Gaming Audio Profile

***Bluetooth*® Profile Specification**

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- **Prepared By:** Audio, Telephony, and Automotive Working Group

Abstract:

Gaming Audio Profile enables features specific to the gaming use case by specifying interoperable configurations of the lower-level audio services and profiles.

Version History

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1 Introduction

Gaming Audio Profile (GMAP) establishes configuration settings of underlying audio-related specifications to allow manufacturers to deliver interoperable conversational, streaming, and broadcast audio user experiences in gaming-related products. The conversational experience, or game chat, uses bidirectional voice for game players to talk with each other during game play. The streaming experience delivers 48 kHz quality audio to the game player and the broadcast experience delivers game audio to multiple audio headsets for a group game experience. Gaming-related products include smartphones, gaming devices, headsets, earbuds, and wireless microphones.

1.1 Language

1.1.1 Language conventions

In the development of a specification, the Bluetooth SIG has established the following conventions for use of the terms *"shall"*, ***"shall not"***, *"should"*, ***"should not"***, *"may"*, *"must"*, and *"can"*. In this Bluetooth specification, the terms in Table 1.1 have the specific meanings given in that table, irrespective of other meanings that exist.

Term	Definition
shall	—used to express what is required by the specification and is to be implemented exactly as written without deviation
shall not	—used to express what is forbidden by the specification
should	—used to express what is recommended by the specification without forbidding anything
should not	—used to indicate that something is discouraged but not forbidden by the specification
may	—used to indicate something that is permissible within the limits of the specification
must	—used to indicate either: 1. an indisputable statement of fact that is always true regardless of the circumstances 2. an implication or natural consequence if a separately-stated requirement is followed
can	—used to express a statement of possibility or capability

Table 1.1: Language conventions terms and definitions

1.1.1.1 Implementation alternatives

When specification content indicates that there are multiple alternatives to satisfy specification requirements, if one alternative is explained or illustrated in an example it is not intended to limit other alternatives that the specification requirements permit.

1.1.1.2 Discrepancies

It is the goal of Bluetooth SIG that specifications are clear, unambiguous, and do not contain discrepancies. However, members can report any perceived discrepancy by filing an erratum and can request a test case waiver as appropriate.

1.1.2 Reserved for Future Use

Where a field in a packet, Protocol Data Unit (PDU), or other data structure is described as "Reserved for Future Use" (irrespective of whether in uppercase or lowercase), the device creating the structure shall set its value to zero unless otherwise specified. Any device receiving or interpreting the structure shall ignore that field; in particular, it shall not reject the structure because of the value of the field.

Where a field, parameter, or other variable object can take a range of values, and some values are described as "Reserved for Future Use," a device sending the object shall not set the object to those values. A device receiving an object with such a value should reject it, and any data structure containing it, as being erroneous; however, this does not apply in a context where the object is described as being ignored or it is specified to ignore unrecognized values.

When a field value is a bit field, unassigned bits can be marked as Reserved for Future Use and shall be set to 0. Implementations that receive a message that contains a Reserved for Future Use bit that is set to 1 shall process the message as if that bit was set to 0, except where specified otherwise.

The acronym RFU is equivalent to Reserved for Future Use.

1.1.3 Prohibited

When a field value is an enumeration, unassigned values can be marked as “Prohibited.” These values shall never be used by an implementation, and any message received that includes a Prohibited value shall be ignored and shall not be processed and shall not be responded to.

Where a field, parameter, or other variable object can take a range of values, and some values are described as “Prohibited,” devices shall not set the object to any of those Prohibited values. A device receiving an object with such a value should reject it, and any data structure containing it, as being erroneous.

“Prohibited” is never abbreviated.

1.2 Table requirements

Requirements in this specification are defined as "Mandatory" (M), "Optional" (O), "Excluded" (X), “Not Applicable” (N/A), or "Conditional" (C.n). Conditional statements (C.n) are listed directly below the table in which they appear.

1.3 Conformance

Each capability of this specification shall be supported in the specified manner. This specification may provide options for design flexibility, because, for example, some products do not implement every portion of the specification. For each implementation option that is supported, it shall be supported as specified.

1.4 Terminology

Table 1.2 lists terms that are needed to understand features used in GMAP. Table 1.2 includes definitions from GMAP and other specifications.

Term	Definition
Application Profile	Defined in Volume 1, Part A, Section 6.3 in the Bluetooth Core Specification [1].
Audio Channel	Defined in Basic Audio Profile (BAP) [2].
Audio Configuration	Defined in BAP [2].
Audio Location	Defined in BAP [2].
Audio Stream	Used to refer generally to Unicast Audio Stream and/or Broadcast Audio Stream in BAP [2].
Broadcast Audio Stream	Defined in BAP [2].
Broadcast Game Receiver (BGR)	GMAP profile role; see definition in Section 2.2.
Broadcast Game Sender (BGS)	GMAP profile role; see definition in Section 2.2.
Broadcast Sink	Defined in BAP [2].
Broadcast Source	Defined in BAP [2].
Capture and Rendering Control	Defined in Common Audio Profile (CAP) [3].
Close Isochronous Event (CIE)	Defined in Volume 6, Part B, Section 4.5.13.4 in [1].
Connected Isochronous Group (CIG)	Defined in Volume 6, Part B, Section 4.5.14.1 in [1].
Context Type	Defined in Published Audio Capabilities Service (PACS) [5].
Cross-Transport Key Derivation (CTKD)	Defined in Volume 3, Part C, Section 14.1 in [1].
Game Audio	Includes audio “associated with video gaming, for example gaming media; gaming effects; music and in-game voice chat between participants; or a mix of all the above” as described for the Game Context Type in Assigned Numbers [14].
Game Chat	Used when referring to only the in-game voice chat portion of Game Audio as described for the Game Context Type in Assigned Numbers [14].
Game Media	Used when referring to only the gaming media, gaming effects, and music portion of Game Audio.
GMA Client	A device supporting GMAP that implements the Generic Attribute Profile (GATT) Client role.
GMA Server	A device supporting GMAP that implements the GMA Service in the GATT Server role.
Microphone Controller	Defined in Microphone Control Profile (MICP) [8].

Term	Definition
Multiplex	Multiple Low Complexity Communication Codec (LC3) codec frames per block in a Service Data Unit (SDU) as described in Section 4 in BAP [2].
Multisink	An Audio Configuration where audio is received in two or more Connected Isochronous Streams (CISes) or Broadcast Isochronous Streams (BISes).
Multisource	An Audio Configuration where audio is transmitted in two or more CISes.
Published Audio Capability (PAC)	Defined in PACS [5].
Set Coordinator	Defined in Coordinated Set Identification Profile (CSIP) [10].
Set Member	Defined in CSIP [10].
Transport Latency	Defined in Section 3.6 and Appendix A.
Unicast Audio Stream	Defined in BAP [2].
Unicast Client	Defined in BAP [2].
Unicast Game Gateway (UGG)	GMAP profile role; see definition in Section 2.2.
Unicast Game Terminal (UGT)	GMAP profile role; see definition in Section 2.2.
Unicast Server	Defined in BAP [2].
Volume Controller	Defined in Volume Control Profile (VCP) [6].
Volume Renderer	Defined in VCP [6].

Table 1.2: Terminology

2 Profile overview

2.1 Profile and protocol stack

The hierarchy diagram in Figure 2.1 shows GMAP as an Application Profile. GMAP specifies configurations and settings of parameters and procedures that are specified in Common Audio Profile (CAP) [3], Generic Access Profile (GAP), and lower-level specifications. GMAP does not define any new procedures or protocols. GMAP does add new Quality of Service (QoS) requirements to deliver lower-latency audio.

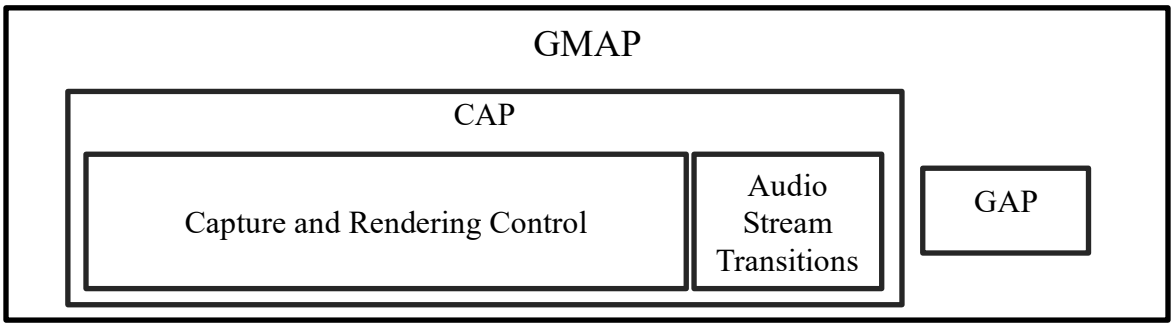


Figure 2.1: GMAP profile and dependencies

GMAP specifies the following:

- GMAP profile roles
- CAP [3] interoperability requirements
- BAP [2] interoperability requirements
- Required BAP parameters, such as codec and QoS settings
- New QoS settings to reduce latency
- Required parameters to use with GAP as specified in [1]

The specifications related to Capture and Rendering Control and Audio Stream Transitions are:

- Capture and Rendering Control:
  - Volume Control Profile (VCP) [6]
  - Volume Control Service (VCS) [7]
  - Microphone Control Profile (MICP) [8]
  - Microphone Control Service (MICS) [9]
- Audio Stream Transitions:
  - Basic Audio Profile (BAP) [2]
  - Broadcast Audio Scan Service (BASS) [12]

    BASS is listed here for completeness. GMAP specifies no additional requirements for the BASS Server (Scan Delegator) or the BASS Client (BAP Broadcast Assistant).
  - Published Audio Capabilities Service (PACS) [5]
  - Audio Stream Control Service (ASCS) [4]
  - Coordinated Set Identification Profile (CSIP) [10]

- Coordinated Set Identification Service (CSIS) [11]

2.2 Roles

GMAP defines the following profile roles (see Section 3 for more details on the required features per role):

- The **Unicast Game Gateway (UGG)** role is defined for devices that send Game Audio and/or receive Game Chat content in one or more Unicast Audio Streams. Example devices implementing the UGG role include smartphones, gaming devices, laptops, tablets, and PCs.
- The **Unicast Game Terminal (UGT)** role is defined for devices that receive Game Audio content and/or send Game Chat content to a source device in one or more Unicast Audio Streams. Example devices implementing the UGT role include headphones, earbuds, and wireless microphones.
- The **Broadcast Game Sender (BGS)** role is defined for devices that send Game Audio content in one or more Broadcast Audio Streams. Example devices implementing the BGS role include smartphones, gaming devices, laptops, tablets, and PCs.
- The **Broadcast Game Receiver (BGR)** role is defined for devices that receive Game Audio content in one or more Broadcast Audio Streams. Example devices implementing the BGR role include headphones and earbuds.

Figure 2.2, Figure 2.3, and Figure 2.4 show some topology examples.

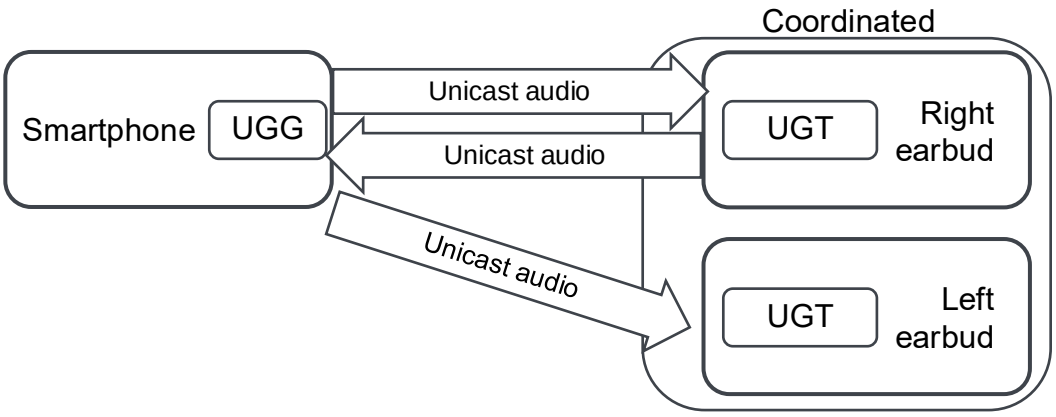


Figure 2.2: Example of smartphone and stereo earbuds that use the Unicast profile roles

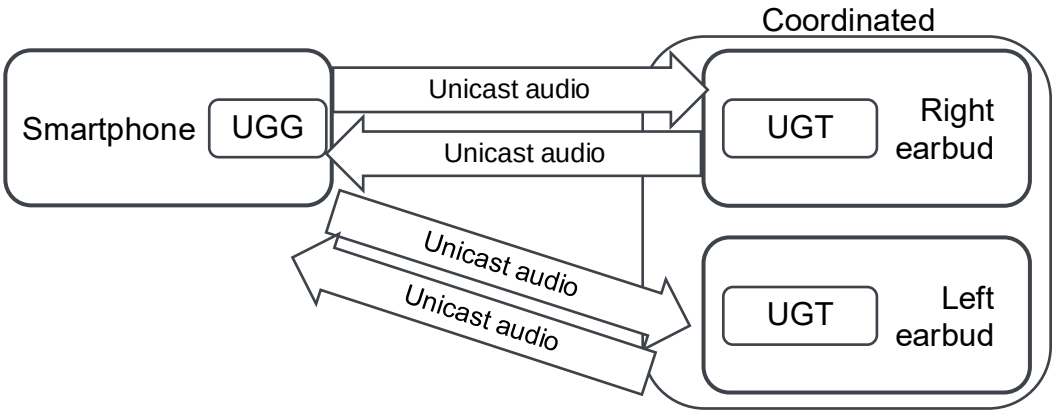


Figure 2.3: Example of smartphone and stereo bidirectional earbuds that use the Unicast profile roles

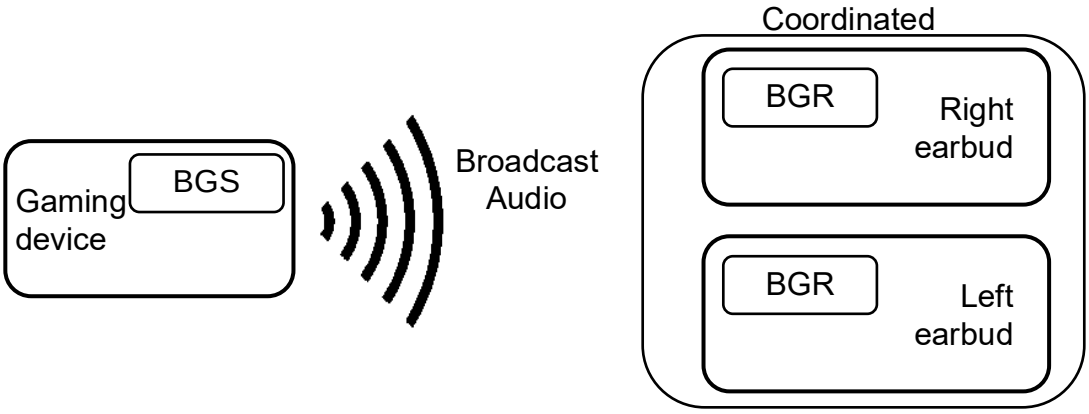


Figure 2.4: Example of a gaming device and stereo earbuds that use the Broadcast profile roles

Each of the GMAP roles supports transmitting and/or receiving audio.

