

# NORDIC tech TOUR

*Introduction to Bluetooth® low energy*

## *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 Special Interest Group formed in 1998
- **18000+** SIG member companies
- **Billions** of products shipped
- **Nordic Semiconductor** is one 9 SIG Board members



Board Members:



ERICSSON



lenovo

Microsoft



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Connecting People



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## *Bluetooth*: terminology

Term	Introduced	Means
BR	<b>1.1 (2002)</b>	Basic Rate (1 Mbit/s)
EDR	<b>2.0 (2004)</b>	Enhanced Data Rate (2 and 3 Mbit/s)
HS	<b>3.0 (2009)</b>	High Speed (Alternate MAC/PHY)
LE	<b>4.0 (2010)</b>	Low Energy (1 Mbit/s ultra low power)

## Bluetooth: terminology

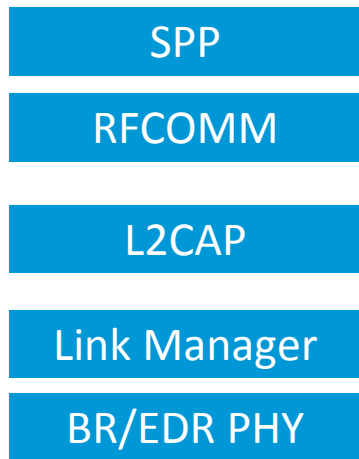
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LE	4.0 (2010)	Low Energy (1 Mbit/s ultra low power)
<i>Bluetooth Smart</i>	4.0	LE-mode, LE-only radio
<i>Bluetooth Smart Ready</i>	4.0	BR/EDR mode, BR/EDR and LE dual radio

nRF51 Series

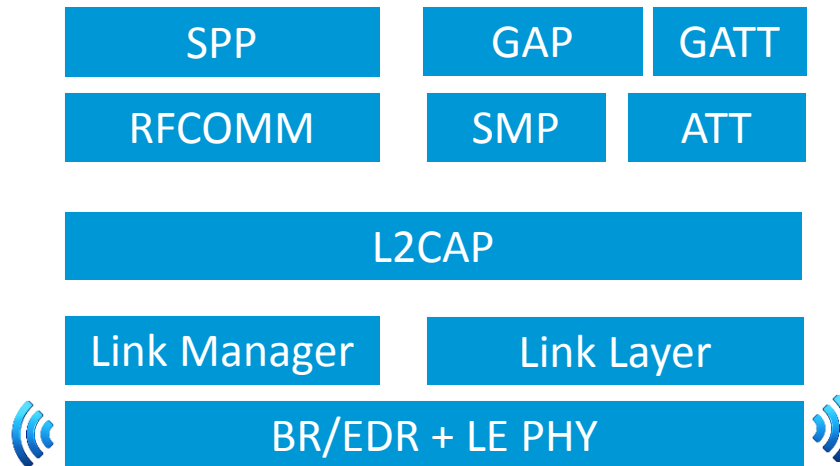
# Bluetooth: configurations



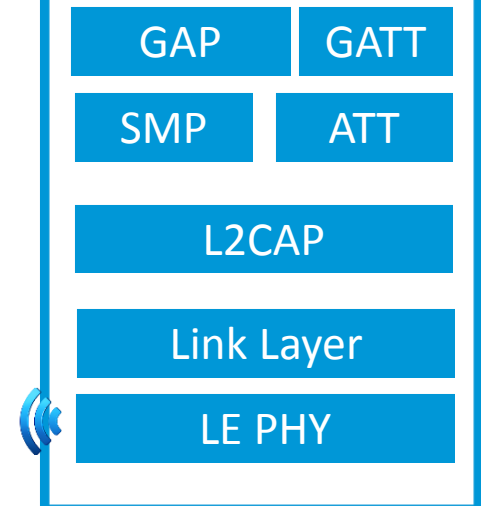
BR/EDR/HS 1.1, 2.0, 3.0



BR/EDR 4.0 Dual Mode (+LE)



LE 4.0 Single Mode



## Bluetooth LE: key features

### ■ Ultra Low Power

- Small packets (20 bytes MTU)
- Short RX and TX windows
- **Race to idle**
  - Turn radio on as seldom as possible
  - Turn radio off as soon as possible

■ Fast connection in 6 ms and teardown (100ms on BR/EDR)

■ Coin-cell battery 1+ year

■ Low memory footprint (8KB on nRF51822)

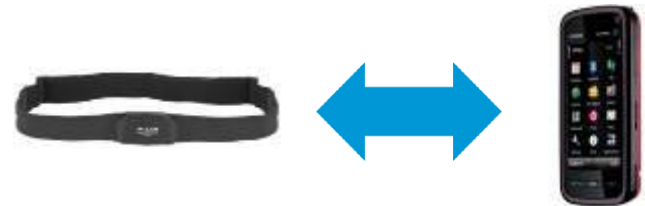
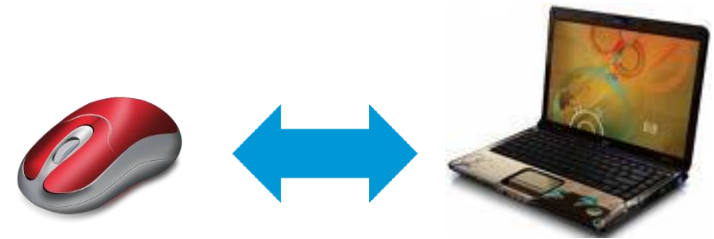
■ Simple stateless operation and data

