Wi-Fi Display
Technical Specification
Version 1.1

This document is the specification for the Wi-Fi Alliance Wi-Fi CERTIFIED Miracast® program, a solution for wireless video streaming.

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1 Introduction

This document is the Technical Specification for Wi-Fi Display, an interoperable mechanism to discover, pair, connect and render multimedia content sourced from a Wi-Fi Display Source at a Wi-Fi Display Sink. This Specification defines the architecture and a set of protocols between Wi-Fi Display Source and Sink.

1.1 Scope of This Document

This Specification meets all the requirements set forth in the Wi-Fi Display Specification Requirements Document. This Specification also includes a set of annexes that specify implementation requirements and provide implementation guidelines. The scope of this Specification is confined to the requirements outlined by the Wi-Fi Display SRD [18], MRD [16], and Use cases [17]. The content in this Specification is designed to ensure interoperability between Wi-Fi Display Source and Sink where Wi-Fi Display (WFD) Devices can be discoverable by, paired and establish WFD Session(s) with other WFD Device(s), and provide guidelines to enhance performance and user experience.

The following system requirement areas are covered:

- WFD device discovery
- WFD capability discovery
- WFD Connection establishment
- WFD Session establishment
- Payload formats for video and audio streams from WFD Source to WFD Sink
- Transport and multiplex protocol for video and audio payload
- Link Content Protection
- WFD Session termination
- Persistent WFD Groups

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2 Definitions

The following definitions and terms are used in this document:

AP: Wi-Fi Access Point

Coupled Sink Operation: An operation hereby a WFD Source transmits video content to a Primary Sink and transmits audio content to a Secondary Sink, after coupling is established between the Primary Sink and the Secondary Sink.

Coupling: A procedure to exchange capabilities between a Primary Sink and a Secondary Sink so that a WFD Source can know the presence of both the Primary Sink and the Secondary Sink if the one of them is discovered via WFD Device Discovery. Once this procedure is done, the Primary Sink and the Secondary Sink is said to be 'Coupled' and both are in 'Coupled state'.

Paired: A WFD Source and a WFD Sink are said to be paired if they have successfully completed WFD Capability Negotiation.

Primary Sink: A Primary Sink is a device that supports rendering video content only or both audio and video contents. A Primary Sink may support Coupled Sink Operation.

Rendering: The process of generating an image or sound from a set of data.

Secondary Sink: A Secondary Sink is a device that supports rendering audio content only. A Secondary Sink may support Coupled Sink Operation. A Secondary Sink also supports rendering audio content directly from a WFD Source regardless of the coupling status with Primary Sink or the presence of the Primary Sink.

WFD Session: 1) A Wi-Fi Display connection between a WFD Source and a WFD Sink or 2) a Wi-Fi Display connections between a WFD Source and a Primary Sink and between a WFD Source and a Secondary Sink, where content is sourced at the WFD Source and rendered at the WFD Sink(s).

WFD Topology: The arrangement in which the Wi-Fi Display Source and Sink are connected to each other for a WFD Session and (in some cases) to other Wi-Fi devices.

Wi-Fi P2P: A protocol that provides Wi-Fi device-to-device connectivity including discovery and pairing, without requiring an AP.

Specification: Within this document, the term Specification is used to refer to this document, i.e., the Wi-Fi Display Technical Specification.

WFD Connection: Layer 2 connection to be used for WFD.

Wi-Fi Display Device (or WFD Device): Either a WFD Source or a WFD Sink

Wi-Fi Display Source (or WFD Source): A device that supports streaming multimedia content to a WFD Sink(s) over a Wi-Fi link.

Wi-Fi Display Sink (or WFD Sink): A device that receives multimedia content from a WFD Source over a Wi-Fi link and renders it. A WFD Sink is either a Primary Sink or a Secondary Sink.

Wi-Fi Display Sink dongle (or WFD Sink dongle): a WFD Sink that supports outputting a video and/or audio signal to an external rendering device.

2.1 Abbreviations

AAC	Advanced Audio Coding
ADTS	Audio Data Transport Stream
AKE	Authentication and Key Interchange
AP	Wi-Fi Access Point
ASCII	American Standard Code for Information Exchange
ASO	Arbitrary Slice Ordering
AU	Access Unit
AV	Audio Video
BSS	Basic Service Set

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BSSID	Basic Service Set Identifier
CABAC	Context Adaptive Binary Arithmetic Coding
CAVLC	Context Adaptive Variable Length Coding
Cb	Blue difference Chroma component
CBP	(H.264) Constrained Baseline Profile
CD	Compact Disk
CEA	Consumer Electronics Association
CHP	Constrained High Profile
CODEC	COmpressorDECompressor
CP	Content Protection
Cr	Red difference Chroma component
DA	Destination Address
DTS	Decode Timestamp
DTV	Digital Television
E-DDC	Enhanced Display Data Channel
EDID	Extended Display Identification Data
FMO	Flexible Macroblock Ordering
GO	P2P Group Owner
GOP	Group of Pictures
gPTP	generalized Precision Time Protocol
HDCP	High-bandwidth Digital Content Protection
HDMI	High Definition Media Interface
HH	Handheld
HID	Human Interface Device
HIDC	Human Interface Device Class
IE	Information Element
IEC	International Electrotechnical Commission
IEEE	Institution of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
IP	Internet Protocol
ISO	International Standards Organization
ITU	International Telecommunication Union
L2	OSI Layer 2, a Data Link Layer protocol
L3	OSI Layer 3, a Network Layer protocol
LAN	Local Area Network
LLC	Logical Link Control
LPCM	Linear Pulse Coded Modulation
MAC	Medium Access Control
MBAFF	Macroblock-Adaptive Frame-Field Coding
MPEG	Moving Picture Experts Group
MRD	Marketing Requirements Document
NAL	Network Abstraction Layer
OOB	Out-Of-Box
OUI	Organizationally Unique Identifier

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(Wi-Fi) P2P	(Wi-Fi) Peer-to-peer (used as a name of a topology or a technology, which has a certification program name as Wi-Fi Direct™)
PAT	Program Association Table
PC	Preferred Connectivity
PCR	Program Clock Reference
PES	Packetized Elementary Stream
PHY	Physical Layer
PicAFF	Picture Adaptive Frame/Field Coding
PID	Packet Identifier
PMT	Program Map Table
PSH	PUSH flag
PTS	Presentation Timestamp
QP	Quantization Parameter
RFC	Request for Comment
RS	Redundant Slices
RTP	Real-time Protocol
RTSP	Real Time Streaming Protocol
SCR	System Clock Reference
SEI	Supplemental Enhancement Information
SKE	Session Key Exchange
SNAP	SubNetwork Access Protocol
SRD	Specification Requirements Document
SSID	Service Set Identifier
STA	Non-AP Station
TCP	Transmission Control Protocol
TDLS	Tunneled Direct Link Setup (See [13])
TLV	Type-Length-Value
TOS	Type of Service
TS	Transport Stream
UDP	Universal Datagram Protocol
UIBC	User Input Back Channel
URG	Urgent Flag
URI	Universal Resource Identifier
URL	Universal Resource Locator
USB	Universal Serial Bus
VCL	Video Coding Layer
VESA	Video Electronics Standards Association
WFD	Wi-Fi Display
WLAN	Wireless Local Area Network
WPA2™	Wi-Fi Protected Access® 2
WSD	Wi-Fi Display Service Discovery

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3 WFD Architecture and Requirements

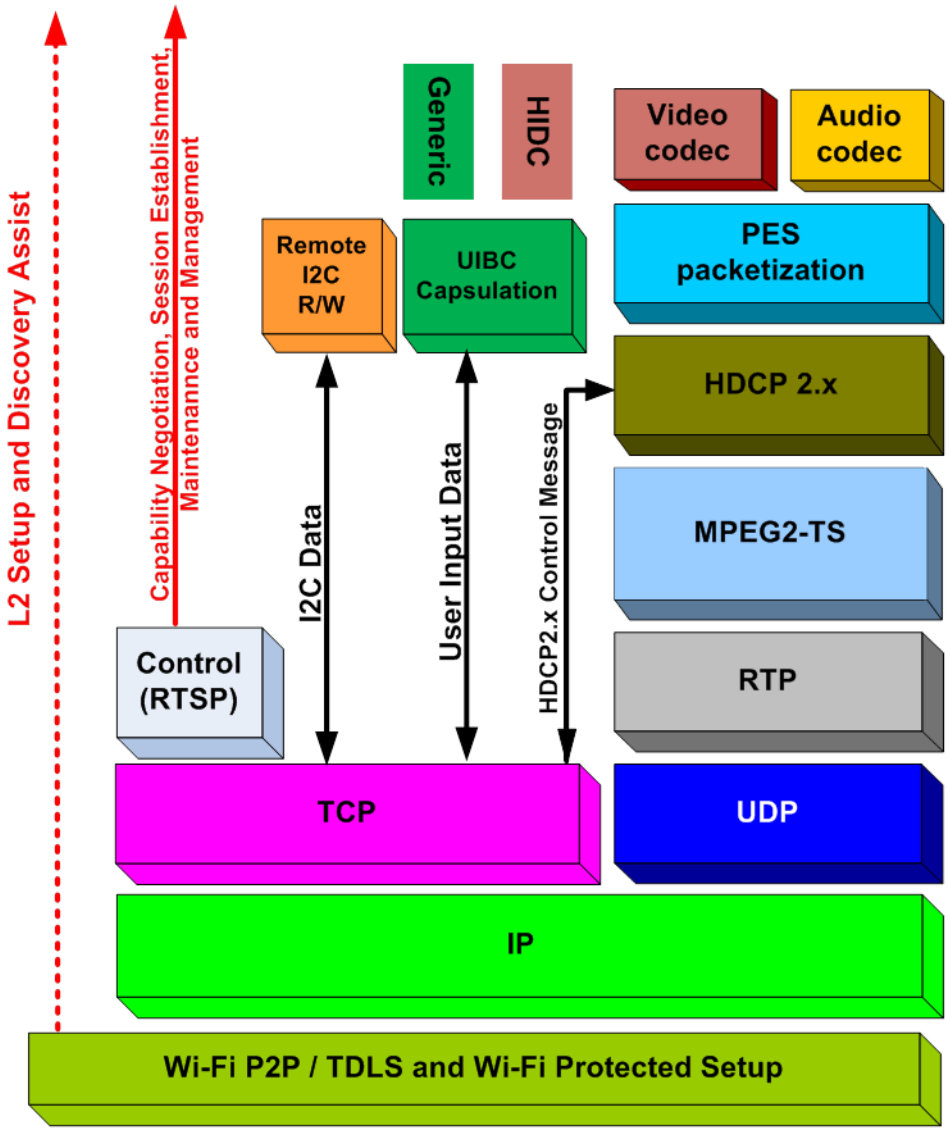

Figure 3-1 illustrates the functional blocks in the Wi-Fi Display data and control planes. The data plane consists of video codec (section 3.4.2 and 3.4.3), audio codec (section 3.4.1), PES packetization (Annex-B), the HDCP system 2.x[1] (section 4.7), and MPEG2-TS over RTP/UDP/IP (section 4.10.2 and Annex-B). The control plane consists of RTSP over TCP/IP (section 6), remote I2C Read/Write (section 7), UIBC with HIDC and generic user input (section 4.11), and the HDCP session key establishment (section 4.7). The Wi-Fi P2P/TDLS block forms the layer-2 connectivity using either Wi-Fi P2P or TDLS as described in section 4.5.

[1] When using "HDCP system 2.x" or "HDCP 2.x" in this Specification, "x" means 0, 1, 2, or higher numerical value. At the time of publication of this Specification, HDCP 2.2 is the latest version.

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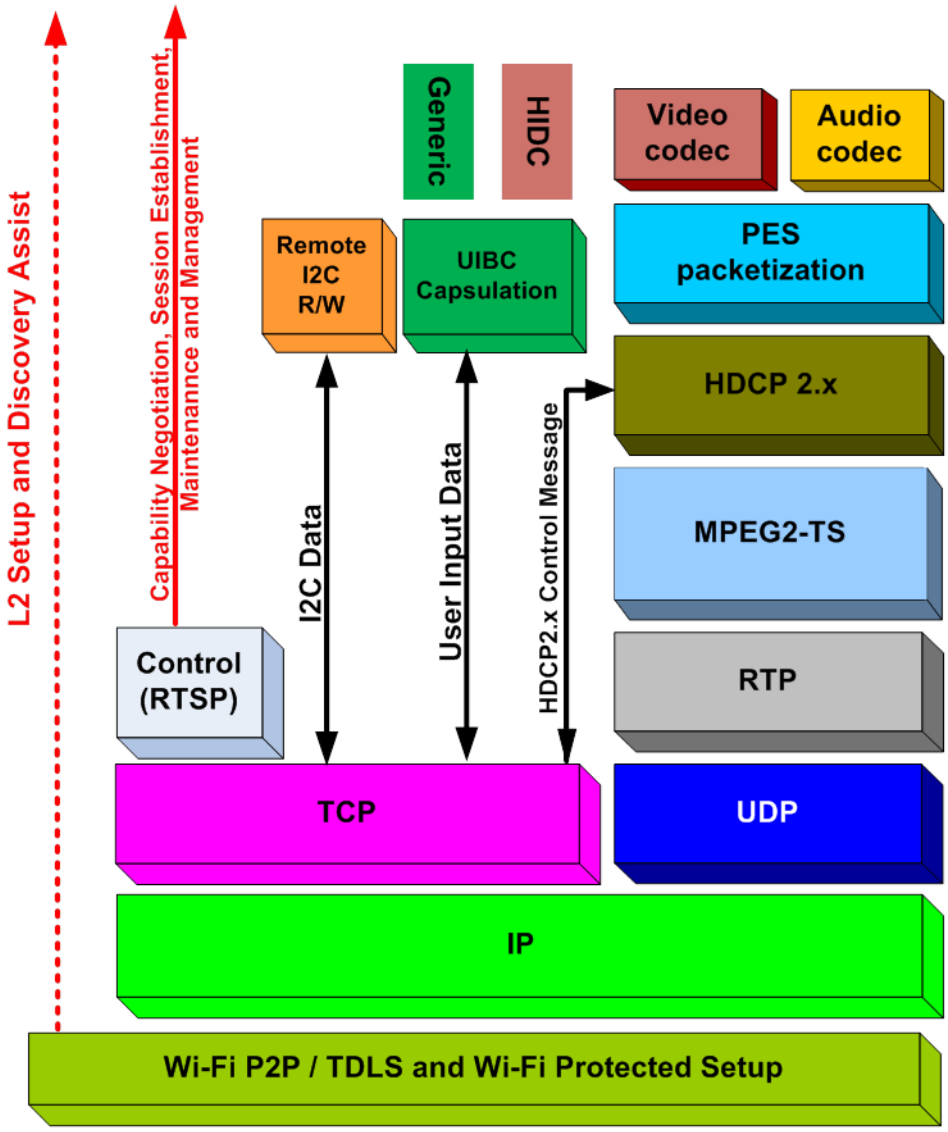

Figure 3-1 : Logical Data and Control Plane Connections

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3.1 WFD Source, Primary Sink, Secondary Sink and WFD Session

Figure 3-2 shows a simplified example of WFD Topology of the WFD Devices in a WFD Session.

Here one WFD Source and one Primary Sink are connected for AV streaming and stream control signaling. Other variations of the WFD Topologies and WFD Sessions are shown in the following sub-sections.

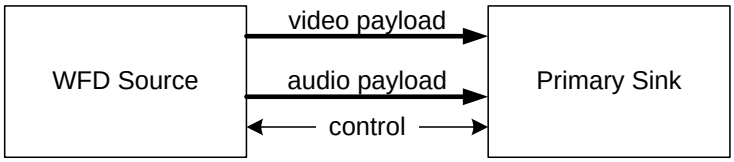

Figure 3-2 : Example of WFD Topology

3.1.1 WFD Source

A WFD Source shall support a single WFD Session. Support of more than one WFD Session is outside the scope of this Specification.

During a WFD Session, a WFD Source shall transmit an MPEG2-TS ([2]) to one WFD Sink.

A WFD Source shall support transmitting an MPEG2-TS that contains multiplexed a single audio and a single video elementary streams.

A WFD Source may choose to transmit an MPEG2-TS that contains only a video elementary stream.

A WFD Source may choose to transmit an MPEG2-TS that contains only an audio elementary stream.

If a WFD Source is connected to a Primary Sink and depending on the capability of the Primary Sink or content itself to be streamed or user's choice, the WFD Source may transmit an MPEG2-TS that contains either 1) an audio elementary stream and a video elementary stream or 2) only a video elementary stream.

If a WFD Source is connected to a Primary Sink and depending on the capability of the Primary Sink or content itself to be streamed or user's choice, the WFD Source may transmit an MPEG2-TS that contains only an audio elementary stream.

If a WFD Source is connected to a Secondary Sink, the MPEG2-TS shall contain only an audio elementary stream.

Table 3-1 summarizes the required capabilities of a WFD Source.

3.1.2 WFD Sink(s)

A WFD sink shall support a single WFD Session. Support of more than one WFD Session is outside the scope of this Specification.

Two types of WFD sinks are defined, i.e., a Primary Sink and a Secondary Sink.

3.1.2.1 Primary Sink:

During a WFD Session, a Primary Sink shall support receiving an MPEG2-TS from one WFD Source.

A Primary Sink shall support receiving an MPEG2-TS that contains multiplexed single audio elementary stream and single video elementary stream.

A Primary Sink shall support receiving an MPEG2-TS that contains only a video elementary stream.

A Primary Sink may support receiving an MPEG2-TS that contains only an audio elementary stream.

If a Primary Sink has an integrated video rendering function, the Primary Sink shall support one of following:

(a) render the video content included in the received MPEG2-TS that contains multiplexed single audio elementary stream and single video elementary stream.

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(b) output the video content included in the received MPEG2-TS that contains multiplexed single audio elementary stream and single video elementary stream to an externally connected video rendering device.

If a Primary Sink supports both of (a) and (b) above, the Primary sink may choose one operation depending on local policy (e.g., detecting attachment or detachment of an external rendering device) or a user may choose one operation.

If a Primary Sink has an integrated video rendering function, the Primary Sink shall support one of following:

(a) render the video content included in the received MPEG2-TS that contains only a video elementary stream.
(b) output the video content included in the received MPEG2-TS that contains only a video elementary stream to an externally connected video rendering device.

If a Primary Sink supports both of (a) and (b) above, the Primary Sink may choose one operation depending on local policy (e.g., detecting attachment or detachment of an external rendering device) or a user may configure the Primary Sink to choose one operation.

If a Primary Sink does not have an integrated video rendering function, the Primary Sink shall support outputting the video content included in the received MPEG2-TS that contains multiplexed single audio elementary stream and single video elementary stream to an externally connected video rendering device.

If a Primary Sink does not have an integrated video rendering function, the Primary Sink shall support outputting the video content included in the received MPEG2-TS that contains only a video elementary stream to an externally connected video rendering device.

If a Primary Sink has an integrated audio rendering function, the Primary Sink shall support one of following depending on implementation:

(a) render the audio content included in the received MPEG2-TS that contains multiplexed an audio and a video elementary streams.
(b) output the audio content included in the received MPEG2-TS that contains multiplexed audio elementary stream and video elementary stream to an externally connected audio rendering device.

If a Primary Sink supports both (a) and (b) above, the Primary Sink may choose one operation depending on local criteria (e.g., detecting attachment or detachment of an external rendering device) or a user may configure the Primary Sink to choose one operation.

If a Primary Sink has an integrated audio rendering function, the Primary Sink may support one of following depending on implementation:

(a) render the audio content included in the received MPEG2-TS that contains only an audio elementary stream.
(b) output the audio content included in the received MPEG2-TS that contains only an audio elementary stream to an externally connected audio rendering device.

If a Primary Sink supports both (a) and (b) above, the Primary Sink may choose one operation depending on local criteria (e.g., detecting attachment or detachment of an external rendering device) or a user may configure the Primary Sink to choose one operation.

If a Primary Sink does not have an integrated audio rendering function, the Primary Sink shall support outputting the audio content included in the received MPEG2-TS that contains multiplexed single audio elementary stream and single video elementary stream to an externally connected audio rendering device.

If a Primary Sink does not have an integrated audio rendering function, the Primary Sink may support outputting the audio content included in the received MPEG2-TS that contains only an audio elementary stream to an externally connected audio rendering device.

Table 3-1 summarizes the required capabilities of a Primary Sink.

3.1.2.2 Secondary Sink:

During a WFD Session, a Secondary Sink shall support receiving an MPEG2-TS from one WFD Source.

A Secondary sink shall support receiving an MPEG2-TS that contains only an audio elementary stream.

Table 3-1 summarizes the required capabilities of a Secondary Sink.

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3.1.3 Requirements for WFD Devices under Coupled Sink Operation

A WFD Source may support Coupled Sink Operation.

A Primary Sink may support Coupled Sink Operation.

A Secondary Sink may support Coupled Sink Operation.

Figure 3-6 illustrates the role of a WFD Source, a Primary Sink and a Secondary Sink under Coupled Sink Operation. In a Coupled Sink Operation, a Primary Sink and a Secondary Sink that support Coupling are Coupled together and in Coupled status (see section 3.1.2 and 4.9.1).

If a WFD Source supports Coupled Sink Operation and operates with a Primary Sink and a Secondary Sink in Coupled status, and if the Primary Sink does not support rendering audio content, the WFD Source shall transmit an MPEFG2-TS that contains a video elementary stream to the Primary Sink and shall transmit an MPEG2-TS that contains an audio elementary stream to the Secondary Sink.

If a WFD Source supports Coupled Sink Operation and operates with a Primary Sink and a Secondary Sink in Coupled status, and if the Primary Sink supports rendering audio content, the WFD Source shall transmit an MPEG2-TS that contains a video elementary stream to the Primary Sink and shall support dynamically switching the destination of an audio elementary stream between the Primary Sink and the Secondary Sink. This switching of the destination of an audio elementary stream may be triggered by a request from either the Primary Sink or the Secondary Sink, and shall not require tearing down of the already established WFD Session. This procedure is specified in section 4.9.6, 6.1.11 and 6.4.10.

A Primary Sink that supports Coupled Sink Operation shall follow the Coupled Sink Operation as described in section 4.9.1.

If a Primary Sink is Coupled with a Secondary Sink and if the Primary Sink operates with a WFD Source that supports Coupled Sink Operation, the Primary Sink shall support receiving an MPEG2-TS that contains a video elementary stream from the WFD Source.

A Secondary Sink that supports Coupled Sink Operation shall follow the Coupled Sink Operation as described in section 4.9.1.

If a Secondary Sink is Coupled with a Primary Sink and if the Secondary Sink operates with a WFD Source that supports Coupled Sink Operation, the Secondary Sink shall support receiving an MPEG2-TS that contains an audio elementary stream from the WFD Source.

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3.1.4 WFD Session

There are four kinds of WFD Sessions as described below:

- Audio only WFD Session where there is only one Primary Sink or one Secondary Sink, as illustrated in Figure 3-3.
- Video only WFD Session where there is only one Primary Sink, as illustrated in Figure 3-4.
- Audio/video WFD Session where there is only one Primary Sink, which renders both audio and video, as illustrated in Figure 3-5.
- Audio/video WFD Session where there is Coupled WFD Sinks, and the Primary Sink renders video while the Secondary Sink renders the corresponding audio. Figure 3-6 shows audio rendered at the Secondary Sink.

