Bluetooth Low Energy

A short introduction to Bluetooth Low Energy and
Nordic Semiconductor

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2016

Agenda

Part 1

Bluetooth Low Energy introduction
followed by an example

Part 2

Code walk-through
Tools offered by Nordic
Resources

Agenda – part 1 – Bluetooth Low Energy

nRF52 Series

- Key features

- Terminology

- Topology

- BLE theory with example

Key features for BLE

nRF52 Series

- Low power protocol   - 1 year on coincell battery

- Maintain connection for long time

- Stateless protocol

- Very flexible topology

- Connect to your own device(s) or a large variety of existing devices
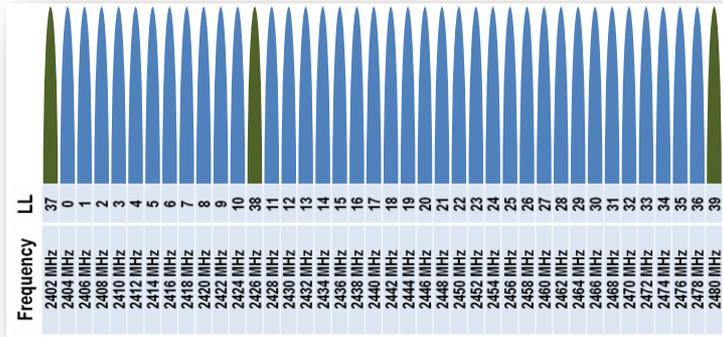
Terminology - roles

- Broadcaster
  - Transmitter only

- Observer
  - Receiver only

- Peripheral:
  - Supports slave role

- Central:
  - Supports master role
  - Supports multiple connections
  - Initiates connections to peripherals

- One device may support multiple roles
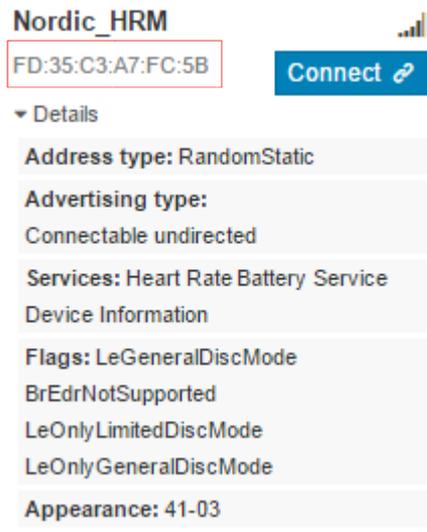
Topology
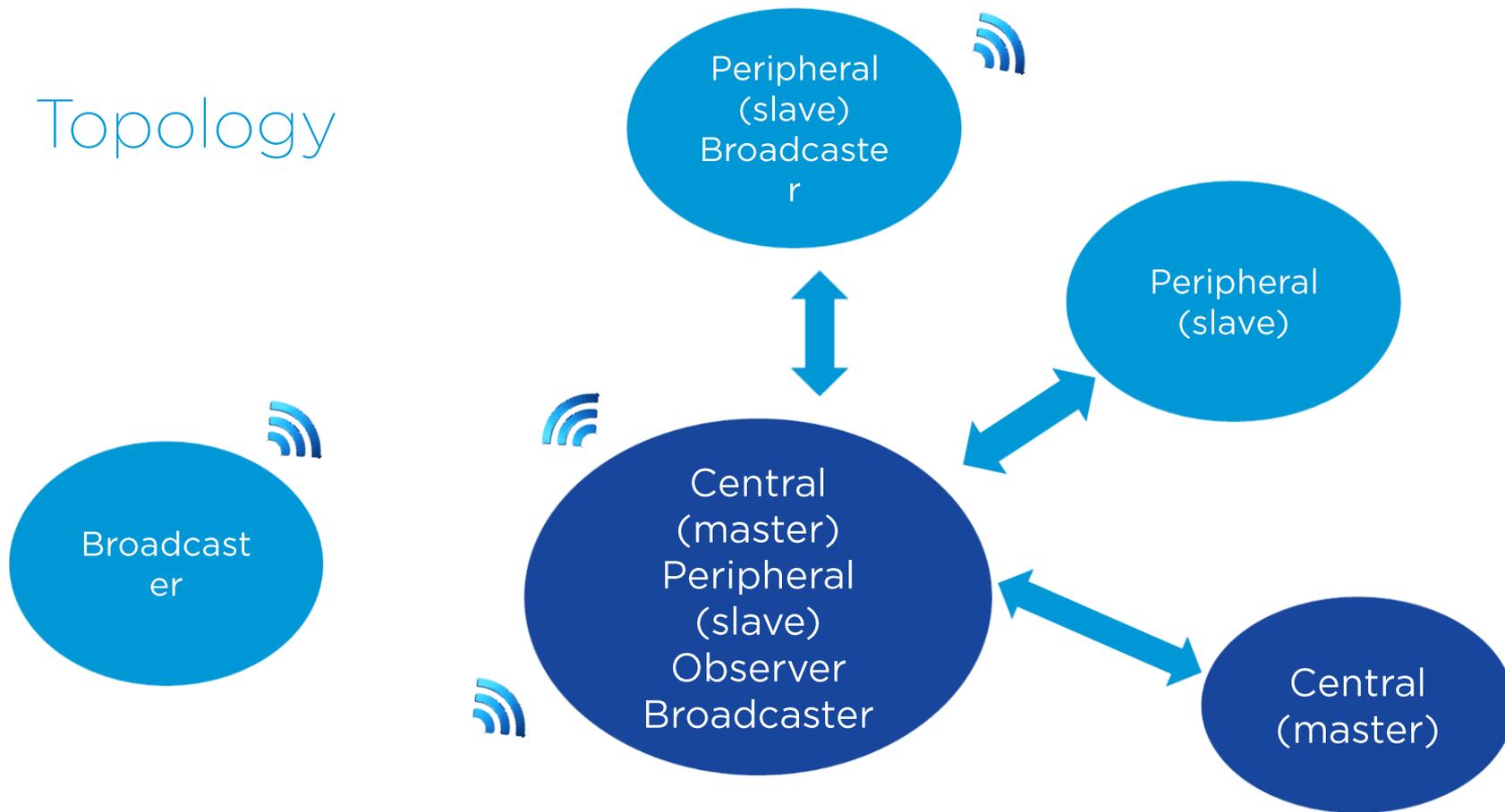
Advertising

