

# Bluetooth Low Energy – Growth Segments are Pushing Lower Power Requirements for Battery Powered Devices

Charles Dittmer, Low Power Wireless IP  
Product Marketing Manager – Sr Staff  
Synopsys ARC<sup>®</sup> Processor Summit 2022



# Agenda

- How we got here – Why Bluetooth Low Energy?
- Key growth segments & applications – What's driving BLE adoption
- It's all about Battery Life: Design considerations
- Future BLE Enhancements

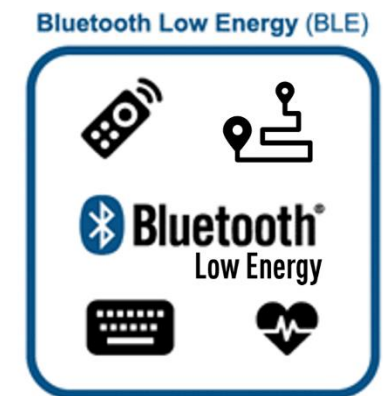
# Bluetooth Past & Present

## Bluetooth Classic:

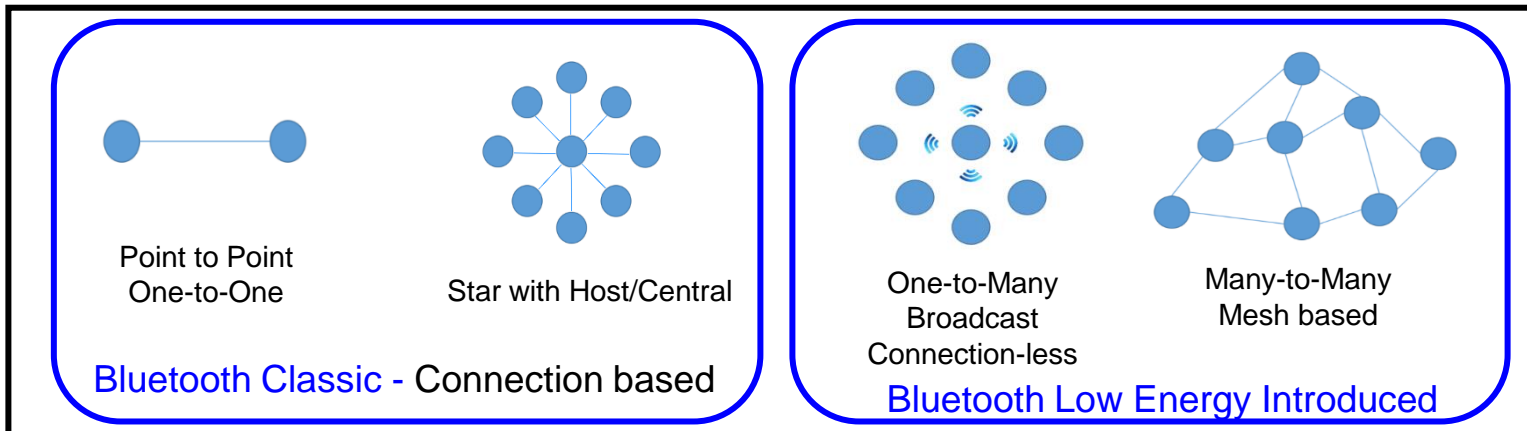
- Historically supported Audio and PC Peripherals
- Battery life in hours/days

## Bluetooth Low Energy:

- Battery life in months/years – Radio is OFF most of the time
- Introduced the concept of connection-less communications
  - Advertising, Beacons, Broadcasting
- Since 2014, Bluetooth SIG enhancements have been focused on BLE