2.3 Concurrency limitations and restrictions

GMAP imposes no limitations and/or restrictions on GMAP roles operating concurrently with other GMAP roles.

2.4 Profile dependencies

GMAP includes requirements from, and in some cases adds additional requirements to, MICP [8], CSIP [10], VCP [6], BAP [2], and CAP [3].

2.5 Bluetooth Core Specification release compatibility

GMAP is compatible with the Bluetooth Core Specification, Version 5.2 or later [1].

3 Profile requirements

GMAP defines a set of profile roles that specify CAP roles and procedures along with Audio Stream features specified by lower-layer specifications. A GMAP role that supports a CAP role inherits the requirements specified for that CAP role. In some cases, GMAP elevates those requirements from Optional to Mandatory. GMAP implementers may support and use Optional inherited requirements regardless of whether those requirements are directly mentioned in the GMAP specification.

Figure 3.1 shows the relationship between GMAP and the Generic Audio blocks.

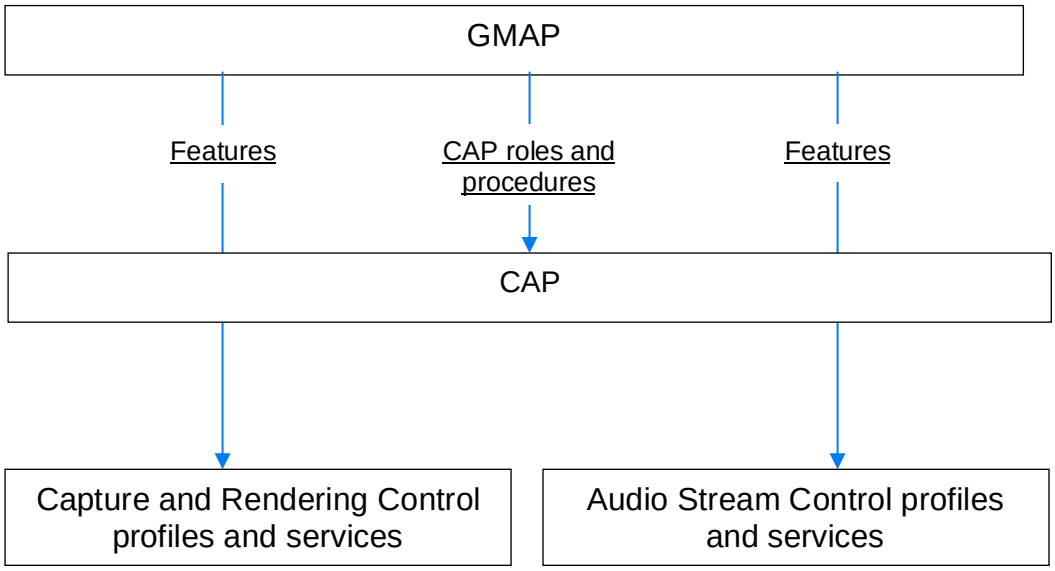


Figure 3.1: GMAP uses profile roles and procedures from CAP

Gaming Audio Service (GMAS) allows GMAP devices to discover GMAP roles supported by other GMAP devices (see Section 4).

3.1 Profile role support requirements

Devices that implement GMAP shall implement profile roles as specified in Table 3.1.

Profile Role	Requirement
Unicast Game Gateway (UGG)	C.1
Unicast Game Terminal (UGT)	C.1
Broadcast Game Sender (BGS)	C.1
Broadcast Game Receiver (BGR)	C.1

Table 3.1: Role requirements for devices implementing GMAP

C.1: Mandatory to support at least one of these roles.

GMAP uses the CAP [3] roles of Initiator, Acceptor, and Commander.

Table 3.2 lists the CAP role support requirements for each GMAP role.

GMAP Roles	CAP Roles		
	Initiator	Acceptor	Commander
UGG	M	X	M
UGT	X	M	X
BGS	M	X	M
BGR	X	M	X

Table 3.2: Mapping of GMAP roles to CAP roles

GMAP defines the following optional features for the UGG role:

- UGG Multiplex: Support transmitting multiple LC3 codec frames per block in an SDU as described in Section 4 in BAP [2]. This feature only applies to Audio Configuration 4 and 5 in Table 3.15.
- UGG 96 kbps Source: Support as a source of Codec Configuration Settings 48_3 and 48_4 from BAP [2].
- UGG Multisink: Support for receiving at least two channels of audio, each in a separate CIS. UGGs that support this feature support Audio Configurations 11(i) and 11(ii) in Table 3.15.

GMAP defines the following optional or conditional features for the UGT role:

- UGT Source: Transmit Unicast Audio Streams as an Acceptor.
- UGT 80 kbps Source: Transmit Unicast Audio Streams as an Acceptor with Codec Capability settings 48_1 and 48_2 from BAP [2].
- UGT Sink: Receive Unicast Audio Streams as an Acceptor.
- UGT 64 kbps Sink: Receive Unicast Audio Streams as an Acceptor with Codec Capability settings 32_1 and 32_2 from BAP [2].
- UGT Multiplex: Support for receiving multiple LC3 codec frames per block in an SDU as defined in Section 4 in BAP [2].
- UGT Multisink: Support for receiving at least two audio channels, each in a separate CIS.
- UGT Multisource: Support for sending at least two audio channels, each in a separate CIS.

GMAP defines the following optional feature for the BGS role:

- BGS 96 kbps: Support of Codec Configuration Settings 48_3 and 48_4 from BAP [2].

GMAP defines the following optional feature for the BGR role:

- BGR Multisink: Support for receiving at least two audio channels, each in a separate BIS.
- BGR Multiplex: Support for receiving multiple LC3 codec frames per block in an SDU as defined in Section 4 in BAP [2].

Table 3.3, Table 3.4, Table 3.5, and Table 3.6 list the feature support requirements for each GMAP role.

UGG Multiplex	UGG 96 kbps Source	UGG Multisink
O	O	O

Table 3.3: Feature requirements for the UGG role

UGT Source	UGT 80 kbps Source	UGT Sink	UGT 64 kbps Sink	UGT Multiplex	UGT Multisink	UGT Multisource
C.1	C.2	C.1	C.3	C.4	C.3	C.2

Table 3.4: Feature requirements for the UGT role

C.1: Mandatory for the UGT to support at least one of the UGT Source feature or the UGT Sink feature.

C.2: Optional for the UGT to support if the UGT supports the UGT Source feature, otherwise Excluded.

C.3: Optional for the UGT to support if the UGT supports the UGT Sink feature, otherwise Excluded.

C.4: Mandatory for the UGT to support if both the BGR and UGT roles are supported and both the BGR Multiplex feature and the UGT Sink feature are supported, otherwise optional for the UGT to support if the UGT supports the UGT Sink feature, otherwise Excluded.

BGS 96 kbps
O

Table 3.5: Feature requirement for the BGS role

BGR Multisink	BGR Multiplex
O	C.1

Table 3.6: Feature requirements for the BGR role

C.1: Mandatory for the BGR to support if both the BGR and UGT roles are supported and the UGT Multiplex feature is supported, otherwise Optional.

Table 3.7 and Table 3.8 list the detailed component requirements for each GMAP role. A dash in a table cell indicates that GMAP makes no change to the requirement as specified in CAP. All other cells indicate requirements that are in addition to the requirements specified in CAP.

GMAP Roles	CAP Components Related to Audio Streams					
	BAP Broadcast Source	BAP Broadcast Sink	BAP Unicast Client		BAP Unicast Server	
			BAP Audio Source Role	BAP Audio Sink Role	BAP Audio Sink Role	BAP Audio Source Role
UGG	–	–	M	M	–	–
UGT	–	–	–	–	C.1	C.2
BGS	M	–	–	–	–	–
BGR	–	M	–	–	–	–

Table 3.7: Mapping of GMAP roles to CAP components related to Audio Streams

C.1: Mandatory for the UGT to support if the UGT supports the UGT Sink feature, otherwise Excluded.

C.2: Mandatory for the UGT to support if the UGT supports the UGT Source feature, otherwise Excluded.

GMAP Roles	CAP Components Related to Capture and Rendering Control			
	VCP Controller	VCP Renderer	MICP Controller	MICP Device
UGG	M	–	O	–
UGT	–	C.1	–	C.2
BGS	–	–	–	–
BGR	–	M	–	–

Table 3.8: Mapping of GMAP roles to CAP components related to Capture and Rendering Control

C.1: Mandatory to support if the UGT supports the UGT Sink feature, otherwise Excluded.

C.2: Optional to support if the UGT supports the UGT Source feature, otherwise Excluded.

3.2 LL feature support requirements

Table 3.9 lists Link Layer (LL) feature support requirements for the GMAP roles.

GMAP Role	UGG	UGT	BGS	BGR
LE 2M PHY	M	M	M	M

Table 3.9: LL feature support requirements

3.3 HCI feature support

If the Controller supports Host Controller Interface (HCI) ISO Data packets, then the Controller supports Time_Stamp fields as specified in Volume 4, Part E, Section 5.4.5 in [1]. Volume 6, Part G, Section 3.3 in [1] explains how the Time_Stamp field is used to determine the reference time of each received SDU.

3.4 Peripheral connection establishment for non-bonded devices

GMAP adopts the connection establishment requirements as specified by CAP and BAP. GMAP adds the following recommendations to those specified by Section 8.1.1.1 in BAP [2] for the BGR and the UGT:

- The extended advertising should include the Appearance AD type (see Part A, Section 1.12 in the Bluetooth Core Specification Supplement (CSS) [13]).
- The extended advertising should include the following:
    - The Service UUID data type (as defined in Part A, Section 1.1 in [13]) containing the GMAS UUID.
    - Advertising space permitting, the Service Data AD type (see Part A, Section 1.11 in [13]), along with the service data as shown in Table 3.10.

Field	Size (Octets)	Description
Length	1	Length in octets of Type and Value fields for AD data type: Length = 0x05 octets
Type: «Service Data - 16-bit UUID»	1	Defined in Bluetooth Assigned Numbers [14]
Value	3	2-octet service UUID followed by additional service data
GMAS UUID	2	Defined in [14]
GMAP Role characteristic value	1	1-octet bitmap defined in Section 4.7.1.1

Table 3.10: Format to advertise GMAP Role characteristic value

3.5 Audio Stream Transitions

3.5.1 Requirements for Unicast roles

This section specifies additional requirements for the BAP Unicast Client and BAP Unicast Server beyond those defined in BAP [2], ASCS [4], and PACS [5].

3.5.1.1 Unicast audio capability support

Table 3.11 lists the required Codec_Specific_Capabilities parameter for the UGT role. Codec_Specific_Capabilities is a parameter in the Source PAC and Sink PAC characteristics as defined in PACS [5]. In Table 3.11, the UGT to UGG streaming direction requirements apply to the Codec_Specific_Capabilities

parameter in the Source PAC characteristic. The UGG to UGT streaming direction requirements apply to the Codec_Specific_Capabilities parameter in the Sink PAC characteristic.

Devices supporting the UGT role shall support the “Game” Context Type value [14] in their Supported_Sink_Contexts field and Available_Sink_Contexts field. Devices supporting the UGG role shall support the “Game” Context Type in the Streaming_Audio_Contexts LTV structure in the Metadata parameter when enabling a Sink or Source Audio Stream Endpoint (ASE).

Codec Capability Settings (See Section 3.5.2 in [2])	**Streaming Direction**	**Sink or Source PAC Characteristic**	**Requirement**
16_1	UGT to UGG	Source	C.1
16_2	UGT to UGG	Source	C.1
32_1	UGT to UGG	Source	C.1
32_2	UGT to UGG	Source	C.1
32_1	UGG to UGT	Sink	C.2
32_2	UGG to UGT	Sink	C.2
48_1	UGT to UGG	Source	C.3
48_2	UGT to UGG	Source	C.3
48_1	UGG to UGT	Sink	C.4
48_2	UGG to UGT	Sink	C.4
48_3	UGG to UGT	Sink	C.4
48_4	UGG to UGT	Sink	C.4

Table 3.11: Additional audio capability support requirements for the UGT

C.1: Mandatory to support if the UGT Source feature is supported, otherwise Excluded.

