Bluetooth BR/EDR (basic rate/enhanced data rate) and Bluetooth LE (Bluetooth low energy)

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Outline

- Introduction
- Technology
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About Bluetooth

- **In 1996, Intel, Ericsson, and Nokia met to plan the standardization of this short-range radio technology to support connectivity and collaboration between different products and industries.**

- **Name**

  RadioWire or **PAN (Personal Area Networking)** or **Bluetooth?**

  "King Harald Bluetooth…was famous for uniting Scandinavia just as we intended to unite the PC and cellular industries with a short-range wireless link."

  —— Intel, Jim Kardach

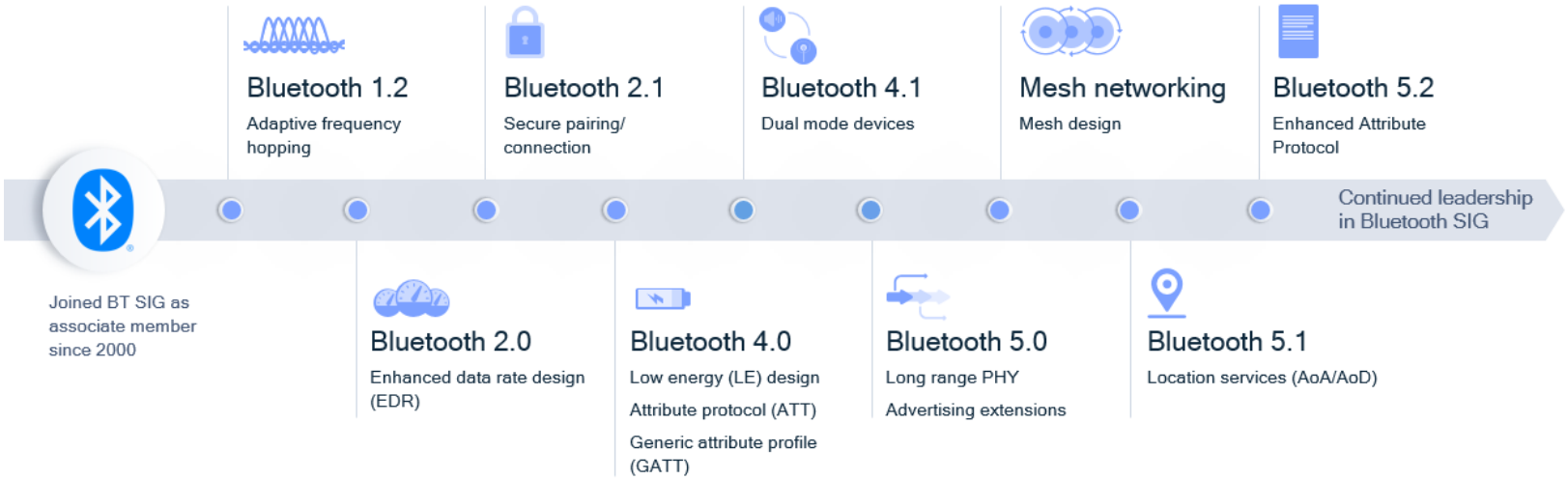
- **Logo**

  Merging Harald's initials from the Younger Futhark runes

  (Hagall) (ᚼ) + (Bjarkan) (ᛒ) =

About Bluetooth

- **In 1998, Ericsson founded Bluetooth Special Interest Group (SIG) in collaboration with Nokia, Intel, IBM, Toshiba, to bring the technology to the consumer market.**



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About Bluetooth

- **Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR)**

  a. Low power radio

  b. Streams data over 79 channels in the 2.4GHz Industrial Scientific Medical Band (ISM) band

  c. Point-to-point device communication

- **Bluetooth Low Energy (LE)**

  a. Operate in very low power

  b. Transmitting data over 40 channels in the 2.4GHz ISM band

  c. Point-to point, broadcast, and mesh divice communication

  d. Direction detection (AoA/AoD)

About Bluetooth

Bluetooth®

The global standard for simple, secure device communication and positioning

Bluetooth® Classic

Solution Areas

AUDIO STREAMING

DATA TRANSFER

Device Communication

POINT-TO-POINT

Basic Rate/Enhanced Data Rate Radio

SPECTRUM: 2.4 GHz ISM band
CHANNELS: 79 one MHz channel with Adaptive Frequency Hopping
BIT RATES: 1 Mb/s, 2 Mb/s, 3 Mb/s