- Broadcasting data

- Connectable or non-connectable

- Scan request – scan response
  - Request more data without initiating a connection

- Transmit on all advertising channels each connection interval

Identifying devices (addresses)

Nordic_HRM
FD:35:C3:A7:FC:5B   Connect 🔗

▾ Details

Address type: RandomStatic

Advertising type:
Connectable undirected

Services: Heart Rate Battery Service
Device Information

Flags: LeGeneralDiscMode
BrEdrNotSupported
LeOnlyLimitedDiscMode
LeOnlyGeneralDiscMode

Appearance: 41-03

- 48 – bit addresses

- Random
  - Random number following a few rules set by BT SIG
  - Static: Typically never changed. Can be changed upon power-cycling.
  - Private
    - Resolvable
    - Non-resolvable

- Public
  - In accordance with "48-bit universal LAN MAC addresses»
  - Obtained from IEEE

Identifying application

Nordic_HRM
FD:35:C3:A7:FC:5B
NOT BONDED   ◢ -50 dBm   ↔ 191 ms

CONNECT ⋮

Type: **BLE only**
Appearance: [833] Heart Rate Sensor: Heart
Rate Belt (Heart Rate Sensor subtype)
Flags: **GeneralDiscoverable,
BrEdrNotSupported**
Complete list of 16-bit Service UUIDs: **0x180D,
0x180F, 0x180A**
Complete Local Name: **Nordic_HRM**

CLONE   RAW   MORE

Heart rate

Device information

Battery service

- Universal Unique Identifier (UUID)

- Identifies the application(s)
  - 16-bit: application defined by BT SIG
  - 128-bit: custom application

Connection – initiate connection
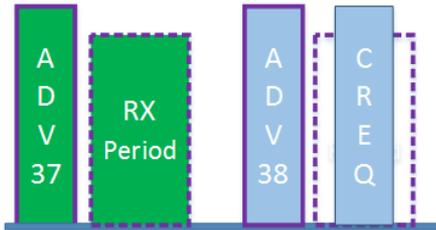
- Initiated by a central

