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WHITE PAPER ON USAGE OF MULTIPLE HEADPHONES

ABSTRACT: This whitepaper describes how one can stream the music from one A2DP SRC device to multiple A2DP SNK devices.

Revision History		
Revision	**Date**	**Description**
1.0RC1	2007-11-14	Sent to BARB for review and approval
1.0RC2	2007-11-26	Edits per BARB comments
1.0RC3	2007-11-29	Added statements regarding support of HFP and AVRCP Cat 1
1.0RC4	2007-12-10	Added Scope statement regarding (lack of) multi-HFP coverage
1.0RC05	2008-02-28	Clarified use of multiple AVRCP CTs

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CONTENTS

1 Terms and Abbreviations

Terms and Abbreviations	
Abbreviation	**Term**
A2DP	Advanced Audio Distribution Profile
ACP	AVDTP Acceptor Role
AVCTP	Audio/Video Control Transport Protocol
AVDTP	Audio/Video Distribution Transport Protocol
AVRCP	Audio/Video Remote Control Profile
CT	AVRCP Controller Role
HFP	Hands-Free Profile
INT	AVDTP Initiator Role
SBC	Low Complex Subband Codec
SEP	Stream End Point
SLC	Service Level Connection
SNK	Sink
SRC	Source
TG	AVRCP Target Role
WP	White Paper

2 Document Terminology

The Bluetooth SIG has adopted Section 13.1 of the IEEE Standards Style Manual, which dictates use of the words ”shall’’, “should’’, “may’’, and “can’’ in the development of documentation, as follows:

The word *shall* is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).

The use of the word *must* is deprecated and shall not be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

The use of the word *will* is deprecated and shall not be used when stating mandatory requirements; *will* is only used in statements of fact.

The word *should* is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain course of action is deprecated but not prohibited (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

3 Scope

The A2DP profile[1] specifies how one shall stream music over *Bluetooth* radios from a SRC device, e.g. a portable music player, to a SNK device, e.g. headphones. The specification only describes how point to point streaming should be performed.

This white paper describes how one can stream the music using A2DP from one SRC device to multiple SNK devices. In places, we refer in this document to device #1, SNK #1 or SNK #2. This is not meant to limit the scope to two SNK devices, but rather to differentiate between existing or original SNK/SRC relationships (#1), and new/additional SNKs (#2) being added to the Multi-SNK session.

This white paper is meant to complement, and not replace our WP “Simultaneous Use of HFP, A2DP, and AVRCP Profiles“[2]. All recommendations in that white paper should be followed and the recommendations here are all in addition to that WP.

This white paper does not address stream synchronization. The general use cases discussed here anticipate headphones, which do not require synchronization. However nothing in this white paper prohibits synchronization.

This white paper also does not address the use of profiles beyond the core A/V profiles. While many devices covered by this white paper will also include the Hands-Free Profile (HFP), nothing in this document addresses recommendations or use cases regarding multiple HFP Service Level Connections between a HF Audio Gateway+A2DP SRC device and two or more HF+A2DP SNK devices.

There are two common scenarios in which multiple SNKs are used. First is an in-car or in-house entertainment system, in which there are multiple dedicated SNKs connected to the same SRC. The second scenario is when two people each have a SRC and a SNK and then decide to connect both SNKs to the same SRC (User #1 is listening to music, User #2 meets User #1, User #2 would like to listen to the same music).

The main problem to solve is on the SRC side, which must determine/obtain an SBC configuration acceptable by both SNK devices. Our white paper “Simultaneous Use of HFP, A2DP, and AVRCP Profiles“ [2] already contains recommendations that the SRC device should control signaling at the A2DP/AVDTP level, and SNK devices may make requests using AVRCP/AVCTP and establish AVDTP connections. This simplifies the use cases by assuming that all A2DP/AVDTP endpoint evaluation and decision making for Multi-SNK scenarios is performed by the SRC device.

The major issues covered in the WP are:

- Configuring all SNK devices to receive same media channel stream
- Ensuring SRC can support bandwidth for as many media streams (SNKs) as it accepts
- Handling SRC AVRCP volume adjustments to Multiple SNKs
- Load Balancing by maintaining multiple streams
- Pairing

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4 Recommendations

Recommendation 1

Regardless of the initiator of the subsequent SNK connections, the SRC device should assume Piconet Mastership of all SNK devices in the Multi-SNK session.

Motivations

A single Piconet is the most desirable topography to prevent the SRC from having to wait as a slave when sending lots of data to multiple devices, as would happen in a scatternet.

Recommendation 2

A SRC device that can accept additional SNK devices should have at least one compatible Stream End Point (SEP) that is not marked as inUse.

Motivations

Connections initiated from the SNK side may abort the connection if it cannot find SEPs on the SRC device that can currently accommodate it for an A2DP streaming connection.