C.2: Mandatory to support if the UGT 64 kbps Sink feature is supported, otherwise Excluded.

C.3 Mandatory to support if the UGT 80 kbps Source feature is supported, otherwise Excluded.

C.4: Mandatory to support if the UGT Sink feature is supported, otherwise Excluded.

3.5.1.1.1 Sink Audio Location values

The Sink Audio Locations characteristic is defined in [5] and Audio Location values are defined in [14]. GMAP adds no requirements on values for the Sink Audio Locations characteristic.

Note that the Sink Audio Locations characteristic values of Front Left and Front Right are particularly appropriate for banded headphones, earbuds, speakers, and other devices designed to render right and/or left channel audio.

For example, a left earbud UGT that exposes a Sink Audio Locations characteristic value of 0x00000001 indicates to the UGG (or other BAP Unicast Client) that it is designed to render left-channel audio to the end user. A headphone that exposes a value of 0x00000003 indicates that it is designed to render both left and right channels.

Sink Audio Locations characteristic values of Front Left and Front Right may not be appropriate for devices that are designed for audio channels other than left and right. For example, a subwoofer might support the UGT role but only expose a Sink Audio Locations characteristic value of Low Frequency Effects 1 or Low Frequency Effects 2.

3.5.1.2 ASE characteristics

A UGT device that supports the BAP Audio Sink role shall include at least one Sink ASE characteristic as defined in ASCS [4]. A UGT device that supports the BAP Audio Source role shall include at least one Source ASE characteristic.

3.5.1.3 ASE control point configuration

3.5.1.3.1 Config Codec operation parameters

The Config Codec operation is defined by ASCS [4]. Table 3.12 lists the Config Codec operation parameter value support requirements for the UGG role when configuring a Sink ASE characteristic (i.e., for the UGG to UGT streaming direction) or a Source ASE characteristic (i.e., for the UGT to UGG streaming direction).

Codec Configuration Setting (See Section 3.6.7 in [2])	**Streaming Direction**	**Requirement**
16_1	UGT to UGG	M
16_2	UGT to UGG	M
32_1	UGT to UGG	M
32_2	UGT to UGG	M
32_1	UGG to UGT	M
32_2	UGG to UGT	M
48_1	UGT to UGG	M
48_2	UGT to UGG	M
48_1	UGG to UGT	M
48_2	UGG to UGT	M
48_3	UGG to UGT	C.1
48_4	UGG to UGT	C.1

Table 3.12: Additional Config Codec operation parameter value requirements for the UGG role

C.1: Mandatory if the UGG supports the UGG 96 kbps Source feature, otherwise Excluded.

Table 3.13 lists the Audio_Channel_Allocation parameter value support requirements for the UGG roles. The Audio_Channel_Allocation parameter is defined in Section 4.3.2 in BAP [2].

Audio Location Value in the Audio_Channel_Allocation LTV (Bit 1 and Bit 0 Only)	**Description**	**Requirements**
		UGG
0b01	Front Left	M
0b10	Front Right	M
0b11	Front Right and Front Left	C.1

Table 3.13: Audio_Channel_Allocation values required for the UGG roles

C.1: Mandatory if the UGG supports the UGG Multiplex feature, otherwise Excluded.

3.5.1.3.2 Config QoS operation parameters

The Config QoS operation is defined by ASCS [4] and includes QoS Configuration settings. The Config QoS operation is required by the BAP Unicast QoS configuration procedure (see Section 5.6.2 in [2]), which is required by the CAP Unicast Audio Start procedure. This section lists requirements for QoS Configuration settings in addition to those specified by BAP [2].

Table 3.14 shows the QoS Configuration settings requirements defined by GMAP for the UGT and UGG roles. The settings in Table 3.14 are different than those in BAP and therefore use a set name with a suffix unique to GMAP. Settings intended for the UGG to UGT streaming direction use a suffix of “gr” for GMAP render. Settings intended for the UGT to UGG streaming direction use a suffix of “gs” for GMAP source.

As in Table 5.2 in BAP [2], Table 3.14 lists HCI-level (see Volume 4, Part E in [1]) parameters. On systems not incorporating HCI, equivalent values for LL-level (CIS) QoS Configuration parameters shall be used.

Retransmission number values in Table 3.14 are minimum value recommendations to the Controller. See Table 3.16 for a range of recommended LL parameters. The Controller should select parameters that result in an RTN value that is no less than the retransmission number from Table 3.14.

Values in the Max_Transport_Latency column of Table 3.14 provide an upper bound to the Controller, as specified in the HCI definition. See Table 3.16 and Appendix A for more details on transport latency as determined by the Controller.

Set Name	Streaming Direction	Codec Capability / Configuration Setting (See Table 3.11 or Table 3.5 in [2] & Table 3.12 or Table 3.11 in [2])	SDU_ Interval (µs)	Framing	Maximum_SDU_Size (Octets)	Retransmission _Number	Max_Transport_Latency (ms)	Presentation _Delay (µs)	Requirement	
									UGG	UGT
16_1_gs	UGT to UGG	16_1	7500[1]	Unframed	30[2] (32 kbps[3])	1	15	60000	M	C.2
16_2_gs	UGT to UGG	16_2	10000[1]	Unframed	40[2] (32 kbps[3])	1	20	60000	M	C.2
32_1_gs	UGT to UGG	32_1	7500[1]	Unframed	60[2] (64 kbps[3])	1	15	60000[5]	M	C.2
32_2_gs	UGT to UGG	32_2	10000[1]	Unframed	80[2] (64 kbps[3])	1	20	60000[5]	M	C.2
48_1_gs	UGT to UGG	48_1	7500[1]	Unframed	75[2] (80 kbps[3])	1	15	60000[5]	M	C.3
48_2_gs	UGT to UGG	48_2	10000[1]	Unframed	100[2] (80 kbps[3])	1	20	60000[5]	M	C.3
32_1_gr	UGG to UGT	32_1	7500[1]	Unframed	60[2] (64 kbps[3])	1	15	10000[6]	M	C.5
32_2_gr	UGG to UGT	32_2	10000[1]	Unframed	80[2] (64 kbps[3])	1	20	10000[6]	M	C.5
48_1_gr	UGG to UGT	48_1	7500[1]	Unframed	75[2] (80 kbps[3])	1	15[4]	10000[6]	M	C.4
48_2_gr	UGG to UGT	48_2	10000[1]	Unframed	100[2] (80 kbps[3])	1	20[4]	10000[6]	M	C.4
48_3_gr	UGG to UGT	48_3	7500[1]	Unframed	90[2] (96 kbps[3])	1	15[4]	10000[6]	C.1	C.4
48_4_gr	UGG to UGT	48_4	10000[1]	Unframed	120 (96 kbps)	1	20[4]	10000[6]	C.1	C.4

[1] Nominal. May be adjusted to accommodate audio clock offset and drift. See Section 5.6.2 in BAP [2].

[2] Settings are based on a UGG communicating with two UGTs, with each UGT being configured for a single Audio Channel and single block of codec frames per SDU. Different Audio_Channel_Allocation values (see Section 4.3.2 in BAP [2]) and/or a greater number of blocks of codec frames per SDU (see Section 4.3.2 in BAP [2]) would require settings to be appropriately scaled.

[3] Bit rates are calculated according to Section 3.2.5 in [15].

[4] The Max_Transport_Latency values for 48_1_gr, 48_2_gr, 48_3_gr, and 48_4_gr apply to Audio Configurations 1, 2, 3, 4, 5, 6, 7, and 8 in Table 3.15.

[5] For the UGT, the supported Presentation_Delay range in the Codec Configured state shall include this value when the ASE is a Source ASE characteristic.

[6] For the UGT, the supported Presentation_Delay range in the Codec Configured state shall include this value when the ASE is a Sink ASE characteristic.

Table 3.14: QoS configuration support setting requirements for the UGG and UGT

C.1: Mandatory if the UGG supports the UGG 96 kbps Source feature, otherwise Excluded.

C.2: Mandatory if the UGT supports the UGT Source feature, otherwise Excluded.

C.3: Mandatory if the UGT supports the UGT 80 kbps Source feature, otherwise Excluded.

C.4: Mandatory if the UGT supports the UGT Sink feature, otherwise Excluded.

C.5: Mandatory if the UGT supports the UGT 64 kbps Sink feature, otherwise Excluded.

The 48_1_gr, 48_2_gr, 48_3_gr, and 48_4_gr settings in Table 3.14 achieve a lower Transport Latency than the 48_1_1, 48_2_1, 48_3_1, and 48_4_1 settings defined in Table 5.2 in BAP [2]. These settings also will result in a higher rate of packet losses in some environments. See the Low Complexity Communication Codec (LC3) Specification [15] for recommendations on packet loss concealment (PLC).

3.5.1.4 Requirements for CAP Unicast procedures

Table 3.2 and Table 3.7 require each GMAP role to support certain CAP roles. In turn, the CAP specification [3] establishes Unicast Audio Stream Transition procedure support requirements for each CAP role. GMAP adds no Unicast Audio Stream Transition support requirements beyond those specified in CAP [3]. CAP roles inherit Audio Configuration requirements from BAP [2].

This section uses the Audio Configurations defined in Table 4.1 in BAP [2]. Using those definitions, Table 3.15 lists the Audio Configuration support requirements, in addition to those specified in BAP [2], for each unicast GMAP role within the following CAP procedures:

- Unicast Audio Start
- Unicast Audio Update
- Unicast Audio Stop

A dash in a table cell indicates that GMAP makes no change to the requirements specified in BAP [2].

Table 3.15 also establishes requirements for QoS Configuration settings within each Audio Configuration. For the UGT, Audio Configuration 6(i), 6(ii), 8(ii), and 11(ii) in Table 3.15 represent Audio Configurations listed in other Table 3.15 rows. In those cases, the UGT requirement cell is grayed out to indicate that the support requirement is listed in other rows. Each grayed-out cell also refers to the Audio Configuration row that contains the support requirement.

Some Audio Configurations require concurrent streams and ASEs. Concurrent streams means that all streams in an Audio Configuration are sent over the air in a single CIG and all ASEs for those streams are in the streaming state. The following list explains the format for a few of the table rows:

- The top row of the 6(i) entry specifies UGG requirements for sending two CISes in a 32_1_gr QoS Configuration in a single CIG to a single UGT. The same row specifies UGT requirements for receiving two CISes in a 32_1_gr QoS Configuration.
- The top row of the 6(ii) entry specifies UGG requirements for sending two CISes in a 32_1_gr QoS Configuration in a single CIG to a pair of UGTs. For 6(ii), each CIS goes to a different UGT. The 6(ii) entry does not specify UGT requirements because they are fully specified in the Audio Configuration 1 entry. The top row of the Audio Configuration 1 entry specifies UGT requirements for receiving a single CIS in a 32_1_gr QoS Configuration.

- The top row of the 8(ii) entry specifies UGG requirements for exchanging two CISes in a single CIG with a pair of UGTs. One CIS is unidirectional, containing 32_1_gr QoS Configured audio to the UGT. The other CIS is bidirectional, containing 32_1_gr QoS Configured audio to the UGT and 32_1_gs QoS Configured audio back to the UGG. The 8(ii) entry does not specify UGT requirements because they are fully specified in the Audio Configuration 1 entry (i.e., for the unidirectional CIS) and the Audio Configuration 3 entry (i.e., for the bidirectional CIS). The top row of the Audio Configuration 3 entry specifies UGT requirements for, in a single CIS, receiving 32_1_gr QoS Configured audio and sending 32_1_gs QoS Configured audio.

Audio Config from [2]	Legend from [2]			# of UGT Devices	Config QoS UGG to UGT Direction	Config QoS UGT to UGG Direction	UGG	UGT
1	UGG	----------▶	UGT	1	32_1_gr	N/A	M	C.2
					32_2_gr		M	C.2
					48_1_gr		M	C.3
					48_2_gr		M	C.3
					48_3_gr		C.1	C.3
					48_4_gr		C.1	C.3
2	UGG	◀----------	UGT	1	N/A	16_1_gs	M	C.4
						16_2_gs	M	C.4
						32_1_gs	M	C.4
						32_2_gs	M	C.4
						48_1_gs	M	C.5
						48_2_gs	M	C.5
3	UGG	◀---------▶	UGT	1	32_1_gr	16_1_gs	M	C.6
					32_2_gr	16_2_gs	M	C.6
					48_1_gr	16_1_gs	M	C.7
					48_2_gr	16_2_gs	M	C.7
					32_1_gr	32_1_gs	M	C.6
					32_2_gr	32_2_gs	M	C.6
					48_1_gr	32_1_gs	M	C.7
					48_2_gr	32_2_gs	M	C.7
					48_1_gr	48_1_gs	M	C.8
					48_2_gr	48_2_gs	M	C.8
					48_3_gr	32_1_gs	C.1	C.7

Audio Config from [2]	Legend from [2]			# of UGT Devices	Config QoS UGG to UGT Direction	Config QoS UGT to UGG Direction	UGG	UGT
					48_4_gr	32_2_gs	C.1	C.7
					48_3_gr	48_1_gs	C.1	C.8
					48_4_gr	48_2_gs	C.1	C.8
4	UGG		UGT	1	32_1_gr	N/A	C.9	C.11
					32_2_gr		C.9	C.11
					48_1_gr		C.9	C.12
					48_2_gr		C.9	C.12
					48_3_gr		C.10	C.12
					48_4_gr		C.10	C.12
5	UGG		UGT	1	32_1_gr	16_1_gs	C.9	C.13
					32_2_gr	16_2_gs	C.9	C.13
					48_1_gr	16_1_gs	C.9	C.14
					48_2_gr	16_2_gs	C.9	C.14
					32_1_gr	32_1_gs	C.9	C.13
					32_2_gr	32_2_gs	C.9	C.13
					48_1_gr	32_1_gs	C.9	C.14
					48_2_gr	32_2_gs	C.9	C.14
					48_1_gr	48_1_gs	C.9	C.15
					48_2_gr	48_2_gs	C.9	C.15
					48_3_gr	32_1_gs	C.10	C.14
					48_4_gr	32_2_gs	C.10	C.14
6(i)	UGG		UGT	1	32_1_gr	N/A	M	C.16
					32_2_gr		M	C.16

