SILICON LABS

Designing for the Smart Home

Smart Home Development Considerations and the Underlying Technologies that Make Smart Home Devices Smart

Even though it is still in its infancy, the smart home represents an impressive collection of technology. Today, consumers can control their lights, music, environment, and safety within their own homes using simple voice commands or smartphones. As the industry evolves, these smart devices will expand their capabilities to further simplify our lives.

The underlying technology required to deploy smart devices, however, is anything but simple.

Bringing a smart device to market involves much more than just connecting it to the internet. **"What Makes a Smart Home Device Smart"** outlines some of the underlying provisions needed to build a smart device. These include sensors, connectivity, interoperability, services, computing resources, local storage, software, energy conservation, certification, and security. As the figure below shows, even a product with limited perceived functionality, such as a smart light bulb, can actually be a complex system relying on an array of technologies, each of which is built on a foundation of tens of thousands of development hours.

Regardless of an original equipment manufacturer's (OEM) IoT experience, navigating these underlying technologies can be challenging. Maintaining a leadership position in the market requires substantial investment, effort, and ability to track the progress of multiple technologies that aren't part of a company's core expertise. This can severely impact task development teams and delay time-to-market.

Advances in IoT continue to simplify smart device design by abstracting more low-level details with each generation of technology. As much as developers no longer need to write their own USB stack for use in their products, it is also no longer necessary to become a wireless expert to build robust connected devices. The key to success in the smart home market is to partner with a silicon manufacturer that is backed by a comprehensive solution ecosystem that integrates these smart technologies to everyone's advantage.

The first step in the smart home development process is to determine the best technology fit early. Done correctly, developers can optimize their designs while at the same time adapt to the evolving smart home market. Understanding how connectivity, interoperability, certification, and software impact smart device design can help OEMs deliver features that consumers want at a welcomed price point. From this foundation, OEMs can then select the best silicon manufacturer and development ecosystem to achieve this goal.

A smart device can be a complicated undertaking, requiring integration of numerous underlying technologies, including sensors, connectivity, interoperability, services, computing resources, local storage, software, energy conservation, certification, and security.

Learn More

Choosing the Right Wireless Technology

Connectivity refers to the technologies used by smart devices to communicate with each other and to the internet. Given the many places a sensor or device can be placed in the home, it is often not practical to design with wired connections. Wireless connectivity provides much more functionality and flexibility than wired implementations. The result is that practically every smart home device utilizes a wireless radio.

The primary wireless communication protocols used in the connected home include Wi-Fi, Bluetooth, Zigbee, Z-Wave, and Thread, in addition to many proprietary protocols that have been developed on sub-GHz frequencies. Each protocol and frequency has its strengths in a given application environment. Using an established protocol offers many benefits, including proven reliability, wide availability of components, and multi-vendor interoperability in the consumer marketplace.

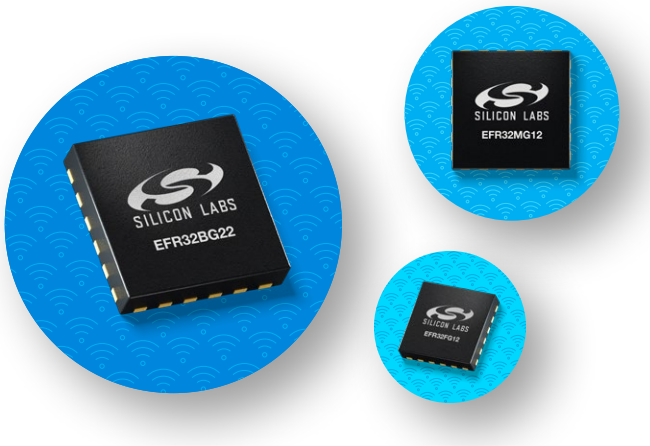
Except for emerging markets, the choices for wireless technology are often already established. In general, if connectivity requirements include far reach, penetration of solid surfaces like walls, and minimal energy consumption, then protocols based on SubGHZ are often the best choice, though these tend to lack standardization. The 2.4 GHz and 5 GHz standards come into play when higher bandwidth is required, typically in closer-reach environments.

