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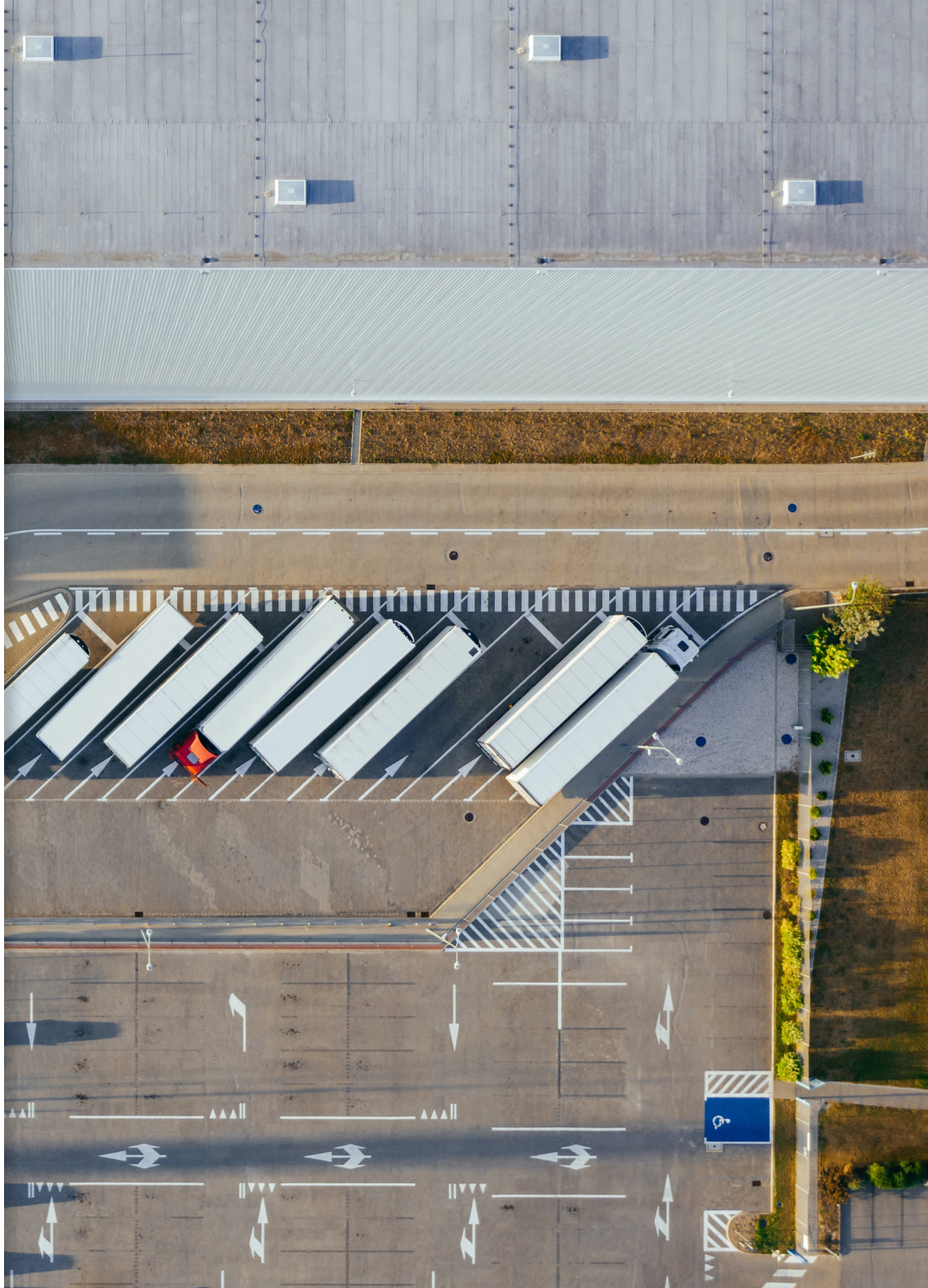
WHITEPAPER

# Bluetooth Technology and Common Terms Introduction

**v2.2**

4/18/2023





# 1. Common Terms Introduction

### BLE

Bluetooth Low Energy. It is a low-power-consumption Bluetooth technology.

### iBeacon

A protocol developed by Apple and introduced in 2012 to comply with the Beacon technology protocol.

