Bluetooth Low Energy

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Bluetooth

Communication protocol for PC peripheral devices

Bluetooth and others evolution

More bandwidth, but one exception

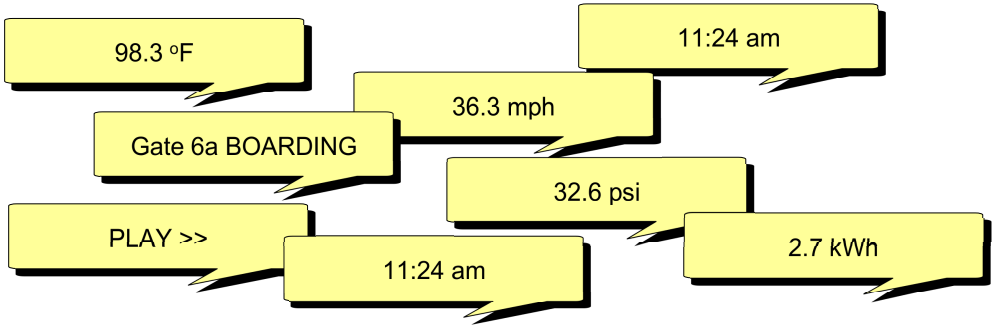
Wi-Fi	
802.11	2Mbps
802.11b	11Mbps
802.11g	54Mbps
802.11n	135Mbps

Ethernet	
802.3i	10Mbps
802.3u	100Mbps
802.3ab	1000Mbps
802.3an	10000Mbps

Bluetooth	
v1.1	1Mbps
v2.0	3Mbps
v3.0	54Mpbs
v4.0 (BTLE)	0.3Mbps

Bluetooth low energy

It's good at small, discrete data transfers



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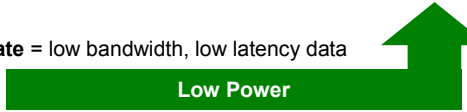
Bluetooth Low Energy

	Voice	Data	Audio	Video	State
Bluetooth ACL / HS	*x*	Y	Y	*x*	*x*
Bluetooth SCO/eSCO	Y	*x*	*x*	*x*	*x*
Bluetooth low energy	*x*	*x*	*x*	*x*	Y
Wi-Fi	(VoIP)	Y	Y	Y	*x*
Wi-Fi Direct	Y	Y	Y	*x*	*x*
ZigBee	*x*	*x*	*x*	*x*	Y
ANT	*x*	*x*	*x*	*x*	Y

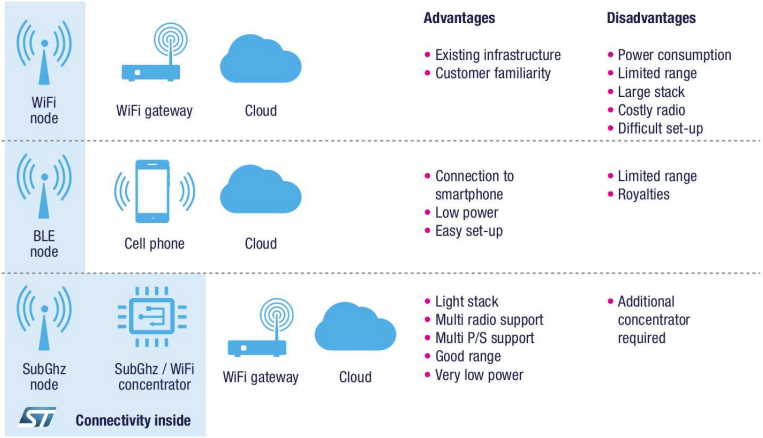


Terminology - roles

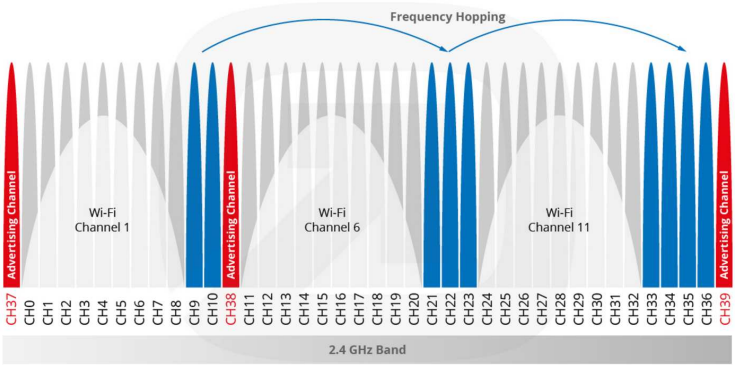
- **Broadcaster:** Transmitter only
- **Observer:** Receiver only
- **Peripheral:** Supports slave role
- **Central:**
  - Supports master roles
  - Supports multiple connections
  - Initates connectfions to peripherals