In many environments, users will have a hub or gateway device that can serve as a bridge for devices to connect to the home network. For environments without such bridges, devices will need to support a second radio to connect to the home network. Typically, this second radio is either Wi-Fi or Bluetooth Low Energy (BLE). Wi-Fi allows the device to connect to the internet through a home router while BLE connects through a cellphone to the cloud, with the interface via a mobile app.

Other factors that often influence protocol choice include industry, application, and regional requirements. Some industries and certain applications require standard protocols and for those, a smart device will be sold with the protocol support clearly defined on its packaging. Standards and frequencies vary from region to region around the world.

Some markets may utilize multiple wireless standards. Conversely, an industry experiencing early growth may use various platforms that smart devices can connect to but each utilizing a different standard. (i.e., Bluetooth for Alexa and Thread for Google Home). To traverse these issues, designers need to be able to repurpose their designs across regional variations. This requires a flexible design platform that supports multiple protocols with the same development tools.

To simplify mesh network development, Silicon Labs offers EFR32 SoCs and modules that support each of the various mesh networking standards.



For example, to simplify implementation of mesh networks, Silicon Labs offers its **EFR32 SoCs and modules**, which support **Thread**, **Zigbee**, and **BLE**. The EFR32 addresses the requirements of low- to mid-volume applications as well as high-volume, chip-down designs. Silicon Labs also has SoCs targeted for **line-powered applications** — including lights, gateways, voice assistants, and meters — as well as ultra-low-power SoCs for **high-volume battery-powered or energy-harvesting IoT applications**.

For applications that need to support more than one wireless standard, Silicon Labs offers a variety of **multi-protocol SoCs and modules**. Multi-protocol components allow a smart device to serve as a hub or gateway between smart devices built on different standards. A multi-protocol architecture also enables a single design to serve as the foundation for product lines that must support different standards to operate in multiple regions, resulting in substantial developmental cost and time savings.

The Silicon Labs **Wireless Starter Kit** includes Zigbee, BLE, and Thread software stacks, sample code, an integrated debug adapter, and a **Radio Abstraction Interface Layer** (RAIL). RAIL provides a consistent radio API so a device can dynamically switch between protocols as required. With RAIL, developers can futureproof their designs and adopt the latest RF technology while minimizing their design efforts.

One of the advantages of working with a platform like the EFR32 is that developers can evaluate multiple radio technologies side-by-side. Using a single board for evaluation enables an apples-to-apples comparison between BLE, Zigbee, and Thread. Developers can then also see how each standard performs with their application in terms of throughput, range under specific operating conditions, energy efficiency, and other important factors.

The six primary wireless communication standards available for use in the connected home

Bluetooth

Designed for data transfer and exchange over short distances, Bluetooth makes use of the unlicensed ISM band at 2.4 GHz. Bluetooth includes a number of capabilities that span from point-to-point audio streaming to large-scale many-to-many (m:m) mesh networks.

Proprietary

Silicon Labs' proprietary wireless devices provide high-performance wireless connectivity and ultra low-power 8-bit and 32-bit microcontroller options. With support for major frequency bands in the 142 to 1050 MHz range and 2.4 GHz, these devices can be used to develop many classes of smart home systems.

THREAD

Thread is an IPv6-based mesh networking protocol designed as a reliable, low-power, secure, and scalable networking solution for connecting Things to the IoT. As a founding board member of the Thread Group, we help accelerate time to market with proven mesh networking hardware and software solutions.

Wi Fi

Wi-Fi is one of the most common technologies for wireless connectivity, providing secure, reliable and fast wireless IP connectivity. Our Wi-Fi solutions are targeted for applications where excellent RF performance, low power consumption, and easy application development together with fast time to market are key requirements.

zigbee

Zigbee is a 2.4Ghz mesh technology with an interoperable application layer that delivers low-latency communication. Battery-operated smart home devices can operate for seven years with our Zigbee technology. Our Zigbee solutions use multi-hop mesh networking to eliminate single points of failure and expand the reach of networks for the smart home.

