**Study of Bluetooth Low Energy (BLE)**

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**Abstract.** In this short-paper, you will be able to find information and details about the Bluetooth Low Energy Technology. The paper begins with a short description and definition of the standard Bluetooth and the Bluetooth Low Energy (BLE), putting in light the differences between the two technologies. The paper then continues with a part talking about BLE’s growth and market acceptance, sectors using the technology with some applications examples. Finally the paper concludes with a comparison between BLE and its potential competitors in the market.

1. **Introduction**

In this document we will study the Bluetooth Low Energy also known as Bluetooth Smart ® or Bluetooth v4.0+. First we will have an overview of the technical specification of BLE and a comparison with the standard Bluetooth. Then we will see how BLE is used especially in the expansion of the IoT. And finally what are its competing technologies.

1. **Specifications of Bluetooth Low Energy**

This part will give an overview of BLE and how it is different from standard Bluetooth.

* 1. **What standard Bluetooth is**

Bluetooth is a wireless technology, alternative to data cable, developed by Ericson in 1994 and working on radio wave length around 2.4GHz. It is also known as Bluetooth BR/EDR (Basic Rate/Enhanced Data Rate) [1]. It has been created to permit connections and data flow between devices in a short range. That’s why it’s hardly linked with the IoT. The technology is standardized as IEEE 802.15.1 as stated in [2] and [5]. One of the advantages of using this frequency band around 2.4GHz is that it allows omnidirectional communication in a small range even if there’s no direct line of sight (ideal to connect two devices separated by a wall for example).

One of the specificity of the standard Bluetooth we can notice is that when two devices are connected, a link is kept even if there are no data transmitted. [2]

* 1. **What Bluetooth smart is**

One of the most important issue of the standard Bluetooth is that it has a “high energy” consumption [2] (too high to face some competing technologies actually). The peak current is around 25mA as shown is Table 1, which is lower than common radio standards, but still, this is not low enough for energy harvesting application. This turned hard the expansion of classic Bluetooth in the market.

That’s why Nokia started developing Wibree later known as Bluetooth Low Energy as an alternative to standard Bluetooth. BLE, that makes two devices communicate on a short range via ad-hoc networks [2], has some noticeable technical differences from standard Bluetooth [2]:

* A different radio
* A lower latency
* A lower duty ratio
* A lower energy consumption

Indeed, BLE’s radio is still working with a frequency band around 2.4GHz, but sit uses a larger modulation index than standard Bluetooth: 40 channels (3 advertising and 37 data) separated by 2MHz each instead of 79 channels separated by 1MHz. Thus it can send longer packets (27 to 251 byte in v4.2).

Moreover, with the expansion of BLE it is now possible to run sensors for a long time on cell batteries (months and even a year as presented in [1]). When it has been designed, the main goals were to make BLE a low-cost, low-energy consuming and easy-to-implement wireless personal area network technology. Finally, another important philosophy behind BLE is the possibility to support an Apps Store model [1]. This point makes easier the expansion of the technology: every developer can create application on existing devices using GATT profile [1] [3] and that is exactly the kind of technology that was needed for the IoT (cf. part3).

* 1. **Comparison of the specifications**

Here we made a comparison of some important specification between standard Bluetooth and Bluetooth Low Energy as a summarize [1] [2] [3]:

**Table 1**.Comparison of the specification of Bluetooth and BLE.

|  |  |  |
| --- | --- | --- |
| **Specification** | **Bluetooth** | **BLE** |
| Range (Line of sight) | Until 100m | Until 150m |
| Data rate in the air | 1 to 3Mb/sec (24Mb/sec in EDR) | 1Mb/sec |
| Topologies | Point to point, scatternet | Point to point, star |
| Duty Cycle | 1% | 0.1% |
| Latency | 100ms | 3ms |
| Peak current | 25mA | 15mA |
| Sleep current | ~1µA | ~1µA |
| Power consumption | 1W as reference | 0.01 to 0.5W |

In addition of having a slightly longer range, BLE’s duty ratio provides a lower consumption as the radio is mainly sleeping [3]. In addition to the lower peak current this permits power consumption until 10 times lower. However, the data rates are lower than the standard Bluetooth (especially EDR).

1. **Actual use and possible evolution of Bluetooth Low Energy**

This part will talk about the way BLE became one of the most important technologies. We will try to point out different applications that the development of BLE has made possible.

* 1. **Why BLE has grown up so fast**

BLE was introduced in 2010, which makes it a relatively young standard. Yet, it has known an incredible rapid adoption rate. Indeed, we rapidly saw numerous product designs including BLE technology, and making it ahead of other wireless technologies at the same point of time in their release cycles.