Audio Config from [2]	Legend from [2]			# of UGT Devices	Config QoS UGG to UGT Direction	Config QoS UGT to UGG Direction	UGG	UGT
					48_1_gr		M	C.17
					48_2_gr		M	C.17
					48_3_gr		C.1	C.17
					48_4_gr		C.1	C.17
6(ii)	UGG		UGT UGT	2	32_1_gr	N/A	M	See Audio Config 1.
					32_2_gr		M	
					48_1_gr		M	
					48_2_gr		M	
					48_3_gr		C.1	
					48_4_gr		C.1	
7(ii)	UGG		UGT UGT	2	32_1_gr	16_1_gs	M	See Audio Config 1 and 2.
					32_2_gr	16_2_gs	M	
					48_1_gr	16_1_gs	M	
					48_2_gr	16_2_gs	M	
					32_1_gr	32_1_gs	M	
					32_2_gr	32_2_gs	M	
					48_1_gr	32_1_gs	M	
					48_2_gr	32_2_gs	M	
					48_1_gr	48_1_gs	M	
					48_2_gr	48_2_gs	M	
					48_3_gr	32_1_gs	C.1	
					48_4_gr	32_2_gs	C.1	
					48_3_gr	48_1_gs	C.1	

Audio Config from [2]	Legend from [2]			# of UGT Devices	Config QoS UGG to UGT Direction	Config QoS UGT to UGG Direction	UGG	UGT
					48_4_gr	48_2_gs	C.1	
8(i)	UGG		UGT	1	32_1_gr	16_1_gs	M	C.18
					32_2_gr	16_2_gs	M	C.18
					48_1_gr	16_1_gs	M	C.19
					48_2_gr	16_2_gs	M	C.19
					32_1_gr	32_1_gs	M	C.18
					32_2_gr	32_2_gs	M	C.18
					48_1_gr	32_1_gs	M	C.19
					48_2_gr	32_2_gs	M	C.19
					48_1_gr	48_1_gs	M	C.20
					48_2_gr	48_2_gs	M	C.20
					48_3_gr	32_1_gs	C.1	C.19
					48_4_gr	32_2_gs	C.1	C.19
8(ii)	UGG		UGT UGT	2	32_1_gr	16_1_gs	M	See Audio Config 1 and 3.
					32_2_gr	16_2_gs	M	
					48_1_gr	16_1_gs	M	
					48_2_gr	16_2_gs	M	
					32_1_gr	32_1_gs	M	
					32_2_gr	32_2_gs	M	
					48_1_gr	32_1_gs	M	
					48_2_gr	32_2_gs	M	
					48_1_gr	48_1_gs	M	
					48_2_gr	48_2_gs	M	

Audio Config from [2]	Legend from [2]			# of UGT Devices	Config QoS UGG to UGT Direction	Config QoS UGT to UGG Direction	UGG	UGT
					48_3_gr	32_1_gs	C.1	
					48_4_gr	32_2_gs	C.1	
11(i)	UGG		UGT	1	32_1_gr	16_1_gs	C.21	C.23
					32_2_gr	16_2_gs	C.21	C.23
					48_1_gr	16_1_gs	C.21	C.24
					48_2_gr	16_2_gs	C.21	C.24
					32_1_gr	32_1_gs	C.21	C.23
					32_2_gr	32_2_gs	C.21	C.23
					48_1_gr	32_1_gs	C.21	C.24
					48_2_gr	32_2_gs	C.21	C.24
					48_3_gr	32_1_gs	C.22	C.24
					48_4_gr	32_2_gs	C.22	C.24
11(ii)	UGG		UGT UGT	2	32_1_gr	16_1_gs	C.21	See Audio Config 3.
					32_2_gr	16_2_gs	C.21	
					48_1_gr	16_1_gs	C.21	
					48_2_gr	16_2_gs	C.21	
					32_1_gr	32_1_gs	C.21	
					32_2_gr	32_2_gs	C.21	
					48_1_gr	32_1_gs	C.21	
					48_2_gr	32_2_gs	C.21	
					48_3_gr	32_1_gs	C.22	
					48_4_gr	32_2_gs	C.22	

Table 3.15: UGG and UGT concurrent Config QoS requirements

C.1: Mandatory if the UGG supports the UGG 96 kbps Source feature, otherwise Excluded.

C.2: Mandatory if the UGT supports the UGT Sink feature and the UGT 64 kbps Sink feature, otherwise Excluded.

C.3: Mandatory if the UGT supports the UGT Sink feature, otherwise Excluded.

C.4: Mandatory if the UGT supports the UGT Source feature, otherwise Excluded.

C.5: Mandatory if the UGT supports the UGT 80 kbps Source feature, otherwise Excluded.

C.6: Mandatory if the UGT supports the UGT Source feature, the UGT Sink feature, and the UGT 64 kbps Sink feature, otherwise Excluded.

C.7: Mandatory if the UGT supports the UGT Source feature and the UGT Sink feature, otherwise Excluded.

C.8: Mandatory if the UGT supports the UGT 80 kbps Source feature and the UGT Sink feature, otherwise Excluded.

C.9: Mandatory if the UGG supports the UGG Multiplex feature, otherwise Excluded.

C.10: Mandatory if the UGG supports the UGG Multiplex feature and the UGG 96 kbps Source feature, otherwise Excluded.

C.11: Mandatory if the UGT supports the UGT Multiplex feature and the UGT 64 kbps Sink feature, otherwise Excluded.

C.12: Mandatory if the UGT supports the UGT Multiplex feature, otherwise Excluded.

C.13: Mandatory if the UGT supports the UGT Multiplex feature, the UGT Source feature, and the UGT 64 kbps Sink feature, otherwise Excluded.

C.14: Mandatory if the UGT supports the UGT Multiplex feature and the UGT Source feature, otherwise Excluded.

C.15: Mandatory if the UGT supports the UGT Multiplex feature and the UGT 80 kbps Source feature, otherwise Excluded.

C.16: Mandatory if the UGT supports the UGT Multisink feature and the UGT 64 kbps Sink feature, otherwise Excluded.

C.17: Mandatory if the UGT supports the UGT Multisink feature, otherwise Excluded.

C.18: Mandatory if the UGT supports the UGT Source feature, the UGT Multisink feature, and the UGT 64 kbps Sink feature, otherwise Excluded.

C.19: Mandatory if the UGT supports the UGT Source feature and the UGT Multisink feature, otherwise Excluded.

C.20: Mandatory if the UGT supports the UGT 80 kbps Source feature and the UGT Multisink feature, otherwise Excluded.

C.21: Mandatory if the UGG supports the UGG Multisink feature, otherwise Excluded.

C.22: Mandatory if the UGG supports the UGG Multisink feature and the UGG 96 kbps Source feature, otherwise Excluded.

C.23: Mandatory if the UGT supports the UGT Multisource feature, the UGT Multisink feature, and the UGT 64 kbps Sink feature, otherwise Excluded.

C.24: Mandatory if the UGT supports the UGT Multisource feature and the UGT Multisink feature, otherwise Excluded.

The UGG Controller should use the LL parameters listed in Table 3.16 and Table 3.17. The four levels in Table 3.16 and Table 3.17 for each Audio Configuration are defined as follows:

- A = Lowest latency: This setting achieves the lowest latency and might experience more lost packets in some environments.
- B = Low latency: This setting achieves low latency with more retransmissions and slightly higher latency.
- C = Balanced: This setting achieves better robustness at the cost of higher latency.
- D = High reliability: This setting reduces the number of lost packets at the cost of the highest latency.

See Appendix A for more details on how the latency figures in Table 3.16 were calculated. All calculations in Table 3.16 assume audio configuration 8(i) as shown in Figure 3.2. Table 3.16 and Table 3.17 calculations also assume the following:

- PHY_C_To_P = PHY_P_To_C = 2 Mbps
- RTN_C_To_P = RTN_P_To_C = RTN
- FT_C_To_P = FT_P_To_C = FT
- BN_C_To_P = BN_P_To_C = BN

QoS Setting, UGG to UGT	QoS Setting, UGT to UGG	ISO_ Interval (ms)	Level	FT	NSE	BN	RTN	Transport Latency (ms)	% BW	Total System Delay (ms) (UGG to UGT Direction)	Total System Delay (ms) (UGT to UGG Direction)
32_1_gr	16_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	2.698 4.122 10.198 11.622	36.0% 55.0% 36.0% 55.0%	26.40 27.82 33.90 35.32	76.40 77.82 83.90 85.32
32_2_gr	16_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.098 4.722 13.098 14.722	31.0% 47.2% 31.0% 47.2%	28.30 29.92 38.30 39.92	78.30 79.92 88.30 89.92
48_1_gr	16_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	2.938 4.482 10.438 11.982	39.2% 59.8% 39.2% 59.8%	26.64 28.18 34.14 35.68	76.64 78.18 84.14 85.68

QoS Setting, UGG to UGT	QoS Setting, UGT to UGG	ISO_ Interval (ms)	Level	FT	NSE	BN	RTN	Transport Latency (ms)	% BW	Total System Delay (ms) (UGG to UGT Direction)	Total System Delay (ms) (UGT to UGG Direction)
48_2_gr	16_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.418 5.202 13.418 15.202	34.2% 52.0% 34.2% 52.0%	28.62 30.40 38.62 40.40	78.62 80.40 88.62 90.40
48_1_gr	32_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.178 4.842 10.678 12.342	42.4% 64.6% 42.4% 64.6%	26.88 28.54 34.38 36.04	76.88 78.54 84.38 86.04
48_2_gr	32_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.738 5.682 13.738 15.682	37.4% 56.8% 37.4% 56.8%	28.94 30.88 38.94 40.88	78.94 80.88 88.94 90.88
48_3_gr	32_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.418 5.202 10.918 12.702	45.6% 69.4% 45.6% 69.4%	27.12 28.90 34.62 36.40	77.12 78.90 84.62 86.40
48_4_gr	32_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	4.058 6.162 14.058 16.162	40.6% 61.6% 40.6% 61.6%	29.26 31.36 39.26 41.36	79.26 81.36 89.26 91.36
48_1_gr	48_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.298 5.02 10.798 12.522	44.0% 67.0% 44.0% 67.0%	27.00 28.72 34.50 36.22	77.00 78.72 84.50 86.22
48_2_gr	48_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.898 5.922 13.898 15.922	39.0% 59.2% 39.0% 59.2%	29.10 31.12 39.10 41.12	79.10 81.12 89.10 91.12

Table 3.16: Recommended LL parameters for Unicast QoS configurations 8(i) and 8(ii)

QoS Setting, UGG to UGT	QoS Setting, UGT to UGG	ISO_ Interval (ms)	Level	FT	NSE	BN	RTN	Transport Latency (ms)	% BW	Total System Delay (ms) (UGG to UGT Direction)	Total System Delay (ms) (UGT to UGG Direction)
32_1_gr	16_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	2.97 4.53 10.47 12.03	39.6% 60.4% 39.6% 60.4%	26.67 28.23 34.17 35.73	76.67 78.23 84.17 85.73
32_2_gr	16_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.45 5.25 13.45 15.25	34.5% 52.5% 34.5% 52.5%	28.65 30.45 38.65 40.45	78.65 80.45 88.65 90.45
48_1_gr	16_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.21 4.89 10.71 12.39	42.8% 65.2% 42.8% 65.2%	26.91 28.59 34.41 36.09	76.91 78.59 84.41 86.09
48_2_gr	16_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.77 5.73 13.77 15.73	37.7% 57.3% 37.7% 57.3%	28.97 30.93 38.97 40.93	78.97 80.93 88.97 90.93
48_1_gr	32_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.69 5.61 11.19 13.11	49.2% 74.8% 49.2% 74.8%	27.39 29.31 34.89 36.81	77.39 79.31 84.89 86.81
48_2_gr	32_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	4.11 6.69 14.41 16.69	44.1% 66.9% 44.1% 66.9%	29.61 31.89 39.61 41.89	79.61 81.89 89.61 91.89
48_3_gr	32_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.93 5.97 11.43 13.47	52.4% 79.6% 52.4% 79.6%	27.63 29.67 35.13 37.17	77.63 79.67 85.13 87.17
48_4_gr	32_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	4.73 7.17 14.73 17.17	47.3% 71.7% 47.3% 71.7%	29.93 32.37 39.93 42.37	79.93 82.37 89.93 92.37
48_1_gr	48_1_gs	7.5	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	3.93 5.97 11.43 13.47	52.4% 79.6% 52.4% 79.6%	27.63 29.67 35.13 37.17	77.63 79.67 85.13 87.17

QoS Setting, UGG to UGT	QoS Setting, UGT to UGG	ISO_ Interval (ms)	Level	FT	NSE	BN	RTN	Transport Latency (ms)	% BW	Total System Delay (ms) (UGG to UGT Direction)	Total System Delay (ms) (UGT to UGG Direction)
48_2_gr	48_2_gs	10	A B C D	1 1 2 2	2 3 2 3	1 1 1 1	1 2 3 5	4.73 7.17 14.73 17.17	47.3% 71.7% 47.3% 71.7%	29.93 32.37 39.93 42.37	79.93 82.37 89.93 92.37

Table 3.17: Recommended LL parameters for Unicast QoS configurations 11(i) and 11(ii)

In addition to the recommendations in Table 3.16, the UGG Controller should do the following to increase the contiguous airtime available to other radio transceivers:

1) For all multiple CIS Audio Configurations, use interleaved packing.

