

Specification of the Bluetooth System

Wireless connections made easy

Architecture & Terminology Overview

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Revision History

The Revision History is shown in the [“Appendix” on page 53](#)[vol. 0].

Contributors

The persons who contributed to this specification are listed in the , [“Appendix” on page 53](#)[vol. 0].

Web Site

This specification can also be found on the official Bluetooth website:
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TABLE OF CONTENTS

Part A
ARCHITECTURE

Contents 11

1 General Description 13

1.1 Overview of Operation 13

1.2 Nomenclature 15

2 Core System Architecture 19

2.1 Core Architectural Blocks 22

2.1.1 Channel manager 22

2.1.2 L2CAP resource manager 22

2.1.3 Device manager 23

2.1.4 Link manager 23

2.1.5 Baseband resource manager 23

2.1.6 Link controller 24

2.1.7 RF 24

3 Data Transport Architecture 25

3.1 Core Traffic Bearers 26

3.1.1 Framed data traffic 27

3.1.2 Unframed data traffic 28

3.1.3 Reliability of traffic bearers 28

3.2 Transport Architecture Entities 30

3.2.1 Bluetooth generic packet structure 30

3.3 Physical Channels 32

3.3.1 Basic piconet channel 33

3.3.1.1 Overview 33

3.3.1.2 Characteristics 33

3.3.1.3 Topology 34

3.3.1.4 Supported layers 34

3.3.2 Adapted piconet channel 34

3.3.2.1 Overview 34

3.3.3 Inquiry scan channel 35

3.3.3.1 Overview 35

3.3.3.2 Characteristics 35

3.3.3.3 Topology 36

3.3.3.4 Supported layers 36



3.3.4	Page scan channel	36
3.3.4.1	Overview	36
3.3.4.2	Characteristics	36
3.3.4.3	Topology	37
3.3.4.4	Supported layers	37
3.4	Physical Links	37
3.4.1	Links supported by the basic and adapted piconet physical channel38	
3.4.1.1	Active physical link	38
3.4.1.2	Parked physical link	38
3.4.2	Links supported by the scanning physical channels	39
3.5	Logical Links and Logical Transports	39
3.5.1	Casting	41
3.5.2	Scheduling and acknowledgement scheme	41
3.5.3	Class of data	42
3.5.4	Asynchronous connection-oriented (ACL)	42
3.5.5	Synchronous connection-oriented (SCO)	43
3.5.6	Extended synchronous connection-oriented (eSCO)	44
3.5.7	Active slave broadcast (ASB)	44
3.5.8	Parked slave broadcast (PSB)	45
3.5.9	Logical links	46
3.5.10	ACL Control Logical Link (ACL-C)	47
3.5.11	User Asynchronous/Isochronous Logical Link (ACL-U)	47
3.5.12	User Synchronous/Extended Synchronous Logical Links (SCO-S/eSCO-S)	47
3.6	L2CAP Channels	48
4	Communication Topology	49
4.1	Piconet Topology	49
4.2	Operational Procedures and Modes	51
4.2.1	Inquiry (Discovering) Procedure	51
4.2.2	Paging (Connecting) Procedure	52
4.2.3	Connected mode	52
4.2.4	Hold mode	53
4.2.5	Sniff mode	53
4.2.6	Parked state	54
4.2.7	Role switch procedure	54



Part B

ACRONYMS & ABBREVIATIONS

1 List of Acronyms and Abbreviations.....57

2 Abbreviations of the Specification Names 65

Part C

CHANGES FROM BLUETOOTH SPECIFICATION V 1.1

Contents 69

1 New Features 71

2 Changes in Wording 73

 2.1 IEEE Language Update 73

 2.1.1 Shall 74

 2.1.2 Must.....74

 2.1.3 Will.....74

 2.1.4 Should 74

 2.1.5 May.....75

 2.1.6 Can.....75

 2.2 Nomenclature Changes 75

3 Structure Changes 77

4 Deprecated Specifications 79

 4.1 Deprecated Features 79

 4.2 Deprecated Profiles.....79



Architecture & Terminology Overview

Part A

Architecture







CONTENTS

1	General Description	13
1.1	Overview of Operation	13
1.2	Nomenclature.....	15
2	Core System Architecture	19
2.1	Core Architectural Blocks.....	22
2.1.1	Channel manager.....	22
2.1.2	L2CAP resource manager.....	22
2.1.3	Device manager	23
2.1.4	Link manager.....	23
2.1.5	Baseband resource manager	23
2.1.6	Link controller	24
2.1.7	RF.....	24
3	Data Transport Architecture.....	25
3.1	Core Traffic Bearers	26
3.1.1	Framed data traffic	27
3.1.2	Unframed data traffic.....	28
3.1.3	Reliability of traffic bearers	28
3.2	Transport Architecture Entities.....	30
3.2.1	Bluetooth generic packet structure.....	30
3.3	Physical Channels.....	32
3.3.1	Basic piconet channel	33
3.3.1.1	Overview	33
3.3.1.2	Characteristics	33
3.3.1.3	Topology	34
3.3.1.4	Supported layers.....	34
3.3.2	Adapted piconet channel.....	34
3.3.2.1	Overview	34
3.3.3	Inquiry scan channel	35
3.3.3.1	Overview	35
3.3.3.2	Characteristics	35
3.3.3.3	Topology	36
3.3.3.4	Supported layers.....	36
3.3.4	Page scan channel.....	36
3.3.4.1	Overview	36
3.3.4.2	Characteristics	36
3.3.4.3	Topology	37
3.3.4.4	Supported layers.....	37



