

***Bluetooth®* Technology – Basics and Brand**

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Agenda

- **Introduction to Bluetooth Technology**
 - Basic Rate/Enhanced Data Rate (BR/EDR)
 - High Speed (HS)
 - Low Energy (LE)
 - Attribute Protocol / Generic Attribute Profile
- **Test, Qualify & Branding your Product**

Introduction to Bluetooth Technology

Low Energy / Basic Rate / Enhanced Data Rate / High Speed



Bluetooth Technology Evolution

2007

- V2.1 + EDR - Secure Simple Pairing allows secure device pairing with a button press, numeric entry, numeric compare, and Out of Band

2009

- V3.0 + HS - High Speed Enables applications to use 802.11 MAC/PHY through addition of Generic Alternate MAC/PHY

2010

- V4.0 - Low Energy Enables new applications in different markets including healthcare, sports/fitness, security, home entertainment

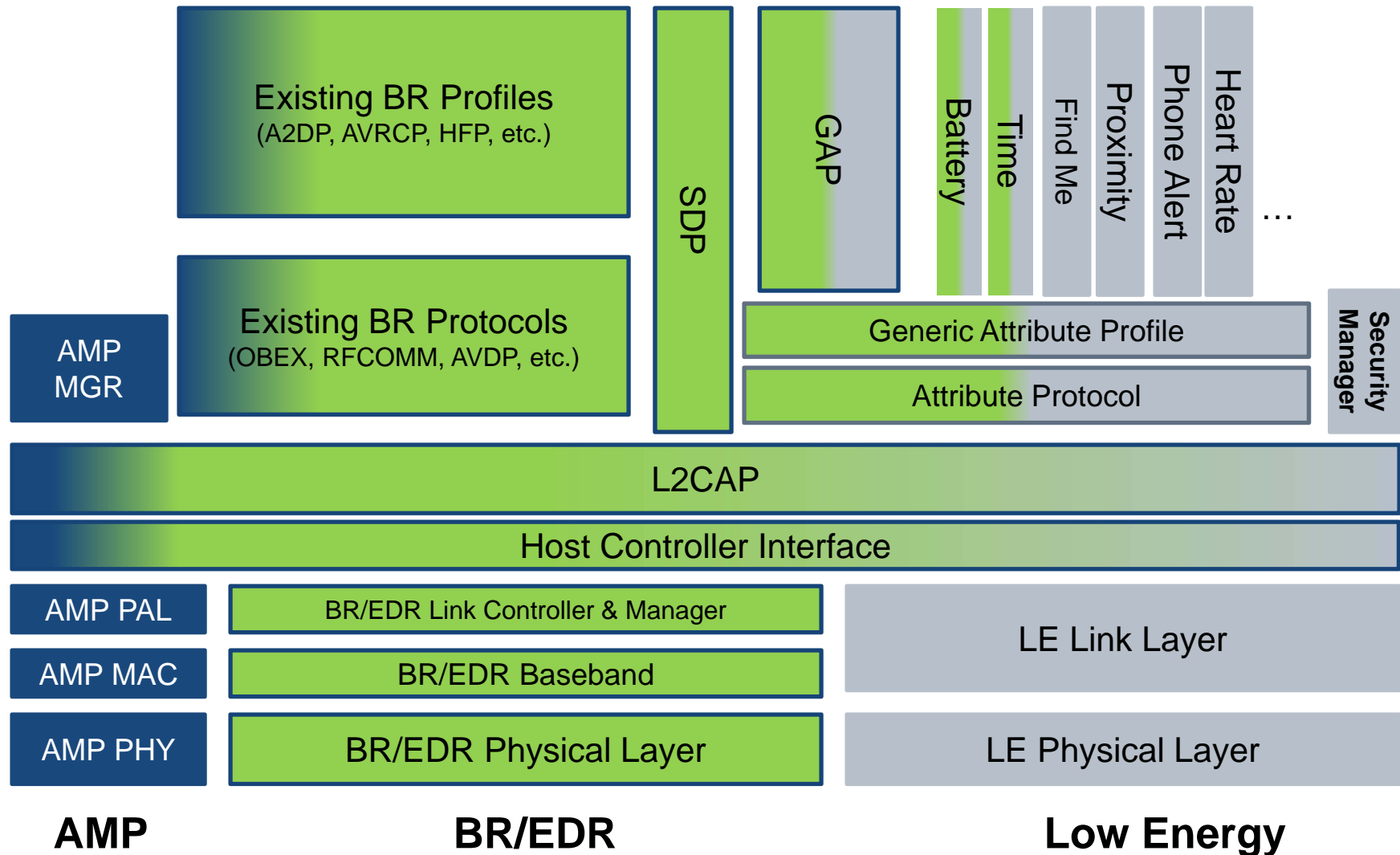
Bluetooth Technology Factsheet

Technology	<i>Bluetooth</i> BR/EDR/HS Technology	<i>Bluetooth</i> Low Energy Technology
Radio Frequency	2.4 GHz ISM	2.4 GHz ISM
Range	10 to 100 meters	10 to 100+ meters
Data Rate	1-3 Mbps (Classic) >400 Mbps (AMP, 802.11n)	1 Mbps
Nodes/Active Slaves	7 / 16777184	Unlimited
Security	56b E0 (classic)/128b AES (AMP) and applications layer user defined	128b AES and application layer user defined
Robustness	Adaptive frequency hopping, FEC	Adaptive frequency hopping
Latency (from non connected state)	100ms	<3ms
Regulatory Acceptance	Worldwide	Worldwide
Voice Capable	Yes	No
Network Topology	Scatternet	Star-bus
Power Consumption	1 as the reference, x10 for AMP	0.01 to 0.5 (use case dependent)
Service Discovery	Yes	Yes

