Bluetooth®

a guide to joining the internet of things:

Opportunities, Technical Considerations, and Development Best Practices

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Bluetooth®

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MAKE YOUR WORLD SMARTER

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Current growth forecasts from IHS Technology project total Internet of Things (IoT) device shipments to increase from the 7.8 billion shipped in 2014 to 12.2 billion in 2019, while the installed base is expected to grow from 31 billion to 62 billion devices. What's more, according to Gartner, Inc., 50 percent of IoT solutions by 2017 will originate in start-ups that are less than three years old—in many cases, creating products we can't currently conceive of because they haven't been invented yet.

> **According to Gartner, Inc., 50 percent of IoT solutions by 2017 will originate in start-ups that are less than three years old—in many cases, creating products we can't currently conceive of because they haven't been invented yet.**

Clearly, opportunities for bringing new products to the IoT abound. But this potential for dramatic growth and innovation also brings competitive challenges. Not every IoT device brought to market will succeed, nor will every supporting technology. We'll look at the opportunities that are driving product plans and analyze key considerations that will help CIOs make winning technology and development decisions.

Business Opportunities in the IoT

The IoT is characterized by "smart" products that collect data from sensors and other input and then communicate that data to other IoT devices or to mobile or cloud-based applications to be stored, shared, aggregated, analyzed, and acted upon as usable information. And while smart products don't have to be mobile, mobility allows consumers to receive data where and when they want, which supports remote monitoring and control of everything from their home thermostat to a loved one's health and wellbeing. In the always-connected IoT landscape, it's no surprise that mobile devices dominate.

The technology landscape for wireless used to be a confusing one for product developers. That changed with the wide scale adoption of Bluetooth 4.0 with low energy technology. All devices need to connect with the cloud through mobile and fixed platforms and there are really only two primary communication technologies that deliver that connectivity: Bluetooth and Wi-Fi. Implement one or both, depending on usability, speed, and power.

Bill Saltzstein
Code Blue Consulting

> **Developers who can successfully define new, high-value capabilities also open up new use cases for their products that can result in improved brand loyalty, as well as potential new revenue streams and partnerships.**

But smart products are more than just connected, mobile devices. To succeed, the information they communicate must provide new value to consumers. Developers who can successfully define new, high-value capabilities also open up new use cases for their products that can result in improved brand loyalty, as well as potential new revenue streams and partnerships (see chart below).

New IoT Use Cases Open Up New Opportunities

These wide-ranging business opportunities highlight a key attribute of the IoT. It is not a market in itself, but a connected ecosystem that underpins many broad horizontal markets—including consumer, industrial, energy, automotive, healthcare, transportation, and smart home—as well as multiple vertical segments within each of those. The defining factor is connectivity, from one device to another and in many cases to the Internet, where the translation from raw device data to actionable information becomes the value driver for IoT products.

Brand Development and Product Line Growth	Consumers expect nearly every new product to have connectivity features that add convenience, entertainment, safety, and cost-savings. Manufacturers have opportunities to add competitive smart features that extend the life of existing product lines—from umbrellas to pacemakers to industrial sensors—and develop entirely new products to meet evolving IoT demands.
Consumer-Driven Product Roadmap	Connected devices allow manufacturers to receive real-time information about product usage and consumer habits. This information can be used by planning teams to extend popular product features and modify or remove those that are not regularly used, resulting in improved product roadmaps that will drive future consumer purchases.
Improved Maintenance and Support	Connected sensors can communicate information back to the manufacturer on the degree of wear and tear of product components, which can help predict when a malfunction might occur. By providing guidance, maintenance, or support even before a failure occurs, manufacturers can improve customer satisfaction and loyalty.
Direct Sales Connection to Consumers	Connected products allow manufacturers unprecedented access to data on consumer behaviors and preferences related to product usage. This opens up new direct-sell, cross-sell, and up-sell revenue opportunities, such as complementary products and accessories, insurance, extended warranties, as well as next-generation product lines.
New Business Partnerships	Smart devices aggregate valuable data on consumer usage patterns, behaviors, and preferences that can be shared among business partners, providing opportunities for mobile advertising as well as new sales channels through partners with complementary connected products.
Common Ecosystem	With collaboration between business partners, an extensive portfolio of connected products from different categories and manufacturers can be managed via a single online application. Brand loyalty to this common ecosystem can expand business opportunities for each partner.

Connectivity Decisions in Creating Smart Devices

The success of the IoT (and of companies betting their business on it) depends on seamless, secure communication between devices with connectivity technology that is simple for consumers to set up and is easy for developers to support and contribute to. Whether you are entering the IoT with innovative, never-seen-before devices or making existing products smarter with the addition of data-gathering and sharing capabilities, connectivity is one of the most critical technology decisions you will make.

> **The success of the IoT (and of companies betting their business on it) depends on seamless, secure communication between devices.**

And while wired connectivity will continue to support specific use cases such as closed industrial systems and applications that connect hard-wired devices to new remote devices and sensors, short-range wireless networks are playing an increasingly important role in the ecosystem of Internet-connected devices. Today's wireless technologies offer levels of speed, reliability, and security that come close to wired, but add the significant advantages of mobility, flexibility, and ease of connection.

Not every application falls neatly into a single category, but some general observations can be made around the two ends of the wireless connectivity continuum, from applications that are designed for relatively stationary usage in one location to those that are designed for mobile, often battery-powered environments.

