Bluetooth 5: A Concrete Step Forward toward the IoT

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Abstract

Six years after the adoption of the standard 4, the Bluetooth Special Interest Group (SIG) has officially released the main features of Bluetooth 5. It is a major development in short-range wireless communication technology. As stated by the SIG, the new standard will change the way people approach the Internet of Things (IoT) significantly. In this article, the future IoT scenarios and use cases that justify the push for Bluetooth 5 are introduced. A set of new technical features that are included in Bluetooth 5.0 are presented, and their advantages and drawbacks are described.

Introduction

Bluetooth is a technology that was developed more than 20 years ago. It was 1994 when the first draft of data transmission that would become part of the digital modem ecosystem was presented. Nowadays, this technology is one of the pillars of the Internet of Things (IoT) [1], a perspective target that provides continuous connections among technological accessories to achieve significant impact and improved performance [2]. Bluetooth is used for data transmission through radio waves, which allows two or more devices to connect with each other. There is no limit to the type of file that can be transmitted, as such files could comprise data collected by sensors, photos, documents, music, and videos. However, the maximum range of a device equipped with Bluetooth does not usually exceed 100 m, although there are three distinct classes, according to the signal coverage range. Class 1, the most powerful category, can reach up to 100 m; Class 2, the most common category, operates only within 10 m; and Class 3 does not exceed 1 m transmission range and is also the least used category, especially recently.

While the Bluetooth technology has been declared dead several times [3], the Bluetooth industry is thriving now and working on expanding the implementation of the technology to short-range wireless communication markets, in addition to audio and stereo communications, such as the IoT and machine-to-machine (M2M) communications [4].

However, for Bluetooth to be suitable for M2M and IoT applications [5], it needs to reduce power consumption [6] so that it can be used in battery-powered devices for a more extended period. In fact, IoT devices have to be connected, but power consumption usually is a real concern. For instance, regarding wearable devices, (e.g., fitness wristbands), the time between recharging could make or break the commercial viability of a product. Even though Wi-Fi technology looks attractive for IoT, the system developers have quickly realized that the power consumption associated with Wi-Fi technology is too high, leading to a short active time before recharging.

The Bluetooth Special Interest Group (SIG) introduced Bluetooth Low Energy (BLE), also called Bluetooth Smart [7], to lure application developers of the emerging IoT. BLE was first specified in Bluetooth 4.0 and further improved in Bluetooth 4.1 and 4.2 [8]. Also, BLE was shown to be an attractive technology for many applications including vehicular networks [9]. Recently, the Bluetooth Special Interest Group (SIG) has presented the specifications of Bluetooth 5 [10], whose primary purpose is to offer significant enhancements compared to the preceding specification regarding the range, speed, and broadcasting capacity. This article presents an overview of the new improvements introduced by Bluetooth 5 and explains the potential advantages of each one. An analysis of how these enhancements will enable current and future applications is presented, showing how Bluetooth 5 will be a competitive technology in IoT applications.

New Features and Concepts

Unlike previous iterations of the Bluetooth standard, released as X.0 and followed by updates (e.g., 4.1 and 4.2), the new standard is known merely as Bluetooth 5. The classic version of Bluetooth 5 is identical to the previous versions, while the significant innovations focus on the BLE version. According to the specification introduced by the SIG, hardware boards can support three types of Bluetooth connections [10]. Bluetooth 5 at 2 Mb/s is the new high-speed connection that has been presented. In this case, at the PHY layer, its speed is 2 Mb/s. Bluetooth 5 Coded is a new particular connection type that comes with Bluetooth 5. Its goal is to provide long-distance connections, but with a lower bit rate. Thus, the primary objective is a broader range rather than speed.