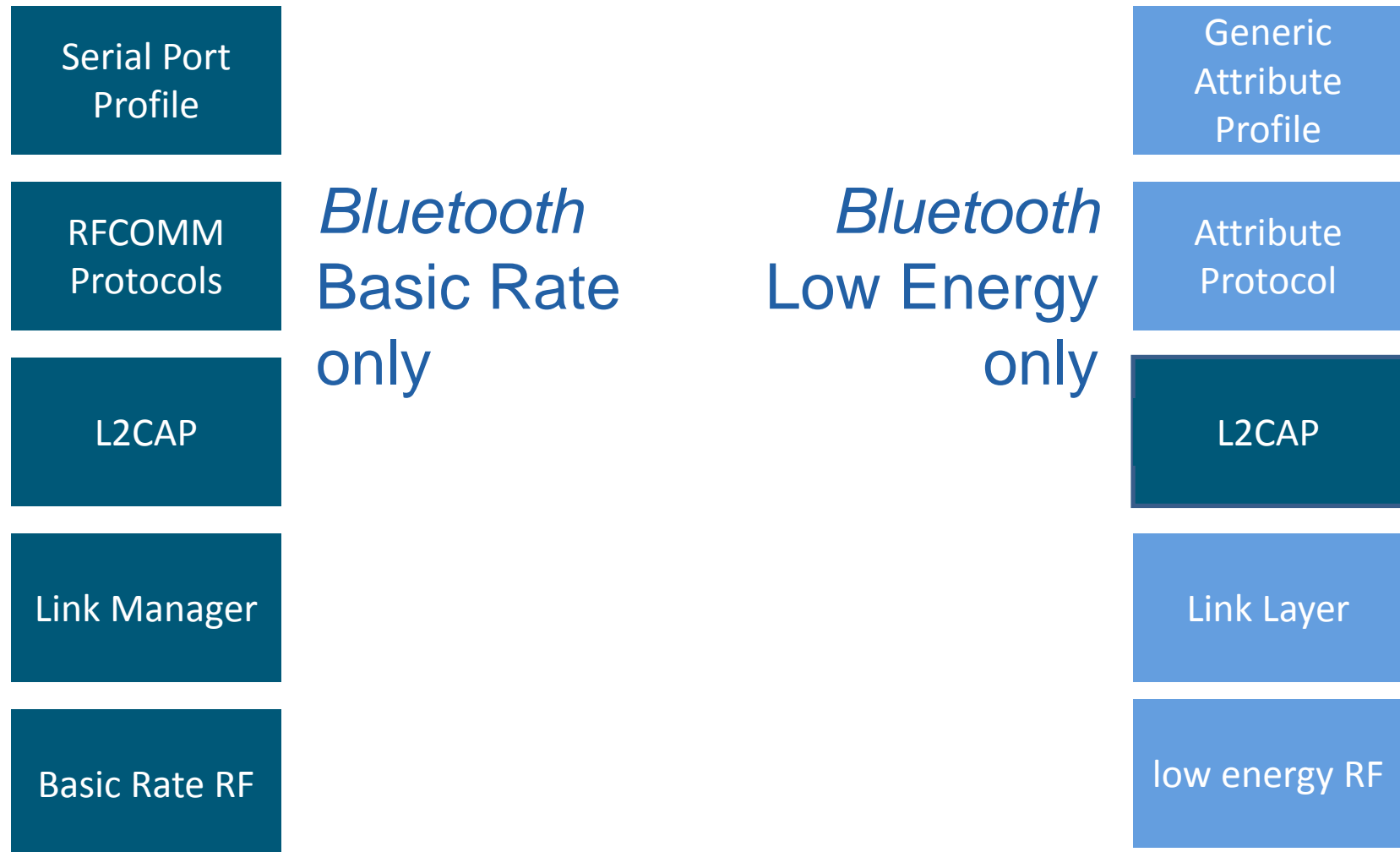
Bluetooth Architecture



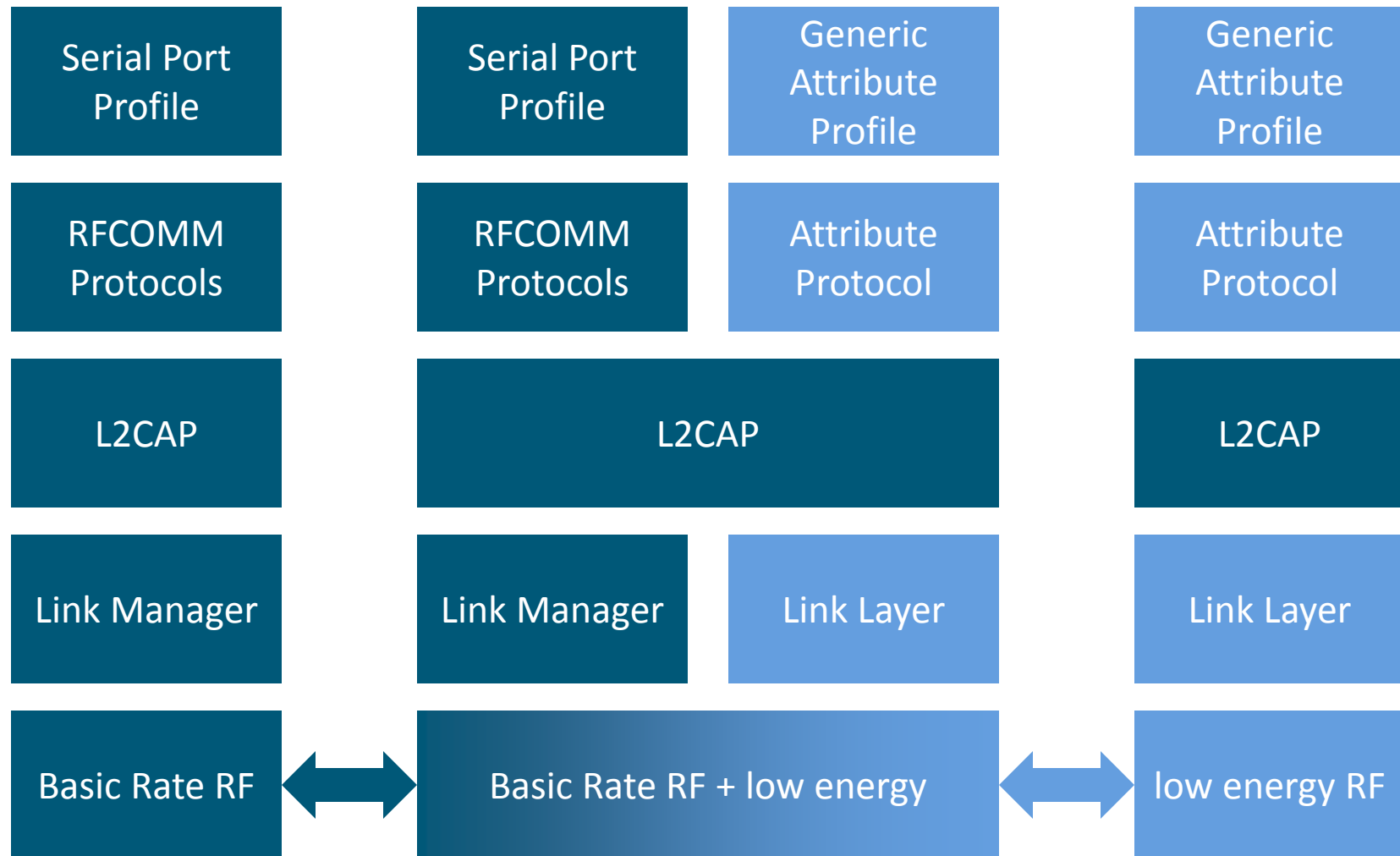
Bluetooth Technology Block Diagram



BR Only and LE Only Architecture



BR/EDR/LE Architecture



Bluetooth Technology Basics

Basic Rate / Enhanced Data Rate / High Speed



Bluetooth BR/EDR Radio (Time)