■ 128-bit AES encryption

=> Following goals and rules of ULP wireless **pioneered** by Nordic

# 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)



# Bluetooth Smart Profiles and Services



BATTERY



PROXIMITY



HRM



TEMP



BP



WEIGHT



TIME SYNC



FIND ME



ALERT



BIKING



CGM



BGM



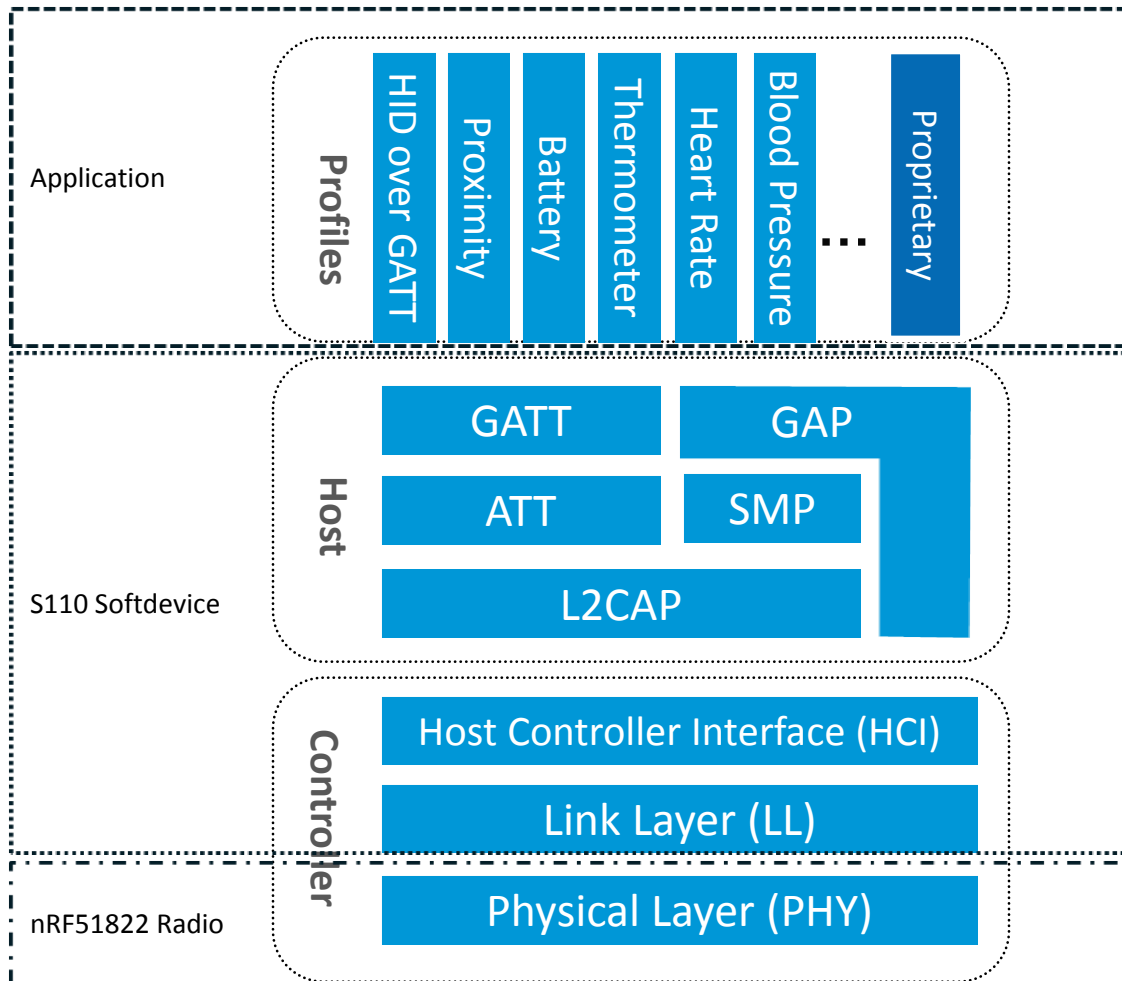
RUNNING



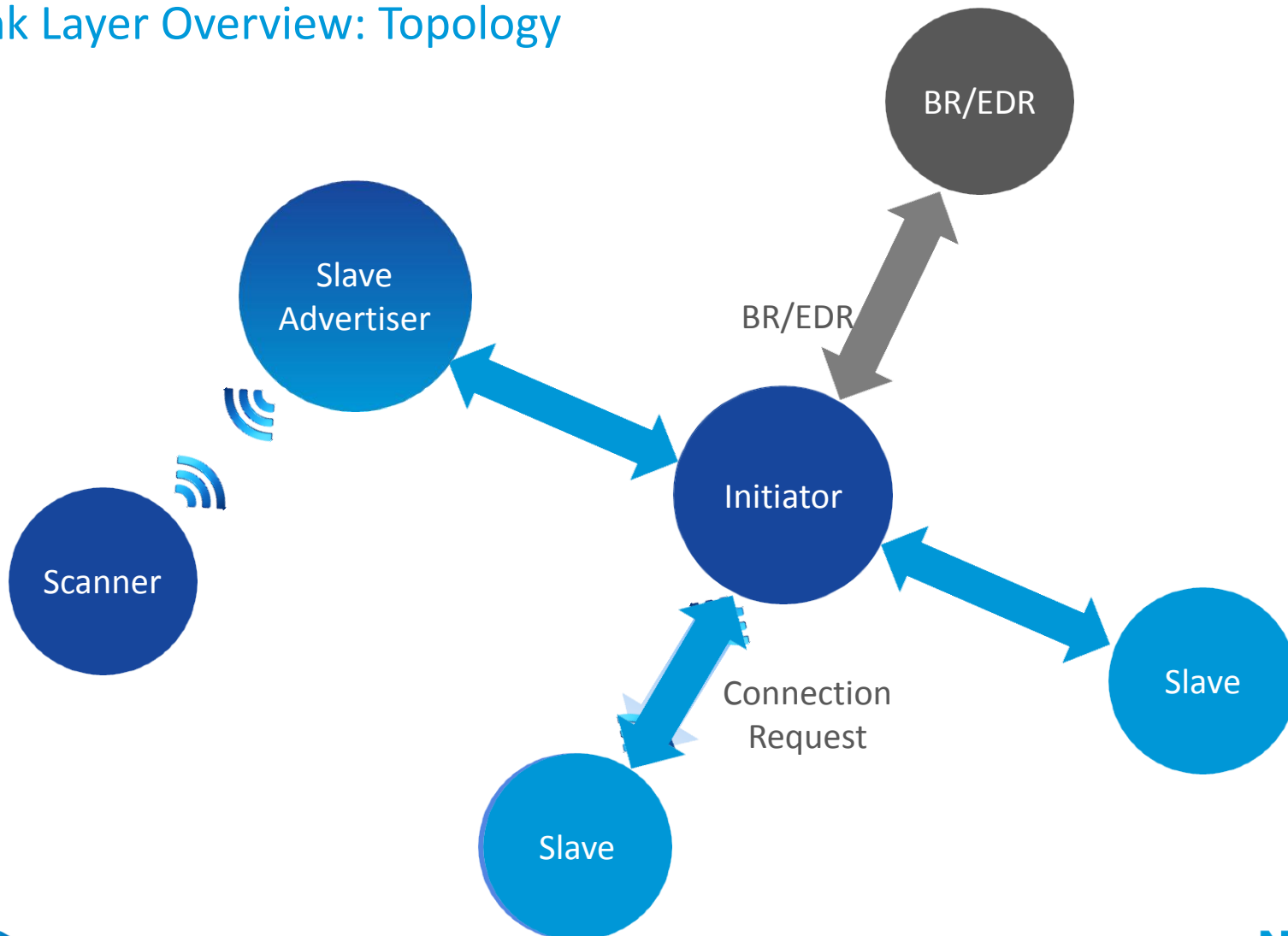
HID



