WHITE PAPER

BLE
BLUETOOTH® LOW ENERGY

BLE: A KEY TECHNOLOGY FOR INNOVATIVE IOT APPLICATIONS

In 2018, more than 1.5 billion smartphones were sold worldwide – a number that is more than three times that of 2011. More than 90 percent of these smartphones are BLE-enabled. This large spread of BLE-enabled end-user devices not only makes the technology attractive to the B2C environment of wireless headphones and smart home applications, but also opens up multiple new possibilities to realize innovative and user-friendly solutions in the B2B sector. The first part of this white paper outlines *different options regarding B2B use*, while the second part focuses on the *potential of BLE-based solutions in B2B applications* by examining practical examples. The final section shares insights into the *technical basics of this radio technology*.

1 BLE: TWO DIFFERENT OPTIONS FOR USE

1. **Identification element:** for simple identification, the transmission of an identification element such as a serial number (UID) is sufficient. This use is suitable for applications where there is no focus on ensuring a high level of security but rather a focus on practical requirements. This applies to B2B solutions as well as to products in the B2C environment.
2. **Issuing certificates:** The second option is particularly suitable for enterprise-wide applications in the B2B area and relies on certificate issuing. This is how BLE applications can be used to map car and person access control as well as digital access control in an individual and connected ecosystem, for example. Another pro argument to deploy BLE instead of other identification technologies in this environment is the comfortable, user-friendly realizability.

BLE – the current standard

At the beginning of 2019, the Bluetooth Special Interest Group (SIG) published the current version of the low energy radio technology Bluetooth 5.1, which was the latest version of the technology until July 2019. This version is fully backwards compatible to the predecessor versions 4.0 to 5.0. If an application also must cover even older Bluetooth versions, a dual mode implementation is required. This is how the classic mode (Bluetooth versions 1 to 3) as well as the low energy mode (Bluetooth versions 4 to 5) can be supported.

From parking to printing

To demonstrate the potential of BLE in an enterprise environment, an exemplar working day will be outlined here. The authentication processes described will illustrate scenarios which currently mostly use RFID cards and key fobs. Why should these applications now be realized with BLE? For the simple reason that user-friendliness can be achieved in these applications for the employees. No additional action is required.

At the entrance to the company's underground car park, readers detect the Bluetooth-capable smartphones that possess the appropriate authorization to enter. Access to the building and time recording are also carried

out via smartphones. Later an employee sends a print job to a central device. The job will not be started until the employee is physically close to the printer together with his smartphone. All these applications work with BLE without the employee having to take the smartphone out of his pocket even once.

To realize such a solution, in addition to a BLE-enabled smartphone of the employee and the BLE reader hardware at entry points and printers, a special software solution is also required. Firstly, for rights management and secondly to use BLE in proximity mode.

Only if the authorized smartphone – and thus the authorized employee – is identified unequivocally at the door or at a printer, is there the same physical security ensured as when deploying RFID cards with reading distance limited to ten centimetres.

Flexible hardware for global deployment

BLE as a linking technology has enormous potential in various applications to become one of the most used IoT technologies in the future. This is initially due to the global spread of BLE-enabled devices – especially smartphones. In the year 2017, 1.54 billion smartphones were sold worldwide while around four billion devices are in use globally. Almost all devices brought to the market now have a Bluetooth interface.

Thanks to this end device potential, in various applications the costly acquisition of identification media will be superfluous when smartphones can take this job. Plus, the software-based management of authorization allows the updating of an access system based on smartphones with BLE connection at any time.

The end-user side – thus the side using identification media – is only a part of the solution. There needs to be flexible reader hardware on the other side too. Flexible because, first, readers as modules or in housing must be smoothly integrable into existing infrastructures (boom barriers, door locking mechanisms, printers, and so on). Second, the hardware installed sometimes is required to act as a bridge between the existing "RFID world", where LF or HF RFID cards as well as key fobs are in use, and BLE as an additional identification technology required by the user. Thirdly, there must be a flexibility with regard to the programmability of a reader, for example using a Software Development Kit (SDK). This enables the user to run his own or external software applications and/or apps on the readers.

