The Bluetooth Boom – Connecting Everything

CSR

Push every boundary.™

Raja Banerjea – Sr. Director, Global Standards CSR

What is Bluetooth Smart?

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Bluetooth® SMART

Low Power

Low Data Flow

Flexible Use

Bluetooth SMART

Bluetooth

INNOVATION

Internet of My Things

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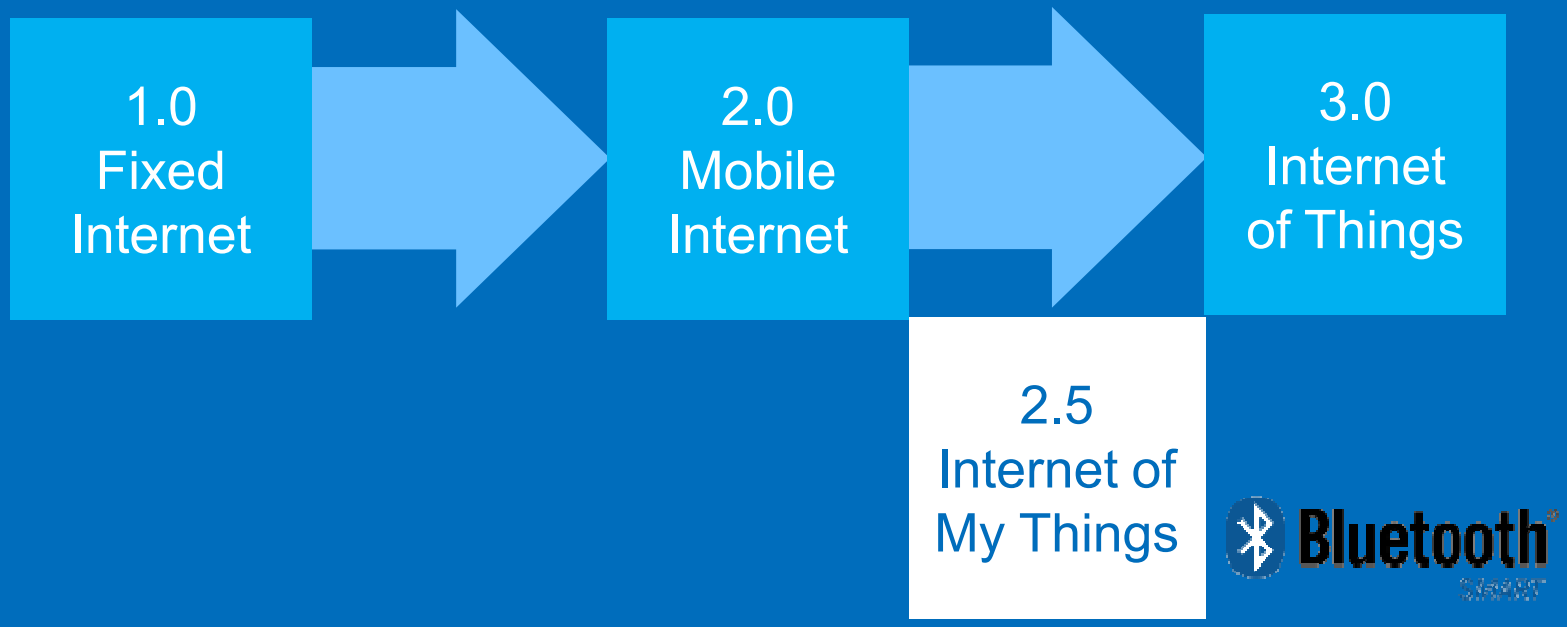

Market Adoption

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Bluetooth Smart Ready Devices

Two thirds of the 821 million smartphones shipped in 2013 will include Bluetooth Smart Ready (source IMS)

Bluetooth Smart Devices

Bluetooth Smart device shipments hard to forecast – but a significant opportunity