# Bluetooth LE: architecture

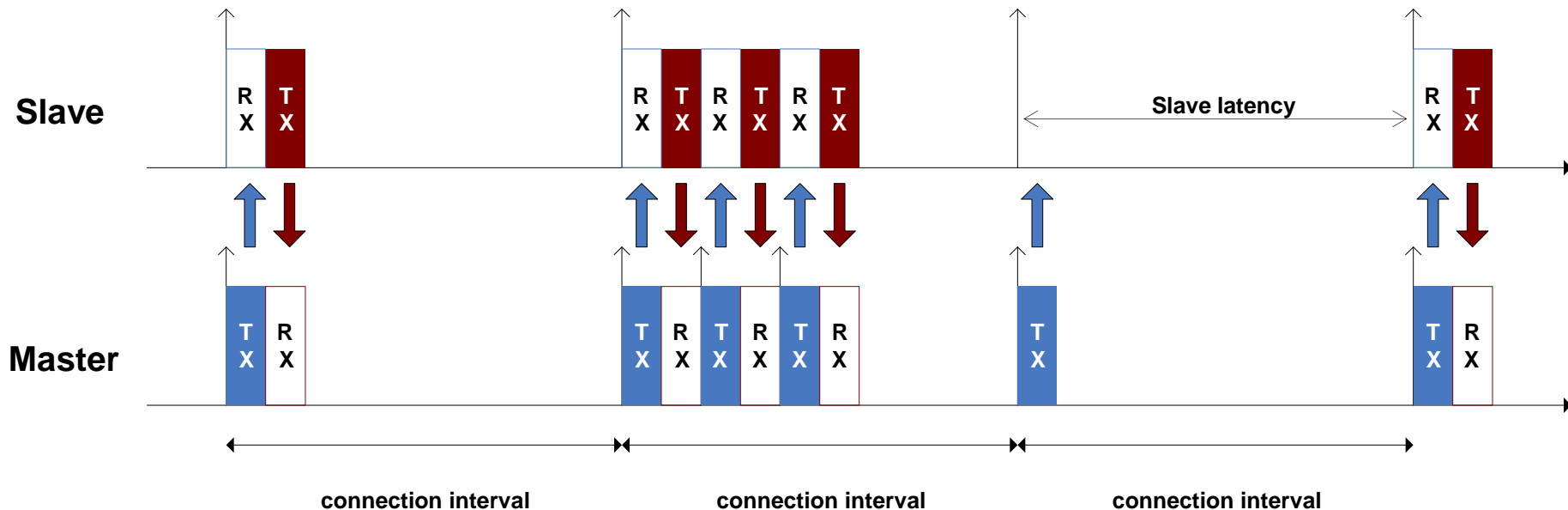


## Link Layer Overview: Topology

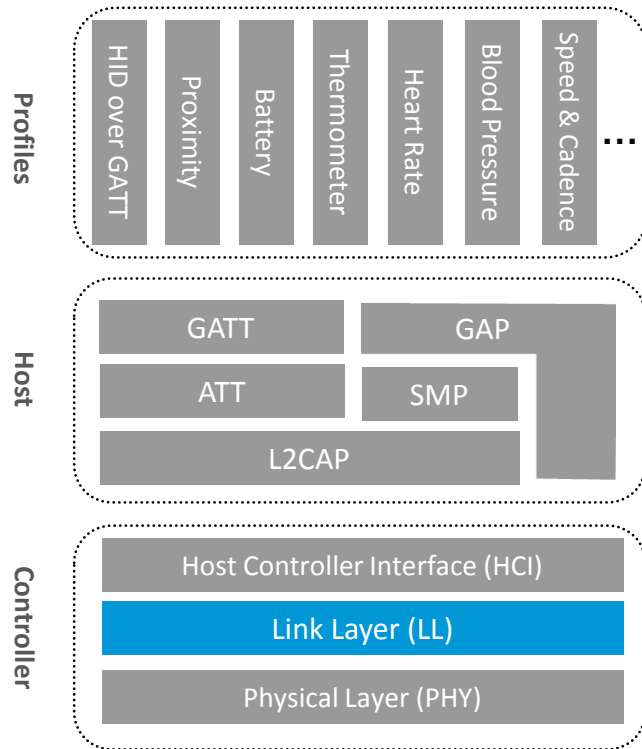


# Link Layer Overview: Connection

- When in a connection, the master sends first, and the slave responds.
- Can do multiple transactions per connection event, which happens each connection interval.
- Connection interval can be from 7.5 ms to 4 seconds.