3.4	Physical Links	37
3.4.1	Links supported by the basic and adapted piconet physical channel	38
3.4.1.1	Active physical link	38
3.4.1.2	Parked physical link	38
3.4.2	Links supported by the scanning physical channels	39
3.5	Logical Links and Logical Transports	39
3.5.1	Casting	41
3.5.2	Scheduling and acknowledgement scheme	41
3.5.3	Class of data	42
3.5.4	Asynchronous connection-oriented (ACL)	42
3.5.5	Synchronous connection-oriented (SCO)	43
3.5.6	Extended synchronous connection-oriented (eSCO)	44
3.5.7	Active slave broadcast (ASB)	44
3.5.8	Parked slave broadcast (PSB)	45
3.5.9	Logical links	46
3.5.10	ACL Control Logical Link (ACL-C)	47
3.5.11	User Asynchronous/Isochronous Logical Link (ACL-U)	47
3.5.12	User Synchronous/Extended Synchronous Logical Links (SCO-S/eSCO-S)	47
3.6	L2CAP Channels	48
4	Communication Topology	49
4.1	Piconet Topology	49
4.2	Operational Procedures and Modes	51
4.2.1	Inquiry (Discovering) Procedure	51
4.2.2	Paging (Connecting) Procedure	52
4.2.3	Connected mode	52
4.2.4	Hold mode	53
4.2.5	Sniff mode	53
4.2.6	Parked state	54
4.2.7	Role switch procedure	54



1 GENERAL DESCRIPTION

Bluetooth wireless technology is a short-range communications system intended to replace the cable(s) connecting portable and/or fixed electronic devices. Key features are robustness, low power, and low cost. Many features of the core specification are optional, allowing product differentiation.

The Bluetooth core system consists of an RF transceiver, baseband, and protocol stack. The system offers services that enable the connection of devices and the exchange of a variety of classes of data between these devices.

This chapter of the specification provides an overview of the Bluetooth system architecture, communication topologies and data transport features. The text in this chapter of the specification should be treated as informational and used as a background and for context-setting.

1.1 OVERVIEW OF OPERATION

The Bluetooth RF (physical layer) operates in the unlicensed ISM band at 2.4 GHz. The system employs a frequency hop transceiver to combat interference and fading and provides many FHSS carriers. RF operation uses a shaped, binary FM modulation to minimize transceiver complexity. The symbol rate is 1 Megasymbol per second (Ms/s) supporting the bit rate of 1 Megabit per second (Mb/s).

During typical operation a physical radio channel is shared by a group of devices that are synchronized to a common clock and frequency hopping pattern. One device provides the synchronization reference and is known as the master. All other devices are known as slaves. A group of devices synchronized in this fashion form a piconet. This is the fundamental form of communication in the Bluetooth wireless technology.

Devices in a piconet use a specific frequency hopping pattern, which is algorithmically determined by certain fields in the Bluetooth address and clock of the master. The basic hopping pattern is a pseudo-random ordering of the 79 frequencies in the ISM band. The hopping pattern may be adapted to exclude a portion of the frequencies that are used by interfering devices. The adaptive hopping technique improves Bluetooth co-existence with static (non-hopping) ISM systems when these are co-located.

The physical channel is sub-divided into time units known as slots. Data is transmitted between Bluetooth devices in packets, that are positioned in these slots. When circumstances permit, a number of consecutive slots may be allocated to a single packet. Frequency hopping takes place between the transmission or reception of packets. Bluetooth technology provides the effect of full duplex transmission through the use of a Time-Division Duplex (TDD) scheme.



Above the physical channel there is a layering of links and channels and associated control protocols. The hierarchy of channels and links from the physical channel upwards is physical channel, physical link, logical transport, logical link and L2CAP channel. These are discussed in more detail in [Section 3.3 on page 32](#) - [Section 3.6 on page 48](#) but are introduced here to aid the understanding of the remainder of this section.

Within a physical channel, a physical link is formed between any two devices that transmit packets in either direction between them. In a piconet physical channel there are restrictions on which devices may form a physical link. There is a physical link between each slave and the master. Physical links are not formed directly between the slaves in a piconet.

The physical link is used as a transport for one or more logical links that support unicast synchronous, asynchronous and isochronous traffic, and broadcast traffic. Traffic on logical links is multiplexed onto the physical link by occupying slots assigned by a scheduling function in the resource manager.

A control protocol for the baseband and physical layers is carried over logical links in addition to user data. This is the link manager protocol (LMP). Devices that are active in a piconet have a default asynchronous connection-oriented logical transport that is used to transport the LMP protocol signalling. For historical reasons this is known as the ACL logical transport. The default ACL logical transport is the one that is created whenever a device joins a piconet. Additional logical transports may be created to transport synchronous data streams when this is required.

The Link Manager function uses LMP to control the operation of devices in the piconet and provide services to manage the lower architectural layers (radio layer and baseband layer). The LMP protocol is only carried on the default ACL logical transport and the default broadcast logical transport.

Above the baseband layer the L2CAP layer provides a channel-based abstraction to applications and services. It carries out segmentation and reassembly of application data and multiplexing and de-multiplexing of multiple channels over a shared logical link. L2CAP has a protocol control channel that is carried over the default ACL logical transport. Application data submitted to the L2CAP protocol may be carried on any logical link that supports the L2CAP protocol.

1.2 NOMENCLATURE

Where the following terms appear in the specification they have the meaning given in [Table 1.1 on page 15](#).

Ad Hoc Network	A network typically created in a spontaneous manner. An ad hoc network requires no formal infrastructure and is limited in temporal and spatial extent.
Active Slave Broadcast (ASB)	The Active Slave Broadcast logical transport that is used to transport L2CAP user traffic to all active devices in the piconet. See Section 3.5.7 on page 44
Beacon Train	A pattern of reserved slots within a basic or adapted piconet physical channel. Transmissions starting in these slots are used to resynchronize parked devices.
Bluetooth	Bluetooth is a wireless communication link, operating in the unlicensed ISM band at 2.4 GHz using a frequency hopping transceiver. It allows real-time AV and data communications between Bluetooth Hosts. The link protocol is based on time slots.
Bluetooth Baseband	The part of the Bluetooth system that specifies or implements the medium access and physical layer procedures to support the exchange of real-time voice, data information streams, and ad hoc networking between Bluetooth Devices.
Bluetooth Clock	A 28 bit clock internal to a Bluetooth controller sub-system that ticks every 312.5µs. The value of this clock defines the slot numbering and timing in the various physical channels.
Bluetooth Controller	A sub-system containing the Bluetooth RF, baseband, resource controller, link manager, device manager and a Bluetooth HCI.
Bluetooth Device	A Bluetooth Device is a device that is capable of short-range wireless communications using the Bluetooth system.
Bluetooth Device Address	A 48 bit address used to identify each Bluetooth device.
BD_ADDR	The Bluetooth Device Address, BD_ADDR, is used to identify a Bluetooth device.
Bluetooth HCI	The Bluetooth HCI provides a command interface to the baseband controller and link manager and access to hardware status and control registers. This interface provides a uniform method of accessing the Bluetooth baseband capabilities.

