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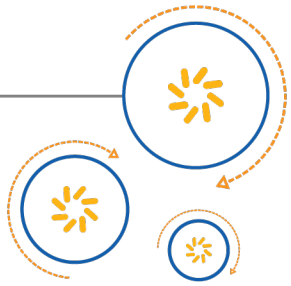

HFP Library

User Guide

80-CT427-1 Rev. AH

October 31, 2017

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Revision history

Revision	Date	Description
1	JUL 2010	Original publication of this document. Alternative document number CS-00206909-UG.
2	AUG 2011	Updated to the latest CSR™ style
3	MAY 2012	Updated to the latest CSR style
4	APR 2014	Updated to the latest CSR style
5	SEP 2016	Updated for HFP v1.7 and Secure Connection support in ADK 4.1. Updated to conform to QTI standards.
6	MAR 2017	Minor formatting changes.
AG	JUL 2017	Note added to highlight the fact that QCC300x and CSR8670 do not support BR/EDR Secure Connections. Document reference Number updated for distribution by createpoint.
AH	OCT 2017	References to `HfpAudioTransfer ()` corrected to `HfpAudioTransferRequest ()`. Added to the Document Management System. DRN updated to use Agile number

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1 HFP overview

The `hfp` library supports multiple connections with a single instance, providing a simplified multipoint API and reducing memory slot use required to support multiple HFP/HSP connections.

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2 Initialization

The HFP library supports HFP 1.7, and HSP 1.2. HFP and HSP can be supported simultaneously however only a single HFP version need be enabled locally as HFP 1.7 is backwards compatible with older specifications.

Each service structure is assigned an RFCOMM channel and a supported profile (there are two services for each supported profile if multipoint is enabled).

Service records are then registered for the service structures, advertising available services to remote devices. If multipoint is enabled then a service is only registered if no other service with the same profile has been registered already, ensuring that the device only advertises each supported profile once.

For further information on functions supported by the `hfp` library see the `hfp` library header documentation. See Figure 2-1

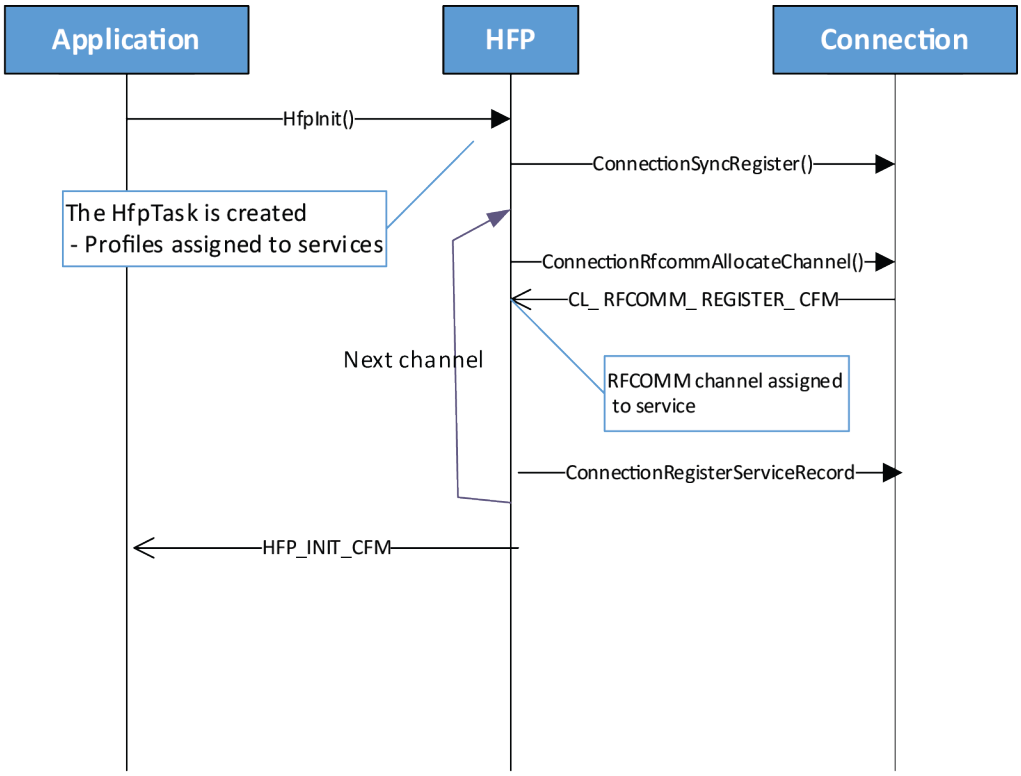

Figure 2-1 HFP library initialization message sequence chart

3 Service level connection

When a connection to an AG is initiated the AG is assigned a link if one is available. Its Bluetooth address (and RFCOMM sink when available) are stored as the link's identifier.

Any incoming notifications from an AG are matched to a link using the incoming Bluetooth address or RFCOMM sink against the link's identifier. The link's SLC state is updated based on these notifications, see Figure 3-1.

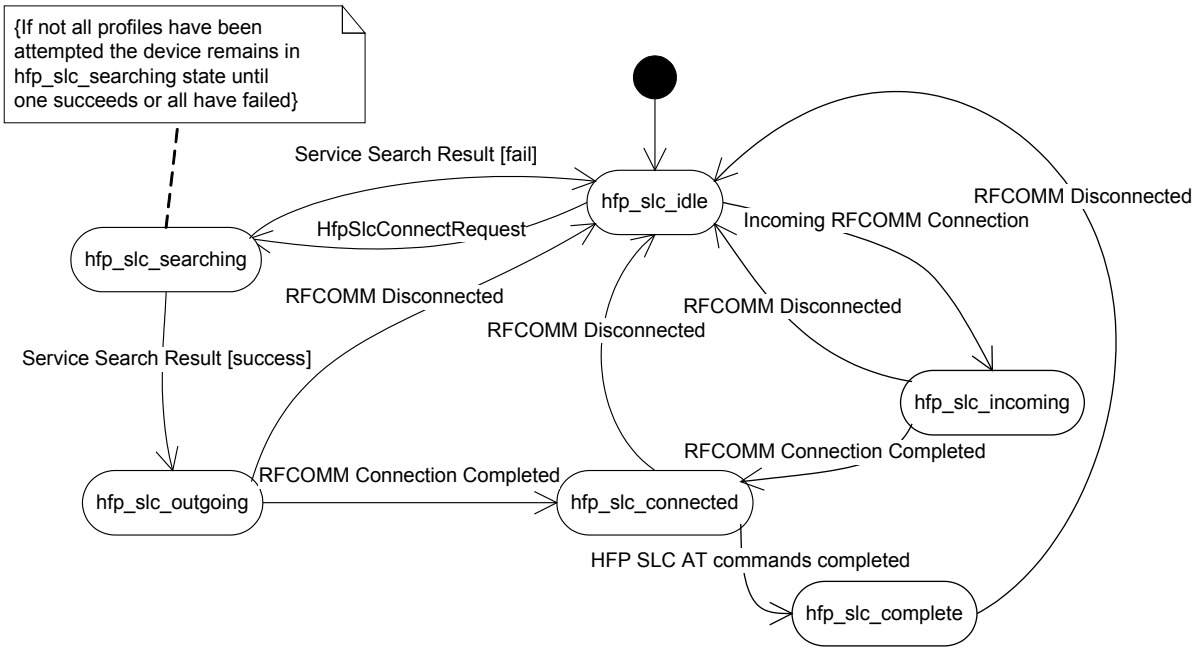

Figure 3-1 SCL states

Each link maintains a pointer to a service that identifies which profile the AG is using and enables hiding of the service on connection and advertising it again on disconnection.

3.1 Outgoing SLC connections

When attempting to establish an outgoing service level connection the application must specify:

- The Bluetooth address of the AG to connect to
- The profiles to attempt to connect, (either all or a subset of HSP 1.2 and HFP 1.7)
- Which profile to attempt first

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If an idle link is available it is assigned to the AG, otherwise the connection attempt fails. A local service is then found that matches the profile to attempt first, followed by a search for an available service on the remote device for the requested profile.

