# Introduction to Bluetooth Low Energy

Lightning talk Hatim.Shahzada@assaabloy.com @geoaxis 5



## Hej!

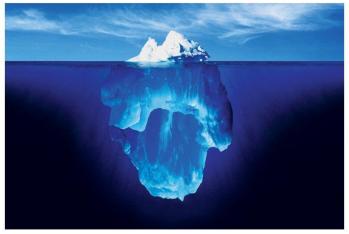
- Who am I?
- Who are you?
- Agenda
  - Basics (Tip of the iceberg)
  - Use cases
  - Resources

#### No Demos

• Questions and comments welcome during break or on twitter/email.





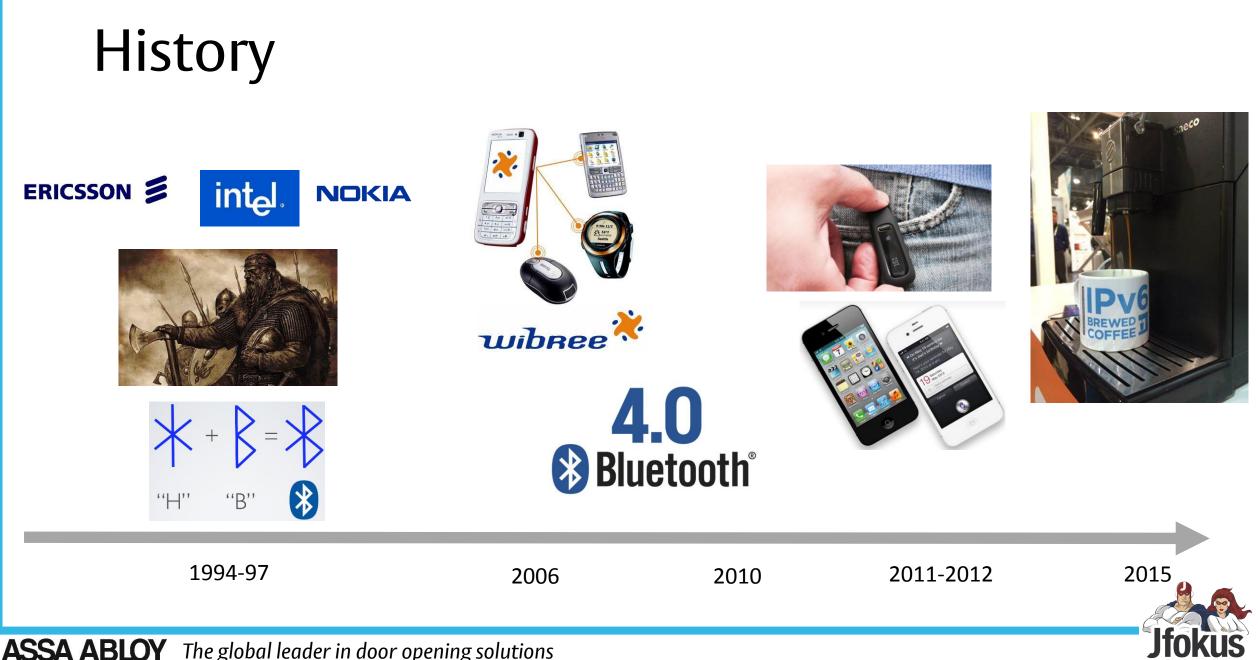




## Bluetooth Low Energy – In short

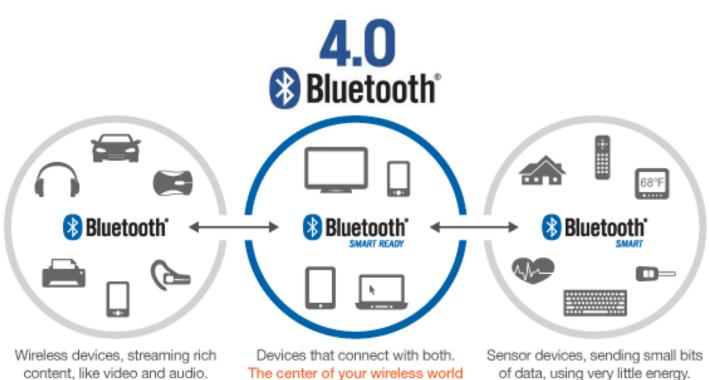
- Wireless technology standard, designed from ground up.
- Simple and easy to use model.
- Small bursts of data.
- Impressive battery life.
- Low cost.
- Works on free 2.4 Ghz band.
- Ideal for sensors/ IoT.