## Network Topologies



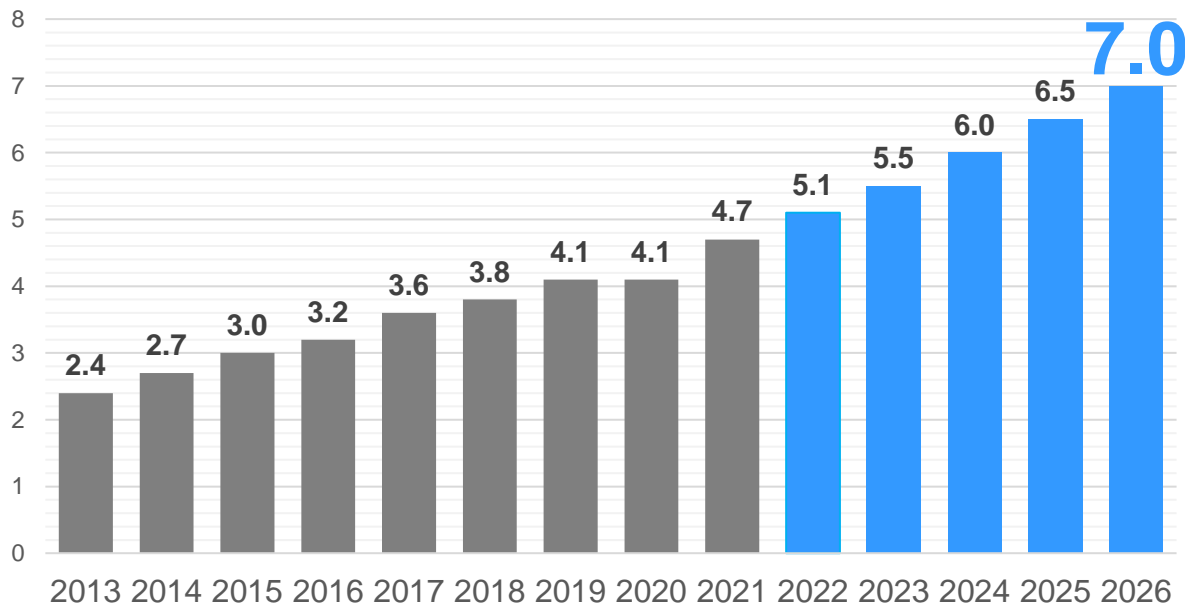
Bluetooth Specification	Release
Bluetooth Classic 1.0 BR	1999
Bluetooth Classic (2.1 + ERD)	Jul 2007
Bluetooth Classic (3.0 + HS)	Apr 2009
<b>Bluetooth 4.0 – Low Energy intro</b>	<b>Jul 2010</b>
Bluetooth 4.2 (BLE Spec)	Dec 2014
Bluetooth 5 (BLE Spec 2Mbps, LR)	Dec 2016
Bluetooth 5 w/Mesh (BLE Spec)	July 2017
Bluetooth 5.1 (Direction Finding)	Jan 2019
<b>Bluetooth 5.2 (BLE Spec - LE Audio)</b>	<b>Dec 2020</b>
Bluetooth 5.3 (BLE Spec)	July 2021

# Bluetooth Market Growth

- The Bluetooth SIG/ABI Research forecasting a unit shipment CAGR of 9% (2022-2026)
- Many other market research firms are reporting Bluetooth CAGR of 11-15%