BLUETOOTH LOW ENERGY APPLICATIONS

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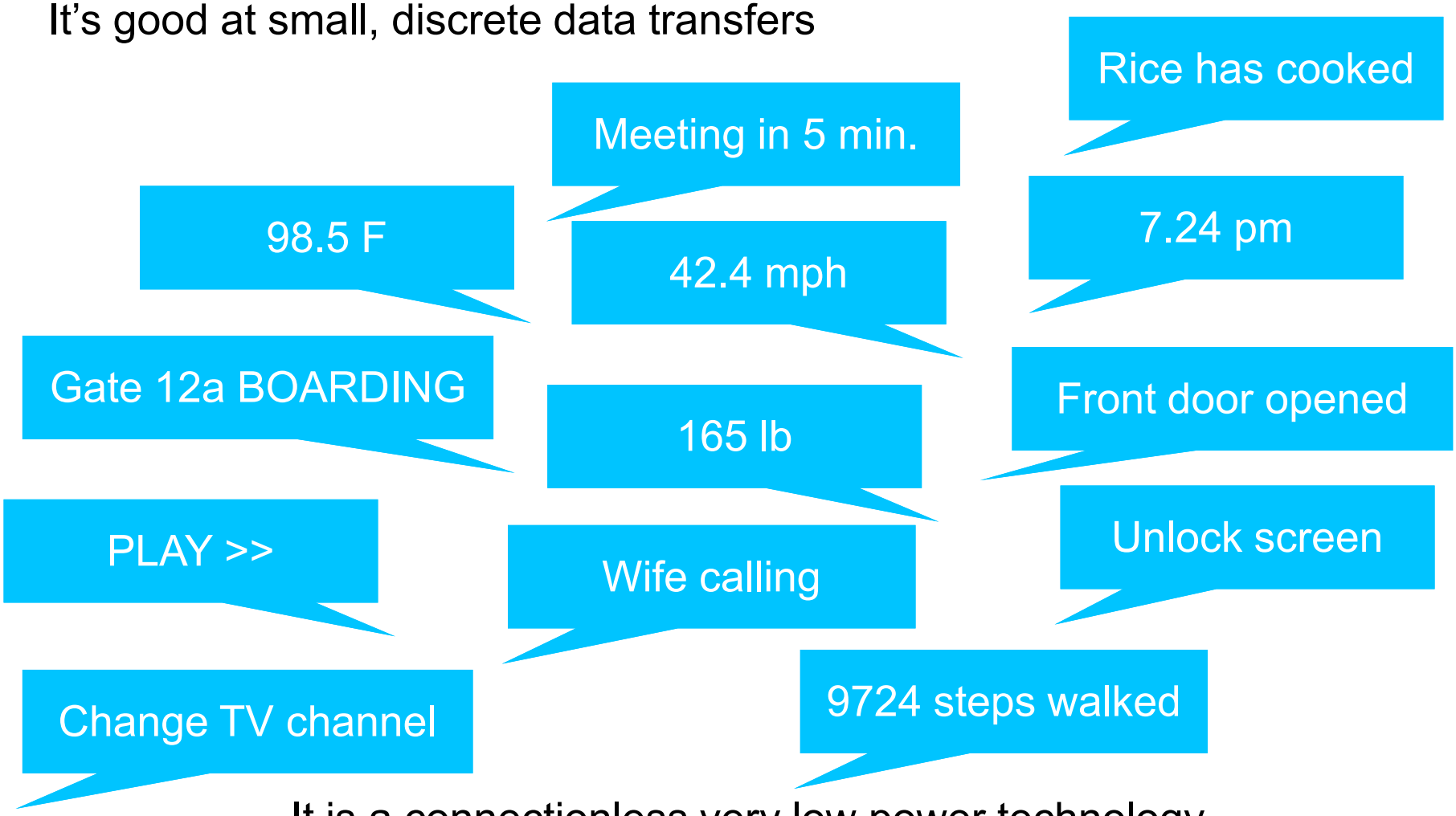
It's good at small, discrete data transfers



It is a connectionless very low power technology
It connects to the Internet

Bluetooth Low Energy – Technical Details

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Range	~ 30 - 100m
Output Power	0.01 - 10 mW
Max current	~15 mA
Latency	3 ms
Topology	Star
Connections	> 2 billion
Modulation	GFSK @ 2.4 GHz
Robustness	Adaptive Frequency Hopping, 24 bit CRC
Security	128 bit AES CCM
Sleep current	~ 1uA
Modes	Broadcast, Connection, Event, Reads, Writes
Data Rate	1 Mbps
Channels	40 channels with 2 MHz spacing

LINK LAYER CHANNELS

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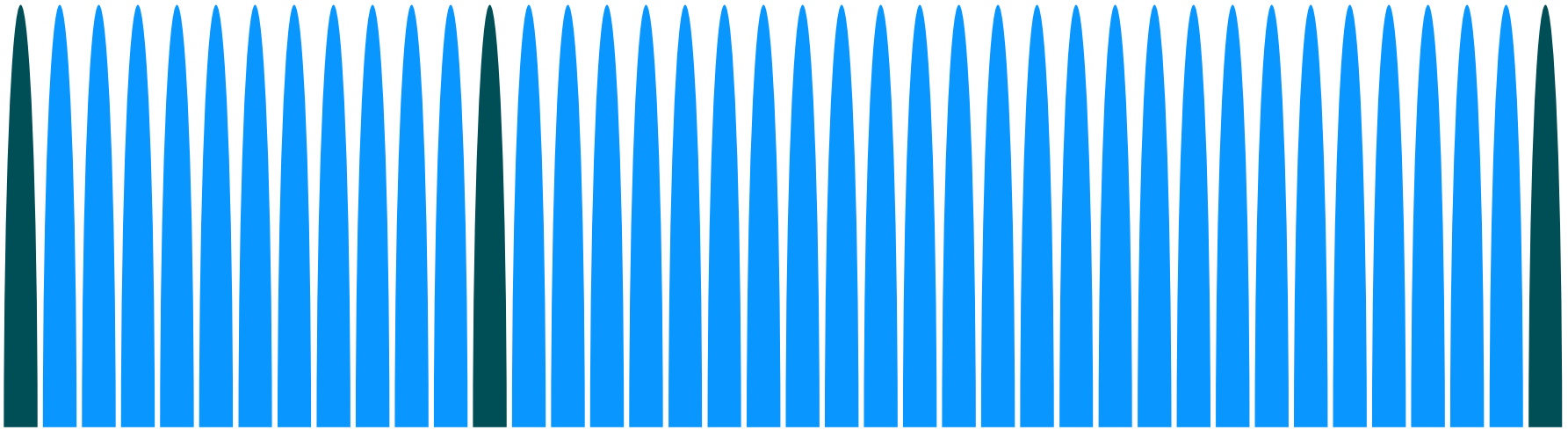
3 Advertising Channels and 37 Data Channels