Table 1.1: Nomenclature.



Bluetooth Host	A Bluetooth Host is a computing device, peripheral, cellular telephone, access point to PSTN network or LAN, etc. A Bluetooth Host attached to a Bluetooth Controller may communicate with other Bluetooth Hosts attached to their Bluetooth Controllers as well.
Channel	Either a physical channel or an L2CAP channel, depending on the context.
Connect (to service)	The establishment of a connection to a service. If not already done, this also includes establishment of a physical link, logical transport, logical link and L2CAP channel.
Connectable device	A Bluetooth device in range that periodically listens on its page scan physical channel and will respond to a page on that channel.
Connected devices	Two Bluetooth devices in the same piconet and with a physical link between them.
Connecting	A phase in the communication between devices when a connection between them is being established. (Connecting phase follows after the link establishment phase is completed.)
Connection	A connection between two peer applications or higher layer protocols mapped onto an L2CAP channel.
Connection establishment	A procedure for creating a connection mapped onto a channel.
coverage area	The area where two Bluetooth devices can exchange messages with acceptable quality and performance.
Creation of a secure connection	A procedure of establishing a connection, including authentication and encryption.
Creation of a trusted relationship	A procedure where the remote device is marked as a trusted device. This includes storing a common link key for future authentication and pairing (if the link key is not available).
Device discovery	A procedure for retrieving the Bluetooth device address, clock, class-of-device field and used page scan mode from discoverable devices.
Discoverable device	A Bluetooth device in range that periodically listens on an inquiry scan physical channel and will respond to an inquiry on that channel. Discoverable device are normally also connectable.
Inquiring device	A Bluetooth device that is carrying out the inquiry procedure.
Inquiry	A procedure where a Bluetooth device transmits inquiry messages and listens for responses in order to discover the other Bluetooth devices that are within the coverage area.

Table 1.1: Nomenclature.

Architecture



Inquiry scan	A procedure where a Bluetooth device listens for inquiry messages received on its inquiry scan physical channel.
Isochronous data	Information in a stream where each information entity in the stream is bound by a time relationship to previous and successive entities.
Known device	A Bluetooth device for which at least the BD_ADDR is stored.
L2CAP Channel	A logical connection on L2CAP level between two devices serving a single application or higher layer protocol.
L2CAP Channel establishment	A procedure for establishing a logical connection on L2CAP level.
Link establishment	A procedure for establishing the default ACL link and hierarchy of links and channels between devices.
Link	Shorthand for a logical link.
Link key	A secret key that is known by two devices and is used in order to authenticate each device to the other
LMP authentication	An LMP level procedure for verifying the identity of a remote device.
LMP pairing	A procedure that authenticates two devices and creates a common link key that can be used as a basis for a trusted relationship or a (single) secure connection.
Logical Channel	Identical to an L2CAP channel, but deprecated due to an alternative meaning in Bluetooth 1.1
Logical link	The lowest architectural level used to offer independent data transport services to clients of the Bluetooth system.
Logical transport	Used in Bluetooth to represent commonality between different logical links due to shared acknowledgement protocol and link identifiers.
Name discovery	A procedure for retrieving the user-friendly name (the Bluetooth device name) of a connectable device.
Packet	Format of aggregated bits that are transmitted on a physical channel.
Page	The initial phase of the connection procedure where a device transmits a train of page messages until a response is received from the target device or a time-out occurs.
Page scan	A procedure where a device listens for page messages received on its page scan physical channel.
Paging device	A Bluetooth device that is carrying out the page procedure.
Paired device	A Bluetooth device with which a link key has been exchanged (either before connection establishment was requested or during connecting phase).

Table 1.1: Nomenclature.



Parked device	A device operating in a basic mode piconet that is synchronized to the master but has given up its default ACL logical transport.
Physical Channel	Characterised by synchronized occupancy of a sequence of RF carriers by one or more devices. A number of physical channel types exist with characteristics defined for their different purposes.
Physical Link	A Baseband-level connection between two devices established using paging.
Piconet	A collection of devices occupying a shared physical channel where one of the devices is the Piconet Master and the remaining devices are connected to it.
Piconet Physical Channel	A Channel that is divided into time slots in which each slot is related to an RF hop frequency. Consecutive hops normally correspond to different RF hop frequencies and occur at a standard hop rate of 1600 hops/s. These consecutive hops follow a pseudo-random hopping sequence, hopping through a 79 RF channel set.
Piconet Master	The device in a piconet whose Bluetooth Clock and Bluetooth Device Address are used to define the piconet physical channel characteristics.
Piconet Slave	Any device in a piconet that is not the Piconet Master, but is connected to the Piconet Master.
PIN	A user-friendly number that can be used to authenticate connections to a device before pairing has taken place.
PMP	A Participant in Multiple Piconets. A device that is concurrently a member of more than one piconet, which it achieves using time division multiplexing (TDM) to interleave its activity on each piconet physical channel.
The Parked Slave Broadcast (PSB)	The Parked Slave Broadcast logical transport that is used for communications between the master and parked devices. Section 3.5.8 on page 45 .
Scatternet	Two or more piconets that include one or more devices acting as PMPs.
Service Layer Protocol	A protocol that uses an L2CAP channel for transporting PDUs.
Service discovery	Procedures for querying and browsing for services offered by or through another Bluetooth device.
Silent device	A Bluetooth device appears as silent to a remote device if it does not respond to inquiries made by the remote device.
Unknown device	A Bluetooth device for which no information (Bluetooth Device Address, link key or other) is stored.

Table 1.1: Nomenclature.

2 CORE SYSTEM ARCHITECTURE

The Bluetooth core system covers the four lowest layers and associated protocols defined by the Bluetooth specification as well as one common service layer protocol, the Service Discovery Protocol (SDP) and the overall profile requirements are specified in the Generic Access Profile (GAP). A complete Bluetooth application requires a number of additional service and higher layer protocols that are defined in the Bluetooth specification, but are not described here. The core system architecture is shown in [Figure 2.1 on page 19](#) except for SDP that is not shown for clarity.

