

**ESPRESSIF**

**Classic Bluetooth Basics**

Karl Wang 王孟阳  
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# Agenda

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- Introduction: Bluetooth is around us
- Bluetooth Protocol Stack
  - Stack Overview
  - Upper Layer
  - SDP and L2CAP
  - Lower Layer: PHY/RF, BB, LC and LM
  - HCI: High-Level Language to Access Bluetooth Radio
- Use a Packet Sniffer
- Summary
- References and Resources



# Introduction: Bluetooth is Around Us

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## What is Bluetooth?

- A short-range wireless communication system intended to replace cables

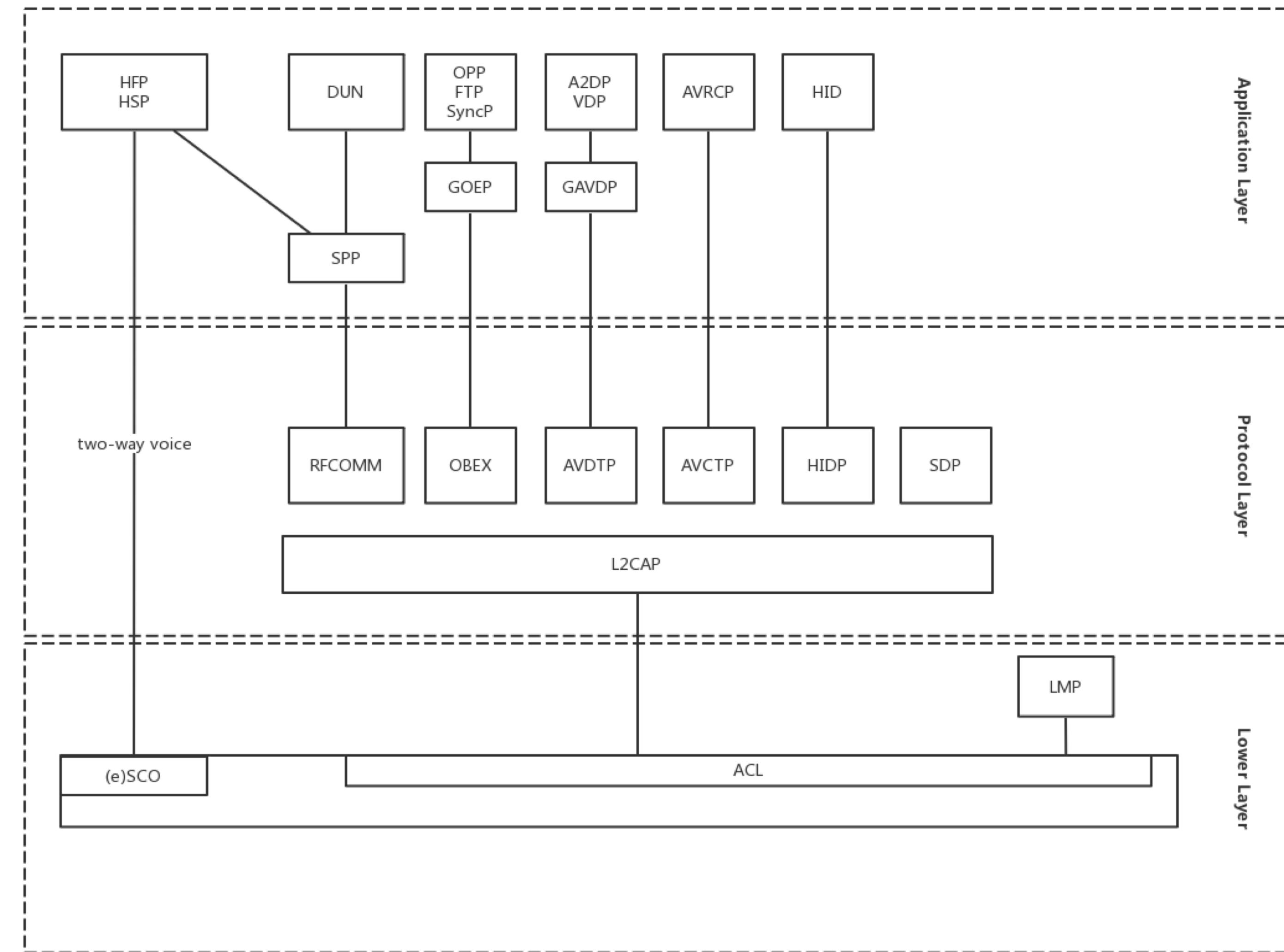
## User scenarios:

- Keyboards, mouses, joysticks: data input & remote control
- Headphones, speakers: audio and voice transmission
- Handhelds, PCs & Automobiles: file sharing
- Others: printers, sensors, etc.

Bluetooth makes personal area free of USB cables, headphone cables, serial ports and various other types of cables/IO ports.



# Bluetooth Protocol Stack Overview





# Bluetooth Protocol Stack: Concepts and Sources

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- Profiles vs. Protocols
  - A Protocol defines the message set exchanged between Bluetooth devices
  - A Profile defines how protocols are used for a specific usage model
- Upper Layer Stack
  - Many protocols to support a wide range of applications
  - Some borrowed from other organizations or standards
  - Some Bluetooth invented
  - Some hybrid



## Bluetooth Protocol Stack--Upper Layer

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- Adopted Protocols -- “Stolen with pride”
  - HIDP: originates from USB HID Specification
  - RFCOMM: uses a subset of ETSI standard GSM 07.10, provides a transport for serial port emulation
  - OBEX: Adaptation of Ir DA Object Exchange Protocol from Infrared Data Association
  - AVDTP: based on RTP Data Transfer Protocol and RTP Control Protocol from IETF RFC3550
  - AVCTP Control: based on AV/C Digital Interface Command Set with some Bluetooth Vendor Dependent extension

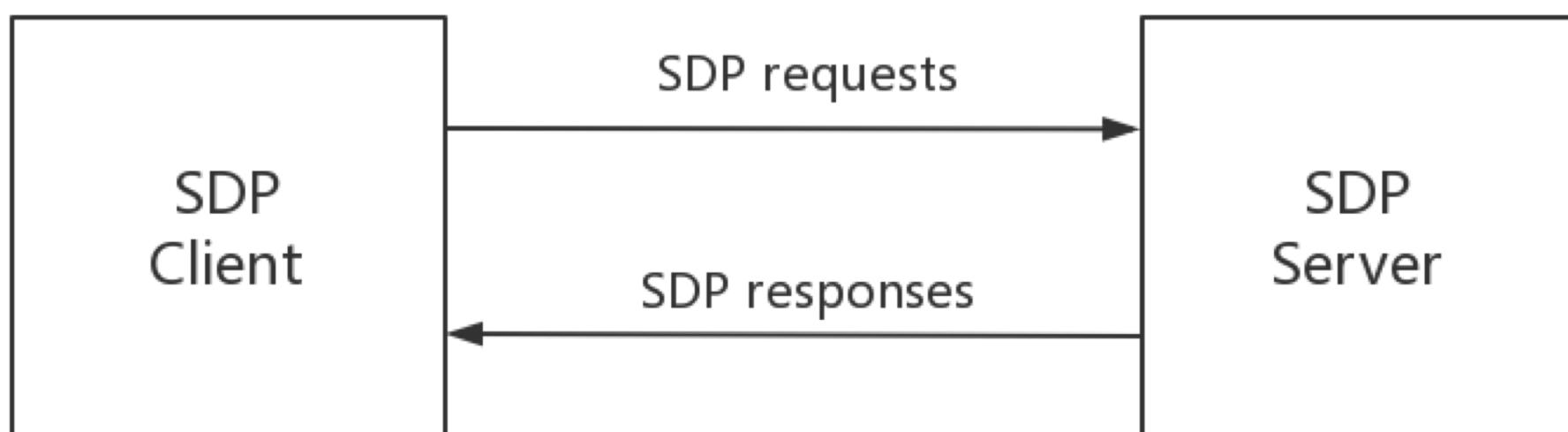


# Bluetooth Protocol Stack--SDP

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## SDP: Service Discovery Protocol