Z-WAVE

Focused 100 percent on the smart home, Z-Wave sub-Ghz technology is interoperable and backwards compatible regardless of type, brand, manufacturer, or version. Our Z-Wave solutions provide whole-home coverage, industry-leading S2 security, and major improvements in energy efficiency, allowing a sensor to last 10 years on a coin-cell battery.

MAKE VS. BUY

When to Go Custom and When to Use Off-the-Shelf

The decision whether to build a custom radio or use a certified module depends upon a number of factors. The point at which one makes greater sense over the other often depends on volumes. Modules offer a fast time-to-market by substantially reducing development time, eliminating costly learning curves, and simplifying the certification process. A custom radio built on an SoC often costs less as an equivalent module but typically requires substantially more development time and effort. Even the largest of companies will start with modules and stay with them, justifying the decision based on ROI and having their engineering teams move on to the next product sooner.

Long-term factors also need to be taken into account. While it may make sense to build a product based on a custom design, OEMs have to consider if they are prepared to go through the expense of redesigning the radio subsystem when a new standard becomes available. Each new design incurs costs that will have to be absorbed again, requires another round of certifications, and delays time-to-market, potentially opening the field to new competitors. A redesign can also be forced on an OEM if key components become unavailable or are discontinued.

With rising privacy, security breaches, and IP protection concerns, security can affect the long-term make-versus-buy consideration. Security is implemented in both software and hardware, and the rate of change in security technology increases year over year. Management of software-based security updates can be simplified by using software libraries, minimizing design effort and investment. However, many new security advances are being implemented in hardware. Smart devices built using modules can more easily and quickly introduce these new hardware-based security capabilities — such as root of trust, secure memory, and new encryption acceleration technology — by transitioning to next-generation modules. Furthermore, security is becoming a legislated requirement in many parts of the world. Modules give companies a fast path to respond to such requirements if legislation changes mid-design.

The make-versus-buy decision doesn't have to be a permanent decision. Many companies use modules to evaluate, design, and deliver products to market quickly. Once a product has tested out and begins to sell in volume, some company take the option to move to a custom design. OEMs who choose to transition to a custom design will want to work with a silicon manufacturer who has a module-to-SoC roadmap and has been through this process numerous times.

Getting Your Smart Device to Play Well with Others

Ensuring interoperability with other smart home devices using the same standards is one of the more challenging aspects of smart device design. Interoperability issues can arise for a number of reasons. In some cases, the standard specification has left certain decisions to be made by the manufacturer, and different implementations can lead to interoperability issues. Some parts of a specification are optional. These options can lead to devices having trouble communicating with devices that don't support the same features.

Interoperability is one of the most important success factors in the smart home market. Consumers adding a smart device to their home network tend to have limited technical expertise — and even less patience. It doesn't matter which device is causing the problem. The new device being added to the network is typically blamed, resulting in a fully functional device being returned to the shop at the manufacturer's expense. Smart devices that offer robust and interoperable experience increase their chance of success in the market.

Ensuring interoperability is another reason many OEMs choose to use wireless modules rather than build their own custom radio designs. Module manufacturers have a large stake in making sure their modules are compliant and interoperable. Because module vendors sell in volume across many OEMs, they can afford to invest in the engineering resources necessary to ensure robustness to a high degree. They are also able to spread the cost of maintaining interoperability across many product lines and customers, resulting in a cost to OEMs that is typically much lower than OEMs could achieve on their own.

Consumers rely heavily on certification logos to determine which products can work with each other and thus which ones to purchase.

CERTIFICATION

Delivering Confidence to Consumers

Another important consideration when it comes to interoperability is certification, and both are critical for success in the smart home market. Certification is a formal guarantee to consumers that a device meets the appropriate specifications. This guarantee takes the form of a standard's logo on the packaging, giving a potential buyer confidence that the device will interoperate with other devices that the consumer has already purchased.