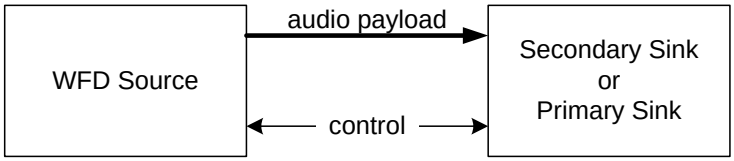

Figure 3-3 : Audio-only WFD Session

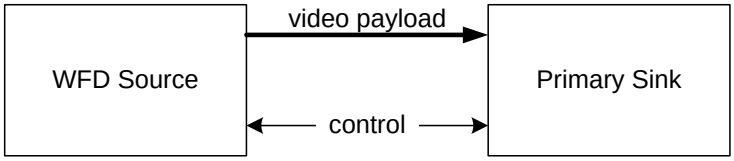

Figure 3-4 : Video-only WFD Session

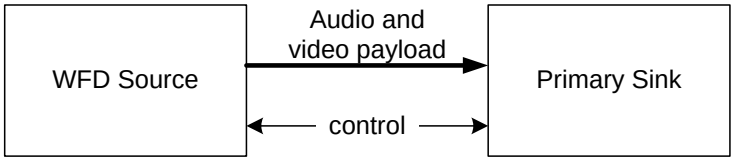

Figure 3-5 : Audio and video WFD Session

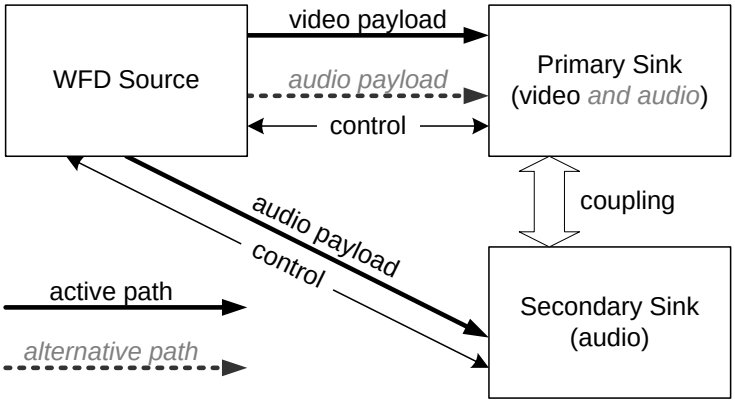

Figure 3-6 : WFD Session under Coupled Sink Operation

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3.2 WFD Connection Topology

A WFD Source shall use a WFD Connection with a WFD Sink for all WFD data and control messages. A WFD Sink shall use a WFD Connection with a WFD Source for all WFD data and control messages. The WFD Connection shall be either Wi-Fi P2P or TDLS.

3.2.1 Wi-Fi P2P

Figure 3-7 shows a WFD Connection using Wi-Fi P2P (Wi-Fi Direct) [7]. A WFD Device shall support a WFD Connection using Wi-Fi P2P.

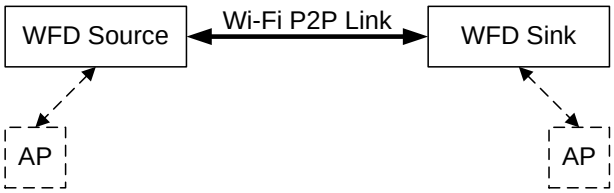

Figure 3-7 : WFD Connection using Wi-Fi P2P

Note: The APs shown in Figure 3-7 may be the same AP, or different APs, or may not exist.

A WFD Device may support concurrent operation with infrastructure BSS.

If a WFD Session including a single WFD Sink, either a WFD Source or a WFD Sink may be a P2P GO. If a WFD Session includes both a Primary Sink and a Secondary Sink, then the WFD Source shall be a P2P GO.

3.2.2 TDLS

Figure 3-8 shows a WFD Connection using TDLS. WFD Devices may support the WFD Connection using TDLS.

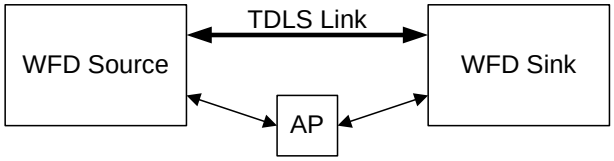

Figure 3-8 : TDLS Topology

If TDLS is used for a WFD Connection, then a WFD Source shall support maintaining connection with an AP (or a P2P GO) that the WFD Source is associated with. If TDLS is used for a WFD Connection, a WFD Sink shall support maintaining connection with an AP (or a P2P GO) that the WFD Sink is associated with.

Although Figure 3-8 has been simplified to show only one WFD Sink, a Secondary Sink in the same BSS may also be part of the same WFD Session; see Figure 3-6. In this case, the Secondary Sink shall have a different TDLS link with the WFD Source from the TDLS link between the WFD Source and the Primary Sink.

3.3 Functions and Services

3.3.1 Basic Wi-Fi Functions and Services

This Specification requires that a WFD Device shall pass the following WFA Certifications:

- 802.11n Certification (implicitly requires WPA2 [19] and WMM)
- Wi-Fi Protected Setup™ Certification [8] (Implicit in Wi-Fi Direct certification)
- Wi-Fi Direct Certification [7]

A WFD Device that supports Wi-Fi Display over TDLS shall pass the following WFA Certification:

- Wi-Fi TDLS Certification [13]

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3.3.2 Wi-Fi Display Specific Functions and Services

Table 3-1 summarizes the functions and services for WFD Devices.

The WFD Source column indicates whether the function/service is Mandatory (M) or Optional (O), for a WFD Source.

The Primary Sink and Secondary Sink columns indicate whether the function/service is Mandatory (M) or Optional (O), for a WFD Sink.

A WFD Device that advertises itself as being capable of both WFD Source and Primary Sink functionality during the WFD Device Discovery shall support both sets of functionalities. For such WFD Devices, one role (WFD Source vs. Primary Sink) shall be selected prior to a single WFD Session and shall not change during that WFD Session. Such WFD Device may support concurrent operation as a WFD Source in a WFD Session and as a Primary Sink in another WFD Session but such operation is outside the scope of this Specification.

Functions and Services	WFD Source	Primary Sink	Secondary Sink
WFD Device Discovery (section 4.3)	M	M	M[3]
WFD Service Discovery (section 4.4)	O	O	O
WFD Capability negotiation (section 4.6)	M	M	M
WFD Coupled Sink Operation (section 4.9)	O	O	O
WFD Connection Setup, with a WFD Sink (section 4.5.2)	M	M	M
WFD Session establishment, with a WFD Sink (section 4.8)	M	M	M
Encode and packetization of the captured Display	M	N/A	N/A
Transport of multiplexed audio and video payload	M	M	N/A
De-multiplex, de-packetization and decode of received audio and video payload	N/A	M[1]	N/A
Rendering of decoded video on local display panel or a display panel that is attached to a WFD Sink (dongle)	N/A	M	N/A
Power Save mechanisms[4]	M	M	M
Session termination (section 4.12)	M	M	M
Encode and packetization of captured audio	M	N/A	N/A
Transport of video payload without audio	O	M	N/A
Transport of audio payload without video	O	O	M
Multiplex video and audio payload	M[2]	N/A	N/A
De-packetization and decode of received audio payload that is not multiplexed with video payload	N/A	O	M
Rendering of decoded audio on local speakers or speakers attached to a WFD Sink (dongle)	N/A	M[1]	M
Link Content Protection (for protected content) (section 4.7) *Note: If Link Content Protection is not supported either by the WFD Source or the WFD Sink, protected content shall not be streamed.*	O	O	O
Time Synchronization (section 4.10.1)	O	O	O
Concurrent WLAN operation (section 4.14)	O	O	N/A

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Persistent WFD group (section 4.13)	O	O	O
AV Stream Control using RTSP (section 6.2.5, 6.2.6, 6.2.7)	M	M	M
AV Audio Stream Routing Control during Coupled Sink Operation (section 4.10.4)	O	O	O
User Input Back Channel (section 4.11)	O	O	N/A
Preferred Display mode (section 8)	O	O	N/A
Remote I2C Read/Write (section 7)	O	O	N/A
WFD Standby / resume (section 4.15)	O	O	O

Table 3-1 : Functions and Services

[1] If a Primary Sink does not have an integrated audio rendering function or an audio output port to be connected to an external audio rendering device, decoding or rendering the audio payload is not required to be supported.

[2] If a Primary Sink does not have an integrated audio rendering function or an audio output port to be connected to an external audio rendering device, the WFD Source may not transmit multiplexed audio and video payload to the Primary Sink.

[3] A Secondary Sink may support initiating the WFD Device Discovery, but shall support following the WFD Device Discovery procedure initiated by a WFD Source or a Primary Sink.

[4.] Capability to support P2P client in WMM-PS is mandatory when acting as Wi-Fi P2P GO, as specified in [7]. Capabilities to follow Opportunistic Power Save and Notice of Absence from Wi-Fi P2P GO are mandatory when acting as Wi-Fi P2P client, as specified in [7].

3.4 Encoder/Decoder Characteristics

The audio/video industry uses a wide variety of different methods to encode and decode AV content and there is considerable potential for different AV devices to be incompatible with one another. This Specification defines a core subset of these methods to ensure interoperability between all WFD Devices at a baseline level (Mandatory), and allows for the inclusion of other methods (Optional) at the discretion of the device manufacturer.

A WFD Sink shall only indicate the audio and video configurations that it supports in an RTSP M3 response message (described in section 6.4.3).

3.4.1 Audio

An audio capable WFD Device shall support the audio format of 2 channel LPCM audio with16 bits per sample and 48000 samples/second as specified in [5]. Other allowable optional audio formats [5], are listed in Table 3-2.

Format Description
LPCM 44.1 ksps, 16 bits, 2 channels; CD Quality Audio
48ksps, 16bits per sample, 2 channels, MPEG-2 AAC-LC using ADTS
48ksps, 16bits per sample, 4 channels, MPEG-2 AAC-LC using ADTS
48ksps, 16bits per sample, 6 channels, MPEG-2 AAC-LC using ADTS
48ksps, 16bits per sample, 8 channels, MPEG-2 AAC-LC using ADTS
48ksps, 16 bits per sample, 2 channels, AC-3
48ksps, 16 bits per sample, 4 channels, AC-3

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48ksps, 16 bits per sample, 6 channels, AC-3

Table 3-2 : Optional Audio CODEC Formats

3.4.2 Video

A WFD Device shall use H.264 [1] as the video CODEC.

A video capable WFD Device shall support 640x480 p60 with the Constrained Baseline Profile (CBP) codec of H.264 at level 3.1 as defined in [1].

A WFD Device may use the H.264 Level from 3.1 to 4.2 for the CBP and CHP in this Specification.

A video capable WFD Device shall support 640x480 p60 with codec of H.264 CBP at level 3.1. If a WFD Device supports higher resolution(s) of 60Hz family (i.e., at least one of 29.97Hz, 30.00Hz, 59.94Hz and 60.00Hz) than 640x480, it shall also support 720x480 p60 with codec of H.264 CBP at level 3.1. If a WFD Device supports higher resolution(s) of 50Hz family (i.e., at least one of 25.00Hz and 50.00Hz) than 640x480, it shall also support 720x576 p50 with codec of H.264 CBP at level 3.1.

All other combinations of 2D video formats listed in Table 3-4, H.264 Profile listed in Table 3-3 and H.264 level (from 3.1 to 4.2) are optional.

Table 3-3 lists H.264 tools for each H.264 Profile included in the Specification.

A Primary Sink shall support tools marked “Y” in the CBP column. If a Primary Sink supports CHP, the Primary Sink shall support tools marked “Y” in the CHP column.

A Primary Sink is not required to support tools marked “N” for each Profile.

A WFD Source may use tools marked “Y” for each Profile. A WFD Source shall not use tools marked “N” for each Profile.

The Constrained High Profile (CHP) is based on the standardized High Profile of H.264, but a WFD Source shall not use the B slice tool or the CABAC entropy coding tool.

Tools	CBP	CHP
I and P Slices	Y	Y
B Slices	N	N
SI and SP Slices	N	N
Multiple Reference Frames	N	Y
In-Loop Deblocking Filter	Y	Y
CAVLC Entropy Coding	Y	Y
CABAC Entropy Coding	N	N
Flexible Macroblock Ordering (FMO)	N	N
Arbitrary Slice Ordering (ASO)	N	N
Redundant Slices (RS)	N	N
Data Partitioning	N	N
Interlaced Coding (PicAFF, MBAFF)	N	Y
4:2:0 Chroma Format	Y	Y
Monochrome Video Format (4:0:0)	N	Y

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4:2:2 Chroma Format	N	N
4:4:4 Chroma Format	N	N
8 Bit Sample Depth	Y	Y
9 and 10 Bit Sample Depth	N	N
11 to 14 Bit Sample Depth	N	N
8x8 vs. 4x4 Transform Adaptivity	N	Y
Quantization Scaling Matrices	N	Y
Separate Cb and Cr QP control	N	Y
Separate Color Plane Coding	N	N
Predictive Lossless Coding	N	N

Table 3-3 : Wi-Fi Display H.264 Profiles

Table 3-4 lists the set of 2D video resolutions and frame rates. For Standard Definition and High Definition modes refer to [11], and VESA formats to [37].

Format		Description	Required minimum H.264 Level
Resolution	**Frames/Fields per second, (i) interlaced or (p) progressive**		
640x480	p60[1]	Standard Definition (Mandatory for all WFD Devices that support video), CEA format.	3.1
720x480	p60[1]	Standard Definition, CEA format.	3.1
720x480	i60[1]	Standard Definition, CEA format.	3.1
720x576	p50	Standard Definition, CEA format.	3.1
720x576	i50	Standard Definition, CEA format.	3.1
1280x720	p30[2]	High Definition, CEA format.	3.1
1280x720	p60[1]	High Definition, CEA format.	3.2
1920x1080	p30[2]	High Definition, CEA format.	4
1920x1080	p60[1]	High Definition, CEA format.	4.2
1920x1080	i60[1]	High Definition, CEA format.	4
1280x720	p25	High Definition, CEA format.	3.1
1280x720	p50	High Definition, CEA format.	3.2
1920x1080	p25	High Definition, CEA format.	3.2
1920x1080	p50	High Definition, CEA format.	4.2
1920x1080	i50	High Definition, CEA format.	3.2
1280x720	p24[3]	High Definition, CEA format.	3.1

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1920x1080	p24[3]	High Definition, CEA format.	3.2
800x600	p30	SVGA; VESA format.	3.1
800x600	p60	SVGA; VESA format.	3.2
1024x768	p30	XGA; VESA format.	3.1
1024x768	p60	XGA; VESA format.	3.2
1152x864	p30	XGA+; VESA format.	3.2
1152x864	p60	XGA+; VESA format.	4
1280x768	p30	WXGA; VESA format.	3.2
1280x768	p60	WXGA; VESA format.	4
1280x800	p30	WXGA; VESA format.	3.2
1280x800	p60	WXGA; VESA format.	4
1360x768	p30	WXGA; VESA format.	3.2
1360x768	p60	WXGA; VESA format.	4
1366x768	p30	WXGA; VESA format.	3.2
1366x768	p60	WXGA; VESA format.	4.2
1280x1024	p30	SXGA (17” and 19” LCD); VESA format.	3.2
1280x1024	p60	SXGA (17” and 19” LCD); VESA format.	4.2
1400x1050	p30	SXGA+ (14” and 15” PC); VESA format.	3.2
1400x1050	p60	SXGA+ (14” and 15” PC); VESA format.	4.2
1440x900	p30	WXGA+ (19” LCD); VESA format.	3.2
1440x900	p60	WXGA+ (19” LCD); VESA format.	4.2
1600x900	p30	VESA format.	3.2
1600x900	p60	VESA format.	4.2
1600x1200	p30	UXGA (20” LCD); VESA format.	4
1600x1200	p60	UXGA (20” LCD); VESA format.	4.2
1680x1024	p30	WSXGA (19” LCD); VESA format.	3.2
1680x1024	p60	WSXGA (19” LCD); VESA format.	4.2
1680x1050	p30	SXGA (22” LCD); VESA format.	3.2
1680x1050	p60	SXGA (22” LCD); VESA format.	4.2
1920x1200	p30	WUXGA; VESA format.	4.2
800x480	p30	Handheld devices	3.1
800x480	p60	Handheld devices	3.1
854x480	p30	Handheld devices	3.1
854x480	p60	Handheld devices	3.1
864x480	p30	Handheld devices	3.1

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864x480	p60	Handheld devices	3.1
640x360	p30	Handheld devices	3.1
640x360	p60	Handheld devices	3.1
960x540	p30	Handheld devices	3.1
960x540	p60	Handheld devices	3.1
848x480	p30	Handheld devices	3.1
848x480	p60	Handheld devices	3.1

Table 3-4 : Supported Video Resolutions and frame rates

Notes:

1. 60fps (frame per sec for progressive and field per sec for interlace) for CEA resolutions here includes 60.000fps and 59.94fps.
2. 30fps for CEA resolutions here includes 30.000Hz and 29.97fps.
3. 24fps for CEA resolutions here includes 24fps and 23.98fps.

DTS/PTS values in PES Header shall not use rounded numbers but shall use the exact number of each frames (or fields) per second.

3.4.3 Stereoscopic 3D video

A WFD Device may support stereoscopic 3D video. If a WFD Device supports stereoscopic 3D video, it shall use H.264 CODEC and profiles as described in Table 3-3 for stereoscopic 3D video.

Table 3-5 lists the combination of video resolutions, refresh rates and the transmission schemes of left and right picture for stereoscopic 3D video.

Transmission Method	Format		Required minimum H.264 Level
	Description	Frames per second, (i) interlaced or (p) progressive	
Top & Bottom [Half]	1920x(540+540)	p60	4.2
	1920x(540+540)	p50	4.2
	1920x(540+540)	p30	4
	1920x(540+540)	p24	3.2
	1280x(360+360)	p60	3.2
	1280x(360+360)	p50	3.2
	1280x(360+360)	p30	3.1
	1280x(360+360)	p25	3.1
	1280x(360+360)	p24	3.1
	640x(240+240)	p60	3.1
	720x(240+240)	p60	3.1
	720x(288+288)	p50	3.1
	1920x1080	p24 for L and p24 for R	4.2

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Frame Sequential	1280x720	p60 for L and p60 for R	4.2
	1280x720	p30 for L and p30 for R	3.2
	1280x720	p50 for L and p50 for R	4.2
	1280x720	p25 for L and p25 for R	3.2
Frame Packing	1920x(1080+45+1080)	i60	4.2
	1920x(1080+45+1080)	i50	4.2
	1920x(1080+45+1080)	p30	4.2
	1920x(1080+45+1080)	p24	4.2
	1280x(720+30+720)	p60	4.2
	1280x(720+30+720)	p30	4
	1280x(720+30+720)	p50	4.2
	1280x(720+30+720)	p25	3.2
Side by Side [Half]	(960+960)x1080	p60	4.2
	(960+960)x1080	i60	4
	(960+960)x1080	p50	4.2
	(960+960)x1080	i50	3.2
	(960+960)x1080	p24	3.2
	(640+640)x720	p60	3.2
	(640+640)x720	p50	3.2
	(640+640)x720	p30	3.1
	(640+640)x720	p25	3.1
	(640+640)x720	p24	3.1
	(320+320)x480	p60	3.1
	(360+360)x480	p60	3.1
	(360+360)x576	p50	3.1

Table 3-5 : Wi-Fi Display Supported Configurations for 3D Video

If a WFD Device supports 3D video using Wi-Fi Display, then it shall support the Top & Bottom [1] transmission scheme with resolution of 1920x(540+540) and a refresh rate of p24.

If a WFD Device supports 3D video with a refresh rate in the 60Hz family (i.e., at least one of 29.97Hz, 30.00Hz, 59.94Hz and 60.00Hz) using Wi-Fi Display, then it shall support the Top & Bottom transmission scheme with a resolution of 1280x(360+360) and a refresh rate of p60.

If a WFD Device supports 3D video with a refresh rate in the 50Hz family (i.e., at least one of 25.00Hz and 50.00Hz) using Wi-Fi Display, then it shall support a Top & Bottom transmission scheme with the resolution of 1280x(360+360) and a refresh rate of p50.

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4 WFD Session – Functional Description and Procedures

The following sections discuss the discovery, connection setup, capability negotiation, content protection and session establishment. At a high level, a user interface on a WFD Source and/or a WFD Sink presents the discovered WFD Devices to the user via a user interface so that the user may select the peer device to be used in a WFD Session. Once device selection is performed by the user, a WFD Connection is established and the transport layer is used to stream AV media from a WFD Source to a peer WFD Sink.

The ability to select a peer is mandatory on a WFD Sink and optional on WFD Source.

Presentation and the method of selection of the discovered WFD Devices is outside the scope of this Specification.

4.1 Reference Model

Figure 4-1shows a reference model for session management of a WFD Source and WFD Sink. This conceptual model includes a set of predefined functions such as WFD Device Discovery, presentation, session control, and transport.

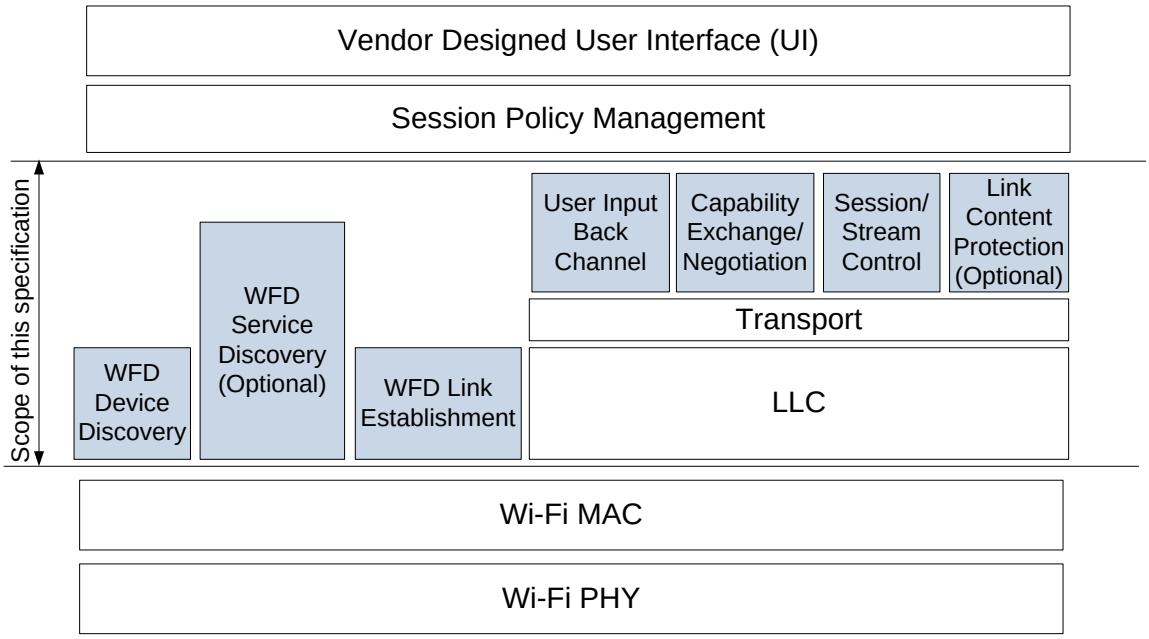

Figure 4-1 : Reference Model for Session Management in WFD Devices

Figure 4-2 shows a reference model for AV payload processing for WFD Source and WFD Sink.

The protocols and procedures for each of the functions illustrated in Figure 4-1 and Figure 4-2 are described in subsequent sections.