- Used for applications to discover available services and determine the features and characteristics of those services from remote device
- Client-Server Architecture





# Bluetooth Protocol Stack--SDP

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- SDP server database
- Example of a Hands-free service record

Item	Definition	Type	Value
Service Record Handle		Uint32	0x10002
ServiceClass ID List			
ServiceClass0		UUID	Hands-Free(0x111e)
ServiceClass1		UUID	Generic Audio(0x1203)
ProtocolDescriptorList			
Protocol0		UUID	L2CAP(0x0100)
Protocol1		UUID	RFCOMM(0x0003)
ProtocolSpecificParam0	Server Channel	Uint8	2
ProfileDescriptorList			
Profile0	Supported Profiles	UUID	Hands-Free(0x111e)
Param0	Profile Version	Uint16	0x0106
ServiceName	Display-able Text Name	String	“Handsfree”
Supported Features		Uint16	0x003f



# Bluetooth Protocol Stack--L2CAP

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- Logical Link Control and Adaptation Protocol
  - OSI Layer 2: Data Link Layer
  - Provides Connection-oriented and connection-less channels
  - Carries User Asynchronous(UA) and User Isochronous(UI) data
- Functionality
  - Protocol/Channel Multiplexing
  - Packet segmentation and reassembly
  - QoS admission control: bandwidth, latency, etc.
- Assumptions
  - Lower Layer provides orderly delivery of data packets
  - Lower Layer provides full-duplex communication link
  - Lower Layer provides a channel with a degree of reliability
- Different operation modes are provided that fit LE, BR/EDR and/or AMP controllers.  
For BR/EDR controller
  - L2CAP basic mode provides basic functionality for a default “best effort” service
  - Enhanced L2CAP operation modes can provide additional flow control, flushing or retransmission mechanism to fit different user scenarios



# Bluetooth Lower Layer Stack--BR/EDR radio

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## Bluetooth BR/EDR PHY and Baseband

- 2.4GHz ISM band.
- 79 hopping channels,  $f_k = (2402 + k) \text{MHz}$ ,  $k = 0, 1, 2, \dots, 78$
- modulation and bit rate
  - Basic Rate(BR): GFSK with BT = 0.5, 1Mbit/s
  - Extended Data Rate(EDR):  $\pi/4$ -DQPSK for 2Mbit/s, 8DPSK for 3Mbit/s
  - Symbol rate is 1MHz for both BR and EDR
- Frequency Hopping Spread Spectrum(FHSS)
  - Frequency hops in a pseudo-random pattern with 1600Hz hopping rate in connection state
- Time-Division Duplex(TDD)
  - divides time in 625us slots



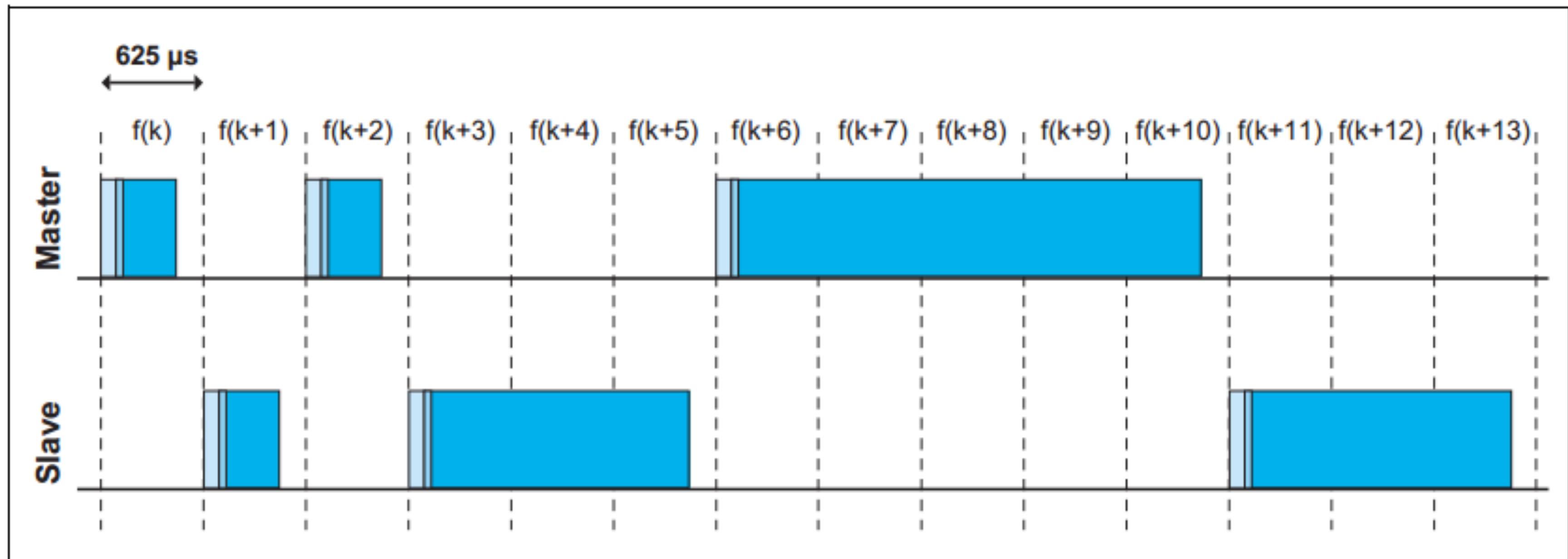
# Bluetooth Lower Layer Stack--Piconet Operation

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- Piconet: Master and 1 to 7 slaves in connection state
- To stay synchronized in a frequency hopping system, devices connected need to:
  - use the same set of hopping frequencies
  - use the same hopping sequence within the frequency set
  - be time synchronized within the hopping sequence
- In a piconet,
  - Hopping frequency set is all 79 channels for normal operation mode or a subset of it when Adaptive Frequency Hopping(AFH) is in use
  - Hopping sequence is determined by master MAC address, hopping phase is determined by master clock
  - Communication begins on new hopping frequency at the start of time slots according to master clock