Stationary, Single-Location Applications

While products for these applications may still be considered mobile, they typically connect to a high-speed, large-scale network, either directly or through a gateway device. IoT products that fall into this category may not often leave that location (and if they do, they may require dual connectivity options). Examples include medical devices used almost exclusively within hospitals and clinics, industrial devices used in manufacturing operations, or devices that are incorporated entirely within a mobile environment such as a vehicle. Characteristics may include:

- More expensive or proprietary devices
- Stringent security controls
- Always-on, high-speed connectivity
- High network capacity
- Size, power, and cost are not prime considerations

Mesh networking technologies are becoming increasingly important in smart home and industrial automation scenarios. While several companies have already announced and are selling products based on today's Bluetooth mesh technologies, they are also working with the Bluetooth SIG to create one standard approach to mesh networking over Bluetooth. This means, that for the first time, there will be true interoperability between all products for mesh networking using Bluetooth technologies.

Steve Hegenderfer
Bluetooth SIG

For these applications, a dedicated gateway device or wireless access point may be required that acts as a central hub to connect to the Internet using wired Ethernet, Wi-Fi, or cellular technologies.

Mobile, Remote, and Battery-Powered Applications

At the other end of the wireless continuum, mobility and low power are defining characteristics. Devices for these applications include the exploding array of healthcare and fitness wearables, through business productivity devices and smart home/smart building products such as remote sensors and devices that must run for long periods of time without recharging or needing a battery change. While some of these applications still require a gateway, the smartphone has become the mobile computing device that consumers depend on to conveniently access IoT data and services and manage their surroundings—that has made the smartphone the preferred gateway for a vast and growing category of mobile and remote IoT devices. Characteristics of these devices often include:

- Complete mobility or flexible use almost anywhere
- Low power and small size
- Ease of setup and operation
- Broad ecosystem support across smartphones, tablets, and laptops as well as other IoT devices
- Cost-effective
- Secure, reliable connectivity
- Extensive developer support to anticipate new consumer demands

> **The smartphone has become the mobile computing device that consumers depend on to conveniently access IoT data and services and manage their surroundings.**

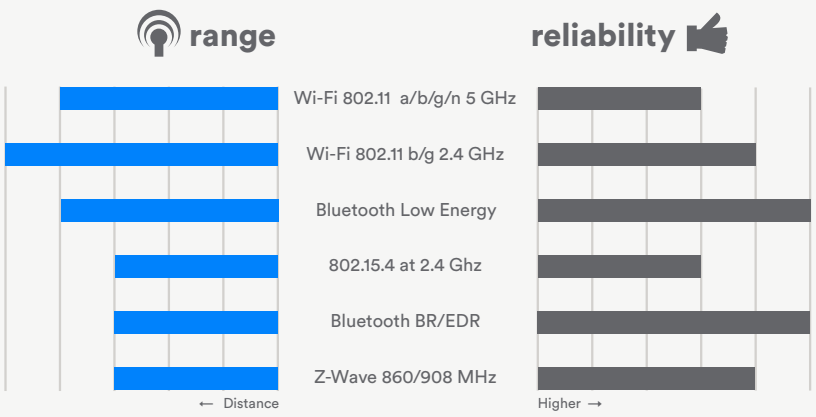
Key Considerations for IoT Technologies

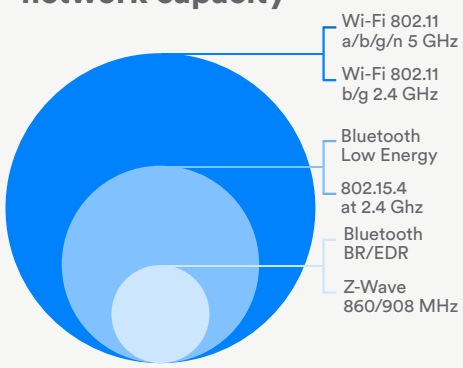
With this wide range of applications and requirements, no single wireless technology is likely to take over the IoT. Each technology offers advantages and disadvantages, and the chosen technology must match the application's principle requirements. But there are a number of key considerations that apply to most IoT applications, which can be viewed below, followed by more detailed discussion.

What kind of interface is important?

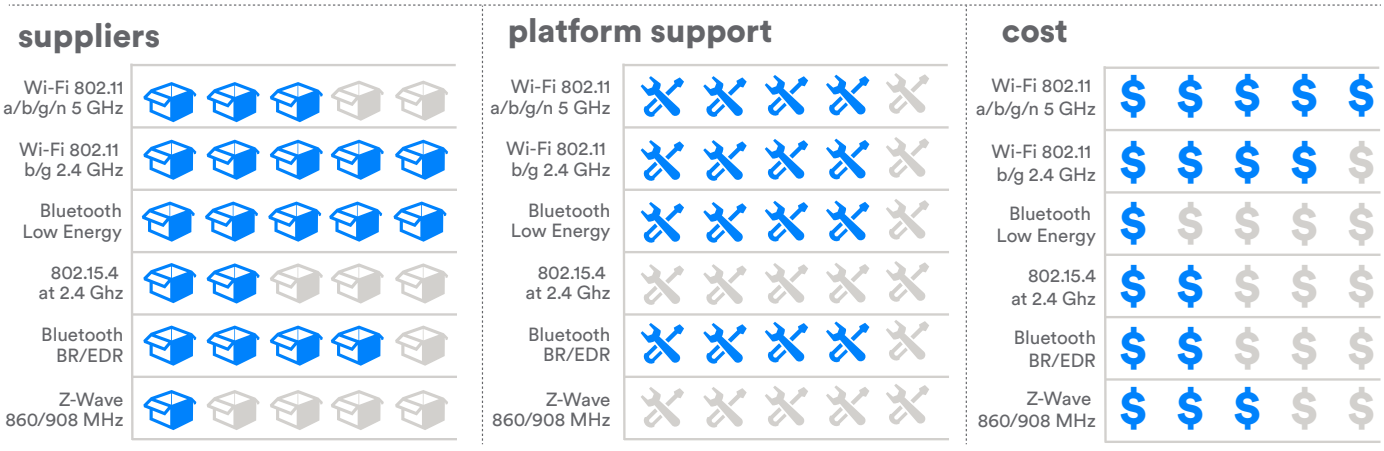
	Wi-Fi 802.11 a/b/g/n 5 GHz	Wi-Fi 802.11 b/g 2.4 GHz	Bluetooth Low Energy	802.15.4 at 2.4 Ghz	Bluetooth BR/EDR	Z-Wave 860/908 MHz
smartphone	✓	✓	✓	✗	✓	✗
smartwatch	✗	✗	✓	✗	✗	✗
laptop	✓	✓	✓	✗	✓	✗

What are your application's range, reliability, and capacity requirements?