The cost of failing to certify a device is that the OEM cannot use the standard's logos, advertise compatibility, or guarantee interoperability with other devices. As consumers don't tend to understand (or care to understand) the technical differences between technologies, these logos are often how users determine which products can work with each other and therefore which they are safe to purchase for their environment.

There are at least two types of certification that a wireless smart device needs to achieve: protocol certification and radio emissions certification (which can change from region to region). There may also be certifications required by industry, such as those for medical and industrial applications.

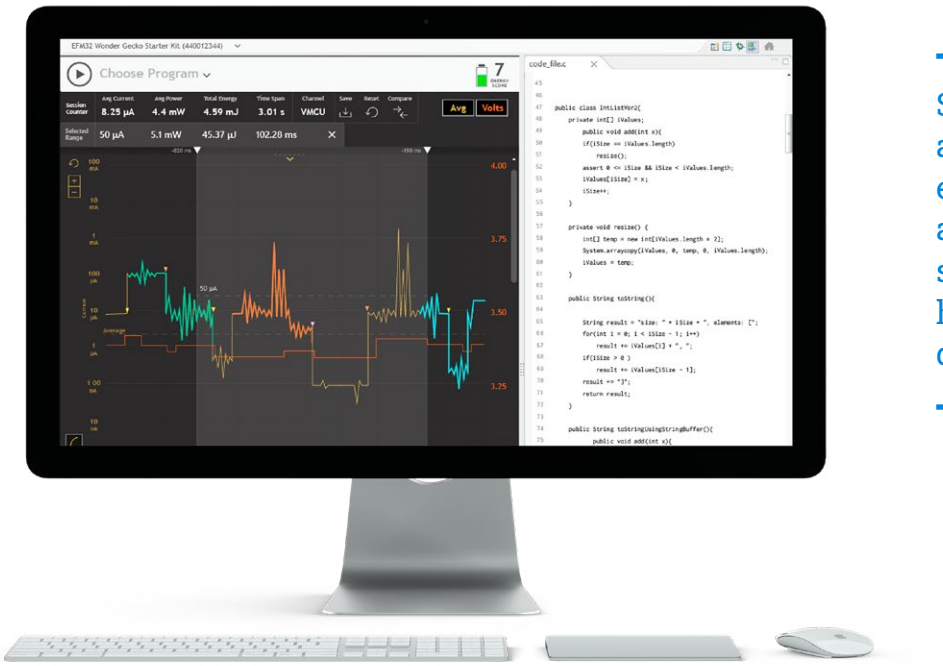
Pre-Certification

Pre-certified modules eliminate the need to invest in the niche engineering and regulatory expertise required to successfully certify a design, resulting in lower development cost and faster time-to-market.

Self-Certification

Certification can introduce significant costs, increase engineering investment, and delay time-to-market. Walking through the certification of a device can be an eye-opening experience for those new to the process. There are expenses associated with each round of certification, as well as delays created through preparing for testing. If a device does not pass, it will require some level of redesign and then the time-consuming process — and expense — of certification begins again.

Certification is an important aspect of design to work into development costs and the engineering timeline. The impact on cost and time-to-market are substantial enough to shift the make-versus-buy decision of using a pre-certified module. Because a module is a complete subsystem in and of itself, it can be pre-certified for both the radio and protocol. The overall system (i.e., final product) still needs to be certified, but so long as the module and antenna design is not modified, the overall system should easily pass certification. Pre-certified modules eliminate the need for an OEM to make the full investment in the niche engineering and regulatory expertise required to successfully certify a design.



Simplicity Studio provides an integrated development environment with the tools and features needed to simplify and optimize smart home device development for developers of all skill levels.

SOFTWARE

Many Layers

Software is the essential glue that coordinates the other technologies that make a smart device. Because it has many layers, software can itself be extremely complex. To facilitate design, silicon manufacturers bring together a development "ecosystem" of partners to provide production-ready software, from firmware drivers to APIs that abstract communications through the protocol and radio. This allows OEMs to concentrate on their own value-added IP and design better products faster.