If the search fails, then the next local service matching a profile to attempt is found and a search is made for a corresponding service on the remote device, (if a profile to attempt was not enabled at initialization then no local service will be found and the next profile will be attempted). This process continues until a remote service is found or all profiles supported locally have been tried.

When a remote service channel is found an RFCOMM connection is initiated. The local service channel is only used to provide a security setting for the RFCOMM connection so the link does not become owner of the service, although a link to the local service is maintained to track the profile the AG is using.

If the HFP profile is being used, AT commands are exchanged when the RFCOMM connection has been established, as per the HFP specification. See Figure 3-4.

Finally `HFP_SLC_CONNECT_CFM` is sent to the application to indicate a successful connection. See Figure 3-2.

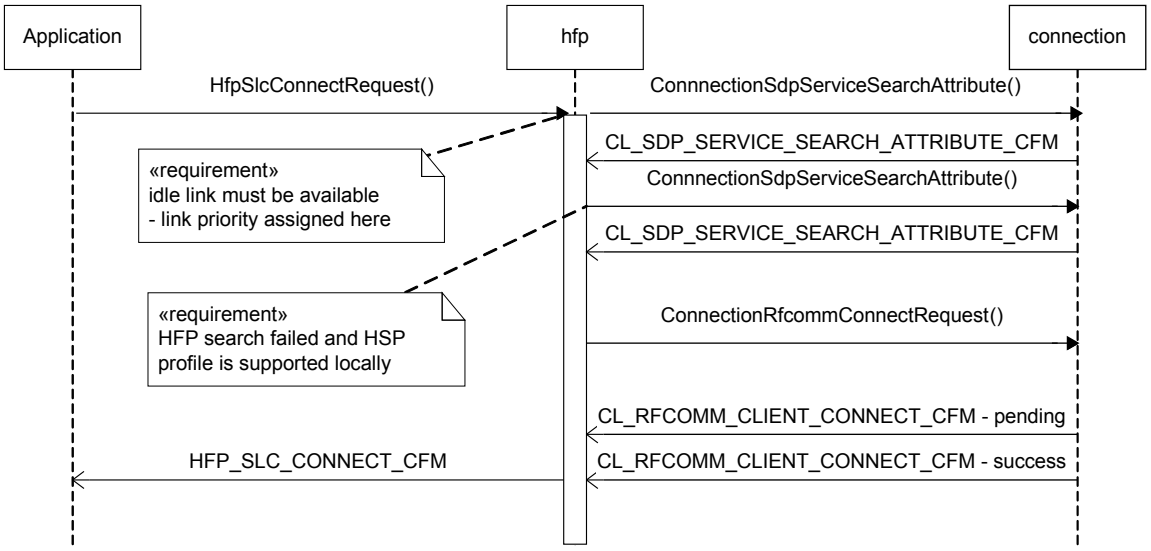

Figure 3-2 HSP outgoing SLC

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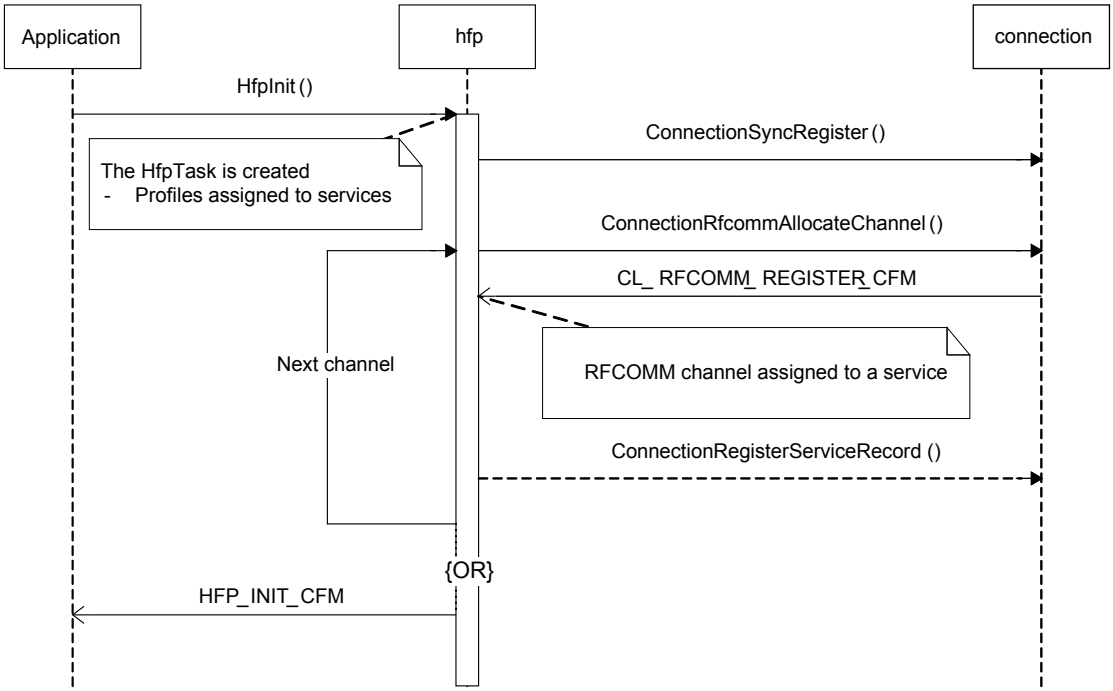

Figure 3-3 HFP library initialization message sequence chart

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Figure 3-4 shows the exchange of AT commands for an outgoing SLC using HFP.

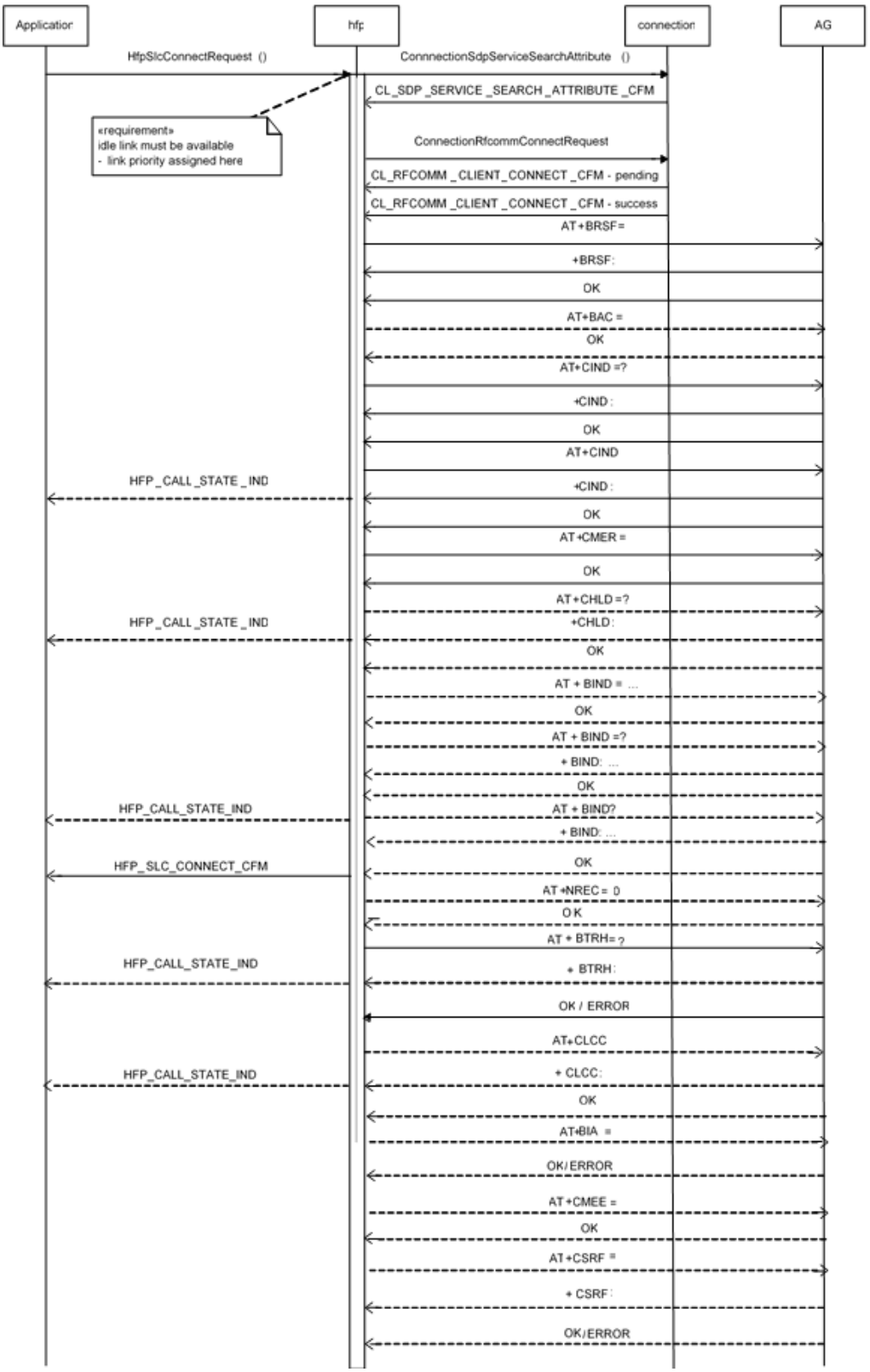

Figure 3-4 HFP outgoing SLC

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3.2 Incoming SLC connections