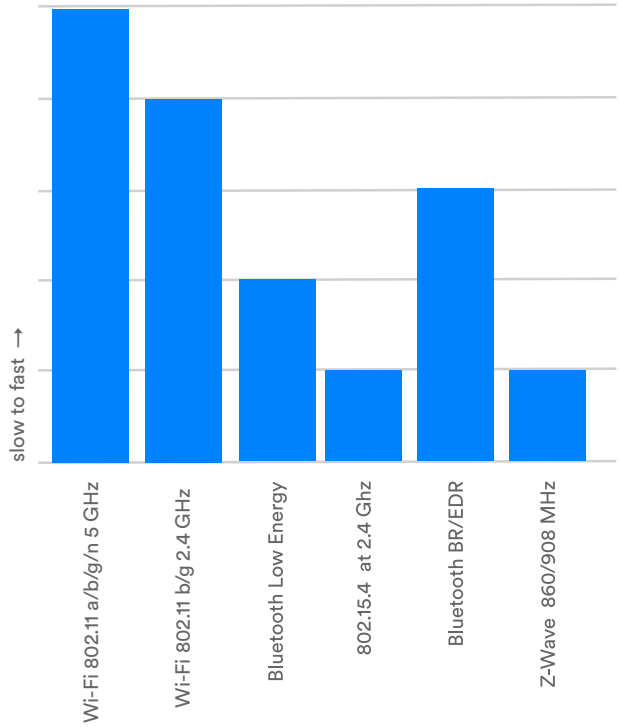
Have you considered industry support and cost?



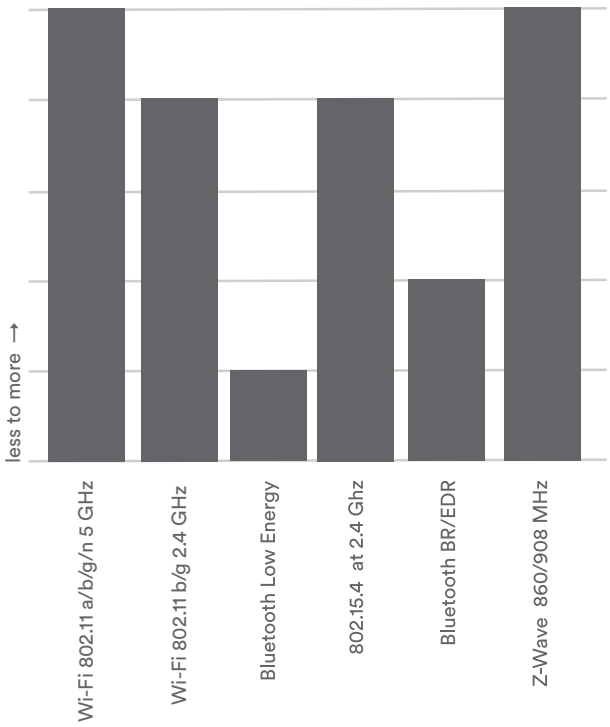
Graphic representations based on independent data gathered from Code Blue Consulting. View the full report here.

What fundamental requirements drive your application?