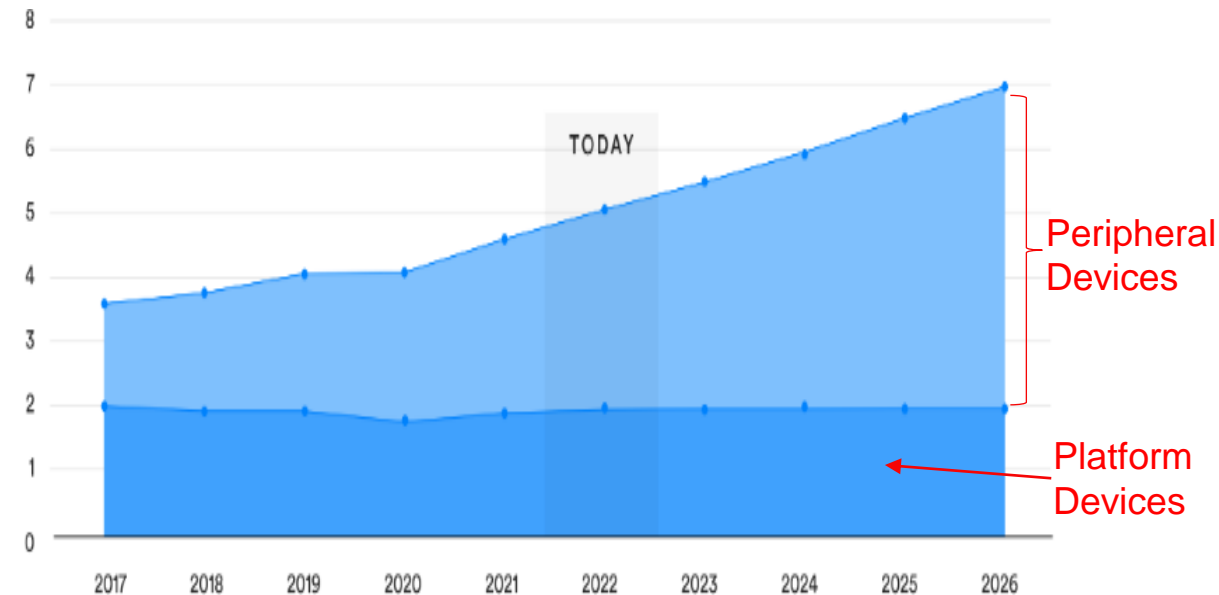
- BLE alone is expected to more than triple
- Growth of Platform Devices (PC, Tablet Phone) is flat.
- Peripherals will account for 72% of all shipments.

Total Annual Bluetooth® Shipments  
Numbers in Billions



Source: ABI Research/BT SIG

Bluetooth® Shipments Platform vs. Peripheral  
Numbers in Billions



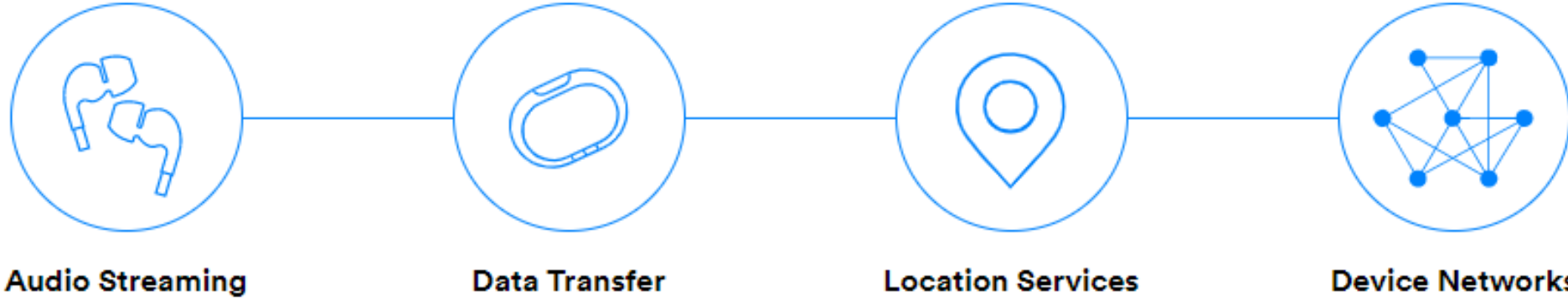
Source: ABI Research/BT SIG

# BLE Market Segmentation & Applications



# Bluetooth Market/Application Segmentation

As defined by the Bluetooth SIG (2022 Market Update @ bluetooth.com)