Note: One device my support multiple roes

Bluetooth Low Energy

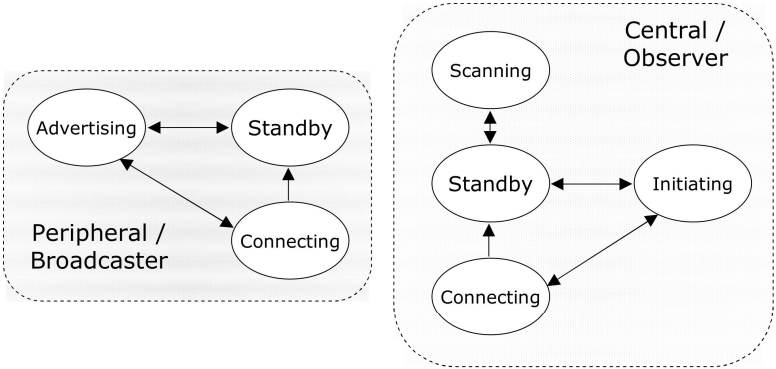


Advertising



- Broadcasting data. The way to let know to other devices that you are present.
- Transmit on all advertising cahnnel on each connection interval.
- Connectable or non-conectable.

Bluetooth LE Modes



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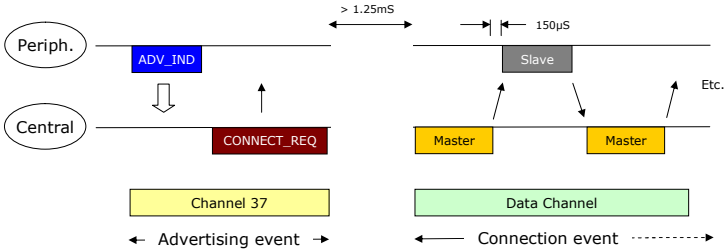
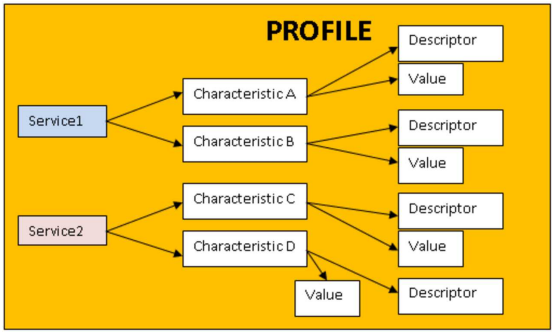


Once a connection is made:

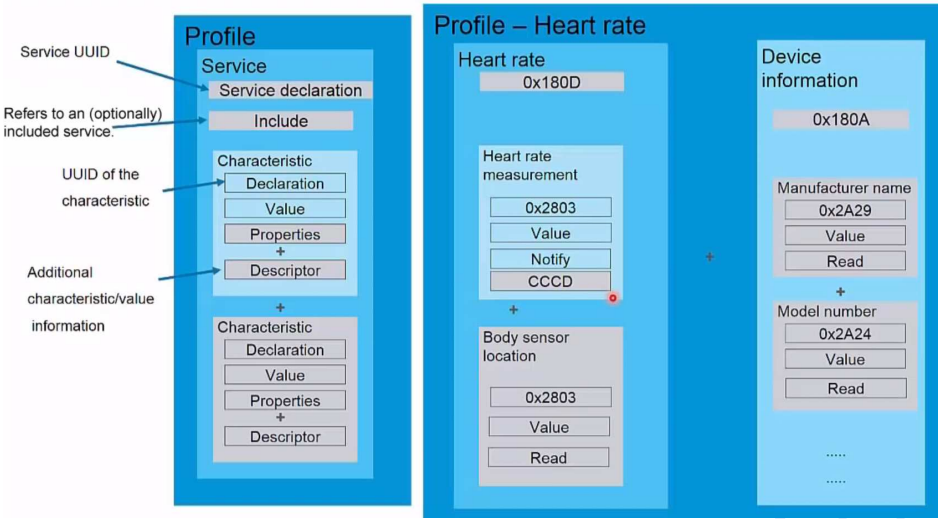
- Master informs slave of hopping sequence and when to wake
- All subsequent transactions are performed in the 37 data channels
- Transactions can be encrypted
- Both devices can go into deep sleep between transactions.