Recommendation 3

Prior to the SRC device initiating the connection to another SNK, the new SNK should be placed into a state capable of accepting connection from the SRC device.

Motivations

Without explicit permission from the new SNK user, we could expose the SNK device to “hijacking”, where a SRC device streams A2DP media to a SNK device without user approval.

Recommendation 4

Upon reception of an AVDTP connection establish request from a new SNK and the current SNK(s) are in a non-IDLE state, The SRC immediately (or after SRC user approval) should commence A2DP discovery and attempt to bring the new SNK into the same state as the current SNK(s).

Motivations

The Multi-SNK scenario works best when the Source is the Initiator of the media streams. The SRC device is the only member of the session with access to the capabilities of all SNKs in the session. The most expedient way to establish the Multi-SNK session is for the SRC to immediately commence the Initiator (INT) role.

Recommendation 5

If new SNK violates WP recommendations by initiating an A2DP streaming connection, and has chosen a configuration that is incompatible with current SNK(s), the SRC should issue an AVDTP CLOSE to the new SNK immediately after completing state transition to STREAMING. The SRC should then initiate setup of the media stream to the new device, bringing it up to the same state as the current SNK(s).

Motivations

The most straightforward way to achieve identical SEP configuration of the multiple SNKs, is for the SRC to claim the INT role in setting up A2DP media connections. One way to achieve this is by allowing legacy initiation by the SNK, and then discarding that setup for one that the SRC chooses. Note that this is a concession for legacy SNKs because SNKs that conform to the white paper “Simultaneous Use of HFP, A2DP, and AVRCP Profiles” [2] should not be initiating the media stream.

Recommendation 6

The encoded media packets should conform to the configuration of both remote devices, such as for SBC, being in the allowable bitpool range (minimum and maximum) for both devices, and allowing for the smallest of the L2CAP MTUs.

Motivations

To avoid encoding/transcoding the same media data multiple times.

Recommendation 7

The SRC device should consider the use case before deciding on the correct way to handle SRC side volume control in a Multi-SNK environment. There are three clear options that may be implemented, each with their own advantages and drawbacks:

i. SRC sends volume control to all attached SNK devices that support AVRCP Category 2 Target (TG). This solution is recommended if Multi-SNK environment is tightly controlled, with all members of the session from the same manufacturer or kit. Its advantages include a consistent volume control interface for all attached SNKs. Its drawback is that it may force additional listeners to listen at a volume level not of their choosing.

ii. SRC sends volume control only to a “Primary” SNK device. Its advantage is protection of secondary listeners, while maintaining interface consistency both in and out of Multi-SNK environments. Its drawback is that it may be problematic determining which SNK is the “Primary” SNK.

iii. SRC has multiple volume controls that track the volume settings on each individual SNK device.

Implementers should be aware that all of these options may be used. Option three is recommended.

Motivations

Having individual volume control is deemed the most appropriate one for the users; the preferred volume level for different persons is most likely not the same.

Recommendation 8

SRC device should strive for maximum compression flexibility (such as min/max SBC bitpools) and consider all service connections. SRC device should attempt to use a more highly compressed (smaller SBC) bitpool if needed to support media streams to multiple devices simultaneously.

Motivations

Maintaining multiple streams may require the SRC to use less *Bluetooth* bandwidth per remote SNK, which can generally be achieved by increasing the compression of the stream.

Recommendation 9

If the SRC device is unable to pair and stream simultaneously, audio playback on the SRC should be suspended, paused or muted. If the media stream must be closed during pairing, the AVDTP signaling channel to current SNKs should be kept open.

Motivations

Pairing can take a significant number of seconds, and audio playback can be a distraction. Additionally, many SNK devices may be unable to handle the media packet jitter variability that may occur while the SRC is pairing with another SNK.

Recommendation 10

Multi-SRC aware SNK devices should provide an interface to facilitate switching from one SRC device to another.

Motivations

There should be an easy way for a user to decide when he is ready to allow a different SRC to connect.

Recommendation 11

The SRC and SNK device should be able to remember multiple remote devices to avoid re-pairing in the future.

Motivations

Pairing during additional SNK addition will always take longer than adding a previously paired device, and will often be accompanied by PIN entry requirements. From a user perspective, it would be aggravating to have to pair each time the connection is established.

Recommendation 12

If a SNK device is removed from the Multi-SNK session, due either to action from the SNK or SRC side, the SRC should continue to maintain the connections to the remaining SNK device(s), up to and including the streaming of media packets.

Motivations

For every use case that includes the dynamic addition of SNK devices to a Multi-SNK session, there is the correlating use case of a SNK leaving the session. This includes going out of range, deliberate disconnects, and low-battery disconnects. The remaining users should not be affected by these occurrences.