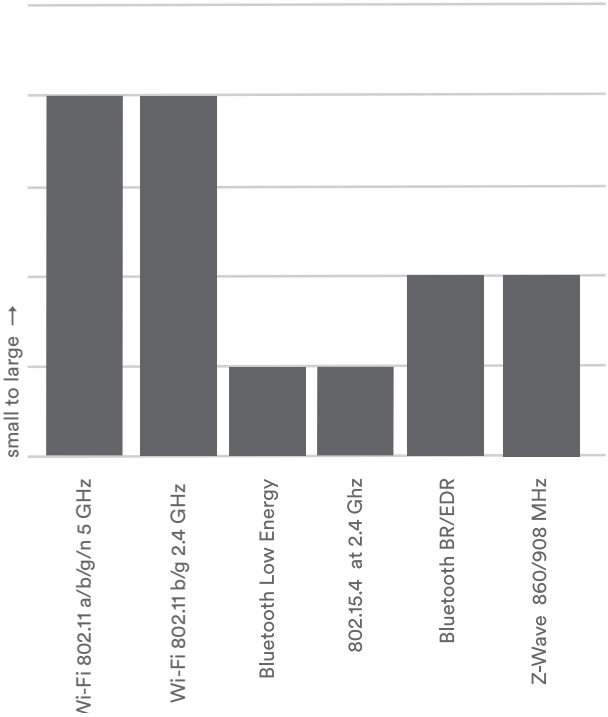
speed



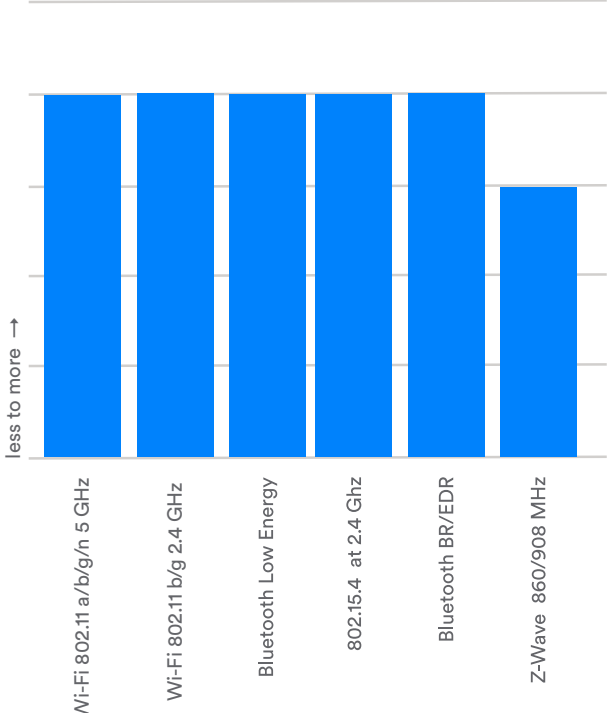
power consumption



size



security



Graphic representations based on independent data gathered from Code Blue Consulting. View the full report here.

Comparison of Common Wireless Technologies

860/908 HMz Z-Wave

Z-Wave is designed for smart home control and monitoring applications that require low power and small size for short-range transmissions. While the protocol is supported by an alliance of vendors, it is owned by Sigma Designs who charges for Z-Wave licenses, limiting the available technology supply chain and making it more costly than other wireless technologies. Sigma Designs promises forward and backward compatibility for Z-Wave certified devices, but different radio frequency requirements around the world mean that devices are not interoperable outside of their "home" region. As a proprietary technology, Z-Wave has a limited ecosystem and does not have native support from any of today's popular operating systems.

Pros:

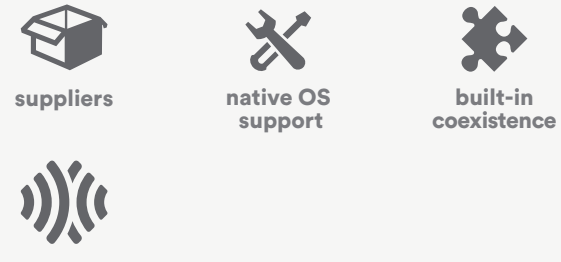
Cons:

2.4 GHz ZigBee/Thread 802.15.4

The IEEE 802.15.4 standard allows for a peer-to-peer topology that supports mesh networks, which gained popularity for low data rate, short-range IoT applications such as sensor networks in industrial and smart-building (especially HVAC) applications. ZigBee and Thread protocols are the best-known protocols based on this standard. Both offer small size, low cost, and low power, with reliable connectivity. However, these protocols have a much smaller ecosystem with many fewer component suppliers and no native OS support for any of the popular platforms such as iOS, Android, or Windows. The 802.15.4 standard also does not have any built-in coexistence methods, resulting in interference issues at 2.4GHz, and while it can be used at the same frequencies as Z-Wave, it further complicates design and regulatory processes with multiple frequencies and country-specific requirements. As other wireless standards add mesh networking support to their other advantages, ZigBee and Thread will become less attractive for new IoT applications.

Pros:

Cons:



2.4 GHz Wi-Fi 802.11 b/g

Wi-Fi offers nearly ubiquitous presence in homes and businesses and via Wi-Fi hotspots around the world. But with the dramatic growth in connected and cordless devices, the popular 2.4 GHz Wi-Fi band is becoming a crowded place, and the interference can impact device communication performance. However, 2.4 GHz Wi-Fi still offers excellent range and network capacity for many single-location IoT applications, as well as the opportunity for strong security (if implemented appropriately). Components for implementing 2.4 GHz Wi-Fi are available from a wide range of suppliers and the technology has native support from all major operating systems. And with Wi-Fi's popularity in homes and businesses, it offers a built-in and familiar Internet gateway for IoT devices. For many IoT applications, however, Wi-Fi's cost, power, coexistence issues (with other 2.4GHz radios and interference) and size requirements may put this technology out of range. In addition, Wi-Fi setup complexity can be a disadvantage for many consumer configurations, especially if strong security is used.

Pros:


native OS support


reliability


high-speed network


ubiquitous

Cons:


size


power


cost


set-up


interference

5 GHz Wi-Fi 802.11 a/b/g/n

Increasing congestion in home and public environments is driving the popularity of 5 GHz Wi-Fi, especially for high-throughput devices such as computers, smartphones, and TVs. And while 5 GHz Wi-Fi shares some of the advantages of 2.4 GHz Wi-Fi, the higher frequency band has significant disadvantages for IoT devices. These include higher complexity, dramatically lower range and limited reach through walls and floors, as well as higher cost and power consumption, and fewer (for now) options in suppliers. For single-location IoT devices with high-throughput requirements, dual-band operation that offers Wi-Fi connectivity at both 2.4 and 5 GHz may be a viable option. However, 5GHz Wi-Fi also brings distinct challenges in getting FCC, international and Wi-Fi approvals, with separate requirements and country-specific restrictions that can add significantly higher costs and regulatory burden for developers.

Pros:


native OS support


interference


high-speed network

Cons:


range


power

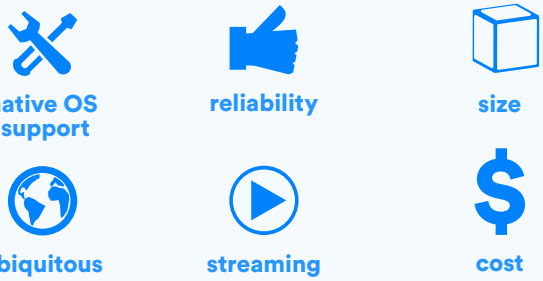

cost


complexity

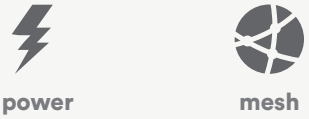
2.4 GHz Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR) Version 2.0/2.1

Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR) establishes a continuous wireless connection which makes it ideal for use cases such as streaming audio. Bluetooth BR/EDR is present in almost all smartphones, laptops, and tablets with native support for all popular operating systems. Today, Bluetooth BR/EDR is typically implemented as dual-mode connectivity that supports both Bluetooth BR/EDR's continuous-connection applications such as audio, as well as Bluetooth with low energy's low-power, short-burst connectivity applications that are better suited to most IoT implementations.