Source: ABI Research / BT SIG

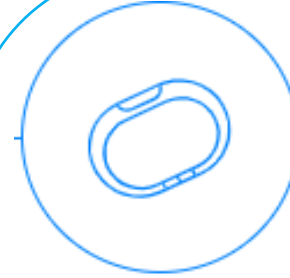
# Segment Use Cases



## Audio Streaming (CAGR = 7%)

- Wireless Headsets (Hearables in many forms)
  - 3x growth in earbuds by 2026, 2.6x in overall hearable shipments
- Wireless Speakers (Bluetooth is now in nearly all wireless speakers)
  - Migrating from BT Classic to Bluetooth Low Energy
- In-Car Systems
  - Infotainment, Hands-free

(\*) Significant growth for BLE as many legacy Bluetooth Classic products are migrating to BLE



## Data Transfer (CAGR = 12 %)

- Sports & Fitness (Wearables) (Migrating to BLE)
  - Fitness trackers, Smart Watches
- PC Peripherals & Accessories
  - HID: Keyboards, Mice, Trackballs (Migrating to BLE)
- Health & Wellness
  - Remote Heart rate & Blood pressure, Glucose monitoring
- Electronic Shelf Labels
  - Dynamic Pricing, Proximity
- Device Provisioning/Access for other wireless devices
  - Switches, Door Locks, Utility meters, etc.

# Segment Use Cases



## Location Services (CAGR = 25%)

- Asset tracking: Real-time Location Systems (RTLS):
  - People, Work site tools, Hospital: Medical devices & Patients
- Indoor Navigation: Indoor Position System (IPS).
- Proximity Services:
  - Visitor navigation: Airports, Malls, Museums, Stadiums
  - Points of Interest, Proximity Marketing
- Digital keys: Secure entry via cell phone:
  - Car, Home, Office Buildings, Hotels
- Personal Item Finding:
  - Tags for keys, wallets, Purses, etc.



## Device Networks (CAGR = 20%)

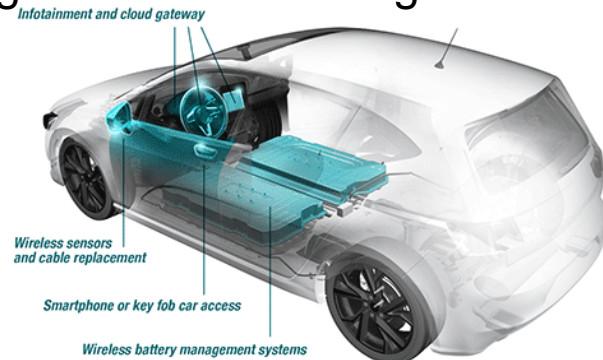
- Control Systems Mesh Networks
  - Lighting, Commercial Building Automation (CAGR 76%), Smart Home (Lighting, Appliance, Thermostats, Door locks)
- Monitory Systems: Wireless Sensor Networks (WSN)
  - Sensor networks for Light, Temperature, Vibration, Humidity, Occupancy
- Automation Systems:
  - HVAC, Security Access, Factory control (Industry 4.0)
- Automotive:
  - eVehicle Battery Monitoring System, Tire Pressure Monitors, Other Cable replacement



# Automotive – Driving multiple BLE applications

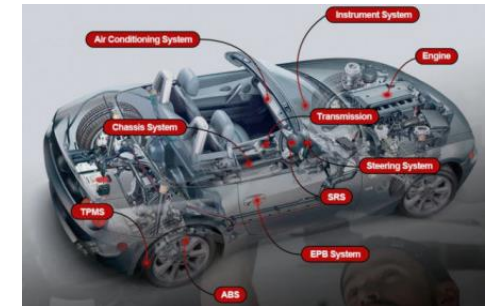
## Enabled via Central & Satellite BLE Modules in Cars

- Tire Pressure Monitoring System (TPMS)
- Battery Management Systems (BMS)
- Infotainment
- Cable Replacement
- Vehicle Servicing/Maintenance/Diagnostics
- Cloud Gateway