LL	Frequency
37	2402 MHz
0	2404 MHz
1	2406 MHz
2	2408 MHz
3	2410 MHz
4	2412 MHz
5	2414 MHz
6	2416 MHz
7	2418 MHz
8	2420 MHz
9	2422 MHz
10	2424 MHz
38	2426 MHz
11	2428 MHz
12	2430 MHz
13	2432 MHz
14	2434 MHz
15	2436 MHz
16	2438 MHz
17	2440 MHz
18	2442 MHz
19	2444 MHz
20	2446 MHz
21	2448 MHz
22	2450 MHz
23	2452 MHz
24	2454 MHz
25	2456 MHz
26	2458 MHz
27	2460 MHz
28	2462 MHz
29	2464 MHz
30	2466 MHz
31	2468 MHz
32	2470 MHz
33	2472 MHz
34	2474 MHz
35	2476 MHz
36	2478 MHz
39	2480 MHz

LINK LAYER CHANNELS - Coexistence

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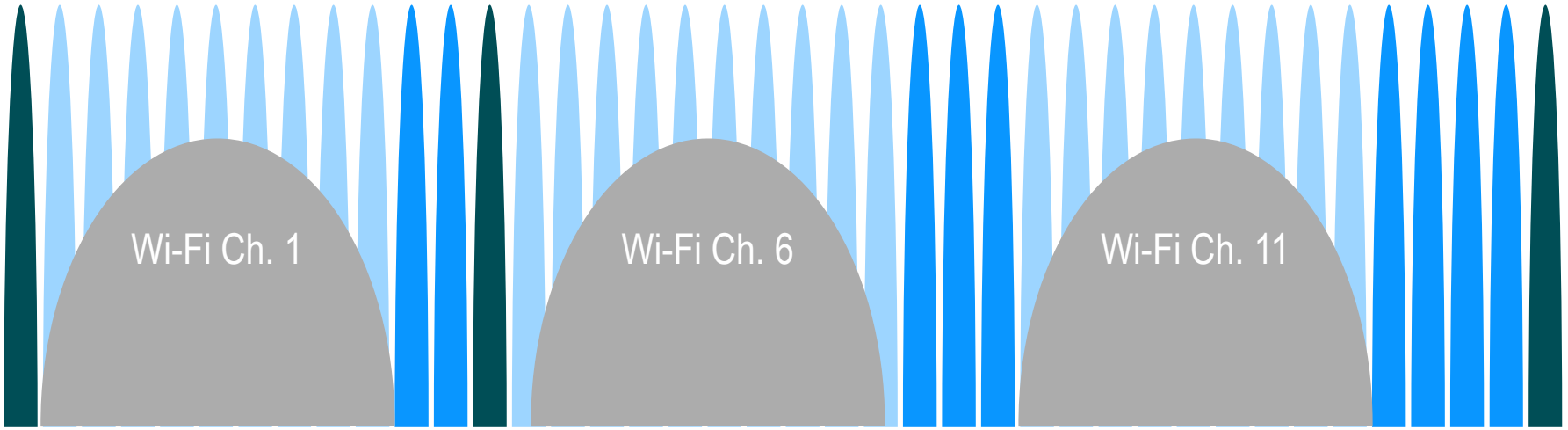
9 LL Data Channels still available