When responding to an incoming RFCOMM connection the `hfp` library accepts the connection if an idle link is available and the RFCOMM channel corresponds to one of the library's services, otherwise the connection is rejected.

The link is then assigned to the AG and the service is associated with the link; the link becomes the owner of the service at this stage as the local service channel is in use.

When an RFCOMM connection is established to an HFP AG, AT commands are exchanged as per the HFP specification. See Figure 3-5.

Finally an `HFP_SLC_CONNECT_CFM` message is sent to the application to indicate a successful connection. The service record is then unregistered to prevent other devices from attempting to connect to the service while it is busy, see Figure 3-6.

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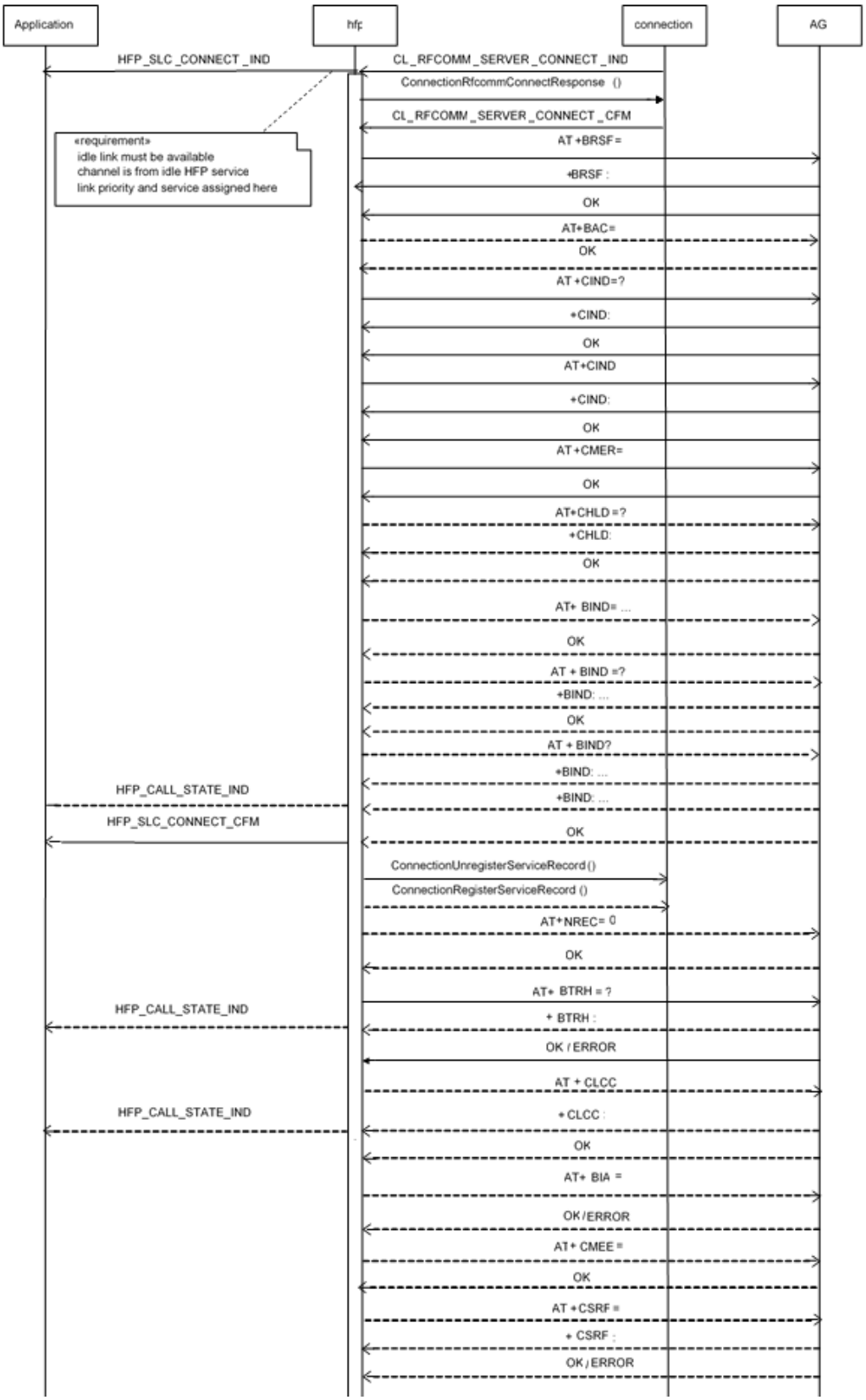

Figure 3-5 HFP incoming SLC

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NOTE If multipoint is supported and another service is available for the same profile as has been connected, then that service is registered to allow extra connections using the same profile.

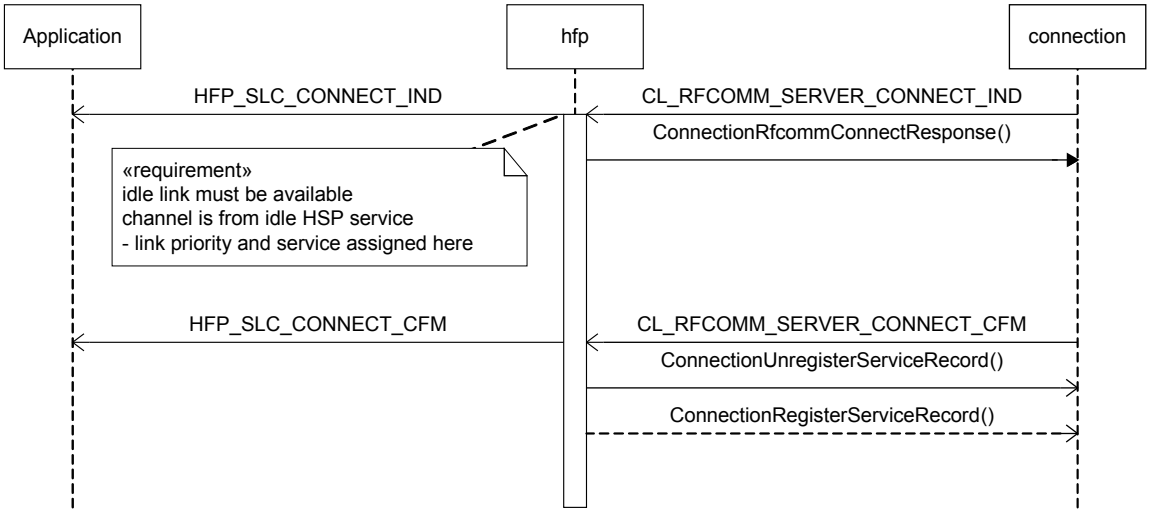

Figure 3-6 HSP incoming SLC

Figure 3-5 shows the exchange of AT commands for an incoming SLC using HFP.

The `HFP_SLC_CONNECT_CFM` message contains the priority of the link that has been established. Priority is assigned when the connection is requested by the application or when an incoming RFCOMM connection request is received.

If no links are currently in use, then the new link becomes the primary link. If a primary link already exists, then the new link becomes the secondary link.