Bluetooth® Low Energy

Solution Areas

AUDIO STREAMING
(COMING)

DATA TRANSFER

LOCATION SERVICES

DEVICE NETWORKS

Device Communication

POINT-TO-POINT BROADCAST MESH

Device Positioning

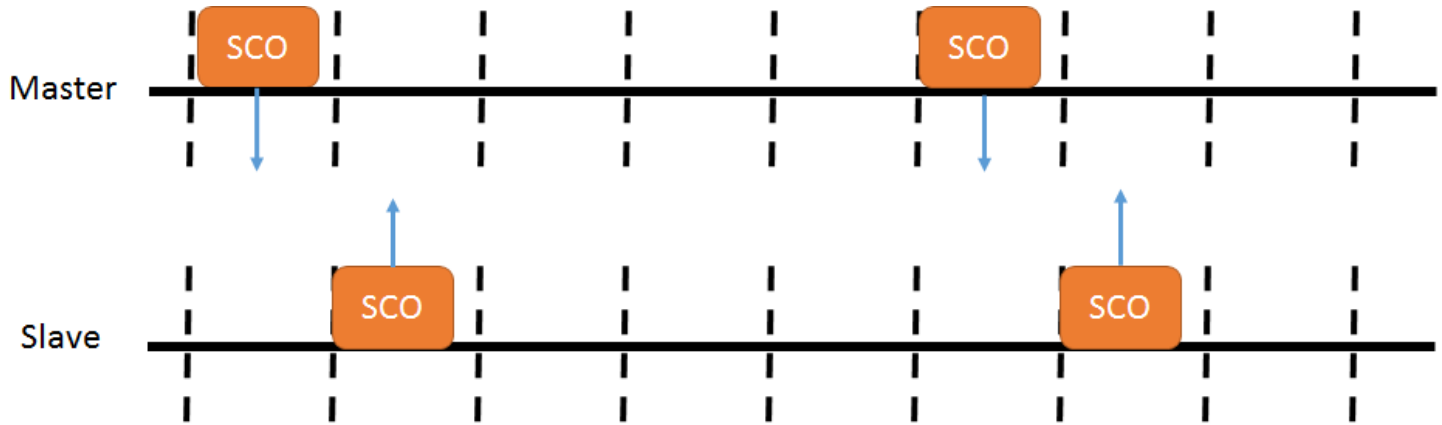
PRESENCE DISTANCE DIRECTION

Low Energy Radio

SPECTRUM: 2.4 GHz ISM band
CHANNELS: 40 two MHz channel with Adaptive Frequency Hopping
BIT RATES: 125 Kb/s, 500 Kb/s, 1 Mb/s, 2 Mb/s

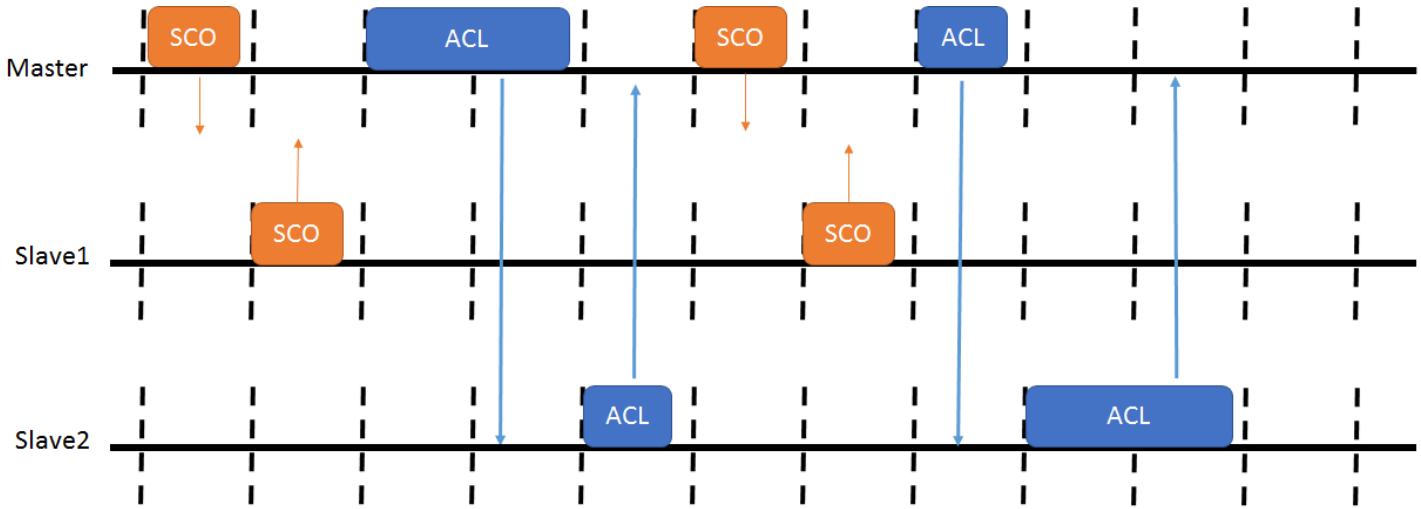
Synchronous Connection Oriented (SCO)

