Low Energy Audio – Discovery, Pairing, and Connection for Earbuds

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If you have any questions or comments on this informational publication or Bluetooth LE Audio specifications, please submit a ticket: https://www.bluetooth.com/leaudio-spec-feedback/

Abstract:

This document presents a simple user scenario along with the underlying Bluetooth procedures that are used to make it happen. The scenario consists of the user pairing a set of Low Energy (LE) Audio earbuds with a Central device like a phone, tablet, or PC. The Bluetooth procedures show how the use of Coordinated Sets helps deliver a user experience consistent with one that consumers have come to expect with BR/EDR earbuds.

Version History

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Contents

1 Introduction

Pairing has always presented a challenge to both manufacturers and users of Bluetooth devices. Manufacturers struggle to make the pairing process smooth and intuitive for the user. End users sometimes struggle to understand and navigate the various mechanisms that products use to pair devices and even to understand the pairing concept itself. Fortunately, over time, the market has converged on a solution for Bluetooth consumer audio. That solution involves the following steps:

1) First, an initial user action puts the Bluetooth Peripheral device in “pairing mode”. This user action is sometimes part of a natural action that the user would do anyway, such as removing an earbud from a case.

2) A subsequent user action puts the Bluetooth Central device in a mode to “find new devices” or similar. This may be a user action or an automatic action periodically done by the Central device.

3) A user action selects a single, desired, Peripheral device from a list of nearby devices displayed on the Central device.

4) A pairing process is carried out by the Central device and that single Peripheral device.

LE Audio introduces two new features for consumer earbuds:

- LE Audio specifies a standard way to stream audio to a pair of earbuds. There are three different types of earbuds:
    - “Untethered” (where the Initiator establishes a Bluetooth connection to each earbud). This document focuses on untethered earbuds, which require the Central device to discover and pair with each earbud separately (as specified in Section 8.2.2 in [4]).
    - “Tethered” (connected by a wire that carries audio where the Initiator establishes a single Bluetooth connection to the set of earbuds through a Bluetooth radio located in one of the earbuds). This document does not cover tethered earbuds.
    - “Partially tethered” (connected by some proprietary communication link where the Initiator establishes a single Bluetooth connection to the set of earbuds through a Bluetooth radio located in one of the earbuds). This document does not cover partially tethered earbuds.
- LE Audio makes it possible to produce a dual-mode set of earbuds–which means that the earbuds support both Basic Rate/Enhanced Data Rate (BR/EDR) audio and LE Audio.

These new features make it possible for a dual-mode set of earbuds to appear as three different Bluetooth audio devices to the Central device:

- Left LE
- Right LE
- BR/EDR

BR/EDR audio profiles necessitated earbuds to function as one Bluetooth device, requiring proprietary solutions for coordinating between the left and right earbuds. Therefore, before LE Audio, there was no need for phones and PCs to discover and pair with multiple devices that act as one set of earbuds. Users

have come to expect to interact with earbuds as a single unit–having them pair each earbud separately contradicts this norm and adds complexity during the product's initial setup, which manufacturers want to avoid.

Fortunately, the Coordinated Set Identification Profile (CSIP) [2] specification and the Coordinated Set Identification Service (CSIS) [3] specification provide a way for Peripheral devices to identify themselves as Set Members within a Coordinated Set and for Central devices to discover members of the set. Cross Transport Key Derivation (CTKD) makes it possible to pair both the BR/EDR and the LE transports of the BR/EDR/LE device with a single action from the user. This document presents the single-action user scenario along with some detailed examples that show how LE Audio and dual-mode devices can deliver the simple user experience (UX) that consumers have come to expect.

The examples illustrate how implementations achieve the following goals.

1. With minimal user interaction, implementations pair a phone with a Coordinated Set of earbuds:
    a. Consisting of LE Audio-only devices, or
    b. Consisting of a dual-mode BR/EDR/LE earbud and an LE Audio earbud
2. A phone (CAP Initiator) presents the Coordinated Set of earbuds as a single entity to the end user.

In the examples, implementations take the following steps to achieve the goals.

1. For the phone:
    a. Discover and pair devices using LE. Use CTKD to pair the BR/EDR part of dual-mode devices.
    b. Represent a Coordinated Set of earbuds as a single entity in user interfaces (UIs).
    c. After the user selects the desired set of earbuds, pair with both earbuds over LE and, for dual-mode earbuds, BR/EDR.
2. For the earbuds:
    a. Make only one earbud discoverable.
    b. Make both earbuds bondable and connectable.
    c. Expose a device name in the discoverable earbud that is representative of the pair of earbuds as a single product.

This is not a Bluetooth specification, therefore, the established Bluetooth SIG specification language conventions for use of the words ***shall***, ***shall not***, ***must***, ***should***, ***should not***, ***may***, and ***can*** do not apply to this document.

