A2DP/GAVDP/AVDTP 浅析

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三个名词

- A2DP(**ADVANCED AUDIO DISTRIBUTION PROFILE SPECIFICATION**)

  ---定义了在acl通路上实现单声道或者高品质音频内容分发的协议或者步骤

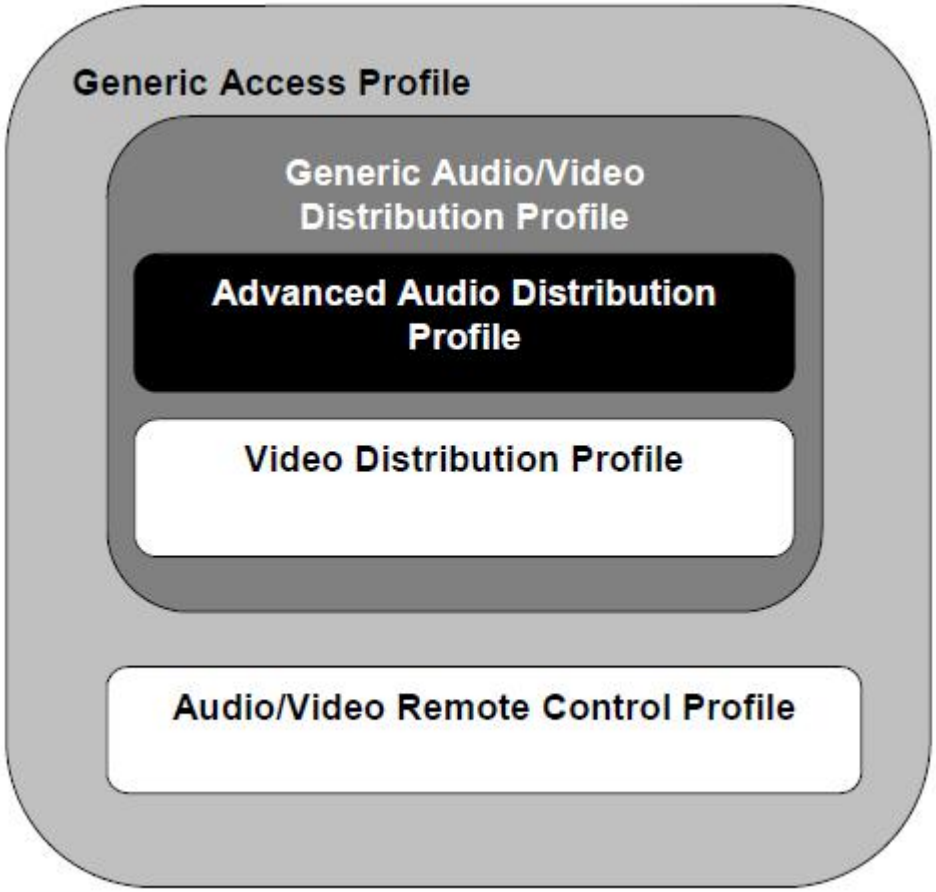
- GAVDP(**GENERIC AUDIO/VIDEO DISTRIBUTION PROFILE**)

  ---定义了通用的在acl通路实现音频内容或者视频内容分发的协议或者步骤

- AVDTP(**AUDIO/VIDEO DISTRIBUTION TRANSPORT PROTOCOL SPECIFICATION**)

  ---定义了蓝牙设备之间音视频数据流句柄的参数协商，建立和传输过程以及相互交换的信令实体形式

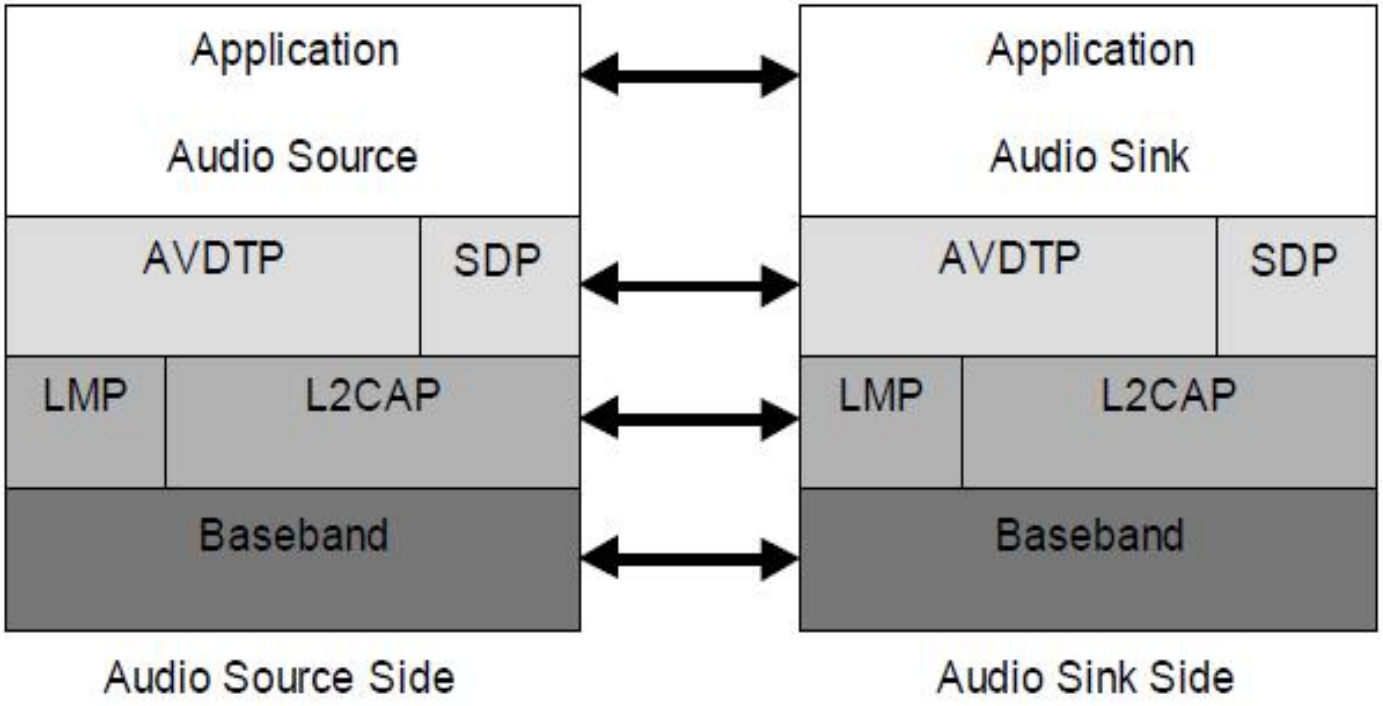
协议依赖:


Generic Access Profile
Generic Audio/Video Distribution Profile
Advanced Audio Distribution Profile
Video Distribution Profile
Audio/Video Remote Control Profile

A2DP的实现依赖于GAVDP和GAP,在GAVDP中定义了流连接的建立过程，在A2DP中定义流的参数和编、解码过程.

AVDTP是A2DP框架的基础协议

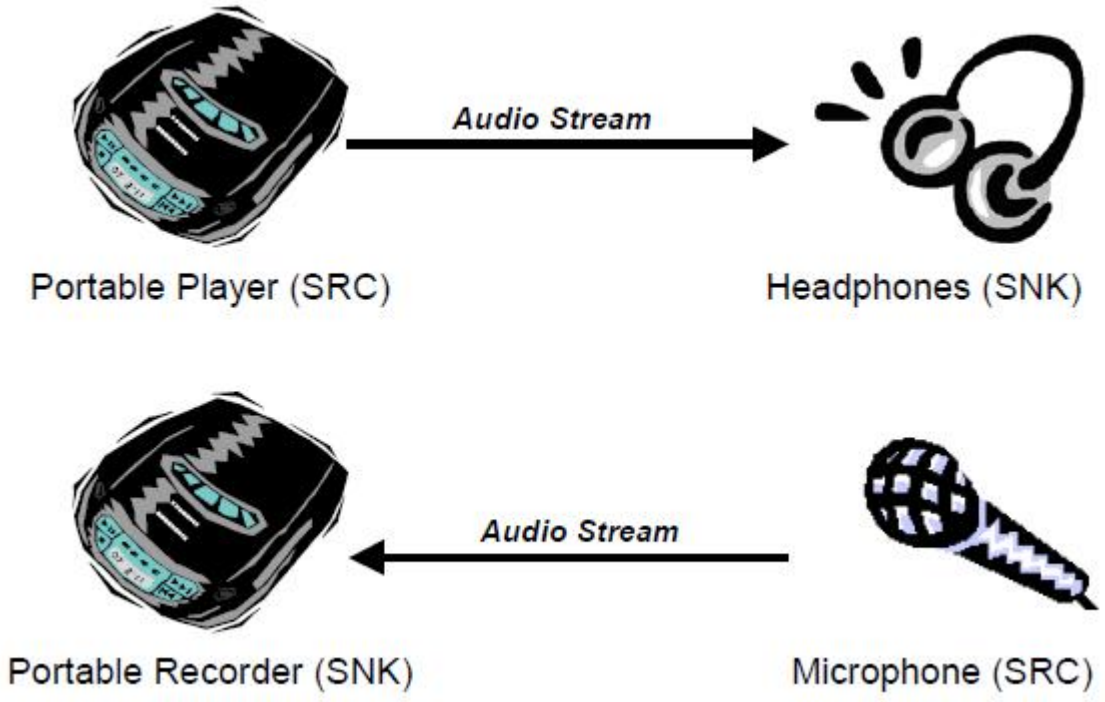
Profile Stacks：



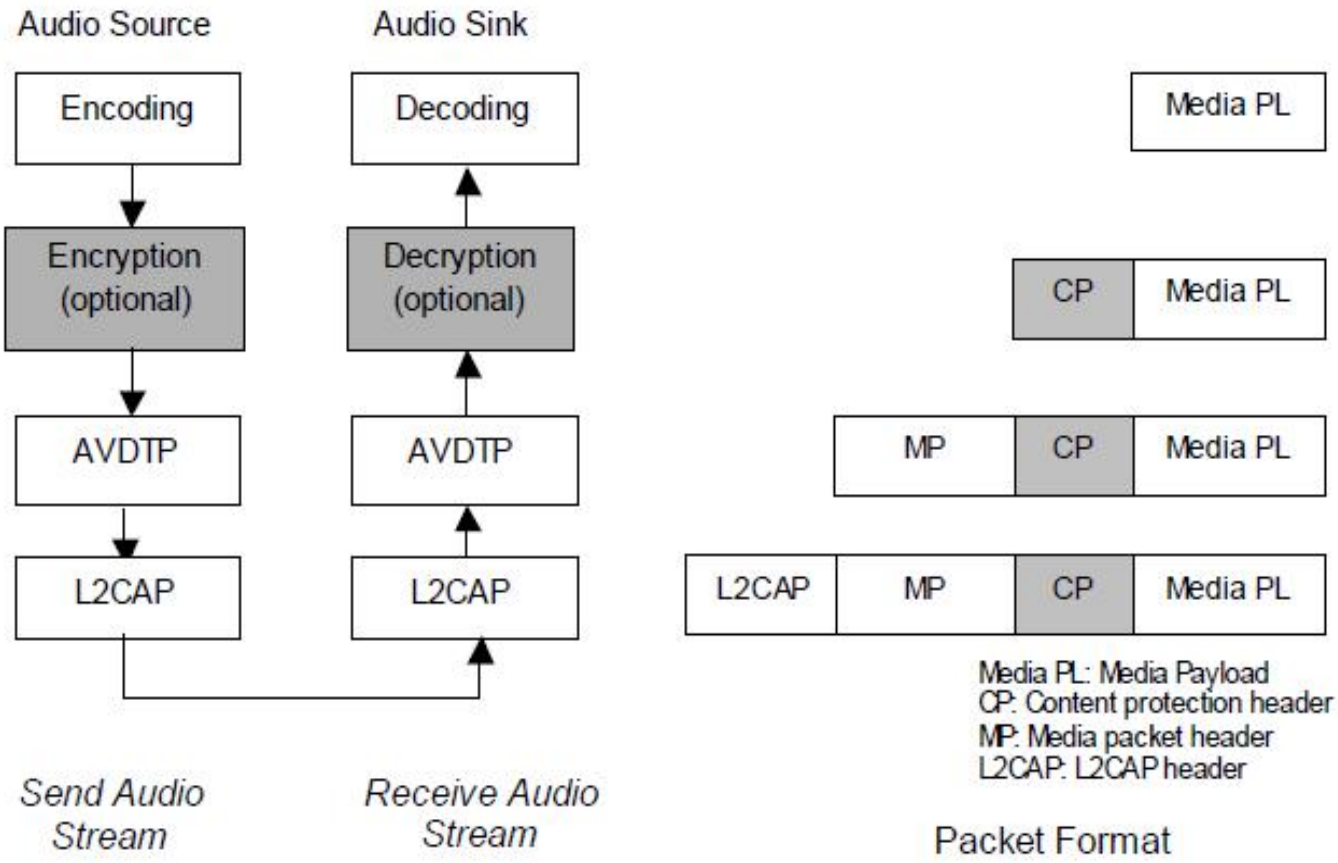
角色定义：

Source (SRC)