## Use Cases enabled by Smart Phone

- Audio Streaming, Hands Free, Navigation
- Virtual Key Access (PaaS: Phone as a Key)
- Personalization / Configuration for Occupants
- Vehicle Diagnostics (OBD2 like)
- Pilot Parking (“assisted” or “remote” Parking)
- Car Charging monitoring Apps

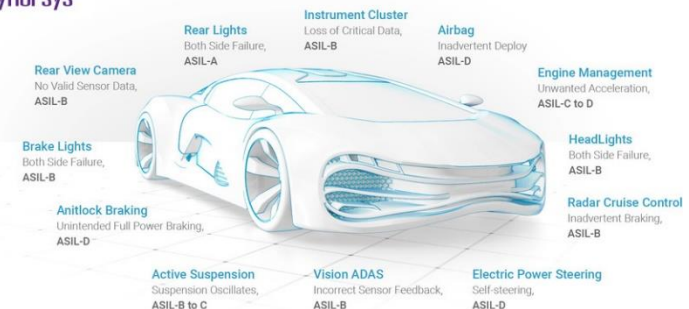


Full Car Diagnostics

## Automotive requirements for Electronic devices:

- ISO-26262 Conformance
  - FuSa Requirements (Functional Safety)
  - ASIL A-D (Automotive Safety Integrity Level)
- Increased Temperature Specs: AEC-Q100 Grade 0/1 (125 -150°C)
- Increase reliability testing: HTOL (High-Temperature Operating Life)

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# Electronic Shelf Labels (ESL)



## Market segmentation:

- Label size
- Display type: LCD, Segmented E-Paper, Full-Graphic E-Paper
  - Less the 3 inches exhibit the highest growth rate: 17% CAGR (Allied Market Research)

## Market size:

- Estimated 7000 labels in average Grocery Super Stores
  - ~64,000 Supermarkets in the US alone
  - ESL Market: 47.1% Supermarkets, 52.9% non-food retail & specialty stores

## Use Cases:

- Enable Dynamic Pricing:
  - Daily Sales, Supply price changes, Happy hour for perishable goods
- Targeted Advertising
- Location finding: LED on ESL flashes when in proximity (Based on check list from Grocery Store App.)



## ESL Product Expectations:

- >3-year battery life, Image stays on if battery dies, Easily changeable battery

# Hearables

*“The upcoming adoption of LE Audio will be the most recent in a long line of Bluetooth enhancements that have made a significant impact on wireless markets”* Mark Powell | CEO | Bluetooth SIG, Inc.

- LE Audio is driving significant growth rates due to limited battery life
- Hearables is a \$26B market in 2020 and will grow at a 14% -18% CAGR thru 2025 (IDTechEx, others)
- In addition to Audio, Wearables are becoming biosensors for heart rate, core body temperature, eye movements, head tracking, Speech reco.

## Hearables Segmentation



What do all the Bluetooth Growth Segments have in common?