1.1 Scope

This document presents examples that focus on the following devices:

1. Untethered consumer earbuds or left and right hearing aids that are designed to present to the end user as a single device

2. Central devices (phones, tablets, or PCs)

All of these devices support the following Bluetooth specifications:

- Coordinated Set Identification Profile (CSIP) [2]
- Coordinated Set Identification Service (CSIS) [3]
- Common Audio Profile (CAP) [4]
- Common Audio Service (CAS) [5]

The devices in these examples also support:

- Basic Audio Profile (BAP) [6]
- Audio Stream Control Service (ASCS) [7]
- Published Audio Capabilities Service (PACS) [8]

Dual-mode, LE Audio devices in these examples also support the following Bluetooth specifications.

- Hands-Free Profile (HFP) [9] and/or
- Advanced Audio Distribution Profile (A2DP) [10]

The examples in this document use a phone as the Central and earbuds as the Peripherals. However, the Central could also be a PC, tablet, or TV, and the Peripherals could be hearing aids or speakers.

The start and end conditions for each example are:

- Start conditions: Peripherals are unpaired, unbonded, and unconnected from the Central
- End conditions: Peripherals are paired, bonded, connected, and ready to use in LE and, for dual-mode devices, BR/EDR

All over-the-air interactions are limited to Bluetooth-specified procedures and protocols. These aspects of the examples are provided for completeness and do not establish or imply new Bluetooth requirements.

1.2 MSC conventions

The message sequence chart (MSC) in this document uses the following conventions.

- Advertisements are shown as dashed arrows starting from the transmitters. The direction of the arrows does not imply that the advertisement is received by any specific device.
- Inquiry messages are shown as dashed arrows starting from the transmitters. The direction of the arrows does not imply that the Inquiry is received by any specific device.
- Some parts of the MSC, where the details are not important to the topic of this paper, are abstracted as white block arrows.
- Point-to-point messages are shown as solid arrows.

2 User experience: Nikki pairs a new set of earbuds

This section presents a scenario from the perspective of a fictional end user named Nikki, who expresses her intentions by pressing buttons, tapping a touch screen or surface, uncasing an earbud, or some other user action. Devices present information to Nikki through visual display, audio prompts, or some other user prompt. Section 3 dives deeper into the Bluetooth features and mechanisms used to deliver a UX that is the same–or better–than Nikki might expect based on her usage of previous Bluetooth BR/EDR earbuds.

Nikki received a brand-new pair of earbuds for her birthday. She has used Bluetooth BR/EDR earbuds before and is eager to try the new LE Audio feature. Nikki starts by activating Bluetooth on her phone and selects “Pair new device” from the Bluetooth device connection menu. She then opens the case holding her new earbuds, removes the left earbud and places it in her left ear. Next, she removes the right earbud and places it in her right ear.

Her phone displays a list of nearby Bluetooth devices, including a single item called “Earbuds XYZ”. Nikki recognizes XYZ as the model of her new earbuds and selects “Earbuds XYZ” from the phone list. Her phone indicates that pairing is in progress, and after a few seconds, indicates that pairing is complete. The phone then automatically connects to Nikki’s newly paired earbuds. At this point, both earbuds are paired and connected.

Bluetooth features in this example include those specified by [2] and [3]. Note that the earbuds may have different configurations (as mentioned in Section 3). They may be:

- Dual mode (where the BR/EDR portion has Inquiry Scan enabled)
- Dual mode (where the BR/EDR portion does not have Inquiry Scan enabled)
- LE Audio only

However, Nikki does not need to know the configuration; her experience will be the same, regardless of the configuration of the earbuds.

3 Device discovery recommendations during pairing

The following examples cover pairing of earbuds implemented as Set Members of a Coordinated Set. Each earbud is a unique LE device. In the first example, the earbuds implement LE Audio profiles only. In the second example, one of the earbuds is a dual-mode BR/EDR/LE device that also implements BR/EDR audio profiles (i.e., it is a dual-mode BR/EDR/LE device). In both examples, the Central and Peripheral device manufacturers operate as described to display a single entity to the user when trying to pair with a new set of LE Audio earbuds.

To achieve this result, the examples include both mandatory and optional behavior from published Bluetooth specifications:

- Where the behavior is mandatory, the example uses the phrase “as mandated by” and references the specification that mandates the behavior.
- If the behavior is optional, but is necessary to achieve the desired result, the example uses the phrase “as made optional by” and references the specification that establishes the optional requirement.
- If the behavior is not explicitly called out by a specification but is also not prohibited, the example uses the phrase “as allowed by” and references the specification or specifications that most closely describe the behavior.

The approaches illustrated in the examples can be easily extended to Coordinated Sets involving more than two Set Member devices.

A set of earbuds that represent themselves as a single device or a banded headphone will not have the same Coordinated Set concerns.