Therefore, flexibility regarding the reader hardware with integrated BLE interface is the elementary basis for rollouts also in global scaling so that even regional-specific requirements are covered technologically and met practically.

Innovation in the hotel: Access with BLE. No more financial effort for acquisition, coding, and replacement of cards, keys, or key fobs.

2 BLE IN PRACTICE

Basically, the majority of applications where BLE could be used today can also be solved with an RFID card. However, there are added values for the user and the application operator when deploying a BLE application. A more detailed view into exemplary applications will follow to demonstrate potential benefits. It is important to keep in mind that only benefits to the process will be outlined. The hardware and software as well as the security measures to be implemented required for the realization will have to be a subject of requirement-specific, individual consulting.

HOTEL

When a hotel guest receives a booking confirmation on the smartphone directly after the booking process via mail or proprietary app of the hotel (group), there are numerous benefits for the guest and the hotel operator. A personal check in at the reception desk is no longer necessary. The guest can get access to the hotel and his room at any time via smartphone. Thus, there are no more costs for acquisition, coding, and replacement of cards, keys, and key fobs. If hotel operators use their own apps, they can also be used for communication with the guests. Time-limited offers for additional services like in the spa or restaurant area, upgrades for loyal guests, bonus programs – the possibi-

OFFICE

The employee's smartphone functions as a universal identification medium for vehicle and personal access, time recording, and for access to the IT infrastructure like PCs and printers. The central rights management allows individually-tailored concepts also for temporary employees or employees who often or regularly change between different company sites – regionally or globally.

MUSEUMS AND EVENTS

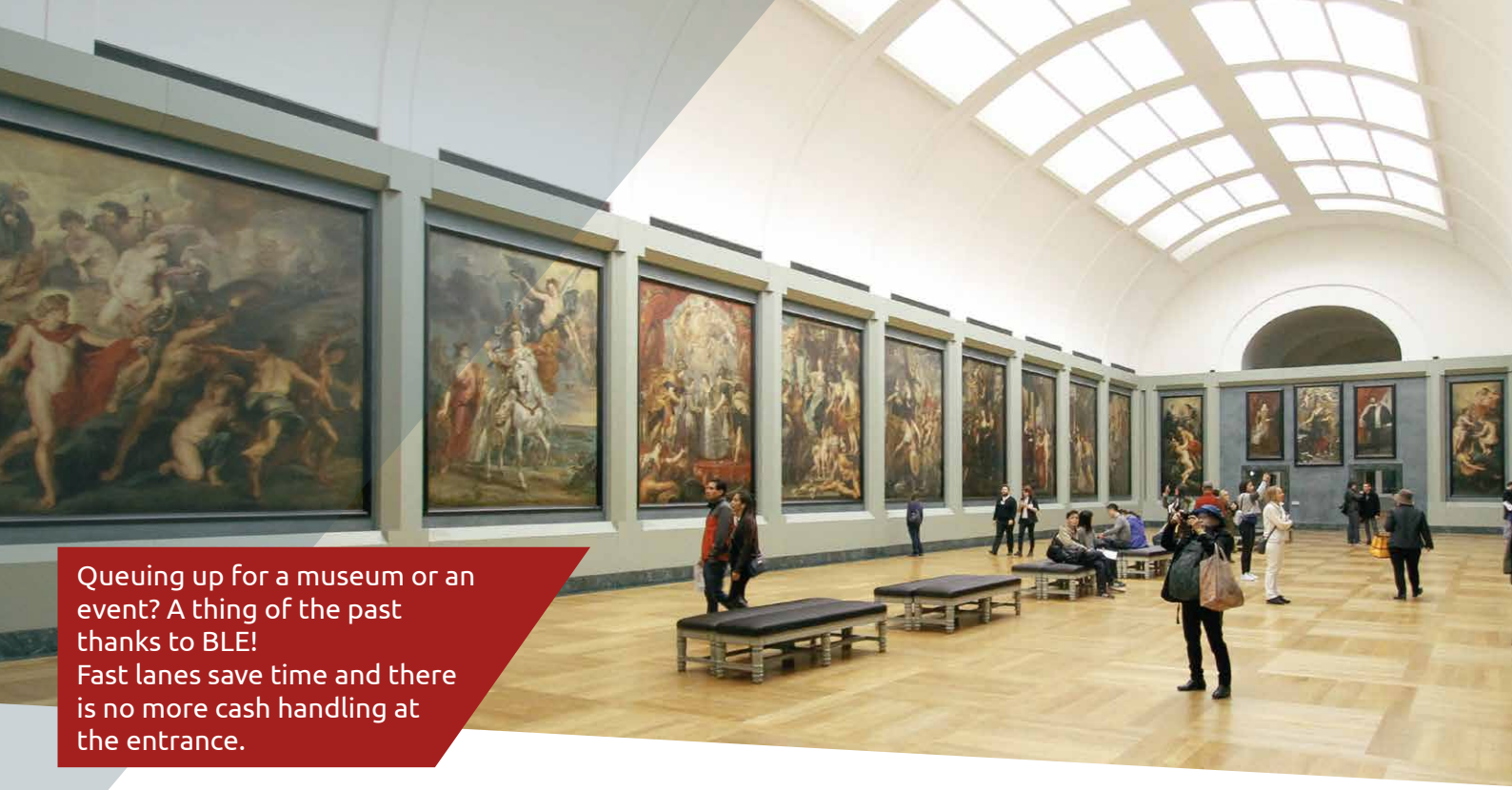
The whole access management can be done with digitally transmitted authorizations. The benefit for the organizer or operator: planning security. Who arrives when? In addition, there are reductions in costs since there is less physical handling of tickets and cash on site. The benefit for the user: avoiding losses. Statistics prove that a smartphone is lost much less often than a ticket. Using fast lanes: no more need for time-consuming queuing up.