### Beacon

A precise positioning technology based on the Bluetooth 4.0 protocol or a later protocol version.

### Eddystone

A cross-platform open-source Beacon format Bluetooth protocol launched by Google in 2015.

The Bluetooth we often talk about in our daily life actually refers to BLE (Bluetooth low energy technology). As the name suggests, the current Bluetooth technology consumes very low power.

Unlike the rumours saying that Bluetooth needs to be turned off to save power when not used, Bluetooth or the power consumption of turning on Bluetooth on the mobile phone for a long time is negligible. In IoT devices, beacons transmit at a fixed interval, and the power consumption is low. Compared with transmitting, in IoT application, Bluetooth receiving consumes more power.

# 2. Origin and classification of BLE

BLE, also known as Bluetooth Low Energy technology, originated from Nokia's Wibree technology in 2006. This technology is similar to Bluetooth technology but only consumes a fraction of the battery power equivalent to Bluetooth technology. The technology was later integrated into Bluetooth and became part of the Bluetooth 4.0 technical specification released by the SIG (Special Interest Group) in 2010.

The BLE protocol stack is shown in the figure below. BLE is a different set of protocols than traditional Bluetooth, and the corresponding device does not implement backward compatibility.

So BLE supports three device types:

### Classic Bluetooth devices

Classic Bluetooth devices, called Bluetooth basic rate/enhanced data rate (BR/EDR) BR/EDR: devices that only support traditional Bluetooth, such as some legacy devices and old mobile phones. Classic Bluetooth uses SPP (Serial Port Profile) to transfer data. SPP defines the Bluetooth device requirements needed to emulate a serial cable connection between two peer devices using RFCOMM setup.

### Bluetooth Smart Ready devices

Known as Bluetooth 4.0 dual mode, support both classic Bluetooth and LE mode devices, being supported by new mobile phones, notebooks, tablet computers such as iOS and Android systems. The dual-mode controller integrates both of the BR/EDR controller and the LE controller, so it support two Bluetooth protocols.

### Bluetooth Smart devices

Also called BLE single-mode. It uses LE controllers and only supports LE-mode devices. Beacon devices only support low energy protocols (LE low power protocols), so they can run for a long time power by a button battery.

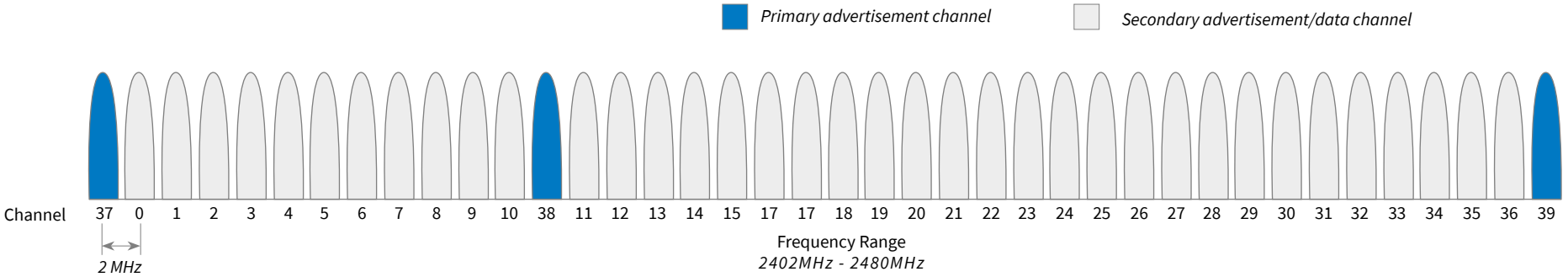
Bluetooth Low Energy technology operates in the same spectrum range (the 2.400– 2.4835 GHz ISM band) as classic Bluetooth technology, but uses a different set of channels.