If the primary link is disconnected and a secondary link exists, then the secondary link is upgraded to primary.

Link priority is used in all further instructions to the library to indicate which link to carry out a given command on.

When an HFP service level connection has been established the library attempt to configure the link, using the options selected at initialization in the following order:

1. If the AG supports disabling noise reduction and echo cancellation and the library is configured to do so HFP sends `AT+NREC=0` to the AG.
2. If the AG supports response and hold functionality HFP attempts to retrieve the response and hold status by sending `AT+BTRH=?` to the AG.
3. If the AG supports three way calling and enhanced call status, then HFP attempts to determine if a multiparty call is in progress by sending `AT+CLCC` to the AG.
4. HFP attempts to enable/disable indicators as configured at initialization by sending `AT+BIA=...` to the AG.
5. If the AG supports extended errors and the library is configured to do so HFP attempts to enable extended errors by sending `AT+CMEE=1` to the AG.

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3.3 Disconnecting SLC connections

A disconnect request can be issued to the HFP library at any point after a link priority has been assigned.

If the link specified in an `HfpSlcDisconnectRequest()` is in the hfp_slc_searching state, then the link data is immediately reset and an `HFP_SLC_DISCONNECT_IND` is sent to the application.

NOTE Any service search results received after the `HFP_SLC_DISCONNECT_IND` is sent are ignored.

In any other state, an RFCOMM disconnect request is issued to the lower layers and an `HFP_SLC_DISCONNECT_IND` is sent to the application when the RFCOMM connection has been aborted/disconnected.

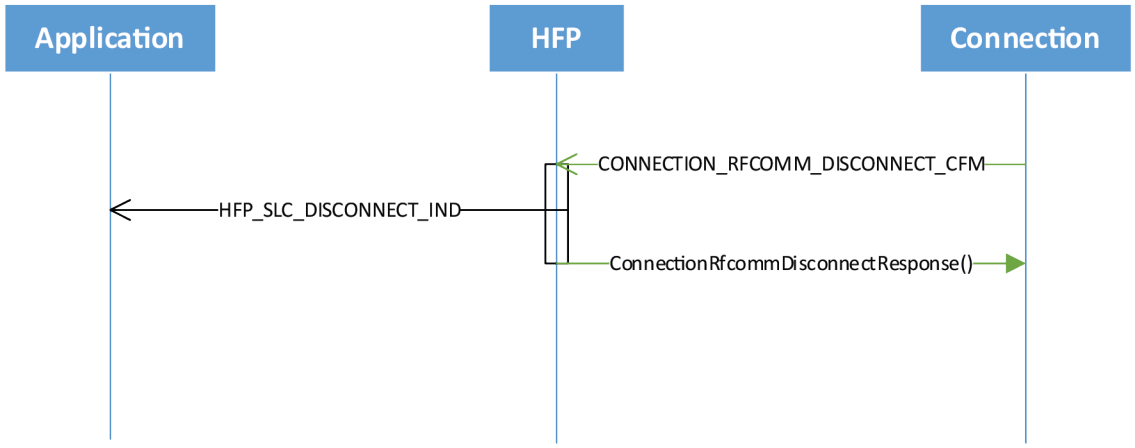

Figure 3-7 Local SLC disconnection

If an RFCOMM disconnect indication is received before an SLC has been fully established, `HFP_SLC_CONNECT_CFM` is sent to the application indicating that the SLC connection has failed.

If an RFCOMM disconnect indication is received for a link in the `hfp_slc_connected` state, then a `HFP_SLC_DISCONNECT_IND` is sent to the application.

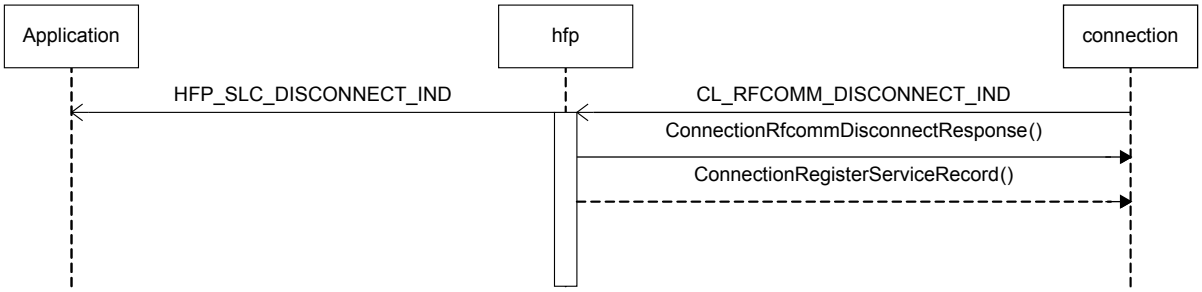

Figure 3-8 Remote SLC disconnection

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3.4 Link loss

If the `hfp` library has a non-zero timeout configured for the link loss timeout and an RFCOMM disconnect indication is received indicating that a link loss has occurred the `hfp` library sends `HFP_SLC_LINK_LOSS_IND` to the application, indicating that a link loss recovery is in progress. See Figure 3-9.

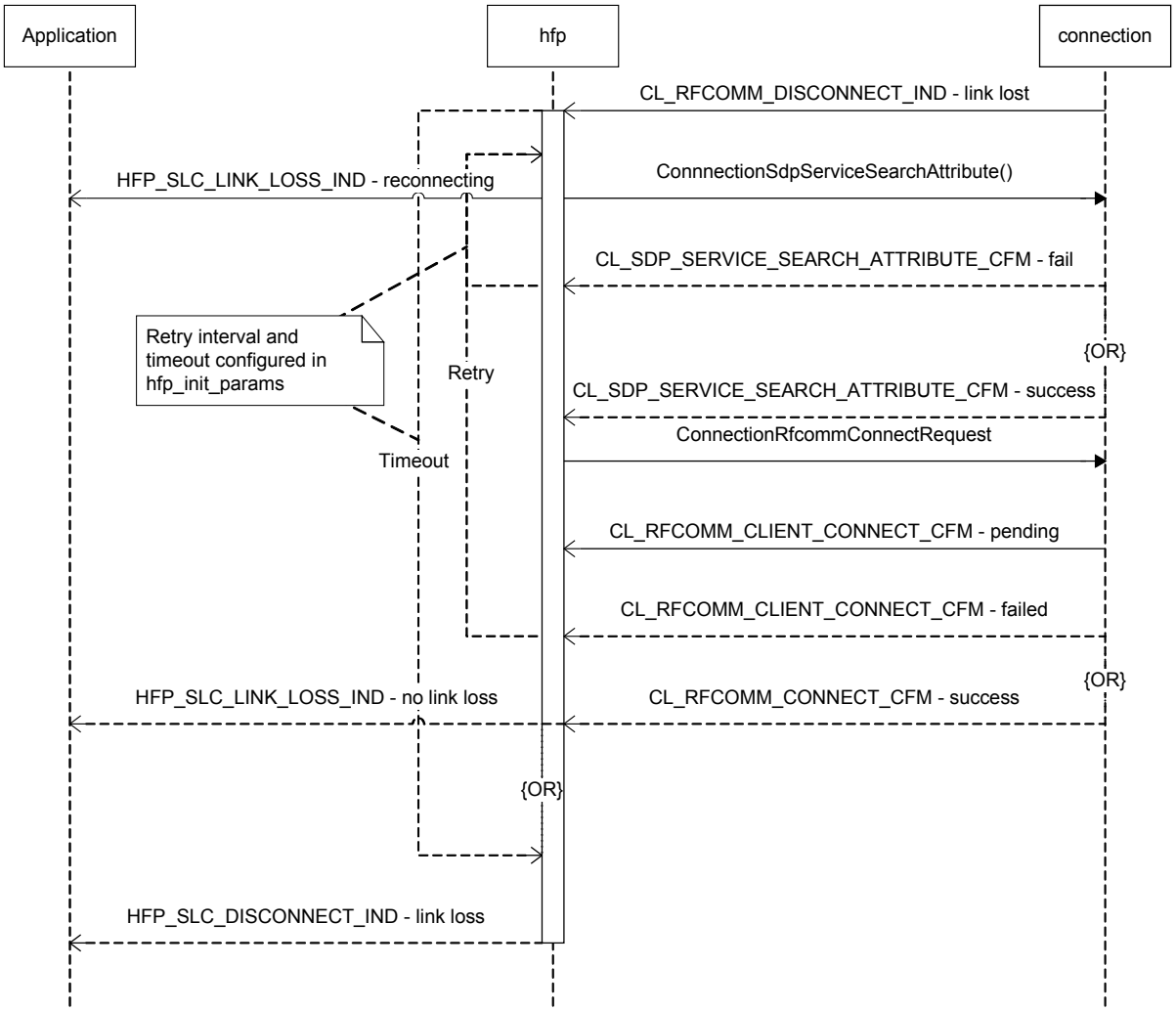

Figure 3-9 SLC link loss

If the link is successfully reconnected before the link loss timeout has expired, then `HFP_SLC_LINK_LOSS_IND` is sent to the application indicating that there is no link loss condition for the link and no change to the link priority takes place.