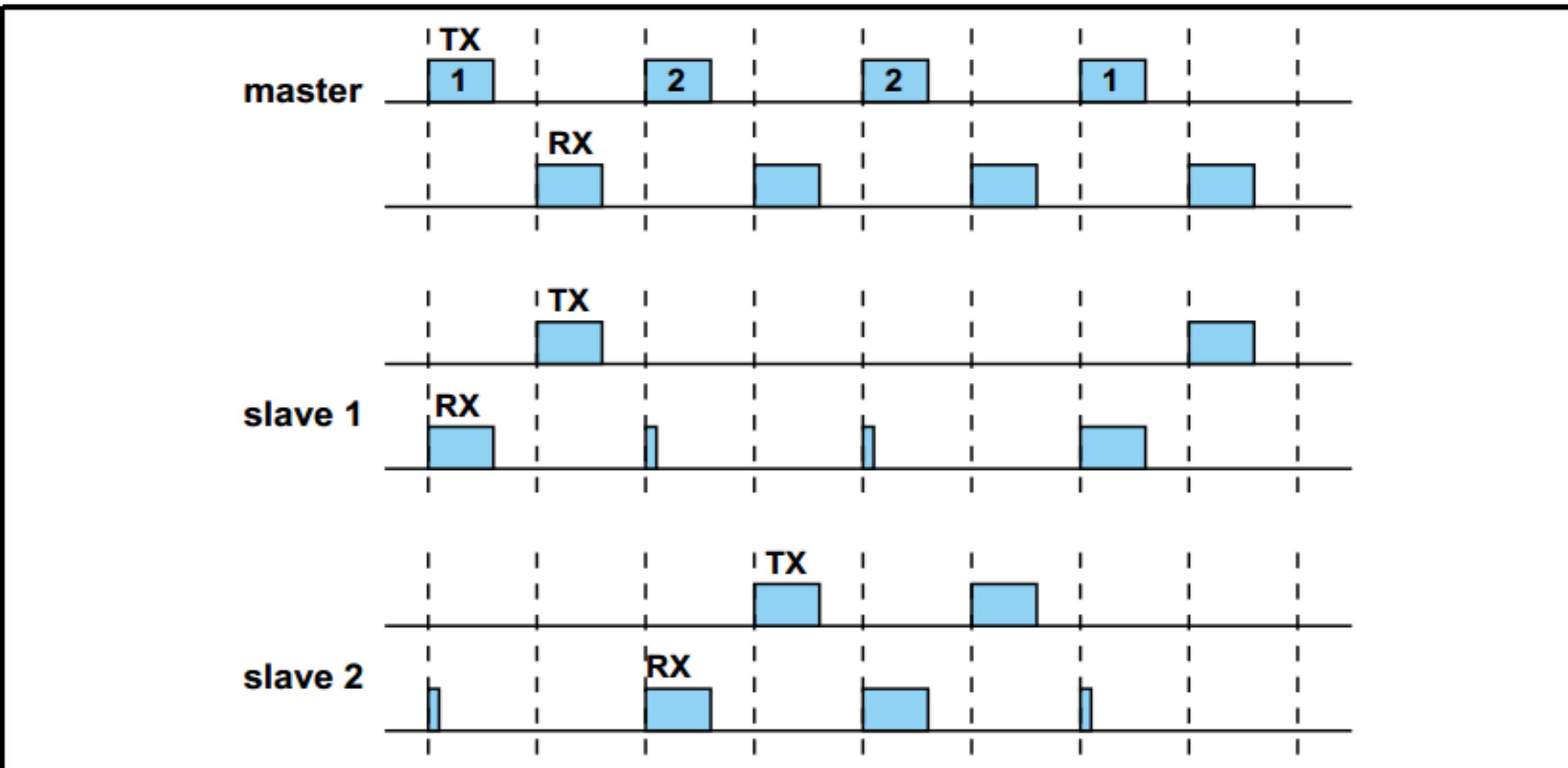
# Piconet Operation: Single-slave case



- Master and Slave alternatively transmit in each slot pairs. Master Tx is at first
- Packet transmission start is aligned with slot start
- Each transmission takes place at a new hopping frequency. Packet duration can fall into 1, 3, or 5 slots
- A polling interval  $T_{pol}$  and a link supervision timer is applied to the connection
- There can be only 1 ACL logical transport and 0 or more SCO or eSCO logical transports between a master and a slave



# Piconet Operation: Multi-slave Case



- Different slaves are addressed by their LT\_ADDR in the packet header. eSCO transport is assigned a different LT\_ADDR
- Total throughput(all the time slots) are shared between piconet members
- Slaves in a piconet cannot exchange packets directly



# Comparison of ACL, SCO and eSCO

# “packet switching” vs. “circuit switching”

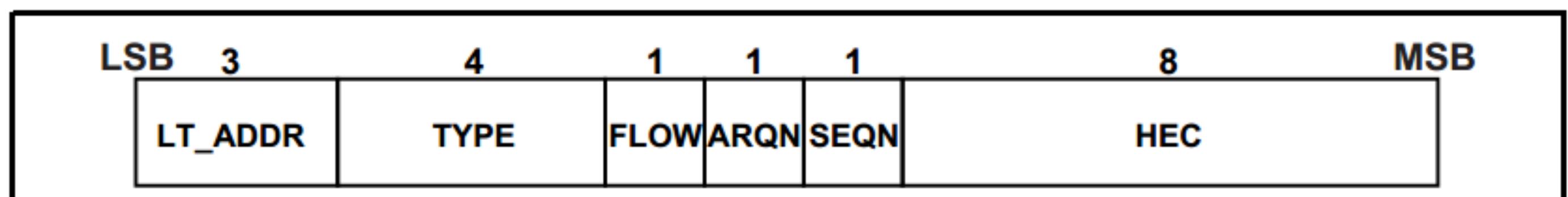
ACL	SCO	eSCO
“packet switching”		“circuit switching”
User Isochronous data(UI) User Asynchronous data(UA) with variable bit rate	User Synchronous data(US) with constant bit rate	
error check and retransmissions used to provide data integrity	no CRC, no retransmission	limited retransmission
focus on data integrity		focus on low latency
throughput is influenced by BER		throughput is unaffected by channel integrity



# BR/EDR Connection Packet Types

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- Packets differ in:
  - time slot occupation
  - payload bit rate(BR, 2Mbit/s or 3Mbit/s EDR)
  - Forward Error Correction(FEC) coding method
  - use of CRC and MIC, etc.
- Packet type can be decided according to:
  - The Logical Transport(ACL, SCO or eSCO), and
  - The “TYPE” field in the packet header
- Packet header format