Recommendation 13

When a SRC device has two or more SNK devices connected to it, it should support these SNK devices to act as AVRCP controllers towards the SRC device. This enables each user of the SNK device to, for instance, start/stop the media. It is the responsibility of the SRC device to manage the contention between these multiple AVRCP controllers, and any controllers local to the SRC, as per Recommendations 31 and 32 from the white paper “Simultaneous Use of HFP, A2DP and AVRCP Profiles” [2].

In some situations it may be beneficial for the SRC to be able to control whether a SNK device should be allowed to control the media player.

Motivations

Allowing both SNK devices to control the media enhances the user experience and allows the user to control the music in the same way regardless of whether he/she is in a multi headphone situation or not.

In some special situations, e.g. two children fighting over which song to listen to, the owner of the SRC may not want the second SNK to control the music and hence the SRC could have the functionality to block controls from a specific SNK.

5 Scenarios

5.1 USE CASES

5.1.1 SRC INITIATES 2ND CONNECTION TO PREVIOUSLY PAIRED SNK

If the decision to open a 2nd media stream is made from a SRC device, the process is fairly straightforward. The 2nd SNK is idle in a connectable state.

A prerequisite for this is that the A2DP SRC is bonded with both A2DP SNK devices.

1. User #1 turns on the A2DP SRC and the A2DP SNK.
2. User #1 presses play on the A2DP SRC device (and if needed selects to use the A2DP SNK device) and listens to the music in the A2DP SNK.
3. User #1 meets user #2.
4. User #2 asks to listen to the music.
5. User #1 adds users User #2's A2DP SNK as a rendering device. This may include a SUSPEND/RECONFIGURE/START of 1st SNK device if the 2nd SNK is not compatible with the 1st config, or even a CLOSE/SET_CONFIG/OPEN/START.
6. Both User #1 and #2 now listens to the music.

It is likely that User #2 already has an A2DP streaming connection open to their own media player, when User #1 decides to add User #2's SNK device to SRC #1. User #2 should be aware of, and have the option to accept or reject the setup of, User #1s audio stream in favor of the existing stream. To handle this scenario, see Recommendation 3.