If the timeout expires and the link cannot be recovered (or a zero length link loss timeout is configured), then an `HFP_SLC_DISCONNECT_IND` is sent to the application indicating link loss has occurred, this is treated as any other disconnection.

NOTE If a reconnection attempt is in progress when the timeout fires, the attempt is allowed to complete before the application is notified of its success/failure.

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If the application issues a disconnect request for a link that is attempting to recover from a link loss, then any pending reconnect attempts are canceled and an `HFP_SLC_DISCONNECT_IND` is sent to the application.

NOTE If a reconnection attempt is in progress, then the attempt is aborted as with a normal disconnect and further reconnection attempts are canceled.

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4 Audio connections

The audio state for a link is maintained independently of its SLC state and the remote device may initiate audio connections before the SLC has been fully established. Figure 4-1 shows how the audio state is updated.

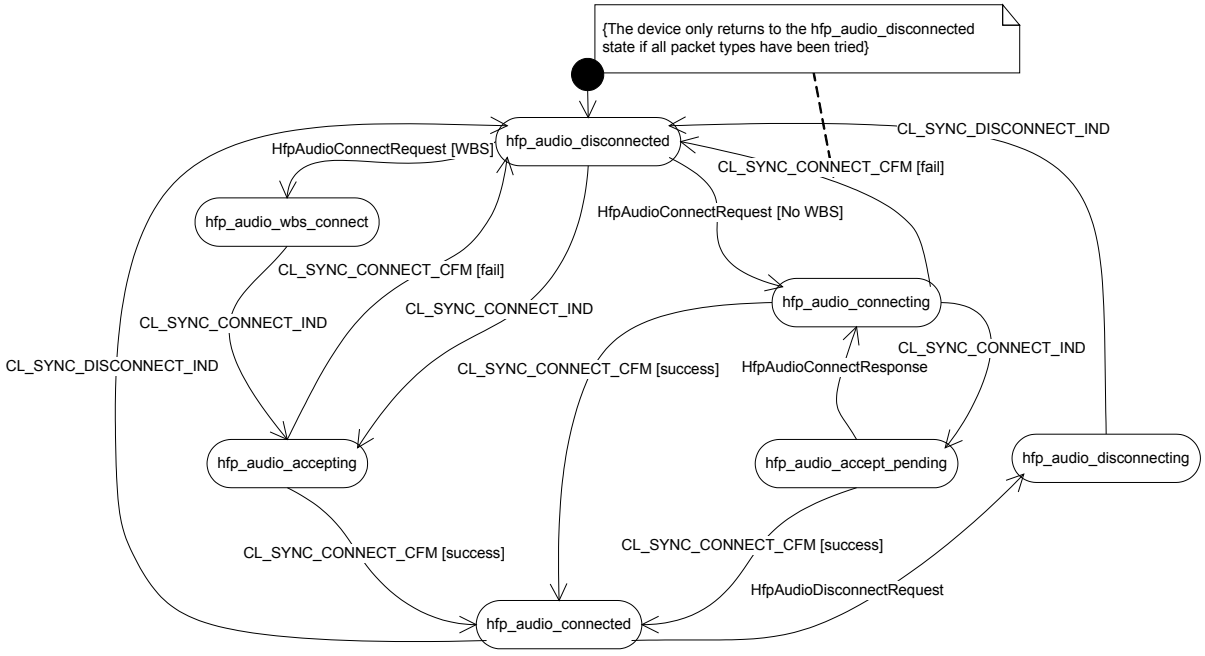

Figure 4-1 Audio states

4.1 Incoming audio connections

On receiving an incoming audio connection request the `hfp` library notifies the application by sending `HFP_AUDIO_CONNECT_IND` for the link in question. The application must then respond using

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`HfpAudioConnectResponse()` indicating whether to accept or reject the connection and which audio parameters to use. See Figure 4-2.

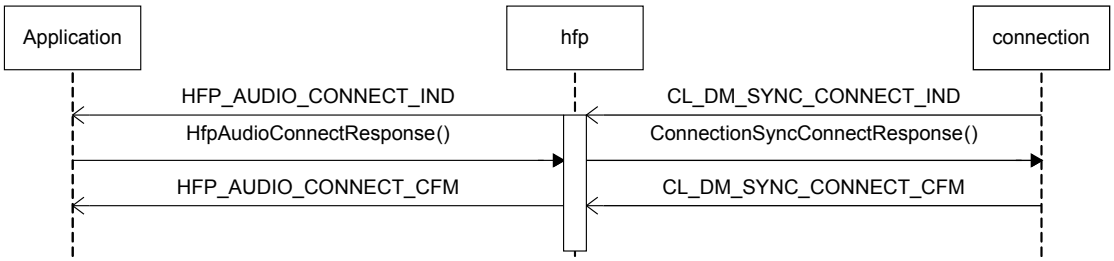

Figure 4-2 Incoming audio connection MSC

4.2 Outgoing audio connections

Outgoing audio connections are handled differently for each of the supported profiles.

4.2.1 HSP

For HSP audio transfer is initiated by the `hfp` library sending `AT+CKPD=200` to the AG. The AG then initiates an audio connection. See Figure 4-3.

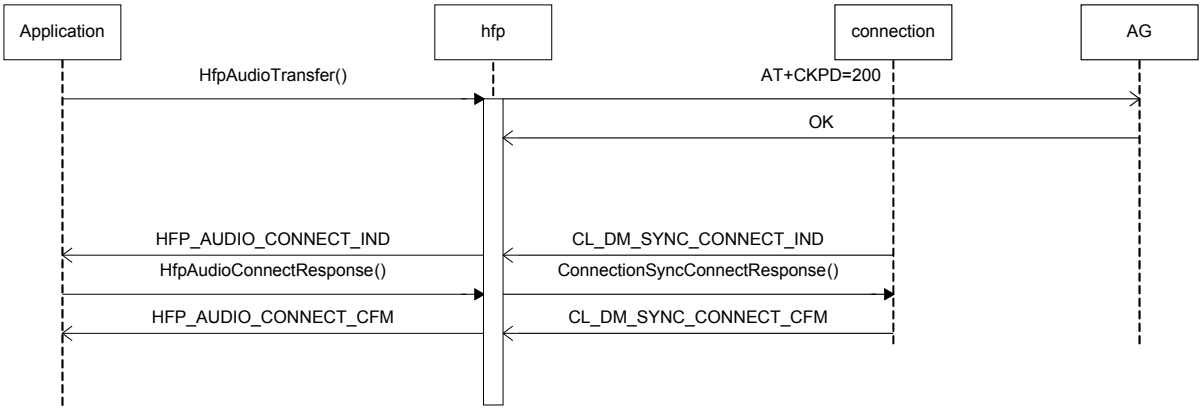

Figure 4-3 HSP outgoing audio connection MSC

4.2.2 HFP

For HFP a codec connection is initiated by the `hfp` library by sending `AT+BCC` to the AG. See Figure 4-3.

The AG then initiates an audio connection when a codec has been selected. When responding to this connection the `hfp` library overrides the application's audio parameters with parameters that allow the

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AG to set up a transparent eSCO using either the T1 or T2 settings given for Wide Band Speech in the *Hands-free Profile Prototyping Specification*.