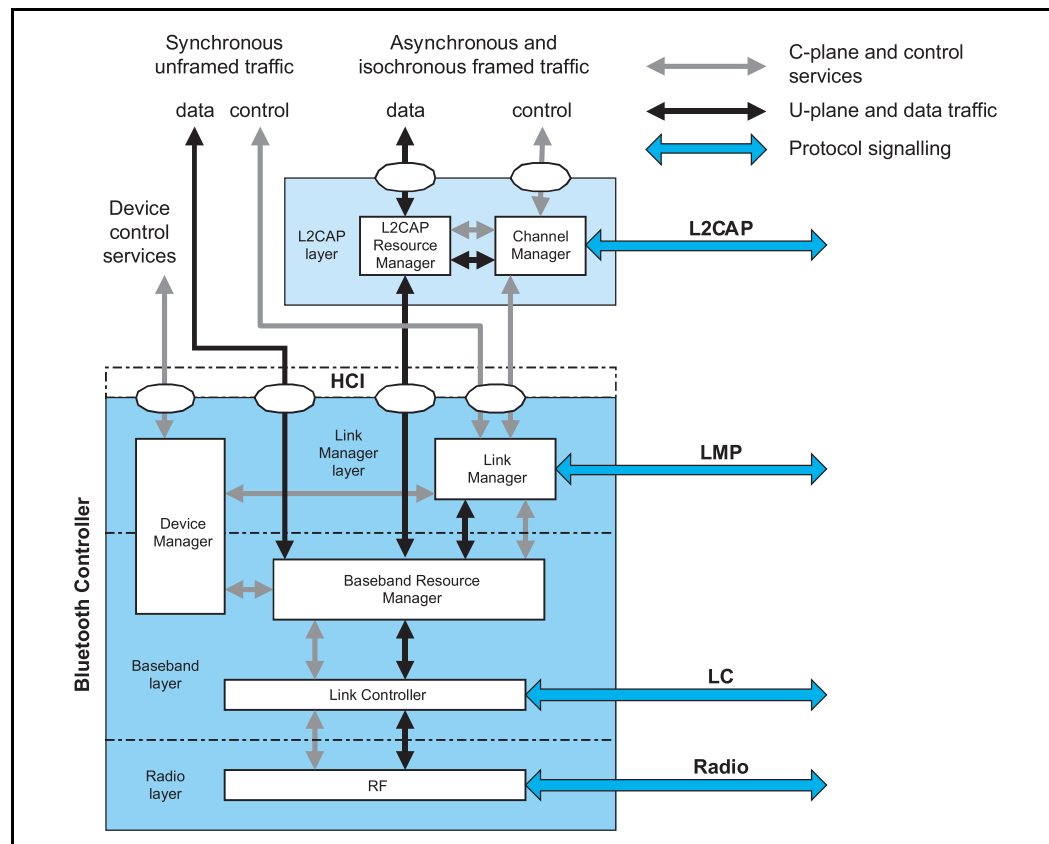


Figure 2.1: Bluetooth core system architecture

[Figure 2.1 on page 19](#) shows the four lowest layers, each with its associated communication protocol. The lowest three layers are sometimes grouped into a subsystem known as the Bluetooth controller. This is a common implementation involving a standard physical communications interface between the Bluetooth controller and remainder of the Bluetooth system including the L2CAP, service and higher layers (known as the Bluetooth host.) Although this interface is optional the architecture is designed to allow for its existence and characteristics. The Bluetooth specification enables inter-operability between independent Bluetooth systems by defining the protocol messages exchanged between equivalent layers, and also inter-operability between independent



Bluetooth sub-systems by defining a common interface between Bluetooth controllers and Bluetooth hosts.

A number of functional blocks are shown and the path of services and data between these. The functional blocks shown in the diagram are informative; in general the Bluetooth specification does not define the details of implementations except where this is required for inter-operability. Thus the functional blocks in [Figure 2.1 on page 19](#) are shown in order to aid description of the system behaviour. An implementation may be different from the system shown in [Figure 2.1 on page 19](#).

Standard interactions are defined for all inter-device operation, where Bluetooth devices exchange protocol signalling according to the Bluetooth specification. The Bluetooth core system protocols are the Radio (RF) protocol, Link Control (LC) protocol, Link Manager (LM) protocol and Logical Link Control and Adaptation protocol (L2CAP), all of that are fully defined in subsequent parts of the Bluetooth specification. In addition the Service Discovery Protocol (SDP) is a service layer protocol required by all Bluetooth applications.

The Bluetooth core system offers services through a number of service access points that are shown in the diagram as ellipses. These services consist of the basic primitives that control the Bluetooth core system. The services can be split into three types. There are device control services that modify the behaviour and modes of a Bluetooth device, transport control services that create, modify and release traffic bearers (channels and links), and data services that are used to submit data for transmission over traffic bearers. It is common to consider the first two as belonging to the C-plane and the last as belonging to the U-plane.

A service interface to the Bluetooth controller sub-system is defined such that the Bluetooth controller may be considered a standard part. In this configuration the Bluetooth controller operates the lowest three layers and the L2CAP layer is contained with the rest of the Bluetooth application in a host system. The standard interface is called the Host to Controller Interface (HCI) and its service access points are represented by the ellipses on the upper edge of the Bluetooth controller sub-system in [Figure 2.1 on page 19](#). Implementation of this standard service interface is optional.

As the Bluetooth architecture is defined with the possibility of separate host and controller communicating through an HCI, a number of general assumptions are made. The Bluetooth controller is assumed to have limited data buffering capabilities in comparison with the host. Therefore the L2CAP layer is expected to carry out some simple resource management when submitting L2CAP PDUs to the controller for transport to a peer device. This includes segmentation of L2CAP SDUs into more manageable PDUs and then the fragmentation of PDUs into start and continuation packets of a size suitable for the controller buffers, and management of the use of controller buffers to ensure availability for channels with Quality of Service (QoS) commitments.