There are several relevant requirements found in BAP [6] and other Bluetooth specifications that, when considered together, help devices like PCs, tablets, and phones to implement a better UX for pairing. For example:

- Section 8.2.1 in [6] requires a dual-mode device to be discoverable over LE if it is discoverable over BR/EDR.
- Section 8.2.3 in [6] requires dual-mode devices to set the Class of Device (CoD) bit indicating support for LE Audio.
- Section 9.1.1 in [6] requires a dual-mode device to support LE to BR/EDR CTKD.

3.1 Earbuds configuration

All the examples in this document involve a set of two earbuds where, during the pairing process, one earbud is discoverable, and the other earbud is not. (This document refers to the discoverable earbud as the First Earbud and the non-discoverable earbud as the Second Earbud. When only one earbud is available for pairing, it acts as the First Earbud.)

This section describes how the First and Second earbuds are configured during the pairing process. How it is determined which earbud is the First Earbud is outside the scope of this document; the implementation might make this determination during manufacturing or dynamically during operation.

Each earbud supports the Set Member role in [2] (as mandated by Section 3 in [4]) and includes an RSI AD Type (See Section 3 in [3]) in their LE advertisements when in Generic Access Profile (GAP) Limited Discoverable mode (as recommended by Section 6.1.2 in [2]).

Table 3.1 classifies the First and Second earbuds for the examples presented in this document. In the first example, the set of earbuds only supports Bluetooth LE. In the second and third examples, the set of earbuds contains one earbud that is dual mode; the dual-mode earbud has Inquiry Scan enabled in the

second example and disabled in the third example. A BR/EDR device with Inquiry Scan disabled is considered non-discoverable over the BR/EDR transport.

Example	**First Earbud, Discoverable During Bondable Mode**	**Second Earbud, Non-Discoverable During Bondable Mode**
LE only	LE only	LE only
Dual Mode with Inquiry Scan enabled	BR/EDR/LE	LE only
Dual Mode with Inquiry Scan disabled	BR/EDR/LE	LE only

Table 3.1: Definition of First and Second earbuds

The user starts the pairing process by causing the set of earbuds to go into pairing or pairable mode. For each example, Table 3.2 describes the operational aspects of the First and Second earbuds during pairing.

Operational Aspects	**First or Second Earbud**	**BR/EDR or LE Component**	**Examples**		
			LE only	**Dual Mode with Inquiry Scan Enabled**	**Dual Mode with Inquiry Scan Disabled**
Bonding, Discovery, and Connection modes[2,3]	First Earbud	LE	Bondable, Limited Discoverable, Connectable	Bondable, Limited or General[1] Discoverable, Connectable	Bondable, Limited Discoverable, Connectable
		BR/EDR	N/A	Bondable, Limited Discoverable, Connectable	Non-Bondable, non-Discoverable, Connectable
	Second Earbud	LE	Bondable, non-Discoverable, Connectable	Bondable, non-Discoverable, Connectable	Bondable, non-Discoverable, Connectable
Advertised address (for LE), address contained in the inquiry response packet (for BR/EDR)	First Earbud	LE	Resolvable private address (RPA)[4]	Public Device Address	RPA[4]
		BR/EDR	N/A	Public Device Address	N/A
	Second Earbud	LE	RPA[4, 5]	RPA[4, 5]	RPA[4, 5]
	First Earbud	LE	Same value as Second Earbud[7]	Same value as the BR/EDR	Same value as the BR/EDR

Bluetooth Device Name				component[6] and Second Earbud[7]	component[6] and Second Earbud[7]
		BR/EDR	N/A	Same value as the LE component[6]	Same value as the LE component[6]
	Second Earbud	LE	Same value as First Earbud[7, 8]	Same value as First Earbud[7, 8]	Same value as First Earbud[7, 8]
CoD	First Earbud	LE	N/A	N/A	N/A
		BR/EDR	N/A	LE Audio bit 14 set to 1	LE Audio bit 14 set to 1
	Second Earbud	LE	N/A	N/A	N/A
Flags AD type[9]	First Earbud	LE	Sets the “BR/EDR not supported” bit	Does not set the “BR/EDR not supported” bit	Does not set the “BR/EDR not supported” bit
		BR/EDR	N/A	N/A	N/A
	Second Earbud	LE	Sets the “BR/EDR not supported” bit	Sets the “BR/EDR not supported” bit	Sets the “BR/EDR not supported” bit
Appearance	First Earbud	LE	0x0941 for earbud (and makes this value available in the Appearance payload of the LE advertisement)	0x0941 for earbud (and makes this value available in the Appearance payload of the LE advertisement)	0x0941 for earbud (and makes this value available in the Appearance payload of the LE advertisement)
		BR/EDR	N/A	N/A	N/A
	Second Earbud	LE	0x0941 for earbud (and makes this value available in the Appearance payload of the LE advertisement)	0x0941 for earbud (and makes this value available in the Appearance payload of the LE advertisement)	0x0941 for earbud (and makes this value available in the Appearance payload of the LE advertisement)

Table 3.2: State of First and Second earbuds during pairing

[1] Because Section 8.1.1.1 in [6] limits the time that a BAP Unicast Server can be in Limited Discoverable mode, and because the LE component needs to be discoverable as long as the BR/EDR Inquiry Scan is enabled, the earbuds might have to switch to General Discoverable mode if they are designed to stay in Discoverable mode for longer than the maximum time allowed.