Instead of the classic Bluetooth 79 1MHz channels, Bluetooth Low Energy has 40 2MHz channels. The bit rate is 1 or 2 Mbit/s. And the advertising and receiving channels are 37, 38 and 39.

| Feature | Bluetooth BR/EDR | Bluetooth LE |
|---|---|---|
| **Frequency band** | ISM 2.4000GHz ~ 2.4835GHz | ISM 2.4000GHz ~ 2.4835GHz |
| **Channels** | 79 channels | 40 channels (37 data channels and 3 advertising channels), note 1. |
| **Channel bandwidth** | 1 MHz | 2 MHz |
| **Spread spectrum technique** | 1600 hops/sec frequency-hopping spread spectrum (FHSS) | FHSS |
| **Modulation scheme** | GFSK, DQPSK, DPSK | GFSK |
| **Power usage** | 1W | ~0.001W to 0.1W, depending on the receiving and broadcasting interval |
| **Data rate** | BR PHY (GFSK): 1 Mb/s<br>EDR PHY (DQPSK): 2 Mb/s<br>EDR PHY (DPSK): 3 Mb/s | LE Coded PHY (S = 8): 125 Kb/s<br>LE Coded PHY (S = 2): 500 Kb/s<br>LE 1M PHY: 1 Mb/s<br>LE 2M PHY: 2 Mb/s |
| **Device discovery** | Inquiry or paging | Advertising |
| **Device address privacy** | None | Private device addressing supported |

| Application | Bluetooth BR/EDR | Bluetooth LE |
|---|---|---|
| Network topology | Peer to peer | Peer to peer, Broadcast, Mesh |
| Audio applications:<br>Bluetooth headsets, watches, speaker | Supported | Supported |
| Positioning and direction finding applications:<br>1. Asset and people tracking: cars and workers<br>2. Indoor navigation: hospitals and shopping malls<br>3. Beacon-based services: advertisement | Not supported | Supported |
| Data transmission applications:<br>• Display devices: E-ink label<br>• Medical and health devices: heart-rate monitor<br>• Sports and fitness devices: heart-rate monitor, step counter, watches | Not supported | Supported |
| Device network applications:<br>• Sensors: temperature and humidity, liquid level, pressure sensors<br>• Monitoring systems and services: tire pressure monitor<br>• Control devices: remote controller | Not supported | Supported |

*Note 1. Channel 37, 38, and 39 are called the Primary Advertising Channels; the other 37 channels are for Secondary Advertisements and for data transfer after a connection is built.*



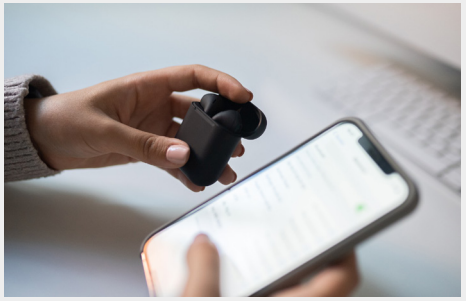
# 3. Features of Beacon Technology

As a positioning technology based on the Bluetooth 4.0 (or higher) protocol, Beacon a BLE based device, has attracted more and more attention in the indoor positioning market.

With the development of IoT and the continuous accumulation of big data acquisition and processing requirements, Beacon technology with low power consumption and low cost has become the focus of indoor positioning applications, and its characteristics have driven the rapid implementation of the IoT indoor positioning system.

## 1. No pairing required

In our impression, we need to pair the Bluetooth devices every day, for example, the Bluetooth headsets, speakers. When the smart bracelet is bound to the mobile phone, it also needs to be paired. The Beacon does not need to be paired.



As mentioned above, it uses the Bluetooth advertising channel to transmit signals and the receiver receives from these channels too. The transmitter and receiver works independently, usually the beacon advertises periodically and the receiver receives only when necessary. The receiver with LoRa, Wi-Fi, 4G, etc. back-haul can be used as a Bluetooth gateway to relay beacons' messages to the cloud. During this process, both parties do not need to be paired.

For details, please refer to 'B-Fixed®PERSONNEL & ASSET TRACKING SOLUTION' or 'B-Mobile®PERSONNEL & ASSET TRACKING SOLUTION'.

## 2. Receive information in the background

Information push based on Beacon positioning requires App support. However, when we use the indoor positioning function to receive Beacon signals, we do not need to open the app.

We only need to open the corresponding app when we need to display the service Beacon pushes.

## 3. Beacon can also transmit data after pair with a receiver

A standard Beacon only advertises messages required for positioning in the form of broadcast data.

But, it can also be paired with a receiver for faster data communication.

## 4. Low power consumption

Lansitec's BLE beacon average current is 35μA at 0dBm TX power and 500 ms advertisement interval.