Profile setup



- **Profile:**
  - In, BLE and application is considered as a Profile designed to exchange data.
  - Overall application functionality
- **Service:** Sub-functionality that consists of characteristics.
- **Characteristics:** Performs its service functionality.

Profile example, heart rate



Bluetooth Low Energy Power Consumption

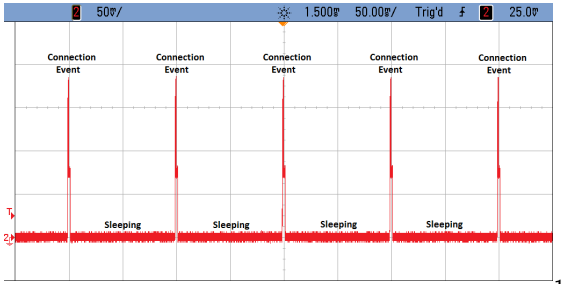


Figure 1- Current Consumption versus Time during a BLE Connection

[1]

- BLE stack will only be consuming current at the peak level while it is transmitting.
- BLE device is transmitting only for a small percentage of the total time that the device is connected.

[1] Texas Insturments, Measuring Bluetooth® Low Energy Power Consumption, Application Note AN092

Bluetooth GAP (Generic Access Profile) roles

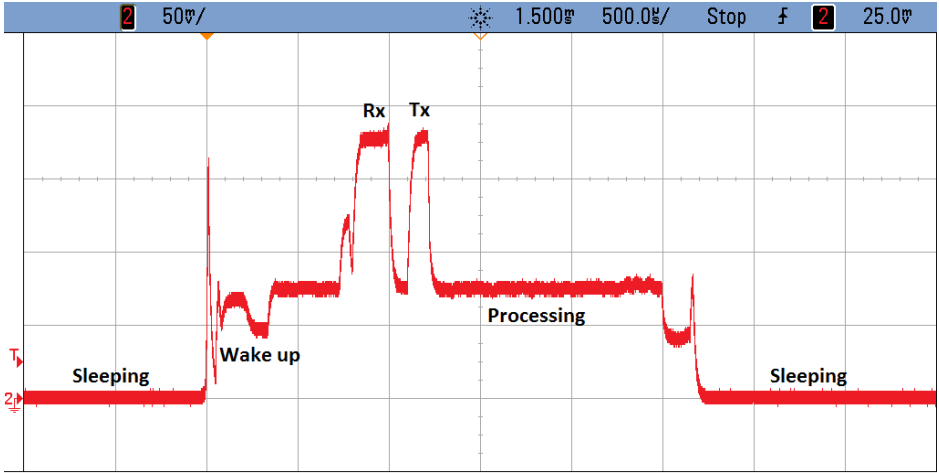


Figure 2- Current Consumption versus Time during a single Connection Event [2]

Bluetooth GAP (Generic Access Profile) roles

	Time [µs]	Current [mA]
State 1 (wake-up)	400	6.0
State 2 (pre-processing)	315	7.4
State 3 (pre-Rx)	80	11.0
State 4 (Rx)	275	17.5
State 5 (Rx-to-Tx)	105	7.4
State 6 (Tx)	115	17.5
State 7 (post-processing)	1325	7.4
State 8 (pre-Sleep)	160	4.1

[(400 µs)*(6 mA) + (340 µs)*(7.4 mA) + (80 µs)*(11 mA) + (190 µs)*(17.5 mA) + (105 µs)*(7.4 mA) + (115 µs)*(17.5 mA) + (1280 µs)*(7.4 mA) + (165 µs)*(4.1 mA)] / (2675 µs) = 8.2463 mA