It is clear that the new standard has been designed to create a communication network that ensures, over a short distance, a communication bandwidth which allows data exchange among the connected appliances and other smart devices of the IoT. This implies a network for automa-

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Feature	Bluetooth Classic	Bluetooth 4.x	Bluetooth 5	IEEE 802.15.4 – ZigBee	IEEE 802.11ah – HaLow
Radio frequency (MHz)	2400 to 2483.5	2400 to 2483.5	2400 to 2483.5	868.3, 902–928, 2400–2483.5	900
Distance/range (meters)	Up to 100	Up to 100	Up to 200	Up to 150	Up to 1000
Medium access technique	Frequency hopping	Frequency hopping	Frequency hopping	CSMA/CA	Restricted access window
Nominal data rate (Mb/s)	1-3	1	2	0.02–0.25	0.15–7.8
Latency (ms)	< 100	< 6	< 3	< 4	~ 1000
Network topology	Piconet, scatternet	Star-bus, mesh	Star-bus, mesh	Mesh	Star-bus
Multihop solution	Scatternet	Yes	Yes	Yes	Up to 2 hops
Profile concept	Yes	Yes	Yes	Yes	No
Nodes/active slaves	7	Unlimited	Unlimited	Unlimited	Unlimited
Message size (bytes)	Up to 358	31	255	100	100
Certification body	Bluetooth SIG	Bluetooth SIG	Bluetooth SIG	ZigBee Alliance	IEEE

Table 1. Technical comparison of Bluetooth versions and other wireless standards.

tion, which further stimulates the development and the deployment of smart and interconnected objects. The Bluetooth SIG summarizes the innovations that the new standard introduces, as compared to the previous versions of Bluetooth standard (Table 1), and they are presented in this section. Table 1 compares the various versions of Bluetooth with two other wireless protocols that are competing to dominate the vast IoT market, IEEE 802.15.4/ZigBee and IEEE 802.11ah/HaLow. Since very few HaLow devices are currently available on the market, in this article, a direct comparison with IEEE 802.15.4, through a real testbed, is presented later.

Larger Range

The first significant change is related to a meaningful increase in the covered range. Bluetooth 4.x has a range between 50 and 100 m, as the crow flies, outdoors and unobstructed, which is reduced to 10/20 m in indoor environments. Bluetooth 5 aims to quadruple the range of BLE devices. In fact, in the worst case, this range should be 200 m outdoors and about 40 m indoors. These values can result in significant savings in the electronics world. Bluetooth 5 proposes a particular connection type that has been developed for long-distance communications. It is important to note that this connection type is not suitable for Bluetooth speakers or syncing smartphones/wearable devices. In fact, this operating mode aims at the IoT, where it is necessary to place low-cost modules all over a building or in an open space and gather data. The obtained data can be anything from light to humidity, temperature, traffic monitors, movement detectors, and so on; in fact, the opportunities are countless. However, these sensors need to send their data to a central hub/gateway and hence require a power supply. The power becomes a non-issue if the device is connected to the AC power supply. In this case, for instance, the device could use Wi-Fi to communicate. Nevertheless, the requirement for energy consumption and Wi-Fi coverage limits the potential of such devices.

In this context, Bluetooth 5 might have an edge since the devices that use Bluetooth do not necessarily require AC mains power. Instead, Bluetooth devices could be installed with a simple battery. A possible solution to extend the range without increasing the power consumption is to decrease the data rate. An impressive feature of the PHY innovations in Bluetooth 5 is the way to enhance the sensitivity. It is realized only in the LE Coded connection type. Typically, in BLE the packet headers and payloads are uncoded (i.e., 1 bit refers to 1 modulated symbol). This feature remains unchanged for both 1 Mb/s and 2 Mb/s connection modes. However, in the LE Coded connection method introduced in Bluetooth 5, two network data rates can be used: 500 kb/s and 125 kb/s. In these cases, the payloads have many symbols for each bit, $S = 2$ for 500 kb/s and $S = 8$ for 125 kb/s, where S is the symbol/bit rate. More symbols per bit translate to an increased tolerance with a weak signal-to-noise ratio (SNR), and still provide a recoverable data stream. This mechanism occurs entirely in hardware in a transparent way to the developer. The coding process involves two stages. The first is the forward error correction (FEC); afterward, a pattern mapper outlines a bit code to the input bits. The effect of these steps is a spreading of the data that provides a recovery using the FEC if bit errors occur and an improved ability to recover the received bitstream. This goal can be reached in conditions where the SNR is reduced to a level at which data recovery would be impracticable without the LE Coded mode.

A four-fold range means a quadruple decrease in the number of access points and range extenders, which in the IoT realm represents an essential capability in keeping all the equipment and nodes in an IoT network connected. Moreover, the increased capacity can allow creating, in a smoother way, communication channels with beacons located in many different places; those open to the public (e.g., in an airport, a train station, or a shopping mall) or those for use in the home. In this way, wireless connectivity, increasingly used to provide location-based services with fewer constraints than current technology, can be fully available. The extended range means that Bluetooth 5 might be able to replace Wi-Fi as a communication technology for many IoT applications.