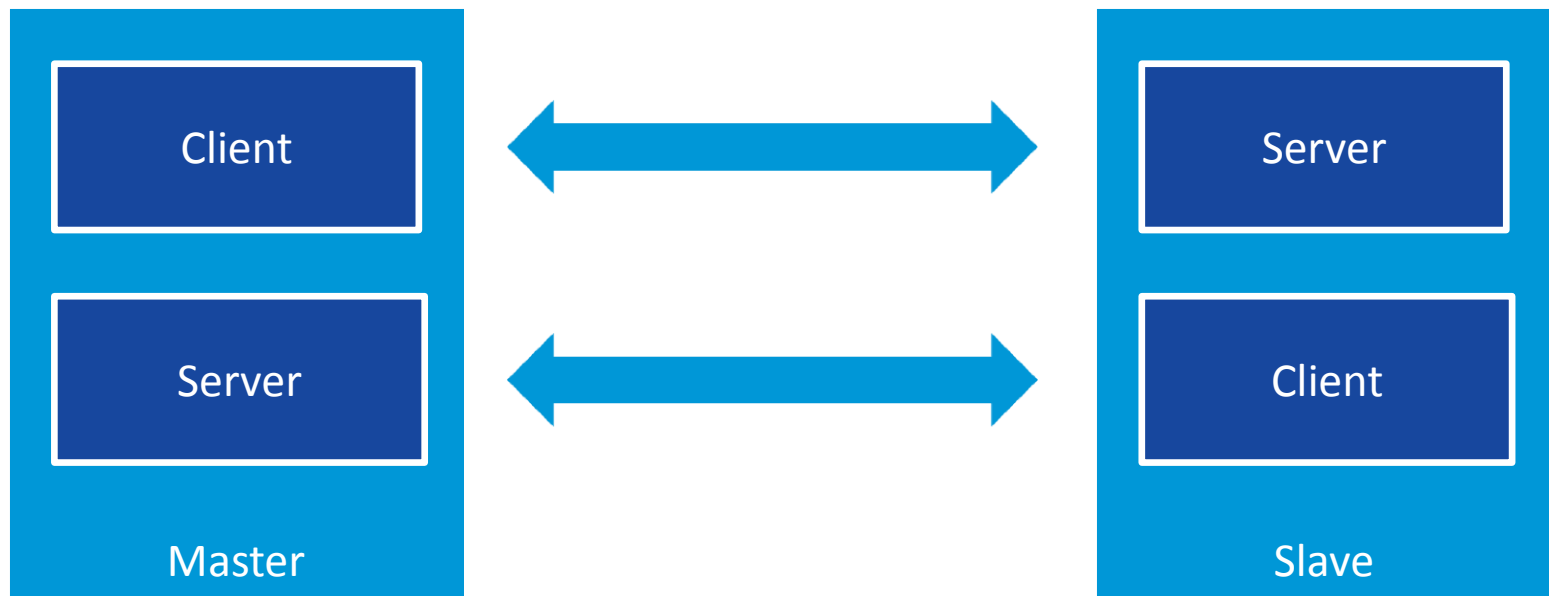


# Link Layer Overview

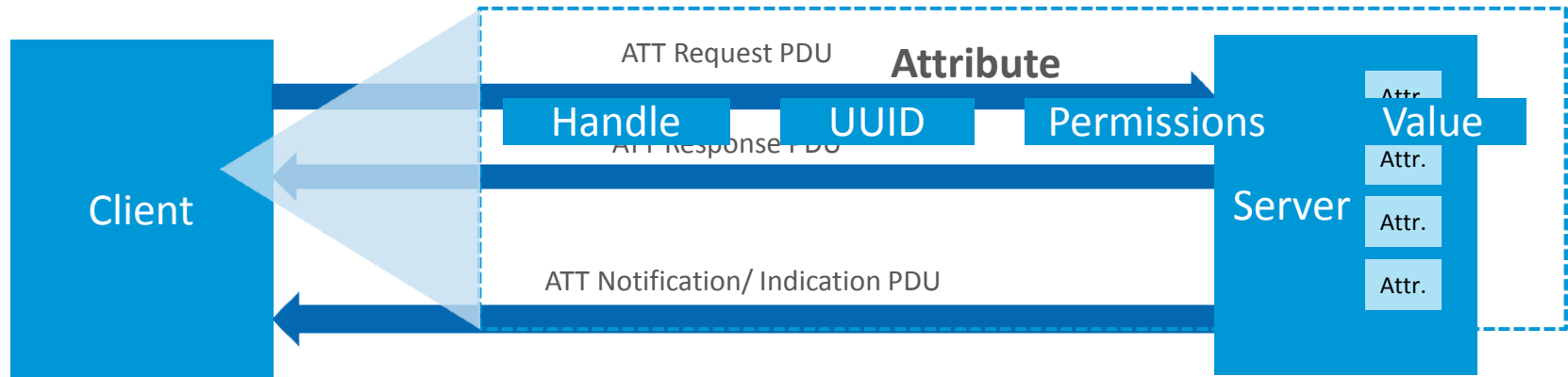


- **Advertising:** connectable and non-connectable
- **Scanning:** active or passive
- **Slave:** connection role
- **Master:** connection role
- **31 bytes** advertising payload size
- **27 bytes** maximum payload size per packet
- **AES-128** built-in encryption