- A symmetric, point-to-point link between the master device and the slave device connected via Bluetooth



Asynchronous Connection-Oriented (ACL)

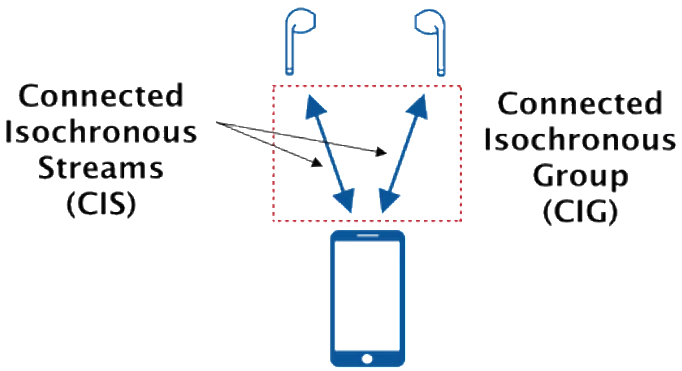
- A point to multipoint link for transmitting general data packets. It is used for irregular traffic between a master device and one or more slave devices



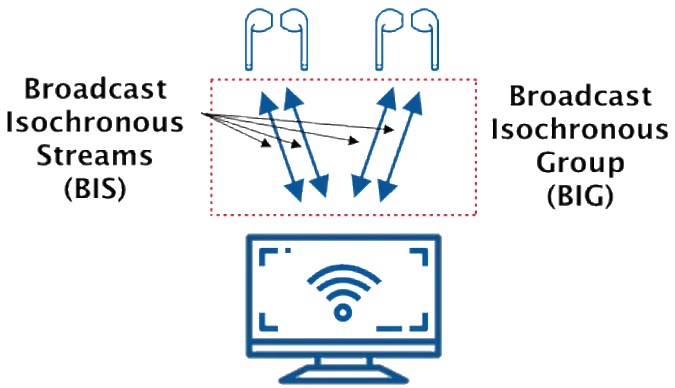
Isochronous Channels (ISOC) (LE)

- Streams that are part of the same Group share timing reference data and allow bi-directional data

Connection-oriented

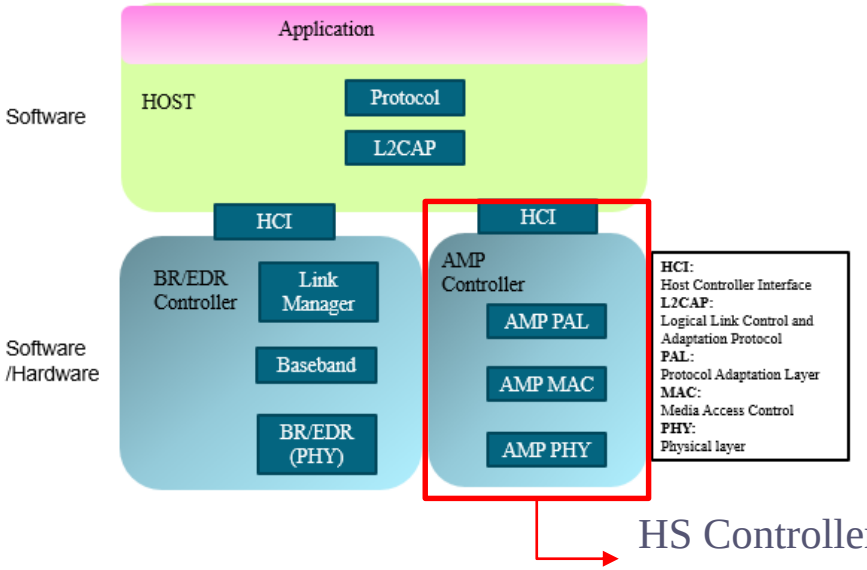


Connectionless (Broadcast)