Finally, regarding the range, the question focuses on the choice of the 125 kb/s or 500 kb/s data rate. It is evident that this decision is related to the requirements of the specific application. In fact, with 500 kb/s it is feasible to achieve about twice the range of standard BLE at 1 Mb/s, whereas with 125 kb/s, twice the range of 500 kb/s can be reached. Nevertheless, considering the packet structure when LE Coded mode is used, shown in Fig. 1, a notable part of the packet is the preamble address, and coding is at 125 kb/s all the time, even when selecting 500 kb/s, which occurs in the 1 bit connection interval (CI) field of the packet. In fact, for considerably simple sensor/actuator operations (e.g., from 4 up to 8 bytes), it is not feasible to save that much at 500 kb/s over 125 kb/s concerning collision avoidance or power consumption, while the broader range is sacrificed. In conclusion, for simple sensor/actuator operations, it is preferable to use 125 kb/s to obtain the extra range, while for higher data transmissions of tens of bytes or more, the data rate of 500 kb/s can be employed to achieve its advantages.

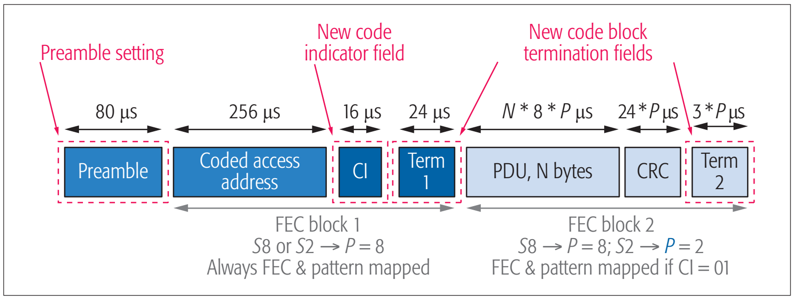

Figure 1. Packet structure with LE Coded mode.

Greater Speed

The improvement in the data transfer speed is a significant feature. While Bluetooth 4.x can reach a maximum speed of 1 Mb/s, the maximum speed that Bluetooth 5 can support is 2 Mb/s. This means that future wearable devices will synchronize at twice the speed of the current ones. For most applications, the speed of the current Bluetooth standard for transferring data is sufficient. In many IoT applications, speed is not a significant issue. This is true for use cases that do not involve streaming. For instance, considering wearable devices such as fitness wristbands, the amount of data to be transferred is pretty modest, and the currently supported BLE data rate is sufficient. Nevertheless, even for such wearable devices, higher transfer speed can allow faster software and firmware updates, and improves users' experience. According to ABI Research estimates [11], over 371 million Bluetooth beacons will be exchanged by 2020. Thanks to a higher data transmission capacity than the current Bluetooth 4.x, the new standard can involve more data transmitted by several smart devices, not just by the classic smartphones and tablets. As a consequence, products used in automotive, home, business, and industrial applications will also be able to exchange information with each other and with the cloud.

Bluetooth 5 consolidates the packet extension feature of Bluetooth 4.2, and by improving the on-air transfer speed, the obtainable network data throughput is doubled, up to about 1400 kb/s. The data is transmitted faster, but the gap among the packets has not been reduced. Bluetooth 5 is about 1.7 times faster than BLE 4.2. Another significant advantage of having a 2 Mb/s data rate is that energy savings become possible.

Beacons Everywhere

Another notable enhancement that comes with Bluetooth 5 is the extended broadcast capacity compared to previous versions. This improvement will have a meaningful result in the world of beacons and will grow the range of use cases for them. Proximity devices and beacon systems are accessories and chipsets capable of automatically sending, to all neighboring devices, localized information including restaurant menus, promotions, data on road traffic and much more.

Bluetooth 5 also improves the capability of sending special data packets, called "advertising packets." This communication strategy allows two Bluetooth devices to exchange packets and information even if they are not synchronized with each other. The advertising packets, for instance, enable the device to scan nearby areas and find out the names of other devices with active Bluetooth technology and capability. In the new standard, the packets are larger, and this makes it possible to also send more information to asynchronous devices. This feature is fundamental to the development of an IoT network.