AIRPORT

Boarding does not require a paper ticket or a QR code on the smartphone display. The smartphone with the boarding authorization and Bluetooth interface activated can remain in the pocket. The deployment of Bluetooth beacons in the airport area, for example, can be used for indoor location and to lead flight passengers and visitors via the airport's own app to the desired destinations – shops, catering, and so on. An added value is the possibility of informing about special offers and activities via the app.

CAR SHARING

For now, RFID readers are the prevailing option in car sharing concepts to identify car renters and to lock and unlock the vehicle. Yet, with BLE communication, there is no longer the need to carry additional cards. Since a smartphone app is already in use to search, find, reserve, and book the vehicle, the deployment of BLE is a further comfort gain for the customers and allows faster business processes for the car sharing provider: no more lengthy shipping of a physical card.



Queuing up for a museum or an event? A thing of the past thanks to BLE!
Fast lanes save time and there is no more cash handling at the entrance.

3 BLE – THE TECHNICAL BASICS

Bluetooth Low Energy (BLE) is a power-consuming variant of the radio technology Bluetooth. BLE was established as a part of the specification from Version 4.0 on, which was published by the Bluetooth Special Interest Group (SIG) in 2009. BLE transmits license exempt via the Industrial, Scientific, and Medical (ISM) frequency band with 40 channels in the frequency range 2.402 to 2.483 GHz. Bluetooth-enabled devices are able to connect within 3 milliseconds. The short signal pulses used for data transmission contribute a maximum of ten milliwatts to the low energy consumption of BLE devices. The data security is ensured by the 128 Bit Advanced Encryption Standard (AES). Currently, there are two different Bluetooth variants: Bluetooth Classic (Versions 1 to 3) and BLE (Versions 4 and 5).

Reading range and data transmission: What is possible?

When Bluetooth 5 was introduced, the performance information attracted attention: maximum data transmission range with visual contact on an open field was multiplied by a factor of five from 40 to now 200 meters. Indoor ranges of around 40 meters are realistic. In parallel to the increased range, the data transfer rate of Bluetooth 5 also doubled from 1 Mbit/s to now 2 Mbit/s. When taking a detailed look at these features, the performance increase becomes obvious, for example when the range is achieved by the higher maximum transmission power of 100 milliwatts compared to the 10 milliwatts before. A similar path was taken for the Wi-Fi standard IEEE 802.11n.