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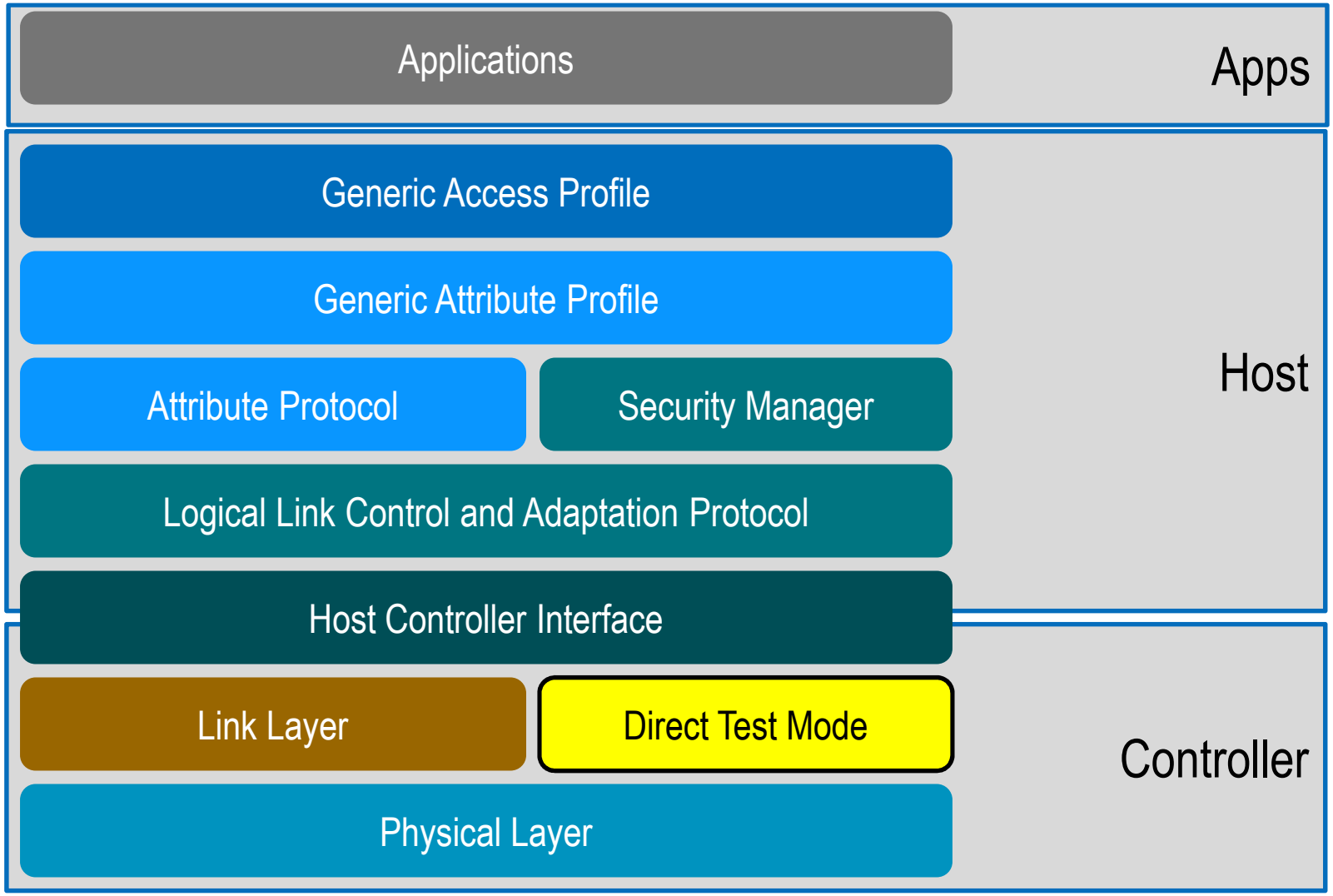