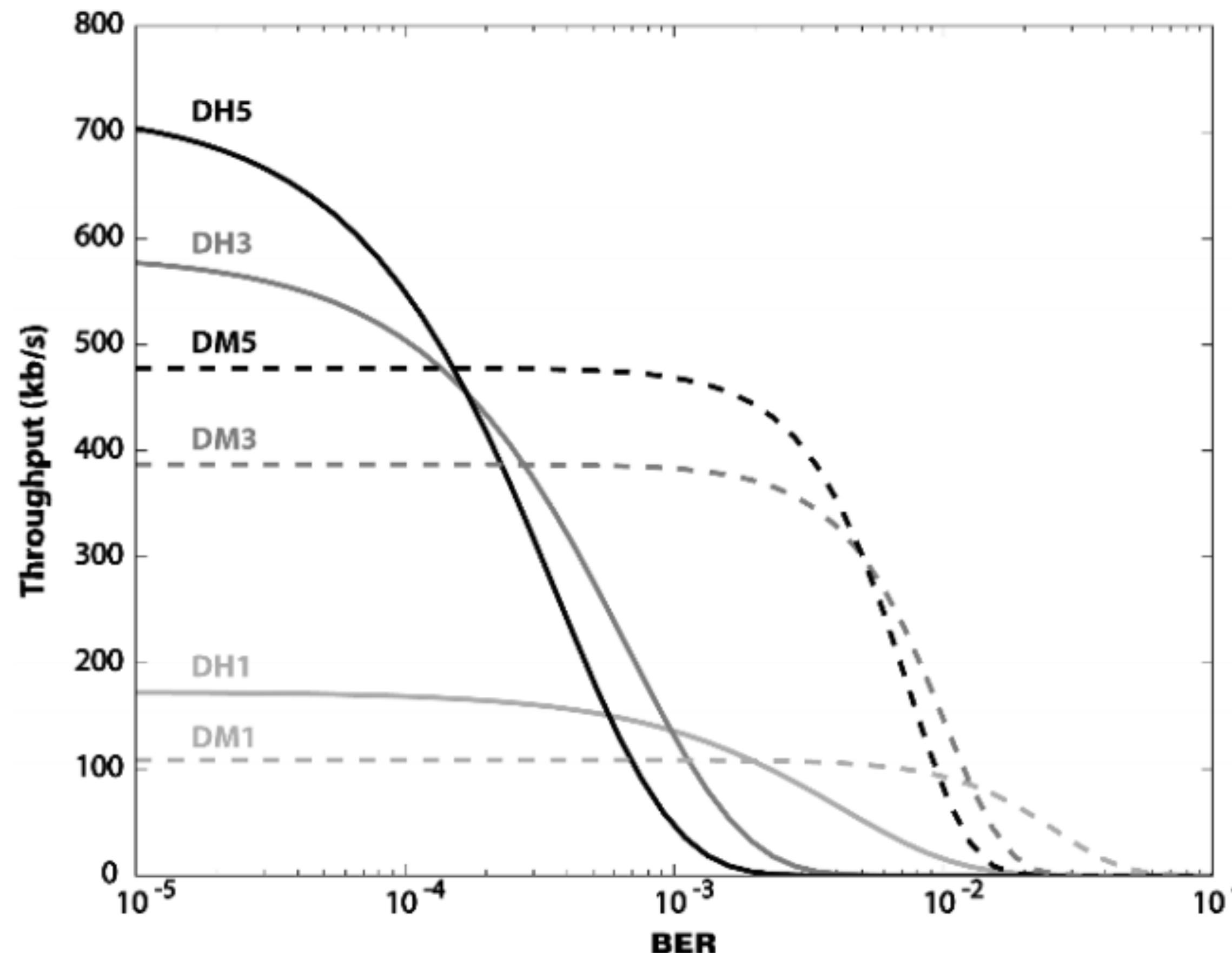
# BR/EDR Connection Packets: ACL Packets

Type	time slot occupation	User Payload (bytes)	BR, 2M-EDR or 3M-EDR	FEC	MIC	CRC	Symmetric Max Rate(kb/s)	Asymmetric Max Rate(kb/s)	
								Forward	Reverse
DM1	1	0-17	BR	2/3	C.1	Yes	108.8	108.8	108.8
DH1	1	0-27	BR	No	C.1	Yes	172.8	172.8	172.8
DM3	3	0-121	BR	2/3	C.1	Yes	258.1	387.2	54.4
DH3	3	0-183	BR	No	C.1	Yes	390.4	585.6	86.4
DM5	5	0-224	BR	2/3	C.1	Yes	286.7	477.8	36.3
DH5	5	0-339	BR	No	C.1	Yes	433.9	723.2	57.6
2-DH1	1	0-54	2M-EDR	No	C.1	yes	345.6	345.6	345.6
2-DH3	3	0-367	2M-EDR	No	C.1	Yes	782.9	1174.4	172.8
2-DH5	5	0-679	2M-EDR	No	C.1	Yes	869.1	1448.5	115.2
3-DH1	1	0-83	3M-EDR	No	C.1	Yes	531.2	531.2	531.2
3-DH3	3	0-552	3M-EDR	No	C.1	Yes	1177.6	1766.4	235.6
3-DH5	5	0-1021	3M-EDR	No	C.1	Yes	1306.9	2178.1	177.1

- DM: Data Medium speed, 2/3 FEC code
  - DH: Data High speed, no FEC
  - Prefix “2-” or “3-” indicates the EDR rate: 2Mbit/s or 3Mbit/s
  - Suffix “1”, “3” or “5” indicates the time slot occupation



# Basic Rate ACL link Throughput under Different BER



# General Rules to achieve high-throughput:

- Use DH5 for BER less than  $10^{-4}$
  - Use DM5 for BER is between  $10^{-4}$  and  $10^{-2}$
  - Use DM1 when BER exceeds  $10^{-2}$

DM5 is used for measuring receiver sensitivity for Bluetooth certification

DM1 packet type is the major packet type for ACL-C(LMP) logical link, to ensure the data integrity of signaling messages

- Mathematical analysis of maximum asymmetric throughput with different basic rate packet types under different Bit Error Rate



# BR/EDR Connection Packets: POLL and NULL

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POLL and NULL are two types of control packets which:

- Consists of access code and packet header only, without any payload.
- Convey ARQ, or FLOW information on the LC level.

Differences between POLL packet and NULL packet:

- POLL is only used by master, NULL can be used by both.
- POLL packet shall have a response packet, NULL may not have to be acknowledged



# BR/EDR Connection Packets: SCO Packets

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Type	time slot occupation	User Payload(bytes)	BR, 2M-EDR or 3M-EDR	FEC	MIC	CRC	Symmetric Max Rate(kb/s)
HV1	1	10	BR	1/3	No	No	64.0
HV2	1	20	BR	2/3	No	No	64.0
HV3	1	30	BR	No	No	No	64.0
DV1	1	10+(0-9)D	BR	2/3 D	No	Yes D	64.0+57.6D

- HV: High-quality Voice
- DV1: Data + Voice contained in the packet
- suffix “1”, “2”, “3” indicates the FEC coding rate: 1/3, 2/3 or 3/3(No FEC)
- SCO link has fixed symmetric rate of 64kbit/s carrying two-way voice, a-law, μ-law or CVSD encoded
- **SCO link has no CRC for error detection and no retransmission**
- For an SCO connection through HV3 packet, 2 slots within every 6 slots are reserved
- For an SCO connection through HV2 packet, 2 slots within every 4 slots are reserved
- For an SCO connection through HV1 packet, all the time slots are occupied



# BR/EDR Connection Packets: eSCO Packets

Type	time slot occupation	User Payload(bytes)	BR, 2M-EDR or 3M-EDR	FEC	MIC	CRC	Symmetric Max Rate(kb/s)
EV3	1	1-30	BR	No	No	Yes	96
EV4	3	1-120	BR	2/3	No	Yes	192
EV5	3	1-180	BR	No	No	Yes	288
2-EV3	1	1-60	2M-EDR	No	No	Yes	192
2-EV5	3	1-360	2M-EDR	No	No	Yes	576
3-EV3	1	1-90	3M-EDR	No	No	Yes	288
3-EV5	3	1-540	3M-EDR	No	No	Yes	864