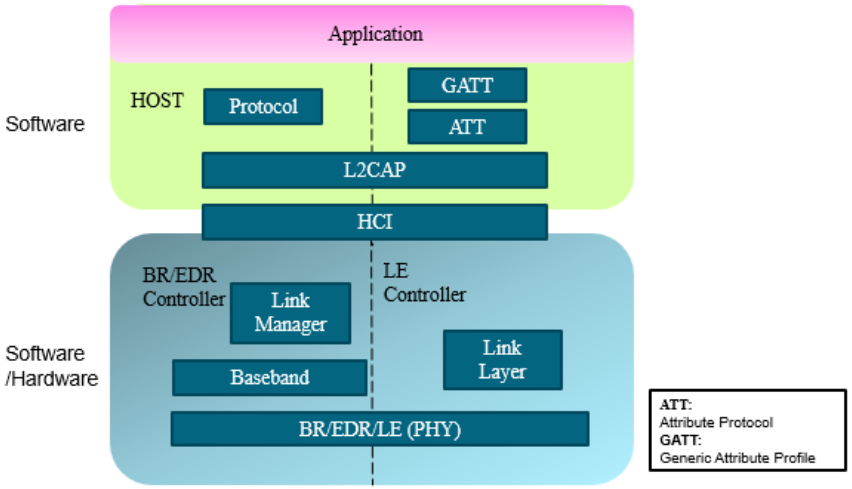
Bluetooth Protocol Stack

BR/EDR, HS(High Speed)



HS Controller
(WiFi tech architecture)

LE (Dual Mode)

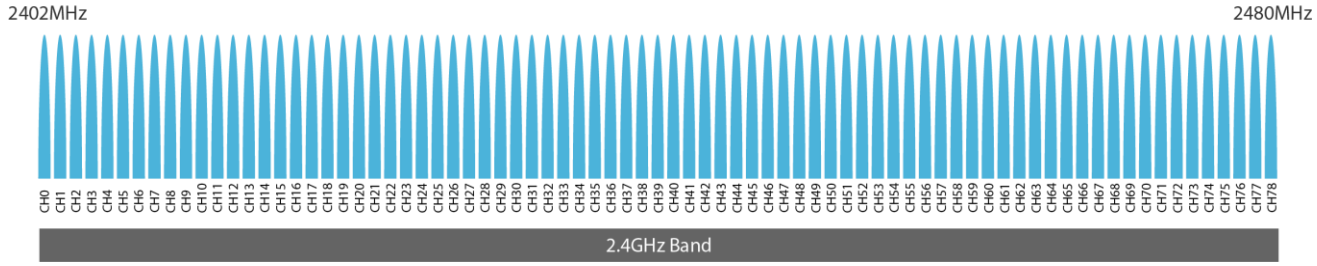


- 5 states of LE: Standby, Advertising, Scanning, Initiating, Connected

Frequency-hopping spread spectrum (FHSS)