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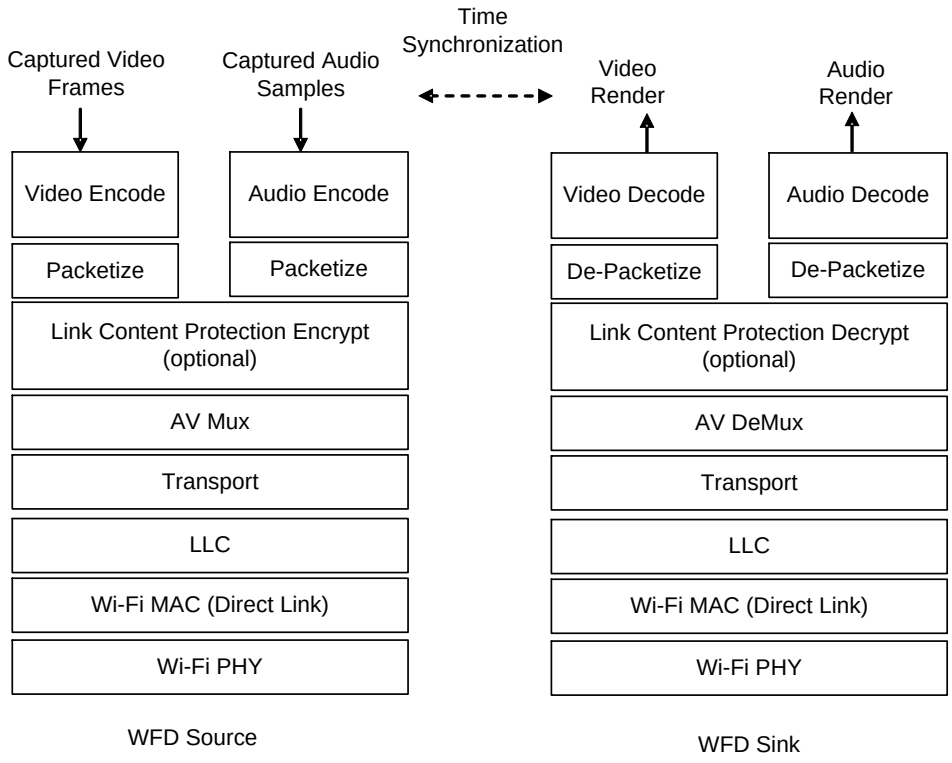

Figure 4-2 : Reference Model Audio/Video Payload Processing

4.2 WFD Connection Setup, WFD Session Establishment and Management Functions

This section describes the management protocols, procedures and order of operations used to establish and manage a WFD Session.

Figure 4-5 and Figure 4-6 below provide pictorial representations of the lifetime of a WFD Session. A WFD Session is defined between a WFD Source and a WFD Sink (or WFD Sinks in case of Coupled Sink Operation). In a WFD Session, the WFD Source transmits audio and/or video content to a WFD Sink (or WFD Sinks) and a WFD Sink receives (and renders) the content or outputs the content to an external device

The general sequence for WFD Connection Setup, WFD Session establishment, and management is as follows:

1. **WFD Device Discovery**: Initially, a WFD Source and a WFD Sink discover each other's presence, prior to WFD Connection Setup. See section 4.3 for details on this process.
2. **WFD Service Discovery**: This optional step allows a WFD Source and a WFD Sink to discover each other's service capabilities prior to the WFD Connection Setup. See section 4.4 for details on this process.
3. **Device Selection**: This step allows a WFD Source or a WFD Sink to select the peer WFD Device for WFD Connection Setup. During this step, user input and/or local policies may be used for device selection.
4. **WFD Connection Setup**: This step selects the method (Wi-Fi P2P or TDLS) for the WFD Connection Setup with the selected peer WFD Device and allows establishment of a WPA2-secured single hop link with the selected WFD Device. See section 4.5.2, 4.5.3 and 4.5.4 for details on this process.
5. **WFD Capability Negotiation:** This step includes a sequence of RTSP message exchanges between the WFD Source and WFD Sink(s) to determine the set of parameters that define the audio/video payload during a WFD Session. See section 4.6 for details on this process.

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6. **WFD Session Establishment**: This step establishes the WFD Session. During this step, the WFD Source selects the format of audio/video payload for a WFD Session within a capability of the WFD Sink and informs the selection to the WFD Sink. See section 4.8 for details on this process.
7. **User Input Back Channel Setup:** This optional step establishes a communication channel between the WFD Source and the WFD Sink for transmitting control and data information emanating from user input at the WFD Sink. See section 4.11 for details on this process.
8. **Link Content Protection Setup**: This optional step derives the session keys for Link Content Protection used for transmission of protected content. See section 4.7 for details on this process.
9. **Payload Control:** Payload transfers are started after the above sequences are completed, and may be controlled during a WFD Session. See section 4.10.3 and 4.10.4 for details of this process.
10. **WFD Source and WFD Sink standby:** This optional step enables the WFD Source and WFD Sink to manage and control power modes such as standby and resume (e.g., wake-up) while the WFD Session is maintained. See section 4.15 for details on this process.
11. **WFD Session Teardown**: This step terminates the WFD Session. See section 4.12 for details on this process.

4.3 WFD Device Discovery

Wi-Fi Display Device Discovery builds upon the P2P Device Discovery mechanisms defined in [7] enabling a WFD Device to quickly find a peer WFD Device and to determine whether a connection may be established for a subsequent WFD Session.

A WFD Source shall support initiating and following the procedures of WFD Device Discovery.

A Primary Sink shall support initiating and following the procedures of WFD Device Discovery.

A Secondary Sink may support initiating WFD Device Discovery.

A Secondary Sink shall support following procedures of WFD Device Discovery initiated by a WFD Source or a Primary Sink.

A WFD Device shall comply with all procedures as specified for P2P Device Discovery in [7] with the following additions.

- A WFD Device shall include the WFD Information Element (WFD IE) in all beacon, probe request and probe response frames. The WFD IE carries basic information such as device-type and device-status as specified in section 5.1.1 so as to facilitate an optimal connection with a peer WFD Device. If a WFD Device is acting as a GO and receives a Probe Request frame containing a WFD IE, then that WFD Device shall respond with a Probe Response frame containing the information of its WFD capable client(s) as specified in section 5.1.11.

- A WFD Device that is associated with an infrastructure AP, and that is operating as a Wi-Fi P2P device, should respond to Probe Requests containing a P2P IE, a WFD IE, and a P2P wildcard SSID. The Probe Response frame shall have the P2P IE and the WFD IE. This Probe Response frame should be transmitted on the channel on which the Probe Request was received.

If a device supports the capability to become either a WFD Source or a Primary Sink, the device may advertise its device-type as a dual role capable device during the WFD Device Discovery. Additionally, such a device may advertise its device-type as a dual-role capable device during a WFD Service Discovery as described in section 4.4. However, the device shall advertise only one of these capabilities (i.e., either a WFD Source or a Primary Sink) during WFD Connection Setup, and WFD Capability Negotiation.

If a WFD Device supports TDLS for a WFD Session, the WFD Device may transmit a tunneled Probe Request frame (Figure 4-3) containing a WFD IE via an AP or a GO to a broadcast destination address (DA).

A WFD Device may transmit a tunneled Probe Request frame via an AP or a GO to a unicast DA (for example, if the MAC address of the target WFD Device is already known) as in the case of previously paired WFD Devices.

If a WFD Device supports TDLS as the connection mechanism for a WFD Session and if the WFD Device receives a tunneled Probe Request frame with the WFD IE, the WFD Device shall respond by transmitting a tunneled Probe Response frame with the WFD IE (via the AP or the GO) to the STA that transmitted the tunneled Probe Request.

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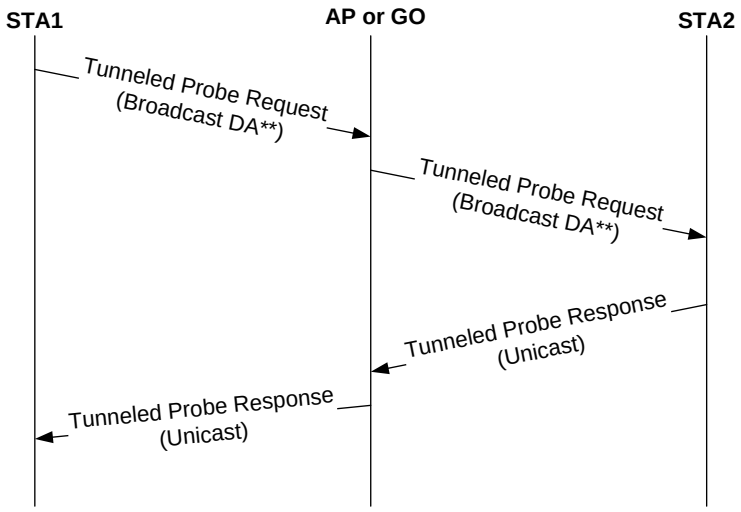
A WFD Device which does not support TDLS may respond to a tunneled Probe Request with a tunneled Probe Response frame.

If a Wi-Fi P2P device does not support intra-BSS distribution then that device shall not attempt to setup a TDLS link and it shall not transmit tunneled Probe Requests or Responses.



** Tunneled Probe Requests may also be sent to Unicast DA, e.g., for subsequent re-connections

Figure 4-3 : Tunneled Probing when TDLS is used

4.4 WFD Service Discovery

Wi-Fi Display Service Discovery is an optional procedure which builds upon the procedures defined in [7] to enable devices to discover additional Wi-Fi Display associated capabilities of peer devices.

WFD Devices may support initiating and following the procedures of WFD Service Discovery, as specified herein.

WFD Devices shall follow all procedures as specified for P2P Service Discovery in [7] with the following additions.

- WFD Service Discovery shall make use of the Service Discovery Request and Response Frames as defined in [7] with a new Service Protocol Type of 0x04 for Wi-Fi Display. The specific Wi-Fi Display Capabilities (Services) are specified as information subelements defined in section 5.1
- The WFD Service Discovery procedure is an optional frame exchange which may be performed with any discovered WFD Device that supports it. A WFD Device indicates its ability to support WFD Service Discovery via the WSD (WFD Service Discovery) Support bit as defined in section 5.1.2. Note that a WFD Device supporting WFD Service Discovery shall also support P2P Service Discovery and shall set the Service Discovery bit in the Device Capability Bitmap of the P2P Capability subelement as specified in [7].
- A WFD Device may transmit a WFD Service Discovery frame to a discovered device only if the discovered device has its WSD bit set. The decision to perform WFD Service Discovery is implementation specific.

4.5 WFD Connection Setup

The primary purpose of the WFD Device Discovery and (optional) Service Discovery procedures is to facilitate the decision of which WFD Devices are to be paired and setup a WFD Session. However the decision process (i.e. whether to establish a pairing between a WFD Source and a WFD Sink) is implementation specific and outside the scope of this Specification.

Consequently WFD Devices shall support WFD Connection Setup as specified herein.

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There are two underlying connectivity schemes for establishing a WFD Connection, i.e., Wi-Fi P2P and TDLS as specified in section 3.2. The connectivity scheme to be employed is determined based on the Connectivity Scheme Resolution as detailed in section 4.5.1.

After a successful WFD Connection Setup between WFD Devices (using either Wi-Fi P2P or TDLS as specified in sections 4.5.2 and 4.5.3 respectively), a WFD Device shall perform WFD Capability Negotiation as specified in section 4.6. Upon successful completion of the WFD Capability Negotiation phase, the two WFD Devices are said to be paired.

If a discovered WFD Device sets WFD Session Availability bits (B5B4) in the WFD Device Information field of the WFD Device Information subelement to 0b00 (i.e., not available), other WFD Devices shall not attempt WFD Connection establishment with that WFD Device until that WFD Device indicates its availability by setting same bits to 0b01 (i.e., available).

4.5.1 Connectivity Scheme Resolution

WFD Devices determine the connectivity scheme to be used for a WFD Session based on the mutual resolution of the Preferred Connectivity (PC) bit and the information in an Associated BSSID subelement carried by the WFD IE.

A WFD Device which supports TDLS and prefers its use for Wi-Fi Display shall set the PC bit in the WFD Device Information field of WFD Device Information subelement within the WFD IE to one, only if either one of the following two compound conditions is fulfilled:

1. If a WFD Device is associated with an AP and
   if the AP has set its TDLS Prohibited bit to zero in the Capabilities field of the Extended Capabilities element, as specified in [13], contained in the Beacon.
2. If a WFD Device is associated with a GO and
   if the GO has set its TDLS Prohibited bit to zero in the Capabilities field of the Extended Capabilities element, as specified in [13], contained in the Beacon, and
   if the GO has set its intra-BSS distribution bit to one in the Device Capability Bitmap of the P2P Capability attribute, as specified in [7], contained in the Beacon.

When both a WFD Source and a WFD Sink attempt to form a WFD Session and are associated with the same AP (as determined from the Associated BSSID subelement within the WFD IE), the connectivity scheme to be used for the WFD Session shall be resolved as per the rules defined in Table 4-1 below.

PC (WFD Source)	PC (WFD Sink)	Associated with same BSSID	Resolved Connectivity Scheme
0	0	Do not care	Wi-Fi P2P
0	1	Do not care	Wi-Fi P2P
1	0	Do not care	Wi-Fi P2P
1	1	No	Wi-Fi P2P
1	1	Yes	TDLS

Table 4-1 : Connectivity Scheme Resolution

A WFD Device that supports TDLS shall include the MAC address of the interface which it intends to use for the subsequent connection as an Alternate MAC Address subelement within the WFD IE in the (tunneled) Probe Response frame if the interface is different from the one on which the (tunneled) Probe Request was received.

The WFD Device shall use the rules defined in Table 4-1 to deduce the connectivity scheme to be used. If the resolved connectivity scheme implies use of an interface different from the one used during device discovery, then the MAC address corresponding to the inferred interface shall be included in the Alternate MAC Address subelement within the WFD IE in the (tunneled) Probe Response frame.

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The WFD Device performing discovery may then use the information indicated in the Alternate MAC Address subelement within the WFD IE received in the (tunneled) Probe Response either to setup a TDLS link with the WFD Device or as a Device ID attribute in the P2P IE in the Probe Request to retrieve the P2P attributes of the WFD Device required for P2P link establishment.

4.5.2 Establishing a WFD Connection using Wi-Fi P2P

A WFD Device which intends to establish a WFD Session using Wi-Fi P2P as the underlying connectivity scheme shall form a P2P group as per the methods specified in [7].

After the establishment of a P2P group, WFD Devices perform WFD Capability Negotiation as specified in section 4.6. Subsequently, the IP address of the P2P client is assigned by the GO, as specified in section 3.2.6 in [7].

A WFD Device which intends to be discovered shall set the P2P Discoverability bit in the Device Capability Bitmap of the P2P Capability attribute to 0b1.

4.5.2.1 Usage of a WFD IE to establish P2P connection

To establish a P2P connection for a WFD Session, a WFD IE with the WFD Device Information subelement (as specified in section 5.1.2) shall be included in the following frames transmitted by a WFD Device:

- Beacon frames (see section 5.2.1),
- Probe Request frames (see section 5.2.2),
- Probe Response frame (see section 5.2.3),
- Association/Reassociation Request frames (see section 5.2.4),
- Association/Reassociation Response frames(see section 5.2.5),
- GO Negotiation Request frames (see section 5.2.6.1),
- GO Negotiation Response frames (see section 5.2.6.2),
- GO Negotiation Confirmation frames (see section 5.2.6.3),
- P2P Invitation Request frames (see section 5.2.6.4),
- P2P Invitation Response frames (see section 5.2.6.5),
- Provision Discovery Request frames (see section 5.2.6.6), and
- Provision Discovery Response frames (see section 5.2.6.7).

The WFD IE may optionally include an Associated BSSID subelement (as specified in section 5.1.3).

The content of the WFD Device Information subelement should be immutable during the period of P2P connection establishment, with the following exceptions:

- WFD Device Type bits
  - If the WFD Device supports dual role capability (i.e., both a WFD Source and a Primary Sink), it can indicate this capability in the WFD Device Type bits (B1B0) of the WFD Device Information field of WFD Device Information subelement within the WFD IE in Probe Request frames and/or Probe Response frames during the P2P Scan phase and/or Find phase and in Beacon frames by setting to 0b11
  - In any other cases, these bits shall not be set to 0b11. The role of a WFD Device shall be fixed as either a WFD Source or a Primary Sink while establishing a WFD Connection.
- WFD Session Availability bits
  - Depending on the availability of the WFD Device for a WFD Session, the value for WFD Session Availability bits (B5B4) of the WFD Device Information field of WFD Device Information subelement within the WFD IE may change.

If the type of WFD Device indicated in the WFD Device Type bits (B1B0) in the WFD Device Information field within the WFD IE in the received GO Negotiation Request frame, Association/Reassociation Request frame, or P2P Invitation Request frame addressed to the recipient is different from the expected value (e.g., indicating that the sender is a WFD Source and the recipient of the request is also a WFD Source), the recipient should indicate a status code of 2 (fail, incompatible parameter) in the Status attribute within the P2P IE when transmitting the corresponding GO Negotiation Response frame, Association/Reassociation Response frame, or P2P Invitation Response frame respectively.

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After the establishment of a WFD Session, the WFD Device that is acting as a P2P GO shall set the WFD Device Type bits (B1B0) of the WFD Device Information field of the WFD Session Information subelement within the WFD IE in all Probe Response frames and P2P Invitation Request/ Response frames, to indicate the type of WFD Device associated.

If the WFD Device is a P2P client of this GO, and indicates its WFD Device Type bits (B1B0) as 0b11 in the WFD Device Information field of the WFD Device Information subelement within the WFD IE in preceding Probe Request/Response frames, the WFD Device that is acting as a P2P GO shall set the WFD Device Type bits (B1B0) of the WFD Device Information field of the WFD Session Information subelement to 0b11 in the WFD IE in all Probe Response frames and P2P Invitation Request/Response frames.

4.5.3 Establish a WFD Connection using TDLS

When two WFD Devices that are associated with a common infrastructure AP or a common GO intend to establish a WFD Session and have determined that TDLS is the preferred connectivity scheme (as per section 4.5.1), each WFD Device shall support acting as either a TDLS initiator STA or a TDLS responder STA to setup the TDLS connection through the AP or the GO as specified in [13].

The TDLS link shall be protected using WPA2.

If an associated infrastructure AP uses WEP or WPA for the link between the AP and the WFD Device, the WFD Device shall not transmit the TDLS Setup Request frame for WFD. If an associated infrastructure AP uses WEP or WPA for the link between the AP and the WFD Device, the WFD Device shall not accept the TDLS Setup Request frame for a WFD Connection. If a WFD Device receives such a request, the WFD Device shall reject it by transmitting a TDLS Setup Response frame with status code as 5 ("Security disabled").

Subsequent to the establishment of a TDLS connection, WFD Devices shall perform WFD Capability Negotiation as specified in section 4.6.

The IP address of a WFD Device to be used in TDLS topology is assigned by a DHCP server or similar entity in the network. The negotiated IP address is used for the Layer-3 (L3) connection over the TDLS link and is conveyed to the peer STA using the Local IP address subelement within the WFD IE as described in the process below.

A WFD Device initiating TDLS Setup with a peer WFD Device shall include a WFD IE with its Local IP Address subelement in its TDLS Setup Request frame. A WFD Device responding to this request shall include a WFD IE with its Local IP Address subelement in its TDLS Setup Response frame.

When transmitting a TDLS Setup Request frame or a TDLS Setup Response frame, a WFD Device shall not set the WFD Device Type bits (B1B0) of the WFD Device Information field of WFD Device Information subelement in the WFD IE to 0b11. The role of a WFD Device shall be fixed as either a WFD Source or a Primary Sink while establishing a WFD Connection when using TDLS.

If the type of WFD Device indicated in the WFD Device Type bits (B1B0) in the WFD Device Information field within the WFD IE in the received TDLS Setup Request frame is different from the expected value (e.g., indicating that the sender is a WFD Source and the recipient of the request is also a WFD Source) the recipient should respond using a TDLS Setup Response frame with status code of 38 (The request has not been successful as one or more parameters have invalid values).

4.5.4 Establishing a TCP connection

Upon successful WFD Connection Setup between WFD Devices attempting to establish a WFD Session (using Wi-Fi P2P described in section 4.5.2 or TDLS described in section 4.5.3), the connected WFD Devices attempt to establish a TCP connection.

TCP connection establishment is specified in IETF STD7 [29]. The TCP connection shall be initiated by the WFD Sink. The WFD Source plays the TCP server role and the WFD Sink plays the TCP client role. A Control Port (default is 7236 [33]) is used to establish and manage sessions between the WFD Source and

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WFD Sink[2]. The protocol running on the Control Port is RTSP (RFC 2326) [23] and is described in section 4.6 and chapter 6.

Once the TCP connection is established, the RTSP protocol stack shall be active on the WFD Device until the RTSP session is torn down. During the lifetime of the RTSP session, an RTP media session is also active.

4.6 WFD Capability Negotiation

After a successful WFD Connection Setup (and establishment of a TCP connection), the WFD Capability Negotiation phase shall commence as specified herein. It takes place prior to the WFD Session establishment.

A WFD Device shall support the WFD Capability Negotiation process as the following sequence of messages exchanged between the WFD Source and WFD Sink(s) using the RTSP protocol described in chapter 6. Figure 4-4 provides an illustrated example of the message sequence for WFD Capability Negotiation.

- **RTSP M1 Messages** (see section 6.4.1)**:** The WFD Source sends an RTSP OPTIONS request message in order to determine the set of RTSP methods (see section 6.2) supported by the WFD Sink. On receipt of an RTSP M1 (RTSP OPTIONS) request message from the WFD Source, the WFD Sink responds with an RTSP M1 (RTSP OPTIONS) response message that lists the RTSP methods supported by the WFD Sink.
- **RTSP M2 Messages** (see section 6.4.2)**:** After a successful RTSP M1 message exchange, the WFD Sink sends an RTSP OPTIONS request message in order to determine the set of RTSP methods (see section 6.2) supported by the WFD Source. On receipt of an RTSP M2 (RTSP OPTIONS) request message from the WFD Sink, the WFD Source responds with an RTSP M2 (RTSP OPTIONS) response message that lists the RTSP methods supported by the WFD Source.
- **RTSP M3 Messages** (see section 6.4.3)**:**
    - **RTSP M3 request**: After a successful RTSP M2 exchange, the WFD Source sends an RTSP GET_PARAMETER request message (RTSP M3 request), explicitly specifying the list of WFD capabilities (See section 6.1) that are of interest to the WFD Source.
    - **RTSP M3 response:** The WFD Sink responds with an RTSP GET_PARAMETER response message (RTSP M3 response).
- **RTSP M4 Messages** (see section 6.4.4)**:**
    - **RTSP M4 request:** Based on the RTSP M3 response, the WFD Source determines the optimal[3] set of parameters to be used for the WFD Session and sends an RTSP SET_PARAMETER request message containing the parameter set to be used in the WFD Session between the WFD Source and WFD Sink.
    - **RTSP M4 response:** On receipt of the RTSP M4 request from the WFD Source, the WFD Sink responds with an RTSP M4 response.

[2] The WFD Source can choose any value other than default 7236, and it should be within 49152 to 65535 (as the Private or Ephemeral Ports as described in [32]).

[3] The WFD Source chooses one appropriate audio and/or video format and other feature(s), from common capabilities supported by the WFD Source and the WFD Sink, possibly also depending on channel conditions, available throughput, original format of the content, available processing power of the WFD Source, and so on.

