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Introduction to Bluetooth® low energy

A brief insight into the ultra low power technology at the core of the nRF51 series

NORDIC SEMICONDUCTOR

Bluetooth: essentials

- Standard for Personal Area Network based on Ericsson research
- Short range, low-power
- Frequency hopping spread spectrum (FHSS)
- 2.4 GHz ISM band
- Bluetooth **S**pecial **I**nterest **G**roup formed in 1998
- **16000+** SIG member companies
- **Billions** of products shipped
- **Nordic Semiconductor** is one 9 SIG **Board members**

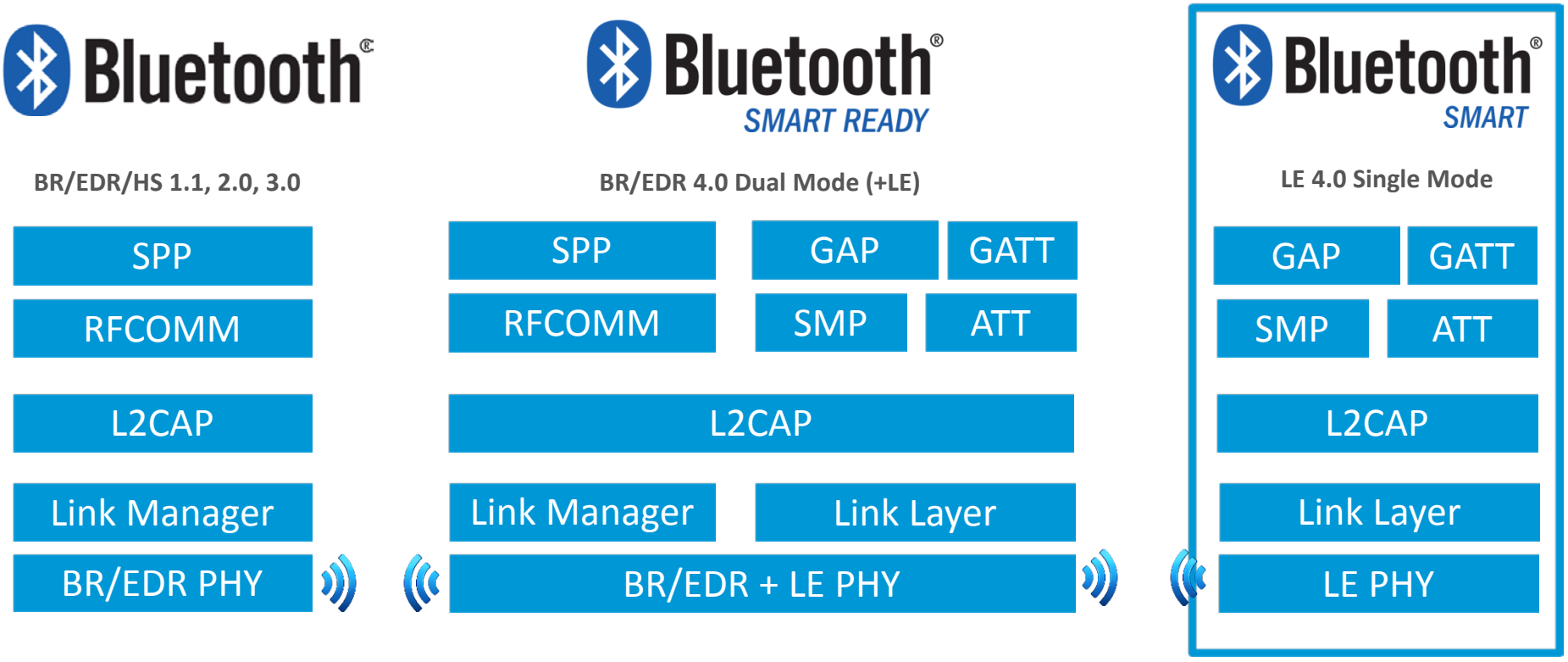
Board Members: Apple, Ericsson, Intel, Lenovo, Microsoft, Motorola, Nokia Connecting People, Nordic Semiconductor, Toshiba

Bluetooth: terminology

Term	Introduced	Means
BR	**1.1 (2002)**	Basic Rate (1 Mbit/s)
EDR	**2.0 (2004)**	Enhanced Data Rate (2 and 3 Mbit/s)
HS	**3.0 (2009)**	High Speed (Alternate MAC/PHY)
LE	**4.0 (2010)**	Low Energy (1 Mbit/s ultra low power)
Bluetooth Smart	**4.0**	…le-mode, LE-only radio
Bluetooth Smart Ready	**4.0**	…de, BR/EDR and LE dual radio

