-Wave, or Matter over Thread.

Z-Wave is commonly used due to its ecosystem interoperability, security features, sub-GHz long range, reliability, and long battery life.

Wi-Fi is a good match for appliances requiring IP connectivity due to its high bandwidth capabilities.

For applications such as environmental management and building/campus management that require extended coverage across different levels and rooms, Z-Wave LR is recommended because it can support a large number of devices and offers reliable communication using sub-GHz technology. Amazon Sidewalk is also a good choice.









	 Bluetooth®	 Bluetooth® mesh	 matter	 amazon sidewalk	 Wi-Fi®	 zigbee	 Z-WAVE®	 Proprietary
Market Focus (Home)	Lighting, Locks	Lighting	Smart Home	Smart Home	Smart Home	Smart Home, Metering	Smart Home and Home Security	Smart Home
Frequency Bands	2.4 GHz	2.4 GHz	2.4 GHz (Thread) 2.4 & 5 GHz (Wi-Fi)	2.4 GHz (Bluetooth) Sub-GHz (FSK & CSS)	2.4 & 5 GHz	2.4GHz	Sub-GHz	2.4 GHz and Sub-GHz
Range	In Home	In Home	Beyond Front Door	Beyond Fence	Beyond Front Door (Wi-Fi Mesh)	Beyond Front Door	Beyond Fence	Beyond Front Door
Native IPv6 Connectivity	No	No	Yes	No	Yes	No	No	No
Cloud Connectivity	Gateway, Phone	Gateway, Phone	Border Router	Amazon	Router	Gateway	Gateway	Gateway
Application Layer	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Existing Infrastructure	Large	Small	Medium	Very Small	Everywhere	Medium-Large	Medium	Fragmented
Ecosystems Support	Amazon, Apple, Google, Signify	Amazon, Leedarson, Alibaba, Xiaomi	Amazon, Apple, Google, Comcast, SmartThings, IKEA	Amazon	All	Amazon, IKEA, Signify, Somfy, Legrand, Tuya	Alarm.com, Ring, ADT, Leedarson, Assa Abloy, Samsung	Amazon, Google, Lutron
Mesh Networking	NA	Yes	Yes	NA	Yes (Infrastructure)	Yes	Yes	Yes
Additional Notes	Location services, Direct phone connectivity	Direct phone connectivity	Self-healing (Thread), State of art security, Large ecosystems interest	Multiple PHY support and long range	Ubiquitous connectivity	Mature technology, 4000+ certified devices, Battery-less ZGP	Mature technology, 4000+ certified devices, new Long Range	Large install base of devices but market is fragmented and devices from different manufacturers don't interoperate

Table 1: Summary of all Protocols









	 Bluetooth®	 Bluetooth® mesh	 matter	 amazon sidewalk	 WiFi	 zigbee	 ZWAVE®	 Proprietary
LED Lighting		✓	✓		✓	✓		
Television			✓		✓			
Air Quality Control			✓					
Access Points			✓					
Controllers and Bridges			✓					
Smart Wearables (Watches, Fitness Trackers)	✓				✓			
White Goods			(Matter Over Wi-Fi) ✓		✓			
Robot Devices			(Matter Over Wi-Fi) ✓		✓			
Switches and Plugs			(Matter Over Thread and Wi-Fi) ✓			✓	✓	✓
Sensors			(Matter Over Thread and Wi-Fi) ✓			✓	✓	✓
Locks			(Matter Over Thread and Wi-Fi) ✓		✓	✓	✓	✓
Thermostats			(Matter Over Thread and Wi-Fi) ✓		✓			
Building Automation				✓				
Cameras			(Matter Over Thread and Wi-Fi) ✓		✓			
Wireless Devices (Keypads, Mouse, Earpods)	✓							
Smart Meter						✓		✓
Smart Appliances	✓				✓			✓
Smart Tags	✓							
Street Lighting				✓			(Z-Wave LR) ✓	
Environmental Monitoring		✓	(Matter Over Thread and Wi-Fi) ✓	✓			(Z-Wave LR) ✓	
Garden and Pool Management				✓			(Z-Wave LR) ✓	
Appliance Predictive Maintenance				✓				
Water Mitigation and Control			(Matter Over Thread and Wi-Fi) ✓	✓				
Building Management				✓			(Z-Wave LR) ✓	
Park Management				✓			(Z-Wave LR) ✓	

Table 3: Smart Home Protocol Selector Guide