# ATT Layer Overview

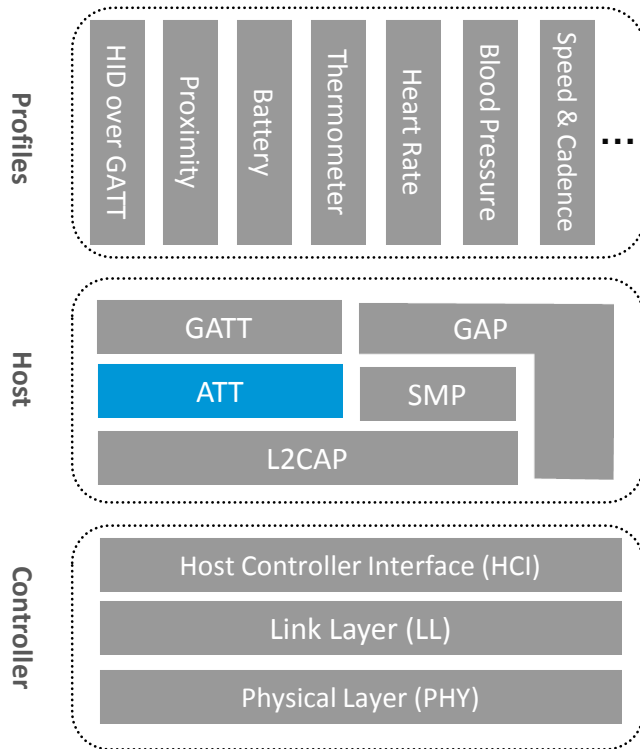


# ATT Transaction



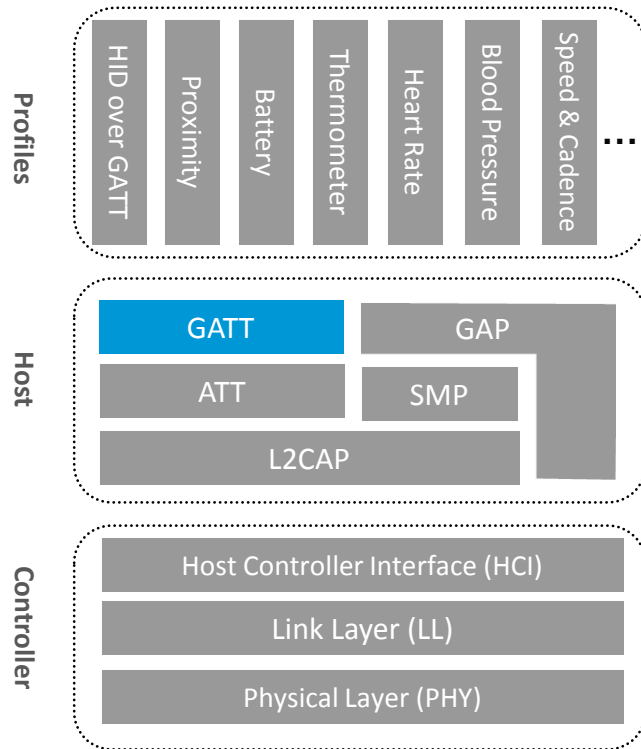
- **Handle** – Index in the ATT Table, used in ATT transaction PDU
- **UUID** – Universal Unique Identifier
  - 128-bit UUID
  - 16-bit short UUID using Bluetooth Base 0000XXXX-0000-1000-8000-00805F9B34FB
- **Permissions** – Read, Write.
- **Value** – data can be read/written by Client

# ATT Overview



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

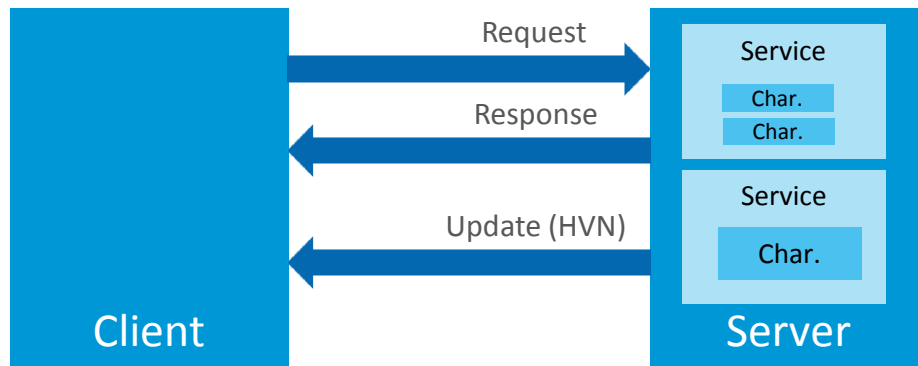
# GATT Overview



- **Generic Attribute Profile**
- Mandatory for all BLE profiles
- Procedures for attribute **discovery** and **access**
- Models the **ATT Table layout**
- Hierarchical classification of Attributes
  - Services
  - Characteristics
  - Descriptors



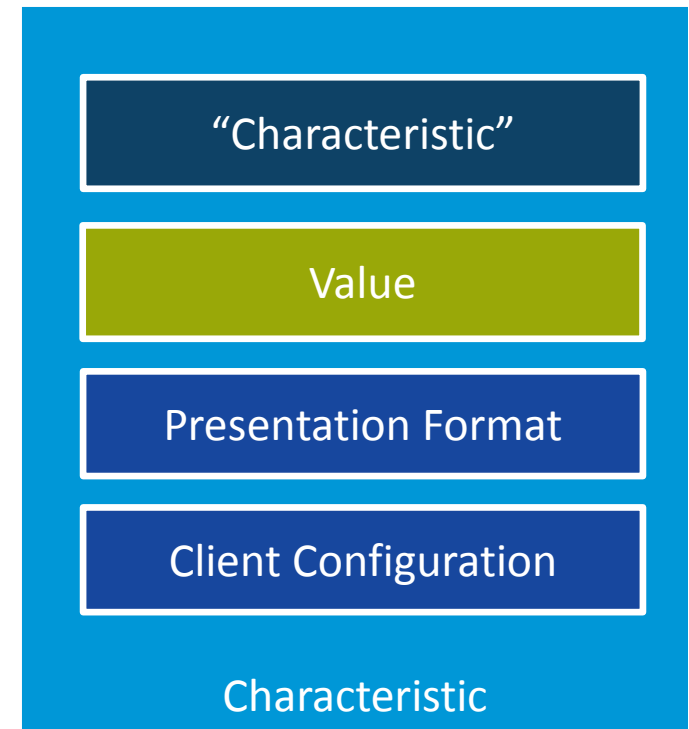
# GATT Overview



- **Identical Client Server Architecture as ATT**
- Data hierarchically categorized in Services
- Actual data values in Characteristics

# GATT Overview - Characteristic

- Characteristics are grouped by “Characteristic”
- Value attribute always immediately after header “Characteristic” followed by descriptors
- The header “Characteristic” defines the properties of the characteristic value:
  - Read
  - Write
  - Write Without Response (No Ack)
  - Notify (No Ack)
  - Indicate(Ack)
- Descriptors defines:
  - Additional information
  - Format of the value
  - Can be vendor specific