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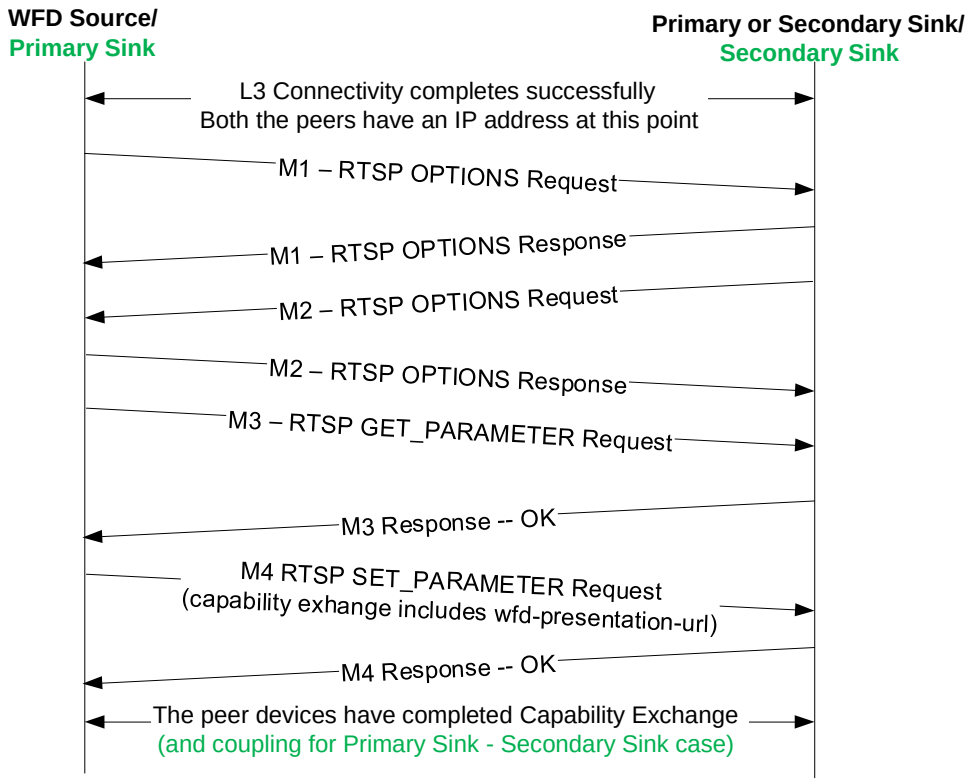

Figure 4-4 : WFD Capability Negotiation (or coupling) Flow using RTSP

Note: WFD Capability Negotiation is performed between a WFD Source and a WFD Sink to determine a common set of capabilities. If the WFD Session involves a Primary and Secondary Sinks as a Coupled Sink Operation, the WFD Source successfully completes the WFD Capability Negotiation procedure with both the Primary and the Secondary Sinks.

4.7 Link Content Protection Setup

In this section, "HDCP (system) 2.x", refers to an exact notation of that version. The corresponding external reference document is identified in Annex-F.

- For example, if a WFD Device implements and uses the HDCP system 2.1[4], the terms “HDCP system 2.x” and “HDCP 2.x” below in this section are interpreted as “HDCP system 2.1” and “HDCP 2.1” respectively”, and the correct reference is [30].

A WFD Source intending to include content subject to Link Content Protection requirements (i.e., protected content) in its RTP payload stream shall establish the HDCP 2.x session key with the WFD Sink, as described in the references identified in Annex-F.

If the WFD Source and WFD Sink support the HDCP system 2.x, both the WFD Source and the WFD Sink shall complete the HDCP 2.x session key establishment before starting any RTP session used for WFD streaming. Refer to the references identified in Annex-F for details.

If the HDCP 2.x session key establishment fails, the WFD Sink supporting the HDCP system 2.x may send an RTSP M7 request message to the WFD Source supporting the HDCP system 2.x to start an RTP streaming. In this case, the WFD Source can only transmit audio and/or video content that is not required to be protected by the HDCP system 2.x to the WFD Sink.

The following applies only when protected content is transmitted from a WFD Source to WFD Sink(s):

AKE, **locality check**, and **SKE** messages described in the references identified in Annex-F shall be transported over a TCP connection that is different from a TCP connection for RTSP messaging. The WFD Sink shall advertise its local TCP port ID for exchanging the HDCP 2.x messages, using

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the `wfd-content-protection` parameter (see section 6.1.5). The WFD Sink shall act as a TCP server for this connection.

If the WFD Session includes a Secondary Sink during Coupled Sink Operation and the audio content also requires content protection, a separate HDCP 2.x session key establishment shall be completed between the WFD Source and the Secondary Sink before starting any RTP session used for WFD streaming.

For the locality check, the recommendation on how to use the TCP/IP layer is described in Annex-C.

When a WFD Source transmits protected content to WFD Sink(s) the corresponding PES payload for video shall be encrypted as described in the references identified in Annex-F. The WFD Source may also encrypt the PES payload for audio using the HDCP system 2.x, depending on its local policy and the requirements of the content.

A WFD Sink which supports receiving protected content shall conform to the HDCP system 2.x specifications as defined in the references identified in Annex-F.

A Primary Sink which supports receiving protected content using the HDCP system 2.x shall support decrypting video content (accompanying audio content does not exist or is not encrypted). In addition, a Primary Sink which supports receiving protected content using the HDCP system 2.x shall support decrypting both audio and video content.

A WFD Sink, independent of support for reception of protected content, shall support handling audio content as "never copy", unless the incoming PES payloads for video are not encrypted by the HDCP system 2.x[4]. This means that the audio content in an audio only streaming session shall always be handled as "never copy".

When both the WFD Source and the WFD Sink support the HDCP system 2.x and have successfully completed the HDCP 2.x session key establishment at least once for establishing (or an already established) WFD Session, following rules are applied:

1. For the purpose of key renewal, the WFD Source and the WFD Sink shall keep the TCP connection for the HDCP 2.x session key establishment open, during the WFD Session.
2. If the WFD Source detects that the TCP connection for the HDCP 2.x session key establishment has been closed, the WFD Source shall immediately attempt to establish a TCP connection to the same port previously used for the HDCP 2.x session key establishment with the WFD Sink and then restart the HDCP 2.x session key establishment for the purpose of session key renewal (as specified in the references identified in Annex-F). Under these conditions, the WFD Source shall not transmit any PES packets which require the HDCP encryption before the successful renewal of the HDCP 2.x session key. Additionally, if the TCP connection for the HDCP 2.x session key establishment cannot be re-opened, the WFD Source shall send an RTSP M5 request message containing the trigger parameter TEARDOWN to terminate the RTSP procedures.
3. If the WFD Sink detects that the TCP connection for the HDCP 2.x session key establishment has been closed, the WFD Sink shall send an RTSP M8 request message to terminate the RTSP procedures.

4.8 WFD Session Establishment

Upon successful completion of the WFD Capability Negotiation phase, the next step is WFD Session establishment and streaming audio and/or video content from the WFD Source to the WFD Sink. When an exchange of RTSP M7 request and response messages has successfully completed between the WFD Source and the WFD Sink, the WFD Session is established.

A WFD Device shall support WFD Session establishment, as specified herein. Table 4-5depicts the WFD Session establishment procedure, followed by WFD Session management (including termination).

[4] Whether PES payload for video is encrypted or not can be inspected by the existence or absence of the HDCP registration descriptor in the PMT and/or the value for PES_extension_flag in PES header for video.

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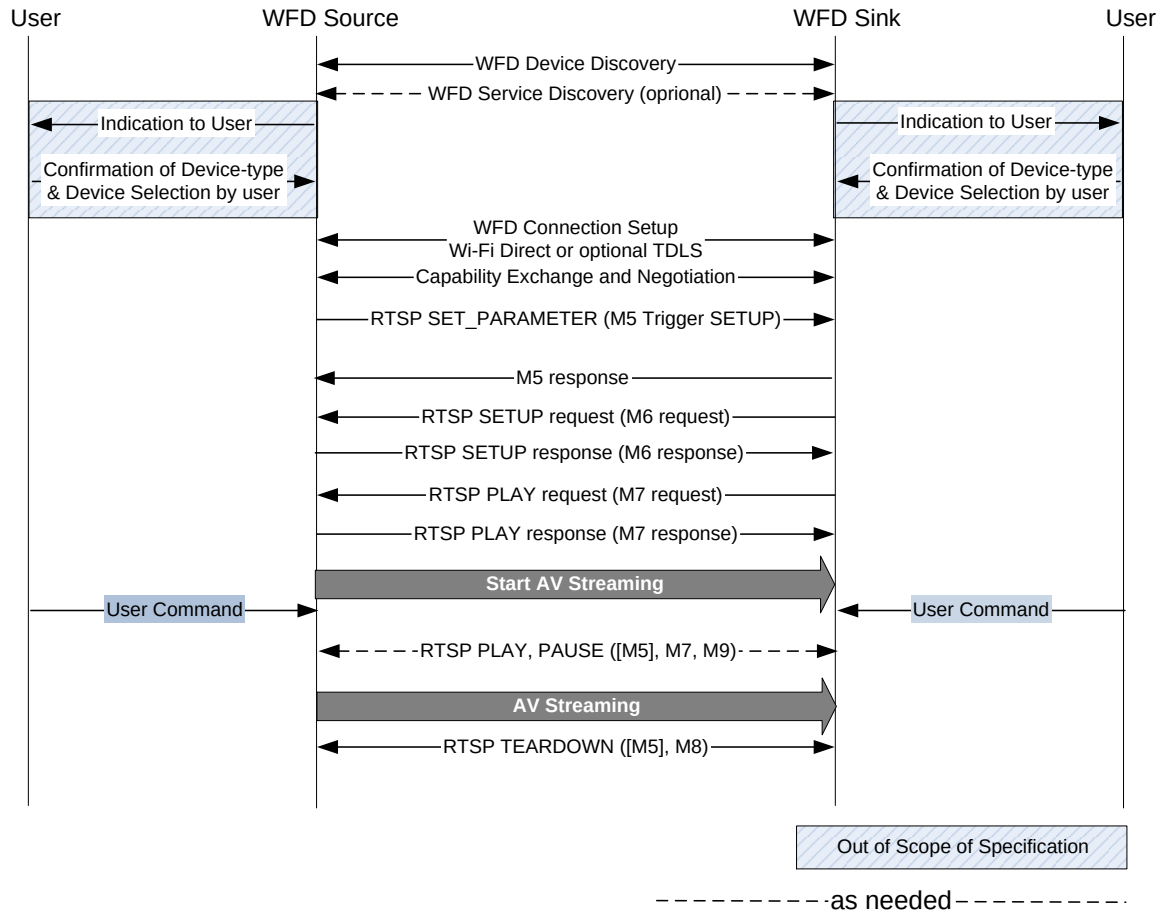

Figure 4-5 : Time-line of a WFD Session

The following describes the messages depicted in the diagram above:-

- **RTSP M5 Messages** (see section 6.4.5)**:** The WFD Source sends an RTSP SET_PARAMETER request (RTSP M5 Trigger SETUP request) message containing the trigger parameter SETUP. The WFD Sink responds with an RTSP SET_PARAMETER response (RTSP M5 response).
- **RTSP M6 Messages** (see section 6.4.6)**:**
  - **RTSP M6 request:** After a successful exchange of an RTSP M5 message containing a `wfd-triggered-method` parameter with the trigger method set to SETUP, the WFD Sink sends an RTSP SETUP request (RTSP M6 request) to the WFD Source.
  - **RTSP M6 response:** The WFD Source responds to the RTSP SETUP request (RTSP M6 request) with an RTSP Setup response message. If the status code is an RTSP OK, the RTSP session establishment is successful, as described in [23].
  - Upon successful RTSP session establishment:
    - The WFD Source may send the following messages:
      - RTSP M5 request (trigger) messages to trigger the WFD Sink to send an RTSP PLAY (RTSP M7) or RTSP TEARDOWN (RTSP M8) request messages to the WFD Source (see section 6.4.5).
    - The WFD Sink may send the following message:
      - RTSP M8 request (TEARDOWN) messages to tear down the RTSP session between the WFD Source and the WFD Sink (see section 6.4.8).
- **RTSP M7 Messages** (see section 6.4.6)**:** After a successful M6 message exchange, the WFD Sink sends an RTSP PLAY request (RTSP M7 request) to the WFD Source. This indicates to the WFD Source that the WFD Sink is ready to receive the RTP stream. The WFD Source responds with an

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RTSP PLAY (RTSP M7) response. If the status code is an RTSP OK, the WFD Session establishment is successful.

- Upon successful WFD Session establishment:
  - The WFD Source may send the following messages in any order:
    - RTSP M3 request (GET_PARAMETER) to obtain capabilities on one or more RTSP parameters supported by the WFD Sink (see section 6.4.3),
    - RTSP M4 request (SET_PARAMETER) to set values for one or more RTSP parameters corresponding to the WFD Session between the WFD Source and the WFD Sink for WFD Capability Re-negotiation to update AV format (see section 4.10.3.2) with `wfd-av-format-change-timing` (see section 6.4.4),
    - RTSP M5 request (TRIGGER) to trigger the WFD Sink to send an RTSP PAUSE (RTSP M9) request message to the WFD Source (see section 6.4.5),
    - RTSP M12 request (SET_PARAMETER with `wfd-standby`) to indicate that the WFD Source is entering WFD Standby mode (see section 6.4.12),
    - RTSP M14 request (SET_PARAMETER with `wfd-uibc-capability`) to select the input type(s), input device(s) and other parameter(s) to be used for UIBC (see section 6.4.14), or
    - RTSP M15 request (SET_PARAMETER with `wfd-uibc-setting`) to enable/disable UIBC (see section 6.4.15).

    Upon receiving the above request messages from the WFD Source, the WFD Sink responds with the corresponding response messages.
  - The WFD Sink may send the following messages in any order:
    - RTSP M7 request (PLAY) to start or resume paused streaming of audio and/or video content from the WFD Source to the WFD Sink (see section 6.4.7),
    - RTSP M9 request (PAUSE) to pause the streaming of audio and/or video content from the WFD Source to the WFD Sink (see section 6.4.9),
    - RTSP M10 request (SET_PARAMETER with `wfd-route`) to request the WFD Source to change the audio rendering device under Coupled Sink Operation (see section 6.4.10),
    - RTSP M11 request (SET_PARAMETER with `wfd-connector-type`) to indicate the change of active connector type to the WFD Source (see section 6.4.11),
    - RTSP M12 request (SET_PARAMETER with `wfd-standby`) to indicate that the WFD Sink is entering WFD Standby mode (see section 6.4.12),
    - RTSP M13 request (SET_PARAMETER with `wfd-idr-request`) to request the WFD Source to send an IDR refresh (see section 6.4.13),
    - RTSP M14 request (SET_PARAMETER with `wfd-uibc-capability`) to select the input type(s), input device(s) and other parameter(s) to be used for UIBC (see section 6.4.14), or
    - RTSP M15 request (SET_PARAMETER with `wfd-uibc-setting`) to enable/disable UIBC (see section 6.4.15).

    Upon receiving any of the above request messages from the WFD Sink, the WFD Source responds with the corresponding response messages.
  - The WFD Source shall send RTSP M16 request messages to ensure keep-alive of the WFD Sink (see section 6.4.16)

    Upon receiving of the above request message from the WFD Source, the WFD Sink responds with the corresponding response messages.

4.9 Coupled Sink Operation

A WFD Source may optionally support Coupled Sink Operation. Coupled Sink Operation is possible only if the WFD Source, the Primary Sink and the Secondary Sink support Coupled Sink Operation. In such a configuration, the WFD Source streams the video content to the Primary Sink and has the ability to route the corresponding audio content either to the Primary Sink or to the Secondary Sink. The methods to determine

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when to switch from rendering the audio payload at the Primary Sink to rendering of the audio payload at the Secondary Sink, and vice versa, are implementation dependent and outside the scope of this Specification.

The underlying connection between the WFD Source and the WFD Sinks can be either Wi-Fi P2P or TDLS. Note that if WFD Devices intend to establish a WFD Session among themselves using TDLS while they are Wi-Fi P2P clients of the same Wi-Fi P2P GO, they can do so only if the Wi-Fi P2P GO supports intra-BSS distribution.

Prior to the Coupled Sink Operation a ‘Coupled’ state needs to be established between the Primary and Secondary Sinks. The coupling procedure is almost identical to the WFD Capability Negotiation described in section 4.6 (see section 4.9.1 for more detail). RTSP messages exchanged during the process of coupling are described in section 4.9.1. This enables the Primary Sink and the Secondary Sink to present a Coupled status to a WFD Source during WFD Device Discovery as described in section 4.3. Figure 4-6 depicts the timeline of a WFD Session using a Coupled Sink Operation.

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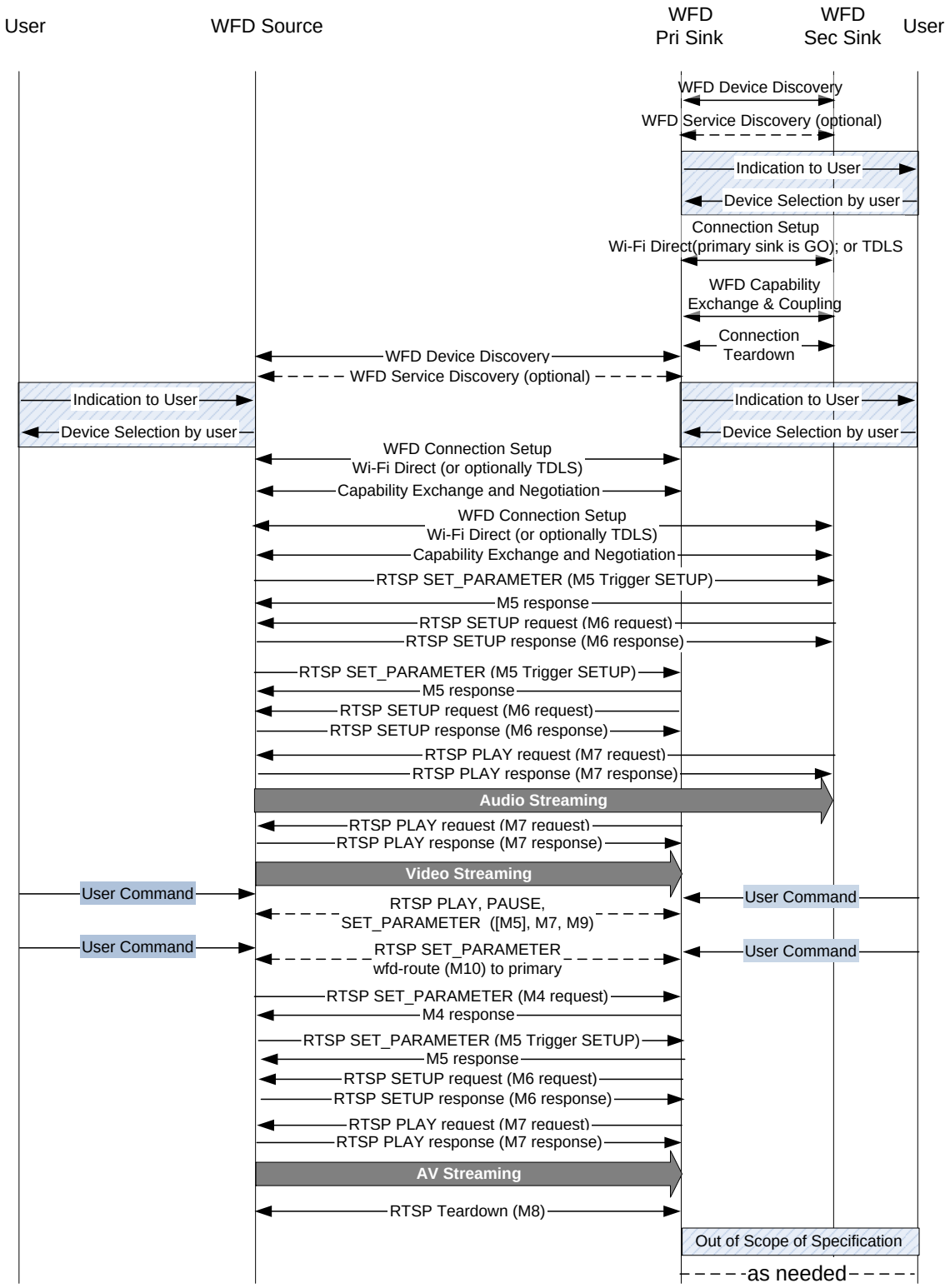

Figure 4-6 : Timeline of a WFD Session with a Secondary Sink

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4.9.1 Primary and Secondary Sink Coupling

The following steps establish coupling between two WFD Sinks, if both the Primary Sink and the Secondary Sink support Coupled Sink Operation:

1. Device Discovery using WFD IE:
   A Primary Sink and a Secondary Sink become aware of each other's existence through the exchange of the WFD IE (which among other information, specifies device-type and device-status) during the Device Discovery Phase as described in section 4.3. A Primary Sink may attempt to couple with a Secondary Sink based on its availability as indicated by the Coupled Sink Status field. The criteria by which a Primary Sink determines to couple with a Secondary Sink are implementation dependent and outside the scope of this Specification.
2. Service Discovery using the WFD Service Discovery Procedure:
   Prior to coupling, both Primary and Secondary Sinks may exchange detailed WFD capability information using the WFD Service Discovery Procedure as described in section 4.4.
3. Connection Establishment:
   The WFD Sinks establish a connection between themselves as described in section 4.5.1, 4.5.2 and 4.5.3.
   During the process of TCP connection establishment, the Primary Sink takes the role of a WFD Source and the Secondary Sink takes the role of the WFD Sink in the procedure defined for the case of the WFD Source and the WFD Sink specified in section 4.5.4.
4. Coupling:
   - The coupling procedure is similar to the WFD Capability Negotiation procedure described in section 4.6, but the role of each WFD Device is different. In terms of which device is the message requester, and which is the message responder, when referring to section 4.6 and chapter 6 (and its sections) for RTSP message exchange the Primary Sink takes the role of a WFD Source and the Secondary Sink takes the role of the WFD Sink.
   - **RTSP M1 Messages** (see section 6.4.1)**:** The Primary Sink sends an RTSP OPTIONS request message in order to determine the set of RTSP methods (see section 6.2) supported by the Secondary Sink. On receipt of an RTSP M1 (RTSP OPTIONS) request message from the Primary Sink, the Secondary Sink responds with an RTSP M1 (RTSP OPTIONS) response message that lists the RTSP methods supported by the Secondary Sink.
   - **RTSP M2 Messages** (see section 6.4.2)**:** After a successful RTSP M1 message exchange, the Secondary Sink sends an RTSP OPTIONS request message in order to determine the set of RTSP methods (see section 6.2) supported by the Primary Sink. On receipt of an RTSP M2 (RTSP OPTIONS) request message from the Secondary Sink, the Primary Sink responds with an RTSP M2 (RTSP OPTIONS) response message that lists the RTSP methods supported by the Primary Sink.
   - **RTSP M3 Messages** (see section 6.4.3)**:**
     - **RTSP M3 request**: After a successful RTSP M2 message exchange, the Primary Sink sends an RTSP GET_PARAMETER request message (RTSP M3 request) that includes the `wfd-audio-codecs` (See 6.1) parameter to the Secondary Sink.
     - **RTSP M3 response:** The Secondary Sink responds with an RTSP GET_PARAMETER response message (RTSP M3 response).

     Note: The Primary Sink could use the latency values from the `wfd-audio-codecs` parameter to accomplish functions like lip sync.
   - **RTSP M4 Messages** (see section 6.4.4)**:**
     - **RTSP M4 request**: After a successful M3 message exchange, the Primary Sink shall send an RTSP SET_PARAMETER request message to the Secondary Sink, containing `wfd-video-formats` and `wfd-3d-formats` parameters that describe support for video and stereoscopic 3D at the Primary Sink.
     - **RTSP M4 response**: The Secondary Sink responds with an RTSP M4 response.

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Note: The Secondary Sink could use the latency values from the `wfd-video-formats` or the `wfd-3d-formats` parameter to perform functions like lip sync.

- At the end of a successful RTSP M4 request/response message exchange, the Primary Sink and the Secondary Sink are Coupled. Subsequently, both the Primary and the Secondary Sinks indicates their coupling status as "Coupled" in their respective `wfd-coupled-sink` parameter when responding to RTSP GET_PARAMETER requests and in the Coupled Sink Information subelement within the WFD IE.

5. Connection Teardown
   Once a pair of WFD Sinks is Coupled, they tear-down their TCP connection and their L2 connection as follows:
   - The TCP connection for RTSP is torn-down using the RTSP TEARDOWN message.
   - If connected using Wi-Fi P2P, one of the WFD Sinks transmits a Deauthentication frame to its peer entity as described in the Deauthentication procedure defined in [7].
   - If connected using TDLS, one of the WFD Sinks transmits a TDLS teardown frame to its peer entity as specified in [13].