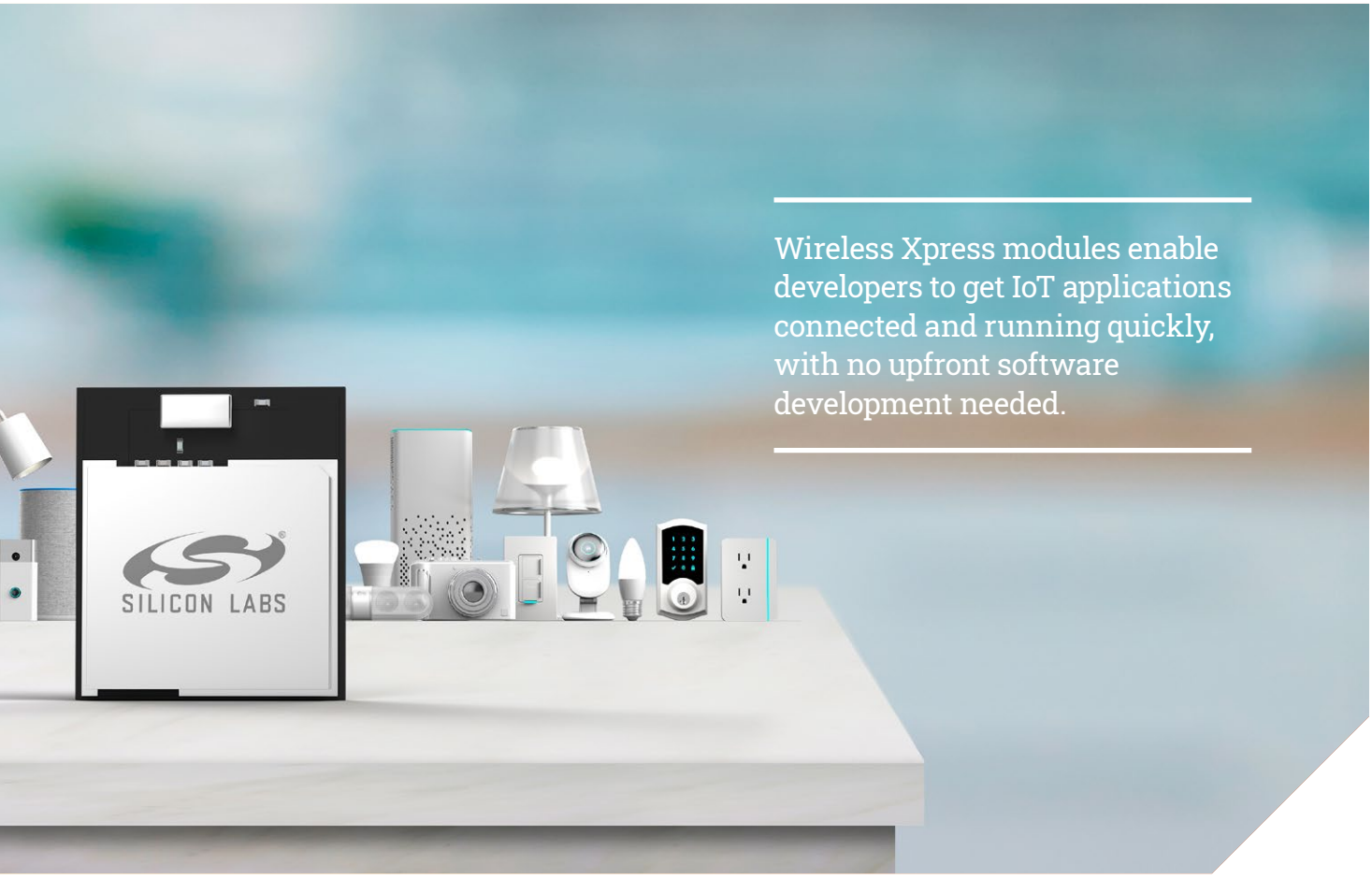
When choosing a silicon manufacturer and development ecosystem, OEMs should consider the breadth of smart technologies that a manufacturer offers and how well silicon, software, and tools are integrated. Ideally, there will be a unified yet flexible integrated development environment (IDE). For example, when an OEM develops a product but works with one vendor supplying the Bluetooth and another supplying Zigbee, the OEM's smart home development team has to design and debug the systems using different toolsets. With a unified IDE, developers can design, develop, and debug different protocols in the same environment.