- Connect request: after receiving an advertising packet

Connection – connection established
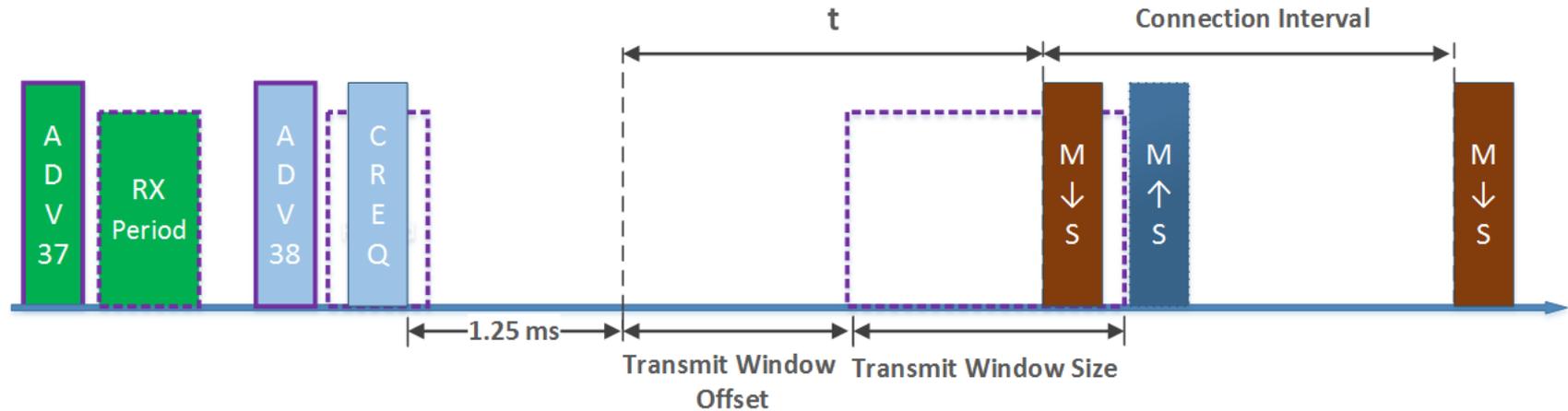
- Stops advertising on consecutive channels when it receives a connection request
- Slave turns on its receiver and waits for a packet from the master
- If it receives a packet, the slave responds, and a connection is established

Profile setup

- Profile
  - overall application functionality

- Service
  - sub-functionality

- Characteristics
  - Performs its service' functionality

Service UUID

Refers to an (optionally) included service.

UUID of the characteristic

Additional characteristic/value information

Profile

Service

Service declaration

Include

Characteristic

Declaration

Value

Properties

+

Descriptor

+

Characteristic

Declaration

Value

Properties

+

Descriptor

Profile – Heart rate

Heart rate

0x180D

Heart rate measurement

0x2803

Value

Notify

CCCD

+

Body sensor location

0x2803

Value

Read

+

Device information

0x180A

Manufacturer n

0x2A29

Value

Read

+

Model number

0x2A24

Value

Read

.....

.....

Data transfer

- Server: Device containing the data
  - Example: heart rate belt
- Client: Device receiving the data
  - Example: Phone, sport watch
- Server updates data to client
  - Update method: notification or indication
  - Client controls when the server is allowed to update data:
    - Enable/disable notifications/indications
    - Enable/disable: client writes to the CCCD for the given characteristic in the server

Typical scenario:

- Peripheral device is server
- Central device is client

Data transfer – data update

Heart rate

Peripheral (slave)

Server:
- Has/collects the heart rate values
- Updates the values to the client using notifications
- Can only transmit the values when notifications are enabled.

1. Initially, notifications are disabled – notifications will not be transferred

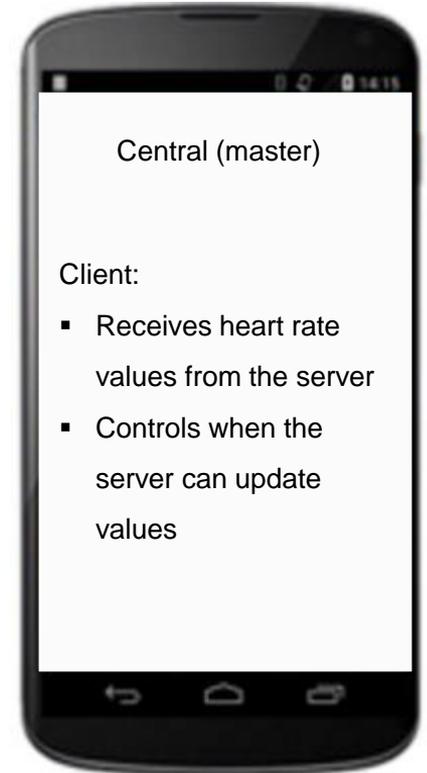2. Enable notifications, write to the CCCD of heart rate measurement characteristic.