Pros:



Cons:

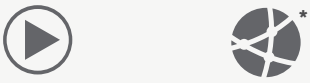


2.4 GHz Bluetooth with Low Energy Version 4.0/4.1/4.2

Bluetooth with low energy technology allows for short bursts of radio connection, making it ideal for IoT applications that don't require a continuous connection but depend on long battery life. While both Bluetooth BR/EDR and Bluetooth with low energy operate in the same 2.4 GHz band as Wi-Fi, Bluetooth uses frequency-hopping and data integrity approaches to avoid interference, making Bluetooth connections much more powerful than 2.4 GHz Wi-Fi, with transmitted data that is rarely lost. Bluetooth with low energy offers a secure, reliable connection for mobile devices, which will extend even further with the expected ratification of the Bluetooth mesh networking profile in 2017 and changes to the core specification that will enable longer range. For non-streaming applications, Bluetooth with low energy offers unmatched advantages in cost, size, power, and component/module availability. Within the IoT, Bluetooth's industry-standard technology offers a distinct advantage over other low-power wireless technologies by ensuring interoperability with a worldwide installed base of devices. In fact, Bluetooth and Wi-Fi are the only two technologies implemented by all major platforms and operating systems, which is a key consideration for IoT developers.

Pros:

Cons:



**There are mesh solutions available from Bluetooth SIG members today, however they are not part of an adopted Bluetooth standard. The Bluetooth SIG is actively working on incorporating mesh technologies into a formal Bluetooth specification that will be available in 2017.*

The Case for Bluetooth with Low Energy in the IoT

Bluetooth with low energy provides a clear advantage for low-cost, low-power, and secure connectivity, with a single global standard enables a wide range of devices from different manufacturers to communicate, no matter where they're installed. All the major smartphone, tablet, and laptop and desktop computing platforms support Bluetooth with low enengy, establishing a viable ecosystem for nearly any connected device. In fact, 96 percent of mobile phones have Bluetooth installed today.* For IoT developers, that eases many connectivity concerns, as consumers can use the smartphone they already own as a host for multiple Bluetooth devices anywhere and anytime, offering services and data to other Bluetooth devices and connection points, including the cloud.

According to the IHS Technology report *Bluetooth® Technology's Role in the Internet of Things* published in May 2015: "Bluetooth technology will play a significant role in the IoT, acting as the low-power link between the "things" and host devices or gateways that facilitate control or the broader distribution of the information or data collected." IHS research shows that the Bluetooth installed base is predicted to grow faster than all other researched wireless technologies combined.

> **"Bluetooth technology will play a significant role in the IoT, acting as the low-power link between the "things" and host devices or gateways that facilitate control or the broader distribution of the information or data collected."** *-IHS Technology*

Commercial smart lighting has emerged as one of the most promising segments of the IoT, but to date there has simply been no global wireless communication standard capable of addressing all the challenges awaiting there. With the outstanding features of the Bluetooth radio, the upcoming mesh specification will deliver the key infrastructure piece that the protocol has lacked so far. We see Bluetooth with mesh as a future go-to technology for connected lights, and a powerful enabler for an entire range of new services, products and business models in the lighting sector. We are extremely excited to take part in this process of technology transition and see many benefits after the adoption.

Marek Wierzbicki
Silvair

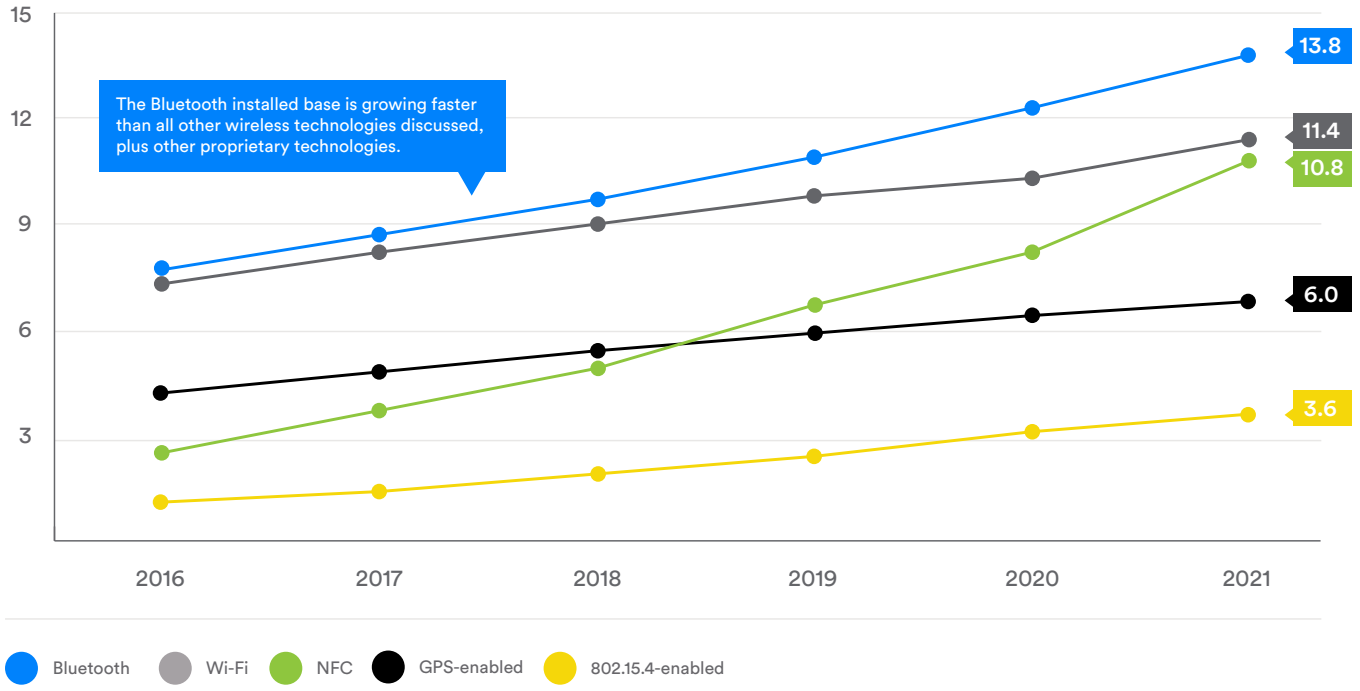
** IHS Technology, "Indoor Positioning to Post Robust Growth in 2015" https://technology.ihs.com/515328*