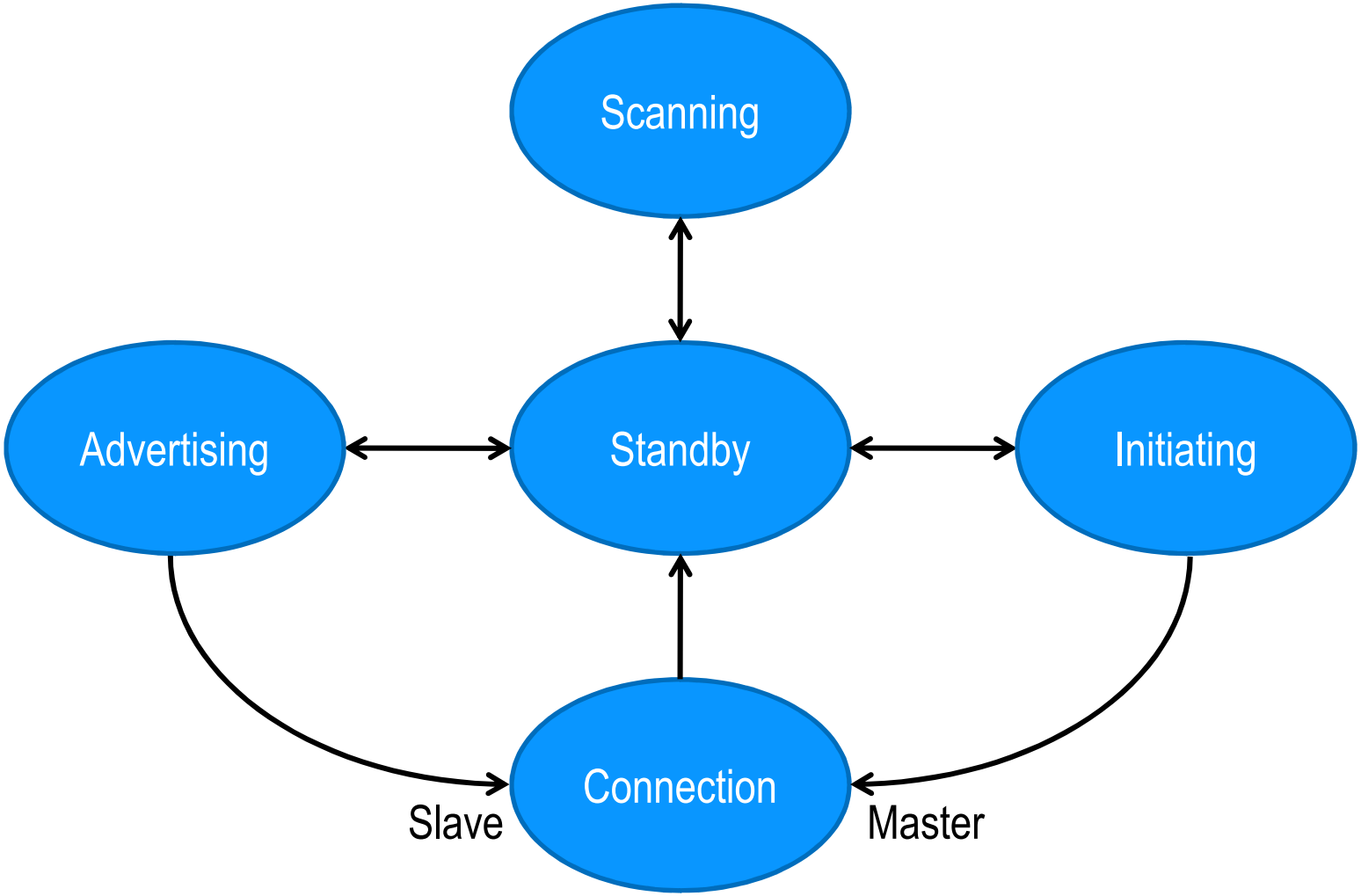
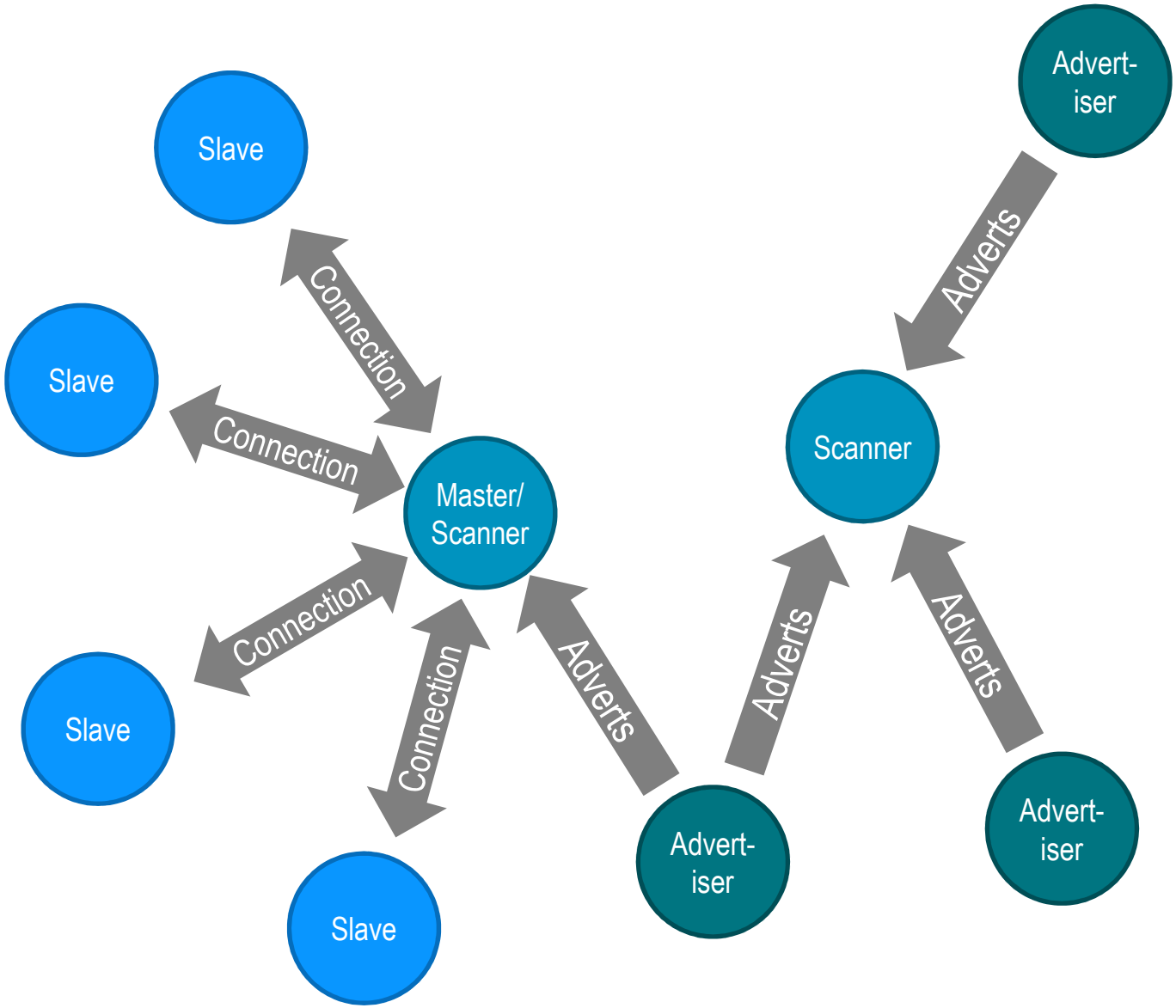
Bluetooth Low Energy – Protocol Stack