### Note on Naming

- Bluetooth 4.0
- Bluetooth Low Energy
  - BLE, BTLE, LE
- SIG Preferred
  - Bluetooth Smart
  - Bluetooth Smart Ready





### **BLE Roles**

Master

Client

*Can read/write data to Slave/Server* 



Central



Slave

Server

Has read/write data

Peripheral



Has read-only broadcast data

Broadcaster

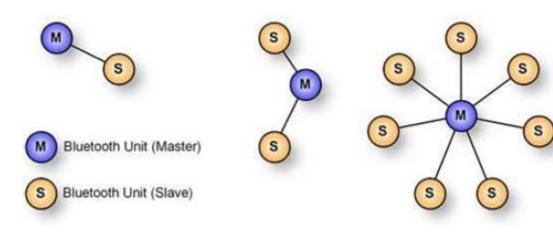


Can receive broadcast data

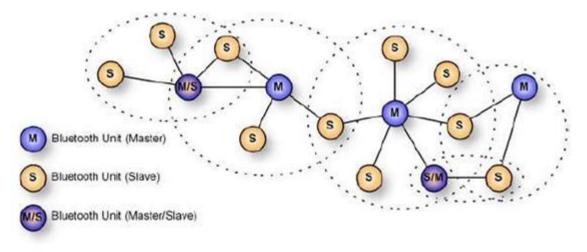


Observer

## Topology



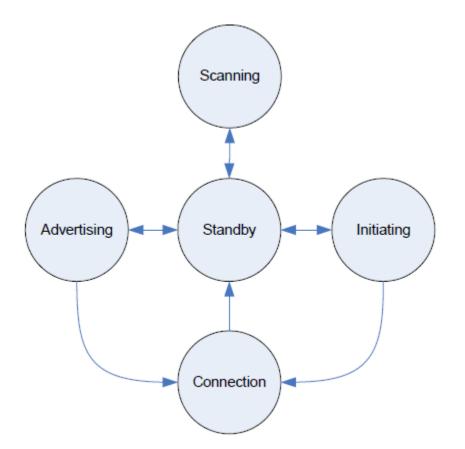
Piconet v4.0



Scatter net v4.1

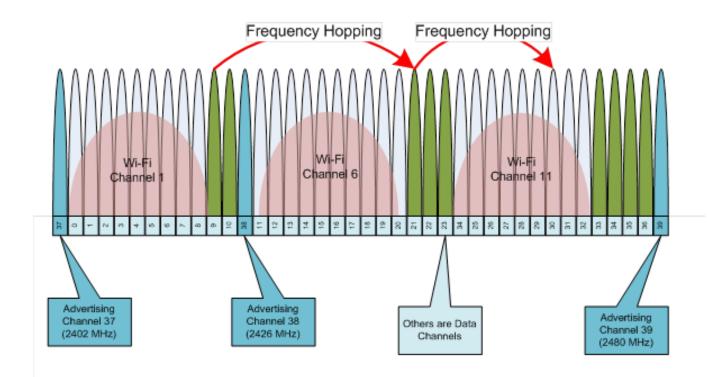








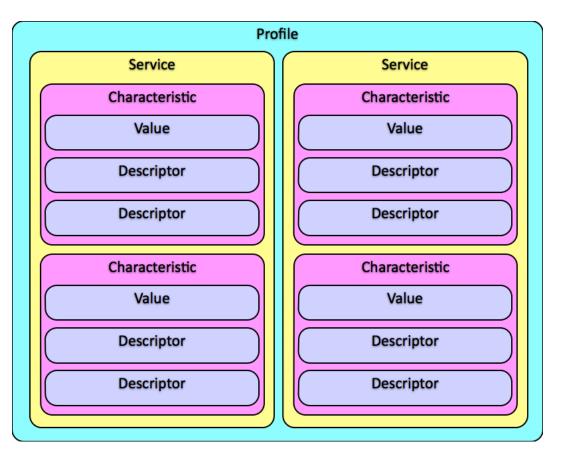
## Spectrum/Adaptive Frequency Hopping

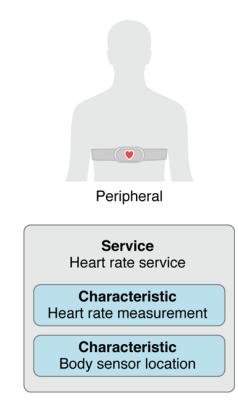






### Generic Attribute Profile - GATT





Services, characteristics, and descriptors are collectively referred to as *attributes*, and identified by <u>UUIDs</u>. 16 bits (e.g. "**180A**") or 128 bits (e.g. "**6BCF0ED3-68E3-4804-96D5-5AB8765FB9BC**")

Jfokus

## **GATT** Operations

- Central can
  - discover UUIDs for all primary services.
  - Find a service with a given UUID.
  - Find secondary services for a given primary service.
  - Discover all characteristics for a given service.
  - Find characteristics matching a given UUID.
  - Read all descriptors for a particular characteristic.
  - Can do read, write, long read, long write values etc.
- Peripheral
  - Notify or indicate central of changes.