IoT Connectible Device Installed Base, by Connectivity Technology, 2016-2021

A detailed examination highlights the advantages of Bluetooth with low energy for IoT developers.

IoT Connectible Device Installed Base By Connectivity Technology

2016-2021 Forecast in Billions



IoT Connectible Device Installed Base By Connectivity Tenchology Source: ABI MD-IOE-105 2Q2016

Native Application Support

Apple iOS, Android, Windows Phone, and Linux all offer built-in Bluetooth support for native applications. The form the APIs take varies but the underlying concepts they model is simple and consistent based on the simplified and straight-forward protocols underlying Bluetooth. The two generic protocols defined (GAP and GATT) allow the application itself to support devices with basic operating system support. Developers working across multiple platforms can easily adopt consistent design patterns across platforms to make testing, maintenance, and support as easy as possible.

Cross-Platform Development

Bluetooth with low energy development tools are available from the Bluetooth Special Interest Group (SIG) as well as multiple third-party vendors. These allow the same application to be created for multiple target platforms from a single code base. Tools supplied by the Bluetooth SIG also allow devices to be defined using industry-adopted or custom services (or a mix of the two) and then use these definitions to create firmware for device implementations using chipset components from several different suppliers.

Power Efficiency

Bluetooth with low energy was designed from the bottom up for low power, and special features are inherent in the specification for devices to operate with coin-cell batteries and to let the device sleep as much as possible, only turning the radio on when there is something to transmit. That makes highly efficient use of battery power in both the IoT device as well as the gateway device—typically a smartphone—including ultra-low peak, average, and idle-mode power consumption. Many IoT devices can run for weeks, months, or even more than a year (depending on application) on a single coin-cell battery. Some applications can even use scavenged energy to power a Bluetooth with low energy technology radio indefinitely.

Security and Ease of Pairing

Security in the IoT, as in other wireless and IT domains, is a key consideration. Bluetooth supports all primary security methods including authentication, encryption, and additional privacy features. Developers can generally rely on the smartphone's operating system's implementation of Bluetooth security and will not need to implement additional security features in application code. However, IoT developers should ensure that the security parameters dictated by application and use model are acceptable with respect to any overall security standards that might apply, and must invoke the appropriate security protocols. Once established, however, Bluetooth with low energy's Secure Simple Pairing makes security and setup much easier for consumers than other wireless standards such as Wi-Fi.

Powerful Connectivity

Bluetooth with low energy divides the allotted RF space into 40 channels and hops between them in a pseudo-random sequence 1600 times per second. All data packets are checked for sequence and data integrity to ensure that the data is correct. Any packets that are lost or corrupted are retransmitted using a different channel. If there is interference from another technology (such as Wi-Fi), Bluetooth quickly switches to another channel to retransmit. Bluetooth with low energy also employs Adaptive Frequency Hopping (AFH) which 'sniffs' for potential interference and blacklists those channels so that they are not used in the hopping sequence for that connection. Bluetooth with low energy can detect Wi-Fi transmissions and block problem channels, allowing for high-reliability coexistence with Wi-Fi.

Profile Design and Publication

The Bluetooth SIG has published a range of adopted profiles and services for Bluetooth to meet common application requirements. However, Bluetooth also allows developers to build their own custom profiles for innovative new applications and unique requirements. Developers have the choice of publishing their custom profiles for reuse by other developers to help achieve interoperability at the application layer, or can choose to retain their own profiles for competitive differentiation.

Common IoT Use Cases for Bluetooth with Low Energy and Smartphones

The following advantages support a wide (and increasing) range of IoT use cases.

Location

Location of a person, place, or thing is a critical element in many IoT scenarios. Bluetooth location technology can be incorporated in dedicated devices known as beacons, which provide a signal to the smartphone that is used to determine that the user is in close proximity to that location. Beacons provide micro-location capabilities that augment the smartphone's built-in GPS for indoor tracking, such as movement within a store. A smartphone application can use location information with the explicit involvement of the user or can take automated action behind the scenes within an appropriate application. In addition, most smartphone platforms allow applications to be created that can turn the smartphone into a mobile Bluetooth beacon so that other devices can recognize and respond to users as they move through an environment, providing a personal, contextual experience.

Data Gathering and Control

IoT use cases often involve large numbers of Bluetooth with low energy equipped sensors. This is especially true in smart home and smart building applications, which acquire and use data relating to numerous aspects of the environment. Smartphone applications will be one of the most important tools that consumers use to interact with, utilize, and control data from a network of Bluetooth with low energy sensors. Bluetooth with low energy's low power consumption becomes a prime consideration for these use cases, allowing long battery life for the IoT devices with short-burst communication with the smartphone application that doesn't drain the smartphone's battery. Some applications might even use scavenged energy to power a low energy radio indefinitely.