Thus, what distinguishes Bluetooth 5 from its predecessors is the manner in which it handles beacons, that is, messages/packets that can be transmitted continuously from a presenting device and received by nearby users on their smartphones, tablets, or wearable devices. A Bluetooth 5 beacon does not require the pairing that comes with speakers, headsets, and other Bluetooth accessories. Considering that the beacon can broadcast information when a Bluetooth-enabled device arrives in range, site-specific content, location-enabled marketing, process updates, and other applications become possible.

With Bluetooth 4.x, beacons can send messages of 31 bytes. This message size is small, considering that these bytes include both the message and any additional protocols to indicate data types in the package. Both Apple, with iBeacon, and Google, with Eddystone, have tried to get around this limitation by using universally unique identifiers (UUIDs), 128-bit values capable of allowing the receiving devices to find a different beacon. However, when it is necessary to introduce more substantial information, such as URLs or telemetry data, it is clear that 31 bytes are not enough. Bluetooth 5 resolves this issue by increasing the size of the messages from 31 bytes to 255 bytes.

Mesh networking support is another feature supported by Bluetooth 5, as previously stated by the SIG [12]. However, although the Bluetooth 5 specifications have been released [10], mesh support is not included in them. In fact, the mesh networking for Bluetooth, known as Bluetooth Mesh, has been released only recently.

Longer Battery Life

The extended range and speed could imply higher energy consumption. However, thanks to some ingenious designing, such as the manner in which the signal is modulated and the advancement in the use of the frequency spectrum, Bluetooth 5 uses fewer energy resources. In fact, in the best case, it can consume about two times less power than the previous version of Bluetooth. If the speed is doubled in a wired device, the direct consequence is doubling of energy consumption. Nevertheless, it should be noted that Bluetooth operates at 2.4 GHz, and this radio frequency dictates the power consumption, not the data rate. Bluetooth 5 enables exchanging twice the amount of data, and the result is that the device consumes half the power to transfer the same data. As mentioned above, the goals of Bluetooth 5 were extended range through greater sensitivity and higher peak output power, at the same time maintaining or reducing the average power.

It is relevant to note that Bluetooth needed to be as good as or better than comparative IEEE 802.15.4 solutions (i.e., ZigBee) to become a real competing technology within living environments. For this reason, new BLE output power classes have been introduced in Bluetooth 5:

- LE Class 1: Max +20 dBm; Min > +10 dBm
- LE Class 1.5: Max +10 dBm; Min –20 dBm
- LE Class 2: Max +4 dBm; Min –20 dBm
- LE Class 3: Max 0 dBm; Min –20 dBm

When selecting a wireless standard for battery-powered IoT applications, providing the same amount of data at half the power is already a very significant advantage. There are also reduced infrastructure costs, since no access points or routers are required. As a consequence, Bluetooth tends to be easier on battery life than Wi-Fi. The overall result should be the ability to make small, robust IoT devices for industrial and consumer applications.

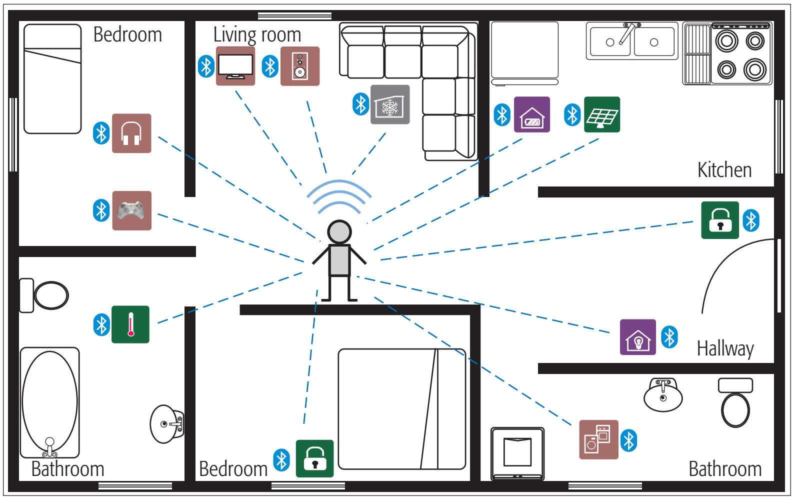

Figure 2. Bluetooth-based home automation system.