Modulation process for a transmission as smooth as possible

BLE is particularly well-suited for the transfer of small data packages in swift succession due to the modulation process used. The modulation is done via Gaussian frequency shift keying (GFSK) and frequency hopping spread spectrum (FHSS). GFSK is a modulation technology via modified frequency shift keying (FSK) using a Gaussian filter. During frequency shift keying, the carrier signal emitted is filtered so that the high frequency part of the signal is removed and less bandwidth is needed for the signal transmission.

FHSS ensures a frictionless transmission and prevents collisions with other signal transmissions by sending at 1,600 frequency hops per second between previously-defined frequency channels. The useable frequency band is divided into 40 channels with a width of 2 MHz each. Three of the 40 channels are reserved for the connection between BLE-enabled devices. At the upper and lower end of the frequency range, there is one frequency band each serving as a safety band to neighbouring frequency ranges.

The smartphone acts as a universal identification medium in the office of the future.

4 BLE VERSIONS AT A GLANCE

Bluetooth 4.0
(basic functions that also apply to the following BLE versions)

- Transfer of small data packages in swift succession
- Ideally suited for IoT applications which do not require constant connectivity but aim at a long battery runtime – five years or more, depending on the application scenario
- Depending on the end device used, e.g. a smartphone, a protocol for energy-saving communication can be used
- Innovative applications in the B2B area: authentication at vehicle entries, doors, printers and other devices, indoor navigation systems, and sensor tag-based logistics monitoring
- Popular applications in the B2C area: wearables like fitness trackers or smartwatches, smart home applications like connected thermostats or light bulbs, door locks in hotels, weather and plant sensors, proximity marketing
- Possibility to design very compact radio modules, only taking a few square millimetres

Bluetooth 4.1

- LTE compatible, automatic coordination of both technologies
- Automatic reconnection after interruptions between previously-paired devices
- Ipv6 supported

Bluetooth 4.2

- Additional features regarding IP connectivity, privacy, and optimized data transmission speed
- Smaller data packages for accelerated server client exchanges
- Internet Protocol Support Profile (IPSP) allows Bluetooth sensors to access the internet directly via IPv6/6LoWPAN

Bluetooth 5.0 and 5.1
Compared to previous versions:

- Maximum data rates increased to 2 Mbit/s
- Increased open field transmission range from 40 meters to around 200 meters
- Higher transmission power from 10 milliwatts to 100 milliwatts
- AoA (angle of arrival) and AoD (angle of departure)

Selected proprietary BLE standards

iBeacon

A standard introduced by Apple in 2013 for indoor locations. The proprietary iBeacon standard is based on BLE from version 4.0 upwards and is supported by iOS as well as Android devices.

Eddystone
A proprietary standard published by Google in the year 2015 also based on BLE that was developed to be an alternative to iBeacon and has similar functionalities.

THE ELATEC EXPERTS FOR BLUETOOTH LOW ENERGY

Dr. Dominik Samson

studied physics at Saarland University, Germany, and did his PhD at TU Wien, Austria. After research activities where he first got into contact with RFID, his path lead to the industrial sector. After working in the consultancy and innovation field he now is at ELATEC GmbH responsible among other things for their strategy. In the course of addressing future topics, BLE, its market impacts, and market entry strategy are his main focusses.

Antonio Nabeiro

has been in the RFID field for more than 15 years, since 2016 for ELATEC GmbH. He is a known specialist for RFID and transponder technologies, particularly for access control. Furthermore, as Director of Business Development Access, he is constantly confronted with new access technologies and gained a vast expertise in BLE. The successful implementation of different major customer projects in the past underlines his expert knowledge.

Verlag & Freie Medien

Verlag & Freie Medien has been supporting the international spread of information on RFID and wireless IoT technologies and applications since 2005. Their media and channels: the magazine *RFID im Blick* in German, the magazine *RFID & Wireless IoT Global* in English, numerous online portals as well as the annual specialist conference and trade fair *RFID & Wireless IoT tomorrow.*

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