Wearables

Wireless wearable products continue to gain market share, with unit shipments growing from 49 million in 2014 to 133 million in 2019. Wearable devices collect information about the wearer such as location, activity, temperature, or physiological information. Smartphones can use Bluetooth with low energy to connect to wearables placed anywhere on the body, and provide an exceptional user interface and cloud gateway for these small, unobtrusive, and low-power wearable devices.

Smart Device Hardware, Software, and Cloud Implementations

Almost any product—new or existing—has a set of features that can be extended with "smart" attributes to bring it into the IoT with the addition of sensors, connectivity, and an online application for reporting, managing, and generating actionable information. Companies that were born into the IoT may have expertise in-house, while manufacturers who are adapting existing products to the IoT may need to consider outsourcing development to a third party who is experienced with the chosen protocols, and who can provide guidance on appropriate modules, chipsets, and sensors.

There is no single path for adding intelligence to products, but the process typically includes an analysis of product features such as functionality, complexity, working modes, power consumption, and user and manufacturer needs. Once a hardware prototype is built, layers of software must be developed, including embedded software that defines how the device works and communicates, an online (often mobile) app that becomes the user interface, and a cloud platform for gathering and processing data.

Hardware

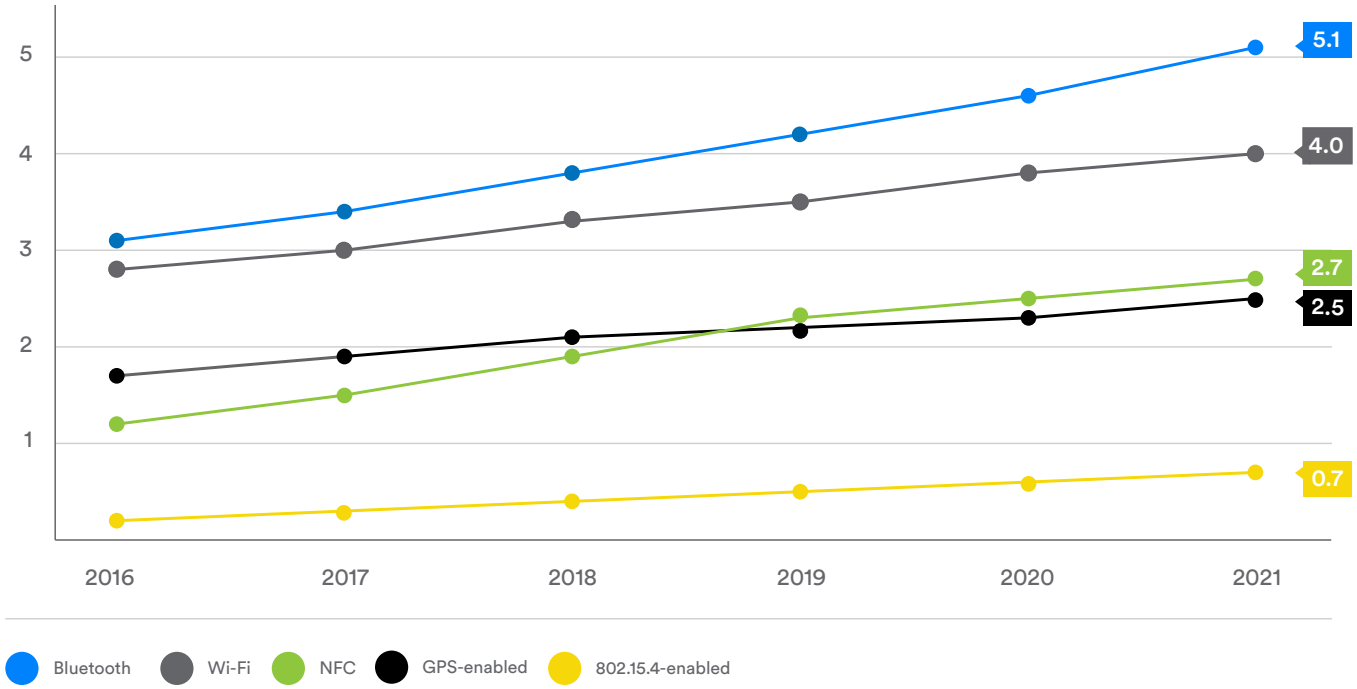
A key aspect of IoT products is which functionalities are executed electrically. Although it may sound trivial, the change from a mechanical power switch with no stand-by mode can lead to the conclusion that the device requires thorough mechanical and electrical redesign to turn it into a connected one that can be controlled remotely. Availability of electrically controlled sensors (temperature, pressure, humidity, status) and actuators (heater, valve, motor) are crucial for successful implementation.

Having clarified the specific device construction, wireless functionality can be added either by installing a Bluetooth with low energy module and interfacing with the existing control solution or completely exchanging the existing controller with a new, connected one. In the case of expensive devices and those using complex control algorithms, the installation of a Bluetooth with low energy module and modification of embedded software is much more cost-effective. In the case of products such as simple home appliances, exchange of the controller and embedded software is often justified.

The landscape of Bluetooth with low energy chipset manufacturers is still changing, but market leaders have emerged and many chip manufacturers are expanding their microcontroller portfolio with wireless functionality. Chipsets dedicated for connected devices are inexpensive and development tools, including reference designs, are mature. Developers continue to gain options as new chips are introduced to the market every four to six months with increased flexibility, enhanced computing power, and reduced RF power consumption.