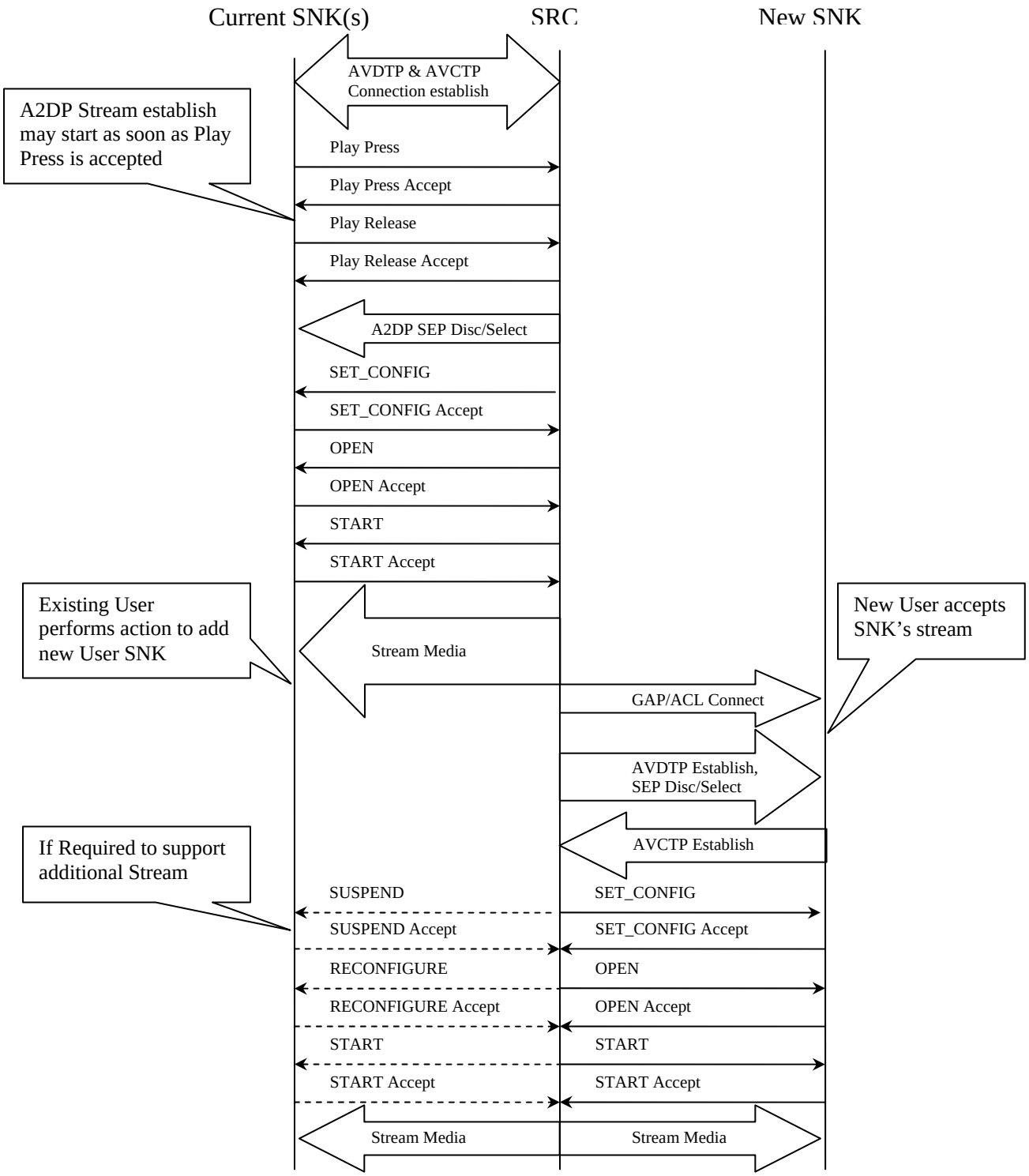

Figure 1: Multi-SNK Session Establishment from SRC

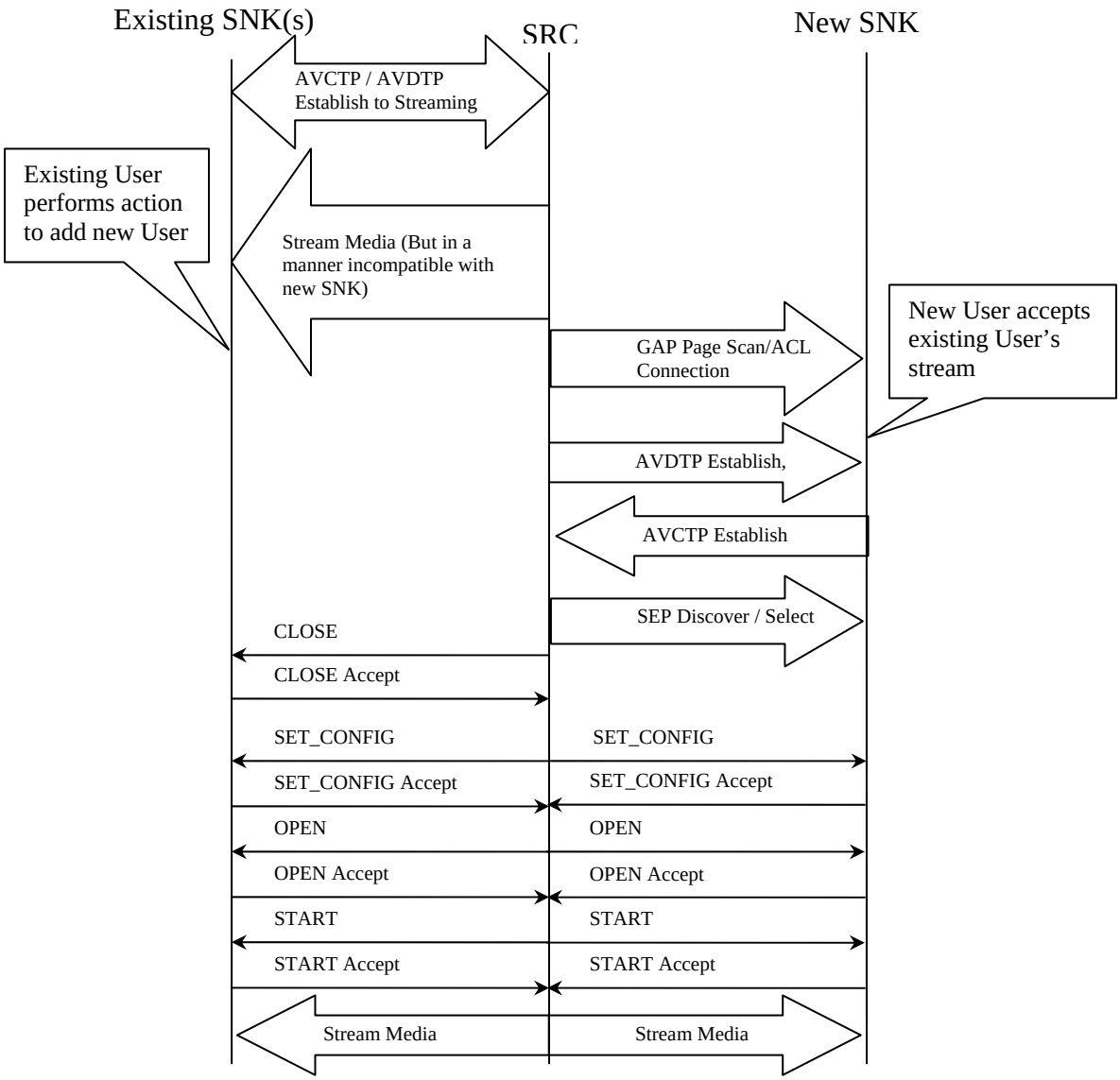

Figure 2: SRC Initiated when Existing session is using an Incompatible Endpoint

5.1.2 SRC INITIATES 2ND CONNECTION TO PREVIOUSLY UNKNOWN SNK

This procedure should only be used if the SRC cannot maintain high quality streaming to SNK #1 while searching for 2nd SNK. Otherwise the procedure from 4.1.1 should be used.

1) User #1 turns on the A2DP SRC and the A2DP SNK #1.
2) User #1 presses play on SRC or SNK #1, establishing an A2DP stream to SNK #1.
3) User #1 meets User #2, User #2 requests to listen to audio stream.
4) User #2 puts SNK #2 into pairing mode (Discoverable/Connectable).
5) SRC audio is Suspended to SNK #1 while SRC seeks for SNK #2.
6) SRC finds SNK #2, and establishes trusted relationship (pairing).
7) SRC finds compatible SEPs on SNK #1 and SNK #2, and Initiates Stream establishment.
8) Both User #1 and User #2 now listen to audio stream.