It is powered by a 2x1000mAh button battery, the battery life is as follows.

| *Advertisement Interval (ms)* | 100 | 300 | 500 | 1000 |
|---|---|---|---|---|
| *Battery Life (year)* | 1.2 | 3.5 | 5 | >6 |

BLE offers low power consumption (5mA TX power or even lower), high data rate (less TX time and more sleep time), multiple channels (less interference) and larger link budget (4dBm TX power and -96dBm sensitivity, longer distance).

same time, the transmission distance is increased, security and stability are improved, and AES encryption and CRC verification are supported for the security of communication between connected devices.

Both BLE and classic Bluetooth cover a range of 100 meters, but BLE has a slightly wider range. Compared with classic Bluetooth, the biggest advantage of BLE is power consumption which is 90% lower than that of classic Bluetooth. At the

With the improvement of Bluetooth protocol and semiconductor technology, Bluetooth 5.0 has a great improvement in performance compared to Bluetooth 4.0, the following is a comparison of two Nordic chips.

| | **Nordic nRF51822** | **Nordic nRF52832** |
|---|---|---|
| *Protocol* | Bluetooth 4.0 | Bluetooth 5.0 |
| *Sensitivity* | -90dBm @ 1Mbps BER=1E-4 | -95dBm @1Mbps BLE ideal transmitter >=128 bytes BER=1E-4<br>-95dBm @1Mbps BLE ideal transmitter, <=37 bytes BER=1E-317 |
| *Peak RX* | 13mA | 5.4mA |
| *Peak TX (0dBm)* | 10.5mA | 5.3mA |
| *Outdoor Distance, TX power 0dBm, Line of sight* | 50m | 200m<br>>1km (FEC, Forward Error Correction on) |

# 4. What is the difference between iBeacon & Eddystone based on Beacon technology?

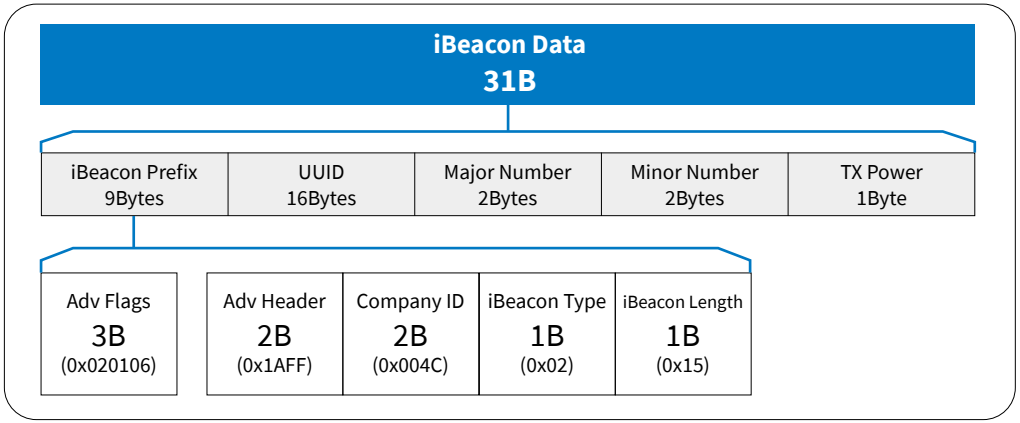
## 4.1 iBeacon introduction

iBeacon is a precise micro-positioning technology based on Bluetooth 4.0 (Bluetooth Smart) launched by Apple at WWDC in 2013. The underlying technology uses BLE which is supported after the iPhone 4S. When your hand-held device, such as a smart phone, is close to a Beacon, the smart phone can receive its signal.

Apple put iBeacon related interfaces into CoreLocation.framework . Google supports this function in Android 4.3 and later versions. To apply iBeacon technology, developers only need to meet the iBeacon technology standards. It is now universally used in almost of beacons.

### 4.1.1 iBeacon frame format

The iBeacon broadcast packet frame format is as follows. We can see that the frame format consists of parameters such as broadcast length, type, company ID, iBeacon type, iBeacon length, UUID, Major, Minor, and Signal Power.




### 4.1.2 Attributes of iBeacon

iBeacon is essentially location information, so Apple has integrated the iBeacon function into Core Location and mainly uses three attributes to identify an iBeacon: Proximity UUID, major and minor.

UUID is used to identify a company. The iBeacon used by each company or organization should have the same Proximity UUID, also known as UUID.