- eSCO link may be used for 64kbit/s two-way voice transmission, as well as transparent data at 64kb/s and other rates; Asymmetric data rate can be configured
- CRC is used for error detection, and limited retransmission can be applied inside retransmission window
- parameter negotiation can be performed for either power or latency considerations targeted on a certain bandwidth



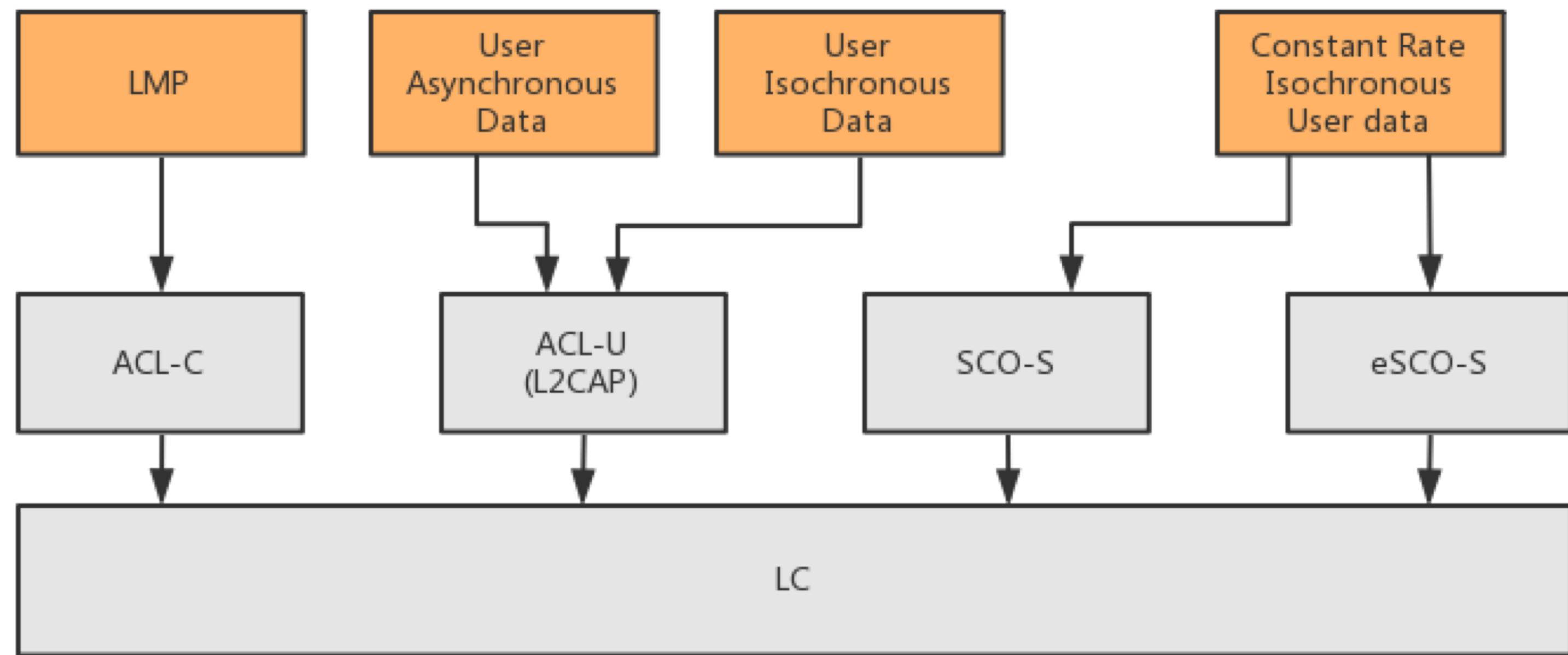
# eSCO Mandatory Parameter Ranges

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	Single-slot packets	3-slot packets
$T_{eSCO}$	EV3: 6 2-EV3: 6-12(Even) 3-EV3: 6-18(Even)	EV4: 16 EV5: 16 2-EV5: 16 3-EV5: 16
$W_{eSCO}$	0, 2, 4	0, 6
packet length M->S	$10 * T_{eSCO}/2$	$10 * T_{eSCO}/2$
packet length S->M	$10 * T_{eSCO}/2$	$10 * T_{eSCO}/2$
air mode	At least one of A-law, $\mu$ -law, CVSD, transparent	transparent

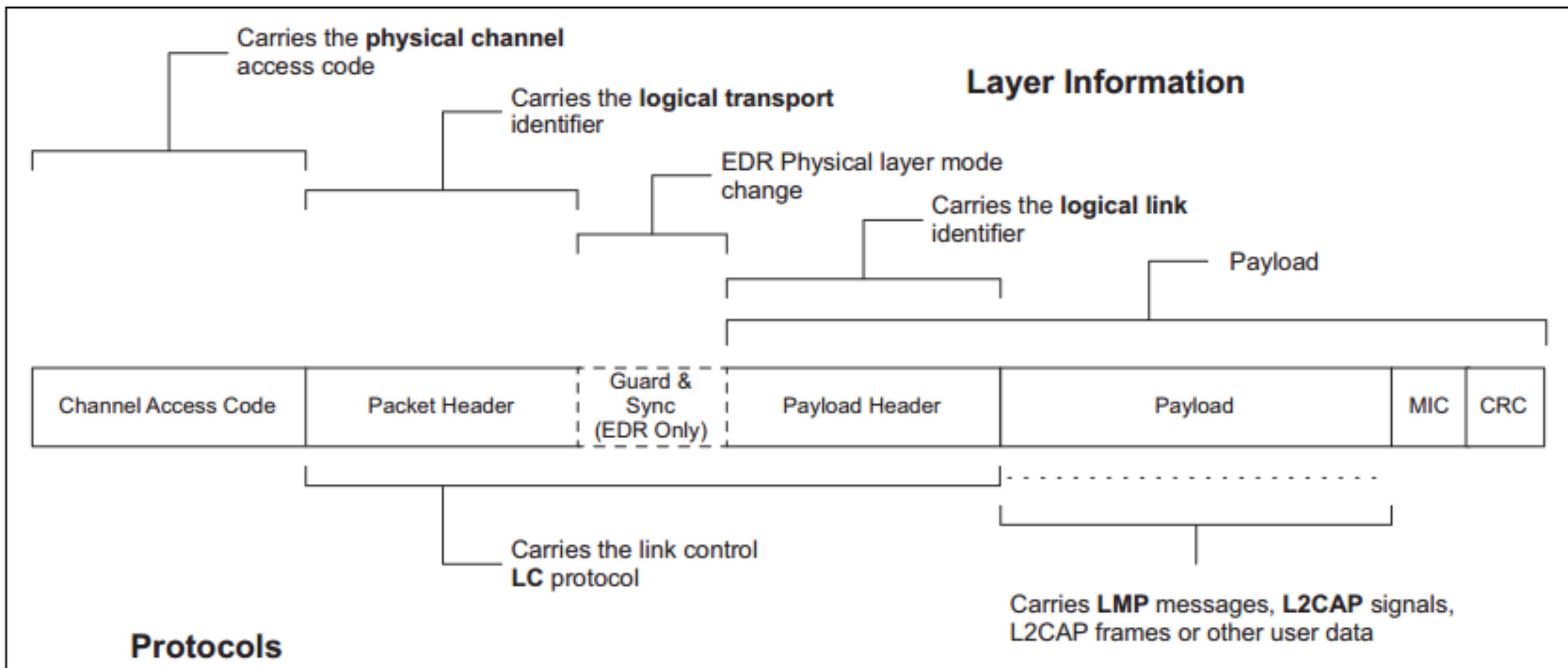


# Piconet Operation: BR/EDR Logical Links





# BR/EDR Packet Structure





# Piconet Operation: Link Manager

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## Link Manager(LM)