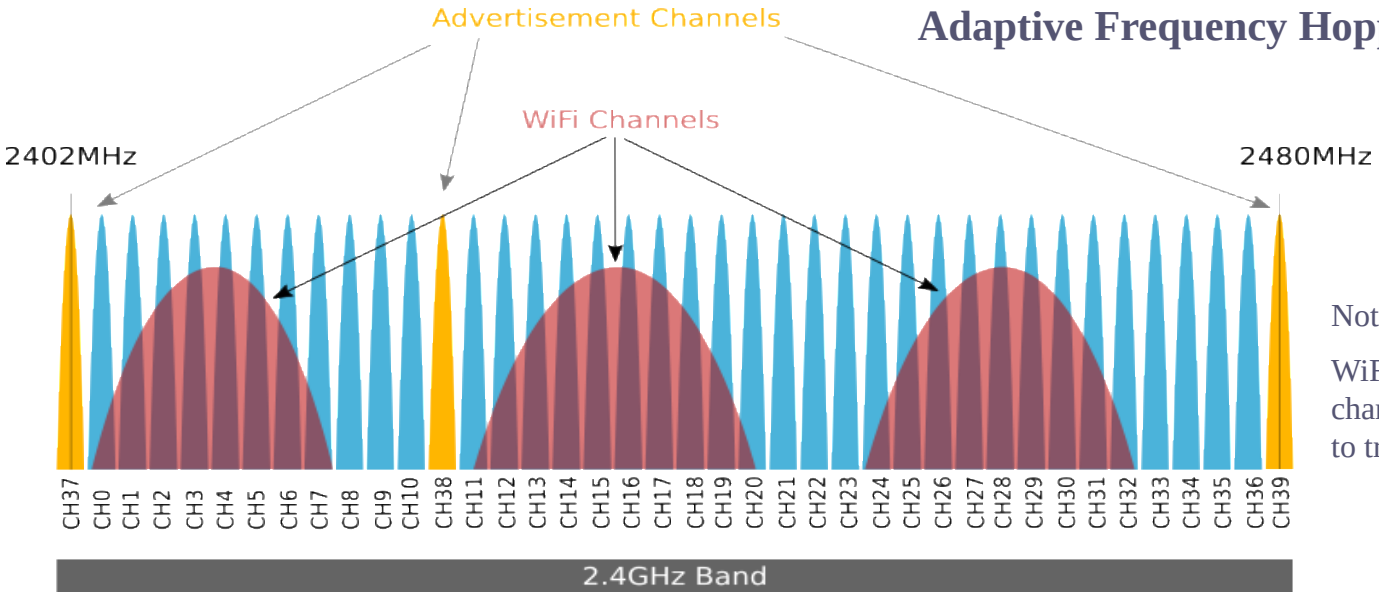
Bluetooth®

BR/EDR



LE

Adaptive Frequency Hopping(AFH)

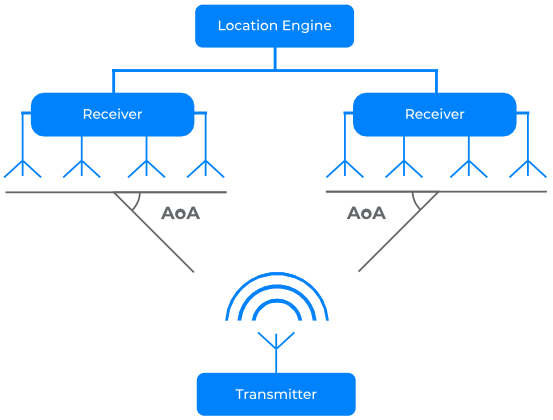


Note:

WiFi use one channel each time to transmit data

AoA and AoD in LE

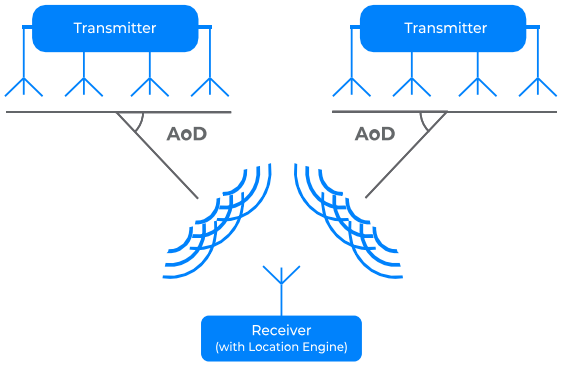
Angle of Arrival (AoA) Method



Transmitter: single antenna
Receiver: multiple antenna arranged in an array

Use Cases:
Asset Tracking, Worker Safety, Player Performance

Angle of Departure (AoD) Method



Transmitter: multiple antenna arranged in an array
Receiver: single antenna

Use Cases:
Indoor Navigation, Autonomous Guided Vehicles (AGVs)

	Bluetooth Basic Rate/Enhanced Data Rate (BR/EDR)	Bluetooth Low Energy (LE)
Frequency Band	2.4GHz ISM Band (2.402 – 2.480 GHz Utilized)	2.4GHz ISM Band (2.402 – 2.480 GHz Utilized)
Channels	79 channels with 1 MHz spacing	40 channels with 2 MHz spacing (3 advertising channels/37 data channels)
Channel Usage	Frequency-Hopping Spread Spectrum (FHSS)	Frequency-Hopping Spread Spectrum (FHSS)
Modulation	GFSK, π/4 DQPSK, 8DPSK	GFSK
Data Rate	EDR PHY (8DPSK): 3 Mb/s EDR PHY (π/4 DQPSK): 2 Mb/s BR PHY (GFSK): 1 Mb/s	LE 2M PHY: 2 Mb/s LE 1M PHY: 1 Mb/s LE Coded PHY (S=2): 500 Kb/s LE Coded PHY (S=8): 125 Kb/s
Tx Power*	≤ 100 mW (+20 dBm)	≤ 100 mW (+20 dBm)
Rx Sensitivity	≤-70 dBm	LE 2M PHY: ≤-70 dBm LE 1M PHY: ≤-70 dBm LE Coded PHY (S=2): ≤-75 dBm LE Coded PHY (S=8): ≤-82 dBm
Data Transports	Asynchronous Connection-oriented Synchronous Connection-oriented	Asynchronous Connection-oriented Isochronous Connection-oriented Asynchronous Connectionless Synchronous Connectionless Isochronous Connectionless
Communication Topologies	Point-to-Point (including piconet)	Point-to-Point (including piconet) Broadcast Mesh
Positioning Features	None	Presence: Advertising Direction: Direction Finding (AoA/AoD) Distance: RSSI, HADM (Coming)