[2] The earbuds in the examples in this document send extended advertisements when in Bondable mode whether they are in Discoverable mode (as mandated by Section 8.1.1.1 in [6]) or non-Discoverable mode (as allowed by Volume 3, Part C, Section 9.2.2 in [1]). These extended advertisements are also undirected BAP General Announcements and undirected CAP General Announcements (as mandated by Section 8.1.2 in [4]). Section 8.1.2 in [4] applies to the earbuds in the examples in this document because they operate as BAP Unicast Servers concurrently with the Volume Control Profile (VCP) Volume Renderer role (see Volume Control Profile [12]) and possibly other roles in Table 8.2 in [4].

[3] The earbuds in the examples in this document all use Limited Discoverable mode (as conditionally mandated by Section 8.2.1 in [6]). The dual-mode earbuds in these examples might use General Discoverable mode if they enable Inquiry Scan (see [1]).

[4] The earbuds in the examples in this document avoid generating a new RPA while any Set Member is discoverable (subject to the recommendations in Volume 6, Part B, Section 6.1 in [1]). See Section 3.4 for more information related to RPA generation.

[5] It is possible (although unlikely because RPAs are randomly generated) that the RPA from the Second Earbud has the same value as the RPA from the First Earbud. If that happens, the pairing will fail for this session. If this possibility is unacceptable, the design might provide a way for the two earbuds to communicate with each other to avoid any possibility of matching RPA values.

[6] As mandated by Volume 3, Part C, Section 3.2.2.1.1 in [1].

[7] In these examples, the LE component for the First and Second earbuds exposes the same value of Bluetooth Device Name. This practice is allowed by Bluetooth specifications and enables the phone to present device names when asking for user consent during the pairing process. In addition, the LE component for the First and Second earbuds makes the Bluetooth Device Name available in the LE advertisements using the Complete Local Name AD type as described in Section 2.1.2 in the Bluetooth Core Specification Supplement [11].

[8] In these examples, the LE component for both the First and Second earbuds advertises the Bluetooth Device Name only during pairing. This practice follows the recommendation in Volume 3, Part C, Section 10.7.1 in [1] as much as is practical while still providing the phone with information to present to the end user during pairing.

[9] The earbuds in the examples in this document include the Flags data type in advertising packets during pairing as mandated by Part A, Section 1.3.1 in [11].

3.2 Example pairing and connection sequence

With the earbuds configured as described in Table 3.2, the phone uses the General Discovery procedure as recommended by Section 8.1.2.2 in [6]. The phone in this example then displays only the First Earbud while hiding the Second Earbud from its UI because the Second Earbud is non-discoverable (see Volume 3, Part C, Section 9.2.2.2 in [1]).

After the user selects the First Earbud to pair with, the phone proceeds to pair and connect with both earbuds. The phone connects to the non-discoverable Second Earbud as specified in Section 4.6.2 in [2].

Figure 3.1 illustrates these steps for the LE-only earbuds in MSC format. Figure 3.2 illustrates these steps for the dual-mode earbuds in MSC format.

Table 3.3 describes the steps involved for each example.