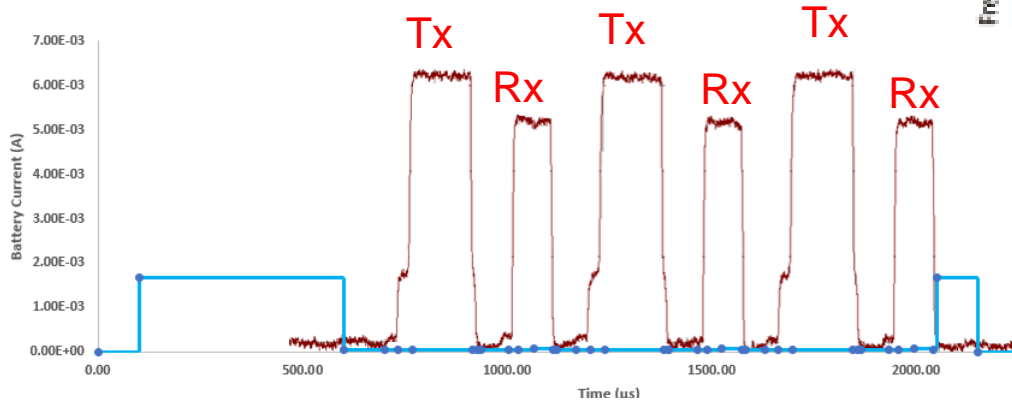
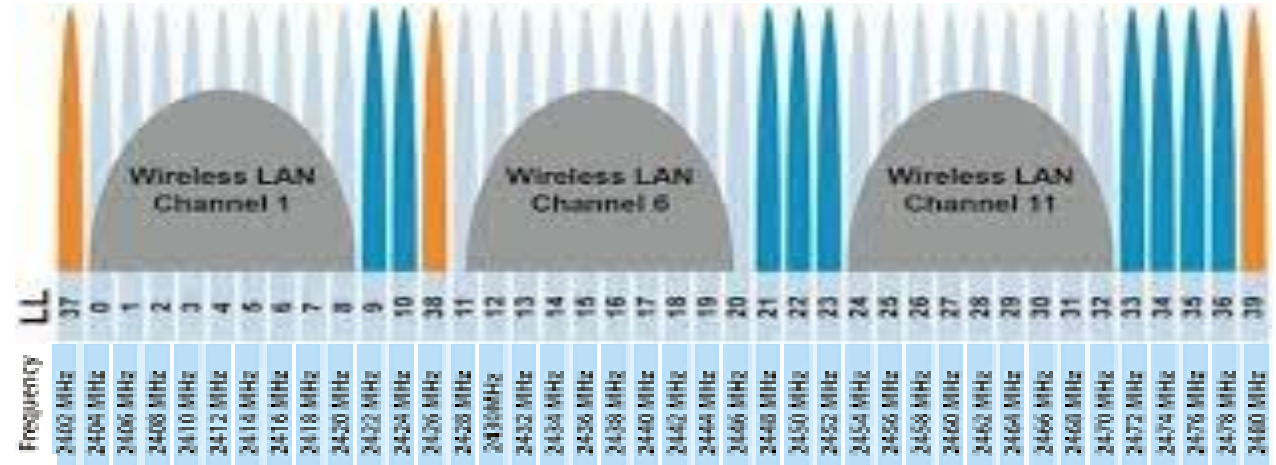


**Longer Battery Life is Essential!**

# Understanding Bluetooth Low Energy Power Consumption

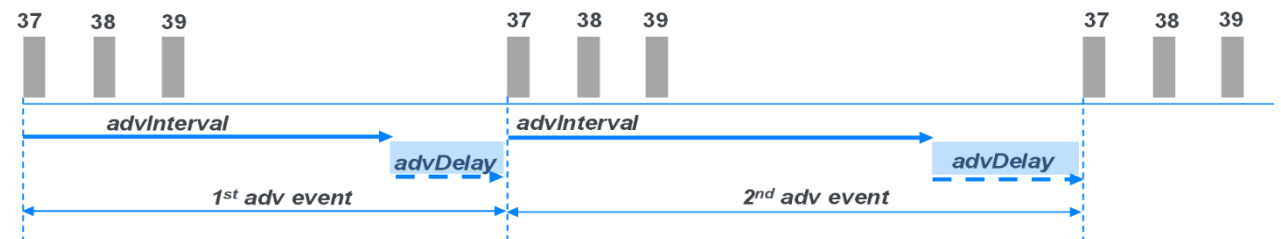
BLE turns on/off the radio very quickly. The radio is off the majority of time

3 Channels used for Advertising, Beacons, Broadcasting



Radio current draw during beacons on each of the 3 Advertising channels (Transmit and listen)