The Baseband layer provides the basic ARQ protocol in Bluetooth. The L2CAP layer can optionally provide a further error detection and retransmission to the L2CAP PDUs. This feature is recommended for applications with requirements for a low probability of undetected errors in the user data. A further optional feature of L2CAP is a window-based flow control that can be used to manage buffer allocation in the receiving device. Both of these optional features augment the QoS performance in certain scenarios.

Although these assumptions may not be required for embedded Bluetooth implementations that combine all layers in a single system, the general architectural and QoS models are defined with these assumptions in mind, in effect a lowest common denominator.

Automated conformance testing of implementations of the Bluetooth core system is required. This is achieved by allowing the tester to control the implementation through the RF interface, which is common to all Bluetooth systems, and through the Test Control Interface (TCI), which is only required for conformance testing.

The tester uses exchanges with the Implementation Under Test (IUT) through the RF interface to ensure the correct responses to requests from remote devices. The tester controls the IUT through the TCI to cause the IUT to originate exchanges through the RF interface so that these can also be verified as conformant.

The TCI uses a different command-set (service interface) for the testing of each architectural layer and protocol. A subset of the HCI command-set is used as the TCI service interface for each of the layers and protocols within the Bluetooth Controller subsystem. A separate service interface is used for testing the L2CAP layer and protocol. As an L2CAP service interface is not defined in the Bluetooth core specification it is defined separately in the Test Control Interface specification. Implementation of the L2CAP service interface is only required for conformance testing.



2.1 CORE ARCHITECTURAL BLOCKS

This section describes the function and responsibility of each of the blocks shown in [Figure 2.1 on page 19](#). An implementation is not required to follow the architecture described above, though every implementation shall conform to the protocol specifications described in subsequent parts of the Bluetooth specification, and shall implement the behavioural aspects of the system outlined below and specified in subsequent parts of the Bluetooth specification.

2.1.1 Channel manager

The channel manager is responsible for creating, managing and destroying L2CAP channels for the transport of service protocols and application data streams. The channel manager uses the L2CAP protocol to interact with a channel manager on a remote (peer) device to create these L2CAP channels and connect their endpoints to the appropriate entities. The channel manager interacts with its local link manager to create new logical links (if necessary) and to configure these links to provide the required quality of service for the type of data being transported.

2.1.2 L2CAP resource manager

The L2CAP resource manager block is responsible for managing the ordering of submission of PDU fragments to the baseband and some relative scheduling between channels to ensure that L2CAP channels with QoS commitments are not denied access to the physical channel due to Bluetooth controller resource exhaustion. This is required because the architectural model does not assume that the Bluetooth controller has limitless buffering, or that the HCI is a pipe of infinite bandwidth.

L2CAP Resource Managers may also carry out traffic conformance policing to ensure that applications are submitting L2CAP SDUs within the bounds of their negotiated QoS settings. The general Bluetooth data transport model assumes well-behaved applications, and does not define how an implementation is expected to deal with this problem.



2.1.3 Device manager

The device manager is the functional block in the baseband that controls the general behaviour of the Bluetooth device. It is responsible for all operation of the Bluetooth system that is not directly related to data transport, such as inquiring for the presence of other nearby Bluetooth devices, connecting to other Bluetooth devices, or making the local Bluetooth device discoverable or connectable by other devices.

The device manager requests access to the transport medium from the baseband resource controller in order to carry out its functions.

The device manager also controls local device behaviour implied by a number of the HCI commands, such as managing the device local name, any stored link keys, and other functionality.

2.1.4 Link manager

The link manager is responsible for the creation, modification and release of logical links (and, if required, their associated logical transports), as well as the update of parameters related to physical links between devices. The link manager achieves this by communicating with the link manager in remote Bluetooth devices using the Link Management Protocol (LMP.)

The LM protocol allows the creation of new logical links and logical transports between devices when required, as well as the general control of link and transport attributes such as the enabling of encryption on the logical transport, the adapting of transmit power on the physical link, or the adjustment of QoS settings for a logical link.

2.1.5 Baseband resource manager

The baseband resource manager is responsible for all access to the radio medium. It has two main functions. At its heart is a scheduler that grants time on the physical channels to all of the entities that have negotiated an access contract. The other main function is to negotiate access contracts with these entities. An access contract is effectively a commitment to deliver a certain QoS that is required in order to provide a user application with an expected performance.

The access contract and scheduling function must take account of any behaviour that requires use of the Bluetooth radio. This includes (for example) the normal exchange of data between connected devices over logical links, and logical transports, as well as the use of the radio medium to carry out inquiries, make connections, be discoverable or connectable, or to take readings from unused carriers during the use of adaptive frequency hopping mode.

In some cases the scheduling of a logical link results in changing to a different physical channel from the one that was previously used. This may be (for example) due to involvement in scatternet, a periodic inquiry function, or page



scanning. When the physical channels are not time slot aligned, then the resource manager also accounts for the realignment time between slots on the original physical channel and slots on the new physical channel. In some cases the slots will be naturally aligned due to the same device clock being used as a reference for both physical channels.

2.1.6 Link controller

The link controller is responsible for the encoding and decoding of Bluetooth packets from the data payload and parameters related to the physical channel, logical transport and logical link.

The link controller carries out the link control protocol signalling (in close conjunction with the scheduling function of the resource manager), which is used to communicate flow control and acknowledgement and retransmission request signals. The interpretation of these signals is a characteristic of the logical transport associated with the baseband packet. Interpretation and control of the link control signalling is normally associated with the resource manager's scheduler.

2.1.7 RF

The RF block is responsible for transmitting and receiving packets of information on the physical channel. A control path between the baseband and the RF block allows the baseband block to control the timing and frequency carrier of the RF block. The RF block transforms a stream of data to and from the physical channel and the baseband into required formats.



3 DATA TRANSPORT ARCHITECTURE

The Bluetooth data transport system follows a layered architecture. This description of the Bluetooth system describes the Bluetooth core transport layers up to and including L2CAP channels. All Bluetooth operational modes follow the same generic transport architecture, which is shown in [Figure 3.1 on page 25](#).