LINK LAYER STATE MACHINE



TOPOLOGY


Slave
Slave
Slave
Slave
Connection
Connection
Connection
Connection
Master/
Scanner
Adverts
Adverts
Adverts
Advert-
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Advert-
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Scanner
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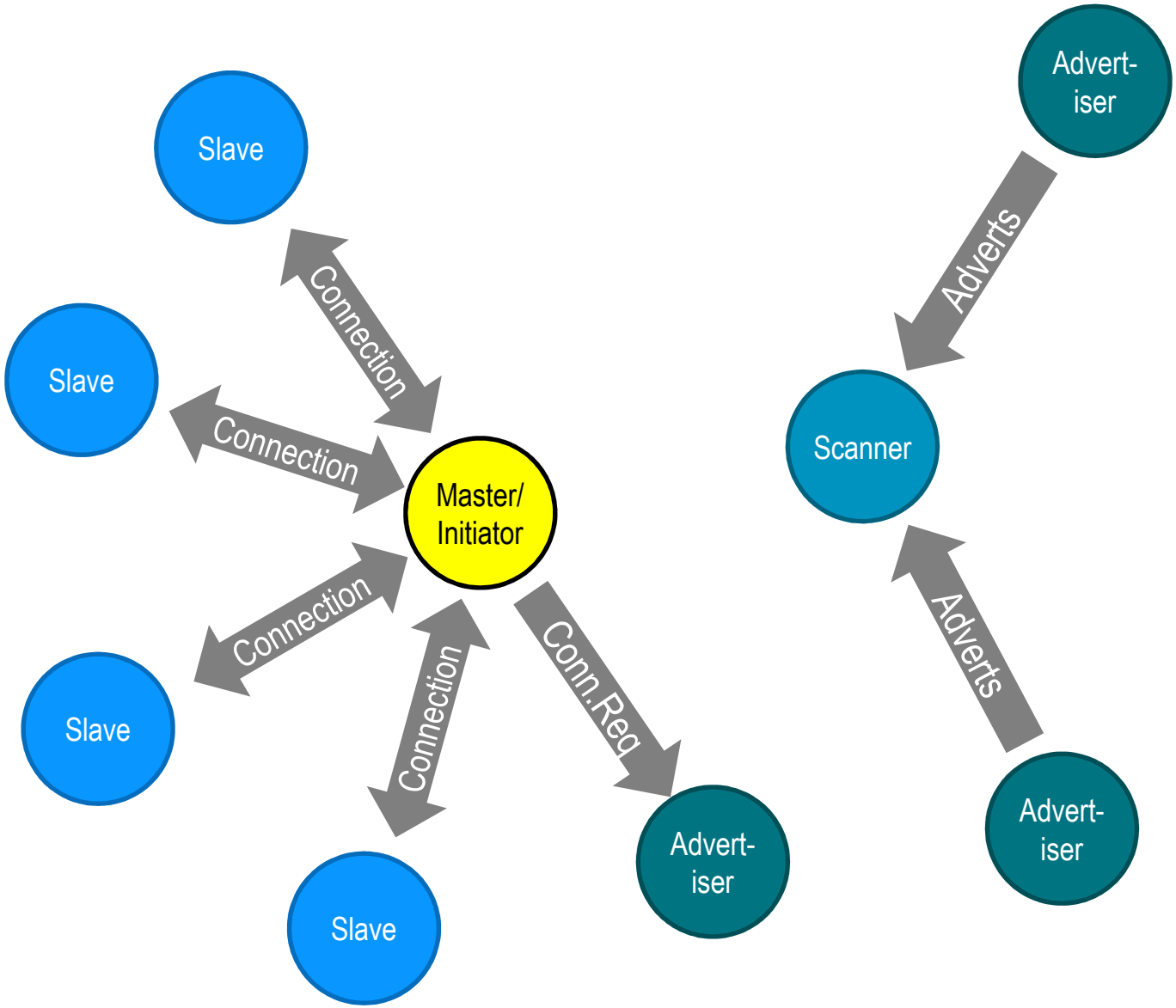
TOPOLOGY