nRF51 Series

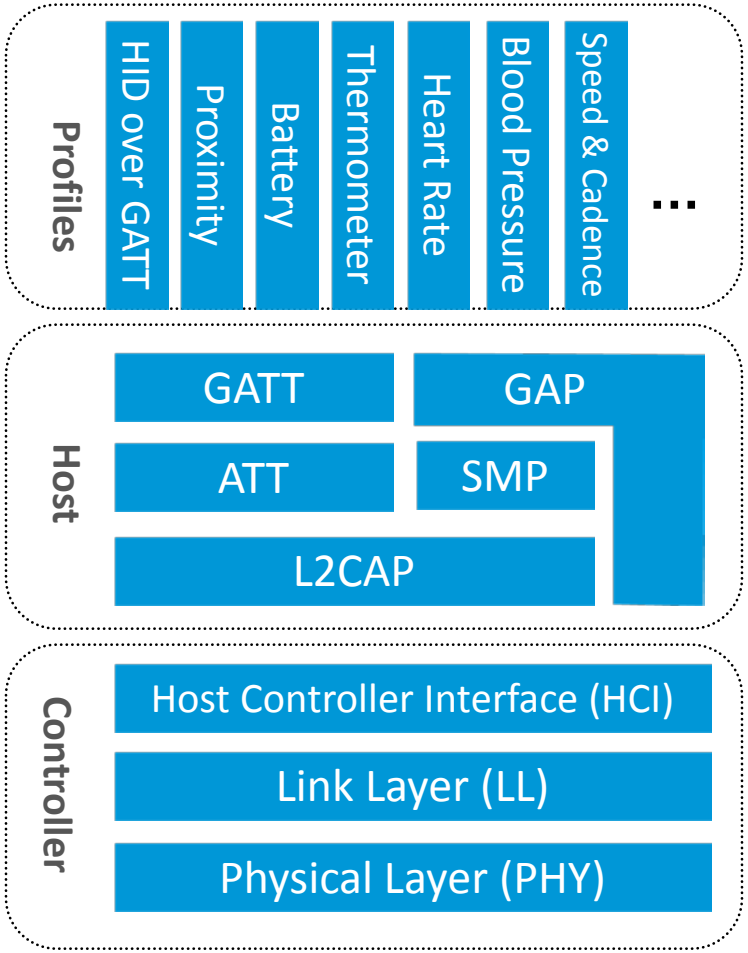
Bluetooth: configurations



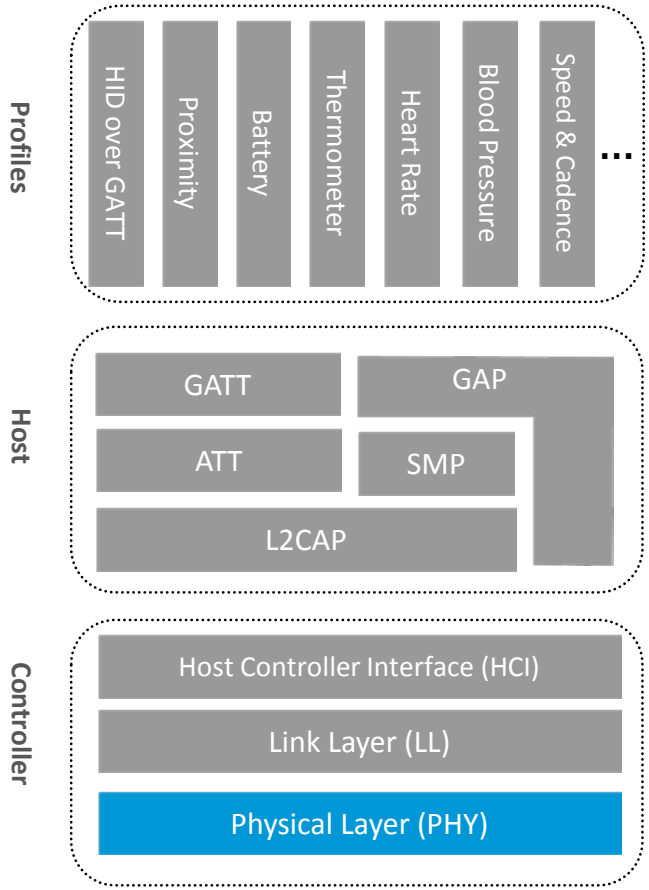
Bluetooth **LE**: key features

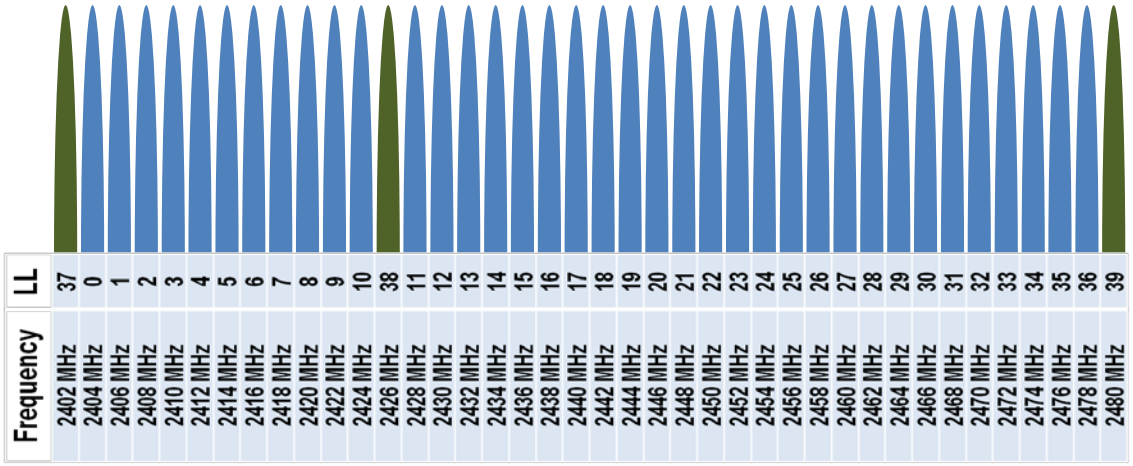
- Following goals and rules of ULP wireless **pioneered** by Nordic
- PHY compatible with all 4.0 Bluetooth devices
- **Ultra Low Power**
  - Small packets
  - Short RX and TX windows
  - **Race to idle**
    - Turn radio on as seldom as possible
    - Turn radio off as soon as possible
- Coin-cell battery 1+ year
- Low memory footprint
- Fast connection in **6 ms** and teardown
- Simple stateless operation, data in form of parameter-value