Simplicity Studio from Silicon Labs is an IDE with the tools and capabilities needed to simplify and optimize smart home development for developers of all skill levels. Simplicity Studio has built-in intelligence to automatically detect the connected MCU or wireless SoC, graphically configure the device, and display the available configuration options to get a new design up and running in minutes. Smart home device development is simplified with one-click access to design tools, documentation, software, and support resources like precompiled demos, application notes, and example applications. With additional capabilities including energy profiling and network analysis, developers can optimize wireless connectivity for their specific application.

Simplicity Studio becomes the centralized launch point for design, providing comprehensive support across different standards, SoCs, modules, and applications. No other integrated development environment delivers the breadth of support for IoT design that Simplicity Studio does. Simplicity Studio runs on Windows, macOS, and Linux and is cross-platform, allowing developers to match their existing design flow and use their compiler and development libraries of choice.

Because connectivity is such a fundamental aspect of IoT design, Silicon Labs also offers software and tools for creating smart devices. For example, **Wireless Xpress** modules enable developers to get IoT applications connected and running quickly, with no upfront software development. To accelerate mobile app development, developers can use the mobile app SDK for both Android and iOS, which provides a flexible framework built on libraries and example applications.

Using a configuration-based development approach, Silicon Labs supplies everything needed to quickly build a smart device, including certified BLE and Wi-Fi modules, integrated protocol stacks, and easy-to-use tools. The result is the ability to prototype a design in hours rather than weeks.



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INNOVATION

Keeping Pace with Rapidly Changing Technologies

Rapidly changing standards and security requirements make keeping a smart device up-to-date a continuous work in progress. For example, recent laws regarding privacy require OEMs to design flexible products that can be updated to counter new security threats. Failure to do so can result in financial penalties as well as brand damage.

Understanding how protocols and other technologies are evolving enables OEMs to define a more accurate product roadmap, as they know which advances in technology they'll be able to take advantage of and when.

One of the most effective ways to stay up-to-date on relevant technologies is to attend industry conferences. There are key events for each of the connectivity standards, providing detailed insight into how to overcome today's design challenges. New to the list of events are integration conferences like Works With. **Works With** is the largest smart home event dedicated to training developers on how to integrate products with any hub or smart home ecosystem. It brings the leading ecosystems together in one place — Amazon, Google, Comcast, Samsung, and many others.

Tracking the progress of multiple technologies and standards remains a challenge for all design teams. This is one of the areas where the right smart home development partner can offer significant value. Silicon manufacturers like Silicon Labs are at the forefront of protocol development, both from a hardware and software perspective, and can do most of the "footwork" for OEMs.

Silicon manufacturers who support a single standard have only a limited industry perspective. Manufacturers with products based on multiple protocols can offer a more balanced perspective of which standard is best for an application. Silicon Labs is the only silicon manufacturer to offer solutions for six major wireless technologies.

We are entering the golden age of IoT and the smart home. The underlying technologies required to build smart devices are readily available off-the-shelf, enabling OEMs to quickly evaluate, prototype, design, and deliver leading-edge smart devices. With the right smart home development partner and ecosystem, OEMs can simplify and accelerate the design process, lower their development costs, and get to market faster. Instead of reinventing technologies like wireless connectivity, developers can focus on designing innovative ways of utilizing IoT to create distinctive smart home devices, drive the market, and improve quality of life.