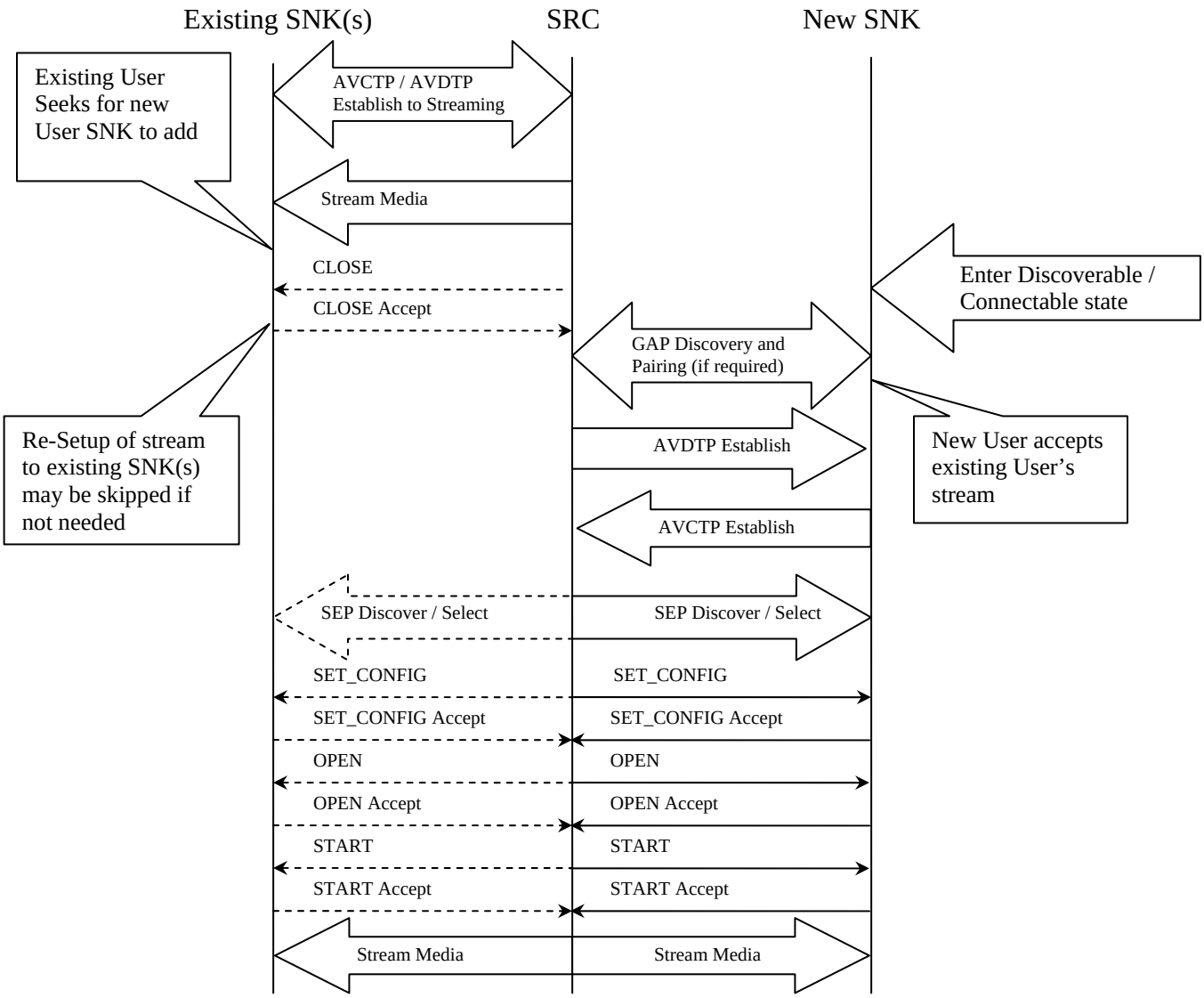

Figure 3: SRC Initiated when new SNK previously unknown

5.1.3 SNK INITIATES 2ND CONNECTION TO PREVIOUSLY PAIRED SRC

This general use case is for standalone SRC devices such as in-car entertainment, where SNK connections are initiated by the users joining from their SNKs:

1. A2DP SRC is powered on.
2. User #1 presses play on the SNK #1, SRC establishes an A2DP stream to User #1 SNK.
3. User #2 presses play on the SNK #2, SNK#2 establishes AVRCP & AVDTP connections towards the SRC.
4. SRC device seeks a compatible A2DP SNK endpoint on User #2 device:
    a. If User #2 SNK service is compatible with the existing User #1 SNK service, SRC device configures the User #2 SNK to compatible session and starts streaming.
    b. If User #2 SNK service is **NOT** compatible with the existing User #1 session, the existing endpoint session with User #1 is closed, and both the Users #1 & #2 devices are brought up in identical (or overlapping) SBC sessions and put into the streaming state.
5. Both Users #1 and #2 now listen to audio stream.

A popular use case is anticipated to be combination cell phone + media players. We anticipate that most SNK devices used in this multi-SNK scenario will themselves be multi-profile devices that support HFP in addition to A2DP, and may therefore be expecting a HFP connection. We therefore refer to the white paper “Simultaneous Use of HFP, A2DP, and AVRCP Profiles“ [2] Recommendation 30, and note that if the HFP Service Layer Connection establishment fails, that the SNK device should continue setting up the AVDTP and AVCTP connections.