- Responsible for:
  - information exchange: version, supported features, name request
  - link control: link set-up/tear-down, power control, AFH
  - packet type negotiation
  - security: authentication, pairing, encryption
  - link policy: role switch, low power mode, QoS
- Link Manager Protocol(LMP)
  - Counterpart in BLE is Link Layer Protocol(LL)
  - Used between LMs on two connected devices
  - Transferred over ACL-C logical link, which is distinguished from ACL-U that is managed by L2CAP
  - Has a higher priority over ACL-U logical link data



# Piconet Operation: Link Controller

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## Functionality:

- baseband packet processing, packet assembly, piconet timing, frequency hopping, error control, data whitening basic security operations
- carrying out low-level link control protocol signaling such as ARQ, flow control, sequencing and payload type, mapped to the packet header
- operating in different states to support: device discovery, connection establishment, low power mode, etc



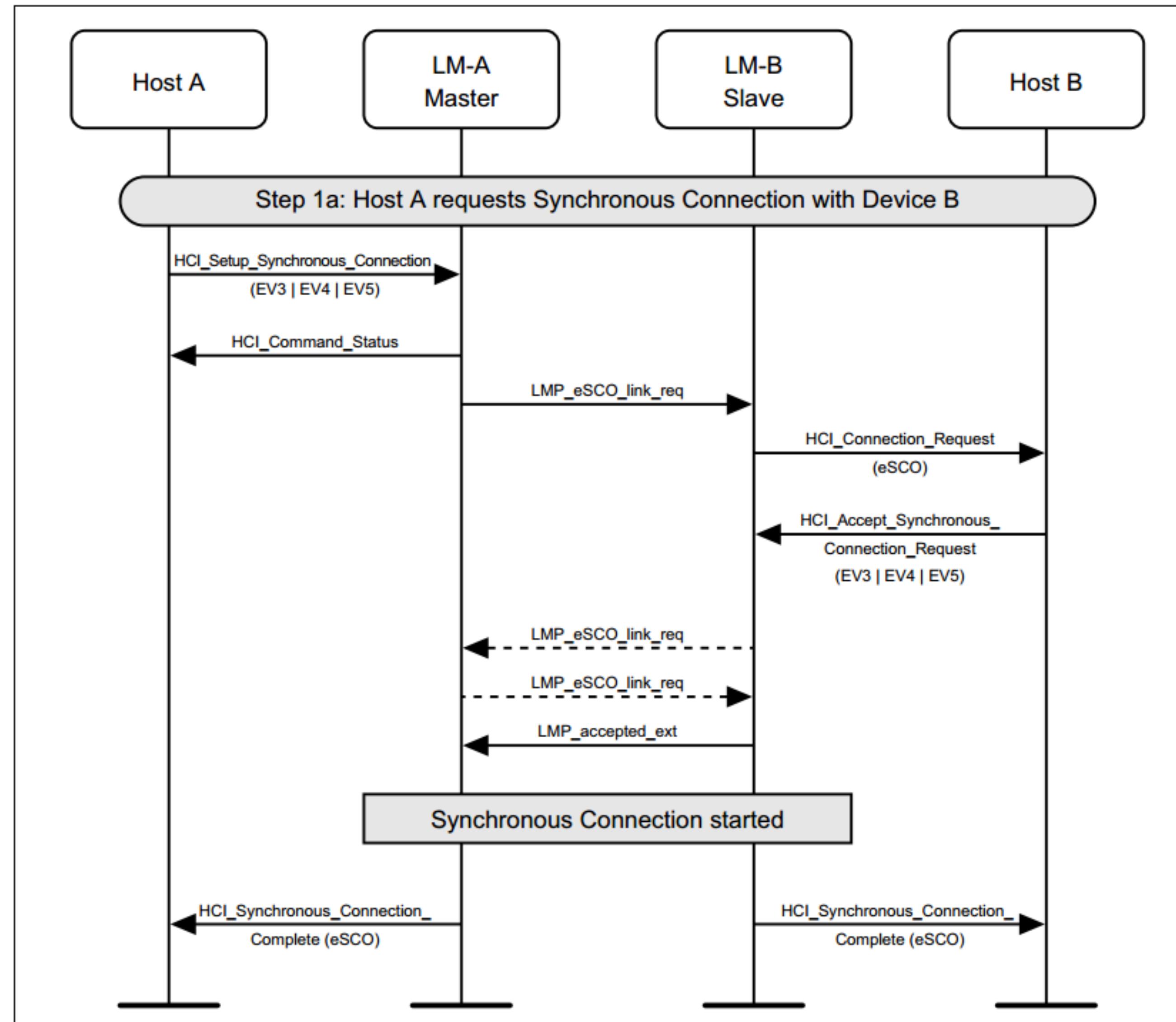
# Host Controller Interface

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- A uniform interface (physical and logical) to handle bluetooth radio and access controller capabilities, allowing vendor-specific extension
- A variety of physical transport can be used: USB, UART, SDIO, etc. The main goal is to achieve transparency in data delivery
- Located below L2CAP and above Link manager
  - allows adopted protocols like TCP/IP run on “Host” such as PC, and multiplexes the upper layer streams into one stream
  - provides a high-level control over the lower layer: an *abstraction* of LC or LM operations
- The logical interface provide four types of HCI packets
  - Command: Host --> Controller, used to direct the controller to perform a task
  - Event: Controller --> Host, used to respond to commands or report notifications to host
  - ACL data: Host <--> Controller, carrying packets on ACL-U, LE-U or AMP-U logical link
  - Synchronous data: Host <-->Controller, carrying packets on SCO-S or eSCO-S logical link
- HCI provides:
  - flow control mechanism for commands, ACL and synchronous data exchange between host and controller
  - segmentation of higher layer message(L2CAP) enabled by Packet\_Boundary\_Flag
  - erroneous data reporting ability for synchronous data packets through Packet\_Status\_Flag



# HCI as a “High-Level Language”



God said, Let there be light: and there was light.

--The Holy Bible

Host said, Let there be a connection: and there was a connection.