- **Time is divided into 625 uS “slots”**
- **Data is exchanged via “Packets” lasting one or more slot**
 - Packets consists of Access Code, Header and Payload
 - EDR introduced Guard, Sync and Trailer
- **Two types of data exchange “mode”**
 - Asynchronous Connection-oriented logical transport (ACL)
 - Synchronous Connection-oriented link (SCO), Enhanced SCO (eSCO)

Bluetooth BR/EDR Discovery

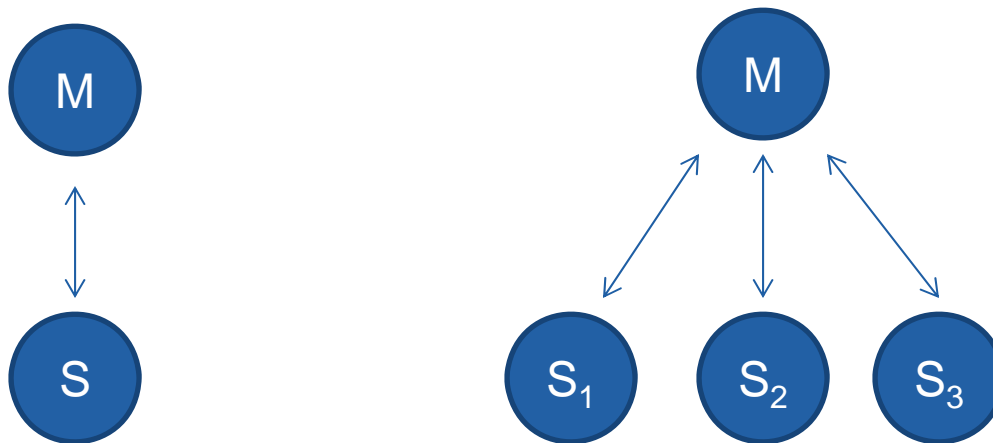
- **One device “looks” for others (Sends ID Packets)**
- **One or more other devices listens (Discoverable)**
 - When acceptable packet is received, replies
- **“Searching” device may continue with this device or continue looking**
- **When desired device is found, connection process begins**

Bluetooth BR/EDR Connection Establishment

- **One device initiates connection**
- **Other device has to be willing to accept a connection**
- **Initiator “pages” the desired device using an ID packet derived from the LAP of the desired device**
- **Once listening device hears the ID packet with it’s address, it replies**

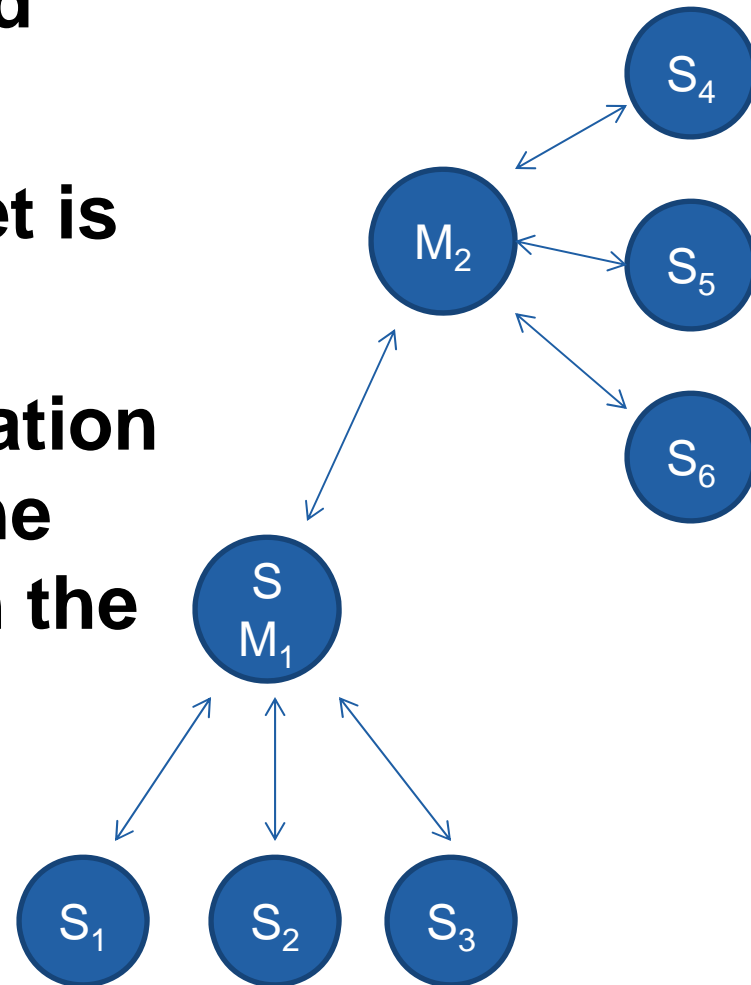
Piconet

- **One Master and up to 7 active slaves**
- **Master controls communication**
- **No slave-to-slave communication**
- **Master has to ensure not to “starve” slaves**