## Security

- Encryption (128 bit AES)
- Pairing (Without key, with a shared key, out of band pairing)
- Passive eavesdropping during key exchange (but fixed in Bluetooth 4.2)
- Many products are building their own security on top of BLE
- Check out <u>Mike Ryan (iSec partners</u>) work on security.



### Use cases – Physical Security





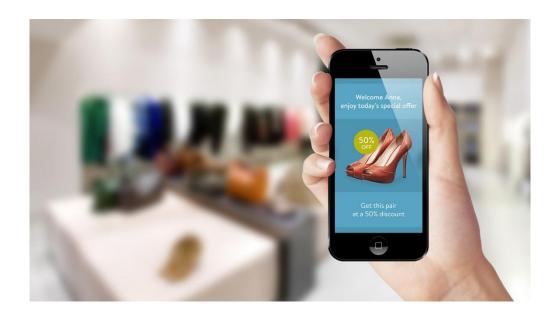
#### Use cases – Home automation







### Use cases – Geo-fencing/ positioning







#### Use cases - Fun



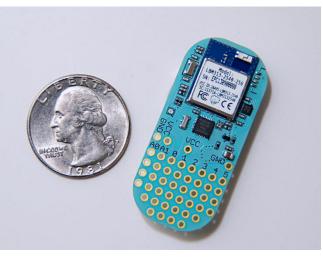




### Development Kits/Boards













## **Operating System Support**

- iOS 8 🙂
- OSX 10.10 🙂
- Android 4.3, 4.4, 5.0 😐
- Linux 3.4, BlueZ 5.0 ⊕
- Windows Phone 8.1 (only central) 😕
- Windows 8.1 (app mode) 😕



### Interesting development tools

iPad 🗇		12:01 PM		\$ 43%
Files Ardu	ino Edit	Bli	nk.ino	Program
AnalogInput.in	10 11/8/13, 2:09 PM	1 /* 2 Blink		
Blink.ino 820 bytes	11/8/13, 2:08 PM	3 Turns on an LED on for or repeatedly.	ne second, then off for one s	econd,
Dimmer.ino 3.6 KB		This example code is in t	the public domain.	
MIDI.ino 2.6 KB	11	<pre>8 // Pin 13 has an LED conner 9 // Pin 11 has the LED on Te 9 // Pin 6 has the LED on Te 1 // Pin 13 has the LED on Te 2 // give it a name: 9 int led = 13; 4 // the setup routine runs of 8 // the setup routine runs of 9 // the setup routine</pre>	eensy++ 2.0 eensy 3.0	
U	17	<pre>// initialize the digital pinMode(led, OUTPUT); }</pre>		
C	22	<pre>void loop() {     digitalWrite(led, HIGH);         level)</pre>	// turn the LED on (HIGH i	s the voltage
	24		<pre>// wait for a second // turn the LED off by mak</pre>	ing the voltage
	26	7 }	// wait for a second	
+ /	et q			