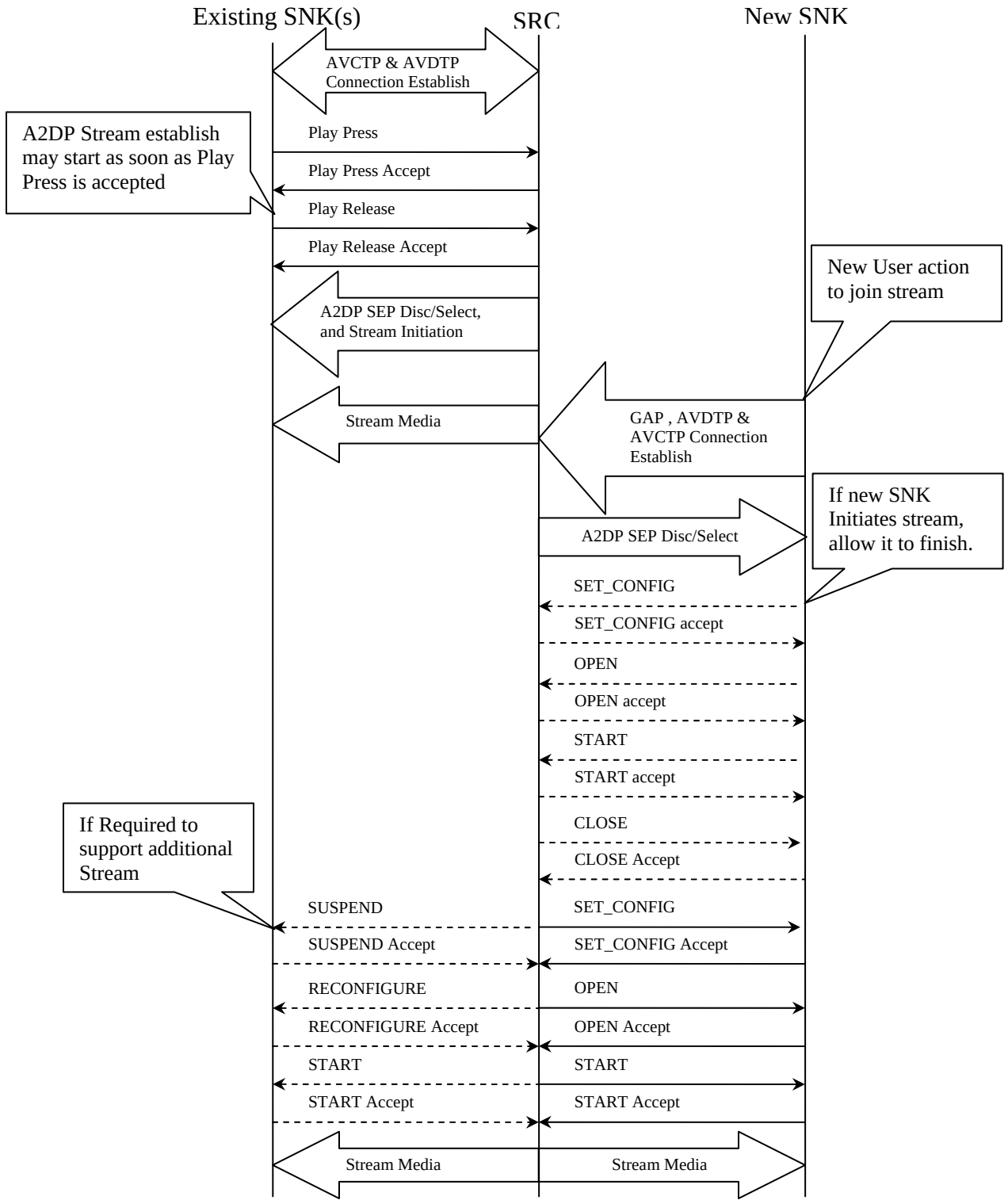

Figure 4: New SNK initiated session establishment

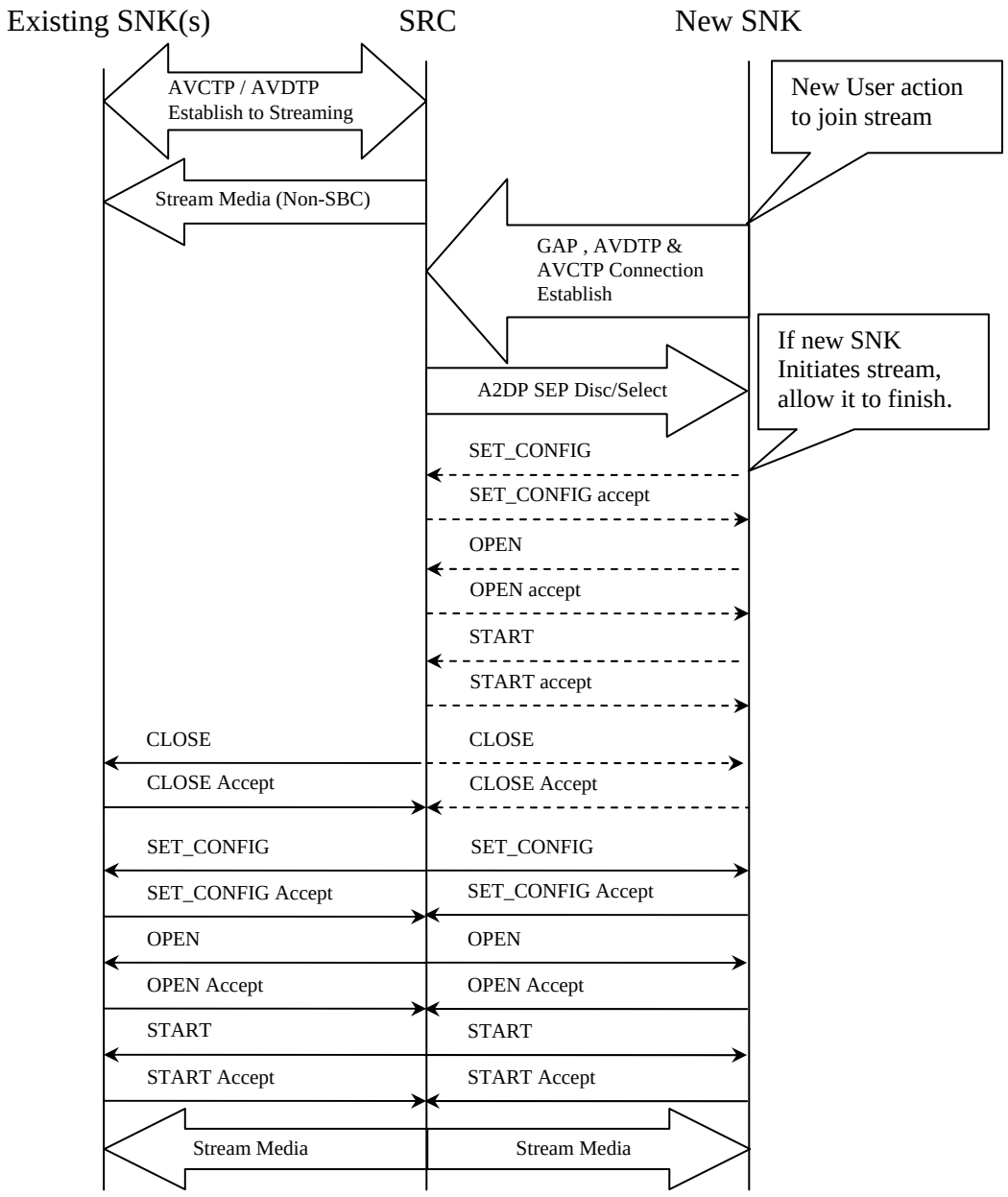

Figure 5: New SNK Initiated when Existing session using Incompatible Endpoint

5.2 TECHNICAL DESCRIPTION

5.2.1 A2DP

Since we are going to send two (or more) streams from the SRC device we need to have two (or more) SEPs on the SRC device that support the SBC codec.

When the SRC connects to another SNK device the configuration of the SBC codec should be the same as the configuration of the SBC codec in the existing SNK device(s).

If the codec used on the connection to the first headphone is not SBC and is not supported by the second headphone the SRC can either:

- Reconfigure the existing connection(s) to ensure that the same codec is used on all connections.
- Use multiple codecs on the multiple connections. This approach will require more processing from the SRC device since the same music must be encoded multiple times.

The approach used should be determined by the SRC and will depend on application design and the processing capabilities on the SRC.

Although not strictly necessary, the same outgoing MTU, sequence numbering and timestamps may be used for both outgoing streams.

Also not strictly required, it is assumed that all SNK devices will be receiving identical A2DP media packets. The music will only be encoded once and then sent over both AVDTP media connections. In addition to having an identical SBC configuration, other steps must be taken to ensure that the same media packet may be delivered to all SNK devices, as described in Recommendation 6.

5.2.2 AVRCP

When the A2DP connection is established to another A2DP SNK device an additional AVRCP connection should also be established. The reason for this is to enable control of the media from all SNK devices and to correctly control the volume on the SNK devices from the SRC device.

AVRCP Category 1 playback control (PAUSE/PLAY/STOP/FF/REW/NEXT/PREV) should follow existing recommendations in the “Simultaneous Use of HFP, A2DP, and AVRCP Profiles” white paper [2]. This includes resolution of playback commands coming from multiple controller sources.

Issue: Different SNK devices and different listeners desire different volume levels of the media streams, while SRC devices that support the AVRCP Category 2 Controller sends remote volume changes to A2DP-SNK devices that support Category 2 Target. We recommend that this issue be addressed according to the use case envisioned by the SRC application described in Recommendation 7.