Bluetooth LE: architecture



PHY Overview





- **2.4 GHz** free ISM band
- **1 Mbit/s** signalling rate
- **GFSK** modulation
- Up to 4 dBm maximum transmit power
- **40** RF channels
- **3** advertising channels reserved for:
  - Discover
  - Connect
  - Broadcast
- **37** data channels

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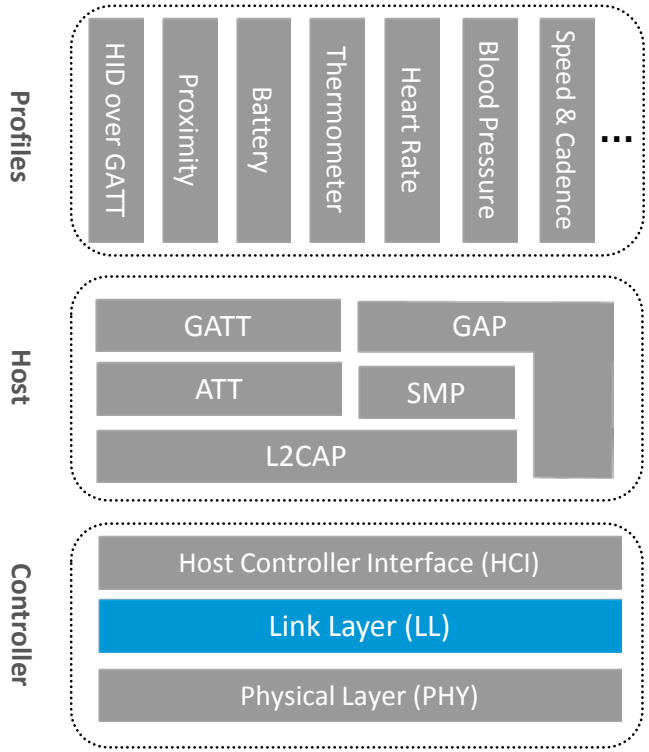
GLOBAL tech TOUR nRF 5 SERIES

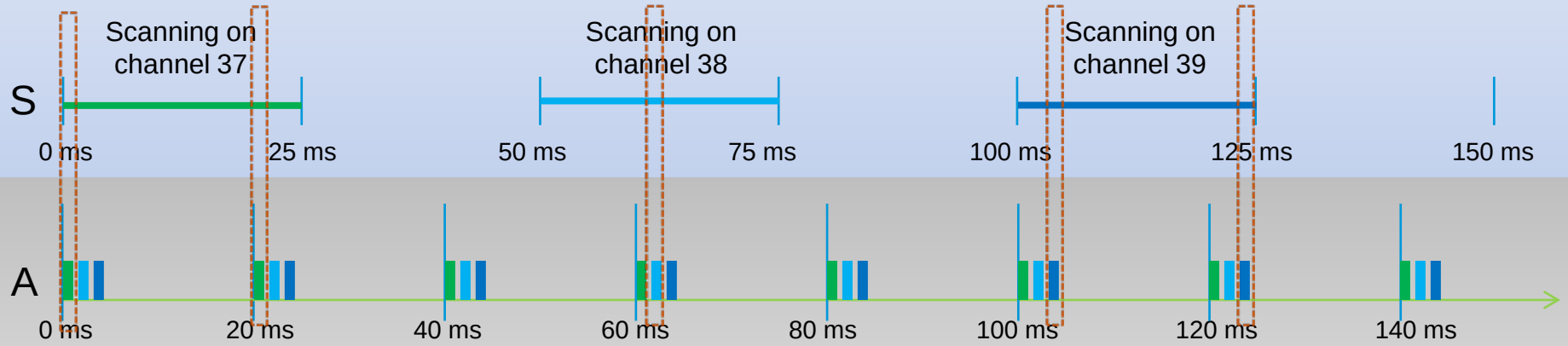
Link Layer Overview



- **Advertising:** connectable and non-connectable
- **Scanning:** active or passive
- **Slave:** connection role
- **Master:** connection role
- **31 bytes** advertising payload size
- **27 bytes** maximum payload size per packet
- **AES-128** built-in encryption
  - CCM
    - Counter with
    - Cipher Block Chaining
    - Message Authentication Code