2) For Audio Configurations 8(i) and 8(ii), schedule the bidirectional CIS to transmit as the earliest CIS in the CIG event.

Both Audio Configurations 8(i) and 8(ii) involve a single CIG containing two CISes, one bidirectional and the other unidirectional. Figure 3.2 shows Audio Configuration 8(i) with example end products. By following recommendation 2, CIS 1 in Figure 3.2 would be the earliest CIS in each CIG event. See Appendix B for more details on how this recommendation results in more contiguous air time for other transmitters.

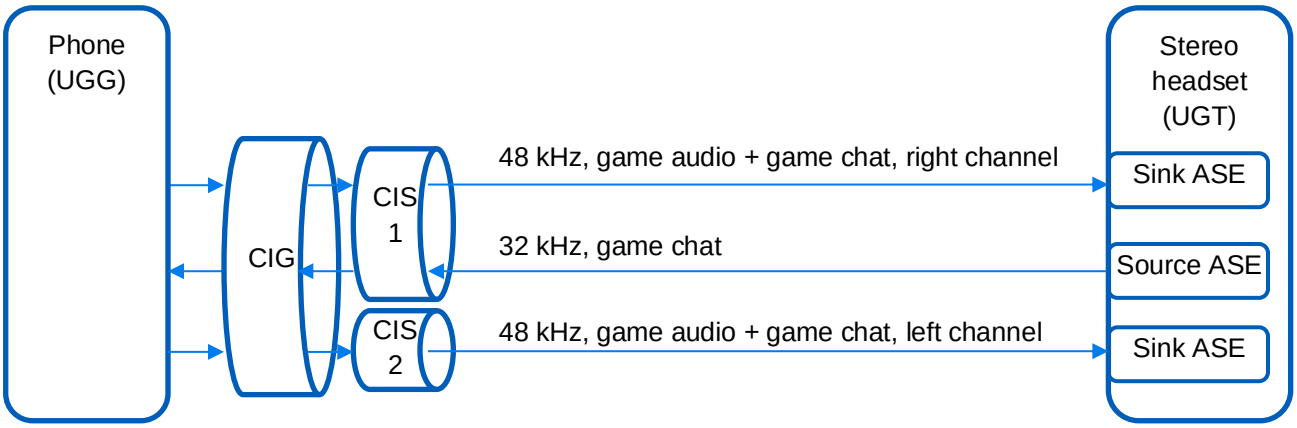


Figure 3.2: Audio Configuration 8(i)

Figure 3.3 shows Audio Configuration 5 with example end products. This configuration makes more efficient use of the air time than scheduling two CISes, but might also result in more lost packets because of the larger packet size.

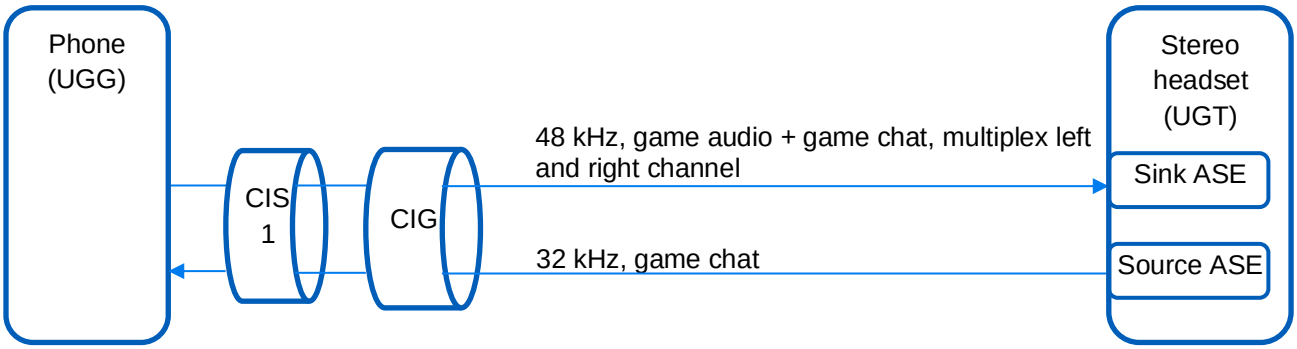


Figure 3.3: Audio Configuration 5

3.5.2 Requirements for Broadcast roles

This section specifies requirements for the BGS and BGR roles in addition to those defined in BAP [2].

3.5.2.1 Broadcast audio capability support

Table 3.18 shows the Codec Capability Setting requirements defined for the BGR role in addition to those required by the BAP Broadcast Sink role. The Codec Capability Setting names are defined in Section 3.7.1 in BAP [2] and refer to Codec_Specific_Capabilities parameter values in PACS [5].

The BGR role shall expose at least one Sink PAC characteristic containing a PAC record that includes Codec Capability Settings defined as Mandatory in Table 3.18.

Devices supporting the BGS role shall use the Streaming_Audio_Contexts LTV structure in the Metadata parameter in the BASE with the value “Game.”

Table 3.18 shows the Codec Configuration Setting requirements defined for the BGS role in addition to those required by the BAP Broadcast Source role. The Codec Configuration Setting names are defined in BAP [2] and refer to Codec_Specific_Configuration values transmitted in Basic Audio Announcements defined in Section 3.7.2.2 in BAP [2].

Codec Configuration Setting for the BGS Role (See Section 3.7.1 in [2]) **Codec Capability Setting for the BGR Role (See Section 3.8.2 in [2])**	**Requirement**	
	BGS	**BGR**
48_1	M	M
48_2	M	M
48_3	C.1	M
48_4	C.1	M

Table 3.18: Codec setting requirements for the BGS and BGR roles

C.1: Mandatory if the BGS 96 kbps feature is supported, otherwise Excluded.

3.5.2.2 Broadcast configuration settings

Table 3.19 lists Audio_Channel_Allocation value requirements for the BGS role. The Audio_Channel_Allocation parameter is defined in Section 4.3.2 in [2].

Audio Location Value in the Audio_Channel_Allocation LTV (Bit 1 and Bit 0 Only)	Description	Requirements
		BGS
0b01	Front Left	M
0b10	Front Right	M

Table 3.19: Audio_Channel_Allocation values required for the BGS role

Table 3.20 lists the Sink Audio Locations characteristic value requirements for the BGR role. The Sink Audio Locations characteristic is defined in Section 3.2 in [5].

Audio Location Value in the Sink Audio Locations Characteristic (Bit 1 and Bit 0 Only)	Description	Requirements
		BGR
0b01	Front Left	C.1
0b10	Front Right	C.1
0b11	Front Right and Front Left	C.1

Table 3.20: Sink_Audio_Location values required for the BGR role

C.1: Mandatory to support one of the 0b01, 0b10, or 0b11 Audio Location Values in bit 1 and bit 0 of the Sink Audio Locations characteristic.

3.5.2.3 Broadcast stream settings

Table 3.21 lists the low-latency media broadcast audio requirements for devices implementing the BGS or BGR role. The Set Names use a suffix of “g” for GMAP.

As in Table 6.4 in BAP [2], Table 3.21 lists HCI-level (see Volume 4, Part E in [1]) parameters. On systems not incorporating HCI, equivalent values for LL-level (BIG) broadcast Audio Stream configuration parameters shall be used.

Retransmission number values in Table 3.21 are minimum value recommendations to the Controller. See Table 3.23 for a range of recommended LL parameters. The Controller should select parameters that result in an RTN value that is no less than the retransmission number value specified in Table 3.21.

Values in the Max_Transport_Latency column of Table 3.21 provide an upper bound to the Controller, as specified in the HCI definition. See Table 3.23 and Appendix A for more details on transport latency as determined by the Controller.

Set Name	Codec Capability / Configuration Setting (See Table 3.18)	SDU_ Interval (µs)	Framing	Maximum_SDU_Size (Octets)	Retransmission_Number	Max_Transport_Latency (ms)	Presentation_Delay (µs)	Requirement	
								BGS	BGR
48_1_g	48_1	7500[1]	Unframed	75[2] (80 kbps[3])	1	8	10000[4]	M	M
48_2_g	48_2	10000[1]	Unframed	100[2] (80 kbps[3])	1	10	10000[4]	M	M
48_3_g	48_3	7500[1]	Unframed	90[2] (96 kbps[3])	1	8	10000[4]	C.1	M
48_4_g	48_4	10000[1]	Unframed	120[2] (96 kbps[3])	1	10	10000[4]	C.1	M

[1] Nominal. May be adjusted to accommodate audio clock offset and drift. See Section 6.3 in BAP [2].

[2] Settings are based on a BIS specifying a single Audio Channel and single block of codec frames per SDU. Different Audio_Channel_Allocation values (see Section 4.3.2 in BAP [2]) and/or a greater number of blocks of codec frames per SDU (see Section 4.3.2 in BAP [2]) would require settings to be appropriately scaled.

[3] Bit rates are calculated according to Section 3.2.5 in [15].

[4] For the BGR, the supported Presentation_Delay range shall include this value.

Table 3.21: QoS configuration support setting requirements for the BGS and BGR

C.1: Mandatory if the BGS 96 kbps feature is supported, otherwise Excluded.

3.5.2.4 Requirements for CAP Broadcast procedures

GMAP requires each GMAP role to support certain CAP roles (see Table 3.2 and Table 3.7). In turn, the CAP specification establishes Broadcast Audio Stream Transition procedure requirements for each CAP role. GMAP adds no Broadcast Audio Stream Transition support requirements beyond those specified in CAP [3].

Section 4.5 in BAP [2] specifies Audio Configuration support requirements for broadcast devices supporting LC3. This section includes GMAP requirements for the BGS and BGR roles within the following CAP procedures:

- Broadcast Audio Start
- Broadcast Audio Update
- Broadcast Audio Stop

Table 3.22 establishes requirements for broadcast QoS settings within each Audio Configuration. One entry in Table 3.22 represents an Audio Configuration listed in another Table 3.22 row. In that case, the cell is grayed out and contains a reference to the Audio Configuration that defines the support requirement.

Some of the entries in Table 3.22 require concurrent broadcast streams. For those entries, concurrent streams means that all streams in an Audio Configuration are sent over the air in a single BIG.

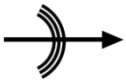
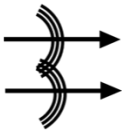
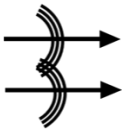
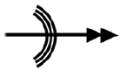
Audio Config from [2]	Legend from [2]			# of BGR Devices	QoS Setting BGS to BGR	BGS	BGR
12	BGS		BGR	1	48_1_g 48_2_g 48_3_g 48_4_g	M M C.1 C.1	M M M M
13	BGS		BGR	1	48_1_g 48_2_g 48_3_g 48_4_g	M M C.1 C.1	C.2 C.2 C.2 C.2
13	BGS		BGR BGR	2	48_1_g 48_2_g 48_3_g 48_4_g	M M C.1 C.1	See Audio Config 12.
14	BGS		BGR	1	48_1_g 48_2_g 48_3_g 48_4_g	O O O O	C.3 C.3 C.3 C.3

Table 3.22: BGS and BGR Config QoS requirements

C.1: Mandatory if the BGS 96 kbps feature is supported, otherwise Excluded.

C.2: Mandatory if the BGR Multisink feature is supported, otherwise Excluded.

C.3: Mandatory if the BGR Multiplex feature is supported, otherwise Excluded.

The BGS Controller should use the LL parameters listed in Table 3.23 for each Audio Configuration and the associated supported QoS configuration in Table 3.22. Table 3.23 does not list PTO because PTO is ignored when IRC = NSE / BN, which is the case for all recommended sets. The analysis in Table 3.23 assumes Audio Configuration 13 and the following processing times:

- Encoder/Algorithm/jitter delay = 6.2 ms
- Audio processing time = 13.7 ms

The four levels in Table 3.23 for each Audio Configuration are defined as follows:

- A = Lowest latency: This setting achieves the lowest latency and might experience more lost packets in some environments.
- B = Low latency: This setting achieves low latency with more retransmissions and slightly higher latency.

- C = Balanced: This setting achieves better robustness at the cost of higher latency.
- D = High reliability: This setting reduces the number of lost packets at the cost of the highest latency.

See Appendix A for more details on these calculations.

QoS Setting from Table 3.22	Level	Link Layer Parameters						Transport_Latency (ms)	% BW	Total System Delay (ms)
		ISO_ Interval	BN	NSE	IRC	Num_BIS	RTN			
48_1_g	A B C D	7.5 ms	1	2 3 4 5	2 3 4 5	2	1 2 3 4	1.89 2.91 3.93 4.95	25.2% 38.8% 52.4% 66.0%	25.59 26.61 27.63 28.65
48_2_g	A B C D	10 ms	1	2 3 4 5	2 3 4 5	2	1 2 3 4	2.29 3.51 4.73 5.95	22.9% 35.1% 47.3% 59.5%	27.49 28.71 29.93 31.15
48_3_g	A B C D	7.5 ms	1	2 3 4 5	2 3 4 5	2	1 2 3 4	2.13 3.27 4.41 5.55	28.4% 43.6% 58.8% 74.0%	25.83 26.97 28.11 29.25
48_4_g	A B C D	10 ms	1	2 3 4 5	2 3 4 5	2	1 2 3 4	2.61 3.99 5.37 6.75	26.1% 39.9% 53.7% 67.5%	27.81 29.19 30.57 31.95

Table 3.23: Recommended LL parameters for Broadcast QoS configuration

3.5.3 Security considerations with coordination

Devices that implement the CSIP Set Member role should request LE Security Mode 1 Level 3 (as defined in Volume 3, Part C, Section 10.2.1 in [1]). If this is not possible because of limited UI capability, then devices that implement the CSIP Set Coordinator role should request user permission when establishing audio with multiple devices.