Once Coupled, both the Primary and the Secondary Sinks shall respond to RTSP GET_PARAMETER requests for the `wfd-coupled-sink` parameter with the `status` field set to 'Coupled' thus enabling a WFD Source to discover the pair of Primary and Secondary Sinks as per the methods described in section 4.9.2.

Once Coupled and when transmitting frames including the WFD IE, both the Primary and the Secondary Sinks shall set Coupled Sink Status bit (B1B0) to 0b01 ('Coupled') in the Coupled Sink Information subelement within the WFD IE.

A Primary Sink may tear-down a previously established coupling with a Secondary Sink at any time by re-establishing a connection (this step is required only if not currently connected) and transmitting an RTSP SET_PARAMETER request with the `wfd-coupled-sink` parameter set to the 'Teardown Coupling' status. Subsequently, both the Primary and the Secondary Sinks shall indicate their status as 'Not coupled' in their respective `wfd-coupled-sink` parameters when responding to RTSP GET_PARAMETER requests for the `wfd-coupled-sink` parameter in an RTSP procedure and in the Coupled Sink Information subelement within the WFD IE.

4.9.2 WFD Device Discovery

A WFD Source and Coupled WFD Sinks discover one another as per the mechanisms defined in section 4.3.

A WFD Source may discover a Primary Sink (or a Secondary Sink) and indirectly discover the Coupled Secondary Sink (or a Primary Sink) using the Coupled Sink Information subelement. It may then determine the presence of the Coupled WFD Sink by a directed Probe Request.

4.9.3 WFD Service Discovery

A WFD Source and Coupled WFD Sinks may optionally exchange additional WFD capabilities using the WFD Service Discovery protocol as specified in section 4.4.

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4.9.4 WFD Device Pairing

A WFD Source and a Coupled pair of WFD (Primary & Secondary) Sinks may establish WFD Connection using either Wi-Fi P2P or (optionally) TDLS, as the underlying connectivity mechanism. The connectivity scheme to be used for the WFD Session shall be resolved as per the rules defined in Table 4-2.

PC (WFD Source)	PC (Primary Sink)	PC (Secondary Sink)	Associated with same BSSID	Resolved Connectivity Scheme
0	0	0	Do not care	Wi-Fi P2P
0	0	1	Do not care	Wi-Fi P2P
0	1	0	Do not care	Wi-Fi P2P
0	1	1	Do not care	Wi-Fi P2P
1	0	0	Do not care	Wi-Fi P2P
1	0	1	Do not care	Wi-Fi P2P
1	1	0	Do not care	Wi-Fi P2P
1	1	1	No	Wi-Fi P2P
1	1	1	Yes	TDLS

Table 4-2 : Connectivity Resolution Scheme when using Secondary Sinks

If the underlying connectivity mechanism is resolved as Wi-Fi P2P, one of the following sequences is used to setup the corresponding connection between the WFD Source and WFD Sink(s)[5]:

(a) If a P2P Group exists with the WFD Source as the P2P GO, the Primary and the Secondary Sinks join the existing P2P Group, or
(b) The Primary or the Secondary Sink initiates a P2P Group formation procedure with the WFD Source setting the GO-intent to zero as defined in [7], indicating preference not to be the GO for the P2P Group (prior to the ensuing GO-negotiation phase of the Wi-Fi P2P connection setup), or
(c) The WFD Source initiates a P2P Group formation procedure with the Primary Sink setting its GO-intent to indicate 'GO-only' prior to the ensuing GO-negotiation phase of the Wi-Fi P2P connection setup.

If the underlying connectivity mechanism is resolved as TDLS, the WFD Source sets up TDLS links with both the Primary and Secondary Sinks respectively as per the methods specified in [13].

4.9.5 WFD Capability Negotiation

Once the WFD Connection is setup, the WFD Source performs WFD Capability Negotiation with both the Primary and Secondary Sinks as described in Figure 4-4 and section 4.6, thereby completing the pairing process.

4.9.6 WFD Session Establishment

If the WFD Source, the Primary Sink and the Secondary Sink support Coupled Sink Operation, using the information derived from the WFD Capability Negotiation, the WFD Source initiates the WFD Session establishment procedure with the Primary and the Secondary Sinks. The WFD Session establishment

[5] Note that this rule is only applied to the WFD Session for Coupled Sink Operation in which there are both a Primary Sink and a Secondary Sink. If there is one WFD Sink, either one of the WFD Source or the WFD Sink may become a GO, as specified in section 3.2.1.

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message exchange is shown in Table 4-6. The procedure of the WFD Session establishment for the optional Coupled Sink Operation is identical to the one described in section 4.8 except for the following:

- The WFD Source shall teardown any existing audio only WFD Session with the Secondary Sink, before establishing a WFD Session for Coupled Sink Operation including that Secondary Sink.
- The WFD Source shall initiate the WFD Session establishment procedure with both the Primary and Secondary Sinks. To establish the WFD Session for the Coupled Sink Operation, both procedures shall be successful. Refer to section 6.5 for timeout rules to establish a WFD Session.
- The initiation of AV streaming depends on the implementation of the WFD Source. The behavior of the WFD Source with respect to the receipt of RTSP M7 messages from the WFD Sinks is an implementation detail and is outside the scope of this Specification.
- Once the WFD Session is successfully established the Primary or the Secondary Sink may at any time send an RTSP M10 message to change the sink at which the audio stream is rendered.

4.10 AV Streaming and Control

Higher-layer data services including the transport of audio/video payload and exchange of control information, such as deriving the HDCP2.x session keys, are protocols layered over IP.

4.10.1 Time Synchronization

Although the audio and video MPEG2-TS streams carry embedded PCR information allowing for the AV decoder to perform clock recovery and render the AV content appropriately; the use of Wi-Fi as the underlying transport is likely to induce a higher degree of jitter than can be tolerated by typical AV decoder implementations, leading to errors in clock recovery, subsequent frame-loss, and glitch events. Additionally, in the case of a WFD Session involving Coupled WFD Sinks, time synchronization may be needed to maintain synchronization between the rendering of audio and video at different WFD Sinks, i.e., lip-sync.

To preserve audio/video fidelity and compensate for jitter, the local clocks at the WFD Source and WFD Sink(s) may require synchronization. The time synchronization mechanism supported by a WFD Device is indicated using the Time Synchronization Support bit in the WFD Device Information field contained in the WFD Device Information subelement.

By setting the Time Synchronization Support bit to one, a WFD Device indicates that it supports the use of the generalized Precision Time Protocol (gPTP) specified in IEEE 802.1AS [15], clause 12, "Media-dependent layer specification for IEEE 802.11 links" for time synchronization. If supporting this mechanism, the WFD Source assumes the role of the grandmaster clock in the gPTP domain. On a WFD Sink supporting this mechanism, synchronization to the grandmaster clock is achieved by exchanging 802.11v [31] Timing Measurement messages with the WFD Source. When this mechanism is supported, a WFD Source and a WFD Sink shall use a synchronized clock source with a clock source used for PCR for this time measurement.

With its clock synchronized to the WFD Source, a WFD Sink may then employ the use of an implementation-specific de-jittering mechanism to minimize the jitter introduced over the Wi-Fi network, as shown in Figure 4-7.

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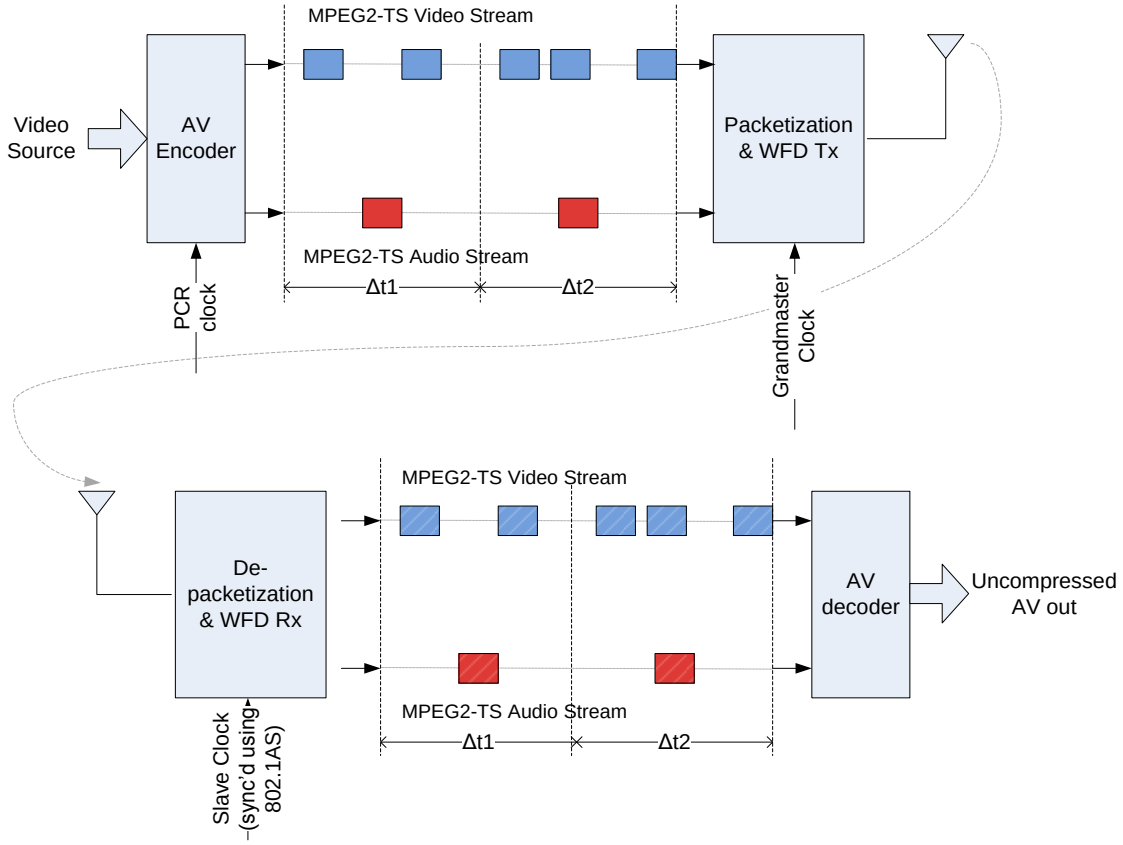

Figure 4-7 : Eliminating Network Jitter using RTP

The AV decoder uses the de-jittered WFD Packets to recover the PCR clock and correctly decode and render content.

4.10.2 AV Streaming

Audio/Video elementary streams generated by a WFD Source shall be packetized using a MPEG2-TS container format and encapsulated by RTP/UDP/IP headers prior to 802.11 packetization and transmission to the WFD Sink. The MPEG System Layer is specified in [2] and Annex-A provides an overview.

Figure 4-8 depicts the structure of a WFD AV frame as generated by a WFD Source.

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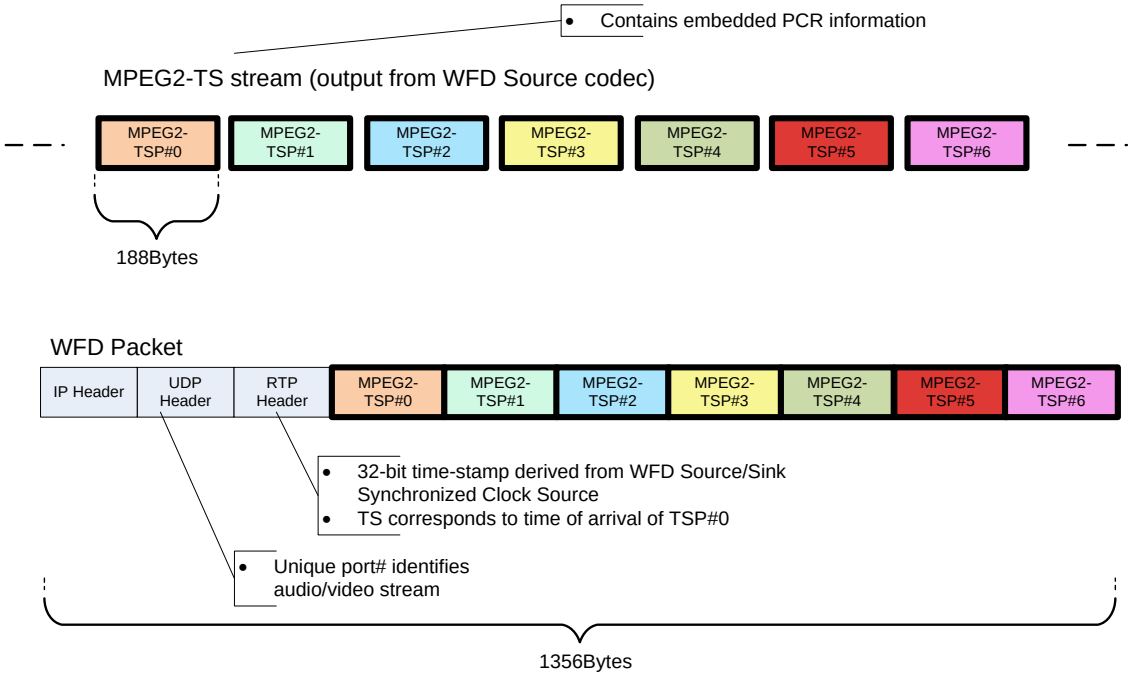

Figure 4-8 : WFD AV Packet Format

A WFD Source shall support multiplexing the audio and/or video streams into a single MPEG2 transport stream containing audio and/or video, as well as program clock reference (PCR) information. Only in the case of Coupled Sink Operation, the WFD Source may optionally support generating separate MPEG2 transport streams for audio and video, each containing its own program clock reference (PCR) time-stamp information.

Settings of the MPEG2-TS parameters for audio/video streams are specified in Annex-B.

The MPEG2-TS packets are packetized using RTP, UDP and IP headers respectively, as shown in Figure 4-8. The method for encapsulating an MPEG2-TS into RTP packets is specified in Annex-B.1.

The 32-bit RTP time-stamp (RTP TS) information [3] is derived from the master-clock maintained by the WFD Source, and is represented in 90 kHz units where one tick corresponds to 11.11us. The RTP TS for a WFD packet is set to map to the time of arrival of the first MPEG2-TS packet at the RTP encapsulation layer.

The relationship between MPEG2-TS usage and the setting at `wfd-client-rtp-ports` parameter in both RTSP M3 response and M4 request messages are specified in section 6.1.10.

Additional rules for usage of H.264 and H.222 specifications are specified in Annex-D.

When the WFD Source transmits video only content to the Primary Sink, it may transmit either a MPEG2-TS containing multiplexed an audio elementary stream and a video elementary stream or a MPEG2-TS containing only a video only elementary stream. In the former case, the audio payload shall use the mandatory format, i.e., LPCM, 16bits, 48ksps and 2ch, and the audio payload shall carry either actual audio data or null data.

A WFD Source shall support transmitting video elementary stream where one picture is constructed by one slice. A Primary Sink shall support receiving video elementary stream where one picture is constructed by one slice.

A WFD Source may support transmitting video elementary stream where one picture is constructed by multiple slices. A Primary Sink may support receiving video elementary stream where one picture is constructed by multiple slices.

Indication of this optional feature is described in section 5.1.5 (2D video) and 5.1.6 (3D video) for WFD Service Discovery, and in section 6.1.3 (2D video), 6.1.4 (3D video) and 6.1.14 (preferred display mode) for RTSP messages. Operation rules for using multiple slices per a picture are described in Annex-D.

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4.10.3 AV Encoding Rate Control

The WFD Source may change the encoding rate depending on various factors such as channel condition, power consumption optimization, and so on. The policy for how the encoding rate control is selected is outside the scope of this Specification.

There are two methods for adjusting the encoding rate control at the WFD Source:-

1. An implicit method without WFD Capability Re-negotiation via the exchange of RTSP M4 Request /Response messages.
   The WFD Source may use, for example, compression ratio change, macroblock skipping, or frame skipping. The former two can be handled within the H.264 standard, and no additional rules need to be included in this Specification. Video frame skipping requires some rules to ensure interoperability, and they are specified in section 4.10.3.1.
2. Initiated explicitly using an RTSP M4 request/response message exchange.
   For example, the WFD Source may request changes in the actual display frame rate, display resolution, and so on. This method requires some rules to ensure interoperability, and they are specified in section 4.10.3.2.

4.10.3.1 Video Frame skipping

If the WFD Sink supports video frame skipping, the WFD Source may skip transmission of some of the encoded video frames to the WFD Sink. As a result the effective video frame rate may be lower than the one negotiated between the WFD Source and WFD Sink during the WFD Capability Negotiation phase. Although the WFD Source decides which encoded video frames to skip, the policy that defines which of the encoded video frames are skipped is outside the scope of this Specification.

A WFD Sink, which indicates this capability, shall tolerate video frame skipping, as long as the interval between two transmitted video frames is smaller than or equal to the interval indicated in the Max Skip Interval bits in the frame-rate-control-bitmap in the `wfd-video-format` or `wfd-3d-formats` or `wfd-preferred-display-mode` parameters in the RTSP M3 messages from the WFD Sink.

In all cases, after any lapse in encoded transmissions, the WFD Source shall ensure that SCR updates are current, and DTS/PTS values are consistent as described in [2].

When video frame skipping is applied, the following rules shall be satisfied.

- A video frame shall not be skipped if it is referenced by another video frame that is not skipped (i.e., when a video frame refers to the other video frame(s), it shall refer to video frame(s) that are not skipped).
- The WFD Source shall maintain the time interval between two successive video frames to be less than or equal to the maximum/allowable time-interval indicated using the Max Skip Interval bits (B3:B1) in frame-rate-control-bitmap included in the `wfd-video-formats` parameter in the RTSP M3 response message from the WFD Sink.
  Note: In the case where Max Skip Interval bits (B3:B1) are set to all zeros (indicating the maximum allowable time interval is unspecified), any interval between two transmitted video frames is acceptable and the behavior of the WFD Sink for scene change recovery is implementation specific.
- When an interlaced format is used, a correct pair of even and odd fields which construct a video frame shall be transmitted at a nominal time interval.
- Frame number (frame_num) in the slice header(s) shall be sequential numbers for transmitted video frames (i.e., skipped video frames are not counted).
- TS packets carrying PCR shall be transmitted at intervals equal to or less than 100msec, as specified in MPEG2-TS specification [2].
- The WFD Source should transmit two (or more) video frames with a nominal interval during the period that does not have skipped frame(s) so that the decoder can update output data.

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4.10.3.2 Explicit AV format change

During the lifetime of a WFD Session, the WFD Source may want to update the parameter set in use which was previously negotiated during the WFD Capability Negotiation phase just prior to the WFD Session establishment.

A WFD Source may update the parameter set used in the WFD Session at any time by transmitting an RTSP SET_PARAMETER request (RTSP M4 request) message containing the appropriate parameter updates (described in section 6.1) to the WFD Sink(s). The updated parameter set takes effect after the WFD Source receives a corresponding RTSP SET_PARAMETER response containing a status code of RTSP OK, from the WFD Sink(s). This RTSP message exchange is called WFD Capability Re-negotiation.

When changing the AV format during one RTP session, the RTSP M4 request message shall include the `wfd-av-format-change-timing` (specified in section 6.1.13) parameter.

If the Primary Sink sets the Video Frame Rate Change Support bit (B4) of the frame-rate-control-support field in the `wfd-video-formats` parameter or the `wfd-3d-formats` parameter in the RTSP M3 response message to zero, then the WFD Source shall not change the video frame rate when performing explicit AV format change(s) using WFD Capability Re-negotiation without user intervention.

If the Primary Sink sets the Video Frame Rate Change Support bit (B4) of the frame-rate-control-support field in the `wfd-video-formats` parameter or the `wfd-3d-formats` parameter in the RTSP M3 response message to one, then the WFD Source may change the video frame rate when performing explicit AV format change using WFD Capability Re-negotiation without any user intervention. With user intervention, the WFD Source may change video frame rate when performing explicit AV format change using WFD Capability Re-negotiation regardless of the value of this bit setting. If this bit is set to zero by the Primary Sink, visible video artifacts may occur at the Primary Sink during the transition from one refresh rate to the next.

The rules specified below apply only to automatic AV format change(s) using the RTSP M4 request message during one RTP session, without any user intervention.

When the AV format changes as a result of user intervention (e.g., a program change at the WFD Source by selecting a different channel, or audio routing changes from a Primary Sink to a Secondary Sink), it is not necessary to follow the rules specified below.

During a WFD Session, the video codec profile in use shall not be changed in an RTSP M4 request message or in an MPEG2-TS.

During a WFD Session, a WFD Source may change H.264 Level in use by indicating this change in an RTSP M4 request message or in an MPEG2-TS. However, changing H.264 level from a lower level to a higher level during a WFD Session may cause a decoder reset at the WFD Sink and may result a discontinuity of video rendering. To avoid such discontinuities, it is recommended that a WFD source sets the highest H.264 level that is supported by both the WFD Source and the WFD Sink.

During a WFD Session, the scan method of video, i.e., progressive or interlace shall not be changed in an RTSP M4 request message or in an MPEG2-TS.

When changing video format, i.e., resolution or refresh rate, the WFD Source shall transmit an IDR picture just after changing video format(s), to reset parameters, as specified in [1]. It should be noted that transmission of an IDR picture may require higher instantaneous peak throughput even if the resolution and/or refresh rate after change is lower than the previous values.

If the WFD Sink supports a refresh rate change, as indicated in the Refresh rate change support field in the `wfd-video-formats` parameter (specified in section 6.1.3) or in the `wfd-3d-formats` parameter (specified in section 6.1.4), the WFD Source may change video refresh rate among supported video refresh rates indicated by the WFD Sink.

During a WFD Session, video resolution and refresh rate shall not be changed simultaneously in an RTSP M4 request message or in an MPEG2-TS.

During a WFD Session, audio format (i.e., sample rate, bits per sample, the number of channels, audio codec) shall not be changed in an RTSP M4 request message or in an MPEG2-TS.

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4.10.4 AV Session Control

WFD Sources that support Coupled Sink Operation shall support the `wfd-route` parameter. On receipt of an RTSP M10 request (RTSP SET_PARAMETER request) message, the WFD Source shall route the audio stream to the destination specified in the `wfd-route` (specified in section 6.1.11) parameter contained in the RTSP M10 request. After transmission of an RTSP M10 response message with a status code of RTSP OK, the WFD Source sends RTSP M4 request message(s) to the Primary Sink and/or the Secondary Sink, as follows;

- If the WFD Source transmits an RTSP M10 response message with a status code of RTSP OK as a response to the RTSP M10 request message that includes the `wfd-route` parameter indicating "primary", the WFD Source shall send an RTSP M4 request message including the `wfd-audio-codecs` parameter and either one of the `wfd-video-formats` parameter, the `wfd-3d-formats` parameter, or the `wfd-preferred-display-mode` parameter to the Primary Sink.
- If the WFD Source transmits an RTSP M10 response message with a status code of RTSP OK as a response to the RTSP M10 request message that includes the `wfd-route` parameter indicating "secondary" the WFD Source shall send an RTSP M4 request message including either one of the `wfd-video-formats` parameter, the `wfd-3d-formats` parameter or the `wfd-preferred-display-mode` parameter (and without the `wfd-audio-codecs` parameter) to the Primary Sink, and the WFD Source shall send an RTSP M4 request message including the `wfd-audio-codecs` parameter (and with neither of the `wfd-video-formats`, the `wfd-3d-formats` nor the `wfd-preferred-display-mode` parameters) to the Secondary Sink.

4.10.5 WFD video recovery

The video decoder in the WFD Sink receives VCL and NAL packets which could be lost due to intermittently degraded channel conditions. Over time the errors could accumulate and eventually render the decoder inoperable or cause the display to show an image with reduced quality. To prevent the decoder from failing, a WFD Sink may detect the error in the bitstream and request the WFD Source to transmit an IDR picture, using the following procedure.