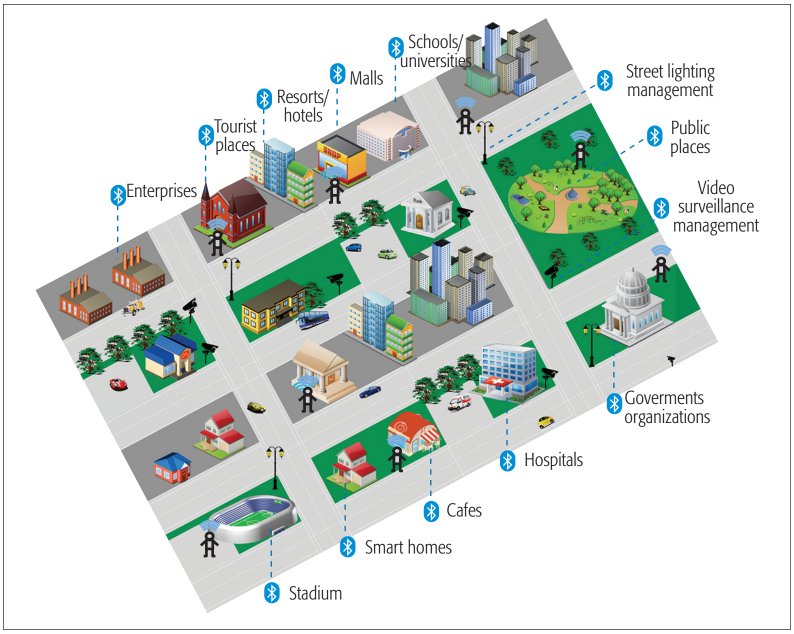

Figure 3. Bluetooth 5: enabling the connected smart city.

Scenarios, Use Cases, and Performance

The improvements in the covered range, higher data rate, and increase in the size of the advertising packet are designed and manufactured precisely to encourage the dissemination and adoption of the new standard in the IoT world.

In a smart home scenario (Fig. 2), for instance, broader coverage not only allows using Bluetooth audio speakers without having the problem of not being able to move with the smartphone in the next room but also to improve communication and make it faster among smartphones and smart watches. Using a smartphone, tablet, or laptop in hand, homeowners can manage the lights, temperature, home appliances, door and window locks, and security systems in their home, even outside the home walls. This purpose may be possible thanks to Bluetooth sensors for temperature, lights, doors, windows, and motion detection deployed in the home. In the end, home owners can monitor and manage everything, from their lighting and home security system to window and door locks with user-friendly applications. Since most home owners already have at least one Bluetooth-compatible smartphone, smart watch, or tablet, they can do this with devices they are already familiar with and know how to use.

Bluetooth 5 can allow IoT devices, like smart watches, to move away from the present paired app-device model and to operate independently. As a consequence, the handshake procedure (pairing), to link to a data source and to authorize to get the data, is no longer required. In this case, some devices might benefit from increased autonomy, as battery power and screen size of a watch or wearable are both limiting factors, often requiring the help of a paired device, which in most circumstances is a smartphone.

In smart cities using IoT technologies (Fig. 3), it is essential to employ an infrastructure that is intended to create hyper-location and automatic services. This context is precisely where the use of beacons come into play. Cities could deploy a mesh of beacons, on public or private networks, to collect and send data back to a centralized hub. The most significant advantage of using beacons is that, compared to other smart city technologies, they could be a lower-cost solution. The use of Bluetooth 5 as a control mechanism also makes it possible for cities to control different types of equipment, further improving efficiency remotely. In fact, Bluetooth-based solutions for connected smart cities can serve as the establishment for delivering next generation innovative services to empower government, businesses, and citizens, thus enabling smarter cities. This transformation to smart cities can be achieved through an ecosystem that brings together solutions from different providers.

For instance, the managers of supermarkets, large retail chains, and museum directors might also be interested in these technological developments. In the first case, beacons facilitate everyday expenditures, guiding users within the various sectors and sending discount coupons and notifications about the latest offers based on their profile and their purchasing habits. All of this can be accomplished without the customer taking any actions. In museums, for instance, Bluetooth can replace the audio guides. Visitors can just turn on the Bluetooth on their smartphones to receive information about the art works. All this can be obtained, as mentioned previously, at very low energy consumption.