Sink (SNK)



音频流和数据包格式：


Audio Source
Audio Sink
Encoding
Decoding
Encryption (optional)
Decryption (optional)
AVDTP
AVDTP
L2CAP
L2CAP
Send Audio Stream
Receive Audio Stream
Media PL
CP
Media PL
MP
CP
Media PL
L2CAP
MP
CP
Media PL
Media PL: Media Payload
CP: Content protection header
MP: Media packet header
L2CAP: L2CAP header
Packet Format

A2DP协议的限制

- (1)不支持synchronized point-to-multipoint distribution。
- (2)在Source和Sink端存在延迟。
- (3)音频数据的速率必须足够小于蓝牙的传输速率
- (4)不提供任何数据保护的方法

编码类型支持：

- 传输音频数据必须在Source端编码，在Sink端解码。A2DP规定了下面几种编码类型

Codec Type	Support
SBC	M
MPEG-1,2 Audio	O
MPEG-2,4 AAC	O
ATRAC family	O

SBC是强制支持的(Mandatory Codec)，其余三种可选(Optional Codec)，除了这些外，也可以有厂家自己的编码形式(Vendor Specific A2DP Codecs)

SBC编码格式

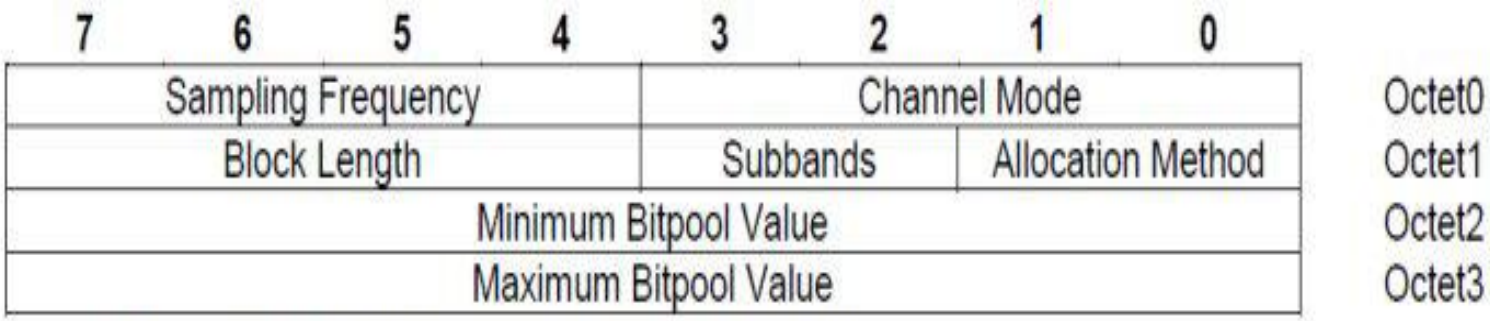


Figure 4.1: Codec Specific Information Elements for SBC

Sampling Frequency

Position	Sampling Frequency (Hz)	Support in SRC	Support in SNK
Octet0; b7	16000	O	O
Octet0; b6	32000	O	O
Octet0; b5	44100	C1	M
Octet0; b4	48000	C1	M
C1: At least one of the values shall be supported			

Table 4.2: Sampling Frequency for SBC

Channel Mode

Position	Channel Mode	Support in SRC	Support in SNK
Octet0; b3	MONO	M	M
Octet0; b2	DUAL CHANNEL	C1	M
Octet0; b1	STEREO	C1	M
Octet0; b0	JOINT STEREO	C1	M
C1: At least one of the values shall be supported			

Table 4.3: Channel Mode for SBC

Block Length

Position	Block length	Support in SRC	Support in SNK
Octet1; b7	4	M	M
Octet1; b6	8	M	M
Octet1; b5	12	M	M
Octet1; b4	16	M	M

Table 4.4: Block Length for SBC

Subbands

Position	Number of subbands	Support in SRC	Support in SNK
Octet1; b3	4	O	M
Octet1; b2	8	M	M

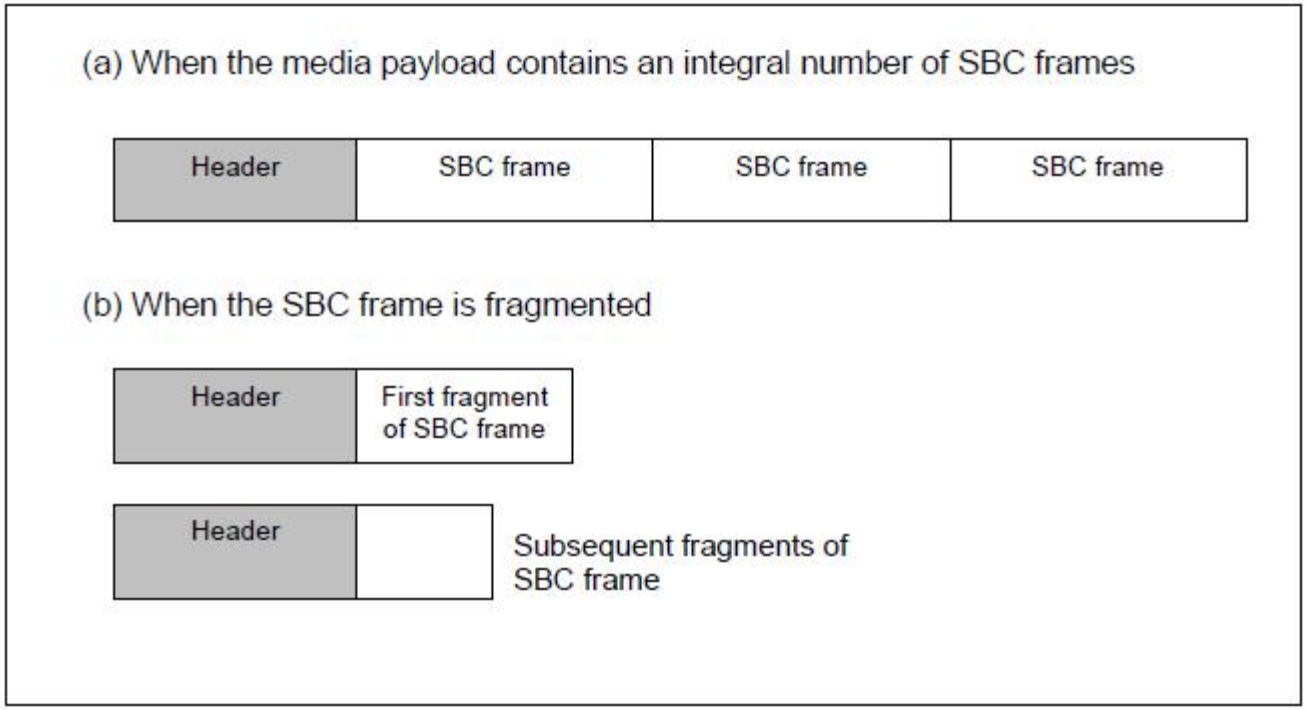
Table 4.5: Number of Subbands for SBC

Minimum / Maximum Bitpool Value

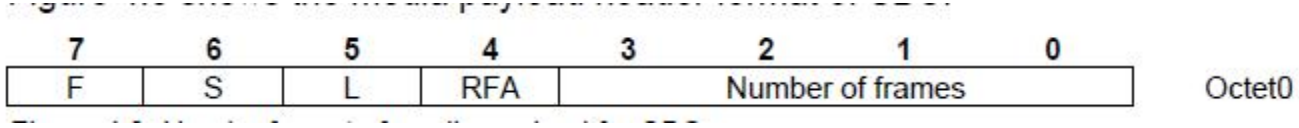
SBC encoder settings*	Middle Quality				High Quality			
	Mono		Joint Stereo		Mono		Joint Stereo	
Sampling frequency (kHz)	44.1	48	44.1	48	44.1	48	44.1	48
Bitpool value	19	18	35	33	31	29	53	51
Resulting frame length (bytes)	46	44	83	79	70	66	119	115
Resulting bit rate (kb/s)	127	132	229	237	193	198	328	345
*Other settings: Block length = 16, Allocation method = Loudness, Subbands = 8								

Table 4.7: Recommended sets of SBC parameters in the SRC device

Media Payload Format



media payload header format



F bit – Set to 1 if the SBC frame is fragmented, otherwise set to 0.

S bit – Set to 1 for the starting packet of a fragmented SBC frame, otherwise set to
0.

L bit – Set to 1 for the last packet of a fragmented SBC frame, otherwise set to 0

RFA Reserved for future additions. Bits with this designation shall be set to zero. Receivers
shall ignore these bits

Number of frames (4 bits)

If the F bit is set to 0, this field indicates the number of frames contained in this packet. If the *F bit is set to 1, this field indicates the number* of remaining fragments, including the current fragment. Thus the last counter value shall be one. For example, if there are three fragments then the counter has value 3,2 and 1 for subsequent fragments. This field is expressed by 4 bit UiMsbf

ios 对编码支持

SubBand Codec (SBC)

Element	Value
Sampling Frequency	44,100 Hz
Channel Mode	Stereo
Block Length	16
Subbands	8
Allocation Method	Loudness
Bitpool range	2 to 53. Accessories for Apple products should support 53.

MPEG 2/4 AAC Codecs

Element	Value
Object Type	MPEG-2 AAC LC
Sampling Frequency	44,100 Hz
Channels	2
Bit rate	264,630 bps
VBR	0

L2CAP互操作性需求

Maximum Transmission Unit

The minimum MTU that a L2CAP implementation for this profile shall support is 335bytes

Sdp互操作性需求

Item	Definition	Type	Value	AttrID	Status	Default
Service Class ID List					M	
Service Class #0		UUID	Audio Source		M	
Protocol Descriptor List					M	
Protocol #0		UUID	L2CAP		M	
Parameter #0 for Protocol #0	PSM	Uint 16	PSM= AVDTP		M	
Protocol #1		UUID	AVDTP		M	
Parameter #0 for Protocol #1	Version	Uint 16	0x0100*		M	
Bluetooth Profile Descriptor List					M	
Profile #0		UUID	Advanced Audio Distribution		M	
Parameter #0 for Profile #0	Version	Uint 16	0x0100*[1]		M	
Supported Features	A2DP features flags	Uint 16	Bit 0 = Player Bit 1 = Microphone Bit 2 = Tuner Bit 3 = Mixer Bit 4-15 = RFA The bits for supported features are set to 1. Others are set to 0.		O	
Provider Name	Displayable Text Name	String	Provider Name		O	
Service Name	Displayable Text Name	String	Service-provider defined		O	

*1 Indicating Version 1.0.