Link Layer Overview: Advertising and Scanning

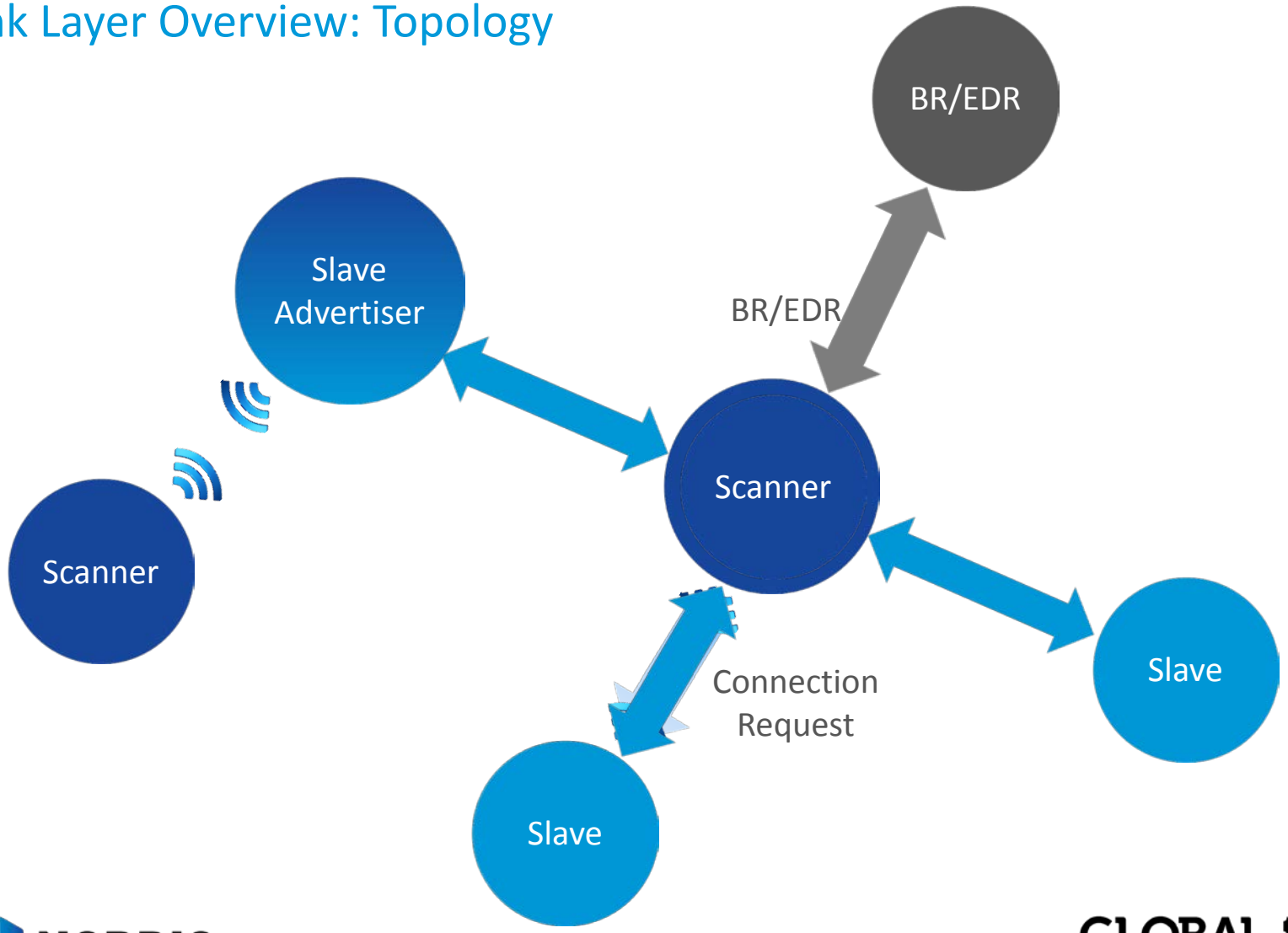
Scanner scan interval = 50 ms
Scanner scan window = 25 ms



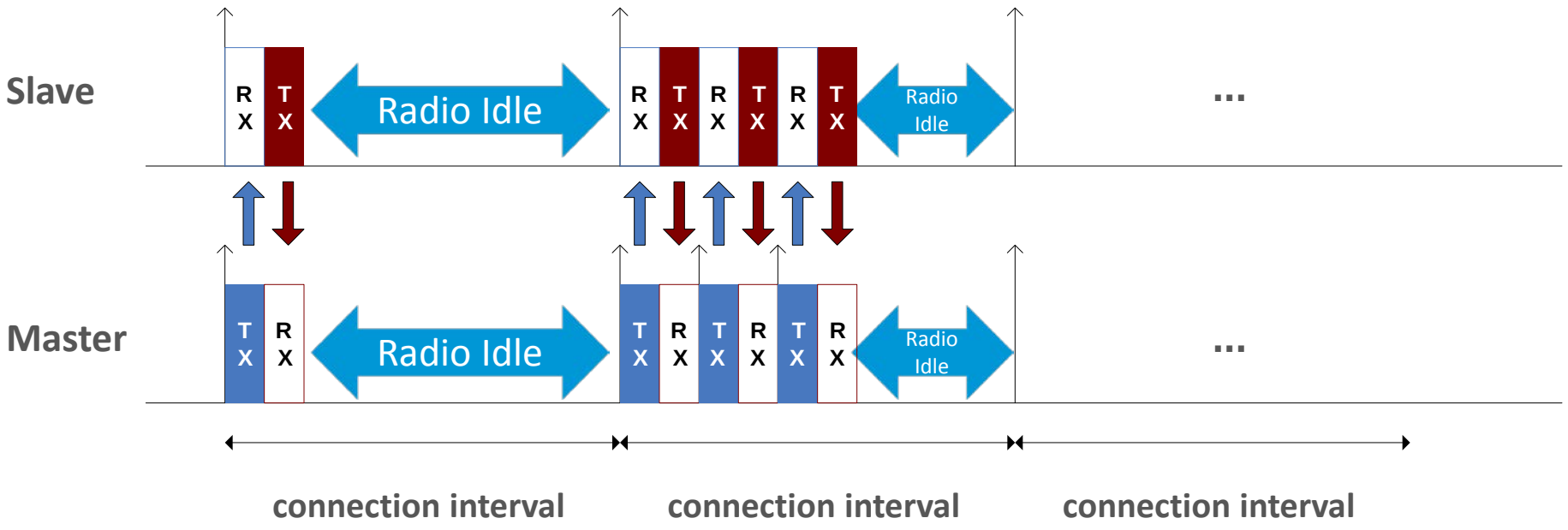
Advertising on **37**, **38** and **39**