Slave
Slave
Slave
Slave
Connection
Connection
Connection
Connection
Master/
Initiator
Conn.Req
Advert-
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Advert-
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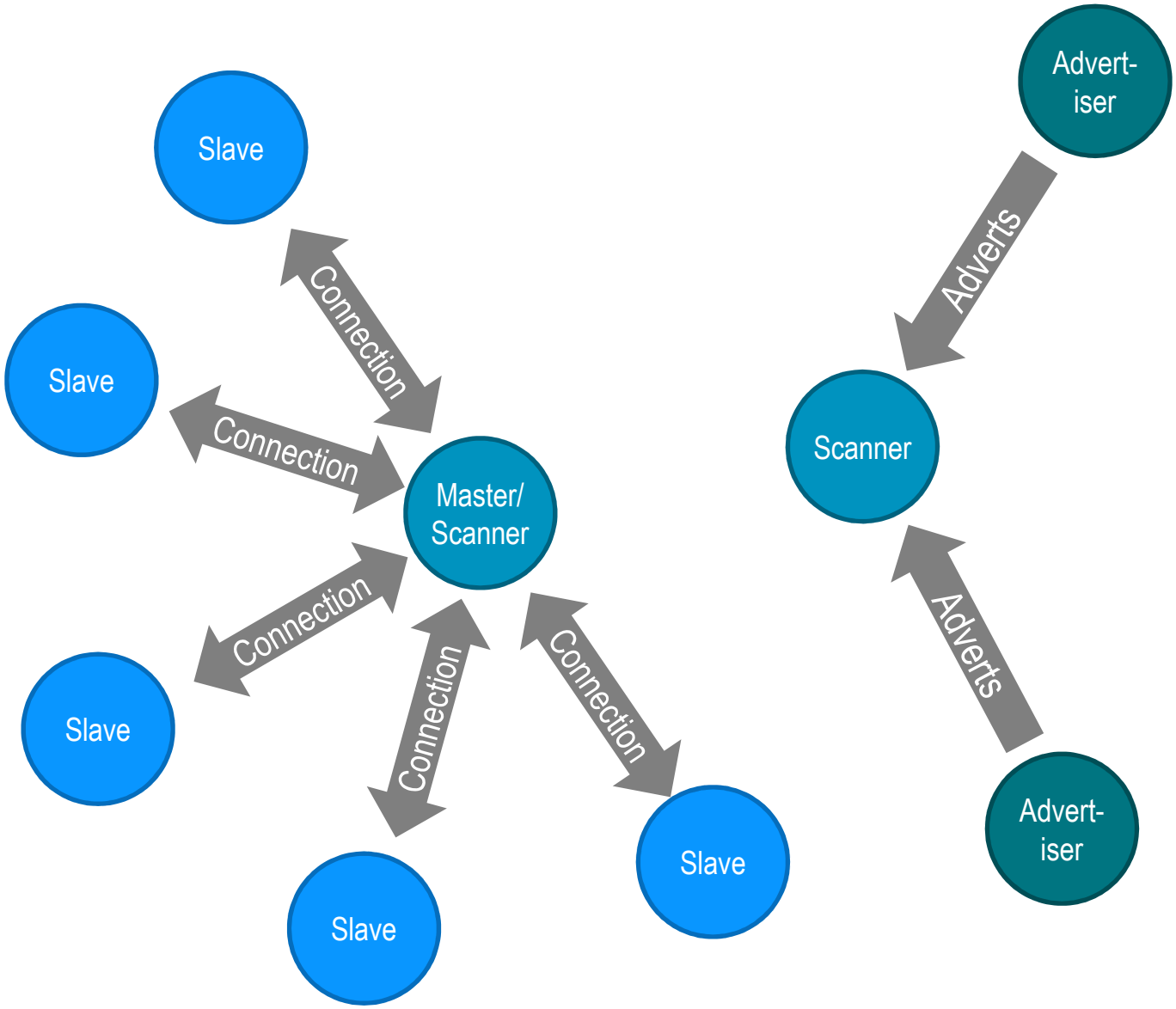
Scanner
Adverts
Adverts

TOPOLOGY


Slave
Slave
Slave
Slave
Slave
Connection
Connection
Connection
Connection
Connection
Master/
Scanner
Advert-
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Adverts
Scanner
Adverts
Advert-
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GENERIC ATTRIBUTE PROFILE

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Handle	Type	Value	Permissions
0x0001	«Primary Service»	«GAP»	R
0x0002	«Characteristic»	{r, 0x0003, «Device Name»}	R
0x0003	«Device Name»	“Temperature Sensor”	R
0x0004	«Characteristic»	{r, 0x0006, «Appearance»}	R
0x0006	«Appearance»	«Thermometer»	R
0x000F	«Primary Service»	«GATT»	R
0x0010	«Characteristic»	{r, 0x0012, «Attribute Opcodes Supported»}	R
0x0012	«Attribute Opcodes Supported»	0x00003FDF	R
0x0020	«Primary Service»	«Temperature»	R
0x0021	«Characteristic»	{r, 0x0022, «Temperature Celsius»}	R
0x0022	«Temperature Celsius»	0x0802	R*

TIME FROM DISCONNECTED TO DATA ~ 3ms (RADIO ACTIVE ~ 1ms)

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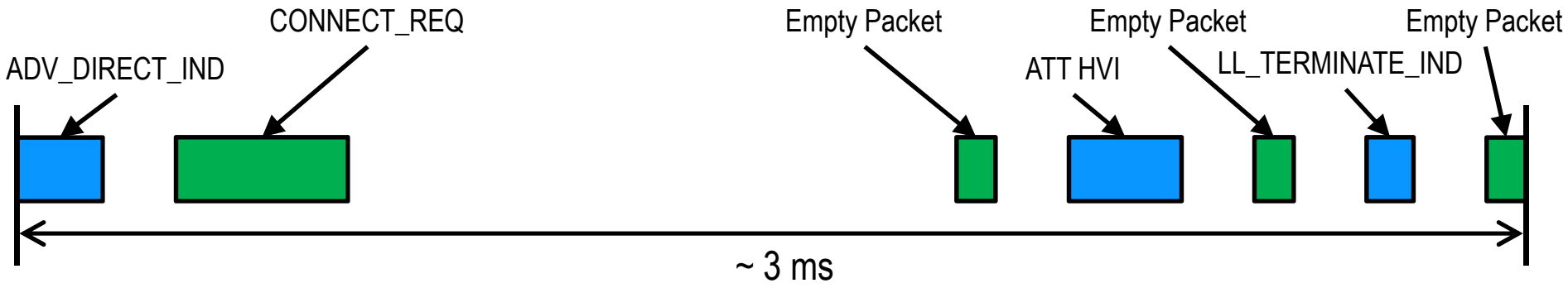
Time (us)	Master Tx	Radio Active (us)	Slave Tx
0		176	ADV_DIRECT_IND
326	CONNECT_REQ	352	
1928	Empty Packet	80	
2158		144	Attribute Protocol Handle Value Indication
2452	Empty Packet (Acknowledgement)	80	
2682		96	LL_TERMINATE_IND
2928	Empty Packet (Acknowledgement)	80	



How Low Can the Energy Get ?