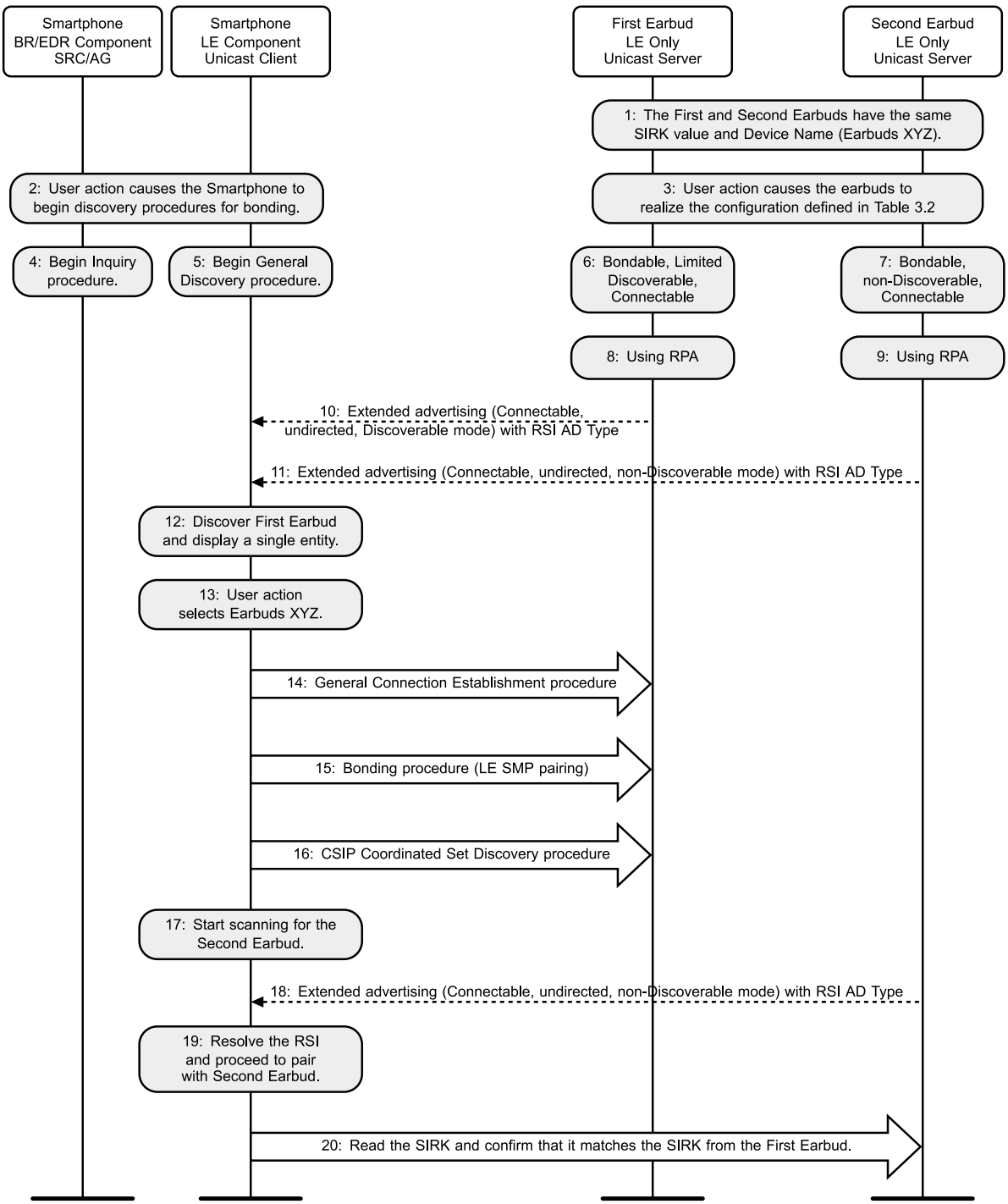

Figure 3.1: Pairing and connection for LE-only earbuds

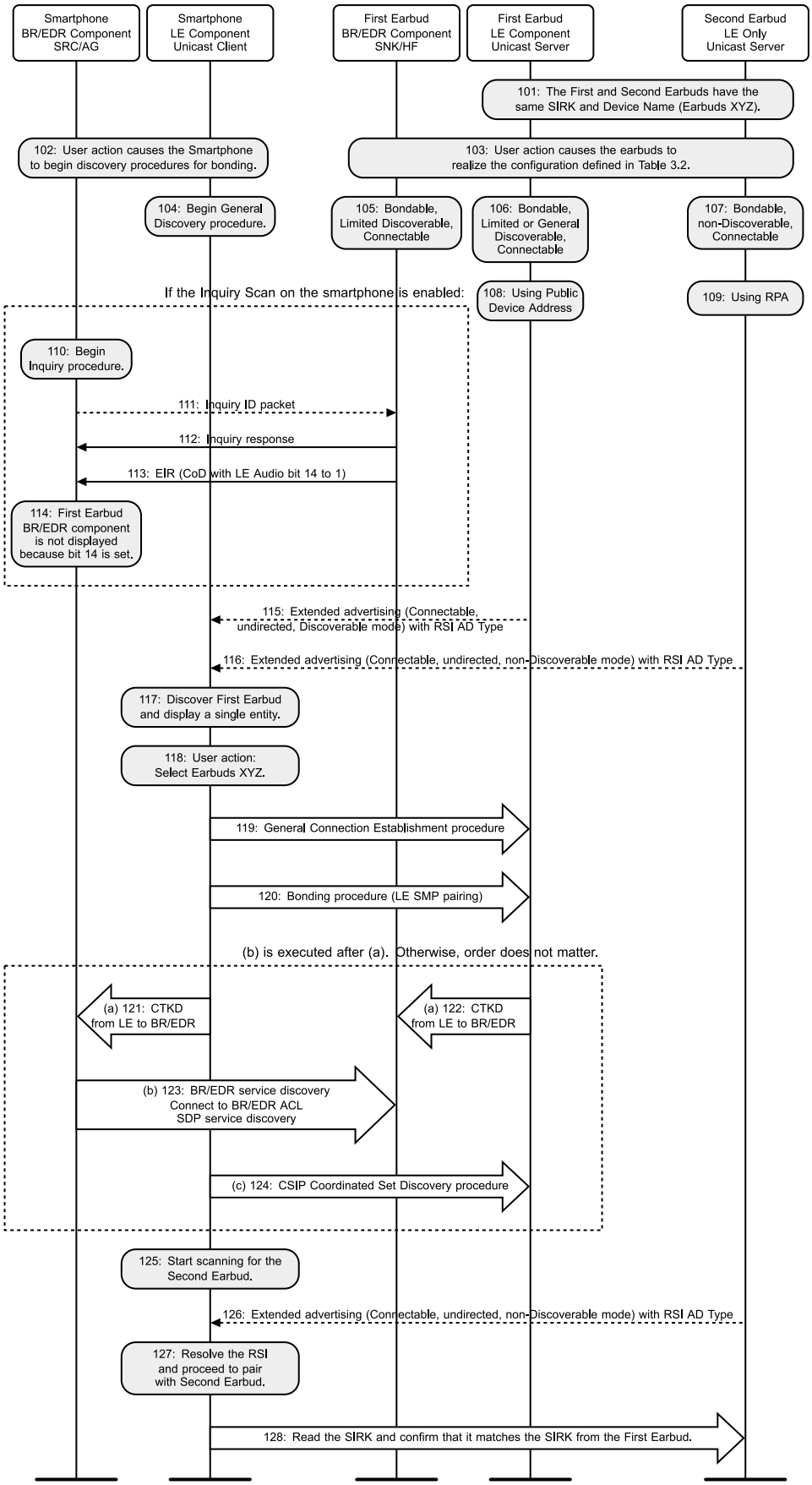

Figure 3.2: Pairing and connection for dual-mode earbuds with Inquiry Scan enabled

Step	Examples	
	LE only	**Dual Mode**
1	The phone establishes an LE ACL with the First Earbud.	
2	The phone pairs with the First Earbud using LE Secure Connections or an out-of-band (OOB) method[1].	
3a	N/A	CTKD and service discovery over BR/EDR[2] (this step can be done before or after Step 3b): The phone uses CTKD from LE to BR/EDR (as allowed by Volume 3, Part C, Section 14.1 in [1]) to pair with the First Earbud - BR/EDR component. After CTKD has completed, the phone establishes the BR/EDR ACL with the BR/EDR component of the First Earbud and proceeds with Service Discovery Protocol (SDP) service discovery.
3b	LE service discovery 1. The phone does Generic Attribute Profile (GATT) LE service discovery (as mandated by Section 4.2 in [2]) on the First Earbud. 2. From the CSIS instance included in CAS [5]: a. The phone finds and reads the SIRK (as mandated by Section 4.6.1 in [2]) from the First Earbud. b. The phone finds and reads the Coordinated Set Size (as mandated by Section 4.6.1 in [2]) from the First Earbud.	
4	The phone scans for the Second Earbud (LE component) by performing the Set Member Discovery procedure as specified in Section 4.6.2 in [2] and examining all received advertisements for an RSI AD Type with an RSI value that can be successfully resolved using the SIRK retrieved from the First Earbud.	
5	If the RSI is successfully resolved, the phone determines whether to proceed with pairing of the purported Second Earbud. For example, the phone might prompt the user for confirmation or use other mechanisms outside the scope of this document. After it makes this determination, the phone proceeds to Step 6 to initiate pairing with the Second Earbud. (See Section 3.6 and 3.7 for more discussion of UX considerations and pairing of additional members of the Coordinated Set.)	
6	The phone establishes an LE ACL with the Second Earbud.	