Scatternet

- Two (or more) “joined” piconets
- Master of one piconet is slave in another
- No direct communication between slaves in one piconet with those in the other



Interference Management

- **Adaptive Frequency Hopping (AFH)**
 - Designed to reduce interference between wireless technologies sharing the 2.4 GHz spectrum
 - Works within the spectrum to take advantage of the available frequency
 - Detects other devices in the spectrum and avoids frequencies in use
- **Provides users with optimal transmission performance even if utilizing other technologies within the same spectrum**

Bluetooth Channels – SCO & eSCO

- **Synchronous Connection Oriented (SCO)**
 - Used for voice data
 - Utilized reserved timeslots with no retransmission but may use forward error correction
 - Four packet types (all single slot): HV1, HV2, HV3, and DV
- **Enhanced SCO (eSCO) adds retransmissions**
 - BR packet types: EV3 (1 slot), EV4 and EV5 (3 slot)
 - EDR packet types: 2-EV3 (1 slot), 2-EV5 (3 slot), 3-EV3 (1 slot), 3-EV5 (3 slot)

Bluetooth BR/EDR Channels - ACL

- **Asynchronous Connection-Less (ACL)**
 - Used for data connections
 - Throughput is best-effort and is impacted by other factors like the number of devices in the piconet
 - Packets
 - DM1: 1 slot, 18 bytes with FEC and CRC
 - DH1: 1 slot, 28 bytes no FEC with CRC
 - AUX1:1 slot, 30 bytes no CRC
 - DM3: 3 slots, 123 bytes with FEC and CRC
 - DH3: 3 slots, 185 bytes no FEC with CRC
 - DM5: 5 slots, 341 bytes with FEC with CRC
 - DH5: 5 slots, 226 bytes no FEC with CRC

Bluetooth BR/EDR Power Classes

- **Three Power Classes:**
 - Class 1: 0dBm to +20dBm (1mW to 100mW)
 - Class 2: -6dBm to +4dBm (250μW to 2.5mW)
 - Class 3: <0dBm (<1mW)
- **Power classes can be used to estimate approximate range:**
 - Class 1: 100 Meters
 - Class 2: 10 Meters
 - Class 3: <10 Meters

Bluetooth High Speed Technology

- **Leverages existing radio technology**
 - 802.11 a,b,g,n
 - Backward compatible with legacy Bluetooth devices
- **It's Bluetooth wireless technology, only faster**
 - Consumers benefit from enhanced data rates without changing the way they utilize Bluetooth technology today
- **Leverages existing 802.11 device capabilities**