Figure 5.1: Service Record for Source

Item	Definition	Type	Value	AttrID	Status	Default
Service Class ID List					M	
Service Class #0		UUID	Audio Sink		M	
Protocol Descriptor List					M	
Protocol #0		UUID	L2CAP		M	
Parameter #0 for Protocol #0	PSM	Uint 16	PSM= AVDTP		M	
Protocol #1		UUID	AVDTP		M	
Parameter #0 for Protocol #1	Version	Uint 16	0x0100*		M	
Bluetooth Profile Descriptor List					M	
Profile #0		UUID	Advanced Audio Distribution		M	
Parameter #0 for Profile #0	Version	Uint 16	0x0100*[1]		M	
Supported Features	A2DP features flags	Uint 16	Bit 0 = Headphone Bit 1 = Speaker Bit 2 = Recorder Bit 3 = Amplifier Bit 4-15 = RFA The bits for supported features are set to 1. Others are set to 0.		O	
Provider Name	Displayable Text Name	String	Provider Name		O	
Service Name	Displayable Text Name	String	Service-provider defined		O	

*1 Indicating Version 1.0.

Figure 5.2: Service Record for Sink

Link Controller 互操作性需求

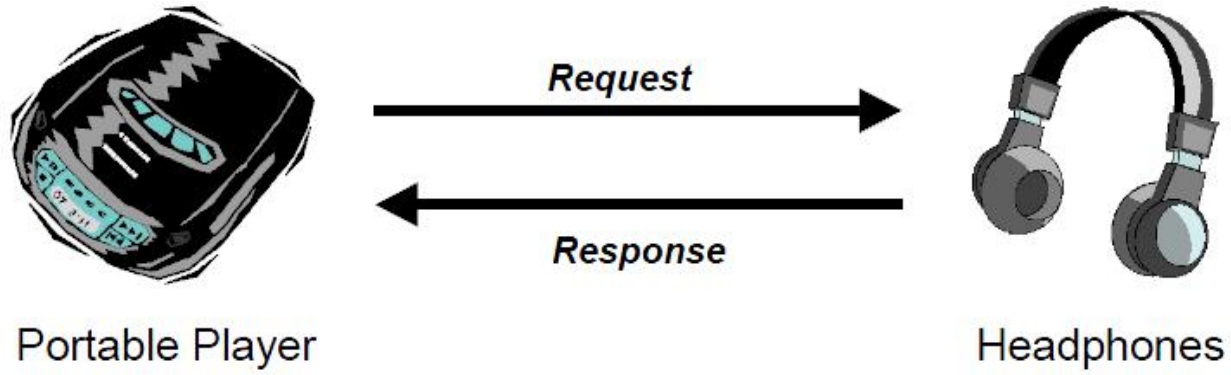
SNK and SRC必须支持 **DH3,**DM3, DH5 and DM5

GAVDP

角色定义：

Initiator (INT) – 发起请求

Acceptor (ACP) – 接受请求



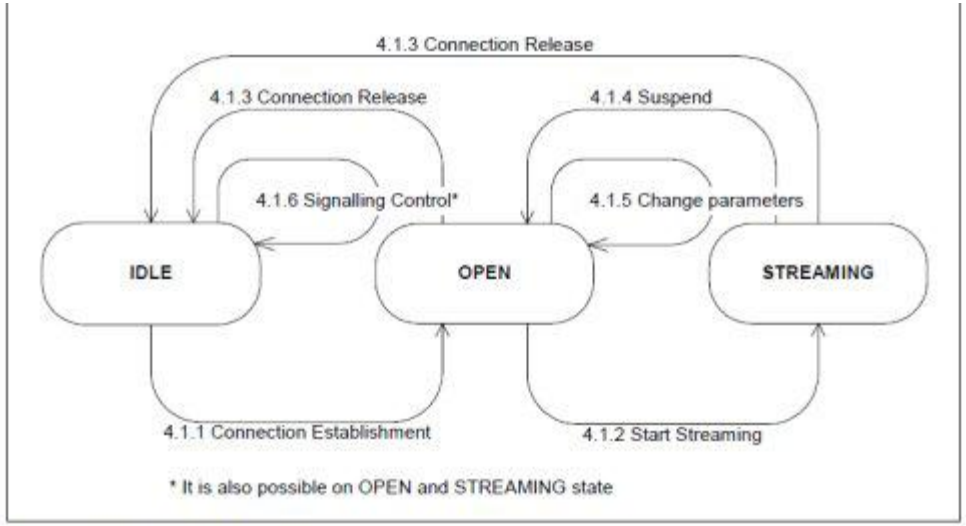
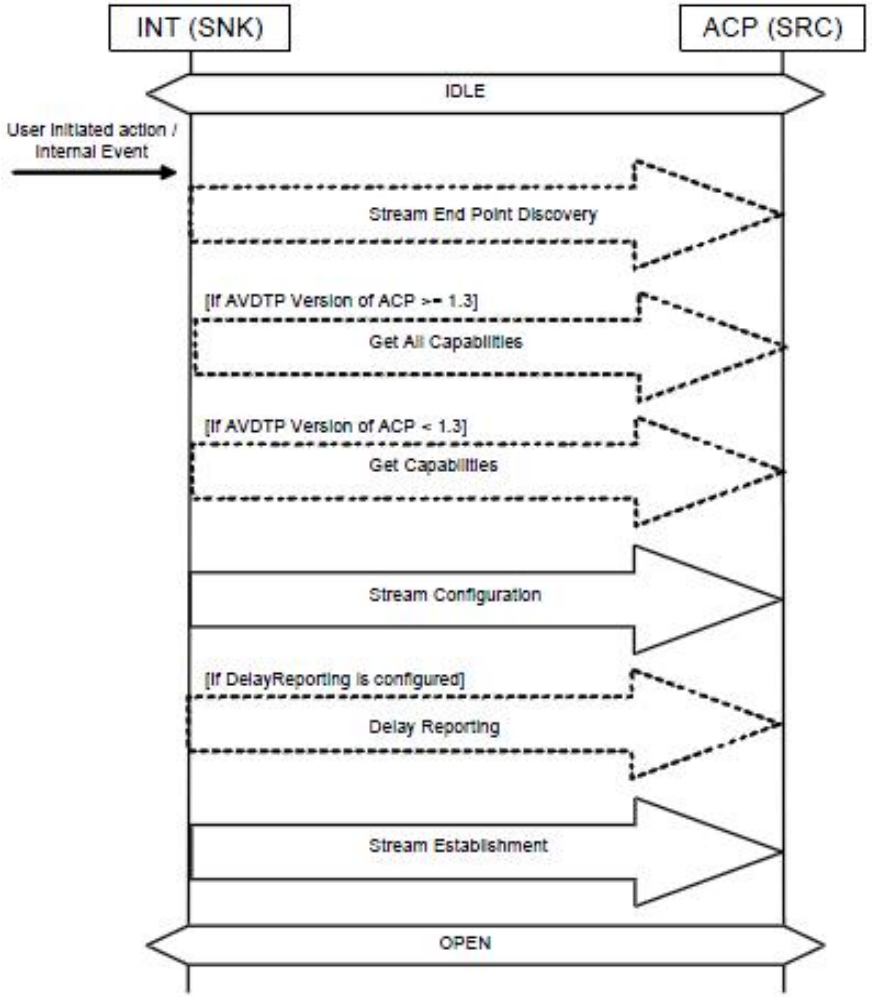
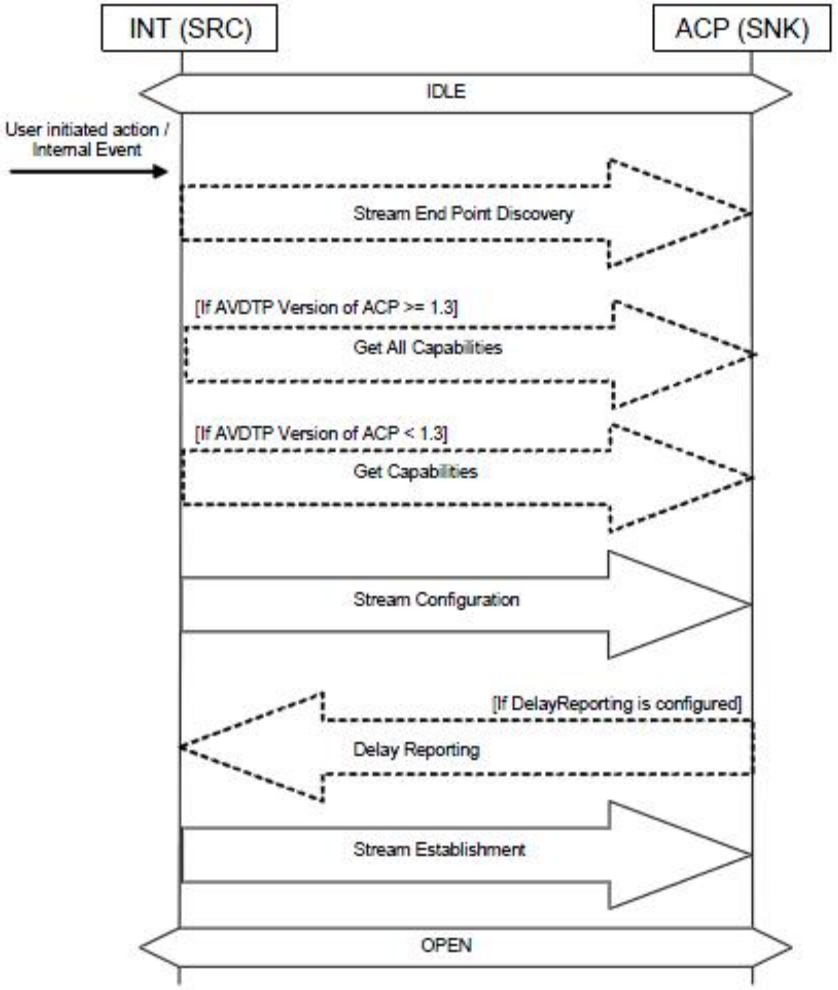