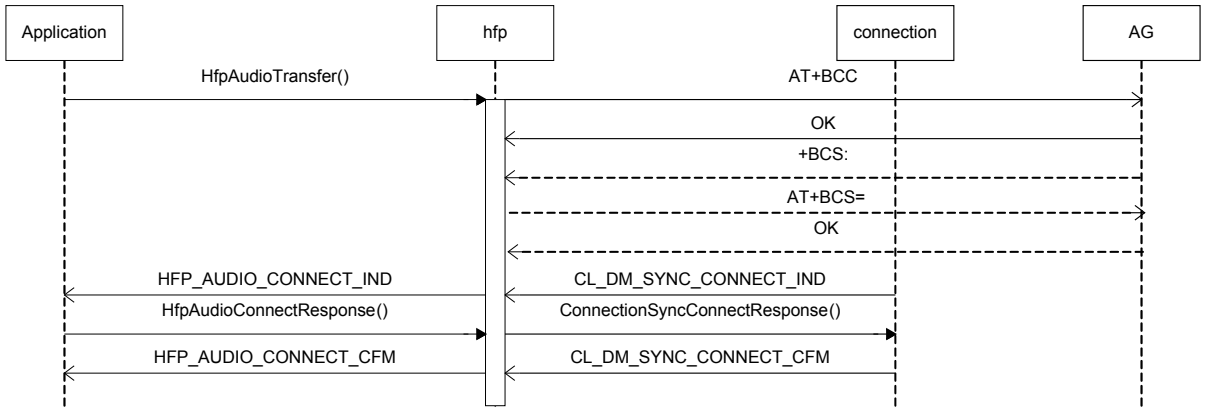

Figure 4-4 HFP outgoing audio connection MSC

4.3 HFP 1.7 S4 audio settings

HFP S4 support is configured as part of the library initialization (see Initialization) by adding the `HFP_ESCO_S4_SUPPORTED` flag to the supported features bitfield. The incoming audio connection and outgoing audio connection with an AG that supports the new eSCO S4 settings is shown below.

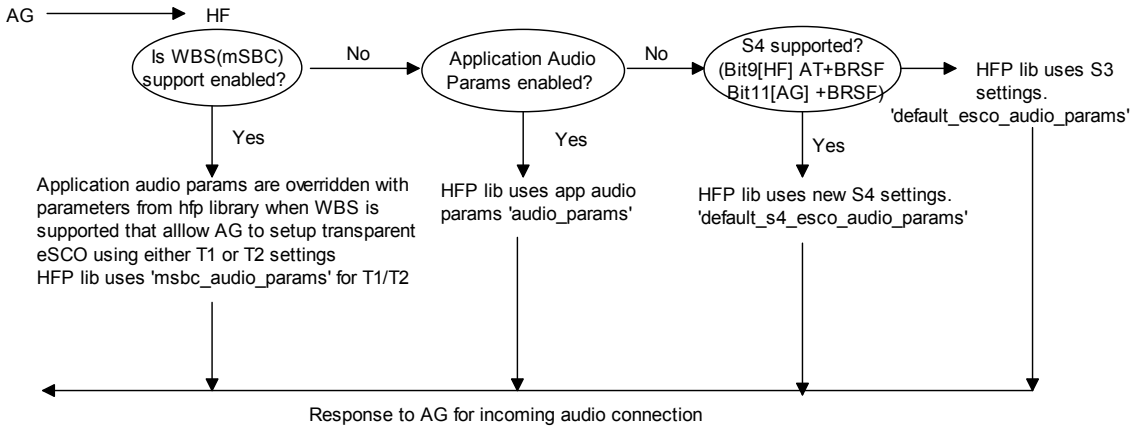

Figure 4-5 Audio connection for an incoming audio connection with S4 settings from AG

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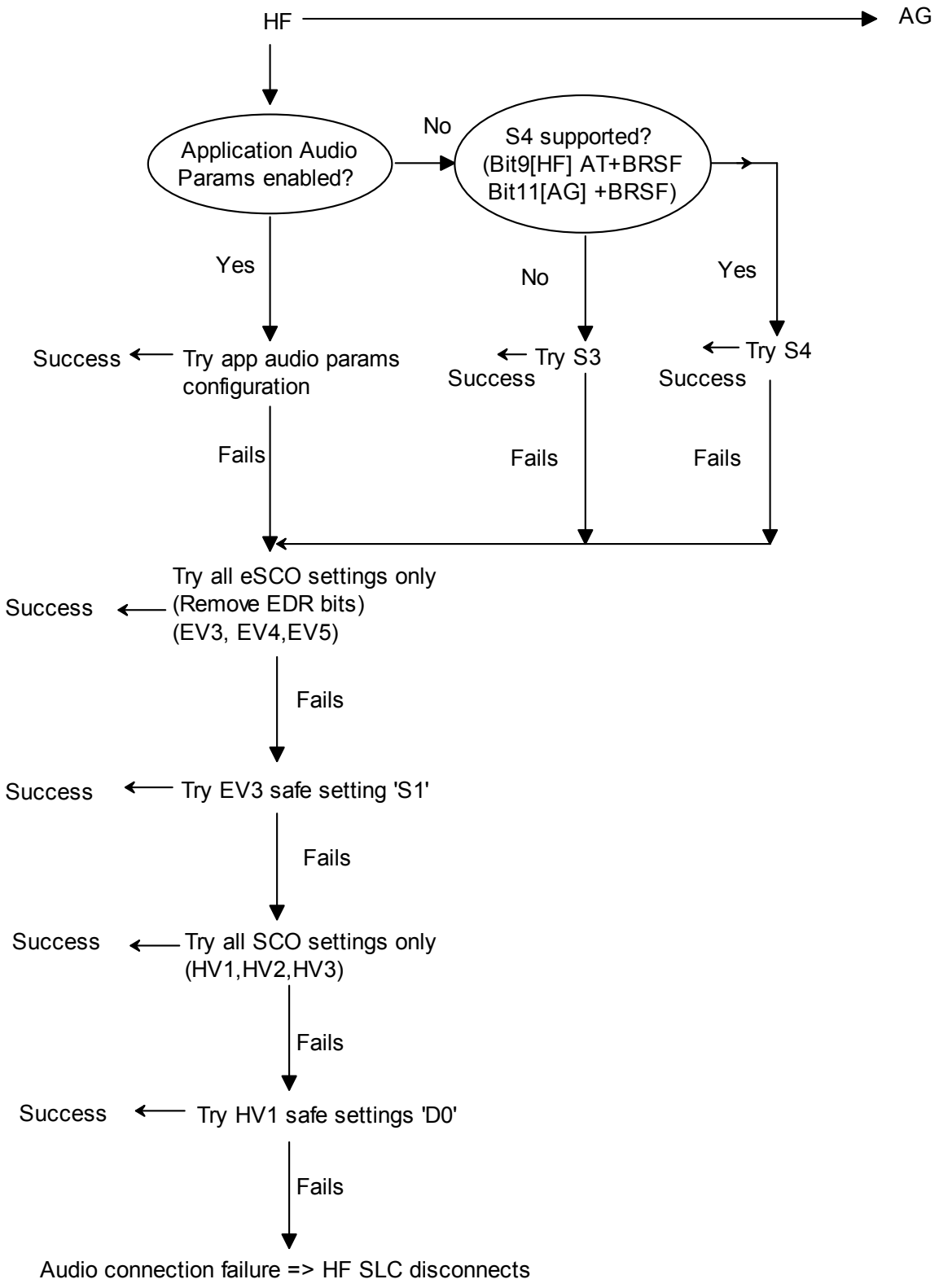

Figure 4-6 Audio connection for an outgoing audio connection with CVSD only codec with S4 settings with AG

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4.4 Secure connection

When BR/EDR Secure Connection is enabled, the outgoing audio connection with an AG, see Figure 4-7.

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NOTE Not all QTIL Bluetooth ICs support BR/EDR Secure Connections, for information on individual ICs, see the appropriate Data Sheet.