Total Wireless Connectivity-Enabled Device Shipments by Technology

2016-2021 Forecast in Billions



Total Wireless Connectivity-Enabled Device Shipments by Technology Source: ABI MD-WCMT-167 1Q2016

Embedded Software

Embedded software plays a fundamental role in functionality and usability and enables additional features that are not directly tied to device operation. Embedded software is responsible for the following tasks:

- Proper interface to sensors and actuators to ensure parameters are measured and presented appropriately (timing, sample frequency, filtering, etc.)
- Fast, unambiguous application control of device functionality
- Device health monitoring, device-use statistics, power consumption, etc.
- Device controller access to all parameters and functions for both the end user and manufacturer

The last task is extremely important in the case of a standardized, wireless interface such as Bluetooth. Although Bluetooth with low energy specifies most of the rules of communication and data-exchange mechanisms, there are still areas of embedded software development where connected device manufacturers set their own standards. Despite several industry alliances, there is no consensus in standardizing data-exchange formats at upper communication and application levels, which has resulted in the proliferation of “market standard” home automation solutions with connectivity limited to devices from a few manufacturers. But with Bluetooth with low energy, the GATT protocol specified by the standard provides a consistent mechanism to represent this data in the form of services and characteristics.

Application Software

For consumers, most new smart devices are controlled from a smartphone, tablet, or PC, all of which have native support for Bluetooth. Application software developers simply need to modify the application to use the target platform's built-in APIs, whether they be iOS, Android, Windows, or some other platform.

Cloud Software

Data collecting is an essential part of the IoT. While connected devices can generate a huge amount of data, the data that provides value should be carefully selected during the system design stage. Useful data will be different for every use case, but there are a few areas that should be considered:

- Device status data is tightly connected to device functionality and is usually displayed to users so they can control their devices remotely and display information about their current status
- Diagnostic data can be used by manufacturers to improve service and maintenance, decrease the possibility of device failure, and address device malfunctions by uploading software patches
- Data about how products are used can be applied to improve functionality in future products

There are a variety of cloud platform options that provide the framework for how data is stored, accessed, and used, and each option offers pros and cons. One popular solution is for manufactures to develop a dedicated cloud application to handle the data from its smart devices. Custom-crafted software fulfills data collection, processing, visualization, storage, and manipulation and new features can be added as needs arise to flexibly manage or share collected data. The drawback to this approach is the high investment required to develop and maintain a cloud solution. Development of a custom software platform can take six to twelve months, and the massive amount of data gathered from connected devices requires the IT platform to be resilient and scalable.

Another common option is to work with one of the existing IoT cloud platforms. Rapid growth and high competition in the IoT market has led to a number of IoT cloud platforms branded by top IT players. These are offered in many different models, such as monthly subscriptions or Platform-as-a-Service (PaaS) or Software-as-a-Service (SaaS). Choosing a universal, existing platform may reduce the cost of service and offers reliability guarantees, but may not offer flexibility or may lack advanced features for certain types of devices. These advanced features may still have to be developed independently, but most PaaS platforms offer application environments for custom development within the PaaS stack.

An efficient option in terms of cost and reliability is to partner with emerging companies that provide a full hardware/software stack, consisting of embedded software and hardware, mobile application, and dedicated cloud solutions.

Bluetooth with Low Energy for Today's—and Tomorrow's—IoT

Bluetooth with low energy was designed from the ground up for low-power, consumer-friendly, and innovative IoT applications. And with broad industry support, the technology continues to evolve to meet new IoT requirements. The host of Bluetooth advancements expected to be ratified in the specification in 2016 will further energize fast-growing industries such as smart home, industrial automation, location-based services, and smart infrastructure, making it the right connectivity choice for many new developments.

Mesh Networking Support and Extended Range

The Bluetooth roadmap for 2017 includes an increase in range of up to 4x to deliver an extended, more powerful connection for full-home or outdoor use cases. A 100 percent increase in speed without increasing energy consumption will enable faster data transfers in critical applications such as medical devices, increasing responsiveness and lowering latency. And mesh networking will enable Bluetooth devices to connect in networks that can cover an entire building or home, opening up home and industrial automation applications that also need Bluetooth's advantage of native OS support in smartphones and computing devices, as well as easy setup, low cost and low power, and secure, reliable communication.

Innovative, Free Development Tools

Bluetooth continues to provide an ideal development environment for new products, with the updated Bluetooth Developer Studio. This no-cost software-based development kit helps developers learn Bluetooth technology quickly and bring products to market faster than ever. The Bluetooth Developer Studio ensures that building for the IoT is simple, consistent, and fast, while still enabling the security, reliability, control, and convenience consumers demand. With its intuitive drag-and-drop user interface, sample code, virtual and physical device testing, and built-in tutorials for faster deployment, the Bluetooth Developer Studio lets developers create quality products that "just work," delivering the IoT experience that consumers want. Additionally, the tool makes it easy to share reference designs and leverage successful implementations created by others.

Alliances for Stronger Security

Mobile devices carry increasing amounts of valuable personal information, resulting in the need for simpler, stronger local device authentication. Currently, options to secure or "lock" mobile devices are commonly a PIN, a gesture, or biometric authentication. A new alliance between the Bluetooth SIG and the Fast Identity Online (FIDO) Alliance is designed to extend the reach of FIDO U2F from the desktop to the mobile device using Bluetooth with low energy. The FIDO Alliance and Bluetooth SIG alliance will allow online authentication from the local device, adding full FIDO U2F security to any over-the-air connection.

With these advancements just around the corner, Bluetooth continues to build on its leadership position as the primary connectivity technology for the IoT. For developers looking to take advantage of exciting business opportunities in the IoT, this makes at least one decision much more straightforward.

For more information and a look at the technology roadmap and tools, visit www.bluetooth.com

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