7	The phone pairs with the Second Earbud using LE Secure Connections or an OOB method[1].	
8	Immediately after pairing with the Second Earbud, the phone finds the Second Earbud's instance of CSIS that is included by CAS (as mandated by Section 4.4.1 in [4]) and reads the SIRK (as mandated by Section 4.6.1 in [2]) via the Read Using Characteristic UUID sub-procedure (as made optional by Volume 3, Part G, Section 4.2 in [1]). If the SIRK is not equal to the SIRK from the First Earbud (LE component), the phone discards the pairing to the Second Earbud (as recommended by Section 4.6.2 in [2]) and returns to Step 4.	

9	The phone does GATT LE service discovery (as mandated by Section 4.2 in [2]) on the Second Earbud.
10	The Coordinated Set Size equals exactly 2 in this example. However, the Central device might be designed to work with other Coordinated Set topologies. In that case, if the Coordinated Set Size is greater than 2, repeat Step 4 through Step 9 until the number of paired devices is equal to the Coordinated Set Size.

Table 3.3: Pairing steps for each example

[1] Section 9.1 in [6]

[2] The phone in this example performs service discovery over BR/EDR to confirm that the dual-mode earbud supports A2DP and HFP.

3.2.1 Considerations for earbuds that send legacy advertisements

Some LE Audio earbuds support LE services in addition to the LE Audio services, and also send discoverable legacy advertisements (as recommended by Volume 3, Part C, Section 9.2 in [1]) to the extended advertisements required by BAP. In many cases, those LE services are designed to interoperate with legacy Central devices that do not yet support LE Audio. The phones in the examples in this document (or Centrals, or to be precise, the discovering device, because the role of Central is only defined in a connection as explained in Volume 6, Part B, Section 1.1 in [1]) are designed to present a single entity to the end user when only a single earbud from a pair of earbuds transmits discoverable extended advertisements (see Section 3.1).