Bluetooth 5 can be used as a street lighting control solution that offers lamp-level management capabilities of every streetlight in the city. This in-depth grid management can give accurate real-time feedback on any change occurring along the grid to reduce both energy loss and energy surges, offering advanced maintenance optimization tools.

Another feature in Bluetooth 5 is the capability to broadcast richer data, including not only location information, but also URLs and multimedia files. For instance, multiple sensors in a store could provide internal GPS-style navigation to a specific item. The next time the consumer goes shopping, for example, there is no need to ask someone for directions. Bluetooth 5 could also be beneficial for self-driving cars, which have to interact with many sensors and external sources like traffic lights. As a direct result of beacons everywhere, with the arrival of Bluetooth 5, the IoT will benefit tremendously, despite the fact that several companies currently focus on the production of accessories and appliances based on Bluetooth 4.x connection. If Bluetooth 5 fulfills the promised expectations, it may be possible that even more vendors will decide to jump into the IoT market, mainly thanks to the much lower cost of the chipset.

Unfortunately, Bluetooth 5 does not allow updating old Bluetooth devices. In fact, the new version of Bluetooth requires a new type of chip that needs to be installed on newer devices. The older versions of Bluetooth can work well on Bluetooth 5, but they do not have the same features., that is, they will still work at their original speed and distance.

Bluetooth 5 Performance

Several experimental measurements have been carried out to evaluate the performance of Bluetooth 5 compared to those of Bluetooth 4.2 and IEEE 802.15.4. In the testbed scenarios, Bluetooth 5 nRF52840 development boards [13] from Nordic Semiconductor have been used. These boards implement a Bluetooth 5 protocol stack and a 32-bit ARM Cortex-M4F microcontroller clocked at 64 MHz. Moreover, they support three types of Bluetooth connections: BLE 4.x, Bluetooth 5 at 2 Mb/s, and Bluetooth 5 Coded (500 kb/s and 125 kb/s). On the contrary, regarding IEEE 802.15.4, prototyping boards equipped with a Microchip PIC24FJ256GB108 microcontroller [14] and an MRF24J40MB radio frequency transceiver [15], both from Microchip Technology, have been adopted. In both cases, the boards have been equipped with a 3 V coin cell battery. Utilizing this battery, its maximum level when fully charged is 250 mA, while the corresponding digital value, obtained through a 10-bit AD converter, is 1024.

Wireless protocol		Remaining battery (digital value)	Consumed battery (percentage)
Bluetooth 5	*Indoor*	707	31
Bluetooth 4.2		645	37
IEEE 802.15.4		0	100
Bluetooth 5	*Outdoor*	604	41
Bluetooth 4.2		725	29
IEEE 802.15.4		0	100

Table 2. Indoor/outdoor scenario: battery consumption comparison.

A home network scenario has been investigated, and the performance has been evaluated in terms of battery consumption and throughput, in both indoor and outdoor contexts. Several nodes have been deployed in a fixed position, while a single device has been used as a mobile. The distance between this mobile board and the fixed ones has been changed between 20 and 5 m in the indoor scenario, and between 35 and 120 m in the outdoor scenario. The duration of the measurements has been 5 h in each instance.

Table 2 shows that both Bluetooth 5 and Bluetooth 4.2 have obtained significantly lower power consumption than IEEE 802.15.4. In fact, using the latter, the battery power has been exhausted even before the 5-h time duration required for the experimental measurement. In the indoor case, Bluetooth 5 has achieved the best result. The same thing has not occurred in the outdoor context. In fact, the Bluetooth 5 Coded connection mode of the nRF52840 development board has slightly higher power consumption than the BLE 4.x mode [13]. Nevertheless, it is necessary to point out that, in this outdoor case, the range between the mobile device and the fixed one has reached up to 120 m. This transmission range was not possible with Bluetooth 4.2 as the maximum range has been about 60 m. A direct consequence of the transmission range is the measured throughput whose values are shown in Table 3. These results prove that, in general, Bluetooth is faster than IEEE 802.15.4, and Bluetooth 5 achieves better throughput performance than Bluetooth 4 in every case. Furthermore, for closer distances, the speed of Bluetooth 5 is significantly faster than BLE 4.2. Also, it is clear that the throughput decreases as the distance increases. In the indoor scenario, the Long Range mode of Bluetooth 5 has not been used and, as a result, as the range increases, the advantages of Bluetooth 5 diminish compared to BLE 4.2 regarding the throughput. However, in the outdoor scenario with line of sight (LoS) communication, the maximum transmission range of Bluetooth 4.2 was about 60 m. Data transmission by Bluetooth 5 not only has reached a range of about 120 m, but has achieved better throughput than the other two wireless protocols even in this case.