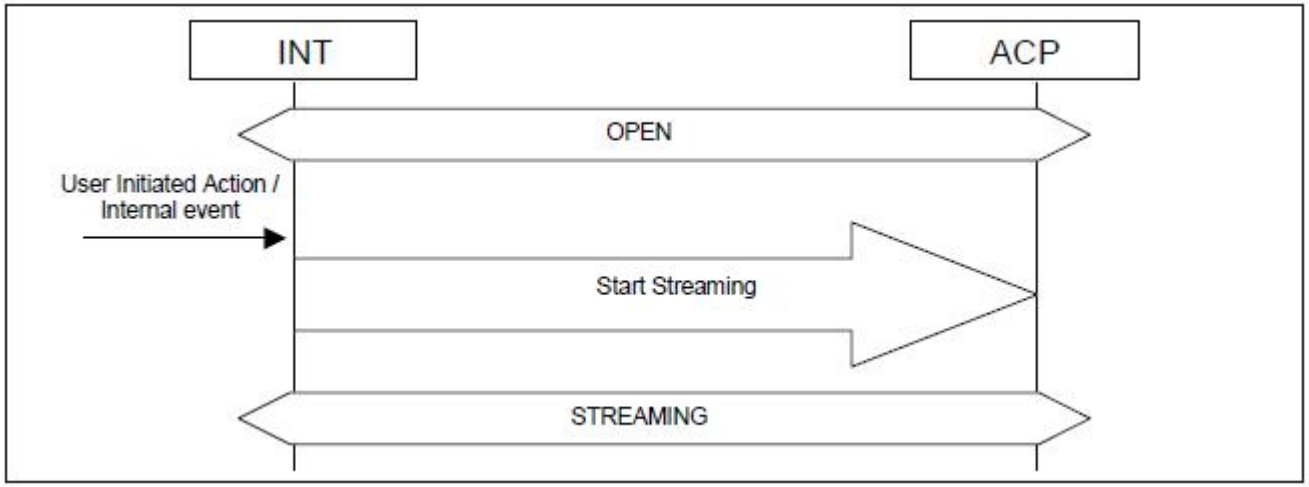
Figure 3.1: Signaling Procedures

建立连接：

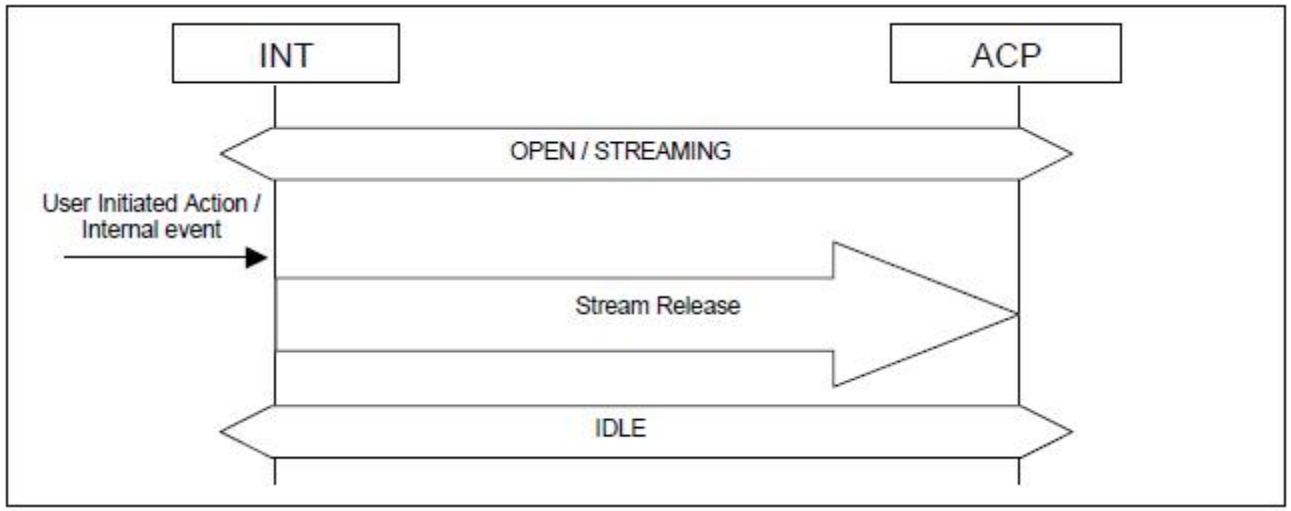

INT (SNK)
ACP (SRC)
IDLE
User initiated action / Internal Event
Stream End Point Discovery
[If AVDTP Version of ACP >= 1.3]
Get All Capabilities
[If AVDTP Version of ACP < 1.3]
Get Capabilities
Stream Configuration
[If DelayReporting is configured]
Delay Reporting
Stream Establishment
OPEN


INT (SRC)
ACP (SNK)
IDLE
User initiated action / Internal Event
Stream End Point Discovery
[If AVDTP Version of ACP >= 1.3]
Get All Capabilities
[If AVDTP Version of ACP < 1.3]
Get Capabilities
Stream Configuration
[If DelayReporting is configured]
Delay Reporting
Stream Establishment
OPEN

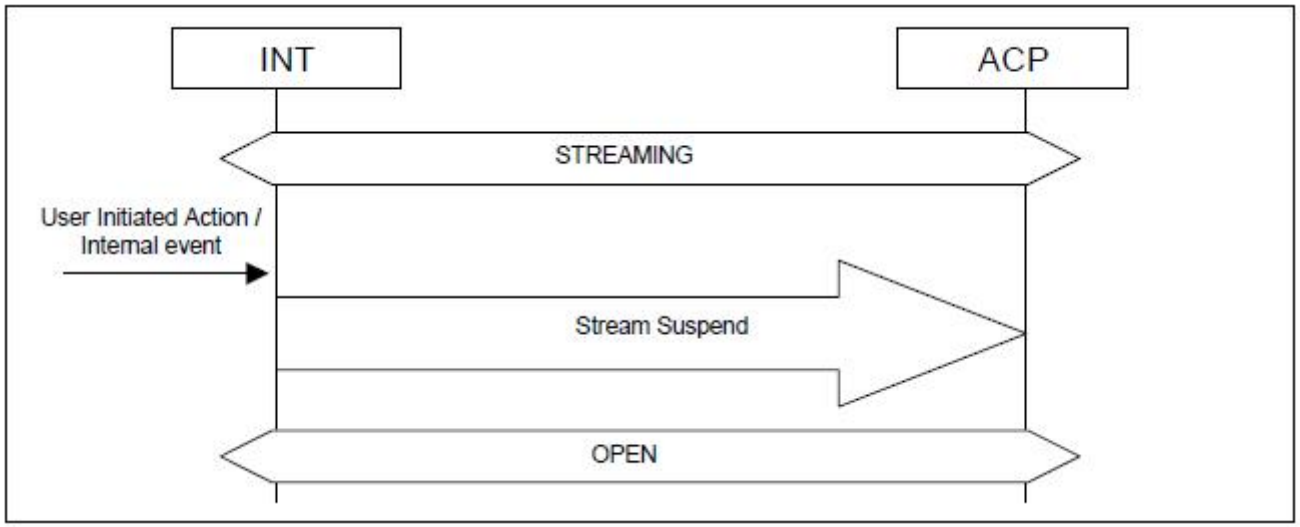
Start Streaming



Connection Release

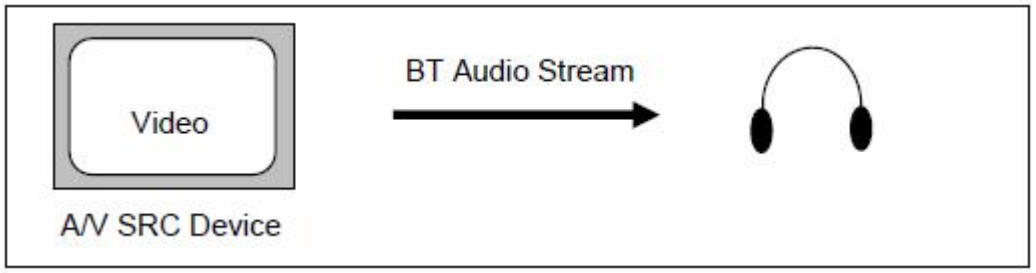


Suspend


INT
ACP
STREAMING
User Initiated Action /
Internal event
Stream Suspend
OPEN

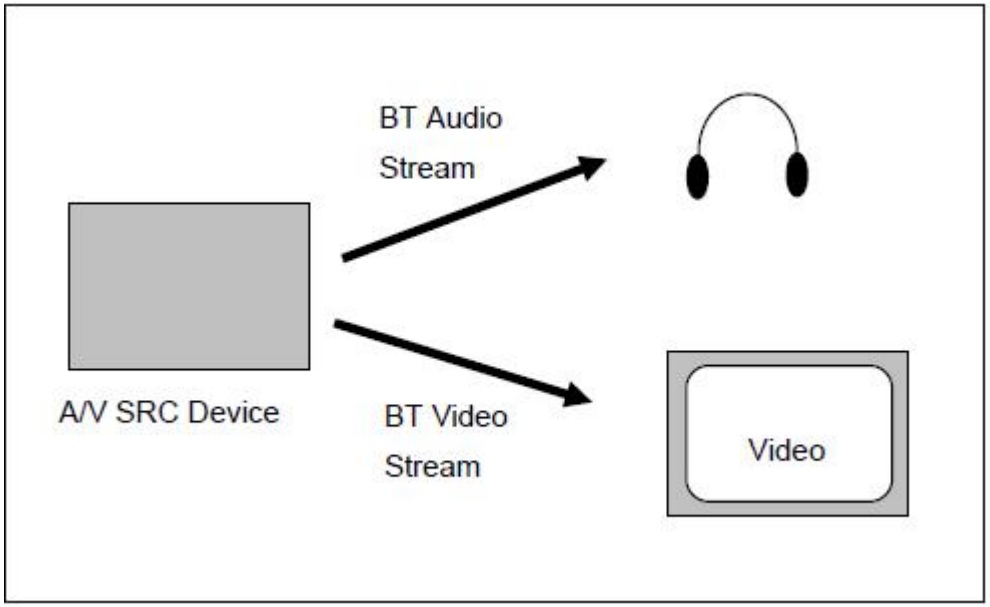
Delay Reporting

Use Case



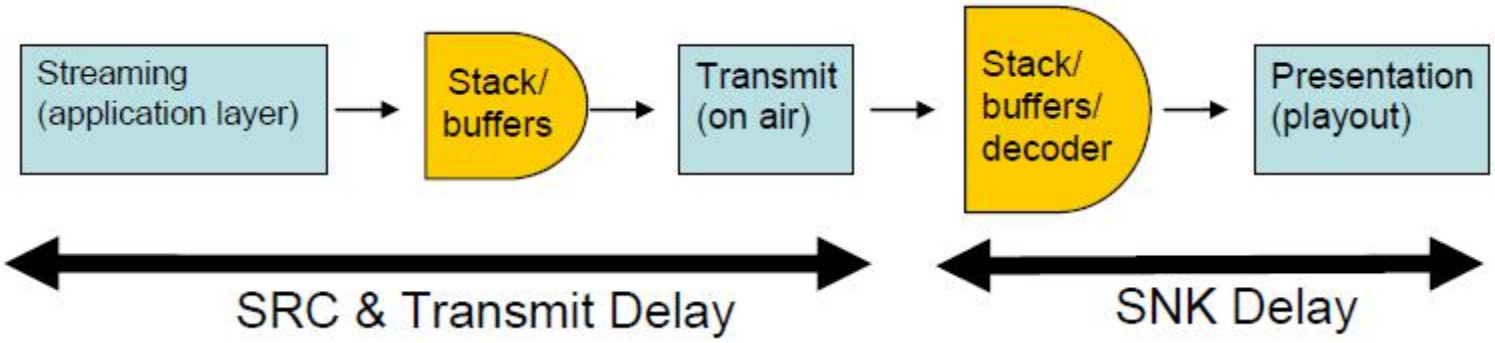
用户观看视频,而听音乐使用蓝牙耳机,,用户感受到音频和视频不同步,存在延迟 (解码;缓冲,传输)

second use case



同步机制基于snk 报告的缓冲,解码,渲染等延迟,src 来保证audio和video同步

Delay Definition



Definition SNK delay	
SNK_delay_start	Media Packet is received by the baseband
SNK_delay_end	Media Packet is presented to the user (e.g. on the loudspeaker or display)

Table 3.1: Sink delay

Allowed Delay Values

最大的音频和视频建议延迟

Delay Values	
Maximum allowed presentation delay between audio and video	+80/-150 ms
Recommended presentation delay between audio and video	+35/-95 ms
Maximum allowed deviation of reported SNK Delay	+/- 30 ms
Recommended deviation of reported SNK Delay	+/- 15 ms

正值代表音频领先于视频

Delay Reporting Service

提供delay value的报告,从snk到src.