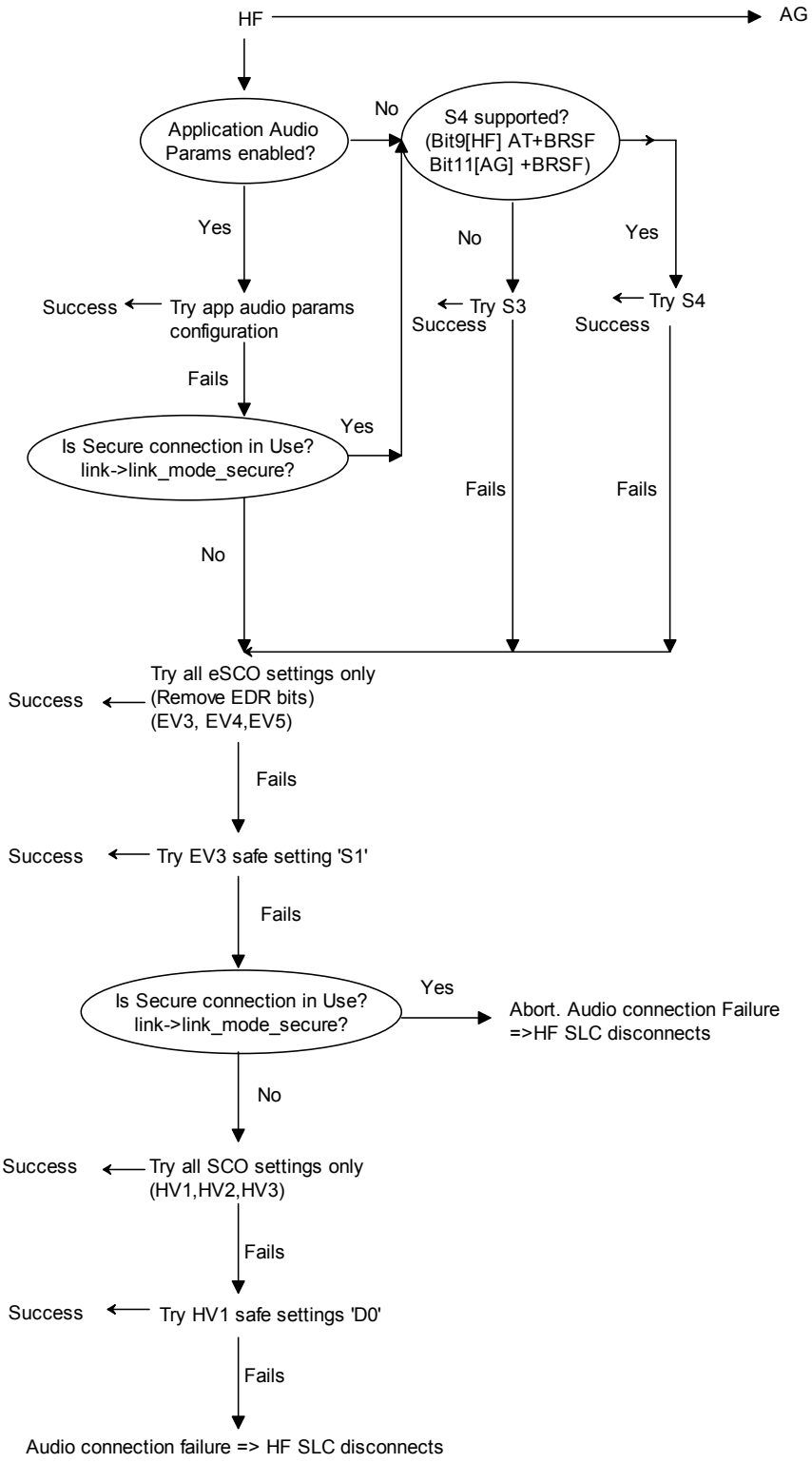

Figure 4-7 Audio Connection for an outgoing audio connection with CVSD only codec with S4 and SC with AG

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4.4.1 HFP1.7 API for setting link mode

A new API `HfpLinkSetLinkMode()` has been introduced. It is used to inform the HFP library whether a link is secured or not. The hfp library updates the `hfp_link_data` structure (associated with each link) based on the link information passed to HFP library. During an incoming/outgoing call this information in hfp library is used to select the required audio settings for a synchronous connection.

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5 Call handling

Call, Call Setup, and Call Held indications are not sent to the application by the `hfp` library. Instead the `hfp` library tracks call state changes on a link internally, notifying the application of any changes in a link's call state by sending `HFP_CALL_STATE_IND`.

The application can respond to these call indications using various call control functions, for example for an incoming call the application should call `HfpAnswerCall()`, using `HfpGetLinkFromCallState()` to find the link in `hfp_call_state_incoming` if not responding to the message immediately.

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Figure 5-1 shows how HFP call handling states are updated. Figure 5-2 shows the MSC for an example of an HFP incoming call.