Distance (meters)	Walls	Bluetooth 5 throughput	Bluetooth 4.2 throughput	IEEE 802.15.4 throughput
Indoor				
20	4	485	380	95
15	2	584	533	130
11	2	910	635	140
5	1	1210	675	180
Outdoor				
120	LoS	105	0	85
80	LoS	278	0	107
60	LoS	577	488	125

Table 3. Indoor/outdoor scenario: throughput comparison.

In conclusion, our experimental measurements demonstrate the excellent improvements in Bluetooth 5. However, there are also dependencies on the underlying hardware capabilities of the radios used. In fact, four distinct data rates are available. Obviously, these are not achievable only through a firmware update because each device must support these features at the physical layer. The four improvements offered by Bluetooth 5 specs — doubling the speed, reducing the power consumption by 50 percent, increasing the range of communication by a factor of four, and the boost in broadcasting — in conjunction with the potential ubiquity of the standard in consumer devices should allow wider adoption of the standard, including the emerging IoT. As a result, it is possible that Bluetooth 5 will eventually become one of the fundamental wireless standards implemented in many IoT applications.

Discussion

IoT is a paradigm shift in coping with human mobility and connectivity. It is anticipated that IoT will provide the necessary ambient intelligence in every environment for handling the needs of people for a substantially improved way of life. Different industry forecasts are projecting 50 billion devices connected to the Internet by 2020. This estimate is an order of magnitude larger than the number of people who are connected to the Internet.

This vision, however, has a myriad of research and technology challenges that have to be met with viable engineering solutions. Below, we highlight some of the most important technical challenges of the future IoT:

- **Scalability:** The sheer number of devices and users and the interactions required between them make scalability a major challenge.
- **Interoperability:** The heterogeneity of enabling devices and platforms make interoperability another key challenge in the IoT.
- **Efficiency in communications:** To have a viable IoT, low-power sensors, wireless transceivers, communications, and networking for M2M will be crucial for efficient communications.
- **Security and privacy:** Huge volumes of data emerging from the physical world, M2M, and new communications in the future IoT imply another major challenge, which involves mining the data, providing secure access, and preserving privacy of the data.
- **Timeliness and freshness of data:** Ensuring the timeliness and freshness of data is another important challenge that has to be met.
- **Mobility, access, and service continuity:** Ubiquity for the IoT brings with it the challenge of addressing mobility, ad hoc, access, and service continuity.
- **Practical naming, resolution, and discovery:** The envisioned global access and discovery in the IoT requires practical naming, resolution, and discovery solutions as well.

Indeed, this is not a comprehensive list of all the challenges associated with the IoT, but it captures some of the most obvious and important ones. To put things into perspective, the main contribution of this article is to show that Bluetooth 5 can address the third challenge mentioned above, namely, the efficiency of communications, which is fundamental for a viable IoT. It would be interesting to explore how Bluetooth 5 fares regarding the other challenges mentioned above (scalability, interoperability, data mining, secure access, ubiquity). Such an investigation would lead to a more rounded global viewpoint, and it is the current direction of our research.

Conclusions

Bluetooth 5 aims to offer significant performance improvements compared to the previous versions of Bluetooth regarding speed, range, and broadcasting capacity. In the fierce competition to dominate the IoT communication standard, these new advantages might help BLE be one of the best choices for IoT. Bluetooth 5 quickly attracted the attention of investors, especially startups and venture capital firms, who look with interest to the burgeoning market of the IoT. Currently, it is hard to predict what will be the adopted wireless standard(s) in the IoT. In fact, the dynamic and evolving world of smart and connected things is still in its infancy. However, considering the significant improvements in speed, power consumption, range, and capacity, it seems like Bluetooth 5 is a strong candidate.

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