3.6 Latency requirements

GMAP establishes Total System Delay requirements for audio transmitted from UGG to UGT and from BGS to BGR. Total System Delay is defined as shown in Figure 3.4. See Appendix A for latency calculation examples.

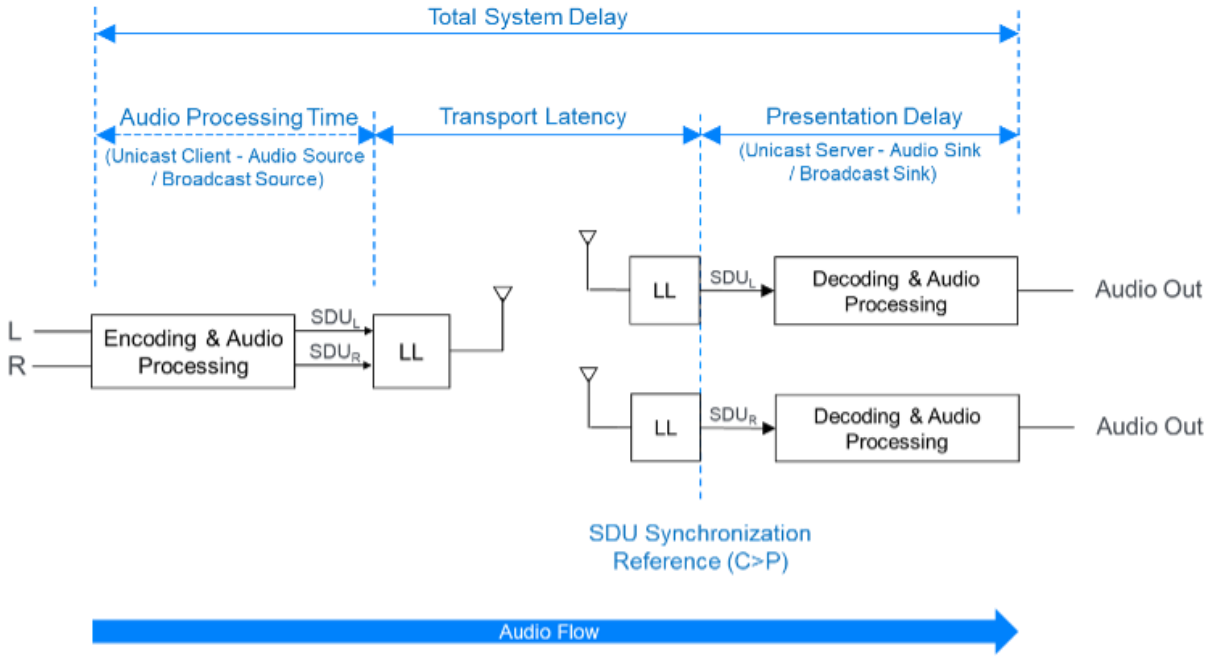


Figure 3.4: Visualization of total system delay for a Bluetooth Low Energy (LE) Audio implementation (from Figure 7.3 in BAP [2])

For each Audio Configuration listed in Table 3.15, using Level A parameters from Table 3.16 and Table 3.17, the UGG to UGT Total System Delay (C to P) shall be no greater than 40 ms; the time from the input to the Encoding and Audio Processing block to the SDU Synchronization Reference shall be no greater than 40 ms minus a UGG to UGT Presentation_Delay value specified in Table 3.14; and the time from the SDU Synchronization Reference to the Audio Out shall be a UGG to UGT Presentation_Delay value specified in Table 3.14 +/- 62.5 µs.

For each Audio Configuration listed in Table 3.22, using Level A parameters from Table 3.23, the BGS to BGR Total System Delay shall be no greater than 40 ms; the time from the input to the Encoding and Audio Processing block to the BIG Synchronization point shall be no greater than 40 ms minus a Presentation_Delay value specified in Table 3.21; and the time from the BIG Synchronization point to the Audio Out shall be a Presentation_Delay value specified in Table 3.21 +/- 62.5 µs.

Implementers may use values of Max_Transport_Latency lower than those listed in Table 3.14 to meet the latency requirements in this section.

For both unicast and broadcast, Audio Out in the Initiator to Acceptor direction is defined as the point at which audio is presented to the end user.

GMAP establishes Total System Delay requirements for audio transmitted from UGT to UGG. Total System Delay is defined as shown in Figure 3.5.

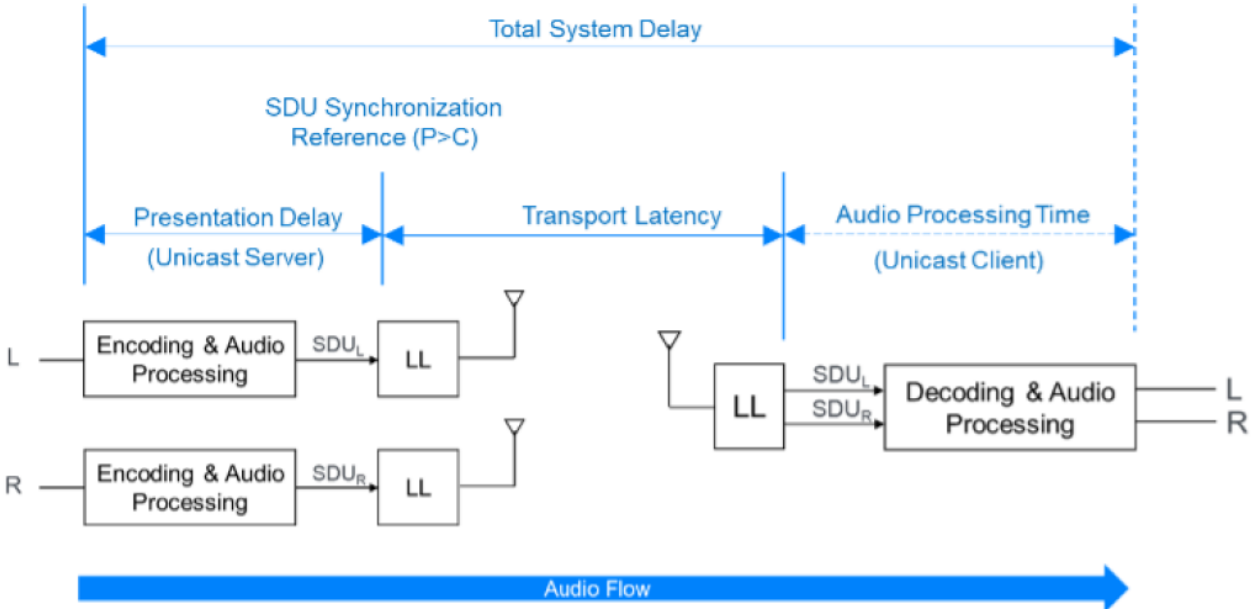


Figure 3.5: Visualization of total system delay for a Bluetooth LE Audio implementation (from Figure 7.4 in BAP [2])

For each Audio Configuration listed in Table 3.15, using Level A parameters from Table 3.16 and Table 3.17, the UGT to UGG Total System Delay (P to C) shall be no greater than 100 ms; the time from the input to the Encoding and Audio Processing block to the SDU Synchronization Reference shall be a UGT to UGG Presentation_Delay value specified in Table 3.14 +/- 62.5 µs; and the time from the SDU Synchronization Reference to the Audio Out shall be no greater than 100 ms minus the Presentation_Delay µs.

Audio Out in the UGT to UGG direction is defined as the point immediately after the Decoding and Audio Processing block.

3.7 Synchronization requirements

The following cases establish requirements for the UGT role and the BGR role. In each of these cases, the point of measurement is defined as the point at which audio is presented to the end user. All synchronization requirements in this section shall be met using the conditions as specified in Section 7.1 in BAP [2]. The test signal may use other frequencies (and features designed to reduce or eliminate phase ambiguity) if the resulting latency equals the one under the conditions defined in Section 7.1 in BAP [2].

Case 1: Unicast Audio Configurations 6(ii), 8(ii), and 11(ii) from Table 3.15. Dual BGR Broadcast Audio Configuration 13 from Table 3.22. An example of this case includes a pair of untethered earbuds. “Untethered” refers to devices that have no wired connection between each other.

Synchronization requirement: The pair of UGT devices shall render Audio Out to within +/- 100 µs static and +/- 25 µs of jitter of each other. The pair of BGR devices shall render audio to within +/- 100 µs static and +/- 25 µs of jitter of each other.

Case 2: Unicast Audio Configurations 6(i), 8(i), 5, and 11(i) from Table 3.15. Single BGR Broadcast Audio Configuration 13 and 14 from Table 3.22. An example of this case includes a banded headphone.

Synchronization requirement: The pair of Audio Out signals from the UGT shall render audio to within +/- 100 µs static and +/- 25 µs of jitter of each other. The pair of Audio Out signals from the BGR shall render audio to within +/- 100 µs static and +/- 25 µs of jitter of each other.

3.8 GMAS requirements

Section 4 specifies the Gaming Audio Service (GMAS) to allow any GATT Client to discover support for GMAP.

UGG, UGT, and BGR devices supporting GMAP shall implement the GATT Server role and instantiate only one GMAS. This is referred to as the GMA Server.

BGS-only devices are not required by GMAP to implement the GATT Server role. Any BGS device that does implement the GATT Server role shall instantiate only one GMAS. An example of such a device might be a TV that allows other GATT Clients to discover its BGS role.

Supporting the GATT Client role for the purpose of accessing GMAS characteristics is referred to as the GMA Client role. UGG devices shall support the GMA Client role; GMAP devices not supporting the UGG role may implement the GMA Client role.

3.8.1 GMA Client requirements

GATT sub-procedure support requirements required by all GATT Clients are defined in Volume 3, Part G, Section 4.6 in [1].

3.8.1.1 Service discovery

The GMA Client shall use GATT Service Discovery to discover the GMAS.

The GMA Client shall perform primary service discovery by using the GATT Discover All Primary Services sub-procedure or the GATT Discover Primary Services by Service UUID sub-procedure.

3.8.1.2 Characteristic discovery

The GMA Client shall perform the GATT Discover All Characteristics of a Service sub-procedure or the GATT Discover Characteristics by UUID sub-procedure to discover the characteristics of the GMAS.

All characteristics are optional for the GMA Client to discover.

3.8.1.3 Additional GATT sub-procedure requirements

The GMA Client shall support the additional GATT sub-procedure requirements stated in Table 3.24.

GATT Sub-Procedure	Requirement
Discover All Primary Services	C.1
Discover Primary Services by Service UUID	C.1
Discover All Characteristics of a Service	C.2
Discover Characteristics by UUID	C.2
Read Characteristic Value	C.3
Read Using Characteristic UUID	C.3

Table 3.24: Additional GMA Client GATT sub-procedure support requirements

C.1: Mandatory to support at least one of Discover All Primary Services sub-procedure or Discover Primary Services by Service UUID sub-procedure.

C.2: Mandatory to support at least one of Discover All Characteristics of a Service sub-procedure or Discover Characteristics by UUID sub-procedure.

C.3 Mandatory to support at least one of Read Characteristic Value sub-procedure or Read Using Characteristic UUID sub-procedure.

4 Gaming Audio Service

Gaming Audio Service (GMAS) defines characteristics to enable discovery of supported GMAP profile roles and features.

4.1 Service dependencies

GMAS does not depend on any other services.

4.2 Bluetooth Core Specification release compatibility

GMAS is compatible with any version of the Bluetooth Core Specification that has not been deprecated or withdrawn.

4.3 Transport dependencies

GMAS uses GATT and therefore has no additional transport dependencies.

4.4 Byte transmission order

All characteristics used with this service shall be transmitted with the least significant octet (LSO) first (i.e., little endian). The LSO is identified in the characteristic definitions in [14].

4.5 GATT sub-procedure requirements

GMAS adds no requirements for the GMA Server beyond those specified in [1] for all GATT Servers.

4.6 Declaration

GMAS shall be instantiated as a «Primary Service» and may be included by other services. The service UUID shall be set to «Gaming Audio Service» as defined in [14].

4.7 Service characteristics

This section defines the characteristic requirements. Table 4.1 defines the GMAS characteristics.

Characteristic Name	Requirement	Mandatory Properties	Optional Properties	Security Permissions
GMAP Role	M	Read	None	None
UGG Features	C.1	Read	None	None
UGT Features	C.2	Read	None	None
BGS Features	C.3	Read	None	None
BGR Features	C.4	Read	None	None

Table 4.1: GMAS characteristics

C.1: Mandatory if the UGG role is supported, otherwise Excluded.

C.2: Mandatory if the UGT role is supported, otherwise Excluded.

C.3: Mandatory if the BGS role is supported, otherwise Excluded.

C.4: Mandatory if the BGR role is supported, otherwise Excluded.

4.7.1 GMAP Role

The GMAP Role characteristic exposes the GMAP role(s) supported by the GMA Server.

4.7.1.1 Characteristic format

The characteristic format is defined in Table 4.2.

Parameter	Size (Octets)	Description
Role	1	Bitmap of supported GMAP roles

Table 4.2: Format of the GMAP Role characteristic

4.7.1.2 Characteristic behavior

The GMAP Role characteristic returns its associated value when it is read by a GMA Client that uses the GATT Read Characteristic Value sub-procedure or the GATT Read Using Characteristic UUID sub-procedure.

Table 4.3 lists the bit locations for the GMAP Role characteristic.

Bit Location	Description	0 value	1 value
Bit 0	Unicast Game Gateway (UGG)	Not supported	Supported
Bit 1	Unicast Game Terminal (UGT)	Not supported	Supported
Bit 2	Broadcast Game Sender (BGS)	Not supported	Supported
Bit 3	Broadcast Game Receiver (BGR)	Not supported	Supported
Bit 4-7	RFU		

Table 4.3: Bit location definitions for the GMAP Role characteristic

4.7.2 UGG Features

The UGG Features characteristic exposes the UGG features supported by the GMA Server.