Discoverable legacy advertisements transmitted by both earbuds may complicate Central device implementations that support LE Audio and are designed to discover and present the pair of earbuds as a single device as described in this document. On reception of discoverable advertisements from the First Earbud and discoverable legacy advertisements from the Second Earbud, a discovering device may display the pair of earbuds as two separate devices, defeating the objective of this document. Earbuds in the examples in this document take the following measures to help mitigate this issue:

1. An earbud that transmits both discoverable legacy and discoverable extended advertisements uses the same address in both advertising sets. This informs the discovering device that both advertisements are transmitted by the same device.
2. An earbud in Bondable mode that transmits discoverable legacy and non-discoverable extended advertisements includes, if space allows, a service UUID for ASCS and/or PACS into the legacy advertisements (as recommended for extended advertisements by Section 8.1.1.1 in [6]). This informs the discovering device that the earbud transmitting these advertisements is an LE Audio device. It also informs the discovering device that if the earbuds behave according to the examples in this document, then the other earbud in the Coordinated Set is transmitting discoverable extended advertisements.

3.3 Using CTKD to improve pairing speed

To reduce the time taken from the beginning of the pairing procedure to a state where the user can start using the earbuds, both the phone and the earbuds in the examples in this document support the following feature:

- CTKD
    - For dual-mode earbuds, CTKD from LE to Classic (as specified in Volume 3, Part C, Section 14.1 in [1]) allows the phone to pair both LE and BR/EDR components with only a single action from the user. This results in simpler user interaction and improved speed.

3.4 Earbud behavior to accommodate RSI caching on a Central device

The Central device in the previous examples might cache some LE scanning results in its memory to speed up the Set Member Discovery procedure (see Section 4.6.2 in [2]) after pairing the First Earbud. However, if the Second Earbud uses RPA in its advertisement and rotates its RPA after pairing with the First Earbud has begun, the Central device might attempt to connect to an outdated RPA. This will lead to an ACL connection failure and the Central device would have to retry pairing with the Second Earbud, adding delays to the pairing procedure.

To avoid these delays, earbuds in the previous examples do not start to advertise their RSI values until the First Earbud enters GAP Limited Discoverable mode (as allowed by the requirements in Section 3.1.1 and Section 6.1.2 in [2]). This reduces the probability that the Central device uses a cached and now outdated LE scanning result prior to pairing. Figure 3.3 shows this operation in flowchart format.

The earbuds in the previous examples also keep RPA and RSI constant while discoverable or bondable. This implies that Discoverable and Bondable modes last for a time long enough to allow them to complete but short enough that the completion happens before the RPA value is rotated (as recommended by Volume 6, Part B, Section 6.1 in [1]).