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Application

- **Audio Streaming**

  Wireless Headsets, Wireless Speakers, In-Car Systems

- **Data Transfer**

  Sports and Fitness, Health and Wellness, PC Peripherals and Accessories

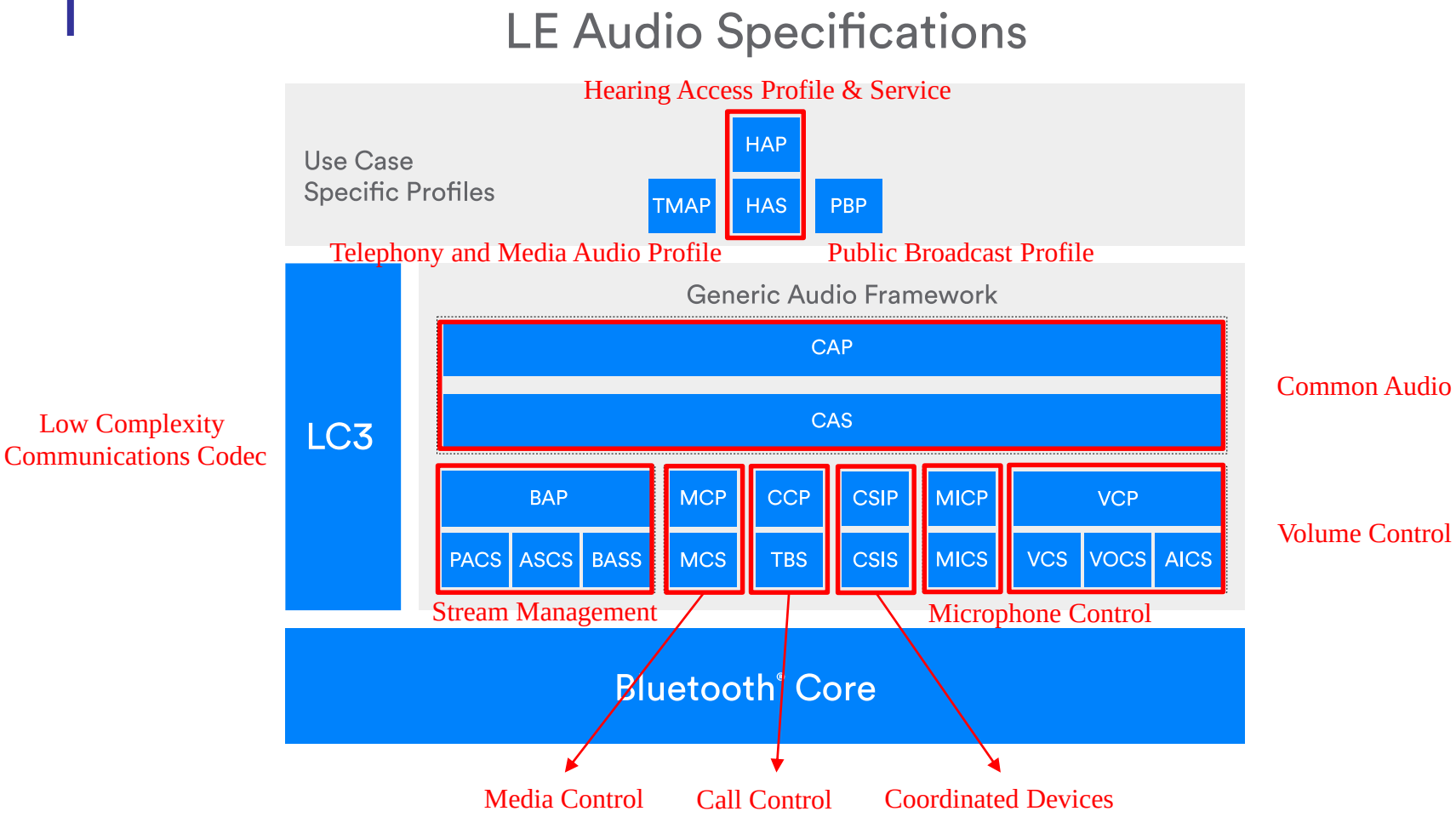
- **Device Networks**

  Control Systems, Monitoring Systems, Automation Systems

- **Location Services**

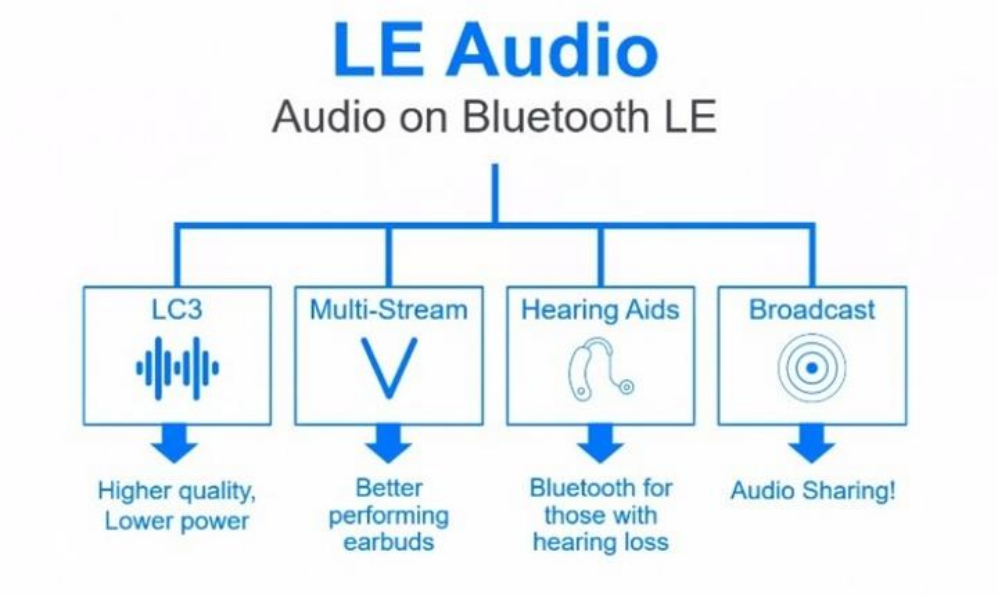
  Asset Tracking

LE Audio


LE Audio Specifications
Hearing Access Profile & Service
Use Case
Specific Profiles
HAP
TMAP
HAS
PBP
Telephony and Media Audio Profile
Public Broadcast Profile
Generic Audio Framework
LC3
CAP
CAS
BAP
PACS
ASCS
BASS
MCP
MCS
CCP
TBS
CSIP
CSIS
MICP
MICS
VCP
VCS
VOCS
AICS
Bluetooth® Core
Low Complexity
Communications Codec
Common Audio
Volume Control
Stream Management
Microphone Control
Media Control
Call Control
Coordinated Devices

LE Audio

- **Low Complexity Communications Coded (LC3):**
  - a. A new high quality, low-power audio codec
  - b. Provides high quality even at lower data rates than the standard SBC codec used in Bluetooth Classic
  - c. Supports multiple, synchronized audio data streams



Qualcomm QCC5171

ACTIVE

QCC5171

	SPECIFICATIONS
Product	QCC5171
CPU	**Architecture:** 32-bit **Clock Speed:** Up to 80 MHz **Features:** Programmable CPU
DSP	**Name:** 1x Qualcomm® Kalimba™ **Clock Speed:** 2x 240 MHz **Data RAM:** 1408 kB **Program RAM:** 384 kB **Features:** Programmable DSP
Bluetooth	**Specification Version:** Bluetooth® 5.3 Qualified **Connection Technology:** Bluetooth® Low Energy, Bluetooth® Classic **Topologies:** Qualcomm TrueWireless™ Mirroring technology **Classic Data Rate:** 3 Mbps, 2 Mbps, 1 Mbps **Low Energy Data Rate:** 1 Mbps, 2 Mbps
Interfaces	UART, I²S, I²C, 1x USB

Nordic nRF5340

nRF5340

Dual-core Bluetooth 5.3 SoC supporting Bluetooth Low Energy, Bluetooth mesh, NFC, Thread and Zigbee