4.7.2.1 Characteristic format

The UGG Features characteristic format is defined in Table 4.4.

Parameter	Size (Octets)	Description
Features	1	Bitmap of supported UGG features

Table 4.4: Format of the UGG Features characteristic

4.7.2.2 Characteristic behavior

The UGG Features characteristic returns its associated value when it is read by a GMA Client that uses the GATT Read Characteristic Value sub-procedure or the GATT Read Using Characteristic UUID sub-procedure.

Table 4.5 lists the bit locations for the UGG Features characteristic.

Bit Location	Description	0 Value	1 Value
0	UGG Multiplex feature support	Not supported	Supported
1	UGG 96 kbps Source feature support	Not supported	Supported
2	UGG Multisink feature support	Not supported	Supported
3 - 7	RFU		

Table 4.5: Bitmap of supported UGG features

4.7.3 UGT Features

The UGT Features characteristic exposes the UGT features supported by the GMA Server.

4.7.3.1 Characteristic format

The UGT Features characteristic format is defined in Table 4.6.

Parameter	Size (Octets)	Description
Features	1	Bitmap of supported UGT features

Table 4.6: Format of the UGT Features characteristic

4.7.3.2 Characteristic behavior

The UGT Features characteristic returns its associated value when it is read by a GMA Client that uses the GATT Read Characteristic Value sub-procedure or the GATT Read Using Characteristic UUID sub-procedure.

Table 4.7 lists the bit locations for the UGT Features characteristic.

Bit Location	Description	0 Value	1 Value
0	UGT Source feature support	Not supported	Supported
1	UGT 80 kbps Source feature support	Not supported	Supported
2	UGT Sink feature support	Not supported	Supported

Bit Location	Description	0 Value	1 Value
3	UGT 64 kbps Sink feature support	Not supported	Supported
4	UGT Multiplex feature support	Not supported	Supported
5	UGT Multisink feature support	Not supported	Supported
6	UGT Multisource feature support	Not supported	Supported
7	RFU		

Table 4.7: UGT features support bitmap

4.7.4 BGS Features

The BGS Features characteristic exposes the BGS features supported by the GMA Server.

4.7.4.1 Characteristic format

The BGS Features characteristic format is defined in Table 4.8.

Parameter	Size (Octets)	Description
Features	1	Bitmap of supported BGS features

Table 4.8: Format of the BGS Features characteristic

4.7.4.2 Characteristic behavior

The BGS Features characteristic returns its associated value when it is read by a GMA Client that uses the GATT Read Characteristic Value sub-procedure or the GATT Read Using Characteristic UUID sub-procedure.

Table 4.9 lists the bit locations for the BGS Features characteristic.

Bit Location	Description	0 Value	1 Value
0	BGS 96 kbps feature support	Not supported	Supported
1 – 7	RFU		

Table 4.9: Bitmap of supported BGS features

4.7.5 BGR Features

The BGR Features characteristic exposes the BGR features supported by the GMA Server.

4.7.5.1 Characteristic format

The BGR Features characteristic format is defined in Table 4.10.

Parameter	Size (Octets)	Description
Features	1	Bitmap of supported BGR features

Table 4.10: Format of the BGR Features characteristic

4.7.5.2 Characteristic behavior

The BGR Features characteristic returns its associated value when it is read by a GMA Client that uses the GATT Read Characteristic Value sub-procedure or the GATT Read Using Characteristic UUID sub-procedure.

Table 4.11 lists the bit locations for the BGR Features characteristic.

Bit Location	Description	0 Value	1 Value
0	BGR Multisink feature support	Not supported	Supported
1	BGR Multiplex feature support	Not supported	Supported
2 – 7	RFU		

Table 4.11: Bitmap of supported BGR features

4.8 GMAS security requirements

The security requirements for all characteristics specified by GMAS shall be LE Security Mode 1 Level 1 as defined in Volume 3, Part C, Section 10.2.1 in [1]. Other characteristics defined by lower-layer profiles require higher levels of security. Therefore, the GMA Server shall allow the GMA Client access to the GMAS characteristics before encrypting the link.

The Privacy feature, as defined in Volume 3, Part C, Section 10.7 in [1], should be used.

4.8.1 GMA Client security requirements for Low Energy

The GMA Client should support bondable mode as defined in Volume 3, Part C, Section 9.4.3 in [1].

The GMA Client should support the bonding procedure defined in Volume 3, Part C, Section 9.4.4 in [1].

The GMA Client shall support LE Security Mode 1 Level 1 and should support LE Security Mode 1 Level 3. The GMA Client should accept the LE Security Mode and the LE Security Level combination that is requested by the GMA Server.

4.8.2 GMA Server security requirements for Low Energy

The GMA Server should support bondable mode as defined in Volume 3, Part C, Section 9.4.3 in [1].

The GMA Server should support the bonding procedure defined in Volume 3, Part C, Section 9.4.4 in [1].

The GMA Server shall support LE Security Mode 1 Level 1.

4.8.3 Security considerations for BR/EDR

When GMAS is supported over Basic Rate/Enhanced Data Rate (BR/EDR), the security requirements for all characteristics defined in GMAS shall be Security Mode 4 Level 2 as defined in Volume 3, Part C, Section 5.2.2.8 in [1].

4.9 SDP interoperability

If GMAS is exposed over BR/EDR, then it shall have the following Service Discovery Protocol (SDP) record shown in Table 4.12.

Item	Definition	Type	Value	Status
Service Class ID List	–	–	–	M
Service Class #0	–	UUID	«Gaming Audio Service»	M
Protocol Descriptor List	–	–	–	M
Protocol #0	–	UUID	Logical Link Control and Adaptation Protocol (L2CAP)	M
Parameter #0 for Protocol #0	Protocol/Service Multiplexer (PSM)	uint16	PSM = Attribute Protocol (ATT)	M
Parameter #1 for Protocol #0	PSM	uint16	PSM = Enhanced Attribute Protocol (EATT)	O
Protocol #1	–	UUID	ATT	M
Protocol #2	–	UUID	EATT	C.1
BrowseGroupList	–	–	PublicBrowseRoot*	M

Table 4.12: SDP record

C.1: Mandatory to support this item if EATT is supported, otherwise Excluded.

* PublicBrowseRoot shall be present; however, other browse UUIDs may also be included in the list.

5 Acronyms and abbreviations

Acronym/Abbreviation	Meaning
AD	advertising data
ADC	Analog to Digital Converter
ASCS	Audio Stream Control Service
ASE	Audio Stream Endpoint
ATT	Attribute Protocol
BAP	Basic Audio Profile
BASS	Broadcast Audio Scan Service
BGR	Broadcast Game Receiver
BGS	Broadcast Game Sender
BIS	Broadcast Isochronous Stream
BN	Burst Number
BR/EDR	Basic Rate/Enhanced Data Rate
CAP	Common Audio Profile
CIG	Connected Isochronous Group
CIS	Connected Isochronous Stream
CSIP	Coordinated Set Identification Profile
CSIS	Coordinated Set Identification Service
CSS	Core Specification Supplement
CTKD	Cross-Transport Key Derivation
EATT	Enhanced Attribute Protocol
FT	Flush Timeout
GAP	Generic Access Profile
GATT	Generic Attribute Profile
GMA	Gaming Audio
GMAP	Gaming Audio Profile
GMAS	Gaming Audio Service
HCI	Host Controller Interface
L2CAP	Logical Link Control and Adaptation Protocol
LC3	Low Complexity Communication Codec
LE	Low Energy
LL	Link Layer
LSO	least significant octet

Acronym/Abbreviation	Meaning
LTV	length-type-value
MCPS	million cycles per second
MICP	Microphone Control Profile
MICS	Microphone Control Service
MSC	message sequence chart
NSE	Number of SubEvents
PAC	Published Audio Capability
PACS	Published Audio Capabilities Service
PDU	Protocol Data Unit
PHY	physical layer
PLC	packet loss concealment
PSM	Protocol/Service Multiplexer
QoS	Quality of Service
RFU	Reserved for Future Use
RTN	retransmission number
SDP	Service Discovery Protocol
SDU	Service Data Unit
SI	SDU Interval
UGG	Unicast Game Gateway
UGT	Unicast Game Terminal
UUID	universally unique identifier
VCP	Volume Control Profile
VCS	Volume Control Service

Table 5.1: Acronyms and abbreviations

6 References

[1] Bluetooth Core Specification, Version 5.2 or later

[2] Basic Audio Profile Specification, Version 1.0.1 or later

[3] Common Audio Profile Specification, Version 1.0

[4] Audio Stream Control Service Specification, Version 1.0

[5] Published Audio Capabilities Service Specification, Version 1.0.1 or later

[6] Volume Control Profile Specification, Version 1.0

[7] Volume Control Service Specification, Version 1.0

[8] Microphone Control Profile Specification, Version 1.0

[9] Microphone Control Service Specification, Version 1.0

[10] Coordinated Set Identification Profile Specification, Version 1.0.1 or later

[11] Coordinated Set Identification Service Specification, Version 1.0.1 or later

[12] Broadcast Audio Scan Service Specification, Version 1.0

[13] Bluetooth Core Specification Supplement, Version 11

[14] Bluetooth Assigned Numbers, https://www.bluetooth.com/specifications/assigned-numbers

[15] Low Complexity Communication Codec Specification, Version 1.0

Appendix A Total system delay calculation

A.1 Overview

This appendix shows the calculations used to determine Total System Delay for GMAP. See Figure 3.4 for a visual representation of Total System Delay.

A.2 Audio processing time

Table A.1 lists all the times included in the Encoding and Audio Processing time and the Decoding and Audio Processing time. The input to the Encoding and Audio Processing block is two full blocks of 10 or 7.5 ms Left/Right samples.

Codec and Device Delays	Definition	LC3, 48 kHz, 80 kbps, 7.5 ms Frame Duration, 2 Channels	LC3, 48 kHz, 80 kbps, 10 ms Frame Duration, 2 Channels
ADC group delay	Delay in the Analog to Digital Converter (ADC) from analog input to digital output.	0	0
Capture delay	Time required to collect enough samples to start encoding.	7.5 ms	10 ms
Encoder delay[1]	Processing time required to encode a single audio frame.	1.4 ms (parallel channel processing), 2.8 ms (serial channel processing)	1.7 ms (parallel channel processing), 3.4 ms (serial channel processing)
Encoder look ahead delay	Audio delay caused by the encoding algorithm separate from the processing time.	4 ms	2.5 ms
Encoder jitter margin	Uncertainty in the encoder scheduling.	0.8 ms	1 ms
Encoding & Audio Processing	Total Audio Processing Time (from Figure 3.4).	13.7 ms (parallel), 15.1 ms (serial)	15.2 ms (parallel), 16.9 ms (serial)
Decoder delay (included in Presentation delay)	Processing time required to decode a single encoded audio frame.	1.5 ms	1.8 ms
Decoder jitter margin (also included in Presentation delay)	Uncertainty in the decoder processing time.	0.48	0.6

Table A.1: Audio processing time

[1] This delay is calculated assuming that encoding 48 kHz audio in real time into 80 kbps LC3 audio frames requires peak processing power of 18.28 million cycles per second (MCPS) per channel for 7.5 ms

frames and 17.14 MCPS for 10 ms frames. These assumptions can be converted into processing time with the following equation:
Processing time per frame = LC3 MCPS / CPU MCPS x frame duration
For 7.5 ms, processing time = 18.28 / 100 x 7.5 ms = 1.371 (round to 1.4) ms
For 10 ms, processing time = 17.14 / 100 x 10 ms = 1.714 (round to 1.7) ms

A.3 Minimum Transport Latency

Table A.2 lists the minimum Transport Latency for various sets of Controller parameters.

Controller Parameters	**LC3 7.5 ms Frame Duration 80 kbps**	**LC3 7.5 ms Frame Duration 96 kbps**	**LC3 10 ms Frame Duration 80 kbps**	**LC3 10 ms Frame Duration 96 kbps**	**Broadcast (LC3 10 ms Frame Duration 80 kbps)**	**TMAP 48_2_1 (10 ms Frame Duration 80 kbps Low Latency)**
SDU Interval (SI)	7.5 ms	7.5 ms	10 ms	10 ms	10 ms	10 ms
Data rate (M)	80 kbps	96 kbps	80 kbps	96 kbps	80 kbps	80 kbps
Audio channels (N) per CIG/BIG. One channel per CIS/BIS.	2	2	2	2	2	2
Max_SDU_Size	75 octets	90 octets	100 octets	120 octets	100 octets	100 octets
Retransmission number (RTN)	2	2	2	2	2	5
CIS configuration	2M PHY Isochronous interval = 7.5	2M PHY Isochronous interval = 7.5	2M PHY Isochronous interval = 10	2M PHY Isochronous interval = 10	2M PHY Isochronous interval = 10	2M PHY Isochronous interval = 10
	Number of SubEvents (NSE) = 3 Burst Number (BN) = 1 Flush Timeout (FT) = 1				NSE = 3 BN = 1 IRC = 3	NSE = 3 BN = 1 FT = 2
Minimum transport latency (See the following paragraphs for detailed calculations.)	4.1 ms	4.4 ms	4.7 ms	5.2 ms	3.5 ms	14.7 ms

Table A.2: Transport latency

The unicast minimum Transport Latency calculation is done according to Volume 6, Part G, Section 3.2.2 in [1], where the CIG_Sync_Delay consists of one or more CIS_events (see Volume 6, Part B, Section 4.5.13.2 of [1]) with latency T_{CIS_event}.

Transport_Latency_C_To_P = CIG_Sync_Delay + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P

If FT=1, and the ISO_Interval = SD_Interval, then the equations simplify to Transport_latency = CIG_Sync_Delay.