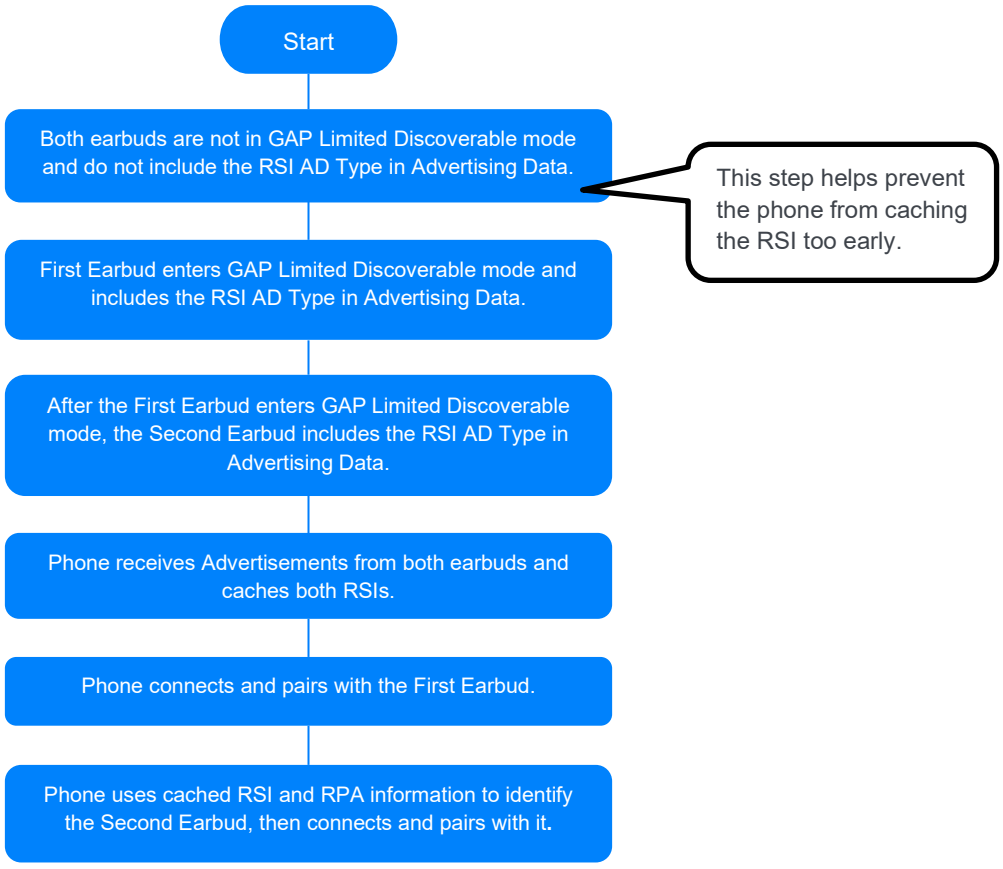

Figure 3.3: Flowchart showing when the Second Earbud starts including RSI AD Type in Advertising Data

3.5 Using directed advertisement to avoid pairing disruption

In the previous examples, it is possible that a Central device (different than the one that paired with the First Earbud) might try to pair with the Second Earbud, disrupting its pairing with the original Central device.

Instead, if the Second Earbud had some OOB, non-Bluetooth communications link with the First Earbud to determine when the First Earbud completed pairing, it could switch from undirected advertisements to directed advertisements toward the Central device that just paired with the First Earbud.

Such an optimization would help reduce the possibility of this pairing disruption.

3.6 Second earbud pairing UX consideration

During a pairing flow that involves a Coordinated Set, after the First Earbud is paired, the Central device identifies the advertisement of the Second Earbud with the RSI AD data resolvable by the SIRK obtained from the First Earbud.

To prevent the Central device from pairing with the Second Earbud or subsequent Set Member without user consent, the Central device's UI in these examples takes measures such as the following:

- Notify the user that they are about to pair with a Coordinated Set when the user selects to pair with the First Earbud, and only automatically pair with subsequent Set Members if they are discovered within a short timeout (e.g., 5 seconds). The previous examples demonstrate this design.

or

- Always request user confirmation whenever the Central device pairs with a Set Member.

3.7 Subsequent pairing for undiscovered Set Members

During Step 4 in Section 3.2, the phone may fail to discover all Set Members for several reasons: Some Set Members may be turned off or out of range; some Set Members may have exited Bondable mode before the Central device discovered them; or some Set Members may have failed to enter Bondable mode. If this happens, the Central (phone) in these examples informs the user and gets permission to scan for any remaining Set Members (as described in Step 4 in Section 3.2).

Upon discovery of another Set Member, the Central in these examples obtains user consent before pairing the additional Set Member devices.

Any Set Members in these examples (other than the First Earbud) that have failed to pair with the phone are in Bondable, Connectable, and non-Discoverable mode to avoid being paired accidentally by a different Central device.

3.8 Error handling

When any of the previous pairing procedures fail for any reason other than a subsequent Set Member not being discovered, the Central device in these examples, for any Set Members that failed pairing, removes all in-progress LE and BR/EDR pairing information in memory and restarts the pairing process from the beginning. The Central device could do this automatically or require user intervention.

4 Summary and conclusions

This document presents examples that show how phones, tablets, PCs, and LE Audio earbuds can present a pairing experience that is consistent with the pairing experience that consumers have come to expect with BR/EDR earbuds.

To achieve these objectives, the examples all share the following key points:

1. They use the Major Service Class bit 14 to “hide” the BR/EDR component of dual-mode earbuds from the pairing UI.
2. They use CTKD (specifically in the LE to BR/EDR direction), to pair the BR/EDR component of dual-mode earbuds after first pairing the LE component.
3. They involve earbuds that make only one earbud discoverable (whichever one that might be at any given point in time) and keep the other earbud non-discoverable to prevent both earbuds from appearing in the pairing UI.
4. They use a modified Set Member Discovery procedure (see Section 4.6.2 in [2]) that uses a generic BLE scan instead of a GAP discovery procedure to find other pairing candidates.

5 References

[1] Bluetooth Core Specification (amended) Version 5.4 or later

[2] Coordinated Set Identification Profile, Version d1.1_VSr03_PR

[3] Coordinated Set Identification Service, Version 1.0.1 or later

[4] Common Audio Profile, Version 1.0.1 or later

[5] Common Audio Service, Version 1.0 or later

[6] Basic Audio Profile, Version 1.0.2 or later

[7] Audio Stream Control Service, Version 1.0.1 or later

[8] Published Audio Capabilities Service, Version 1.0.2 or later

[9] Hands-Free Profile, Version 1.9 or later

[10] Advanced Audio Distribution Profile, Version 1.4 or later

[11] Bluetooth Core Specification Supplement, Version 12

[12] Volume Control Profile, Version 1.0 or later