- Energy per transaction
  - 3ms per transaction
  - Estimate of transmit power is 15 mW
  - For a 1.5v battery, this is 10ma. => 45 uJoules
- How long could a sensor last on a battery?
  - An example battery: Lenmar WC357, 1.55v, 180mAh, $2
  - 180mAh/10ma = 18 hours = 21.6 M transactions
  - Suppose this sensor sends a report every minute = 1440 / day
  - For just the Bluetooth LE transactions, this is 15,000 days or > 40 years
  - This far exceeds the life of the battery and/or the product
- In fact, the communication cost will be only part of the battery consumption
  - Leakage currents put the upper limits on the battery life
  - The sensor could run on scavenged power, e.g. ambient light.

The Billion Unit Markets - 2020

	TAM
Phone accessories & apps	> 10 billion
Smart Energy (meters & displays).	~ 1 billion
Home Automation	> 5 billion
Health, Wellness, Sports & Fitness	> 10 billion
Assisted Living	> 5 billion
Animal Tagging	~ 3 billion
Intelligent Transport Systems	> 1 billion
M2M (Internet connected devices)	> 10 billion

Over 90% of the next 50 billion devices may use a gateway topology

CSR Bluetooth Smart

- Bluetooth Smart is rapid growth area
  - Smartphones, tablets and PCs including Bluetooth Smart Ready
  - IOS7, Android catalysts

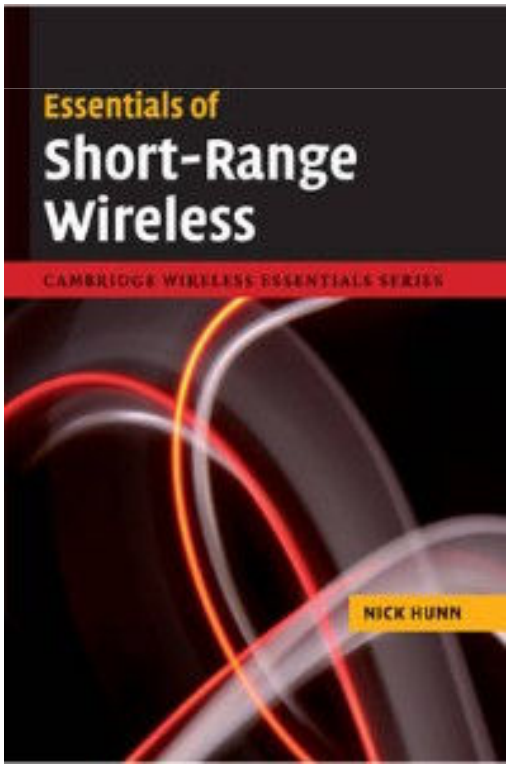
- CSR is world number one provider of Bluetooth
  - Reputation and brand has strong value in Bluetooth Smart

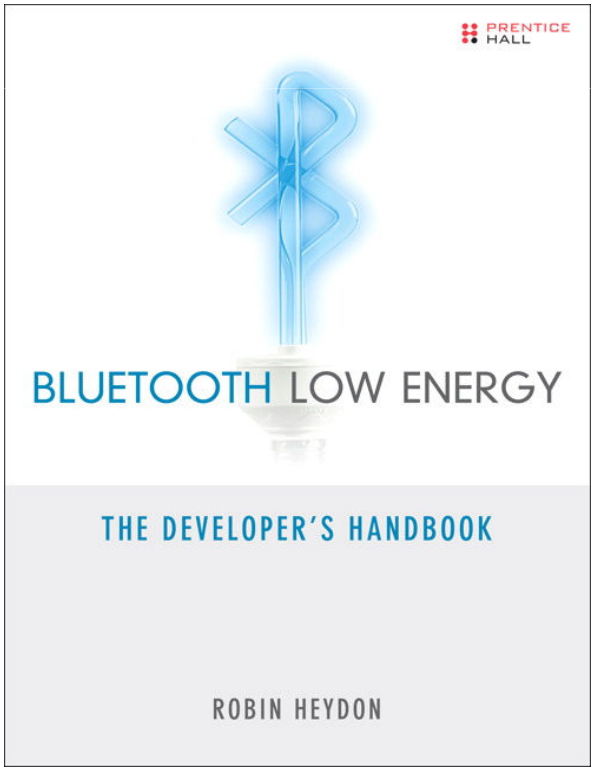




Resources:

- SIG site: http://www.bluetooth.com/lowenergy
- Books:
  - Essentials of Short Range Wireless, by Nick Hunn
  - Bluetooth Low Energy, by Robin Heydon





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