Bluetooth Technology Basics

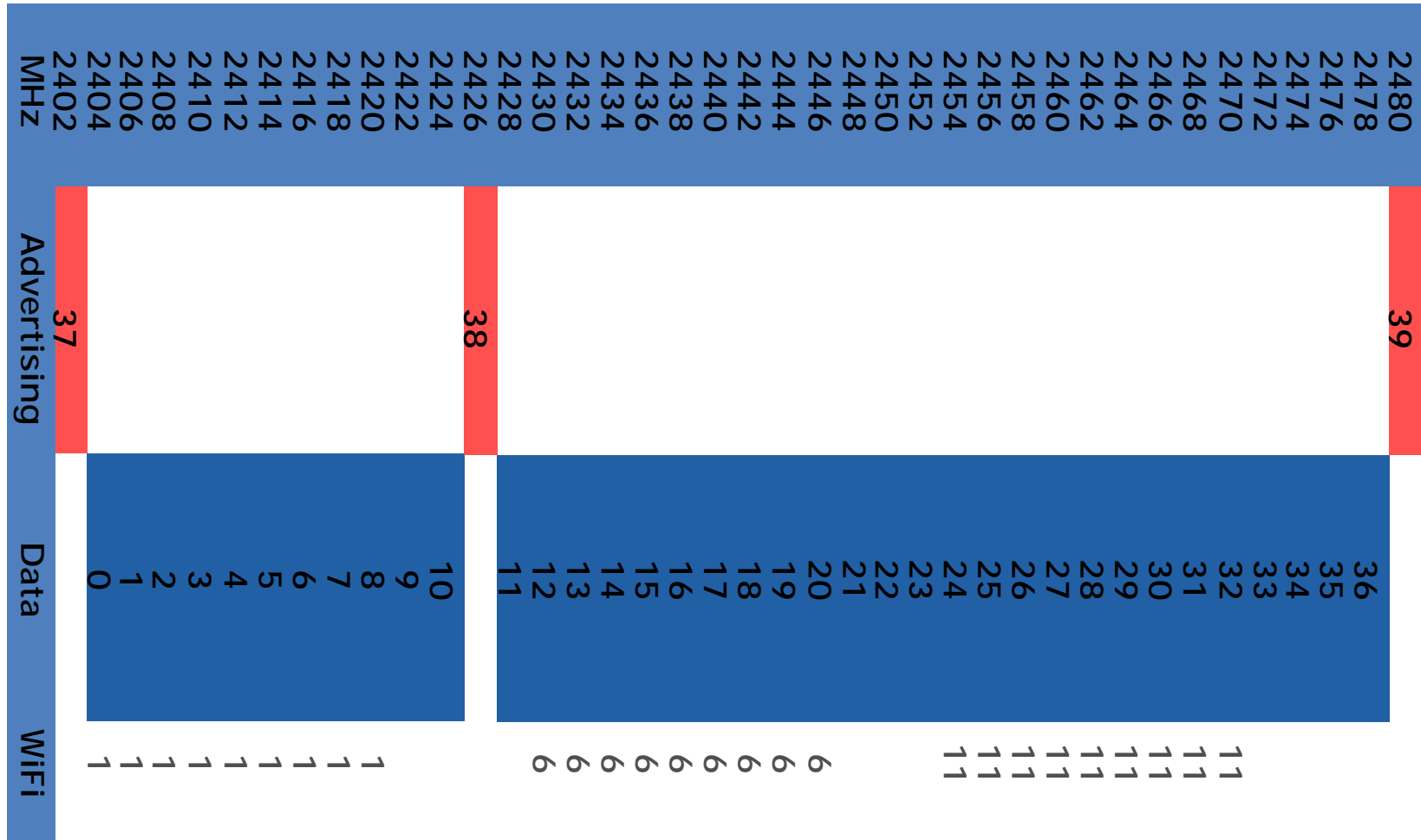
Low Energy



Physical Channels

- **ISM band split into 40 channels of two types**
 - Advertising Channels
 - Data channels
- **Advertising Channels**
 - Frequencies: 2402 (37), 2426 (38), 2480 (39)
 - Usage
 - Discovering devices
 - Initiating a connection
 - Broadcasting data
- **Data Channels**
 - Frequencies: 2404-2424 (0-10), 2428-2478 (11-36)
 - Usage: Communicating between connected devices

Bluetooth Low Energy Frequency Plan



Lower guard band of 2MHz, upper guard band of 3.5MHz

L2CAP Channel Types

- **Higher Level Protocol Multiplexing**
- **Packet Segmentation and reassembly**
- **L2CAP in Bluetooth low energy operates in Basic Mode**
 - Offers only fixed channel types

Channel Type	Local CID (sending)	Remote CID (receiving)
Attribute Protocol	0x0004 (fixed)	0x0004 (fixed)
Signaling	0x0005 (fixed)	0x0005 (fixed)
Security Manager Protocol	0x0006 (fixed)	0x0006 (fixed)

Generic Access Profile (GAP)

- **Defines procedures for:**
 - Discovering identities, names, and basic capabilities
 - Creating bonds
 - Exchange of security information
 - Establishing connections
- **Defines Advertising and Scan Response Data formats**
- **All profiles are built upon GAP**
- **Defines profile roles**
 - Broadcaster – sends non-connectable advertisement and never connect
 - Observer – listens to advertisement packets but never connect
 - Peripheral – Always take the role of slave
 - Central – Always take the role of master