注意:

一旦delay 报告服务使用,snk必须确保两次报告之间的精度在+/- 30 ms

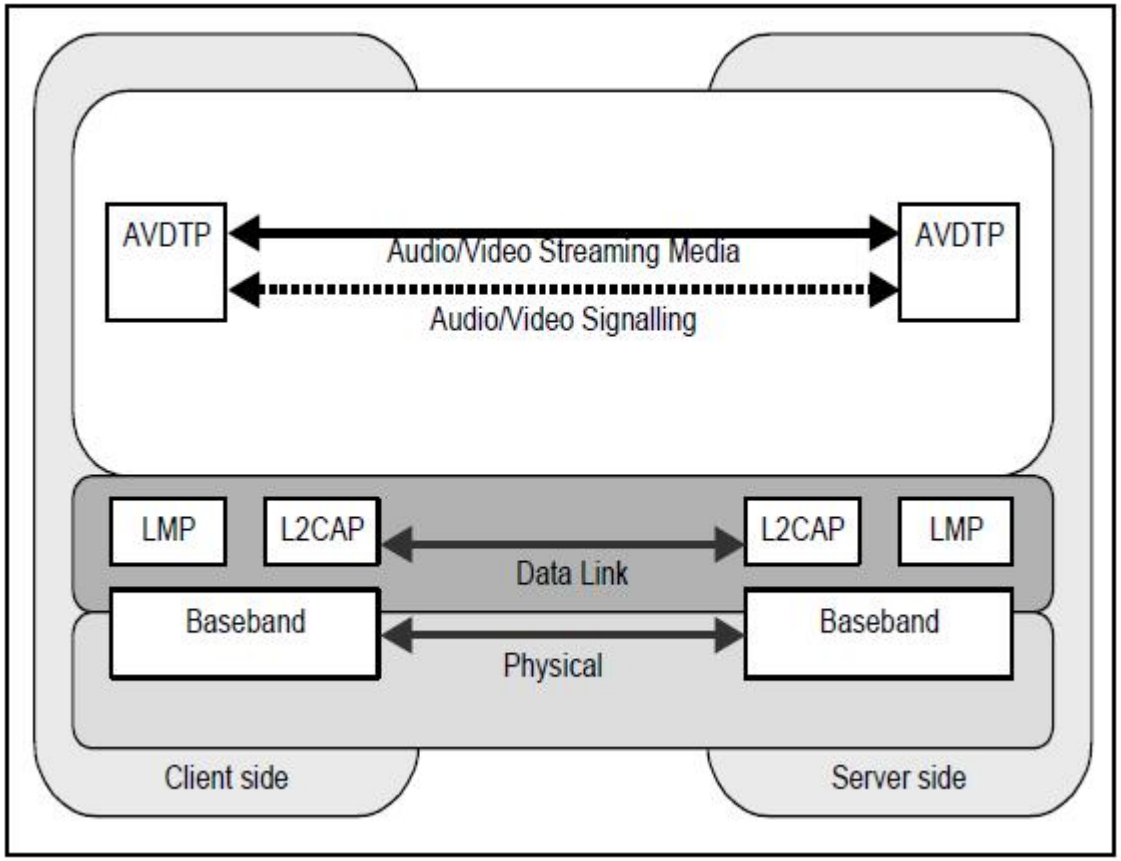
如果音频和视频是通过蓝牙传输，SRC设备应补偿报告延迟值的差异，使这两个流都在表中定义的公差范围内。如果只有一个流通过蓝牙发送，而另一个是本地渲染，SRC需要知道本地渲染设备的延迟，以补偿不同的延迟值

对于动态变化的延迟值SRC设备应保持音频和视频的同步渲染。

可以如:通过复制或删除视频帧或视频时间戳修改

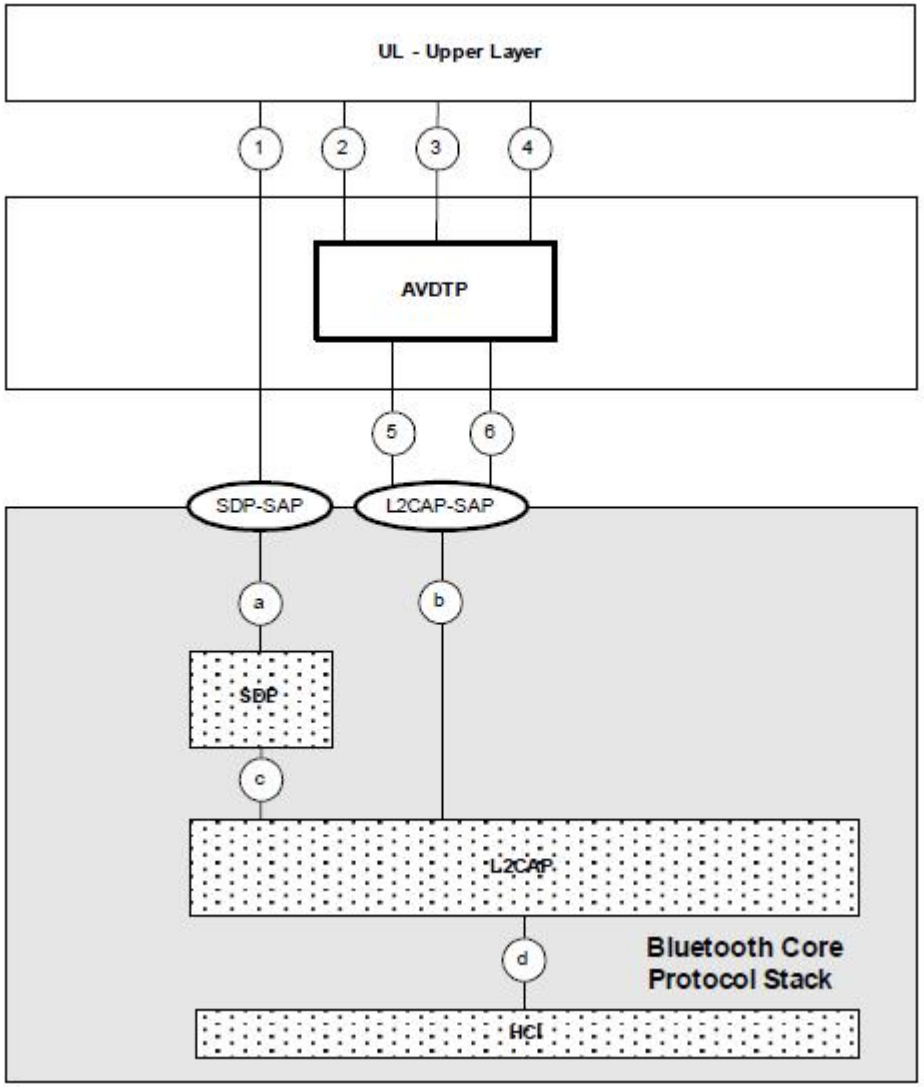
AVDTP

AVDTP(AUDIO/VIDEO DISTRIBUTION TRANSPORT PROTOCOL)是用来描述音频/视频在蓝牙设备间的传输的协议，是A2DP协议的基础协议，其在协议栈中的位置如下：



AVDTP协议建立在connection-oriented L2CAP channel上，只能支持point-to-point signaling

Architecture Block Diagram



- 术语:

Stream：

音/视频设备之间端到端流媒体传输的数据形式

- **Stream End Point (SEP) :**

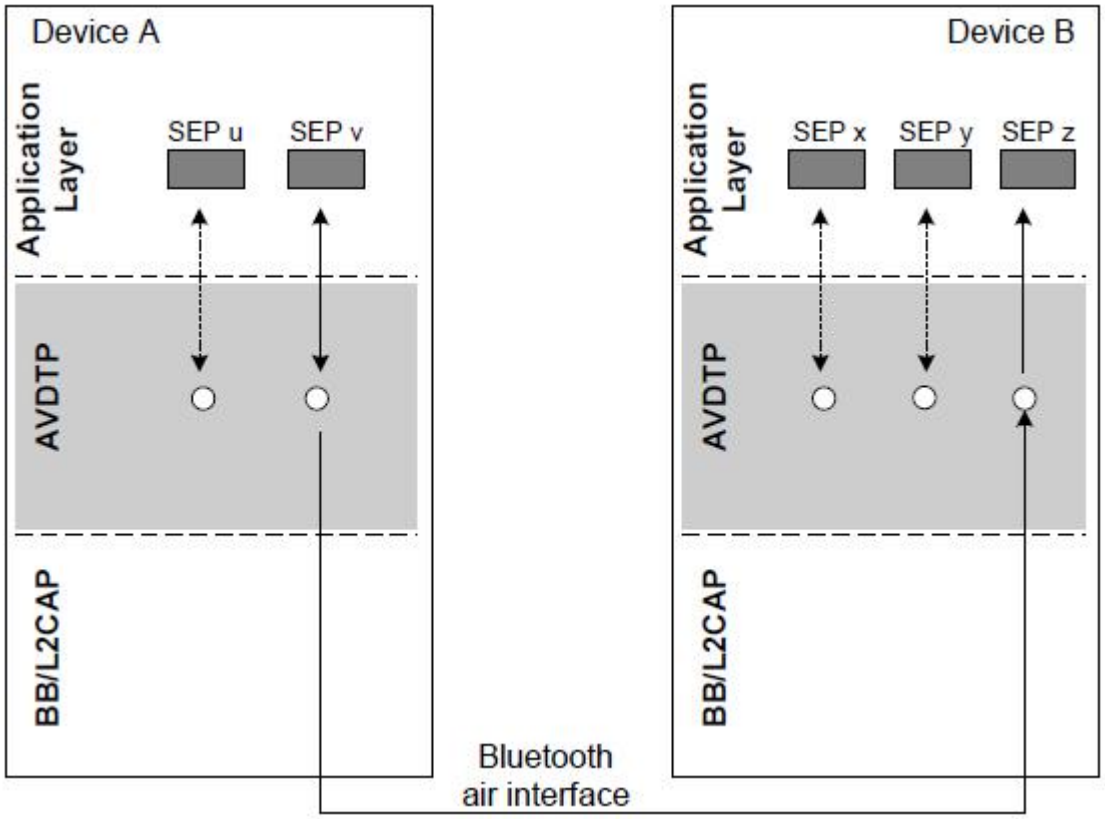
  应用程序通过这个接口提供Transport Services and AV capabilities来建立Stream