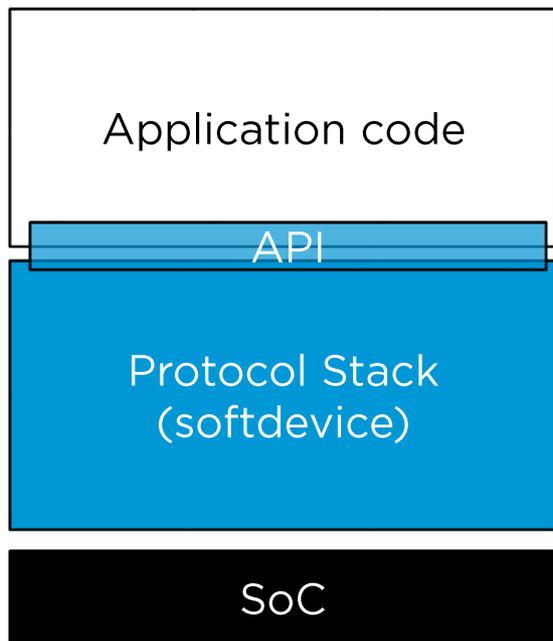3. Update/transmit heart rate values to the client using notifications.

4. Disable notifications, write to the CCCD of heart rate measurement characteristic.

5. Update/transmit heart rate values to the client disabled

Central (master)

Client:
- Receives heart rate values from the server
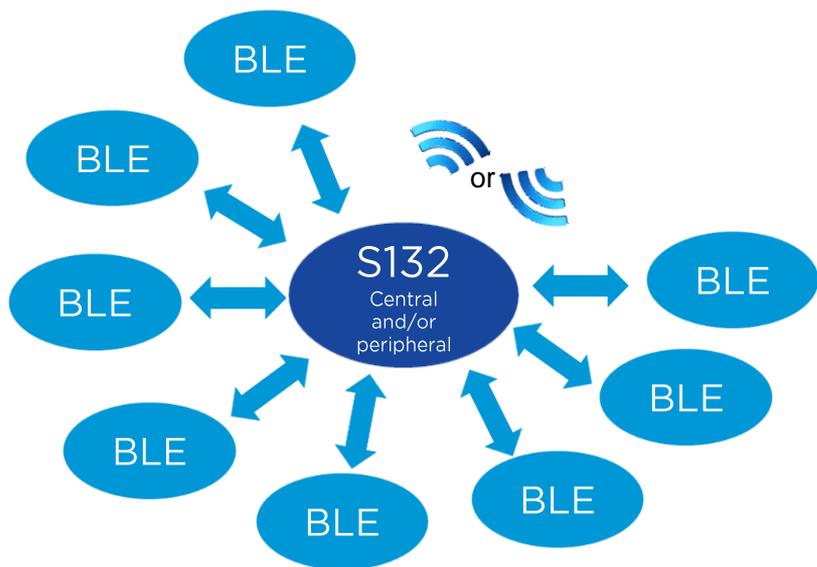- Controls when the server can update values

Nordic – BLE applications

- Softdevice: Precompiled BLE stack
- Clean separation of application and stack code
  - Two different compiles
- Use of softdevice:
  - Call functions
  - Handle events
- API with message sequence charts on the infocenter

Softdevice S132

- Supports concurrent roles:
  - Central
  - Peripheral
  - Observer
  - Broadcaster

- Up to 8 connections along with one observer or one broadcaster
  - Max 1 peripheral connection

- Throughput:
  - Depends on number of connections
    - Time-multiplex
  - Max: 149.2 kbps

SDK

Wide range of examples

- 29x BLE peripheral examples

- 5x BLE central examples

- 2x concurrent BLE central and peripheral

- Over-the-air-update (DFU)

- NFC

- Proprietary RF

- 37 x peripheral examples

  - UART, SPI, timer, radio, etc

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