Advertiser advertising interval = 20 ms

Link Layer Overview: Topology

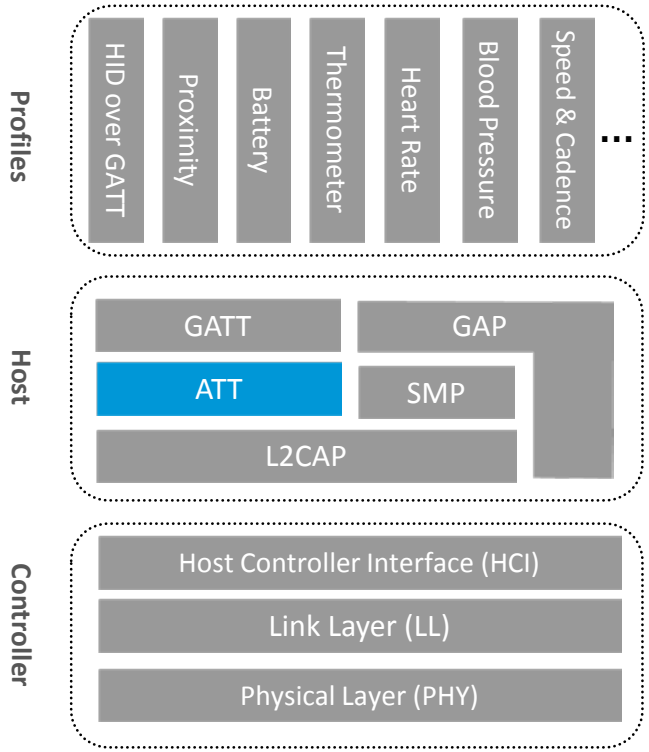


Link Layer Overview: Connection



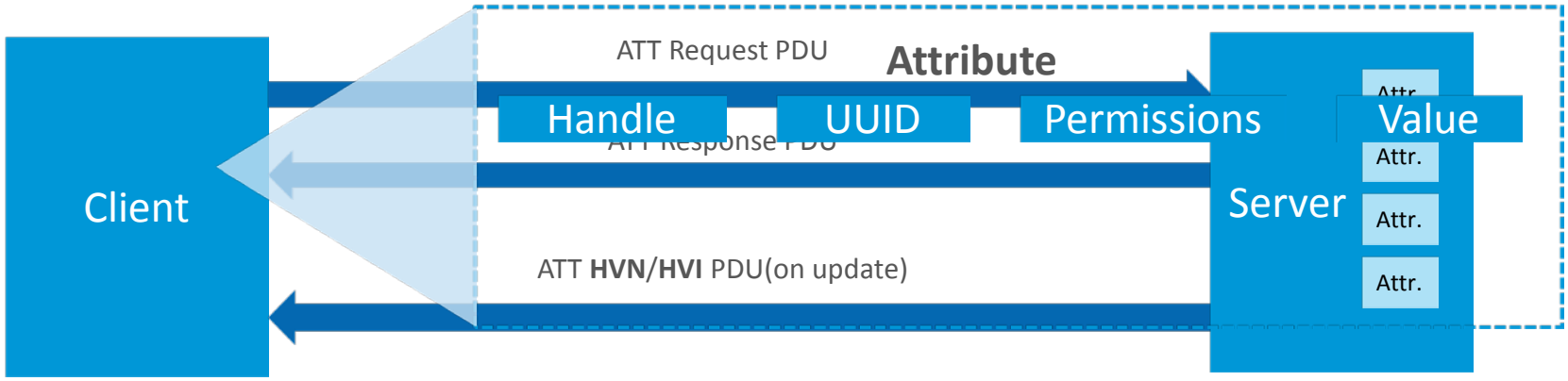
- Selectable Connection Interval: **7.5 ms to 4 s**

ATT Overview



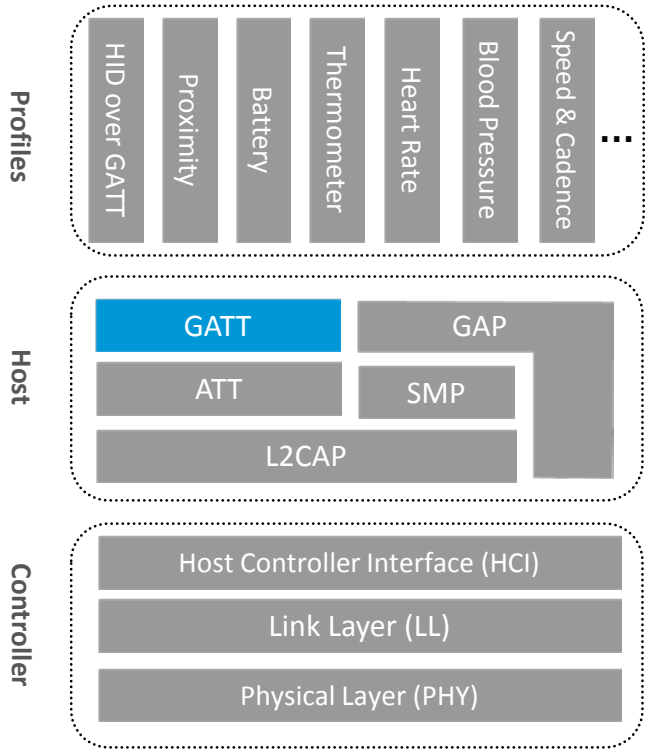
- **Attribute Protocol**
  - Mandatory and used for all data transfers in BLE
  - Fast, simple, independent of connection logic
- Client – Server architecture
  - Server stores data
  - Client requests data
  - Server initiates Notifications and Indications
- Supports for fine-grained security