## Use a Packet Sniffer

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BR/EDR air packets are difficult to sniffer

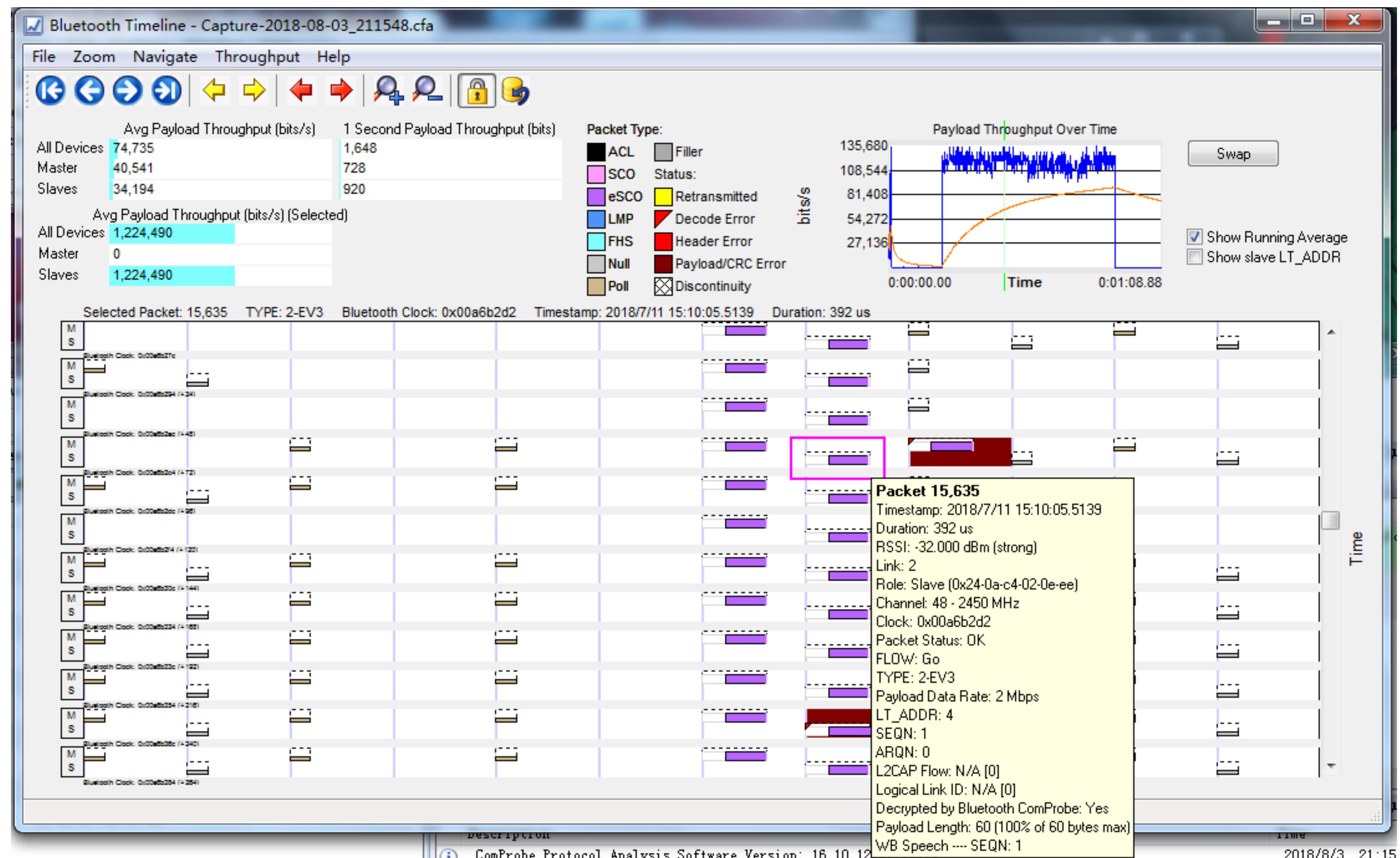
- Operations like encryption, AFH, role switch brings extra challenge to the sniffer packets
- Usually a full-band sniffer is needed to track the bluetooth packets

A bluetooth air sniffer and packet analyzer is expensive, but is also essential for lower-layer debugging

With your PC and a bluetooth dongle, you can use wireshark to analyze the bluetooth HCI traffic.



# Packet Capture Example 1: eSCO transmission





# Packet Capture Example 2: HFP Codec Negotiation

The screenshot shows the Wireshark application window titled "Frame Display - 001.cfa". The menu bar includes File, Edit, View, Format, Live, Filter, Bookmarks, Options, Window, and Help. The toolbar contains various icons for file operations, search, and analysis. A summary pane on the left displays detailed information about a selected frame (Frame 3,305, Slave, Len=39). The main pane shows a list of frames with columns for B..., Frame#, Role, Addr., Hands-Free data, AT Cmd, and Indication. The "Hands-Free" tab is selected. The bottom pane shows the binary, decimal, and ASCII representations of the selected frame's data.

Frame 3,305: (Slave) Len=39

Baseband:

- RSSI: -30.125 dBm (strong)
- Link: 2
- Role: Slave (0x24-0a-c4-02-0e-ee)
- Channel: 31 - 2433 MHz
- Clock: 0x00a5eb26
- Packet Status: OK
- FLOW: Go
- TYPE: 2-DH1
- Payload Data Rate: 2 Mbps
- LT\_ADDR: 3
- SEQN: 1
- ARQN: 0
- L2CAP Flow: Go
- Logical Link ID: L2CAP start or no fragmentation
- Decrypted by Bluetooth ComProbe: Yes
- Payload Length: 18

L2CAP:

- Role: Slave
- Address: 3
- PDU Length: 14
- Channel ID: 0x004f (RFCOMM)

RFCOMM:

Hands-Free:

- Link: 2
- Role: Slave
- Address: 3
- AT Command: Select Codec mSBC

Unfiltered | Info | Errors | Baseband | LMP | PreConnection-FHS | Bluetooth FHS | L2CAP | SDP | RFCOMM | **Hands-Free** | WB Speech

B...	Frame#	Role	Addr.	Hands-Free data	AT Cmd	Indication
	2,773	Master	3	..+CIEV: 4,4..		Signal indicator's status report
	3,298	Master	3	..+CIEV: 2,1..		Call Setup indicator's status report
	3,300	Master	3	..+BCS: 2..		Select Codec mSBC
	3,305	Slave	3	AT+BCS=2..	Select Codec mSBC	
	3,316	Master	3	..OK..		
	3,326	Master	3	..RING..		Incoming Call/Call progress indication
	3,328	Master	3	..+CLIP: "15692131969",129..	+CLIP: "15692131969",129	
	3,466	Master	3	..+CIEV: 4,5..		Signal indicator's status report
	5,630	Master	3	..RING..		Incoming Call/Call progress indication

**Frame Data:**

Format	Value
BINARY	00010101 00000011 00011111 00100110 11101011 10100101 00000000 10100011 00011010 00000100 11101110 00001110 00000010 11000100 00001010 00100100 10110001 00001111 11111111 00010010 00000000 00001110 00000000 01001111 00000000 00010001 11111111 00010011 00000100 01000001 01010100 00101011 01000010 01000011 01010011 00111101 00110010 00001101 10100011
DECIMAL	15 03 1f 26 eb a5 00 a3 1a 04 ee 0e 02 c4 0a 24 b1 0f ff 12 00 0e 00 4f 00 11 ff 13 04 41
CHARACTER	N E U & E A N A S E E S S C L \$ B S F D / N S N O N D / F % E T A T + B C S = 2 R 3