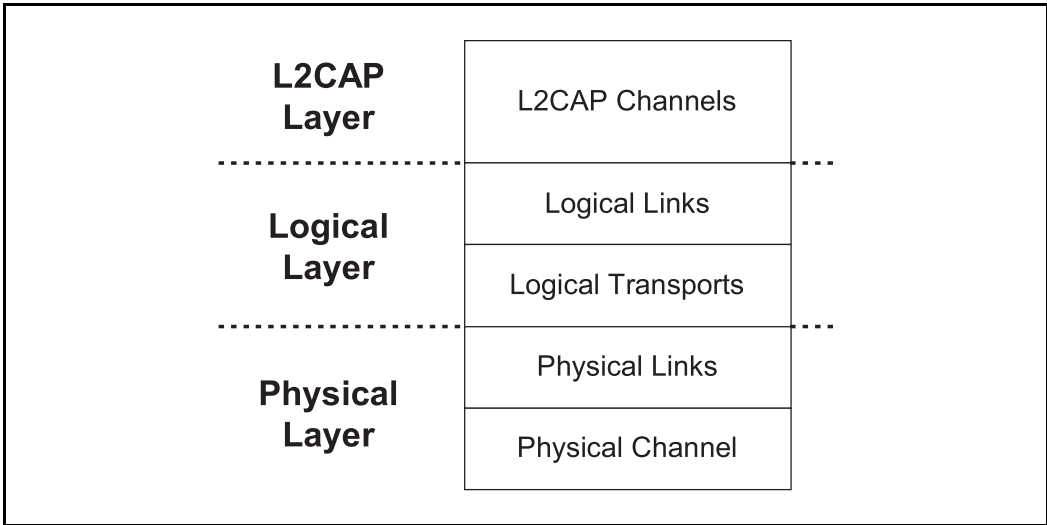


Figure 3.1: Bluetooth generic data transport architecture

For efficiency and legacy reasons, the Bluetooth transport architecture includes a sub-division of the logical layer, distinguishing between logical links and logical transports. This sub-division provides a general (and commonly understood) concept of a logical link that provides an independent transport between two or more devices. The logical transport sub-layer is required to describe the inter-dependence between some of the logical link types (mainly for reasons of legacy behaviour.)

The Bluetooth 1.1 specification described the ACL and SCO links as physical links. With the addition of Extended SCO (eSCO) and for future expansion it is better to consider these as logical transport types, which more accurately encapsulates their purpose. However, they are not as independent as might be desired, due to their shared use of resources such as the LT_ADDR and acknowledgement/repeat request (ARQ) scheme. Hence the architecture is incapable of representing these logical transports with a single transport layer. The additional logical transport layer goes some way towards describing this behaviour.

3.1 CORE TRAFFIC BEARERS

The Bluetooth core system provides a number of standard traffic bearers for the transport of service protocol and application data. These are shown in [Figure 3.2 on page 26](#) below (for ease of representation this is shown with higher layers to the left and lower layers to the right).

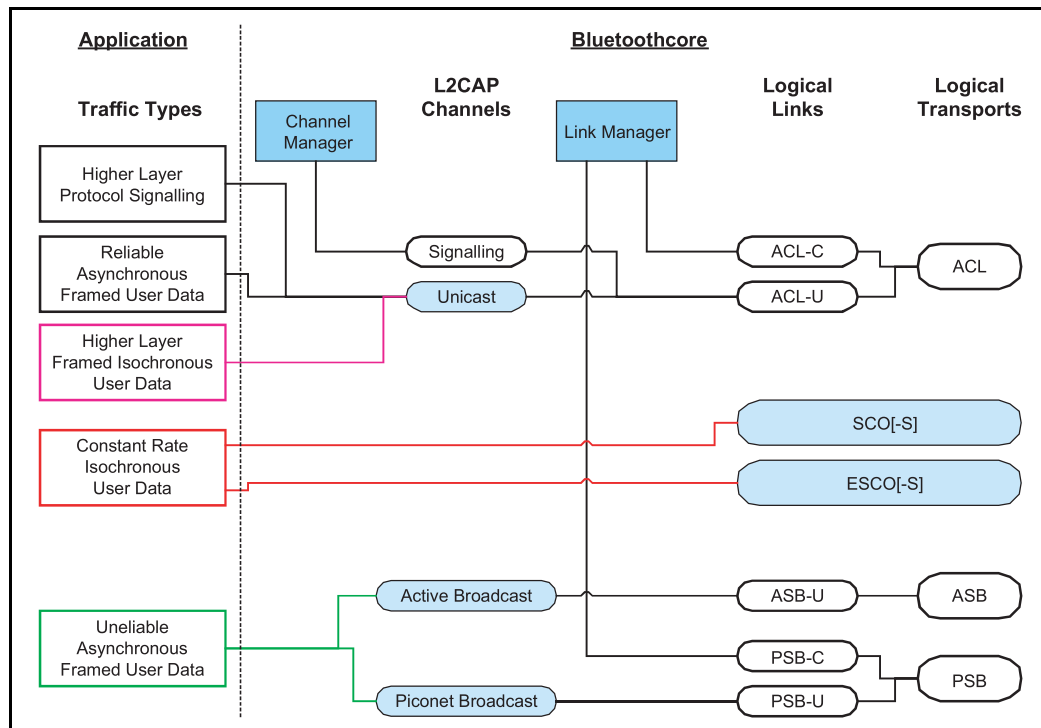


Figure 3.2: Bluetooth traffic bearers

The core traffic bearers that are available to applications are shown in [Figure 3.2 on page 26](#) as the shaded rounded rectangles. The architectural layers that are defined to provide these services are described in [Section 2 on page 19](#). A number of data traffic types are shown on the left of the diagram linked to the traffic bearers that are typically suitable for transporting that type of data traffic.

The logical links are named using the names of the associated logical transport and a suffix that indicates the type of data that is transported. (C for control links carrying LMP messages, U for L2CAP links carrying user data (L2CAP PDUs) and S for stream links carrying unformatted synchronous or isochronous data.) It is common for the suffix to be removed from the logical link without introducing ambiguity, thus a reference to the default ACL logical transport can be resolved to mean the ACL-C logical link in cases where the LMP protocol is being discussed, or the ACL-U logical link when the L2CAP layer is being discussed.