It is quite easy to explain why BLE has grown up so fast. Compared to other wireless standards, BLE has been released during the phenomenal growth in smartphones, tablets, and mobile computing. Adding to this the early and active adoption of BLE by industry monsters like Apple and Samsung, and you result with an incredible growth and used of the technology [8][9].

Another and less obvious explanation of BLE rapid adoption is that BLE has been designed to serve as an extensible framework to exchange data [1][8], that’s maybe one of the most important difference between BLE and standard Bluetooth which focused on a strict set of use cases. Indeed the philosophy behind BLE is that they wanted to allow anyone with an idea and some data points coming from any accessory to realize it without having an important knowledge about the underlying technology. Smartphones providers understood that major opportunity and quickly provided flexible and reliable low-level APIs in order to give mobile application developers the capability to use the BLE framework as much as they wanted to.

* 1. **What applications BLE is good for**

Basically, BLE is good for every application connecting the devices we carry with us [9], it is also ideal for applications requiring episodic or periodic transfer of small amounts of data. Simply because BLE provides the following features [8][9][10]:

* Very low power consumption
* Good real-time features
* Very short wake-up/connection time
* High numbers of communication nodes with limited latency

BLE used cover a various range of different fields from phone accessories (Internet, apps centric devices) to Smart Energy, Home Automation, Health, Wellnes, Sports & Fitness, Assisted Living, Animal Tagging, Intelligent Transport Systems, M2M.  
One “interesting“ or unfortunate feature is the user tracking. For example [11], devices in stores could use the BLE device in your smartphone in order to know exactly where you are standing, what you are looking at, and therefore what is supposed to interest you, what you might want to buy. Knowing all of this, the store manager could target ads, offer you deals.

But there are so much other things that we can do with BLE. During our research, we found an app named Tile App [12]. Tile is described, as “a tiny Bluetooth tracker and easy-to-use app that finds everyday items in seconds – like your phone, keys, and wallet. “ [12]. It is a great feature of BLE low cost energy advantage. Indeed, the tracker using BLE can be up during a long time period, making it reliable in order to find the object tracked.

Even if people are rushing in every type of applications that BLE can be good for, it seems that the possibilities and the capacities of BLE haven’t been explored entirely yet, but the more it goes, and the more there is some people digging into BLE potential, knowing that the applications are only limited by people’s imaginations.

BLE is evolving every day and more applications are developed, we may inevitably live in an even more connected world based on Bluetooth Low Energy data exchanges.

1. **Bluetooth Low Energy competing technologies**

Bluetooth Low Energy has to deal with competing technologies that provide the same services; there is kind of a geopolitical opposition between these technologies. We will make here a comparative study of BLE and 2 main competing technologies:

* ZigBee
* ANT

**Table 2**.Comparison of specification between BLE and the competing technologies:

|  |  |  |  |
| --- | --- | --- | --- |
| **Specification** | **BLE[2]** | **ZigBee[6]** | **ANT[7]** |
| Band | 2.4GHz | 2.4GHz | 2.4GHz |
| Range | Up to 150m | <100m | 30m |
| Topology | Point to point, star | Mesh, allow routing | Point-to-point, star, tree, mesh |
| Peak current | 15mA | >15mA | 22mA |
| Data rate | 1Mb/sec | 250kb/sec | Max 60kb/sec |
| Use | Everywhere (phone, computer, car …) | Building, automotive, health care … | Mostly in sport application |

As we can see, BLE is operating at the same frequency but it can provide a higher range of distance that ZigBee or ANT. In term of consumption, ZigBee and ANT have low energy consumption but not as low as BLE. Finally the data rate of BLE is much higher than the other technologies’ one. Besides, even if BLE is quite new in the market, there’s a compatibility with standard Bluetooth with dual mode, which exists for 4 years now (ZigBee and ANT exists for 6 and 3 years [2]). And the fact is that standard Bluetooth is already implemented in a lot of devices (watches, cars, computers etc.) and it’s deeply present in the development of the IoT as stated in the previous part. All these strength make BLE a stronger technology on the market compare to its competing technologies.

To respond to BLE and not to sink, ZigBee has developed an enhanced ZigBee and applications profile to be used in different sectors (building, automotive...) [3]. The mesh topology of ZigBee is also an advantage as it can enlarge its range to longer distances than BLE [6].

1. **Conclusions**

We’ve seen how Bluetooth Smart emerged from the standard Bluetooth and what were the main evolutions: lower energy consumption, lower latency, easy application developing. We’ve also seen how BLE takes part in the growth of the IoT and what the multiple use of it are, and even if BLE is considered as quite new technology, it already has a big impact on the market that is not going to stop any soon. BLE might have some strong concurrent in the future, but as it had been adopted and used by almost every major actors of the industry, it seems unlikely to see a new Bluetooth-like technology take BLE’s place on the market.

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