P.nbr.	Time (us) +0 =0	Channel 0x25	Access Address	Adv PDU Type	2ype 0	Adv PDU Header TxAdd RxAdd POU-Length 0 0 38	AdvA 0x0013430540P7	AdvData 02 01 06 02 0A 04 05 12 08 00 10 00 11 07 7 60 22 A0 8E AF 09 80 DE 48 75 62 F1 84 28 0		RSSI (dBm) -46	FCS
P.nbr. 2	Time (us) +6755 =0755	Channel 0x25	Access Address	Adv PDU Type	Type 0	Adv PDU Header TxAdd SxAdd PDU Length 0 0 36	AdvA 0x001343054385	AdvData 02 01 06 02 08 04 05 12 08 00 10 00 11 07 7 60 22 80 BE AF C0 BD DE 43 73 62 F1 04 28 D		RSSI (dBm) -38	FCS
P.nbr. 3	Time (us) +95618 -104373	Channel 0x25	Access Address 0x8E898ED6	Adv PDU Type	Type 0	Adv PDU Header TxAdd DxAdd PDU-Length 0 0 36	AdvA 0x0013430540F7	AdvData 02 01 06 02 0A 04 05 12 08 00 10 00 11 07 7 50 22 A0 BE AF C0 BD DE 48 79 62 F1 64 28 D		R\$5I (dBm) -16	FCS
P.nbr.	Time (us) +5630 =110003	Channel 0x25	Access Address	Adv PDU Type	2урн Q	Adv PDU Header TxAdd RaAdd PDU-Length D 0 36	AdvA 0x001343054385	AdvData 02 01 06 02 0A 04 05 12 08 00 10 00 11 07 7 60 22 A0 85 AF 00 80 05 48 75 62 F1 64 28 0	CRC 0x853E68	RSSI (dBm) -38	FCS
P.nbr. S	Time (us) 199368 -209371	Channel 0x25	Access Address	Adv PDU Type	Type	Ady PDU Header TxAdd SxAdd FDU-Length 0 0 36	AdvA 0x0013430540r7	AdvData 02 01 06 02 0A 04 05 12 03 00 10 00 11 07 7 60 22 A0 BE AF CO BD DE 43 79 62 F1 04 23 D	CRC 0x002278	RSSI (dBm) -46	FCS DK
P.nbr. 6	Time (us) +620 =210001	Channel 0x25	Access Address	Adv PDU Type	Type	Adv PDU Header TxAdd DxAdd PDU-Length 0 0 36	AdvA 0x001343054385	AdvData 02 01 06 02 0A 04 05 12 08 00 10 00 11 07 7 50 22 A0 BF AF CO BD DE 48 79 62 F1 64 28 D	CRC 0x853266	RSSI (dBm) -38	FCS OX
P.nbr. 7	Time (us) +104998 =314999	Channel 0x25	Access Address	Adv PDU Type	Type 0	Adv PDU Header Taðdd Raðdd PDU-Leouth D 0 36	AdvA	AdvData	CRC	RSSI (dBm) -35	FCS
P.nbr. C	Time (us) +101243 =416242	Channel 0x25	Access Address	Adv PDU Type	Type	Adv PDU Header TxAdd RxAdd PDU-Length 0 0 36	AdvA 0x0013430540r7	AdvData 02 01 06 02 0a 04 05 12 03 00 10 00 11 07 7 60 22 a0 DE ar c0 DD DE 43 73 62 F1 04 23 D	CRC 0xDD2278	RSSI (dBm) -46	FCS
P.nbr. 9	Time (us) +4379 -420621	Channel 0x25	Access Address	Adv PDU Type	Type 0	Adv PDU Header TxAdd RxAdd PDU-Length 0 0 36	AdvA 0x001342054385	AdvData 02 01 06 02 0A 04 05 12 08 00 10 00 11 07 0 50 22 A0 BE AF CO BD DE 48 78 62 F1 84 28 D	CRC 0x853E66	RSSI (dBm) -38	FCS
P.nbr.	Time (us) +99994 =520615	Channel 0x25	Access Address	Adv PDU Type	2ype 0	Adv PDU Header TxAdd RxAdd PDU-Length 0 0 36	AdvA 0x0013430540F7	AdvData 02 01 06 02 0A 04 05 12 08 00 10 00 11 07 7 60 22 A0 BE AF C0 BD DE 48 73 62 F1 84 28 D	CRC 0xDR2278	RSSI (dBm) -46	FCS
Pabr	Time (us)	Channel	Access Address	Adv POLLTrop		Adv PDU Header	AdvA	AdvData	CRC	RSSI	FCS

Field Name:	Template:			Filter management	
			Fint And	[	Add
ADV PDU Type			Add	-	Barrova
ADV_CONNREG A ADV_CONNREG IN E			Banova   All		Open
ADV_DP_ND AM ADV_DP_ND IntA			Applytiter		Sava
ADV_DISCAdyA ADV_ND AdvA				l	Merge
ADV_ND AdvA ADV_NONCONN A ADV_SCANRED A			Tum of fitter	1	
ADU REAMDED D. Y					

#### Evothings Workbench

00	Evothings Workbench	0.8.0	
	TOOLS	FORUM	FEEDBACK
Arduino LED On/Off TCP examples/arduino-led-onoff-tcp/app/i	ndex.html	COD	E RUN
Arduino LED On/Off BLE examples/arduino-led-onoff-ble/app/i	ndex.html	COD	ERUN
Arduino Scriptable examples/arduino-scriptable-tcp/app/	index.html	COD	E RUN
Arduino BLE examples/arduino-ble/app/index.html	i.	COD	E RUN
BLE Scan examples/ble-scan/index.html		COD	E RUN
BLE Discovery xamples/ble-discovery/index.html		COD	E RUN
BLE TI SensorTag examples/ble-ti-sensortag/index.html		COD	E RUN
Beacon scan examples/ibeacon-scan/index.html		COD	ERUN
Connect URL: 192.168.20.141:4042			Clients: 1 Files:





### Resources

- A <u>compilation</u> of resources at my Blog.
- Bluetooth <u>SIG</u> (Bluetooth Europe conference).
- IoT Stockholm <u>meetup</u> (we are meeting tonight).



• Books





# Tack 🙂

Questions and comments welcome after this talk or on twitter/email. We are hiring <u>http://www.assaabloy.com/en/com/Career/</u>

Slides will be posted on Jfokus website