The mapping of application traffic types to Bluetooth core traffic bearers in [Figure 3.2 on page 26](#) is based on matching the traffic characteristics with the



bearer characteristics. It is recommended to use these mappings as they provide the most natural and efficient method of transporting the data with its given characteristics.

However, an application (or an implementation of the Bluetooth core system) may choose to use a different traffic bearer, or a different mapping to achieve a similar result. For example, in a piconet with only one slave, the master may choose to transport L2CAP broadcasts over the ACL-U logical link rather than over the ASB-U or PSB-U logical links. This will probably be more efficient in terms of bandwidth (if the physical channel quality is not too degraded.) Use of alternative transport paths to those in [Figure 3.2 on page 26](#) is only acceptable if the characteristics of the application traffic type are preserved.

[Figure 3.2 on page 26](#) shows a number of application traffic types. These are used to classify the types of data that may be submitted to the Bluetooth core system. The original data traffic type may not be the same as the type that is submitted to the Bluetooth core system if an intervening process modifies it. For example, video data is generated at a constant rate but an intermediate coding process may alter this to variable rate, e.g. by MPEG4 encoding. For the purposes of the Bluetooth core system, only the characteristic of the submitted data is of interest.

3.1.1 Framed data traffic

The L2CAP layer services provide a frame-oriented transport for asynchronous and isochronous user data. The application submits data to this service in variable-sized frames (up to a negotiated maximum for the channel) and these frames are delivered in the same form to the corresponding application on the remote device. There is no requirement for the application to insert additional framing information into the data, although it may do so if this is required (such framing is invisible to the Bluetooth core system.)

Connection-oriented L2CAP channels may be created for transport of unicast (point-to-point) data between two Bluetooth devices. A connectionless L2CAP channel exists for broadcasting data. In the case of piconet topologies the master device is always the source of broadcast data and the slave device(s) are the recipients. Traffic on the broadcast L2CAP channel is uni-directional. Unicast L2CAP channels may be uni-directional or bi-directional.

L2CAP channels have an associated QoS setting that defines constraints on the delivery of the frames of data. These QoS settings may be used to indicate (for example) that the data is isochronous, and therefore has a limited lifetime after which it becomes invalid, or that the data should be delivered within a given time period, or that the data is reliable and should be delivered without error, however long this takes.

The L2CAP channel manager is responsible for arranging to transport the L2CAP channel data frames on an appropriate baseband logical link, possibly multiplexing this onto the baseband logical link with other L2CAP channels with similar characteristics.



3.1.2 Unframed data traffic

If the application does not require delivery of data in frames, possibly because it includes in-stream framing, or because the data is a pure stream, then it may avoid the use of L2CAP channels and make direct use of a baseband logical link.

The Bluetooth core system supports the direct transport of application data that is isochronous and of a constant rate (either bit-rate, or frame-rate for pre-framed data), using a SCO-S or eSCO-S logical link. These logical links reserve physical channel bandwidth and provide a constant rate transport locked to the piconet clock. Data is transported in fixed size packets at fixed intervals with both of these parameters negotiated during channel establishment. eSCO links provide a greater choice of bit-rates and also provide greater reliability by using limited retransmission in case of error. SCO and eSCO logical transports do not support multiplexed logical links or any further layering within the Bluetooth core. An application may choose to layer a number of streams within the submitted SCO/eSCO stream, provided that the submitted stream is, or has the appearance of being, a constant rate stream.

The application chooses the most appropriate type of logical link from those available at the baseband, and creates and configures it to transport the data stream, and releases it when completed. (The application will normally also use a framed L2CAP unicast channel to transport its C-plane information to the peer application on the remote device.)

If the application data is isochronous and of a variable rate, then this may only be carried by the L2CAP unicast channel, and hence will be treated as framed data.

3.1.3 Reliability of traffic bearers

Bluetooth is a wireless communications system. In poor RF environments, this system should be considered inherently unreliable. To counteract this the system provides levels of protection at each layer. The baseband packet header uses forward error correcting (FEC) coding to allow error correction by the receiver and a header error check (HEC) to detect errors remaining after correction. Certain Baseband packet types include FEC for the payload. Furthermore, some Baseband packet types include a cyclic redundancy error check (CRC).

On ACL logical transports the results of the error detection algorithm are used to drive a simple acknowledgement/repeat request (ARQ) protocol. This provides an enhanced reliability by re-transmitting packets that do not pass the receiver's error checking algorithm. It is possible to modify this scheme to support latency-sensitive packets by discarding an unsuccessfully transmitted packet at the transmitter if the packet's useful life has expired. eSCO links use a modified version of this scheme to improve reliability by allowing a limited number of retransmissions.



The resulting reliability gained by this ARQ scheme is only as dependable as the ability of the HEC and CRC codes to detect errors. In most cases this is sufficient, however it has been shown that for the longer packet types the probability of an undetected error is too high to support typical applications, especially those with a large amount of data being transferred.

The L2CAP layer provides an additional level of error control that is designed to detect the occasional undetected errors in the baseband layer and request retransmission of the affected data. This provides the level of reliability required by typical Bluetooth applications.

Broadcast links have no feedback route, and are unable to use the ARQ scheme (although the receiver is still able to detect errors in received packets.) Instead each packet is transmitted several times in the hope that the receiver is able to receive at least one of the copies successfully. Despite this approach there are still no guarantees of successful receipt, and so these links are considered unreliable.

In summary, if a link or channel is characterised as reliable this means that the receiver is capable of detecting errors in received packets and requesting retransmission until the errors are removed. Due to the error detection system used some residual (undetected) errors may still remain in the received data. For L2CAP channels the level of these is comparable to other communication systems, although for logical links the residual error level is somewhat higher.

The transmitter may remove packets from the transmit queue such that the receiver does not receive all the packets in the sequence. If this happens detection of the missing packets is delegated to the L2CAP layer.

On an unreliable link the receiver is capable of detecting errors in received packets but cannot request retransmission. The packets passed on by the receiver may be without error, but there is no guarantee that all packets in the sequence are received. Hence the link is considered fundamentally unreliable. There are limited uses for such links, and these uses are normally dependent on the continuous repetition of data from the higher layers while it is valid.

Stream links have a reliability characteristic somewhere between a reliable and an unreliable link, depending on the current operating conditions.