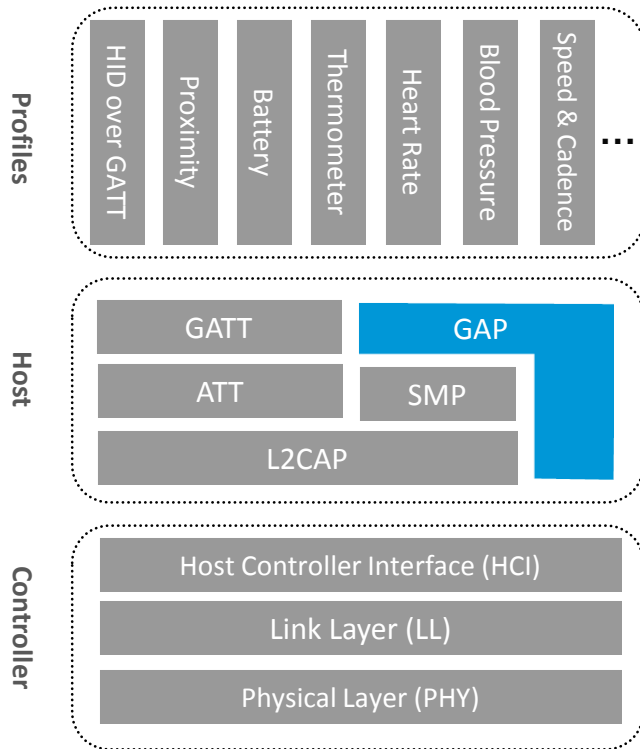
# ATT Table

Battery State Service

Proprietary  
Thermometer  
Humidity Service

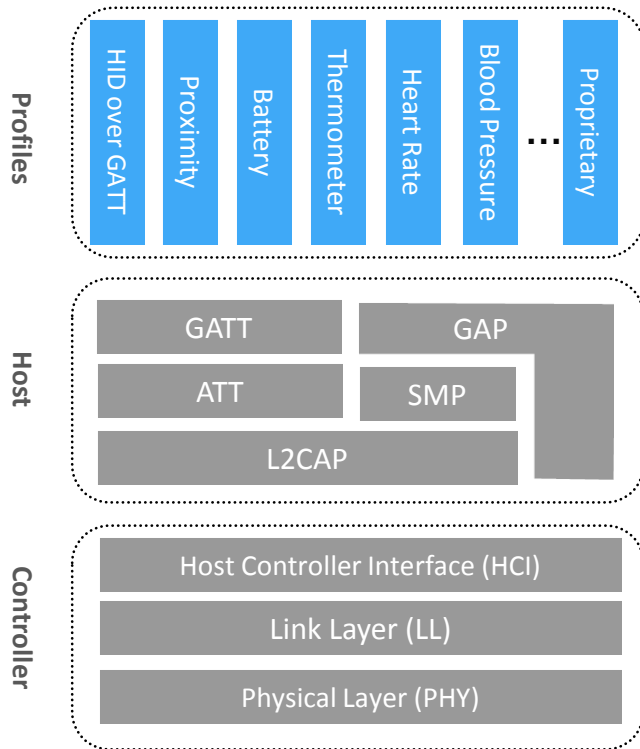
Handle	UUID (Type)	Value (Type)
0x0001	0x2800 (Service)	0x1800 (GAP Service)
0x0002	0x2803 (Characteristic)	{0x0A, 0x0003, 0x2A00}
0x0003	0x2A00 (Device Name)	“Example Device”
0x0010	0x2800 (Service)	0x1801 (GATT Service)
0x0100	0x2800 (Service)	0x180A (Battery State Service)
0x0101	0x2803 (Characteristic)	{0x02, 0x0102, 0x2A19}
0x0102	0x2A19 (Battery Level)	0x04
0x0200	0x2800 (Service)	0x5AB20001-B355-4D8A-96EF-2963812DD0B8
0x0201	0x2803 (Characteristic)	{0x12, 0x0202, 0x5AB2FF01-B355-4D8A-96EF-2963812DD0B8}
0x0202	0x5AB2FF01-B355-4D8A-96EF-2963812DD0B8 (Proprietary Temperature Characteristic)	0x028A
0x0203	0x2904 (Characteristic Format)	{0x0E, 0xFE, «Celsius», «Outside»}
0x0204	0x2901 (Characteristic User Description)	“Outside Temperature”
0x0205	0x2902 (Client Characteristic Configuration Descriptor)	0x0000
0x0210	0x2803 (Characteristic)	{0x12, 0x0211, 0x5AB2FF02-B355-4D8A-96EF-2963812DD0B8}
0x0211	0x5AB2FF02-B355-4D8A-96EF-2963812DD0B8 (Proprietary Humidity Characteristic)	0x27
0x0212	0x2904 (Characteristic Format)	{0x04, 0x00, «Percent», «Outside»}
0x0213	0x2901 (Characteristic User Description)	“Outside Relative Humidity”
0x0214	0x2902 (Client Characteristic Configuration Descriptor)	0x0000

# 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



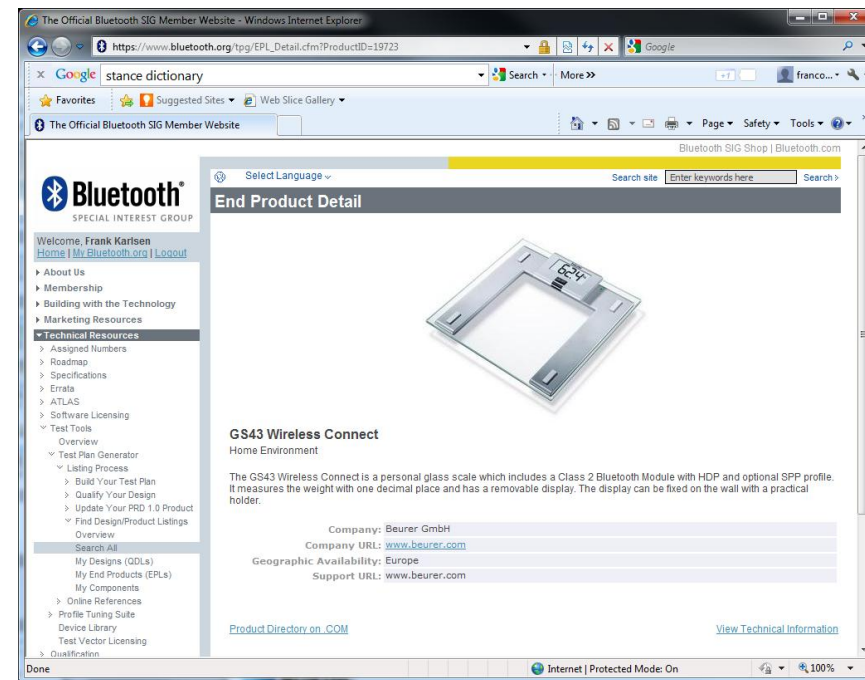
- Selects required features from the GAP and GATT
- Describes a particular use case
- Requires a particular set of GATT services
- Defines
  - Roles
  - Procedures
  - Security
- Key to inter-operability