- **Stream Handle**

  由INT和ACP的AVDTP实体建立流连接独立分配。

- **Stream End Point Identifier (SEID)**

Stream End Point Architecture



SignalingProcedures

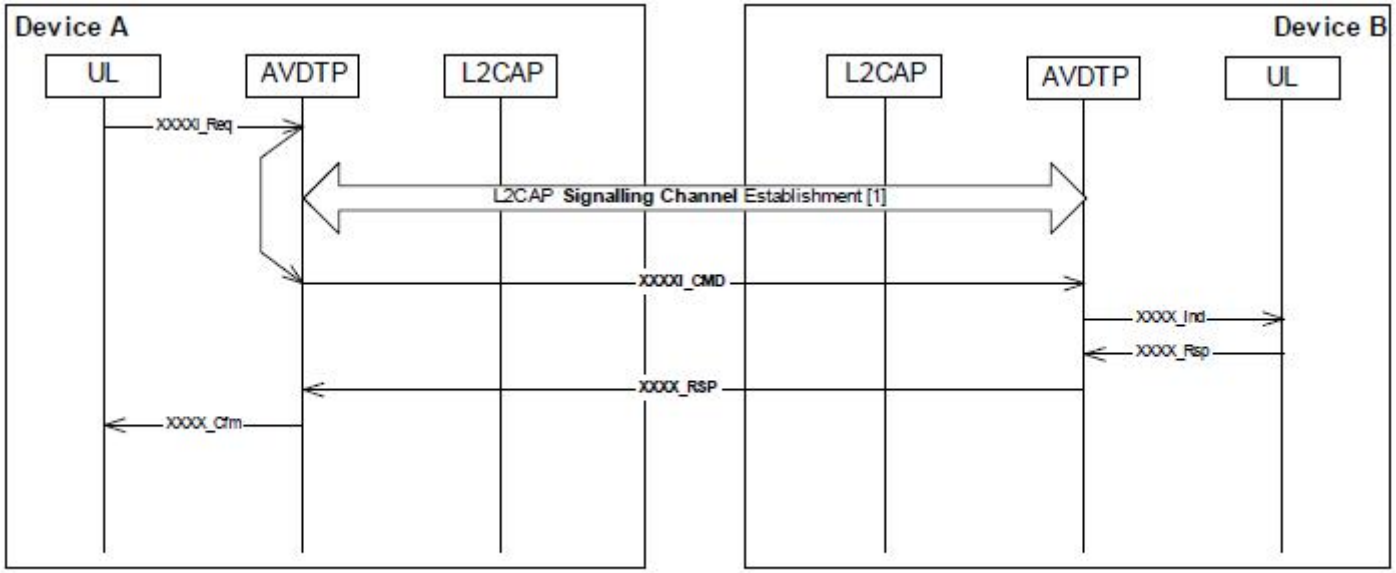
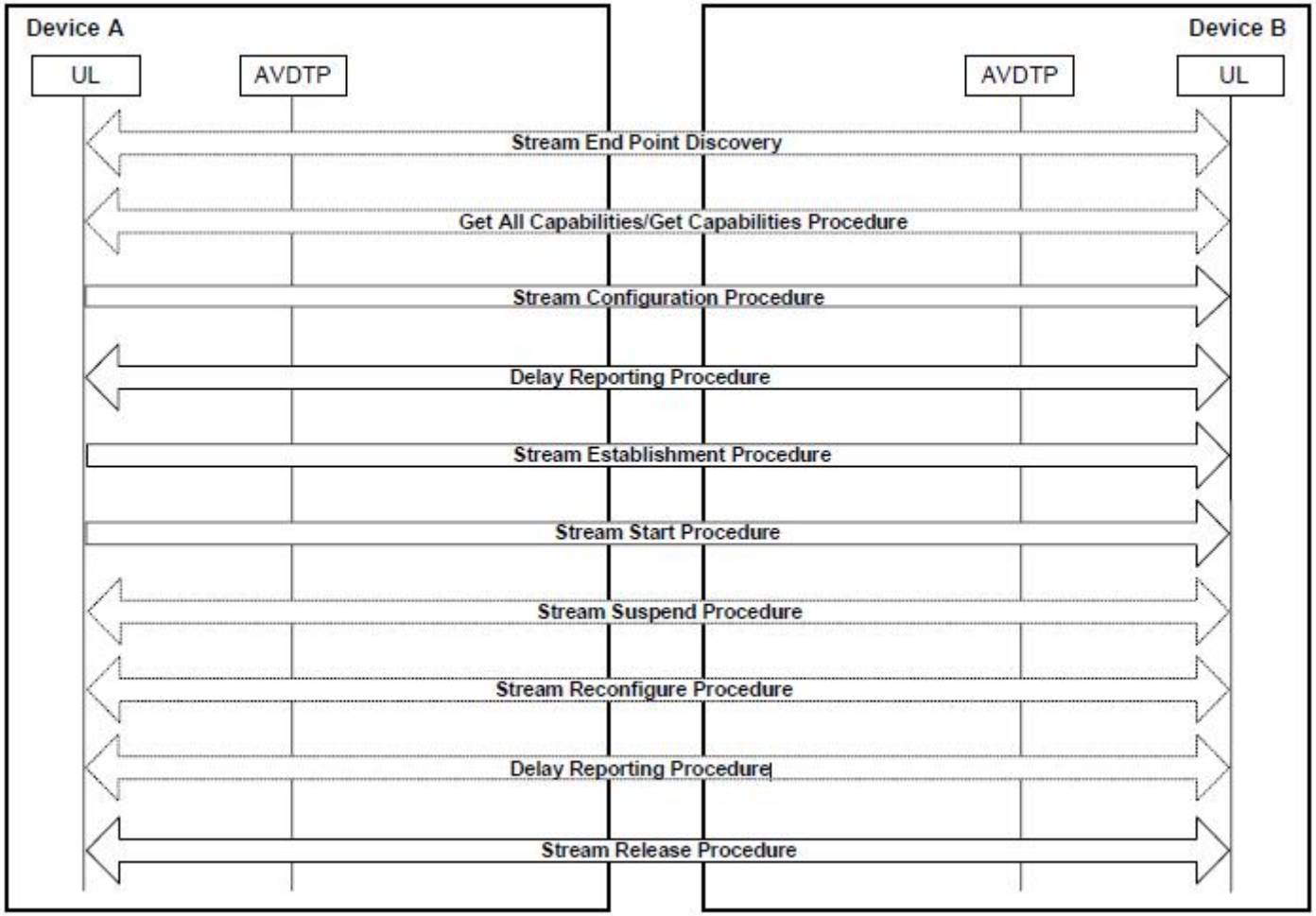


Figure 6.1: Signaling Channel Establishment Procedure

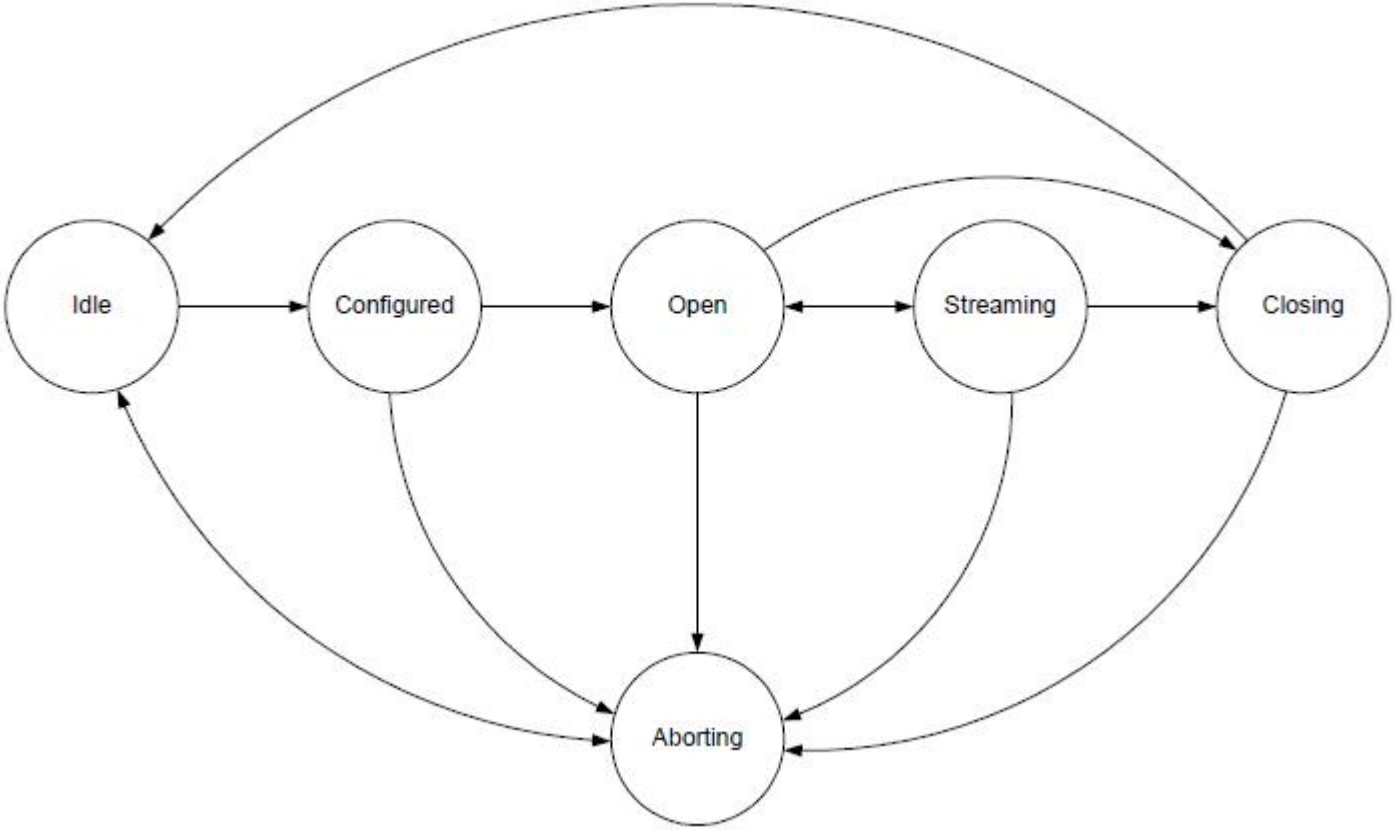
Stream End-point Discovery to Stream Release



Signal Command Set

Command
AVDTP_DISCOVER
AVDTP_GET_CAPABILITIES
AVDTP_SET_CONFIGURATION
AVDTP_GET_CONFIGURATION
AVDTP_RECONFIGURE
AVDTP_OPEN
AVDTP_START
AVDTP_CLOSE
AVDTP_SUSPEND
AVDTP_SECURITY_CONTROL
AVDTP_ABORT
AVDTP_GET_ALL_CAPABILITIES
AVDTP_DELAYREPORT

State Machine



Transport Procedures

Basic Service

The basic service offered to the upper layer by AVDTP provides only signaling and media streaming