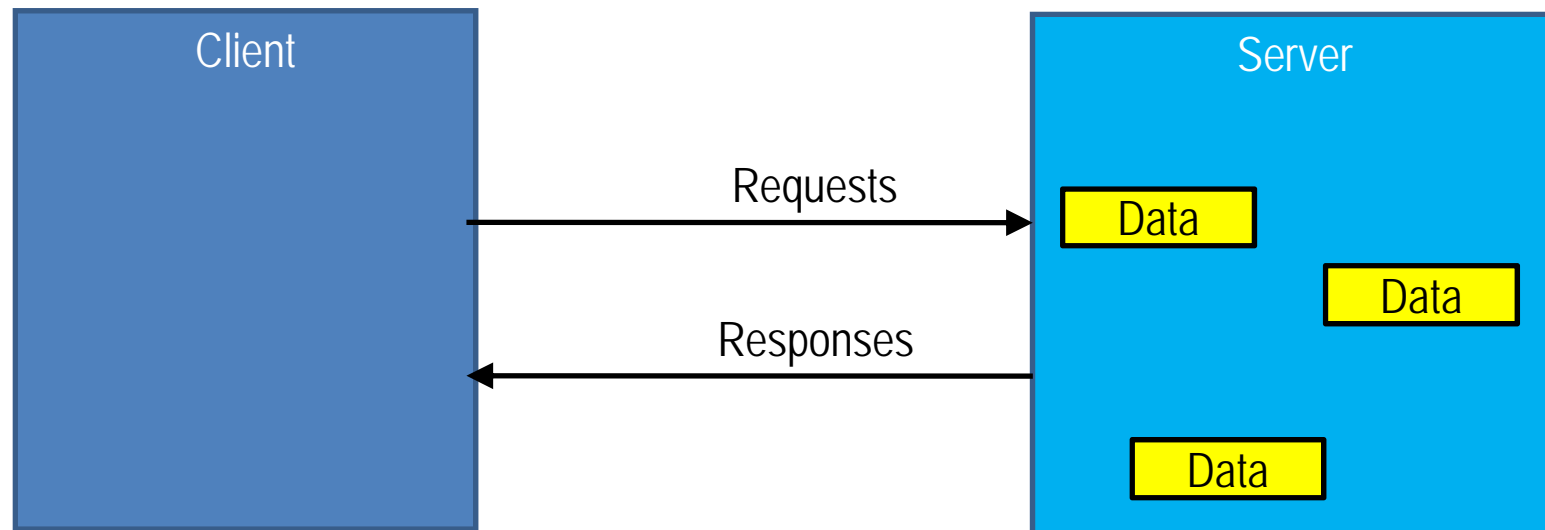
Bluetooth Technology Basics

Attribute Protocol & Generic Attribute Profile



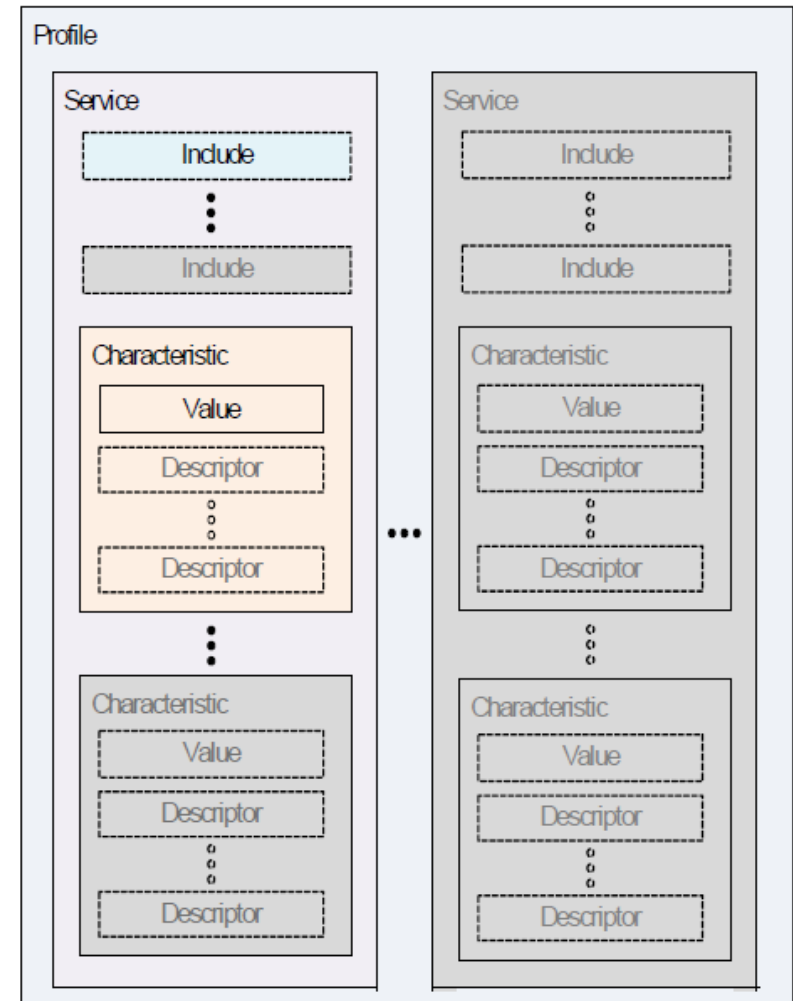
Attribute Protocol (ATT)