ATT Transaction



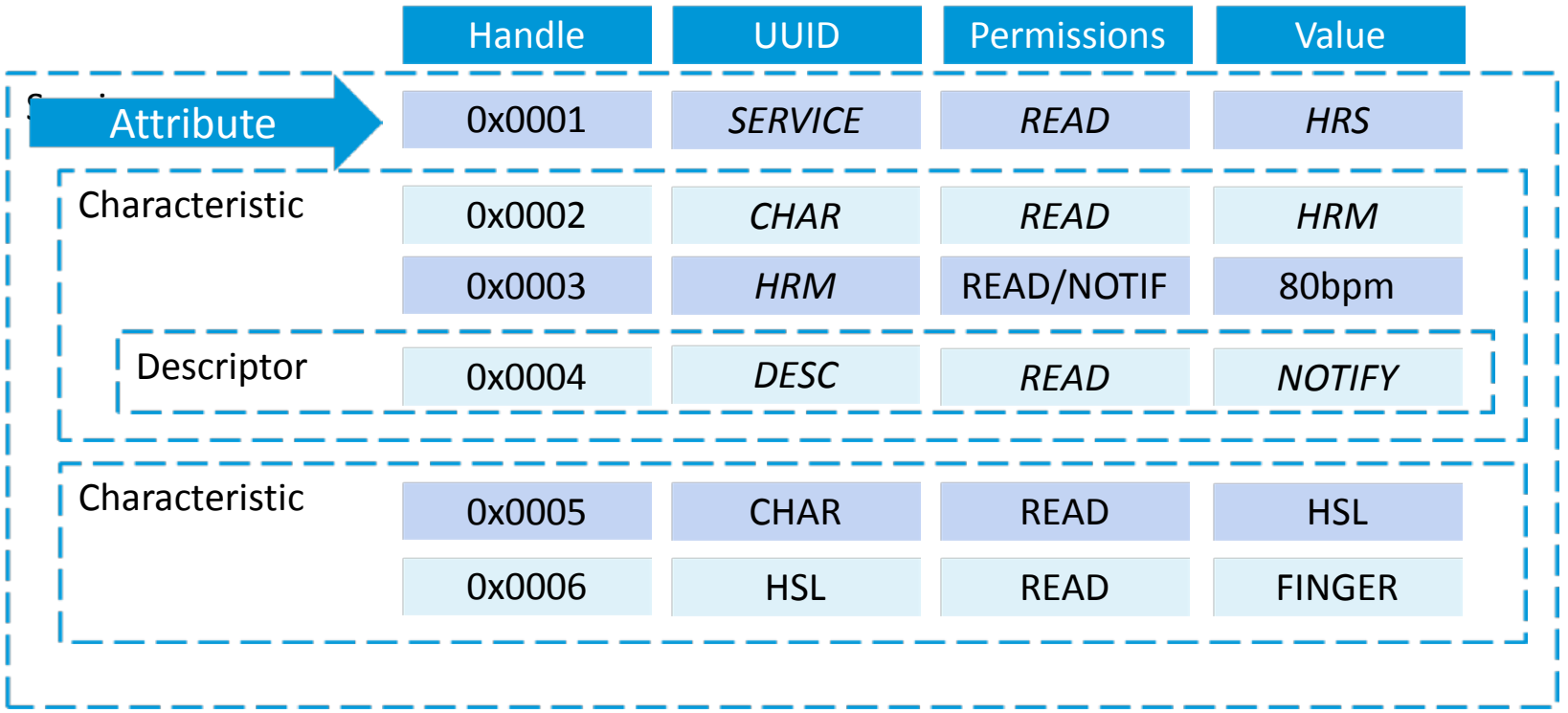
- **Handle** – Index in the ATT Table, used in ATT transaction PDU
- **UUID** – Universal Unique Identifier
- **Permissions** – Read, Write, Authenticated, Encrypted etc.
- **Value** – data read/written by Client

GATT Overview

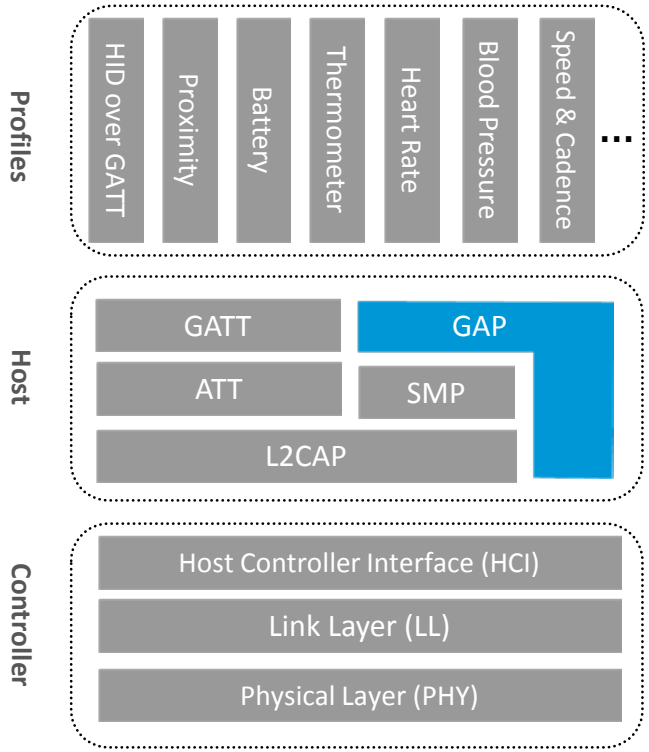


- **Generic Attribute Profile**
- Mandatory for all BLE profiles
- Procedures for attribute **discovery** and **access**
- Models the **ATT Table layout**
- 16-bit (SIG Assigned) and 128-bit (Proprietary) **UUIDs**
- Hierarchial classification of Attributes
  - Services
  - Characteristics
  - Descriptors