3.2 TRANSPORT ARCHITECTURE ENTITIES

The Bluetooth transport architecture entities are shown in [Figure 3.3 on page 30](#) and are described from the lowest layer upwards in the subsequent sections.

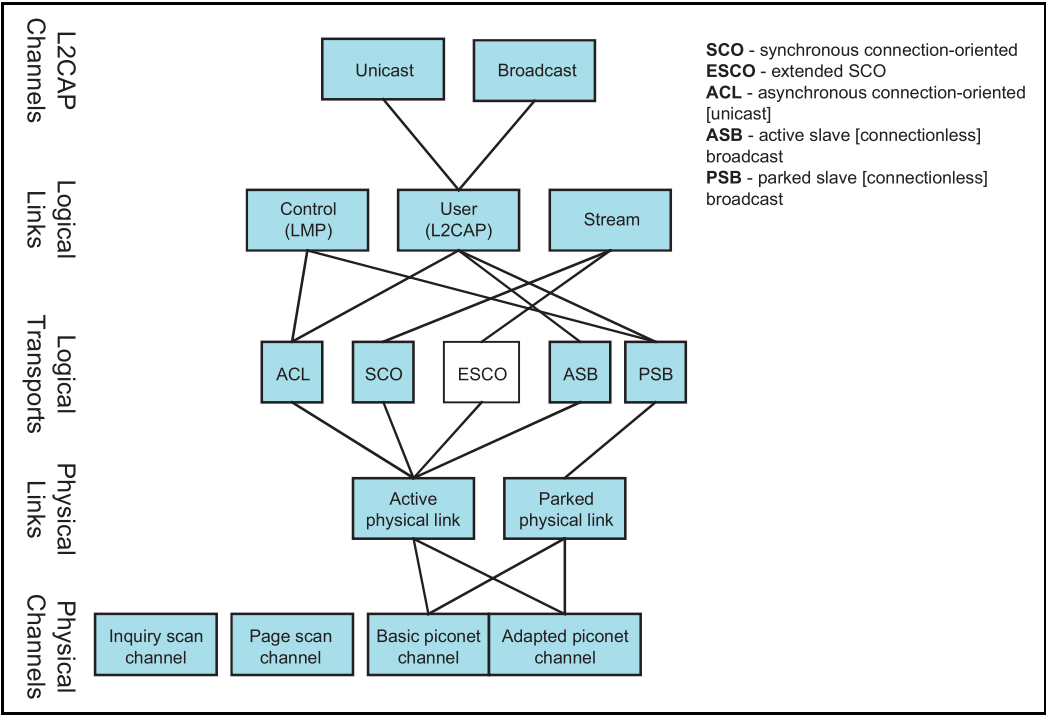


Figure 3.3: Overview of transport architecture entities and hierarchy

3.2.1 Bluetooth generic packet structure

The general packet structure nearly reflects the architectural layers found in the Bluetooth system. The packet structure is designed for optimal use in normal operation. It is shown in [Figure 3.4 on page 30](#).

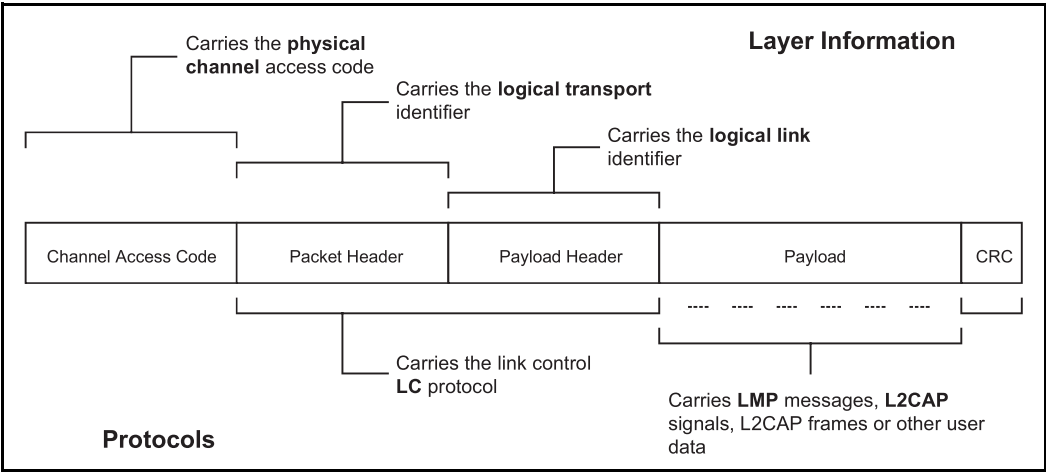


Figure 3.4: Bluetooth packet structure



Packets normally only include the fields that are necessary to represent the layers required by the transaction. Thus a simple inquiry request over an inquiry scan physical channel does not create or require a logical link or higher layer and therefore consists only of the channel access code (associated with the physical channel.) General communication within a piconet uses packets that include all of the fields, as all of the architectural layers are used.

All packets include the channel access code. This is used to identify communications on a particular physical channel, and to exclude or ignore packets on a different physical channel that happens to be using the same RF carrier in physical proximity.

There is no direct field within the Bluetooth packet structure that represents or contains information relating to physical links. This information is implied in the logical transport address (LT_ADDR) carried in the packet header.

Most packets include a packet header. The packet header is always present in packets transmitted on physical channels that support physical links, logical transports and logical links. The packet header carries the LT_ADDR, which is used by each receiving device to determine if the packet is addressed to the device and is used to route the packet internally.

The packet header also carries part of the link control (LC) protocol that is operated per logical transport (except for ACL and SCO transports that operate a shared LC protocol carried on either logical transport.)

The payload header is present in all packets on logical transports that support multiple logical links. The payload header includes a logical link identifier field used for routing the payload, and a field indicating the length of the payload. Some packet types also include a CRC after the packet payload that is used to detect most errors in received packets.

The packet payload is used to transport the user data. The interpretation of this data is dependent on the logical transport and logical link identifiers. For ACL logical transports Link Manager Protocol (LMP) messages and L2CAP signals are transported in the packet payload, along with general user data from applications. For SCO and eSCO logical transports the payload contains the user data for the logical link.