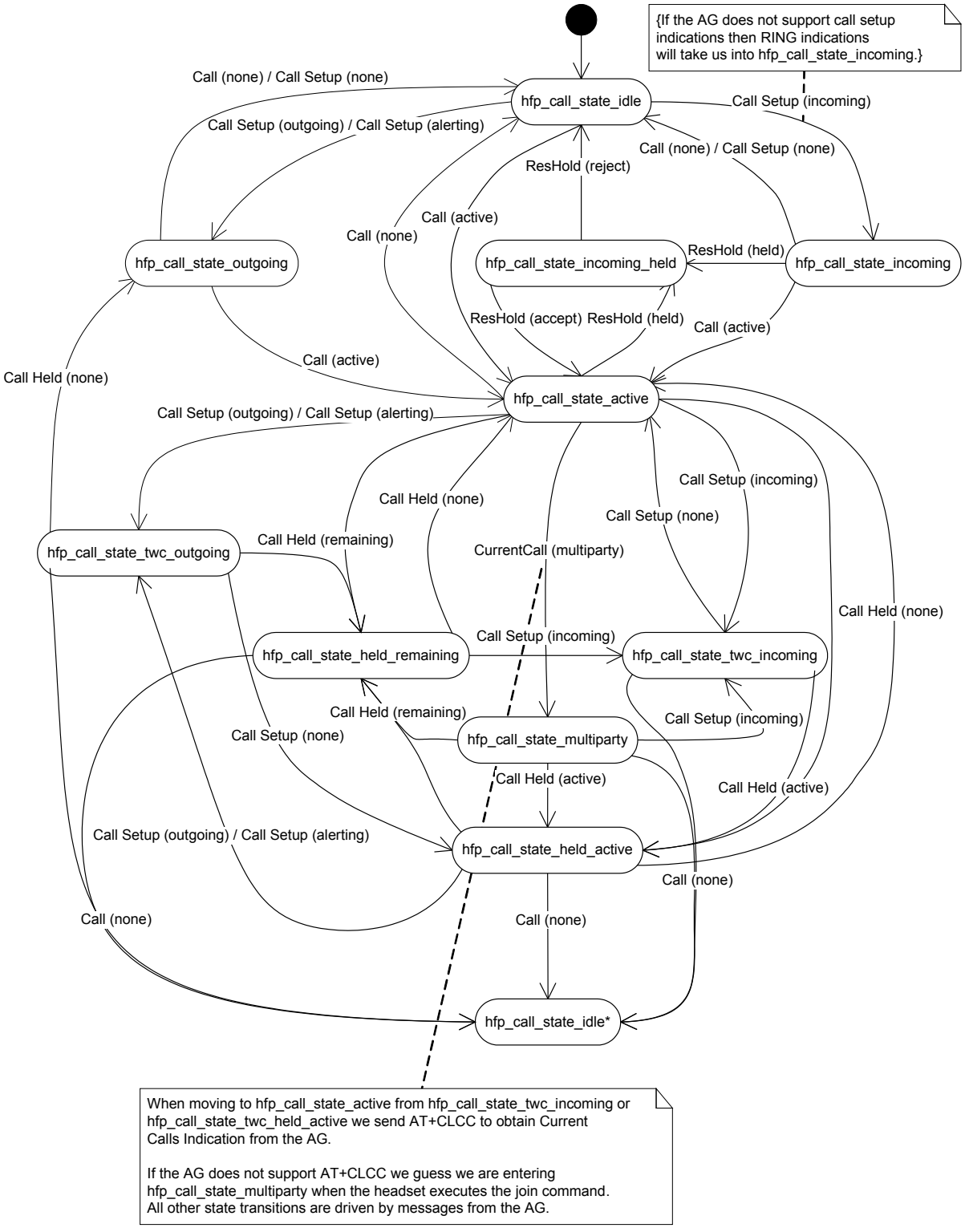

Figure 5-1 HFP call states

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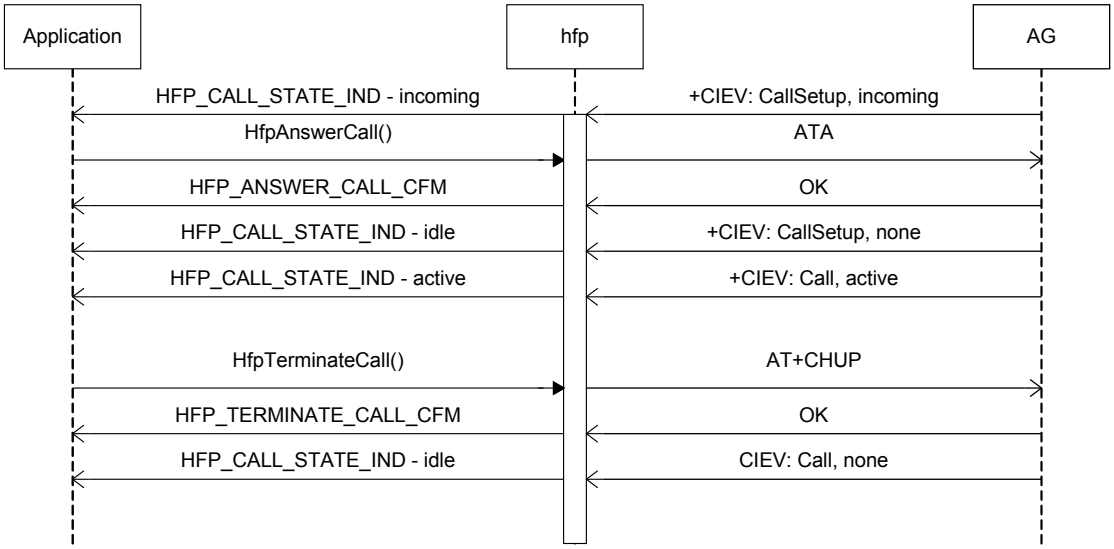

Figure 5-2 HFP incoming call example MSC

5.1 HSP call states

HSP call states are a subset of those used for an HFP link, see Figure 5-3.

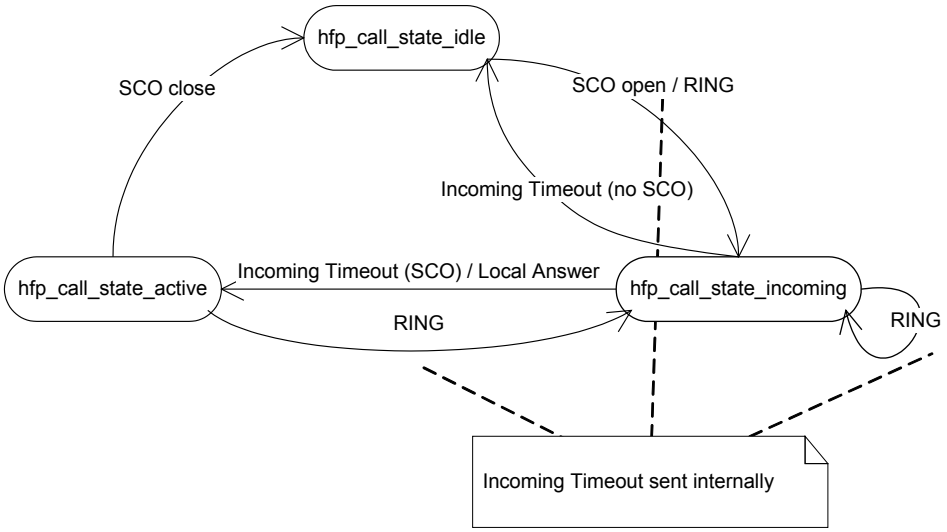

Figure 5-3 HSP call states

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Changes in HSP call state are determined using different cues to HFP, such as RING indications or the presence/absence of an audio connection. These are sent to the application in the same way as for an HFP link and can be responded to using the same functions. See Figure 5-4.

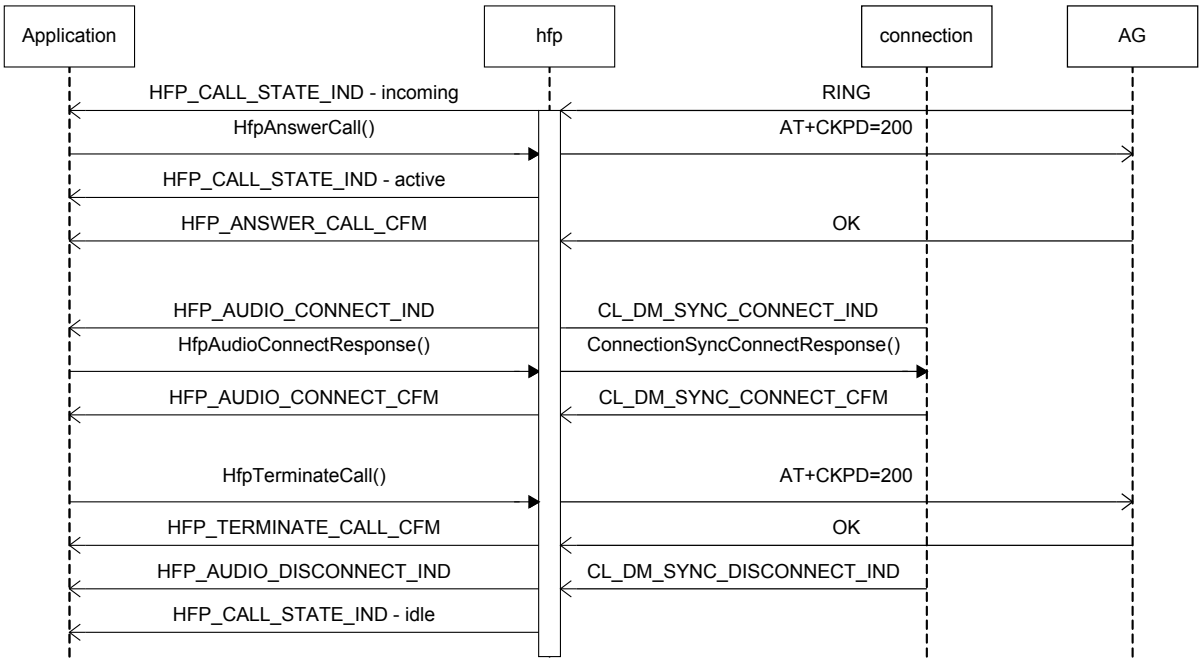

Figure 5-4 HSP incoming call example MSC

5.2 HfpLinkGetCallState()

For an application, to more accurately determine its state the `HfpLinkGetCallState()` function is provided to query the state of a given link.

This function is required when supporting multiple connections to obtain the call state of the other link when handling an `HFP_CALL_STATE_IND` message.

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Document references

Document	Reference
Specification of the Bluetooth System	Core Version 3.0 + HS 21 April 2009
Handsfree Profile	Specification of the Bluetooth System, Profiles, v1.7, Handsfree Profile
Headset Profile	Specification of the Bluetooth System, Profiles, v1.2, Headset Profile
Wide Band Speech in the Hands-free Profile Prototyping Specification	WB-Speech in HFP_PS 2010-01-20

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Terms and definitions

Term	Definition
AG	Audio Gateway
AT	ATtention (modem command prefix)
Bluetooth	Set of technologies providing audio and data transfer over short-range radio connections
EDR	Enhanced Data Rate
eSCO	Extended SCO
HFP	Handsfree Profile
HSP	HeadSet Profile
IC	Integrated Circuit
MSC	Message Sequence Chart
QTIL	Qualcomm Technologies International, Ltd.
RFCOMM	Radio Frequency COMMunication
SCO	Synchronous Connection-Oriented
SLC	Service Level Connections