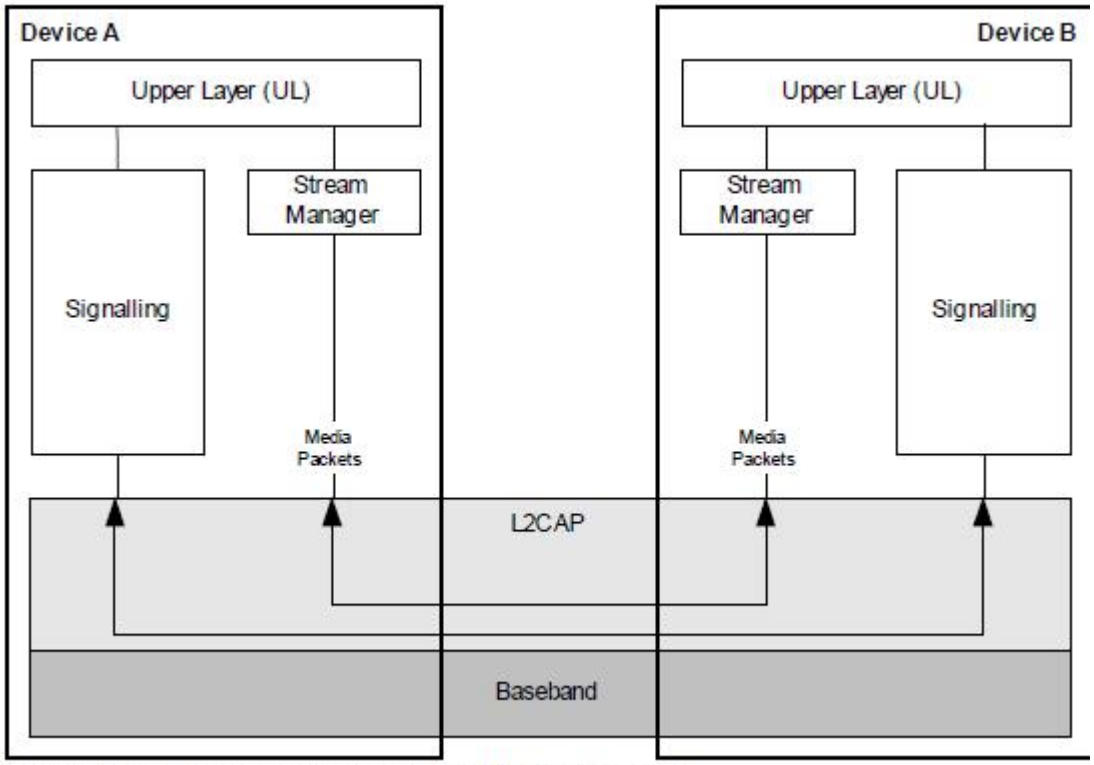
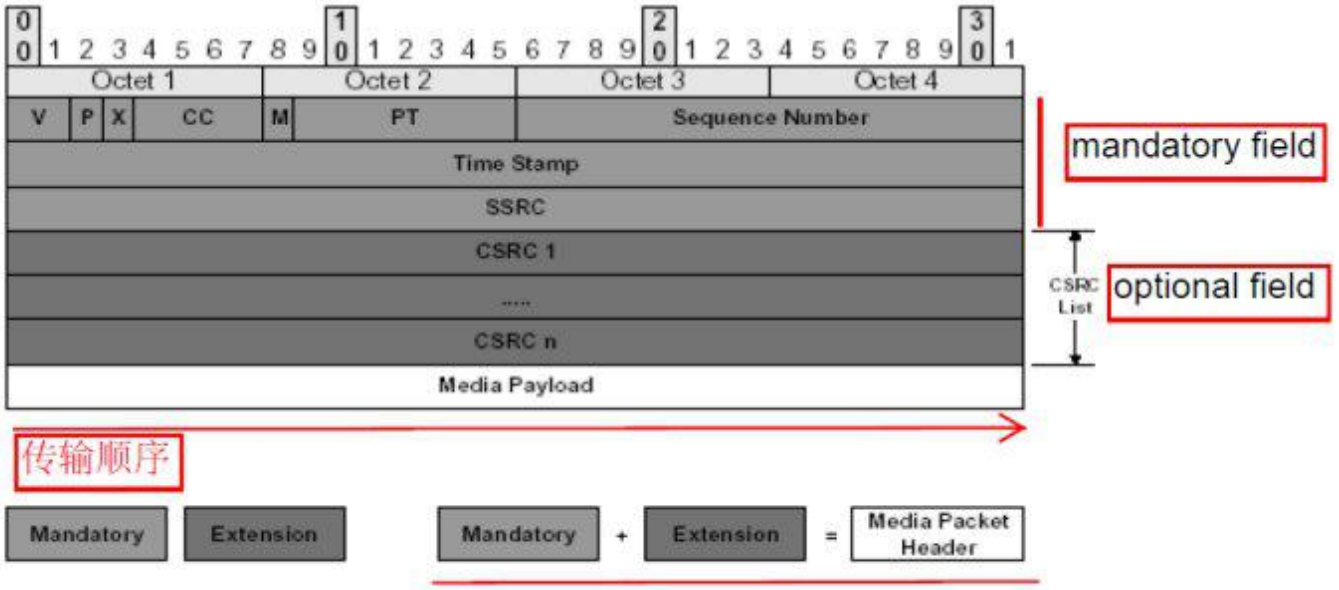


Figure 7.1: Transport Channels for Media Transport

Media Packet Format



igure 7.2: Media Packet Format

Information Element	Description	Length
Version (V)	Version of the RTP implementation	2 Bits
Padding (P)	If the padding bit is set, the packet contains one or more additional padding octets at the end, which are not parts of the payload. The last octet of the padding contains a count of how many padding octets **should** be ignored.	1 Bit
Extension (X)	If the extension bit is set, the fixed header is followed by exactly one header extension.	1 Bit
CSRC count (CC)	The CSRC count contains the number of CSRC identifiers that follow the fixed header.	4 Bits
Marker (M)	The interpretation of the marker is defined by a profile. It is intended to allow significant events such as frame boundaries to be marked in the packet stream.	1 Bit
Payload Type (PT)	This field identifies the format of the RTP payload and determines its interpretation by the application. A profile specifies default static mapping of payload type codes to payload formats.	7 Bits

Information Element	Description	Length
Sequence Number	The sequence number increments by one for each media packet sent, and **may** be used by the receiver to detect packet loss and to restore packet sequence.	16 Bits
Time Stamp	The Time Stamp reflects the sampling instant of the first octet in the media packet.	32 Bits
SSRC	The SSRC field identifies the synchronization source. This identifier is chosen randomly, with the intent that no two-synchronization sources, within the same media transport session, **shall** have the same SSRC identifier.	32 Bits
CSRC list	The CSRC list identifies the contributing sources for the payload contained in this packet.	0 to 15 items, 32 Bits each

Reporting Service

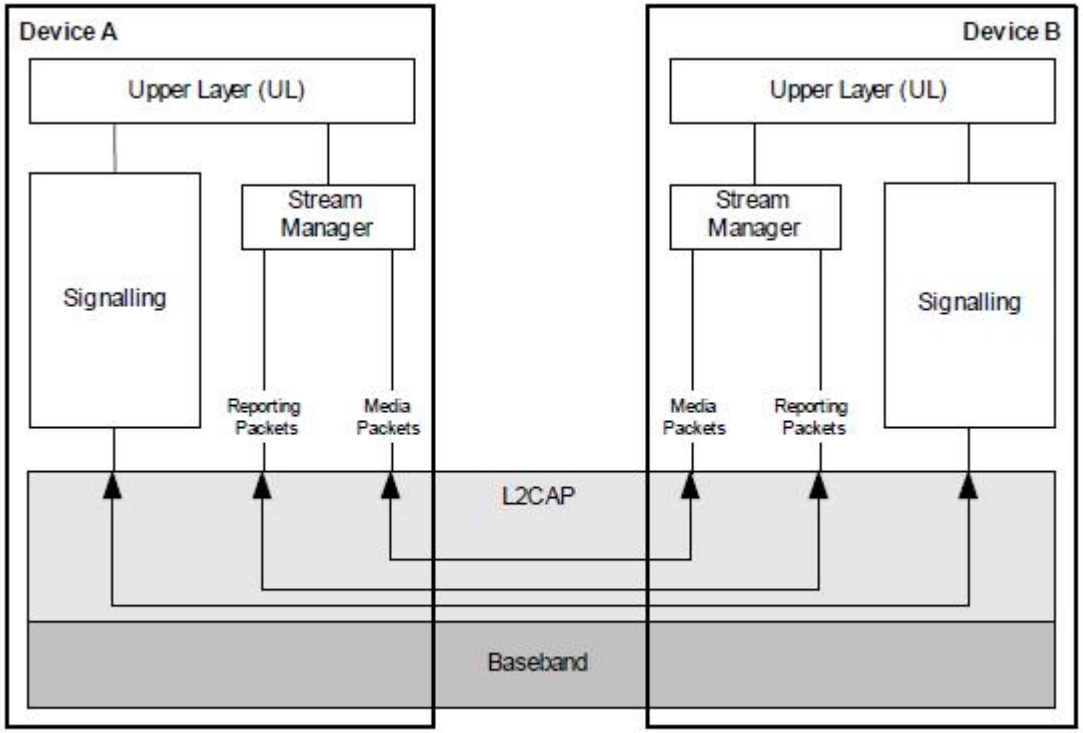


Figure 7.3: Transport Channels for Media Transport and Reporting

Sender Report Reporting packet

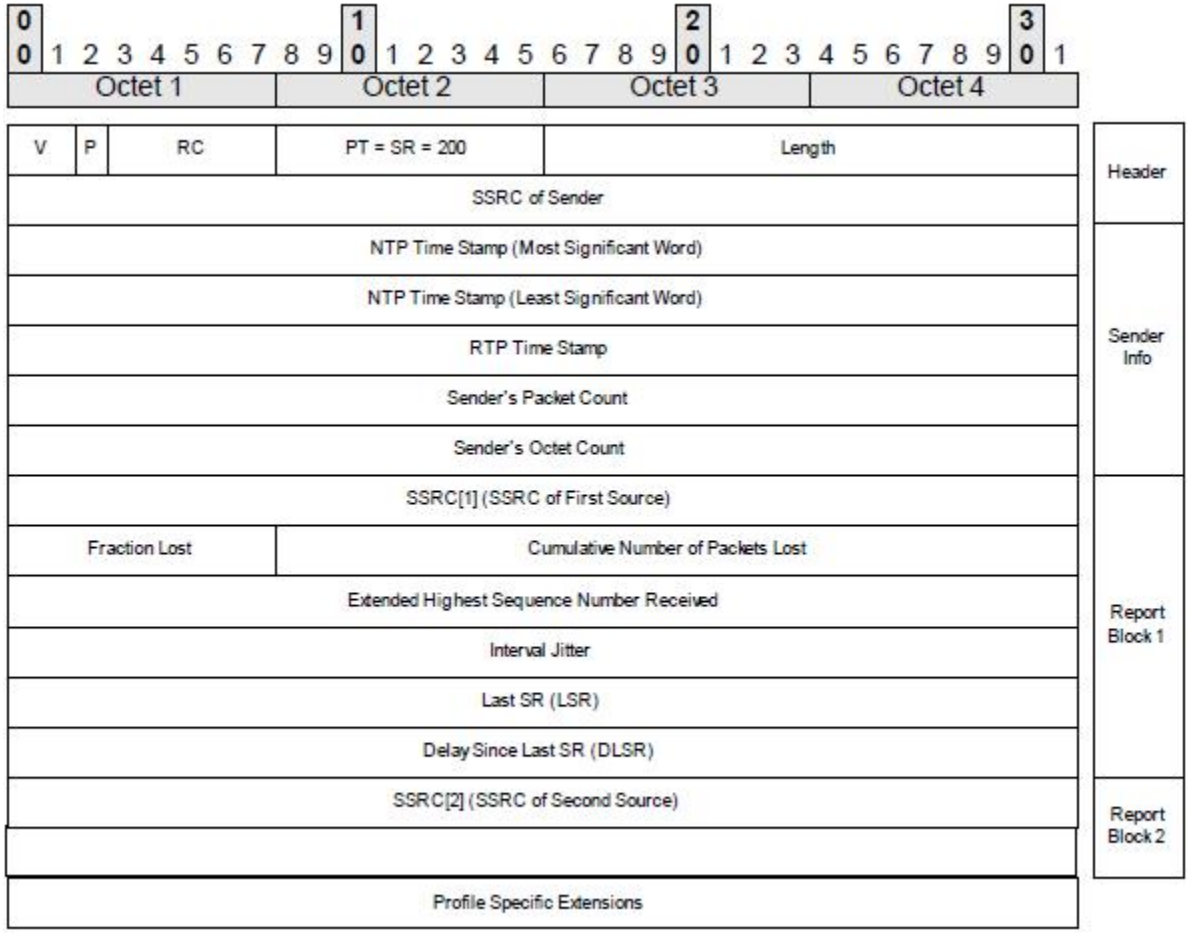
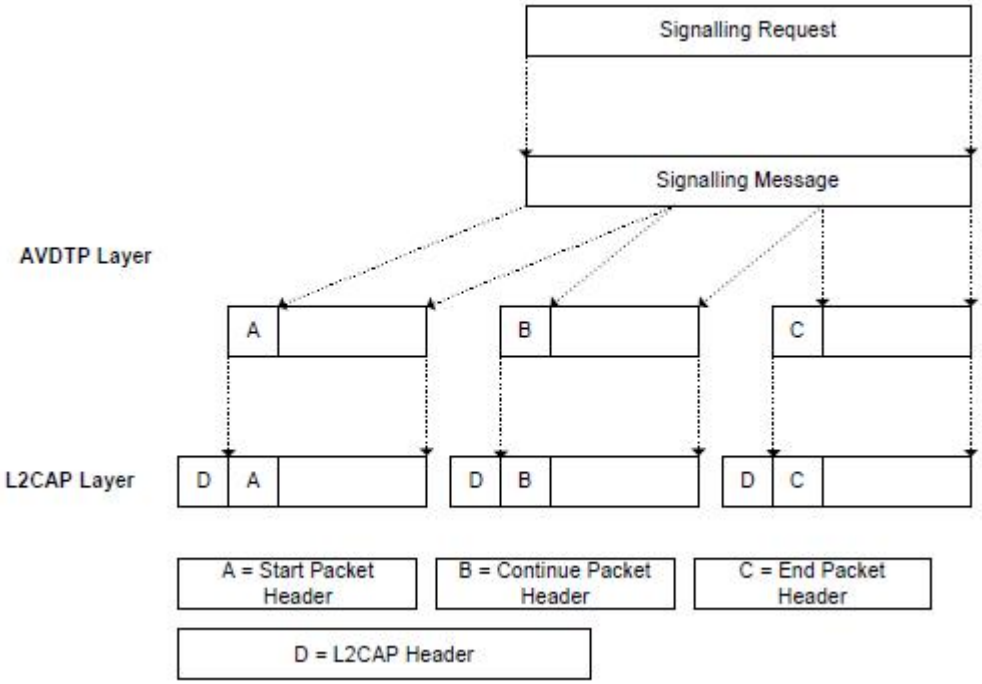