# Qualification



# Qualification

- All Bluetooth products must be qualified to obtain the Bluetooth intellectual property license and applying the Bluetooth trademarks
- **End Product Listing (EPL)** is the goal
- Requires to refer to an **EP-QDL (Qualified Design Listing)**
- Nordic can help!
- We've qualified an EP-QDL for nRF51
- Only **RF-PHY** retesting required




# Qualification

← → ↻ [https://www.bluetooth.org/tpg/EPL\\_Detail.cfm?ProductID=28186](https://www.bluetooth.org/tpg/EPL_Detail.cfm?ProductID=28186)

Bluetooth.com

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## End Product Detail



**Proximity key fob**  
Mobile Phone Accessory

This product is fully compatible with the latest version 4.0 of Bluetooth that includes Bluetooth low energy as a hallmark feature. The services of Bluetooth 4.0 are used to provide unique security and alert features in wide range applications. The out-of-range feature provides a security service by automatically locking the guarded PC, laptop and Smartphone by measuring the distance to the key fob. The key fob can also help to locate the linked personal properties, such as the Smartphone and wallet.

**Company:** Dayton Industrial Co. Ltd.  
**Company URL:** <http://www.dayton.com.hk/>  
**Geographic Availability:** Africa, Asia, Australia, Europe, North America, South America  
**Support URL:** <http://www.dayton.com.hk/>

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SPECIAL INTEREST GROUP

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- ▶ Profile Tuning Suite
- ▶ Errata
- ▶ Regulatory
- ▶ Resources
- ▶ Report Issues



# Qualification: EP-QDL

- **QDID:** B020654
- **Product Name:** nRF51822 SoC with S110 Bluetooth stack
- **Product Type:** End Product
- **Specification Name:** 4.0
- **Product Description:** Nordic nRF51822 SoC using the S110 SoftDevice with integrated Bluetooth 4.0 stack. Support for Bluetooth low energy peripheral device role. RF Phy conformance based on the nRF51822 developer kit.

## Qualified Design Listing Details

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Qualified Design ID (QD ID)	B020654   <a href="#">Export PICS</a>		
PRD 1.0 ID (QP ID)			
Design Name	nRF51822 SoC with S110 Bluetooth stack		
Wi-Fi® Certification ID			
Subsetted Designs	Date Created	Type	PICS
	Feb 20, 2013	Main	<a href="#">PICS</a>
Member Company	Nordic Semiconductor ASA		
Specification Name	4.0		
Core Spec Addenda	N/A		
Design Model Number	nRF51822		
Hardware Version Number	C0		
Software Version Number	4.x		
Qualification Assessment Date	March/07/2013		
Listing Date	March/07/2013		
Design Description	Nordic nRF51822 SoC using the S110 SoftDevice with integrated Bluetooth 4.0 stack. Support for Bluetooth low energy peripheral device role. RF Phy conformance based on the nRF51822 developer kit.		
Product Type	End Product		
<a href="#">Technical Data Sheet (RIN)</a>	<b>** <a href="#">Open Reference Integration Notes (RIN)</a> **</b>		
Listed By	<a href="#">Miles Smith</a>		
BQE	<a href="#">Noemi Perez Dans</a>		
Profile / Protocol	Role / Version (If Any)		
Logical Link Control and Adaptation Protocol			
Generic Access Profile			
RF PHY			
Link Layer			
Generic Attribute Profile	Attribute Protocol Supported over LE Generic Attribute Profile Client Generic Attribute Profile Server		
Attribute Protocol	Attribute Protocol Client Attribute Protocol Server Attribute Protocol Supported over LE		

# Qualification: EP-QDL

- **QDID:** B020820
- **Product Name:** S110\_nRF518xx HOGP subsystem
- **Product Type:** Profile Subsystem
- **Specification Name:** 4.0
- **Product Description:** HID over GATT profile subsystem for the Nordic S110 Software stack and the nRF51xxx series SOC devices. This subsystem also includes the Device Information Service, Battery Service and HID Service.