GATT Overview

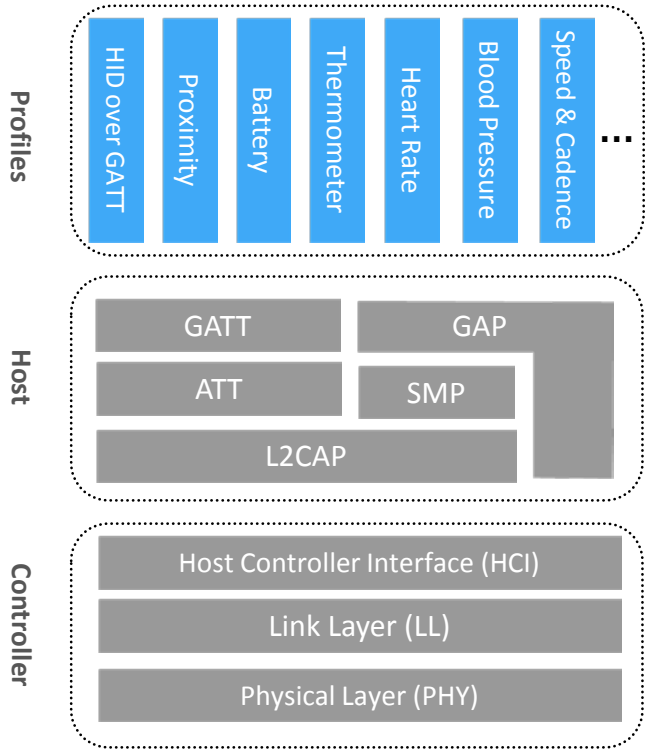


GAP Overview

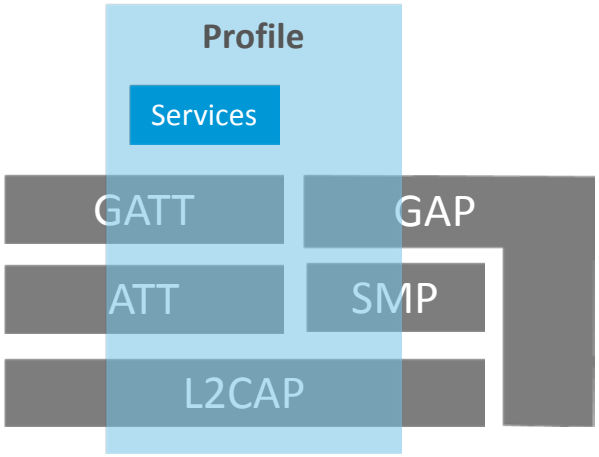


- **Generic Access Profile**
- Common to BR/EDR and BLE
- Mandatory for all BLE profiles
- Procedures to discover, and connect to devices
- Roles
  - Peripheral (Slave)
  - Central (Master)
  - Broadcaster (Advertiser)
  - Observer (Scanner)
- Security
  - Creating bonds with peer devices
  - Attribute access security requirements
  - Privacy and address control
- Advertising data format

Profiles overview

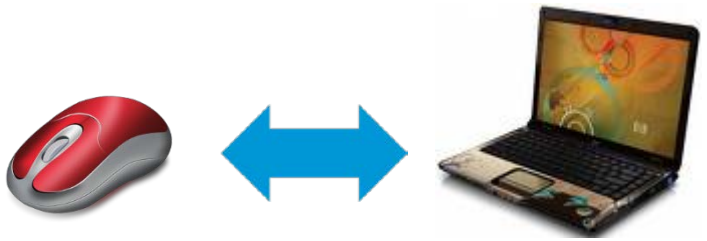


- **Vertical slice** across protocol stack
- Selects required features from the stack
- Describes a particular use case
- Requires a particular set of GATT services
- Defines
  - Roles
  - Procedures
  - Security
- Key to inter-operability

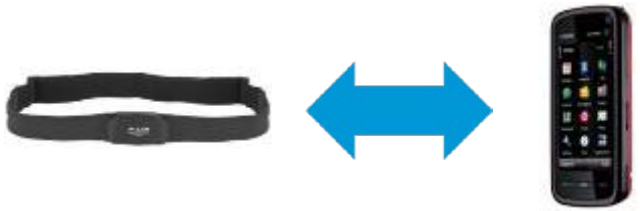


Profiles overview: Examples and roles

- **HID over GATT**: Wireless Human Interface Devices
  - **Host** (PC, tablet, phone)
  - **Device** (keyboard, mouse, trackpad, …)



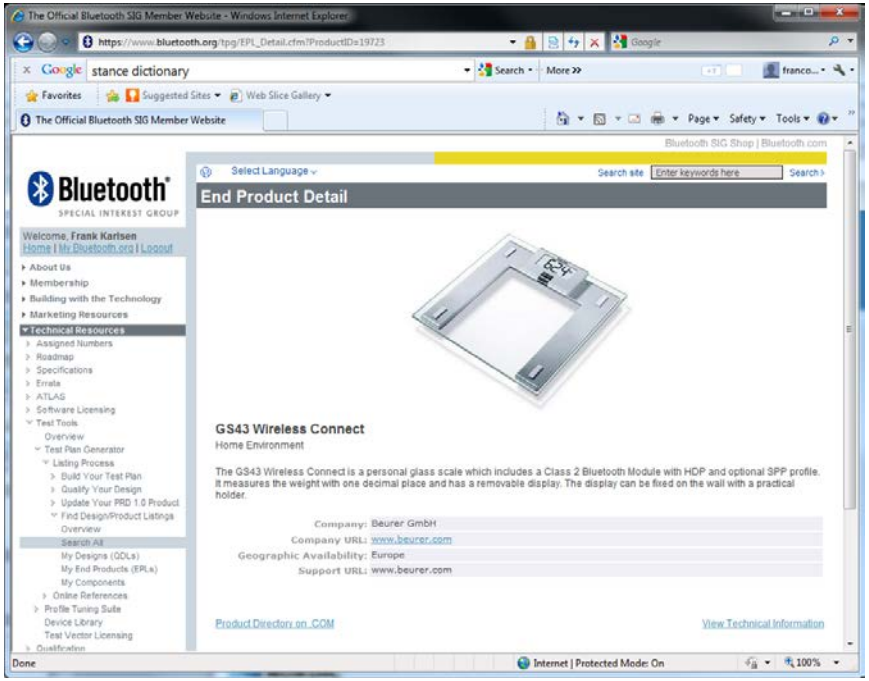
- **Heart Rate**: Both sport and medical Heart Rate transmission
  - **Collector** (PC, tablet, phone)
  - **Sensor** (Heart Rate belt or similar)