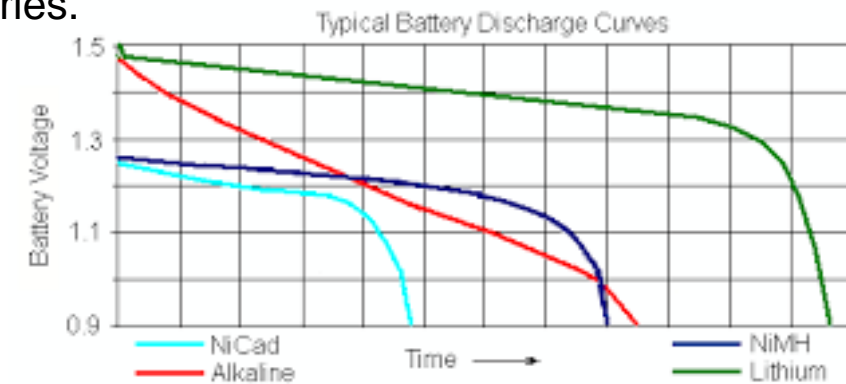
Advertising Interval: Integer multiple of 0.625 mS in the range of 20 to 10,485 mS



# Extending Battery life = Extending Product life

## Product Design Decisions:

- Trade-off between Throughput and Distance
  - Choice of PHY: 1 Mbps, 2 Mbps, Long Range (Coded PHY 125/500 Kbps)
  - Data Packet Length: Trade-off on duration on the air, Frequency of Tx, PER/retries.
- Distance is a function of both TX and RX capabilities
  - TX output power selection: 0 dBm, 6 dBm, 10+ dBm, use of external PA's.
  - Receive Sensitivity: The ability to “listen”. -96 dBm to -98 dBm is desired
- Advertising/Beacon interval requirements for your application
  - Frequency of turning on/off the radio
- Battery Selection: Chemistry types based on physical size, cost, weight vs mAH capacity & discharge/decay rates
- Power supply efficiency: SoC working voltage range (Step down from Vbat).
  - LDOs vs. Switchers
- **Selection of BLE silicon/IP - Performance**
  - TX/RX power consumption specifications will vary along with other SoC features and specifications
  - Make sure to convert from mA to mW at the RF supply voltage for apples-to-apples comparison

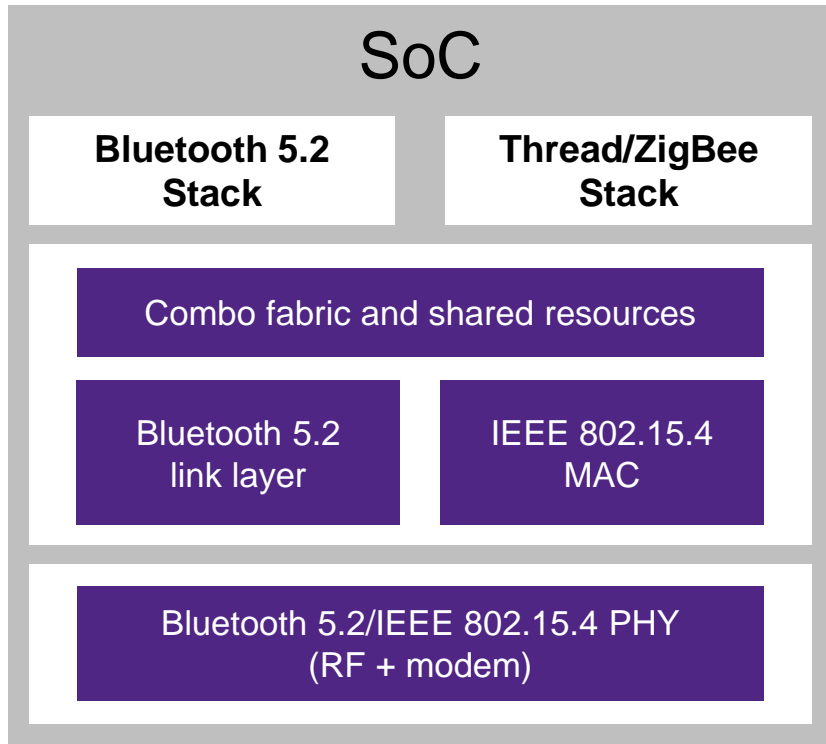


# Complete Bluetooth Low Energy / 802.15.4 IP Solution

Silicon-Proven Controller and PHY for Low-Power IoT Applications & Wireless Audio