Major is used to identifying a group of associated beacons. For example, in a warehouse, beacons of each type of part should have the same major. The role of a major is similar to grouping to manage a large number of Beacon devices better.

Minor is used to distinguish a specific beacon, and you can assign a minor for each device in a warehouse.

If these attributes are not specified, they will be ignored when the device is paired or received. You can only know the UUID of the Beacon, but can't differentiate each one of them.

In addition, we can see that the entire iBeacon data payload is fixed, and each piece of code is restricted. If you want to use it on mobile phones, developers or users can only use the same format and cannot make additional modifications or develop it yourself.

If you use a Bluetooth beacon or a Bluetooth sensor and a Bluetooth gateway (receiving device), you can change the data format as needed, as long as the receiving device can decode it. In this way, data from various sensors can be transmitted using the iBeacon protocol. For some technologies like LoRaWAN, the data rate is slow, and the package size is small. The gateway should filter useless data and only send useful ones. For more information, please refer to "How Lansitec Bluetooth Gateway works", document Number 990 -00522.

## 4.2 Eddystone introduction

Eddystone is a cross-platform open-source beacon format Bluetooth LE beacon launched by Google on July 15, 2015. It is mainly used to send information to people in public places.

Since Google has positioned it as an open-source project, according to tradition, Google does not name those open-source projects with the name of Google.

For example, the Android operating system does not use the name Google. The public does not need to know which company developed Eddystone, only the Beacon OEMs and corresponding app developers know.

### 4.2.1 Properties of Eddystone

In addition to the advantage of being open-source, Eddystone also supports multiple frameworks. iBeacon and Google's The Physical Web only support one.

The Eddystone multiple frameworks contain data in four formats: UUID, URL, TLM, and EID.

The original intention of Eddystone's UID is to be compatible with iBeacon UUID. To break the limitation of only iBeacon UUID, the UID can be freely set by the merchant, and the app can choose to only accept messages from this UID. Through the unique identification code of the UID, the merchant app can also find out which branch the user is globally and push corresponding information, such as coupons, Wi-Fi connection, etc.

URL links are obviously more widely used and simpler than UUIDs. Any mobile phone has a browser, and they can open the URL.

TLM, this remote telemetry framework, is useful for businesses that need to control many beacons. Since beacons are mostly battery-powered, they will need to be replaced or recharged after some time. The telemetry data frame allows the Beacon to send its status and power information to surrounding workers, so that workers can perform maintenance and replacement.

EID is a security framework, a beacon that allows only authorized users to read information. For example, in a company, beacons are placed in the lobby to broadcast to all customers and visitors. However, the company also has messages only for employees, and it doesn't want these messages to be seen by customers and visitors.