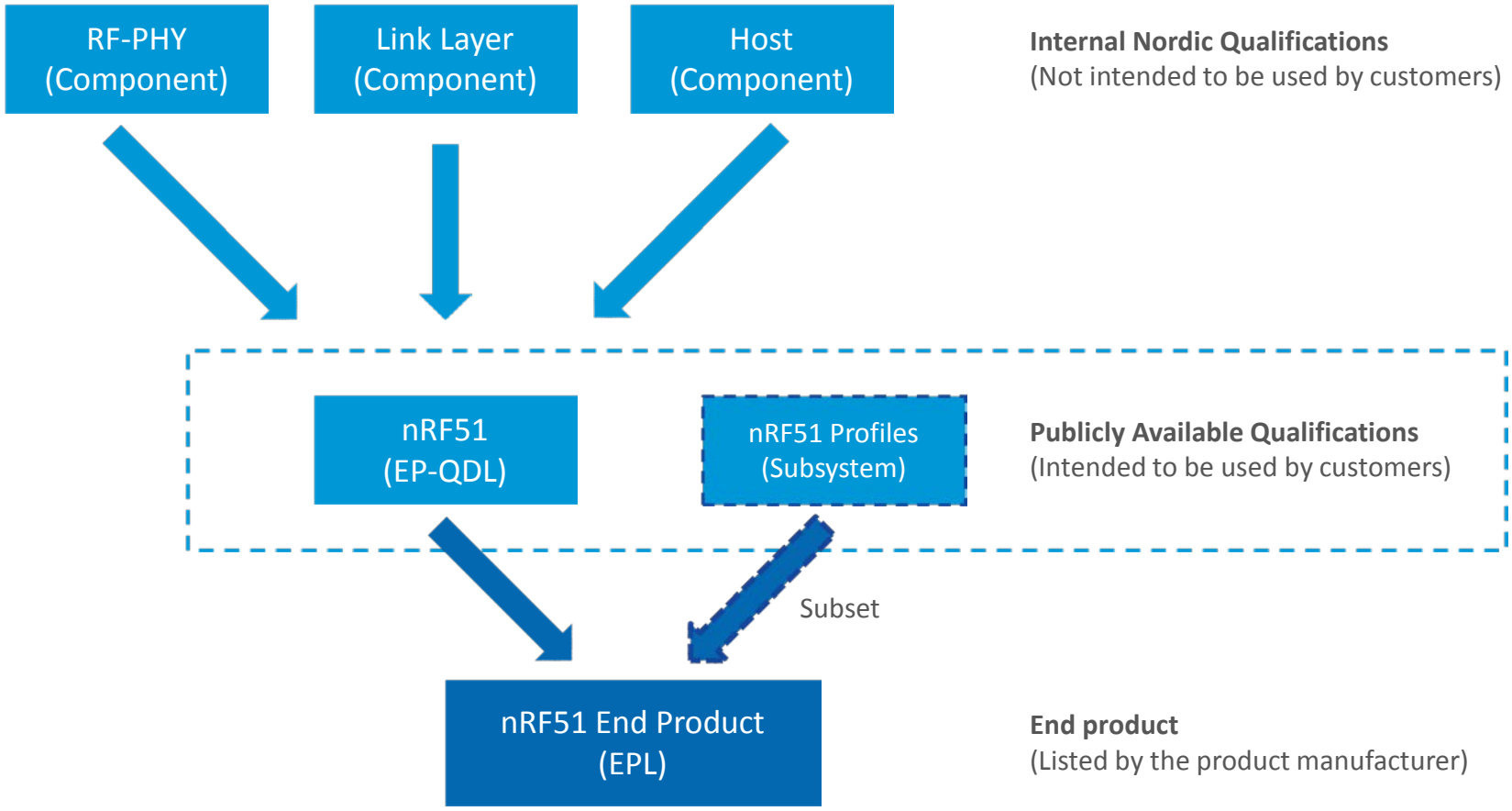
- **Proximity / Find Me**: Locate devices and detect presence
  - **Monitor** (PC, tablet, phone)
  - **Reporter** (keyfob, phone)

Qualification

- All Bluetooth products must be qualified
- **End Product Listing** is the goal
- Requires an **EP-QDL (Qualified Design Listing)**
- Nordic can help!
- We will provide an EP-QDL for nRF51
- No qualification fees
- Only **RF-PHY** retesting required



Qualification



Annex: Operating System support today

- Microsoft Windows:
  - Windows XP, Vista and 7: 1.1 – 2.1 BR/EDR only
  - Additional full replacements commonly shipped by OEMs
  - Windows 8: 4.0 BR/EDR and low energy natively supported
- Apple
  - Mac OS X (10.6 and above): 4.0 BR/EDR and low energy
  - iOS (5 and above): 4.0 BR/EDR and low energy
- GNU/Linux:
  - Vanilla BlueZ (~4.93 and above): 4.0 BR/EDR and low energy
  - Android: BR/EDR only as of 4.1 (Jelly Bean)
    - Several vendors offer patched versions with 4.0 LE support

Thank you for your attention

Questions