	SPECIFICATIONS
Product	nRF5340
CPU	128/64 MHz Arm Cortex-M33
Memory	1 MB Flash + 512 KB RAM
Cache	8 KB 2-way set associative cache
Performance	514/257 CoreMark
Efficiency	66/73 CoreMark/mA
Wireless protocol support	Bluetooth Low Energy/Bluetooth mesh/ NFC/Thread/Zigbee/802.15.4/ANT/2.4 GHz proprietary
On-air data rate	Bluetooth LE: 2 Mbps/1 Mbps/125 kbps 802.15.4: 250 kbps
Bluetooth Low Energy	Bluetooth 5.3 LE Audio Direction Finding 2 Mbps, Advertising Extensions and Long Range
Interfaces	Full-speed USB 96 MHz encrypted QSPI 32 MHz high-speed SPI

Airoha AB1585

	SPECIFICATIONS
Product	AB1585
Host Processor (CPU)	ARM® Cortex®-M33F
DSP Processor	on Cadence® HiFi5®Audio Engine DSP coprocessor
Bluetooth	Bluetooth 5.3 BR, EDR, Bluetooth Low Energy, LE audio, Dual-mode
Flash	Embedded Flash 8MB/16MB
Power Management	Highly integration PMU Li-ion battery charger for internal charging

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S.W.O.T. Analysis of BLE

Strength

- Low Energy, extend batteries usage
- Various communication topologies
- LE Audio: high quality of audio, simple codec, lower cost

Weakness

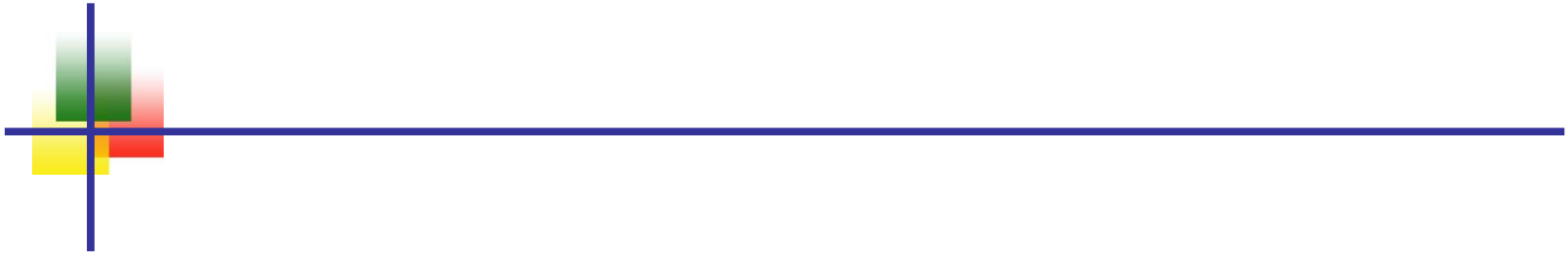
- Short range(distance) communication
- Adding extra bits to check the correctness of data

Opportunities

- Direction Finding
- Application in different field

Threats

- Improvement of other wireless technique (Ex: Wifi, Zigbee.....)
- New wireless technique



Thank you for your attention!

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- https://www.bluetooth.com/about-us/bluetooth-origin/
- https://www.allaboutcircuits.com/news/bluetooth-technology-the-slow-road-to-an-industry-standard/
- https://www.bluetooth.com/learn-about-bluetooth/tech-overview/
- https://ithelp.ithome.com.tw/articles/10241541
- https://www.argenox.com/library/bluetooth-low-energy/ble-advertising-primer/
- https://www.argenox.com/library/bluetooth-classic/introduction-to-bluetooth-classic/
- https://www.bluetooth.com/learn-about-bluetooth/recent-enhancements/direction-finding/
- https://novelbits.io/bluetooth-version-5-2-le-audio/
- https://www.techbang.com/posts/77005-with-the-benefits-of-the-new-le-audio-specification-is-the-future-true-wireless-headset-expected-to-reduce-costs-when-is-the-new-product-on-line-bluetooth-technology-alliance-answers-for-itself
- https://www.qualcomm.com/news/onq/2020/09/essential-role-technology-standards
- https://www.qualcomm.com/products/application/audio/qcc5100-series/qcc5171#Overview
- https://www.nordicsemi.com/Products/nRF5340
- https://www.airoha.com/products/p/UATZlIz8hZq3TDky