## Qualified Design Listing Details

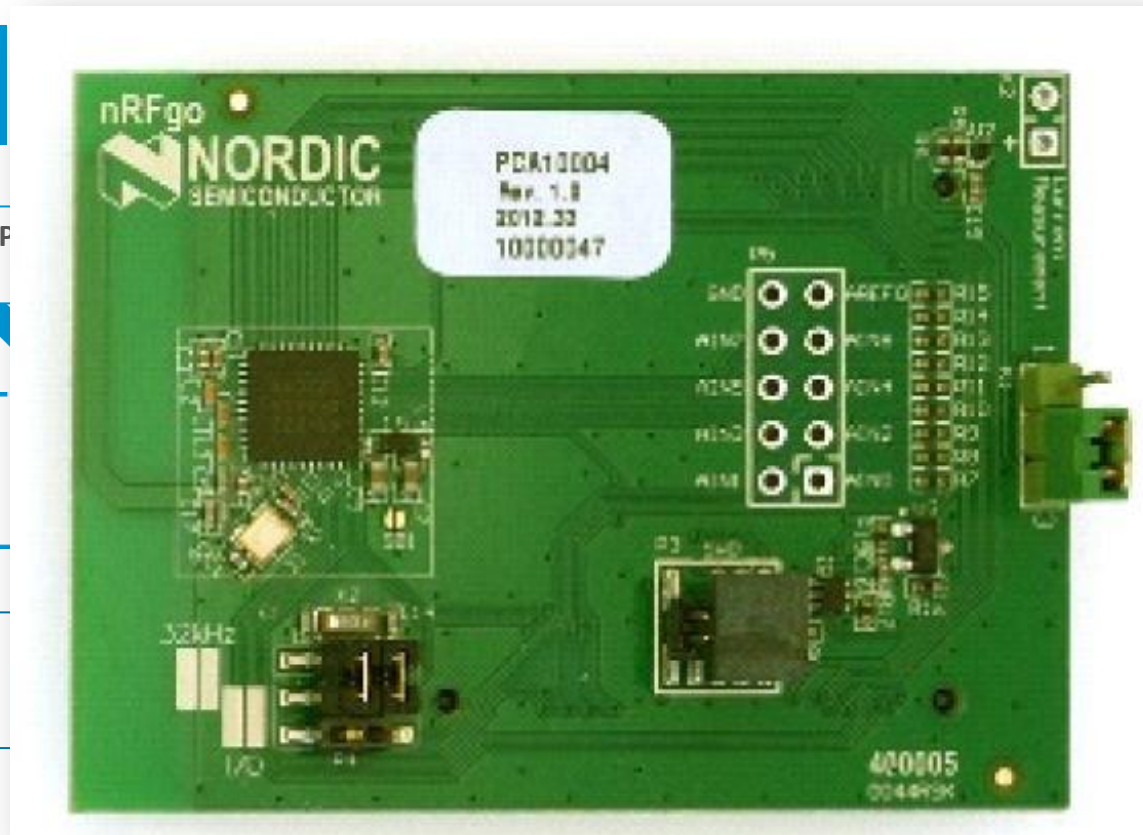
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Qualified Design ID (QD ID)	<div> <div>B020820</div> <div> </div> <div> <a href="#">Export PICS</a> </div> </div>		
PRD 1.0 ID (QP ID)			
Design Name	S110_nRF518xx HOGP subsystem		
Wi-Fi® Certification ID			
Subsetting Designs	Date Created	Type	PICS
	Feb 25, 2013	Main	<a href="#">PICS</a>
Member Company	Nordic Semiconductor ASA		
Specification Name	4.0		
Core Spec Addenda	N/A		
Design Model Number	n/a		
Hardware Version Number	n/a		
Software Version Number	4.0.0		
Qualification Assessment Date	April/05/2013		
Listing Date	April/05/2013		
Design Description	HID over GATT profile subsystem for the Nordic S110 Software stack and the nRF51xxx series SOC devices. This subsystem also includes the Device Information Service, Battery Service and HID Service.		
Product Type	Profile Subsystem		
<a href="#">Technical Data Sheet (RIN)</a>	** <a href="#">Open Reference Integration Notes (RIN)</a> **		
Listed By	<a href="#">Miles Smith</a>		
BQE	<a href="#">Noemi Perez Dans</a>		
Profile / Protocol	Role / Version (If Any)		
Interoperability Test Specification			
Device Information Service			
Battery Service	Service supported over LE		
HID Service	Service supported over LE		
HID over GATT Profile	HID Device (Server) HOGP 1.0 Profile supported over LE		

# Qualification

RF-PHY  
(Component)

The EP



nRF51 End Product  
(EPL)

End product  
(Listed by the product manufacturer)

# Qualification

RF-PHY retest needed

RF-PHY (Component)

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Qualified Listings

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## List of BQTFs

A *Bluetooth* Qualification Test Facility (BQTF) is formally recognized by the Bluetooth SIG as competent to perform those *Bluetooth* qualification conformance tests identified as "Category A" within the Test Case Reference List (TCRL) and Test Plan Generator (TPG). A BQTF may also offer additional *Bluetooth* testing services such as Profile and Protocol conformance and interoperability. The definitive description of the BQTF role is in the *Bluetooth* Qualification Program Reference Document (PRD).

► Search Criteria

Total BQTF(s) Found: 36

1 2 3

Testing Scope	Name	Country	Contact	Accredited
-Profile -RF	<a href="#">AT4 wireless</a> 16F-7 Nr.266 Sec. 1 Wen Hua 2nd Road Linkou Township Tel: +886277053320	Taiwan	Carlos Batllés	21-Jan-2011
-Profile -Protocol -RF	<a href="#">SGS Group</a> 134, Wu Kung Road Wuku Industrial Zone Tel: +886 2 22993279 #1571	Taiwan	Ricky Chen	21-Feb-2003
-Protocol -RF	<a href="#">Intel Corporation</a> 2111 NE 25th Avenue Tel: 5037046723	United States	Munir Chhibber	07-Mar-2013
-Profile -RF	<a href="#">KTL (Korea testing laboratory)</a> 723, Hae-an-ro, Sangnok-gu Tel: 82-31-500-0132	South Korea	Sung-Kyu Cho	20-Nov-2010
-RF	<a href="#">Allion Labs, Inc.</a> 9F, No.3-1, Yuan Ku Street, Taipei Tel: 886-2-77228800	Taiwan	Leo Chou	16-Jul-2012
-Profile -Protocol	<a href="#">Cambridge Silicon Radio</a> Churchill House, Cambridge Business Park Cowley Road Tel: 01223 692000	United Kingdom	Nigel Hall	18-Jul-2006
-RF	<a href="#">Attestation of Global Compliance (Shenzhen) Co., Ltd.</a> 2F., Building 2, No.1-No.4, Chaxi Sanwei Technical Industrial Park, Gushu Xixiang, Baoan District Tel: 86-755-2978 4310	China	Randy He	28-Jan-2013
-Profile -Protocol -RF	<a href="#">TUV Rheinland Korea Ltd</a> 4F, E&C Venture Dream Tower VI, 197-28, Guro-dong, Guro-gu Tel: +82-2-860-9910	South Korea	jongshik her	19-Feb-2003
-RF	<a href="#">TRaC Global Ltd</a> Unit E South Orbital Trading, Park Hedon Road Tel: +44 1482 801801	United Kingdom	Simon Hindle	09-Jun-2009
-RF	<a href="#">Samsung Electronics Co., Ltd.</a> 416, Maetan-3dong Yeongtong-gu Tel: +82-31-279-1746	South Korea	Kyunghee Jang	01-Jan-2005

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