5.2.3 HFP

While many SNK devices may also include a Handsfree service, we do not expect HFP to impact the Multi-SNK use cases. All recommendations from the “Simultaneous Use of HFP, A2DP, and AVRCP Profiles” white paper[2] should be followed to resolve multi-profile (A2DP/HFP) issues.

5.2.4 AVAILABLE BANDWIDTH

When sending two SBC streams over *Bluetooth* radios, the used bandwidth will be double compared with only sending one SBC stream. Since the recommended bitrate for high quality SBC streaming is 328 kb/s it is not realistic to send two of these streams over *Bluetooth* basic rate.

If the middle quality is acceptable for the use case it would be possible to use *Bluetooth* basic rate to send to two different headphones.

If *Bluetooth* EDR rate is available it is possible to stream two or more high quality SBC streams over *Bluetooth* radios.

It should be left to the SRC device to determine acceptable quality and determine, based on the EDR characteristics of the remote device(s) (based on remote features), whether or not subsequent SNK devices may be added at the present time.

Multi-SNK aware SRC devices should be aware of the limitations of their baseband when devices go out of range, to properly handle situations arising from one SNK of a Multi-SNK session moving out of range.

ISSUE: Piconet/Scatternet may not have the bandwidth available to handle multiple A2DP media streams at high audio quality. The SRC should manage the bandwidth according to Recommendation 8.

5.2.5 PAIRING

Pairing may occasionally be required if either device does not know about the other, and requires authentication to establish an AVDTP service connection. If bonding is either known or suspected to be required, streaming to all devices should be momentarily suspended until the pairing process is complete. Because of the complexity involved in pairing, and because most legacy devices already support it, the SRC device should initiate the pairing process by initiating GAP Discovery and Pairing. Some SRC devices are able to simultaneously initiate pairing, and maintain an A2DP stream to existing devices without interruption. Those that cannot should follow Recommendation 9. SNK devices that are Multi-SRC aware should follow Recommendation 10. To minimize the need to repair in the future, both SRC and SNK devices should follow Recommendation 11.

6 References

1. *Bluetooth* A2DP Specification 1.0 or later
2. Simultaneous Use of HFP, A2DP, and AVRCP Profiles white paper