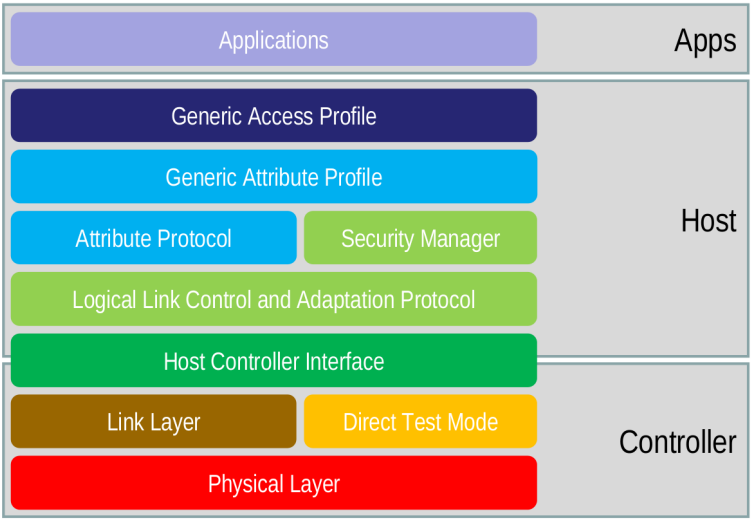
[(1000 ms – 2.675 ms)*(0.001 mA) + (2.675 ms)*(8.2463 mA)] / (1000 ms) = 0.0230 mA [3]

[3] Texas Insturments, Measuring Bluetooth® Low Energy Power Consumption, Application Note AN092

Bluetooth GAP (Generic Access Profile) roles

$(230mAh)/(0.023mA) = 10000 \text{ hours} = 416 \text{ days} = 1.14 \text{ years}$

Bluetooth LE Layers



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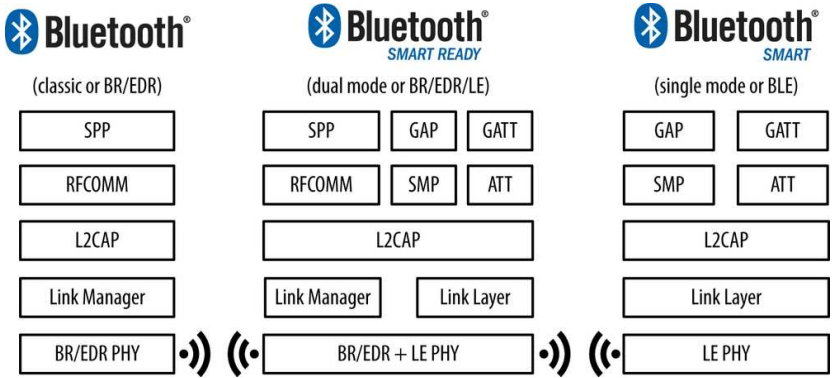
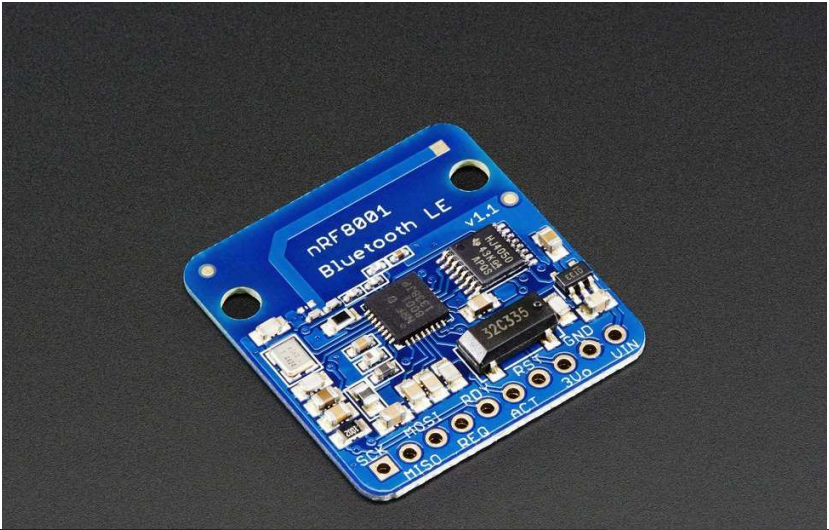


Bluetooth LE Modules



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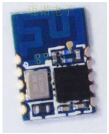
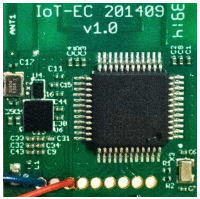


2.6 x 2.6mm



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