Figure 7.4: SR Reporting packet Format

Information Element	Description	Length
Version (V)	See Table 7.1	
Padding (P)	See Table 7.1	
Reception Report Count (RC)	The number of reception report blocks contained in this packet.	5 Bits
Packet Type (PT)	Contains the constant 200 to identify this as an RTCP SR packet.	8 Bits
Length	The length of this RTCP packet in 32-bit words minus one, including the header and any padding.	16 Bits

Signaling Message format

Signal Fragmentation



Signal command and response headers

7	6	5	4	3	2	1	0	Octet
Transaction Label				Packet Type		Message Type		0
RFA		Signal Identifier						1

Table 8.1: Signaling message format for single packets

7	6	5	4	3	2	1	0	Octet
Transaction Label				Packet Type		Message Type		0
NOSP = Number Of Signal Packets see § 8.20.4								1
RFA		Signal Identifier						2

Table 8.2: Signaling message format for start packets

7	6	5	4	3	2	1	0	Octet
Transaction Label				Packet Type		Message Type		0

Table 8.3: Signaling message format for continue and end packets

Transaction Label

事务唯一的标记

Packet Type

2 Bits		
3	**2**	
0	0	Single Packet
0	1	Start Packet
1	0	Continue Packet
1	1	End Packet

Table 8.4: Packet Type field values

Message Type

2 Bits		
1	**0**	
0	0	Command
0	1	General Reject
1	0	Response Accept
1	1	Response Reject

Table 8.5: Message Type field values

Signaling command set

Signal Identifier	Value
Reserved	0x00
AVDTP_DISCOVER	0x01
AVDTP_GET_CAPABILITIES	0x02
AVDTP_SET_CONFIGURATION	0x03
AVDTP_GET_CONFIGURATION	0x04
AVDTP_RECONFIGURE	0x05
AVDTP_OPEN	0x06
AVDTP_START	0x07
AVDTP_CLOSE	0x08
AVDTP_SUSPEND	0x09
AVDTP_ABORT	0x0A
AVDTP_SECURITY_CONTROL	0x0B
AVDTP_GET_ALL_CAPABILITIES	0x0C
AVDTP_DELAYREPORT	0x0D

Stream End Point Discovery Command

7	6	5	4	3	2	1	0	Octet
Signaling Header see 8.4								0
RFA		AVDTP_DISCOVER						1

Stream End Point Discovery Response

Signaling Header see 8.4				0
RFA	AVDTP_DISCOVER			1
First ACP SEID		In Use	RFA	2
Media Type	TSEP	RFA		3
[Other ACP SEID Information (2 octets each)]				:

Stream End-point IDentifier

Description	This information element identifies a unique identifier for the SEP. In the course of stream session a local SEID at each side of the SEP connection. See definition in 4.10
Length	6 Bits
Possible Values	0x00 – Forbidden 0x01 – 0x3E valid SEID values 0x3F – RFD

Stream End-point Type, Source or Sink (TSEP)

Description	This field indicates if the stream end-point is SNK or SRC. The bit assignment of the TSEP field is shown below.
Length	1 Bit
Possible Values	0 = Stream End Point (SEP) is of type SRC 1 = Stream End Point (SEP) is of type SNK

Stream End Point in Use (In Use)

Description	This information element indicates if a stream end-point is currently In Use or not.
Length:	1 Bit
Possible Values	0 = SEP is Not In Use 1 = SEP is In Use

Get Capabilities Command

7	6	5	4	3	2	1	0	Octet
Signaling Header see 8.4								0
RFA		AVDTP_GET_CAPABILITIES						1
ACP SEID						RFA		2

Table 8.10: Get Capabilities Command message format

Get Capabilities Response

7	6	5	4	3	2	1	0	Octet
Signaling Header see 8.4								0
RFA		AVDTP_GET_CAPABILITIES						1
Service Capabilities see § 8.21								:

- **Service Capabilities**

Generic Service Capabilities information elements

7	6	5	4	3	2	1	0	Octet
Service Category, see § Table 8.11								
Length Of Service Capabilities (LOSC), see § 8.20.2								:
Service Capabilities Information Elements, see § 8.21								

Table 8.46: Generic Service Capabilities field format

- *Service Category information element field values*

Bits								Basic Capability (see § 6.7)	
7	6	5	4	3	2	1	0		
0	0	0	0	0	0	0	1	x	Media Transport
0	0	0	0	0	0	1	0	x	Reporting
0	0	0	0	0	0	1	1	x	Recovery
0	0	0	0	0	1	0	0	x	Content Protection
0	0	0	0	0	1	0	1	x	Header Compression
0	0	0	0	0	1	1	0	x	Multiplexing
0	0	0	0	0	1	1	1	x	Media Codec
0	0	0	0	1	0	0	0		Delay Reporting
Other values									RFD

- **Length of Service Capability (LOSC)**

Description	A total length of the individual service capability. The LOSC field provides only the length of the service capability following this LOSC information element.
Length:	8 Bits
Possible Values	0x00 to 0xFF (In Octets)

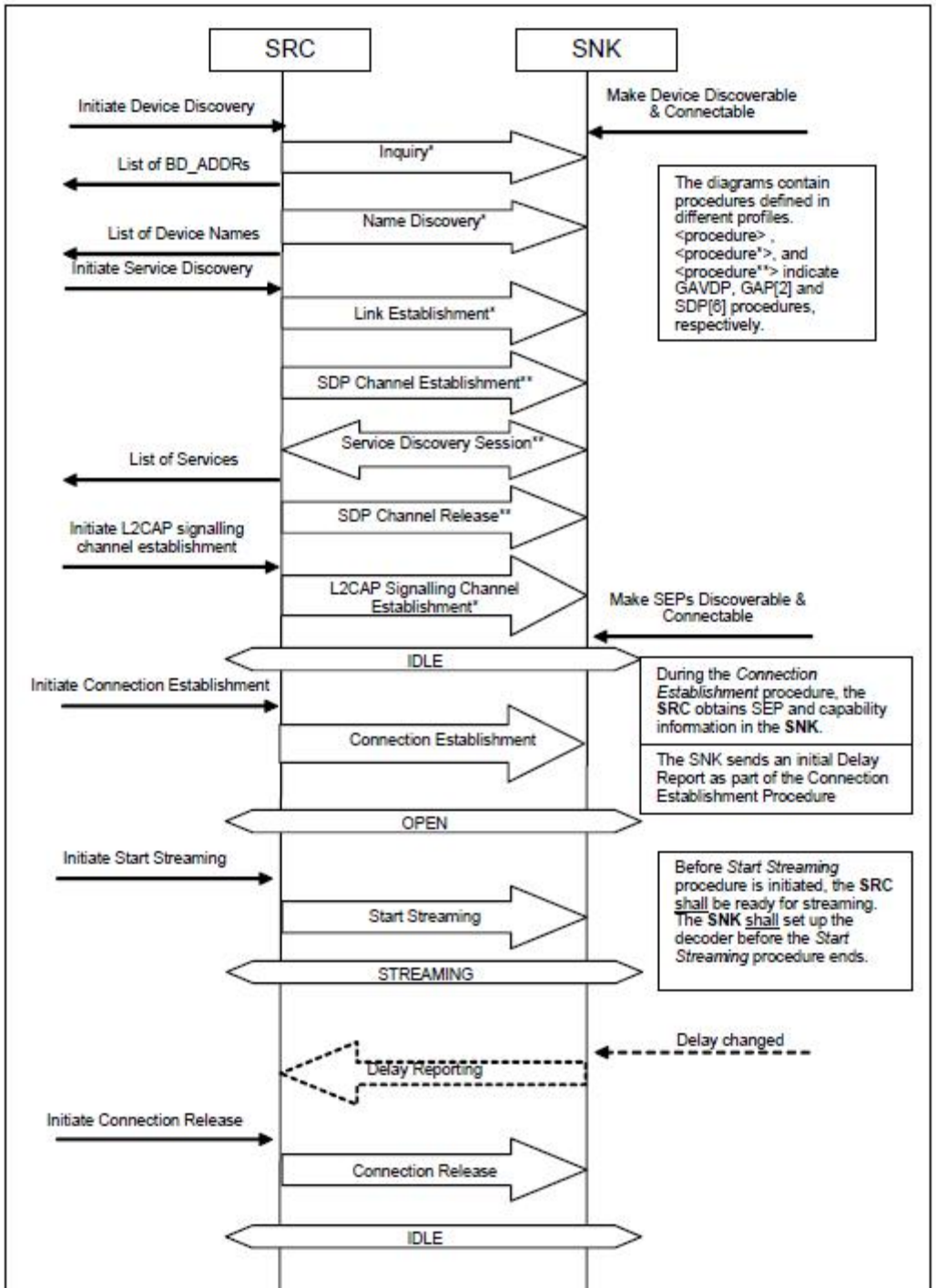
- **Media Transport Capabilities**

7	6	5	4	3	2	1	0	Octet
Service Category = Media Transport								0
Length Of Service Capability (LOSC) = 0x00, see § 8.20.2								1

- **Media Codec Capabilities**

7	6	5	4	3	2	1	0	Octet
Service Category = Media Codec Capabilities								0
Length Of Service Capability (LOSC) see § 8.20.2								1
Media Type				RFA				2
Media Codec Type								3
Media Codec Specific Information Elements								:

State Diagrams


SRC
SNK
Initiate Device Discovery
Make Device Discoverable & Connectable
Inquiry*
List of BD_ADDRs
The diagrams contain procedures defined in different profiles. <procedure> , <procedure*>, and <procedure**> indicate GAVDP, GAP[2] and SDP[6] procedures, respectively.
Name Discovery*
List of Device Names
Initiate Service Discovery
Link Establishment*
SDP Channel Establishment**
Service Discovery Session**
List of Services
SDP Channel Release**
Initiate L2CAP signalling channel establishment
L2CAP Signalling Channel Establishment*
Make SEPs Discoverable & Connectable
IDLE
Initiate Connection Establishment
During the Connection Establishment procedure, the SRC obtains SEP and capability information in the SNK.
Connection Establishment
The SNK sends an initial Delay Report as part of the Connection Establishment Procedure
OPEN
Initiate Start Streaming
Before Start Streaming procedure is initiated, the SRC shall be ready for streaming. The SNK shall set up the decoder before the Start Streaming procedure ends.
Start Streaming
STREAMING
Delay changed
Delay Reporting
Initiate Connection Release
Connection Release
IDLE

Thanks!

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