The WFD Sink may request the IDR picture from the WFD Source by sending a SET_PARAMETER message containing a `wfd-idr-request` parameter (section 6.1.20). Upon successful reception of the SET_PARAMETER message containing a `wfd-idr-request` parameter, the WFD Source shall send an IDR picture with SPS and PPS in the bit stream and send a response message with a status code of RTSP OK at the earliest opportunity.

4.11 User Input Back Channel

The User Input Back Channel (UIBC) is an optional WFD feature that when implemented facilitates communication of user inputs to a User Interface, present at the WFD Sink, to the WFD Source.

All UIBC user inputs are packetized using a common packet header and transported over TCP/IP. The user input categories include Generic and HIDC.

The Generic category is used for device agnostic user inputs that are processed at the application level. Generic user inputs are formatted using the Generic Input Body. Generic user inputs include inputs such as mouse and keyboard events as well as conceptual inputs such as zoom and scroll. HIDC is used for user inputs generated by HIDs like remote control, keyboard, etc. HIDC user inputs are formatted using the HIDC Input Body.

4.11.1 UIBC Data Encapsulation

The TCP payload structure for UIBC including the common packet header for user inputs is shown in Figure 4-9.

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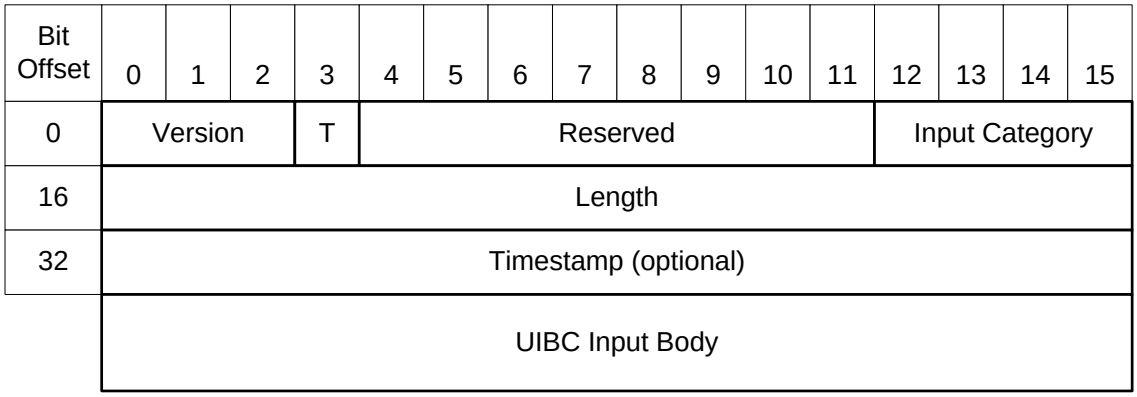

Figure 4-9 : Encapsulations of User Inputs over TCP/IP

The fields in the common packet header are described below:

- **Version (3 bits):**

The version of the protocol. This field shall be set to 0b000.

- **T (1 bit):**

Presence of the optional timestamp before the input body, where 0 means the timestamp field does not exist, and 1 means the timestamp field exists.

- **Reserved (8 bits):**

These bits are reserved for future use, and shall be set to all zeros on transmission and ignored on reception.

- **Length (16 bits):**

The length of the entire TCP payload in units of 8 bits, from bit offset 0 to the end of the UIBC Input Body (including padding if any).

- **Input Category (4 bits):**

The category of the inputs delivered by this TCP payload. The Input Category codes are shown in Table 4-3.

Input Category	Category	Notes
0	Generic	User input data is (are) formatted using the Generic Input Body.
1	HIDC	User input data is (are) formatted using the HIDC Input Body.
2-15	Reserved	

Table 4-3 : Input Category Code

- **(Optional) Timestamp (16 bits):**

The last 16 bits of the WFD Source marked RTP timestamp of the frames that are being displayed when user inputs are applied.

After a common packet header, a UIBC Input Body field follows.

- **UIBC Input Body:**

This field is either a Generic Input Body or an HIDC Input Body as indicated in Input Category field and contains information describing one or more user inputs. One user input corresponds to one Generic Input message or one HIDC message, depending on the selected Input Category. In addition, this field should be padded up to an integer multiple of 16 bits to have an even integer number in the Length field.

4.11.2 UIBC Establishment and Maintenance

The UIBC is established and maintained using RTSP GET_PARAMETER and SET_PARAMETER messages. The message sequences are shown in Figure 4-10 and Figure 4-11.

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The TCP port number to be used by the WFD Source for UIBC message transactions is included in the `wfd-uibc-capability` parameter in the RTSP M4 and/or M14 request message, and this port at the WFD Source shall be ready to accept incoming connections from the WFD Sink before sending a subsequent RTSP M4 and/or M14 request message containing the `wfd-uibc-capability` parameter. Once established, a single TCP connection between the WFD Source and the WFD Sink shall be used for the duration of the WFD Session for all UIBC data exchange.

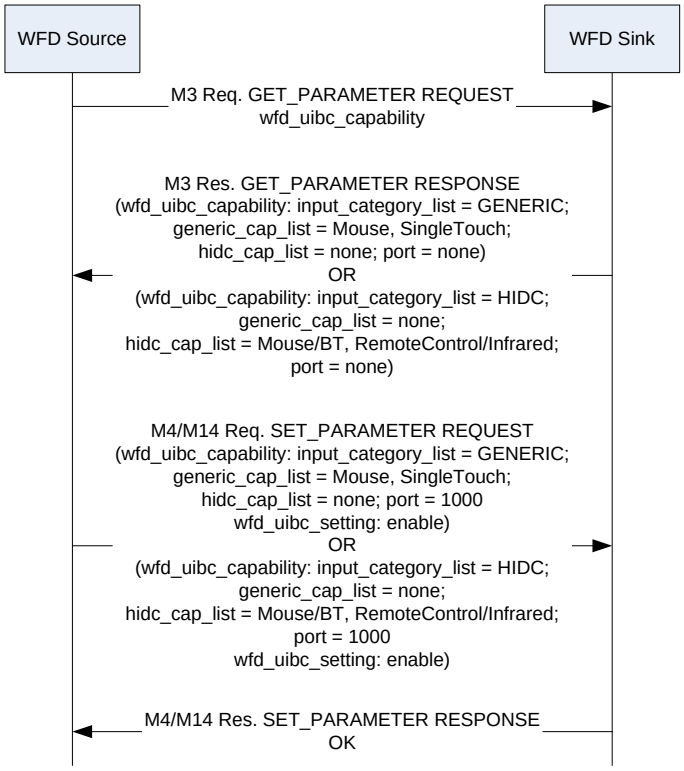

Figure 4-10 : UIBC Capability Negotiation

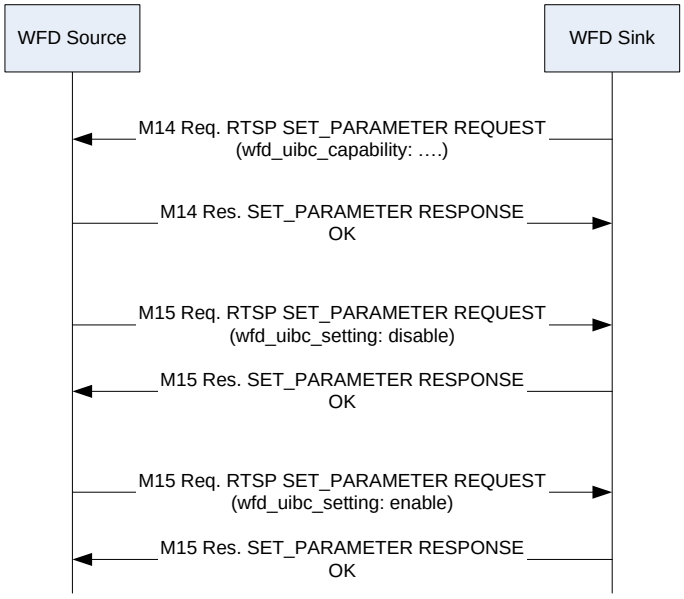

Figure 4-11 : UIBC Update

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Control information is associated with a user input. Control information of user input includes a query about UIBC capabilities, identifying specific UIBC input type & category and requests to enable or to disable a UIBC. The control information is transmitted over the RTSP control plane. See section 6.4.15, 6.1.16, 6.4.14 and 6.4.15.

4.11.3 UIBC Input Body

4.11.3.1 Generic Input Body Format

The Generic Input Body has one or more Generic Input messages. The format of each Generic Input message is shown below:

Field	Size (Octet)	Value
Generic Input Type ID	1	Input type such as Zoom In, Scroll, etc. See Table 4-5
Length	2	Length of the following fields in octets
Describe	Variable	The details of the user inputs

Table 4-4 : Generic Input Message Format

Generic Input Type ID	Notes
0	Left Mouse Down/Touch Down
1	Left Mouse Up/Touch Up
2	Mouse Move/Touch Move
3	Key Down
4	Key Up
5	Zoom
6	Vertical Scroll
7	Horizontal Scroll
8	Rotate
9-255	Reserved

Table 4-5 : Generic Input Type ID for User Inputs of the Generic Category

The Describe field of Generic Input message for the Left Mouse Down/Touch Down Generic Input Type ID is shown in Table 4-6. The coordinate origin (0, 0) is defined to be the top-left corner of the rectangular display region.

Field	Size (Octet)	Notes
Number of pointers (N)	1	Number of pointers of a multi-touch motion event. When set to 0x01, it indicates a single-touch motion event.
For i = 1: N {		
Pointer ID	1	The identification number of this pointer. The value lies in [0,1,…]

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X-coordinate	2	X-coordinate for mouse/touch down event normalized with respect to the negotiated resolution of the video stream.
Y-coordinate	2	Y-coordinate for mouse/touch down event normalized with respect to the negotiated resolution of the video stream.
}		

Table 4-6 : Describe Field of the Generic Input Message for Left Mouse Down/Touch Down

The Describe field of the Generic Input message for the Left Mouse Up/Touch Up Generic Input Type ID is shown in Table 4-7. The coordinate origin (0, 0) is defined to be the top-left corner of the rectangular display region.

Field	Size (Octet)	Notes
Number of pointers (N)	1	Number of pointers of a multi-touch motion event. When set to 0x01, it indicates a single-touch motion event.
For i = 1: N {		
Pointer ID	1	The identification number of this pointer. The value lies in [0,1,…]
X-coordinate	2	X-coordinate for mouse/touch up event normalized with respect to the negotiated resolution of the video stream.
Y-coordinate	2	Y-coordinate for mouse/touch up event normalized with respect to the negotiated resolution of the video stream.
}		

Table 4-7 : Describe Field of the Generic Input Message for Left Mouse Up/Touch Up

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The Describe field of the Generic Input message for the Left Mouse Move/Touch Move Generic Input Type ID is shown in Table 4-8. The coordinate origin (0, 0) is defined to be the top-left corner of the rectangular display region.

Field	Size (Octet)	Notes
Number of pointers (N)	1	Number of pointers of a multi-touch motion event. When set to 0x01, it indicates a single-touch motion event.
For i = 1: N {		
Pointer ID	1	The identification number of this pointer. The value lies in [0,1,…]
X-coordinate	2	X-coordinate for mouse/touch move event normalized with respect to the negotiated resolution of the video stream.
Y-coordinate	2	Y-coordinate for mouse/touch move event normalized with respect to the negotiated resolution of the video stream.
}		

Table 4-8 : Describe Field of the Generic Input Message for Left Mouse Move/Touch Move

The Describe field of the Generic Input message for the Key Down Generic Input Type ID is shown in Table 4-9. The key codes are ordered in increasing time.

Field	Size (Octet)	Notes
Reserved	1	Reserved
Key code 1 (ASCII)	2	The key code of the first key down event. The basic/extended ASCII code [26] [27] uses the lower one byte. The higher one byte is reserved for future ASCII compatible key codes. The higher one byte shall be sent before the lower one byte.
Key code 2 (ASCII)	2	The key code for the second key down event. The value is set to 0x00 00 (NULL), if the second key code is not present. The basic/extended ASCII code [26] [27] uses the lower one byte. The higher one byte is reserved for future ASCII compatible key codes. The higher one byte shall be sent before the lower one byte.

Table 4-9 : Describe Field of the Generic Input Message for Key Down

The Describe field of the Generic Input message for the Key Up Generic Input Type ID is shown in Table 4-10. The key codes are ordered in increasing time.

Field	Size (Octet)	Notes
Reserved	1	Reserved
Key code 1 (ASCII)	2	The key code of the first key up event. The basic/extended ASCII code [26] [27] uses the lower one byte. The higher one byte is reserved for future ASCII compatible key codes. The higher one byte shall be sent before the lower one byte.
Key code 2 (ASCII)	2	The key code for the second key up event. The value is set to 0x00 00 (NULL), if the second key code is not present. The basic/extended ASCII code [26] [27] uses the lower one byte. The higher one byte is reserved for future ASCII compatible key codes. The higher one byte shall be sent before the lower one byte.

Table 4-10 : Describe Field of the Generic Input Message for Key Up

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The Describe field of the Generic Input message for the Zoom Generic Input Type ID is shown in Table 4-11. The coordinate origin (0, 0) is defined to be the top-left corner of the rectangular display region.

Field	Size (Octet)	Notes
X	2	The reference X-coordinate for the zoom operation normalized with respect to the negotiated resolution of the video stream.
Y	2	The reference Y-coordinate for the zoom operation normalized with respect to the negotiated resolution of the video stream.
Integer times to zoom	1	The unsigned integer portion of the number of times to zoom
Fraction times to zoom	1	The fraction portion of the number of times to zoom. The unit of the fractional part shall be 1/256, and the sign of the fractional part is always positive.

Table 4-11 : Describe Field of the Generic Input Message for Zoom

The Describe field of the Generic Input message for the Vertical Scroll Generic Input Type ID is shown in Table 4-12.

Field	Size (Octet)	Notes
Amount to vertically scroll	2	B15B14; Scroll Unit Indication bits. 0b00; the unit is a pixel (normalized with respect to the WFD Source display resolution that is conveyed in an RTSP M4 request message). 0b01; the unit is a mouse notch (where the application is responsible for representing the number of pixels per notch). 0b10-0b11; Reserved.
		B13; Scroll Direction Indication bit. 0b0; Scrolling down. 0b1; Scrolling up.
		B12:B0; Number of Scroll bits. Number of units for a vertical scroll.

Table 4-12 : Describe Field of the Generic Input Message for Vertical Scroll

The Describe field of the Generic Input message for the Horizontal Scroll Generic Input Type ID is shown in Table 4-13.

Field	Size (Octet)	Notes
Amount to horizontally scroll	2	B15B14; Scroll Unit Indication bits. 0b00; the unit is a pixel (normalized with respect to the WFD Source display resolution that is conveyed in an RTSP M4 request message). 0b01; the unit is a mouse notch (where the application is responsible for representing the number of pixels per notch). 0b10-0b11; Reserved.

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		B13; Scroll Direction Indication bit. 0b0; Scrolling to the right. Scrolling to the right means the displayed content being shifted to the left from a user perspective. 0b1; Scrolling to the left. Scrolling to the left means the displayed content being shifted to the right from a user perspective.
		B12:B0; Number of Scroll bits. Number of units for a Horizontal scroll.

Table 4-13 : Describe Field of the Generic Input Message for Horizontal Scroll

The Describe field of the Generic Input message for the Rotate Generic Input Type ID is shown in Table 4-14.

Field	Size (Octet)	Notes
Integer portion of rotation amount	1	The signed integer portion of the amount to rotate in units in radians. A negative number indicates to rotate clockwise; a positive number indicates to rotate counter-clockwise
Fraction portion of rotation amount	1	The fraction portion of the amount to rotate in units of radians. The unit of the fractional part shall be 1/256, and the sign of the fractional part is always positive.

Table 4-14 : Describe Field of the Generic Input Message for Rotate

4.11.3.2 HIDC Input Body Format

The HIDC Input Body has one or more HIDC messages. The format of each HIDC message is shown below.

In this case, actual user input data is in the format as defined in an external HID specification. Refer to [24] for USB and as [25] for Bluetooth.

Field	Size (Octet)	Value
HID Input Path	1	HID Input Path. See Table 4-16.
HID Type	1	HID Type. See Table 4-17.
Usage	1	This field indicates the usage of the HIDC value field in this table. The value of this field shall be set to 0x00 if the HIDC value field contains a HID input report. The value of this field shall be set to 0x01 if the HIDC value field contains a HID report descriptor.
Length	2	Length of the HIDC value in octets.
HIDC value	Variable	This field contains a HID input report or a HID report descriptor.

Table 4-15 : HIDC Message Format

Value	HID Input Path
0	Infrared
1	USB
2	Bluetooth

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3	Zigbee
4	Wi-Fi
5-254	Reserved
255	Vendor Specific HID interface

Table 4-16 : HID Input Path

Value	HID Type
0	Keyboard
1	Mouse
2	Single Touch
3	Multi Touch
4	Joystick
5	Camera
6	Gesture
7	Remote controller
8-254	Reserved
255	Vendor specific HID type

Table 4-17 : HID Type

A HID report descriptor [24], [25] describes the format of its associated HID input reports. For each HID interface type and HID type combination, a WFD Sink should send its associated HID report descriptor to the WFD Source before it sends HID input reports to the WFD Source. The WFD Sink may send HID report descriptors to the WFD Source at multiple occasions to ensure that the WFD Source has the up-to-date HID report descriptors.

Default descriptors for USB keyboard and mouse HID input reports are specified. If the HID input reports that a WFD Sink sends are based on the default report descriptors for USB keyboard and mouse, the WFD Sink is not required to send HID report descriptors. The default USB HID report descriptor for keyboard is set to the one specified in Section E.6 “Report Descriptor (keyboard)” in [24]. The default USB HID report descriptor for mouse is set to the one specified in Section E.10 “Report Descriptor (Mouse)” in [24].

4.12 WFD Session and WFD Connection Termination

If a WFD Session has been established and if a WFD Device tries to terminate a WFD Connection, the WFD device should initiate a WFD Session termination using RTSP TEARDOWN as specified in section 6.4.8.

There are two other cases of WFD Session termination without an explicit RTSP TEARDOWN message exchange.

- If a WFD Session has been established and if a WFD Device detects a timeout, the WFD Device terminates the WFD Session as specified in section 6.5.
- If a WFD Session has been established and a user turns WFD functionality in a WFD Device off, a WFD Session is terminated without any explicit signaling.

If possible, a WFD Device may terminate a WFD Connection as described in section 4.12.1 and 4.12.2 after a termination of a WFD Session.

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4.12.1 Termination of a WFD Connection Using Wi-Fi P2P

When using Wi-Fi P2P, the WFD Source or the WFD Sink may perform an orderly termination of the WFD Connection using the connection tear-down procedure defined in [7].

4.12.2 Termination of a WFD Connection Using TDLS

When using TDLS either the WFD Source or the WFD Sink may perform an orderly termination of the WFD Connection using the connection tear-down procedure defined in [13].

If the TDLS link is torn down before a successful RTSP TEARDOWN, the WFD Source and the WFD Sink shall stop transmitting and shall discard any received frames (containing RTP/MPEG2-TS and/or RTSP message) related to the WFD Session that was ongoing over that TDLS link. Whether to attempt to re-establish the TDLS link before RTSP timeout to keep streaming, or to wait for the timeout to stop streaming, is implementation-specific and outside the scope of this Specification.

4.13 Persistent WFD Groups

A Persistent WFD Group is a WFD Group for which required information is stored and may be made available for reuse after the initial use completes.

If Wi-Fi P2P is used as the WFD Connection mechanism, the required information to be stored is the P2P Group ID and Credentials. Such a Persistent WFD Group has a lifetime that may extend over a number of distinct sessions beyond the initial use until the group is deliberately “dissolved”.

If TDLS is used as the WFD Connection mechanism, the required information to be stored is the MAC address of the peer device. Such a Persistent WFD Group has a lifetime that may extend over a number of distinct sessions beyond the initial use until the group is deliberately terminated (described in section 4.13.2.3).

A Persistent WFD group eases the process of WFD Device Discovery and WFD Connection establishment with a peer WFD Device.

A Persistent WFD group may be operated over P2P (described in section 4.13.1) or TDLS (described in section 4.13.2).

4.13.1 Persistent WFD Group over Wi-Fi P2P

Persistence for WFD over Wi-Fi P2P is the same as persistence in Wi-Fi P2P as described in [7]. No additional Wi-Fi Display specific information is cached in the persistent store.

4.13.2 Persistent WFD Group over TDLS

The procedure for forming persistent WFD group over TDLS is described below.

4.13.2.1 Formation of a Persistent WFD Group over TDLS

If a WFD Device that supports formation of a persistent WFD group over TDLS intends to form a persistent WFD group over TDLS or to be discovered as capable of forming one, the WFD Device shall set the PC bit in the WFD Device Information subelement to one and the TDLS Persistent Support bit in the WFD Extended Capabilities bitmap within the WFD IE in the Probe Request and Response frames to one.

A WFD Device that is expected always to be connected to the same AP may set the TDLS Persistent BSSID Support bit in the WFD Extended Capabilities bitmap to one so that the peer WFD Device can take advantage of the information of the persistent WFD group over TDLS during re-invocation. If this bit is set to one by the WFD Device, it shall also set the TDLS Persistent Support bit in the WFD Extended Capabilities bitmap to one.

After a preferred peer WFD Device for a WFD Session has been selected, subsequent TDLS Setup Request frame from the WFD Device shall contain the WFD IE with the TDLS Persistent Group bit of the WFD Information field set to one. If the peer WFD Device entertains formation of a persistent WFD group over TDLS, it shall store, if not already present, a {Peer MAC, Associated BSSID, WFD extended Capability}

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tuple for future reference, and shall respond with the TDLS Persistent Group bit of the WFD Information field of the WFD IE set to one in the TDLS Setup Response frame.

The initiator of the TDLS Setup shall also store the same information about the peer WFD Device for future usage upon reception of the TDLS Setup Response frame and shall proceed with TDLS link setup and WFD Session establishment. If the TDLS link setup fails, WFD Devices shall delete the information for the persistent WFD group over TDLS.

In the case of Coupled Sink Operation, both a WFD Source and a Primary Sink may store the information about a Secondary Sink during first WFD Session establishment using the mechanism outlined above.

4.13.2.2 Operation of a Persistent WFD Group over TDLS

Re-invocation of WFD Sessions over TDLS is best-effort based. A WFD Device may use the information of the persistent WFD group to re-invoke the WFD Session if required. In order to do so, the WFD Device should first check if a TDLS link with the peer WFD Device already exists. If the direct link exists then it shall establish a WFD Session over the already existing link. Otherwise, the following procedure shall be performed.

If no direct link with the peer WFD Device exists, the WFD Device should check the TDLS Persistent BSSID Support bit in the WFD Extended Capabilities field in the WFD IE in the persistent record corresponding to the peer WFD Device. This bit indicates the likelihood of the peer WFD Device being associated to the same AP and therefore whether the WFD Device should directly proceed with TDLS link establishment. However, if the bit is not set to one, the WFD Device should re-invoke the session using the following procedure:-

1. The WFD Device shall transmit a unicast Probe Request to the peer with the TDLS Persistent Group Re-invoke bit of the WFD Device Information field in the WFD IE set to one. Additionally, the Probe Request shall include an Associated BSSID subelement in the WFD IE to assist the peer WFD Device that is associated with the same AP in case the peer WFD Device has no record of the persistent WFD group over TDLS corresponding to the MAC address of the initiator.
2. The peer WFD Device shall transmit a Probe Response with the TDLS Persistent Group Re-invoke bit set to indicate the acceptance of re-invocation. It may reject the request by setting this bit to zero, if it is not interested in WFD Session establishment or for reasons outside the scope of this Specification. For security reasons, if the responding WFD Device is connected to some other AP, the responding WFD Device shall discard the Probe Request. After a successful Probe Request/Response exchange both WFD Devices should try to associate to the same AP if they are not already associated.
3. Subsequently, the initiator shall transmit a TDLS Setup Request with bit settings as described in the formation procedure of a persistent WFD group. If no response from the peer WFD Device is received within dot11TDLSResponseTimeout (as specified in [13]), the WFD Device should delete all information of the persistent WFD group over TDLS regarding the peer WFD Device and/or indicate to the user about non-availability of the peer WFD Device.