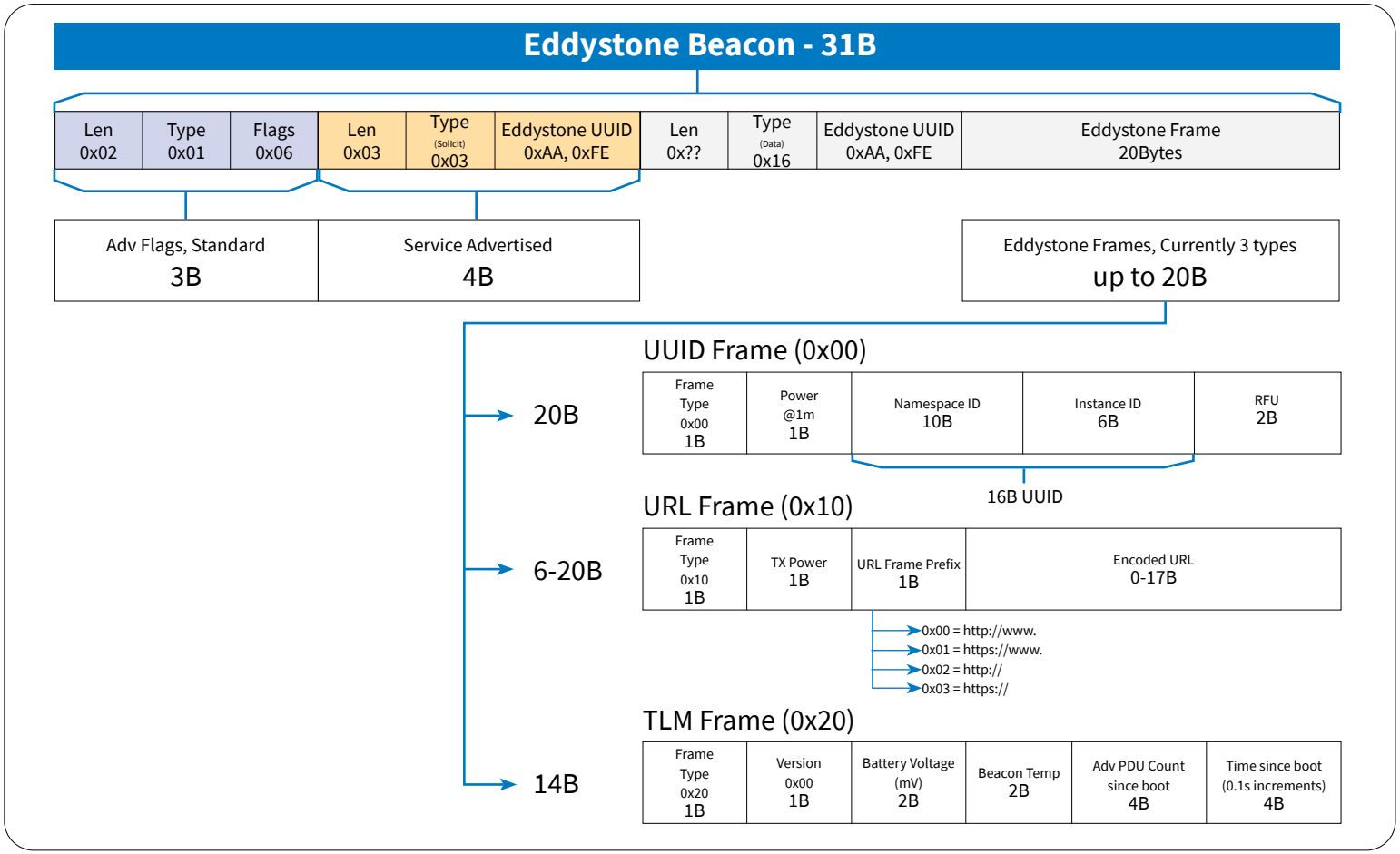
### 4.2.2 Eddystone frame format

Instead of using the manufacturer data field, Eddystone places the value 0xFEAA in the full 16-bit service UUID field and uses the associated service data field to hold the Beacon information. Full details can be found below:

#### Eddystone Use Scenarios

- In close-range promotion of products, such as customers shopping near supermarkets and restaurants
- Obtain location information at airports, railway stations, scenic spots, and museums
- Track assets to prevent loss
- Navigate indoors in shopping malls
- Transmit data from sensors

*Lansitec LoRa Bluetooth gateway supports both iBeacon and Eddystone. For more information, please refer to 'How Lansitec Bluetooth Gateway works', doc. Number 990-00522.*



# 5. How Beacon Devices Use BLE

*The content above shows us what BLE, Beacon, iBeacon, and Eddystone are. So, how do beacon devices realize functions based on BLE technology?*

*First of all, let's take a look at the complete connection process of BLE.*

## 5.1 BLE's broadcast-scan-connect process

The master and the receiver must be connected to build a one-on-one channel before data communication for devices like headsets, speaker or Bluetooth OTA. The connection includes four steps: advertising, scanning, initiating, and connection.

We will not go into the details in this paper. Please contact us if you want to know more about it.

## 5.2 How to use a beacon

Beacon devices only use the advertisement channels, so there is no BLE follow-up connection-related steps. And, this is precisely the reason beacon is used at the application field of low-power indoor precise positioning and sensor data advertising. As the literal meaning of beacon, this device sends data packets at a fixed time interval, and the data can be received by a Central device such as a mobile phone or a Bluetooth gateway.

E.g., A temperature and humidity sensor, the data can be put into the iBeacon payload and the sensor advertises it every second. The sensor does not connect with any other devices. And the Bluetooth gateway nearby only receives the message of the Beacon, and then transfers the temperature, humidity, major and minor to the server or based station through the backhaul. If it is a LoRa-based Bluetooth gateway, the Bluetooth gateway can transmit the data to a LoRa gateway through LoRa, and then to the cloud. As shown below.