- Compliant with Bluetooth 5.2 & Mesh; 802.15.4 for ZigBee, Thread, Matter
- LE Audio support enables new Broadcast, Audio Sharing, Wireless Stereo applications
- Integrated with 3rd-party software stacks
- DesignWare Wireless Combo PHY (BLE/802.15.4)
  - TSMC55ULPeF, TSMC40ULP, TSMC40ULPeF, TSMC22ULL
  - Low BoM cost w/ fewer external components, simplifying board design
  - Industry best power consumption, Small footprint (PPA)
- DesignWare Wireless Combo Controller (BLE/802.15.4)
  - Concurrent connectivity between BLE and 802.15.4 (Thread & ZigBee)
  - LC3 Codec IP



Supporting the new Bluetooth Low Energy standards releases in 2023

# Bluetooth Future Enhancement

*“The Bluetooth community continues to expand the capabilities of Bluetooth technology – powering innovation, creating new markets and redefining what’s possible in wireless communications”*

Quote from the Bluetooth SIG



## LE Audio

Expect additional enhancements to audio quality over BLE, supporting a wide range of hearable devices and broadcast audio applications



## Higher Accuracy Distance Measurement

From Location-Based Services to Asset Tracking to Proximity based responses, methods will be developed to not only improve distance measurements but to identify the user and their preferences



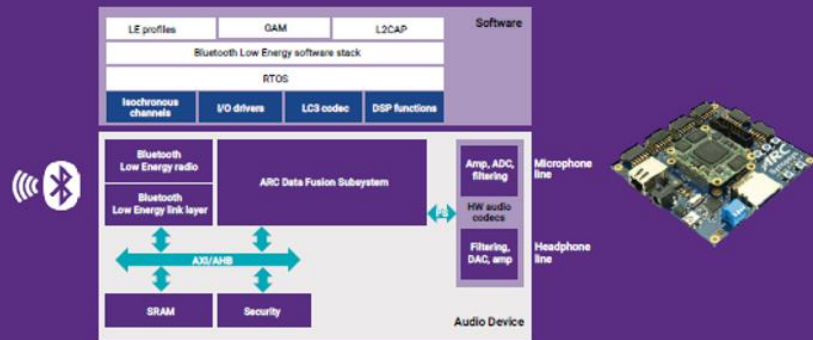
## Higher Data Throughput

Applications like gaming and AR/VR along with other applications will drive the need for higher throughput across BLE communications



# Take a look at the Low Power Wireless Demos

## Bluetooth 5.2 Audio Demo with Synopsys IP



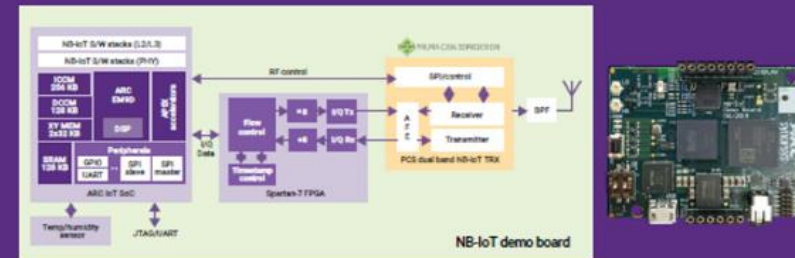
### BLE Audio provides multiple audio streams

- Auracast™ Audio Sharing
- Wireless stereo capabilities over BLE

### Synopsys IP Includes

- Bluetooth Low Energy PHY and Link Layer
- LC3 Codec
- ARC Processors

## Low-Power NB-IoT Communications



- Complete IoT communications solution (Cat-NB2) running on ARC® EM9D-based platform
- Full PHY/L2/L3 protocol stack
- Ideal for IoT wearables, industrial automation and smart energy applications