Any failure situation during the re-invocation procedure should lead the WFD Device to use standard discovery processes for WFD Session establishment.

4.13.2.3 Termination of a Persistent WFD Group over TDLS

A WFD Device may decide (as indicated by user policy) not to be a part of a persistent WFD group over TDLS, by locally purging any information for the persistent WFD group over TDLS about a peer WFD Device.

It should also set the TDLS Persistent Group bit (defined in Table 5-5) of the WFD Device Information field of the WFD IE to zero in subsequent TDLS Setup Request/Response frames exchanged with the peer WFD Device. This prevents the peer WFD Device from caching any information about the WFD Device.

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4.14 WFD MAC Procedures -- Concurrency

4.14.1 Concurrent WLAN access with Wi-Fi P2P

When using Wi-Fi P2P for WFD Sessions, the WFD Source and/or WFD Sink may also be associated with an AP. Such a WFD Device should support concurrent traffic access over the Wi-Fi BSS, with minimal disruption to the BSS and other devices on the Distribution System that it may be connected to.

A WFD Device that is concurrently associated with an AP shall conform to the procedures in [7] for concurrent access over the Wi-Fi and the P2P link.

4.14.2 Concurrent WLAN access with TDLS

When using TDLS for WFD Sessions, the WFD Source and WFD Sink are associated with the same AP or GO. Therefore, support for concurrent traffic access with an AP (or a GO) and with a peer TDLS STA is implicit, per IEEE802.11z [13].

4.15 WFD Standby

The feature in this section is optional, and the capability is indicated by RTSP M3 message exchange (and optional WFD Service Discovery).

WFD Standby mode in this Specification is as a mode that a WFD Device can go into for power saving at an application layer. The exact function(s) which a WFD Device will perform while in this mode is implementation specific and is outside the scope of this Specification.

WFD Sources and Sinks can go into WFD Standby mode for power saving for a number of reasons. For example:

- A notebook computer can go into WFD Standby mode due to lack of user input activities.
- A TV or monitor can go into WFD Standby mode due to lack of activity on display inputs.

In order for WFD Devices to maximize potential power savings and for them to be able to wake up from WFD Standby mode in a timely manner, a WFD Source needs to be able to inform a WFD Sink that it is going into WFD Standby mode and vice versa.

A WFD Source/Sink indicates to the WFD Sink/Source that it is going into WFD Standby mode by sending a SET_PARAMETER request message with the parameter `wfd-standby` (specified in section 6.1.18). A WFD Source/Sink indicates it is leaving or asking to leave WFD Standby mode by sending a SET_PARAMETER request message with the parameter triggered-method set to PLAY (specified in section 6.4.5) and/or by sending PLAY(specified in section 6.4.7).

If the WFD Source and the WFD Sink support the standby/resume feature, upon receiving an RTSP SET_PARAMETER request message with the `wfd-standby` parameter (RTSP M12 request message) and the WFD Source sends an RTSP M12 response message with a status code of RTSP OK, the WFD Source shall perform the following:

- Continue to maintain the WFD Session with the WFD Sink, and
- Continue to respond to RTSP commands from the WFD Sink.

In addition, the WFD Source should perform the following:

- Discontinue transmission of RTP packets that carry an MPEG2-TS to the WFD Sink.
- Go into WFD Standby mode at an application layer, e.g., shutdown MPEG-TS multiplexer and audio/video encoder.

If the WFD Source and the WFD Sink support the standby/resume feature, upon receiving an RTSP SET_PARAMETER request message with the `wfd-standby` parameter (RTSP M12 message) and the WFD Sink sends an RTSP M12 response message with a status code of RTSP OK, the WFD Sink shall perform the following:

- Continue to maintain the WFD Session with the WFD Source, and
- Continue to respond to RTSP commands from the WFD Source.

In addition, the WFD Sink may perform the following:

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- Shut down display interface(s) or integrated display function.
- Go into WFD Standby mode at an application layer, e.g., shutdown MPEG2-TS demultiplexer and audio/video decoder.

To resume from WFD Standby mode, there are four cases.

First case:

If the WFD Source and the WFD Sink support this feature, when the WFD Source wants to leave WFD Standby mode, the WFD Source and the WFD Sink shall perform the following steps in order:

- the WFD Source in WFD Standby mode sends an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PLAY to the WFD Sink to indicate that the WFD Sink is being requested to send an RTSP M7 message. This implies that the WFD Source in WFD Standby mode is leaving WFD Standby mode.
- the WFD Sink sends an RTSP M5 response message.
- upon a receiving the RTSP M5 response message indicating a status code of RTSP OK, the WFD Source exits WFD Standby mode.
- after a successful completion of an RTSP M7 message exchange, the WFD Source starts transmitting RTP packets that carry an MPEG2-TS to the WFD Sink.
- the WFD Sink receives and decodes (and renders if it has integrated rendering device or outputs to externally connected rendering device) an MPEG2-TS transmitted by the WFD Source.

Second case:

If the WFD Source and the WFD Sink support the standby/resume feature and the WFD Sink is in WFD Standby mode, when the WFD Source wants to ask the WFD Sink to leave WFD Standby mode, the WFD Source and the WFD Sink shall perform following steps in order:

- the WFD Source sends an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PLAY to the WFD Sink to indicate that the WFD Sink is being requested to send an RTSP M7 request message. This also implies that the WFD Source is asking the WFD Sink in WFD Standby mode to resume.
- upon receiving the RTSP M5 request message and responding to it with an RTSP M5 response message indicating a status code of RTSP OK, the WFD Sink exits WFD Standby mode.
- the WFD Sink enables its display interface(s) or internal display if currently disabled. (This step may be done in different order and is outside the scope of this Specification.)
- the WFD Sink sends an RTSP M7 request message after successful completion of the RTSP M5 message exchange.
- after successful completion of the RTSP M7 message exchange, the WFD Source starts transmitting RTP packets that carry an MPEG2-TS to the WFD Sink.
- the WFD Sink receives and decodes (and renders if it has an integrated rendering device or outputs to externally connected rendering device) an MPEG2-TS transmitted by the WFD Source.

Third case:

If the WFD Source and the WFD Sink support the standby/resume feature, when the WFD Sink wants to leave WFD Standby mode, the WFD Source and the WFD Sink shall perform the following steps in order:

- the WFD Sink in WFD Standby mode sends an RTSP M7 request message to the WFD Source to indicate that the WFD Sink is requesting resumption of the audio and/or video stream. This implies that the WFD Sink in WFD Standby mode is leaving WFD Standby mode.
- the WFD Sink exits WFD Standby mode.
- the WFD Sink enables display interface(s) or internal display, if currently disabled. (This step may be done in different order and is outside the scope of this Specification.)
- after successful completion of the RTSP M7 message exchange, the WFD Source starts transmitting RTP packets that carry an MPEG2-TS to the WFD Sink.
- the WFD Sink receives and decodes (and renders if it has an integrated rendering device or outputs to externally connected rendering device) an MPEG2-TS transmitted by the WFD Source.

Fourth case:

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If the WFD Source and the WFD Sink support the standby/resume feature, when the WFD Sink wants to ask the WFD Source in WFD Standby mode to leave WFD Standby mode, the WFD Source and the WFD Sink shall perform following steps in order:

- the WFD Sink sends an RTSP M7 request message to the WFD Source to indicate that the WFD Sink is requesting resumption of the audio and/or video stream. This implies that the WFD Sink is asking the WFD Source in WFD Standby mode to resume.
- upon receiving the RTSP M7 request message, the WFD Source exits WFD Standby mode.
- after successful completion of the RTSP M7 message exchange, the WFD Source starts transmitting RTP packets that carry an MPEG2-TS to the WFD Sink.
- the WFD Sink receives and decodes (and renders if it has an integrated rendering device or outputs to externally connected rendering device) an MPEG2-TS transmitted by the WFD Source.

When the WFD Source re-starts transmitting RTP packets that carry an MPEEG2-TS to the WFD Sink as described in the above 4 cases, the WFD Source should transmit the PAT/PMT in the MPEG2-TS first. When the WFD Sink re-starts receiving audio and/or video payload in the MPEG2-TS from the WFD Source, the WFD Sink shall parse an MPEG2-TS without the PAT/PMT at the beginning of the resumed MPEG2-TS.

If both the WFD Source and the WFD Sink are in WFD Standby mode, the first case and the second case (or the third case and the fourth case) are combined, but only one RTSP M5 (or M7) request message is transmitted to leave WFD Standby mode at both the WFD Source and the WFD Sink.

The WFD Source in WFD Standby mode shall not send any RTSP request messages except for the RTSP M16 request message and the RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PLAY or to TEARDOWN.

If the WFD Source in WFD Standby mode receives an RTSP M7 request message, an RTSP M8 request message or an RTSP M12 request message, the WFD Source shall respond as specified in section 6.4.7, 6.4.8 or 6.4.12, respectively. If the WFD Source in WFD Standby mode receives other RTSP request messages, the WFD Source in WFD Standby mode shall send an RTSP response message with status code “406” (meaning “not acceptable”) and reason phrase “in-standby-mode”.

The WFD Sink in WFD Standby mode shall not send any RTSP request messages except for the RTSP M7 request message and the RTSP M8 request message.

If the WFD Sink in WFD Standby mode receives an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PLAY or to TEARDOWN, or an RTSP M12 request message, the WFD Sink shall respond as specified in section 6.4.5 or 6.4.12, respectively. If the WFD Sink in WFD Standby mode receives other RTSP request messages, the WFD Sink in WFD Standby mode shall send RTSP response message with status code “406” (meaning “not acceptable”) and reason phrase “in-standby-mode”.

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5 Frame Formats

This section describes the information elements and frame formats used to perform the procedures described in Chapter 4.

The WFD communication protocol is based on the use of the WFD Information Element (WFD IE) and WFD action frame formats. These utilize the Vendor Specific Information Element and Vendor Specific Action frame formats as specified in IEEE Std 802.11-2007 [14] with the WFA OUI and OUI Type indicating Wi-Fi Display. A number of WFD subelements are defined; a single WFD IE carries one or more WFD subelements.

Byte ordering within the multi-octet fields shall be in network byte order (big-endian).

5.1 WFD Information Element

5.1.1 WFD IE Format

The vendor specific information element format (as defined in IEEE Std 802.11-2007 [14]) is used to define the WFD information element (WFD IE) in this Specification. The format of the WFD IE is shown in Table 5-1.

Field	Size (octets)	Value (Hexadecimal)	Description
Element ID	1	DD	IEEE 802.11 vendor specific usage
Length	1	Variable	Length of the following fields in the IE in octets. The length field is variable and set to 4 plus the total length of WFD subelements.
OUI	3	50-6F-9A	WFA Specific OUI
OUI Type	1	0A	Identifying the type or version of the WFD IE. Setting to 0x0A indicates WFA WFD v1.0
WFD subelements	Variable		One or more WFD subelements appear in the WFD IE

Table 5-1 : WFD IE Format

The WFD subelements are defined to have a common general format consisting of a 1 octet WFD subelement ID field, a 2 octets Length field and variable-length subelement specific information fields as shown in Table 5-2.

Field	Size (octets)	Value (Hexadecimal)	Description
Subelement ID	1		Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	Variable	Length of the following fields in the subelement
Subelements body field	Variable		Subelement specific information fields

Table 5-2 : General Format of a WFD Subelement

Subelement ID (Decimal)	Notes

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0	WFD Device Information
1	Associated BSSID
2	WFD Audio Formats
3	WFD Video Formats
4	WFD 3D Video Formats
5	WFD Content Protection
6	Coupled Sink Information
7	WFD Extended Capability
8	Local IP Address
9	WFD Session Information
10	Alternative MAC Address
11-255	Reserved

Table 5-3 : WFD Subelement ID Definitions

A WFD Device that encounters an unknown or reserved subelement ID value within a WFD IE which was received without error shall ignore that WFD subelement and parse any remaining fields for additional WFD subelements with recognizable subelement ID values. A WFD Device that encounters a recognizable but unexpected subelement ID value in the received WFD IE may ignore that WFD subelement.

More than one WFD IE may be included in a single frame. If multiple WFD IEs are present, the complete WFD subelement data consists of the concatenation of the WFD subelement fields of the WFD IEs. The WFD subelements field of each WFD IE may be any length up to the maximum (251 octets). The order of the concatenated WFD subelement data shall be preserved in the ordering of the WFD IEs in the frame. All of the WFD IEs shall fit within a single frame and shall be adjacent in the frame. If a WFD subelement is not contained entirely within a single WFD IE, the WFD subelement ID field and Length field for that subelement occur only once at the start. This is the same rule for P2P IE as specified in section 4.1.1 of [7], and an example for P2P IE is shown in Figure 16 of [7].

5.1.2 WFD Device Information Subelement

The WFD Device Information subelement is used to signal information required by a peer WFD Device during discovery to facilitate a decision as to whether to attempt pairing with the peer WFD Device and creating a WFD Session. The format of the WFD Device Information subelement is as shown in Table 5-4.

Field	Size (octets)	Value	Description
Subelement ID	1	0	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	6	Length of the following fields of the subelement.
WFD Device Information	2		Bitmap defined in Table 5-5 detailing WFD Device Information.
Session Management Control Port	2	Valid TCP port	Default 7236 [33]. TCP port at which the WFD Device listens for RTSP messages. (If a WFD Sink that is transmitting this subelement does not support the RTSP

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			server function, this field is set to all zeros.) The WFD Device can choose any value other than default 7236[6].
WFD Device Maximum Throughput	2		Maximum average throughput capability of the WFD Device represented in multiples of 1Mbps

Table 5-4 : WFD Device Information Subelement

Table 5-5 lists the interpretation of the WFD Device Information field.

Bits	Name	Interpretation
1:0	WFD Device Type bits	0b00: WFD Source 0b01: Primary Sink 0b10: Secondary Sink 0b11: dual-role possible, i.e., either a WFD Source or a Primary Sink
2	Coupled Sink Operation Support at WFD Source bit	0b0: Coupled Sink Operation not supported by WFD Source. 0b1: Coupled Sink Operation supported by WFD Source This bit is valid for WFD Device Type bits set to value 0b00 or 0b11. When WFD Device Type bits value is 0b01 or 0b10, the value of this b2 is ignored upon receiving.
3	Coupled Sink Operation Support at WFD Sink bit	0b0: Coupled Sink Operation not supported by WFD Sink 0b1: Coupled Sink Operation supported by WFD Sink This bit is valid for WFD Device Type bits set to value 0b01, 0b10 or 0b11. When WFD Device Type bits value is 0b00, the value of this b3 is ignored upon receiving.
5:4	WFD Session Availability bits	0b00: Not available for WFD Session 0b01: Available for WFD Session 0b10, 0b11: Reserved
6	WSD Support bit	0b0: WFD Service Discovery (WSD): Not supported 0b1: WFD Service Discovery (WSD): Supported
7	PC bit	0b0: Preferred Connectivity (PC): P2P 0b1: Preferred Connectivity (PC): TDLS
8	CP Support bit	0b0: Content Protection using the HDCP system 2.x: Not supported 0b1:Content Protection using the HDCP system 2.x [7] : Supported

[6] When not choosing default 7236, it is recommended to choose a port number within 49152 to 65535 (as the Private or Ephemeral Ports as described in [32]).

[7] Because a transition period from HDCP 2.0 to HDCP 2.1 defined by DCP LLC has been expired, this 0b1 means "Content Protection using the HDCP system 2.1 Supported", on the WFD Devices seeking WFD certification. After a transition period from the previous version of HDCP 2 to the newest version of HDCP 2 defined by DCP LLC has been expired, this 0b1 means "Content Protection using the newest version of HDCP system 2 Supported", on the WFD Devices seeking WFD certification. Refer to section 5.2 of [39] (or later version) for more detail.

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9	Time Synchronization Support bit	0b0: Time Synchronization using 802.1AS: Not supported 0b1: Time Synchronization using 802.1AS: Supported
10	Audio un-supported at Primary Sink bit	0b0: all cases except below 0b1: If B1B0=0b01 or 0b11, and this WFD Device does not support audio rendering when acting as a Primary Sink
11	Audio only support at WFD Source bit	0b0: all cases except below 0b1: If B1B0=0b00 or 0b11, and this WFD Device supports transmitting audio only elementary stream when acting as a WFD Source
12	TDLS Persistent Group bit	0b0: TDLS persistent group not intended 0b1: TDLS persistent group intended
13	TDLS Persistent Group Re-invoke	0b0: all other cases except below 0b1: The request is for re-invocation of TDLS persistent group
15:14	Reserved	Set to all zeros

Table 5-5 : WFD Device Information Field

WFD Devices which intend or accept establishment of a WFD Connection or the Coupling operation shall set WFD Device Type bits (B5B4) of the WFD Device Information field of the WFD Device Information subelement to 0b01.

5.1.3 Associated BSSID Subelement

The Associated BSSID subelement is used to indicate the address of the AP (or the GO) that the WFD Device is associated with. The format of the Associated BSSID subelement is as shown in Table 5-6.

If a WFD Device is associated with more than one AP(s) and/or GO(s), the WFD Device shall select one of them to be indicated in this Associated BSSID subelement. Although it is recommended to select one that can be used in TDLS topology, selection is outside the scope of this Specification.

Field	Size (octets)	Value	Description
Subelement ID	1	1	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	6	Length of the following fields of the subelement.
Associated BSSID	6		Address of the infrastructure AP or the GO to which the WFD Device is associated.

Table 5-6 : Associated BSSID Subelement

5.1.4 Coupled Sink Information Subelement

The Coupled Sink Information subelement signals the status of a WFD Sink's coupling with another WFD Sink. The format of the Coupled Sink Information subelement is as shown in Table 5-7.

Field	Size (octets)	Value	Description
Subelement ID	1	6	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.

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Length	2	7	Length of the following fields of the subelement.
Coupled Sink Status bitmap	1		Bitmap defined in Table 5-8 detailing Coupled Sink Status.
Coupled Sink MAC Address	6		MAC address of other WFD Sink with which Coupling established. If the WFD Device has not Coupled, these six octets shall be set to all zeros.

Table 5-7 : Coupled Sink Information Subelement

5.1.4.1 Coupled Sink Status Bitmap

The Coupled Sink status bitmap signals the status of a WFD Sink's coupling with another WFD Sink. This bitmap is also used by the `wfd-coupled-sink` parameter described in section 6.1.7.

Table 5-8 defines the fields of the Coupled Sink Status Bitmap.

Bits	Name	Interpretation
1:0	Coupled Sink Status bits	0b00: Not coupled/Available for Coupling 0b01: Coupled 0b10: Teardown Coupling 0b11: Reserved
7:2	Reserved	Set to all zeros

Table 5-8 : Coupled Sink Status Bitmap

5.1.5 WFD Video Formats Subelement

The WFD Video Formats subelement is used to indicate the capability of a WFD Device. The format of the WFD Video Formats subelement is as shown in Table 5-9.

In a public action frame used for WFD Service Discovery, multiple WFD Video Formats subelements may be included to indicate multiple supported H.264 profiles with corresponding resolution/refresh rates and so on.

Field	Size (octets)	Value	Description
Subelement ID	1	3	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	21	Length of the following fields of the subelement.
CEA Resolutions/Refresh Rates bitmap	4		Bitmap defined in Table 5-10 detailing CEA resolutions and refresh rates supported by the CODEC.
VESA Resolutions/Refresh Rates bitmap	4		Bitmap defined in Table 5-11 detailing VESA resolutions and refresh rates supported by the CODEC.
HH Resolutions/Refresh Rates bitmap	4		Bitmap defined in Table 5-12 detailing HH resolutions and refresh rates supported by the CODEC.
Native Resolutions/Refresh Rates bitmap	1		Bitmap defined in Table 5-13 detailing native display resolutions and refresh rates supported by the WFD Sink.

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Profiles bitmap	1		Bitmap defined in Table 5-14 detailing the H.264 profile indicated by this instance of the WFD Video Formats subelement.
Levels bitmap	1		Bitmap defined in Table 5-15 detailing the H.264 level indicated by this instance of the WFD Video Formats subelement.
Latency field	1		Specifying the latency of the video decoder at the Primary Sink as an integer multiple of 5 msec. This field shall be set to all zeros when transmitted by the WFD Source in a WFD Service Discovery Response frame. This field should be set to all zeros when transmitted by the WFD Source in an RTSP M4 request message and the WFD Sink shall ignore this field upon reception. If the Primary Sink does not support this field, it shall set this field to all zeros. Otherwise the WFD Sink shall set this field to a best-effort estimate of the worst-case time between the availability of source data at the input interface of the decoder, and the presentation of the corresponding decoded data at the input interface of the rendering device, rounded up to the next higher multiple of 5 msec.
Minimum slice size field	2		Specifying the smallest slice size expressed in number of macroblocks. If this field is transmitted by the WFD Source, this value shall be the smallest encoded slice it can support. If this field is transmitted by the Primary Sink, this value shall be the smallest slice size it can decode. WFD Devices that do not support slice encoding in which a picture is constructed by multiple slices shall set this field to 0x00 00.
Slice Encoding Parameters bitmap	2		Bitmap defined in Table 5-16 detailing parameters for the slice encoding in which a picture is constructed by multiple slices.
Video Frame Rate Control Support bitmap	1		Bitmap defined in Table 5-17 detailing the video frame skipping support with its parameter and frame rate change support.

Table 5-9 : WFD Video Formats Subelement

5.1.5.1 CEA Resolutions/Refresh Rates Bitmap

The CEA Resolutions/Refresh rates bitmap represents the set of CEA resolutions and corresponding refresh rates that a WFD Device supports. This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3).

In the `wfd-video-formats` parameter that is included in RTSP M3 responses or in WFD Service Discovery frames:

- B0 of the Supported CEA resolution/refresh-rates bitmap (Table 5-10) shall be set to one for all WFD Devices (except for Secondary Sink) indicating all WFD Devices shall support 640x480p60 as a mandatory mode of operation.
- The WFD Devices that support higher resolution(s) at 60Hz family than 640x480 shall set B1 to one, and the WFD Devices that support higher resolution(s) at 50Hz family than 640x480 shall set B3 to one, of Table 5-10.

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The frame rate described in Table 5-10, Table 5-11 and Table 5-12 refer to the rate at which video payload is sourced from the WFD Source. The transport stream may include information that is used to determine if the video payload corresponds to 60 (59.94), 30 (29.97), 50, 25, or 24 (23.98) fps as defined in [2]. The WFD Source selects a frame rate to be used for the WFD Session. The selected frame rate is conveyed to the WFD Sink during WFD Capability Negotiation using the RTSP M4 request message. The decoder at the WFD Sink shall have support for 59.94, 29.97, or 23.98 fps when the WFD Sink advertised it support of 60, 30, or 24 fps, respectively.

See section 3.4.2 for complete details of mandatory configurations.

Index is used for the Native Resolution/Refresh Rate bitmap.

Bits	Index	Interpretation
0	0	640x480 p60
1	1	720x480 p60
2	2	720x480 i60
3	3	720x576 p50
4	4	720x576 i50
5	5	1280x720 p30
6	6	1280x720 p60
7	7	1920x1080 p30
8	8	1920x1080 p60
9	9	1920x1080 i60
10	10	1280x720 p25
11	11	1280x720 p50
12	12	1920x1080 p25
13	13	1920x1080 p50
14	14	1920x1080 i50
15	15	1280x720 p24
16	16	1920x1080 p24
31:17	-	Reserved

Table 5-10 : Supported CEA Resolution/Refresh Rates

5.1.5.2 VESA Resolutions/Refresh Rates Bitmap

The VESA Resolutions/Refresh Rates bitmap represents the set of VESA resolutions and corresponding refresh rates that a WFD Device supports. This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3).