Total Frames: 41,653 | Frames Filtered In: 38 | Frame #s Selected: 3,305; (1 total) | Filtering... | 100%



# Packet Capture Example 3(Wireshark): HSP SDP record

The figure shows a Wireshark interface with the following details:

- Title Bar:** 001.pcapng [Wireshark 2.1.1 (Git Rev Unknown from unknown)]
- Menu Bar:** File Edit View Go Capture Analyze Statistics Telephony Tools Internals Help
- Toolbar:** Includes icons for file operations, search, and analysis.
- Filter Bar:** Filter: Expression... Clear Apply 保存
- Table:** No. Time Source Destination Protocol Length Info
- Selected Packet (Row 42):** 42 0.547178 FengfanB\_01:2d:2e localhost () SDP 35 Rcvd Service Search Attribute Response
- Packet Details:** PDU: Service Search Attribute Response (0x07)  
Transaction Id: 0x0001  
Parameter Length: 21  
Attribute List Byte Count: 18  
Data Fragment  
Continuation State: no (00)  
[Reassembled Attribute List]  
Attribute Lists [count = 1]  
Data Element: Sequence uint16 86 bytes  
0011 0... = Data Element Type: Sequence (6)  
.... .110 = Data Element Size: uint16 (6)  
Data Element Var Size: 86  
Data Value  
Attribute List [count = 7] (Headset)  
Data Element: Sequence uint16 83 bytes  
0011 0... = Data Element Type: Sequence (6)  
.... .110 = Data Element Size: uint16 (6)  
Data Element Var Size: 83  
Data Value  
Service Attribute: Service Record Handle (0x0), value = 0x00010010 (65552)  
Service Attribute: Service Class ID List (0x1), value = Headset -> Headset HS -> Generic Audio  
Service Attribute: Protocol Descriptor List (0x4), value = L2CAP -> RFCOMM:13  
Service Attribute: Language Base Attribute ID List (0x6), value = (Lang: en, Encoding: UTF-8, Attribute Base: 0x0100)  
Service Attribute: Bluetooth Profile Descriptor List (0x9), value = Headset 1.2  
Service Attribute: Service Name (0x100), value = Headset  
Service Attribute: (HSP) Remote Audio Volume Control (0x302), value = true
- Hex/Bin/Prefs/Ascii:** Hex dump of the selected packet.
- Status Bar:** Frame (35 bytes)/Reassembled SDP (89 bytes) Packets: 11069 · Displayed: 11069 (100.0%) · Load time: 0:00.085



# Packet Capture Example 4(Wireshark): A2DP Codec

The screenshot shows the Wireshark interface with the following details:

- File Menu:** File, Edit, View, Go, Capture, Analyze, Statistics, Telephony, Tools, Internals, Help.
- Toolbar:** Includes icons for file operations (Open, Save, Print, Copy), search, and various analysis tools.
- Filter Bar:** A dropdown menu for filters, with options Expression..., Clear, Apply, and Save.
- Table Headers:** No., Time, Source, Destination, Protocol, Length, Info.
- Table Data:** A list of 139 captured frames. Frame 126 is highlighted in blue. The "Info" column shows the protocol (AVDTP) and message type (ResponseAccept - GetAllCapabilities). Other frames show commands like SetConfiguration and Open.
- Frame Details:** Frame 126 details show it has 28 bytes on wire and 28 bytes captured on interface 0. It is identified as a Bluetooth L2CAP Protocol frame with CID 0x0042, PSM 0x0019 (AVDTP), and length 19. It includes a link-layer address (FengfanB\_01:2d:2e).
- Protocol Tree:** The tree view shows the structure of the frame, starting with Bluetooth, then L2CAP, and finally the AVDTP protocol.
- Hex and ASCII panes:** The bottom pane shows the raw hex and ASCII representations of the selected frame. The hex pane shows bytes 0000-0010, and the ASCII pane shows the corresponding characters and control codes.



# Summary

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- PHY: FHSS & TDD, 1MHz Symbol Rate, master controls the piconet with a polling scheme
- Bluetooth has a bunch of packet types differed in packet length, modulations, type of data conveyed as well as FEC coding
- Five Logical Links: LC, ACL-C(LMP), ACL-U(L2CAP), SCO-S and eSCO-S
  - LC information is conveyed over packet header, it deals with lower-layer flow control, and retransmission
  - LMP carries packets exchanged between LMs. LM is responsible for link management: packet type, power control, security, baseband parameter negotiation
  - SCO-S and eSCO-S carries two-way voice in reserved slots at a regular interval. SCO packets are never retransmitted, and eSCO packets can be retransmitted in a limited retransmission window
  - L2CAP multiplexes the upper-layer protocols into one stream and provides segmentation and reassembly for upper service packets. L2CAP different modes and optional ability like QoS, FCS can be enabled according to fit different user scenarios.
- Bluetooth higher layer adopts and adapts a variety of protocols from other domain
- Packet sniffer is a powerful tool in learning and problem analyzing



# Untouched Topics

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- Device Discovery Procedure (Inquiry & Inquiry Scan)
- Connection Establishment Procedure (Page & Page Scan)
- Adapted Frequency Hopping (AFH)
- Low power modes: sniff and hold
- Security aspects: pairing, authentication, encryption
- Active Slave Broadcast and L2CAP group traffic
- Scatternet
- AMP controller
- Test and Qualification



# References

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- Bluetooth: Operation and Use, Robert Morrow
- Bluetooth Essentials For Programmers, Albert S Huang, Larry Rudolph
- Bluetooth Low Energy: The Developer's Handbook
- Bluetooth Master/Slave Communications and Sniff/Sniff Subrating Modes White Paper
- Discovery Whitepaper Service Discovery Applications
- Bluetooth Core Specification, Version 4.2
- Generic Audio/Video Distribution Profile, Version 1.3
- Advanced Audio Distribution Profile, Version 1.3.1
- Audio/Video Remote Control Profile, Version 1.6.1
- Audio/Video Distribution Transport Protocol Specification, Version 1.3
- Audio/Video Control Transport Protocol Specification, Version 1.4
- Hands-Free Profile, Version 1.7.1
- Human Interface Device Profile, Version 1.1
- Generic Object Exchange Profile, Version 1.1.1
- RFCOMM with TS 07.10, Specification of the Bluetooth System, Version 1.2
- Serial Port Profile, Version 1.2



# Useful Readings and Resources

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## Books

- 《Wireshark网络分析就这么简单》 -- 林沛满
- 《Wireshark网络分析的艺术》 -- 林沛满

## Internet Resources

- [www.bluetooth.org](http://www.bluetooth.org)
- [www.wikipedia.org](http://www.wikipedia.org)

## Free Bluetooth Stack Resources:

- [www.bluez.org](http://www.bluez.org)
- [source.android.com/devices/bluetooth/](http://source.android.com/devices/bluetooth/)
- [bluekitchen-gmbh.com](http://bluekitchen-gmbh.com)
- [www.zephyrproject.org](http://www.zephyrproject.org)

*Thanks for your attention!*