The following equation assumes a single channel of audio in one direction:

Transport Latency = CIG_Sync_Delay
$= T_{CIS\_event} = (NSE \times T_{Subevent\_Interval}) - T_{MSS}$
$= NSE \times (T_{C>P} + T_{\_IFS} + T_{P>C} + T_{\_MSS}) - T_{MSS}$
$= NSE \times (((SDU\_Size \times 8 + 15 \times 8)/2000) + 0.15 + 0.044 + 0.15) - 0.15$

Audio Configuration 6(i) uses a CIG with two unidirectional CISes (CIS1 and CIS2) to carry stereo audio from the UGG to the UGT. In that case, the equations expand as follows:

Transport_Latency_C_To_P = CIG_Sync_Delay + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P

Transport_Latency_C_To_P = T_{CIS_event} + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P
= (NSE × $T_{Subevent\_Interval}$) – T_{MSS} + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P
= NSE × ($T1_{C>P}$ + $T_{\_IFS}$ + $T1_{P>C}$ + $T_{\_IFS}$ + $T2_{C>P}$ + $T_{\_IFS}$ + $T2_{P>C}$ + $T_{\_MSS}$) – T_{MSS} + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P

= NSE x ((SDU1_Size_C_To_P+15 + SDU2_Size_C_To_P+15)x8/2000 + 0.15 + 0.044 + 0.15 + 0.15 + 0.044 + 0.15) – 0.15 + FT_C_To_P x ISO_Interval – SDU_Interval

= NSE x ((2xSDU_Size+30)/250 + 0.688) – 0.15 + FT x ISO_Interval – SDU_Interval

Column 1 in Table A.2 is calculated as follows:

NSE = 3, FT = 1, SDU_Size = 75, ISO_Interval = 7.5 ms, SDU_Interval = 7.5 ms
Transport_Latency = 4.074 ms (rounded to 4.1 ms in Table A.2)

Audio Configuration 8(i) uses a CIG with one bidirectional CIS (CIS1) and one unidirectional CIS (CIS2) to carry stereo audio from the UGG to the UGT and voice audio from the UGT to the UGG. In that case, the equations expand as follows:

Transport_Latency_C_To_P = CIG_Sync_Delay + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P

Transport_Latency_C_To_P = T_{CIS_event} + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P
= (NSE × $T_{Subevent\_Interval}$) – T_{MSS} + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P
= NSE × ($T1_{C>P}$ + $T_{\_IFS}$ + $T1_{P>C}$ + $T_{\_IFS}$ + $T2_{C>P}$ + $T_{\_IFS}$ + $T2_{P>C}$ + $T_{\_MSS}$) – T_{MSS} + FT_C_To_P × ISO_Interval - SDU_Interval_C_To_P

= NSE x ((SDU1_Size_C_To_P+15 + SDU1_Size_P_To_C+15 + SDU2_Size_P_To_C+15)x8/2000 + 0.15 + 0.15 + 0.15 + 0.044 + 0.15) – 0.15 + FT_C_To_P x ISO_Interval – SDU_Interval

= NSE x ((2xSDU1_Size_C_To_P + SDU1_Size_P_To_C + 45)/250 + 0.644) – 0.15 + FT x ISO_Interval – SDU_Interval

Row 1, Level D of Table 3.16 is calculated as follows:

NSE = 3, FT = 2, SDU_Size_C_To_P = 75, SDU_Size_P_To_C = 60, ISO_Interval = 7.5 ms, SDU_Interval = 7.5 ms
Transport Latency = 12.342 ms

The previous equations make the following assumptions. These assumptions make the Transport Latency equal to the Minimum Transport latency:

1. The Central starts sending packets as early as possible (i.e., the first CIS anchor point is equivalent to the CIG reference point).
2. The Central uses the minimum possible subevent spacing = T_MSS = 150 us.
3. The Central uses unframed packets.
4. SDU_Size is given in units of octets.

The broadcast minimum Transport Latency calculation is done according to Volume 6, Part G, Section 3.2.2 in [1]. Because (NSE ÷ BN – IRC) = 0, PTO = 0, Control Subevents = 0, and ISO_Interval=SD_Interval, the equations simplify to Transport_latency = BIG_Sync_Delay as follows (see Volume 6, Part B, Section 4.4.6.4 in [1]).

Transport Latency = BIG_Sync_Delay = (Num_BIS – 1) × BIS_Spacing + (NSE – 1) × Sub_Interval + MPT

For Interleaved,
BIS_Spacing = MPT + $T_{\_MSS}$
Sub_Interval = Num_BIS × (MPT + $T_{\_MSS}$)

Resulting in,
Transport Latency = (Num_BIS – 1) × (MPT + $T_{\_MSS}$) + (NSE – 1) × Num_BIS × (MPT + $T_{\_MSS}$) + MPT
= [(Num_BIS – 1) + (NSE – 1) × Num_BIS] × (MPT + $T_{\_MSS}$) + MPT
= (Num_BIS × NSE – 1) × (MPT + $T_{\_MSS}$) + MPT
= Num_BIS × NSE × (MPT + $T_{\_MSS}$) – (MPT + $T_{\_MSS}$) + MPT
= Num_BIS × NSE × (MPT + $T_{\_MSS}$) – $T_{\_MSS}$

Calculating the Transport Latency in units of ms, for a 2 Mbps PHY results in,

= Num_BIS × NSE × (((SDU_Size×8 + 15×8)/2000) + 0.15) – 0.15

A.4 Total system delay

The following delay estimations are examples; some systems might require more encode/decode time and some use additional buffers. These calculations demonstrate that it is possible for devices to achieve 30 ms of latency or better.

Total system delay = Audio processing time + Transport latency + Presentation delay

Example 1:

Gaming audio LC3 7.5 ms 80 kbps, stereo:

Total system delay = 13.7 + 4.1 + 10 = 27.8 ms (parallel processing)

Total system delay = 15.1 + 4.1 + 10 = 29.2 ms (serial processing)

Example 2:

Gaming audio LC3 7.5 ms 80 kbps, stereo and Voice audio LC3 64 kbps:

Total system delay = 13.7 + 4.9 + 10 = 28.6 ms (parallel processing)

Total system delay = 15.1 + 4.9 + 10 = 30.0 ms (serial processing)

Example 3:

Gaming audio LC3 7.5 ms 96 kbps, stereo:

Total system delay = 13.7 + 4.4 + 10 = 28.1 ms (parallel processing)

Total system delay = 15.1 + 4.4 + 10 = 29.5 ms (serial processing)

Example 4:

Gaming audio LC3 10 ms 80 kbps, stereo:

Total system delay = 15.2 + 4.7 + 10 = 29.9 ms (parallel processing)

Total system delay = 16.9+ 4.7 + 10 = 31.6 ms (serial processing)

Example 5:

Gaming audio LC3 10 ms 80 kbps, stereo and Voice audio LC3 64 kbps:

Total system delay = 15.2 + 5.7 + 10 = 30.9 ms (parallel processing)

Total system delay = 16.9 + 5.7 + 10 = 32.6 ms (serial processing)

Example 6:

Gaming audio LC3 10 ms 96 kbps, stereo:

Total system delay = 15.2 + 5.2 + 10 = 29.4 ms (parallel processing)

Total system delay = 16.9 + 5.2 + 10 = 32.1 ms (serial processing)

Example 7:

Broadcast Gaming audio LC3 10 ms 80 kbps, stereo:

Total system delay = 15.2 + 3.5 + 10 = 28.7 ms (parallel processing)

Total system delay = 16.9 + 3.5 + 10 = 30.4 ms (serial processing)

Example 8:

TMAP 48_2_1:

Total system delay = 15.2 + 14.7 + 40 = 69.9 ms (parallel processing)

Total system delay = 16.9 + 14.7 + 40 = 71.6 ms (serial processing)

Appendix B CIS scheduling

Figure B.1 and Figure B.2 show the timing involved when sending Audio Configuration 8(i) with stereo 48 kHz in one direction and 32 kHz audio in the reverse direction. Both diagrams assume that all PDUs are successfully received on the first attempt. The preferred scheduling in Figure B.1 allows all CIS transmissions to complete in the shortest time.

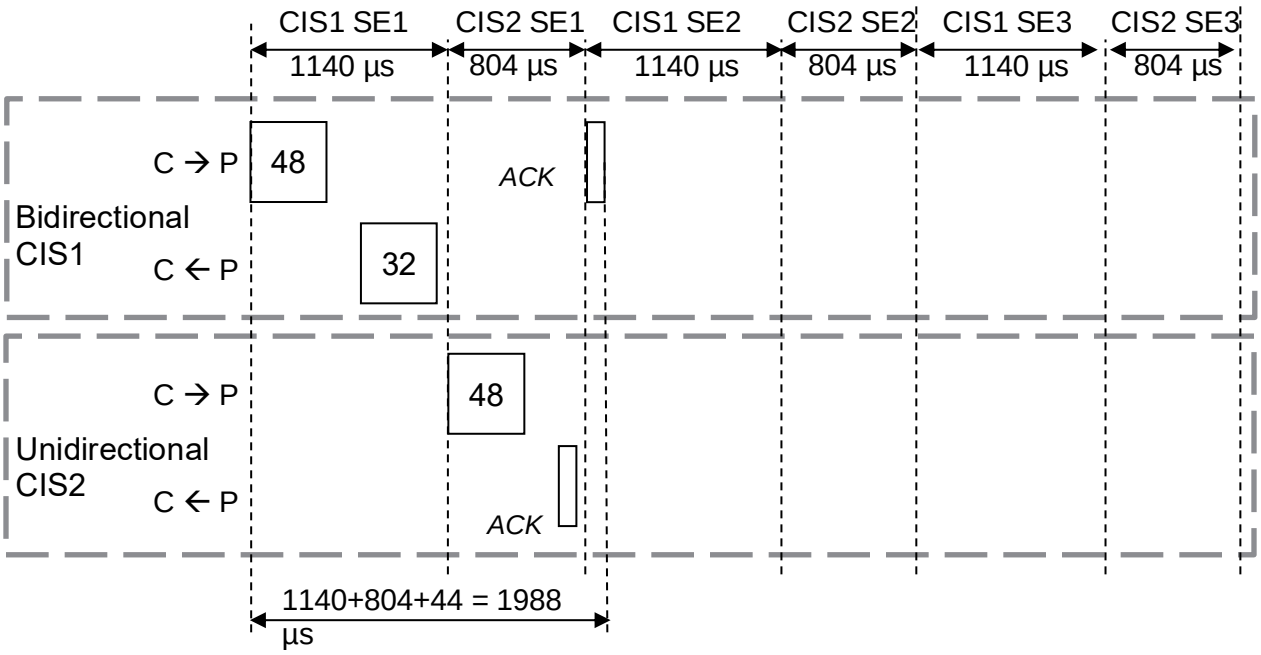


Figure B.1: Preferred scheduling for Audio Configuration 8(i) schedules the bidirectional CIS before the unidirectional CIS

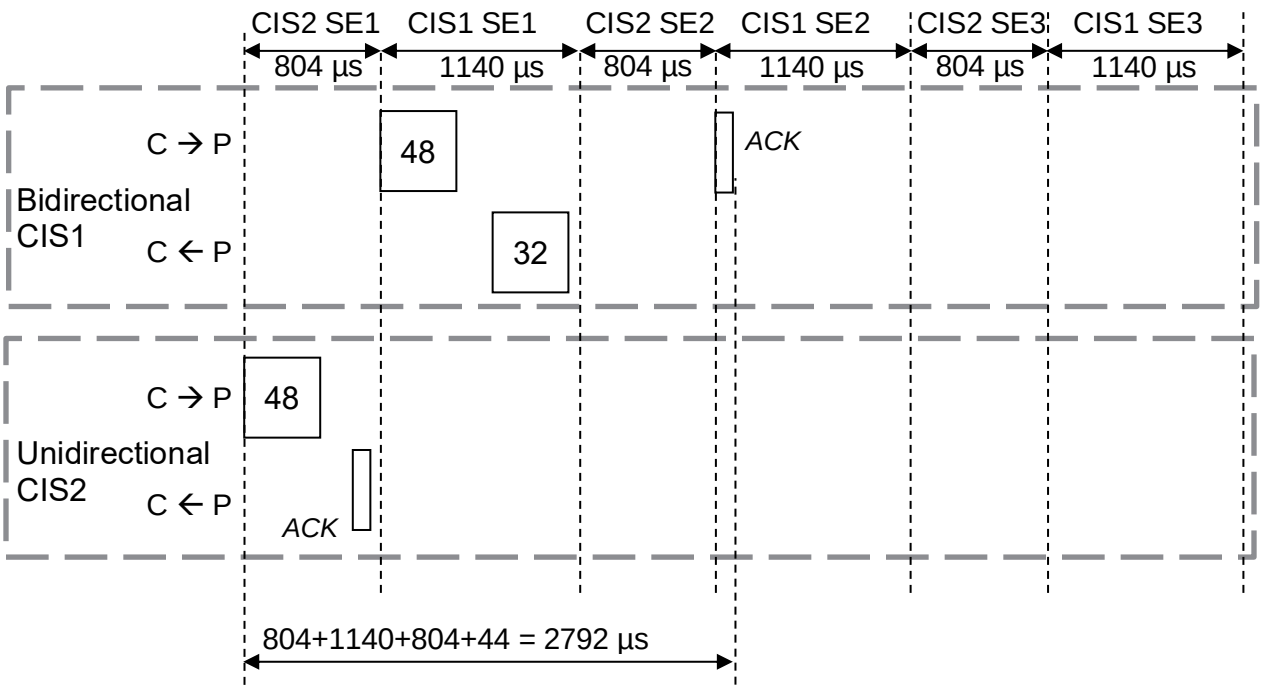


Figure B.2: Non-preferred scheduling for Audio Configuration 8(i) schedules the unidirectional CIS before the bidirectional CIS