To cite an internal example, we deployed a beacon at the entrance. When a tracker or a Bluetooth gateway receives the payload, it filters the UUID, major, and minor and then forward major, minor and RSSI to a LoRaWAN gateway, then to the cloud. The server calculates the distance between the Beacon and tracker with RSSI to determine where the tracker is.

Since the advertiser and the receiver operate on channel 37, 38, and 39 randomly, if a beacon advertises every 1s and a gateway opens a '1s receiving window' periodically, there is a chance that the gateway can't receive the Beacon. We recommend setting the receiving duration more than two times before the beacon's advertisement interval.

With the popularization of LPWAN, WIFI, and 5G technologies, Beacon application cases based on BLE technology have blossomed everywhere in the market. Beacon technology, especially Beacon+LPWAN technology, has many proven solutions on the market, such as smart parking lots, museums, warehouses, cold-chains, stores, nursing homes, hospitals, exhibition centers, and other Beacon application solutions.

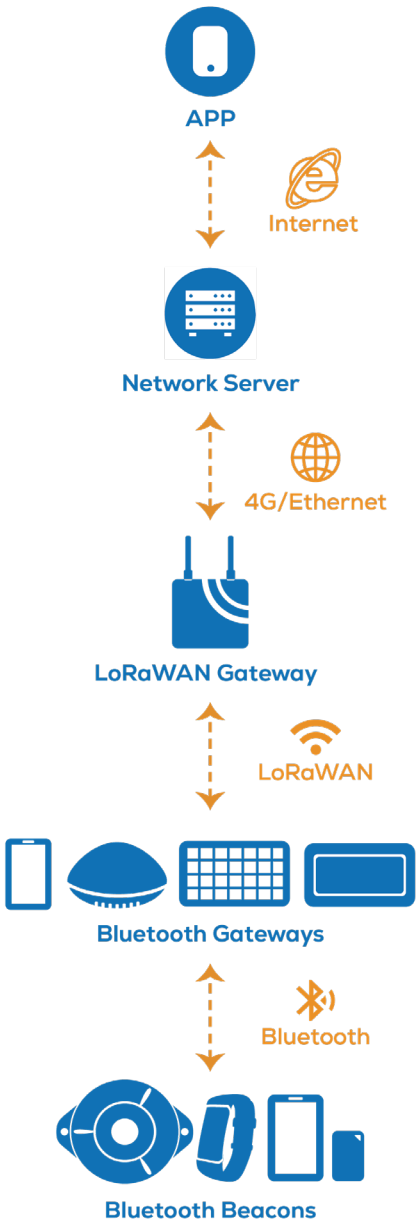



Figure 1. B-Mobile® Solution data flow

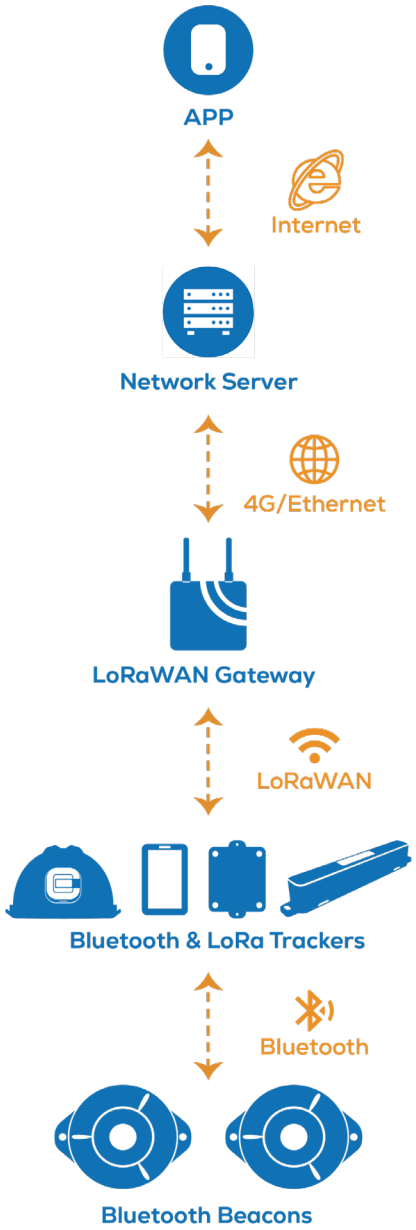



Figure 2. B-Fixed® Solution data flow