- **Client Server Architecture**
 - servers have data
 - clients request data to/from servers
- **Servers expose data using Attributes**



Generic Attribute Profile (GATT)

- Built on top of ATT
- Provides a framework for developing profiles
- A profile is composed of one or more services
- A service is composed of characteristics or references to other services
- Each characteristic contains a value and may contain optional information about the value



GATT-Based Profile Specifications

- **Profile specifications**
 - Use case
 - Behaviors
 - Discovery Procedures
 - Connection Parameters (slave latency, conn Interval) etc
 - Profile Roles
- **Service specifications**
 - Characteristics (Mandatory, Optional)
 - Characteristics Properties (Broadcast, Control Point etc)
- **Characteristics specifications**
 - Specify structure of value – Eg: Alert Level – 1 byte
 - Permissible values – Eg: 0 – No Alert, 1 – Medium Alert, 2 – High Alert
 - Permissions – Read/Write

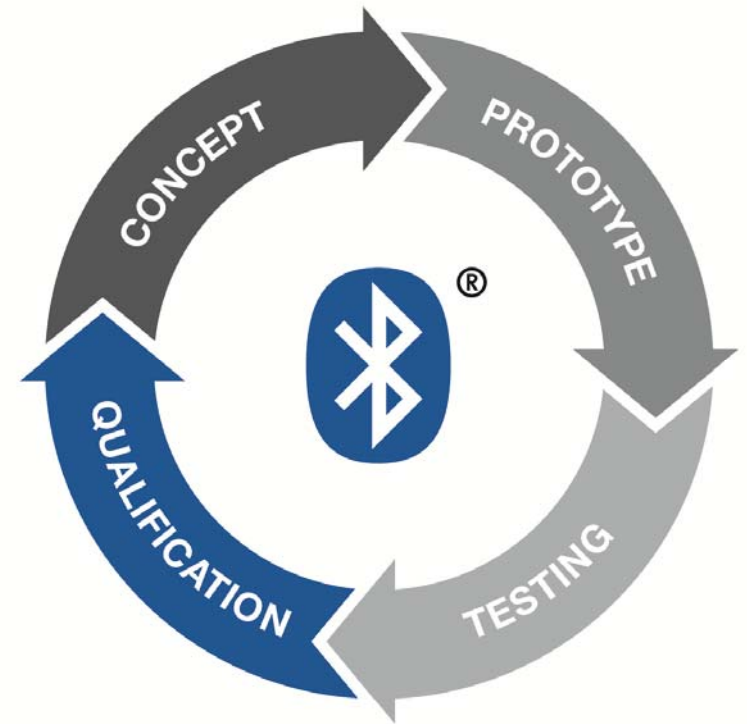
Test, Qualify, Branding Your Product

Testing and Qualifying your Design and Branding your Product



Four Phases of Product Development

- **Concept:** Learn about the technology and process
- **Prototype:** Build a design based on your concept
- **Testing:** Test your prototype for compliance
- **Qualification:** List your design and product, declare compliance. IP license protection and Brand use.



Testing Requirements Overview

- **Implementation Conformance Statement (ICS)**
 - Defines structure for the selection of mandatory and optional features implemented in a Bluetooth design
- **Test Specification**
 - Defines test structures, sequence charts and procedures for specification conformance and interoperability testing of Bluetooth designs
 - Test Case Mapping Table maps test cases to specific ICS items and features
- **Test Case Reference List (TCRL)**
 - Specifies the category and required Test Platform to perform each test case

Qualification Phase

- **Qualification: List your design and product, declare compliance. Obtain IP license protection and Brand/logo use.**
- **Process:**
 - Obtain a QD ID (anytime)
 - Complete test plan
 - Upload test results
 - Match TPG project to QD ID
 - Complete Compliance Folder
- **Qualified Design Listing (QDL)**
- **Product Listing (EPL)**
- **Attend Qualification & Testing session for more information**

SMART Core Configuration Requirements

- Requirement: Low Energy Core Configuration (CC)

LE Host CC
GATT
ATT
GAP
SM
L2CAP

LE Controller CC
LL
RF PHY



SMART READY Core Configuration Requirements

- Requirement: BR/LE Combined Core Configuration (CC)

BR and LE Combined Host CC
GATT
ATT
GAP
SM
SDP
L2CAP
BR and LE Combined Controller CC
LL
RF PHY
LMP
BB
RF