When specifying support for VESA format, the WFD Sink shall indicate support for a resolution with higher refresh rate(s) if and only if it also indicates support for a corresponding lower refresh rate. For instance, support for 720x480p60 can be indicated only if support for 720x480p30 is also indicated.

Index is used for the Native Resolution/Refresh Rate bitmap.

Bits	Index	Interpretation
0	0	800x600 p30

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1	1	800x600 p60
2	2	1024x768 p30
3	3	1024x768 p60
4	4	1152x864 p30
5	5	1152x864 p60
6	6	1280x768 p30
7	7	1280x768 p60
8	8	1280x800 p30
9	9	1280x800 p60
10	10	1360x768 p30
11	11	1360x768 p60
12	12	1366x768 p30
13	13	1366x768 p60
14	14	1280x1024 p30
15	15	1280x1024 p60
16	16	1400x1050 p30
17	17	1400x1050 p60
18	18	1440x900 p30
19	19	1440x900 p60
20	20	1600x900 p30
21	21	1600x900 p60
22	22	1600x1200 p30
23	23	1600x1200 p60
24	24	1680x1024 p30
25	25	1680x1024 p60
26	26	1680x1050 p30
27	27	1680x1050 p60
28	28	1920x1200 p30
31:29	-	Reserved

Table 5-11 : Supported VESA Resolution/Refresh Rates

5.1.5.3 HH Resolutions/Refresh Rates Bitmap

The HH Resolutions/Refresh Rates bitmap represents the set of resolutions and corresponding refresh rates commonly supported in handheld devices that a WFD Device supports. This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3).

Index is used for the Native Resolution/Refresh Rate bitmap.

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Bits	Index	Interpretation
0	0	800x480 p30
1	1	800x480 p60
2	2	854x480 p30
3	3	854x480 p60
4	4	864x480 p30
5	5	864x480 p60
6	6	640x360 p30
7	7	640x360 p60
8	8	960x540 p30
9	9	960x540 p60
10	10	848x480 p30
11	11	848x480 p60
31:12	-	Reserved

Table 5-12 : Supported HH Resolutions/Refresh Rates

5.1.5.4 Native Resolutions/Refresh Rates Bitmap

The Native Resolution/Refresh Rate bitmap represents the native resolutions and corresponding refresh rates of a WFD Device. This bitmap is used in WFD Video Formats subelement. This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3) and the `wfd-3d-formats` parameter (specified in section 6.1.4). If this bitmap is included in the WFD Video Formats subelement transmitted by a WFD Source, it shall be set to all zeros. If this bitmap is included in an RTSP M4 request message, a WFD Source should set this bitmap to all zeros and a Primary Sink shall ignore this bitmap upon reception.

Bits	Name	Interpretation
2:0	Table Selection bits	0b000: Resolution/Refresh rate table selection: Index to CEA resolution/refresh rates (Table 5-10) 0b001: Resolution/Refresh rate table selection: Index VESA resolution/refresh rates (Table 5-11) 0b010: Resolution/Refresh rate table selection: Index HH resolutions/refresh rates (Table 5-12) 0b011~0b111: Reserved
7:3	Index bits	Index into resolution/refresh rate table selected by [B2:B0]

Table 5-13 : Display Native Resolution Refresh Rate

5.1.5.5 Profiles Bitmap

The Profiles Bitmap represents the H.264 profiles supported by a WFD Device. This bitmap is also used in the WFD 3D Video Formats subelement. The Profiles Bitmap when included in a WFD subelement shall either have B0 or B1 (but not both) of the bitmap set to one

This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3), the `wfd-3d-formats` parameter (specified in section 6.1.4) and the `wfd-preferred-display-mode` parameter (specified in section 6.1.14).

Bits	Name	Interpretation

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0	CBP bit	0b0: Constrained Baseline Profile (CBP) not supported 0b1: CBP supported
1	CHP bit	0b0: Constrained High Profile (CHP) not supported 0b1: CHP supported
7:2	Reserved	Set to all zeros

Table 5-14 : Profiles Bitmap

5.1.5.6 Levels Bitmap

The Levels bitmap indicates the maximum H.264 level supported for the corresponding H.264 profile indicated in the Profiles Bitmap. Only one bit in the Levels Bitmap used in a WFD subelement shall be set to one. This bitmap is also used in the WFD 3D Video Formats subelement.

This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3), the `wfd-3d-formats` parameter (specified in section 6.1.4) and the `wfd-preferred-display-mode` parameter (specified in section 6.1.14). In this case, the bitmap represents either:

- the maximum level supported for the H.264 profile indicated in the Profiles Bitmap supported by the WFD Device in an RTSP M3 response message (only one bit set to one) or
- the level and the corresponding H.264 profile selected by the WFD Source in an RTSP M4 request message (only one bit set to one).

Bits	Name	Interpretation
0	H.264 Level 3.1 bit	0b0: H.264 Level 3.1 not supported 0b1: H.264 Level 3.1 supported
1	H.264 Level 3.2 bit	0b0: H.264 Level 3.2 not supported 0b1: H.264 Level 3.2 supported
2	H.264 Level 4 bit	0b0: H.264 Level 4 not supported 0b1: H.264 Level 4 supported
3	H.264 Level 4.1 bit	0b0: H.264 Level 4.1 not supported 0b1: H.264 Level 4.1 supported
4	H.264 Level 4.2 bit	0b0: H.264 Level 4.2 not supported 0b1: H.264 Level 4.2 supported
7:5	Reserved	Set to all zeros

Table 5-15 : Maximum H.264 Level Supported

5.1.5.7 Slice Encoding Parameters Bitmap

The slice encoding parameters bitmap is two octets long and describes the parameters to be used in slice encoding in which a picture is constructed by multiple slices. This bitmap is also used in the WFD 3D Video Formats subelement. This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3), the `wfd-3d-formats` parameter (specified in section 6.1.4) and the `wfd-preferred-display-mode` parameter (specified in section 6.1.14).

Bits	Name	Interpretation
9:0	Max Slice Num bits	Maximum number of slices per a picture, minus 1.
12:10	Max Slice Size Ratio bits	When this bitmap is used in a WFD subelement:

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		Ratio of Maximum slice size to be used and Minimum slice size indicated in minimum-slice-size field in WFD Video Formats or WFD 3D Video Formats subelement. When this bitmap is used in an RTSP message: Ratio of Maximum slice size to be used and Minimum slice size indicated in minimum-slice-size field in `wfd-video-formats` or `wfd-3d-formats`.
15:13	Reserved	Set to all zeros

Table 5-16 : Slice Encoding parameters bitmap

If this bitmap is used in a subelement and the Minimum slice size field in the WFD Video Formats subelement or the WFD 3D Video Formats subelement is all zeros, all bits in this bitmap shall be set to zero.

If this bitmap is used in an RTSP message and the minimum-slice-size field in the `wfd-video-formats` parameter or the `wfd-3d-formats` parameter is all zeros, all bits in this bitmap shall be set to zero.

The subfields [B9:B0] and [B12:B10] shall be set to a non-zero value in other cases.

5.1.5.8 Video Frame Rate Control Support Bitmap

The Video Frame Rate Control Support bitmap indicates support for Frame Rate Change and support for Video Frame Skipping. If Video Frame Skipping is supported, the maximum time intervals in unit of 0.5 seconds that can be elapsed between two successive video frames are also indicated.

This bitmap is also used in the WFD 3D Video Formats subelement. This bitmap is also used by the `wfd-video-formats` parameter (specified in section 6.1.3), the `wfd-3d-formats` parameter (specified in section 6.1.4) and the `wfd-preferred-display-mode` parameter (specified in section 6.1.14).

Bits	Name	Interpretation
0	Video Frame Skipping Support bit	0b0: Not supported 0b1: Supported
3:1	Max Skip Interval bits	Reserved if B0 is 0b0 (video frame skipping not supported) These bits indicate the maximum/allowable time-interval between two video frames after skipped as expressed equation as follows, except for 0b000. (value in decimal) x 0.5 second(s) 0b000 : No limitation 0b001~ 0b111 : parameter for indicating time-interval
4	Video Frame Rate Change (see section 4.10.3.2) Support bit	0b0: Dynamic video refresh rate change without user intervention not supported 0b1: Dynamic video refresh rate change without user intervention supported
7:5	Reserved	Set to all zeros

Table 5-17 : Video Frame Rate Control Support Bitmap

5.1.6 WFD 3D Video Formats Subelement

The WFD 3D Video Formats subelement is used to indicate the 3D video format capability of a WFD Device. The format of the WFD 3D Video Formats subelement is as shown in Table 5-18.

In a public action frame used for WFD Service Discovery, multiple WFD 3D Video Formats subelements may be included to indicate multiple supported H.264 profiles with corresponding resolution/refresh rates.

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Field	Size (octets)	Value	Description
Subelement ID	1	4	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	17	Length of the following fields of the subelement.
3D Video Capability bitmap	8		Bitmap defined in Table 5-19 detailing 3D video resolutions/refresh rates and packing method supported by codec.
Native Resolution / Refresh Rate bitmap	1		Bitmap defined in Table 5-13. See section 5.1.5.4.
Profiles bitmap	1		Bitmap defined in Table 5-14. See section 5.1.5.5.
Levels bitmap	1		Bitmap defined in Table 5-15. See section 5.1.5.6
Latency field	1		See section 5.1.5.
Minimum slice size field	2		See section 5.1.5.
Slice Encoding Parameters bitmap	2		Bitmap defined in Table 5-16. See section 5.1.5.7.
Video Frame Rate Control Support bitmap	1		Bitmap defined in Table 5-17. See section 5.1.5.8.

Table 5-18 : WFD 3D Video Formats Subelement

5.1.6.1 3D Video Capability Bitmap

The 3D Video Capability bitmap encodes the support for stereoscopic 3D capabilities a WFD Device supports. This bitmap is used by the `wfd-3d-formats` parameter (specified in section 6.1.4) or in WFD Service Discovery frames.

- bit 0 of the 3D Video Capability bitmap shall be set to one for all WFD Devices that support 3D video over Wi-Fi Display.
- The WFD Devices that support 3D video with a refresh rates at 60Hz family over Wi-Fi Display shall set B1 of the 3D Video Capability bitmap to one, and the WFD Devices that support 3D video with a refresh rates of 50Hz family over Wi-Fi Display shall set B2 of the 3D Video Capability bitmap to one.

Frame rate described in the Table 5-19, refer to the rate at which video payload is sourced from the WFD Source. The transport stream may include information that is used to determine if the video payload corresponds to 60 (59.94), 30 (29.97), 50, 25 or 24 (23.98) fps as defined in [2]. The WFD Source selects a frame rate to be used for the WFD Session. The selected frame rate is conveyed to the WFD Sink during WFD Capability Negotiation using the RTSP M4 request message. The decoder at the WFD Sink shall have support for 59.94, 29.97, or 23.98 fps when the WFD Sink advertised it support of 60, 30, or 24 fps, respectively.

Bits	Index	Interpretation
0	0	1920x(540+540) p24, Top & Bottom[Half]
1	1	1280x(360+360) p60, Top & Bottom[Half]
2	2	1280x(360+360) p50, Top & Bottom[Half]
3	3	1920x1080 (p24L+p24R), Frame Sequential

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4	4	1280x720 (p60L+p60R), Frame Sequential
5	5	1280x720 (p30L+p30R), Frame Sequential
6	6	1280x720 (p50L+p50R), Frame Sequential
7	7	1280x720 (p25L+p25R), Frame Sequential
8	8	1920x(1080+45+1080) p24, Frame Packing
9	9	1280x(720+30+720) p60, Frame Packing
10	10	1280x(720+30+720) p30, Frame Packing
11	11	1280x(720+30+720) p50, Frame Packing
12	12	1280x(720+30+720) p25, Frame Packing
13	13	(960+960)x1080 i60, Side by Side[Half]
14	14	(960+960)x1080 i50, Side by Side[Half]
15	15	640x(240 + 240) p60, Top & Bottom [Half]
16	16	(320+320)x480 p60, Side by Side [Half]
17	17	720x(240+240) p60, Top & Bottom [Half]
18	18	(360+360)x480 p60, Side by Side [Half]
19	19	720x(288+288) p50, Top & Bottom [Half]
20	20	(360+360)x576 p50, Side by Side [Half]
21	21	1280x(360+360) p24, Top & Bottom [Half]
22	22	(640+640)x720 p24, Side by Side [Half]
23	23	1280x(360+360) p25, Top & Bottom [Half]
24	24	(640+640)x720 p25, Side by Side [Half]
25	25	1280x(360+360) p30, Top & Bottom [Half]
26	26	(640+640)x720 p30, Side by Side [Half]
27	27	1920x(540+540) p30, Top & Bottom [Half]
28	28	1920x(540+540) p50, Top & Bottom [Half]
29	29	1920x(540+540) p60, Top & Bottom [Half]
30	30	(640+640)x720 p50, Side by Side [Half]
31	31	(640+640)x720 p60, Side by Side [Half]
32	32	(960+960)x1080 p24, Side by Side [Half]
33	33	(960+960)x1080 p50, Side by Side [Half]
34	34	(960+960)x1080 p60, Side by Side [Half]
35	35	1920x(1080+45+1080) p30, Frame Packing
36	36	1920x(1080+45+1080) i50, Frame Packing
37	37	1920x(1080+45+1080) i60, Frame Packing
63:38	-	Reserved

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Table 5-19 : Supported 3D Video Formats

5.1.7 WFD Audio Formats Subelement

The WFD Audio Formats subelement is used to indicate the capabilities of a WFD Device. The format of the WFD Audio Formats subelement is shown in Table 5-20.

Field	Size (octets)	Value	Description
Subelement ID	1	2	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	15	Length of the following fields of the subelement.
LPCM Modes bitmap	4		Bitmap defined in Table 5-21 detailing LPCM audio formats supported by the codec on the WFD Device.
LPCM decoder latency field	1		Specifying the latency of the LPCM decoder at the WFD Sink as an integer multiple of 5 msec. This field shall be set to all zeros when transmitted by the WFD Source in a WFD Service Discovery Response frame. This field should be set to all zeros when transmitted by the WFD Source in an RTSP M4 request message and the WFD Sink shall ignore this field upon reception. If the WFD Sink does not support this field, it shall set this field to all zeros. Otherwise the WFD Sink shall set this field to a best-effort estimate of the worst-case time between the availability of source data at the input interface of the decoder, and the presentation of the corresponding decoded data at the input interface of the rendering device, rounded up to the next higher multiple of 5 msec.
AAC Modes bitmap	4		Bitmap defined in Table 5-22 detailing AAC audio formats supported by the codec on the WFD Device.
AAC decoder latency field	1		Specifying the latency of the AAC decoder at the WFD Sink as an integer multiple of 5 msec. This field shall be set to all zeros when transmitted by the WFD Source in a WFD Service Discovery Response frame. This field shall be set to all zeros when transmitted by the WFD Sink that does not support AAC format at all, in a WFD Service Discovery Response frame. This field should be set to all zeros when transmitted by the WFD Source in an RTSP M4 request message and the WFD Sink shall ignore this field upon reception. If the WFD Sink does not support this field, it shall set this field to all zeros. Otherwise the WFD Sink shall set this field to a best-effort estimate of the worst-case time between the availability of source data at the input interface of the decoder, and the presentation of the corresponding decoded data at the input interface of the rendering device, rounded up to the next higher multiple of 5 msec.
AC3 Modes bitmap	4		Bitmap defined in Table 5-23 detailing AC3 audio formats supported by the codec on the WFD Device.

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AC3 decoder latency field	1		Specifying the latency of the AC3 decoder at the WFD Sink as an integer multiple of 5 msec. This field shall be set to all zeros when transmitted by the WFD Source in a WFD Service Discovery Response frame. This field shall be set to all zeros when transmitted by the WFD Sink that does not support AC3 format at all, in a WFD Service Discovery Response frame. This field should be set to all zeros when transmitted by the WFD Source in an RTSP M4 request message and the WFD Sink shall ignore this field upon reception. If the WFD Sink does not support this field, it shall set this field to all zeros. Otherwise the WFD Sink shall set this field to a best-effort estimate of the worst-case time between the availability of source data at the input interface of the decoder, and the presentation of the corresponding decoded data at the input interface of the rendering device, rounded up to the next higher multiple of 5 msec.

Table 5-20 : WFD Audio Formats Subelement

5.1.7.1 LPCM Modes Bitmap

The LPCM Modes bitmap represents LPCM configurations supported by the WFD Device. This bitmap is also used in the 'modes' field of `wfd-audio-codecs` as described in section 6.1.2.

In a `wfd-audio-codecs` parameter that is included in an RTSP M3 response message or in a WFD Service Discovery frame, B1 of the LPCM Modes bitmap (Table 5-21) shall be set to one for all WFD Devices to indicate support of 2-channel LPCM audio at 16 bits/channel at 48000 samples/second as a mandatory mode of operation (except for a Primary Sink that does not have audio rendering[8] capability, e.g., typical office projector). Other LPCM audio formats are optional at all WFD Devices.

Bits	Interpretation		
	Sampling Frequency (kHz)	Bit-width (bits)	#channels
0	44.1	16	2
1	48	16	2
31:2	Reserved		

Table 5-21 : LPCM Modes bitmap

5.1.7.2 AAC Modes Bitmap

The AAC Modes bitmap represents AAC configurations supported by the WFD Device. This bitmap is also used in the 'modes' field of `wfd-audio-codecs` as described in section 6.1.2.

Bits	Interpretation			
	Sampling Frequency (kHz)	Bit-width (bits)	Number of channels	Codec Option

[8] A device is deemed audio rendering capable if it can playback audio payload with or without the help of an external transducer (e.g., attached speaker).

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0	48	16	2	AAC-LC
1	48	16	4	AAC-LC
2	48	16	6	AAC-LC
3	48	16	8[9]	AAC-LC
31:4	Reserved			

Table 5-22 : AAC Codec bitmap

5.1.7.3 AC3 Modes Bitmap

The AC3 Modes bitmap represents Dolby Digital (also known as AC3) configurations supported by the WFD Device. This bitmap is also used in the 'modes' field of `wfd-audio-codecs` as described in section 6.1.2.

Bits	Interpretation			
	Sampling Frequency (kHz)	Bit-width (bits)	Number of channels	Codec Option
0	48	16	2	Dolby Digital (AC-3)
1	48	16	4	Dolby Digital (AC-3)
2	48	16	6	Dolby Digital (AC-3)
31:3	Reserved			

Table 5-23: AC3 Modes bitmap

5.1.8 Content Protection Subelement

The Content Protection subelement is used to indicate the support of content protection by a WFD Device. The format of the Content Protection subelement is as shown in Table 5-24.

Field	Size (octets)	Value	Description
Subelement ID	1	5	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	1	Length of the following fields of the subelement.
Content Protection bitmap	1		Bitmap defined in Table 5-25 detailing content protection scheme(s) supported at WFD Devices.

Table 5-24 : Content Protection Subelement

5.1.8.1 Content Protection Bitmap

The Content Protection bitmap describes the supported content protection scheme over Wi-Fi Display.

Bits	Name	Interpretation

[9] In ISO/IEC standard, down-mix method is not defined for 8-ch (7.1ch), and it is recommended that the WFD Sink that does not support 8-ch (7.1ch) natively should not set this bit to one.

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0	HDCP 2.0 Support bit	0b0: the HDCP system 2.0 is not supported 0b1: the HDCP system 2.0 is supported
1	HDCP 2.1 or higher version Support bit	0b0: the HDCP system 2.1 and higher version is not supported 0b1: the HDCP system 2.1 or higher version is supported
7:2	Reserved	Set to all zeros

Table 5-25 : Content Protection Bitmap

If the HDCP 2.1 or higher version Support bit (B1) is set to 0b1, the HDCP 2.0 Support bit (B0) shall also be set to 0b1.

5.1.9 WFD Extended Capability Subelement

The WFD Extended Capability subelement is used to indicate the capabilities for miscellaneous and optional functions of a WFD Device. The format of the WFD Extended Capability subelement is as shown in Table 5-26.

Field	Size (octets)	Value	Description
Subelement ID	1	7	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	2	Length of the following fields of the subelement.
WFD Extended capabilities bitmap	2		Bitmap defined in Table 5-27detailing capabilities for miscellaneous and optional functions

Table 5-26 : WFD Extended Capability Subelement

5.1.9.1 WFD Extended Capabilities Bitmap

The WFD Extended Capabilities bitmap describes support for UIBC, I2C Read/Write, Preferred Display mode and WFD Standby/resume control by a WFD Device.

Bits	Name	Interpretation
0	UIBC Support bit	0b0: Not supported 0b1: Supported
1	I2C Read/Write Support bit	0b0: Not supported 0b1: Supported
2	Preferred Display mode Support bit	0b0: Not supported 0b1: Supported
3	Standby and Resume Control Support bit	0b0: Not supported 0b1: Supported
4	TDLS Persistent Support bit	0b0: Not supported 0b1: Supported
5	TDLS Persistent BSSID Support bit	0b0: Not supported 0b1: Supported
15:6	Reserved	Set to all zeros

Table 5-27 : WFD Extended Capabilities Bitmap

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5.1.10 Local IP Address Subelement

The Local IP Address subelement is used to convey the local IP address to a WFD peer STA during TDLS Setup. Only if a WFD IE is included in a TDLS Setup Request/Response as described in section 4.5.3, the WFD IE shall include Local IP Address subelement. Table 5-28 depicts the format of this subelement.

Field	Size (octets)	Value	Description
Sub-element ID	1	8	Defined in Table 5-3.
Length	2	5	Length of the following fields in this subelement
Version	1	1	Version 1: IPv4 address field follows
IPv4 address	4		This field is the IPv4 host address of the STA

Table 5-28 : Local IP Address Subelement

5.1.11 WFD Session Information Subelement

The WFD Session Information subelement describes WFD Session information. Table 5-29 depicts the format of this subelement. A WFD Device that is acting as a GO based on P2P connection includes a list of descriptors of all WFD Devices which are associated in its group and indicate that P2P Discoverability bit in Device Capability Bitmap of P2P Capability attribute equals to 0b1. WFD Device Info Descriptor field is shown in Table 5-30.

Field	Size (octets)	Value	Description
Subelement ID	1	9	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	variable	Length of the following fields of the subelement.
WFD Device Info Descriptor	Sum of all WFD Device info (24octets * number of clients)		List of WFD Device Info Descriptor in WFD group

Table 5-29 : WFD Session Information Subelement

The WFD Device Info Descriptor includes information corresponding to each WFD Device in the group. The WFD Device that is acting as a GO based on P2P connection already knows about all its clients, and it can advertise the known information for other clients of the group to other WFD Devices that are not part of the group. Note that this subelement shall not include GO itself. When the GO does not have associated client that is WFD capable, this subelement shall not be included in the WFD IE.

Field Name	Size (octets)	Value	Description
Length	1	23	Length of the following fields.
Device address	6		Device address
Associated BSSID	6		Address of the infrastructure AP or the GO to which the WFD Device is associated.

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			If the WFD Device described in this descriptor is not associated with the infrastructure AP, these 6 octets shall be set to all zeros. If the WFD Devices associated with more than one AP(s) and/or GO(s), the WFD Device shall choose one of them to be indicated in this Associated BSSID subelement. How to choose one is out-of-scope of this Specification, but it is recommended to choose one that can be used in TDLS topology.
WFD Device Information	2		Bitmap defined in Table 5-5 detailing WFD Device Information.
WFD Device Maximum Throughput	2		Maximum average throughput capability of the WFD Device represented in multiples of 1Mbps
Coupled Sink Information	7		Coupling Status and address of the Coupled Primary or Secondary Sink to which the WFD Devices is Coupled or ready to couple. The first one byte is Coupled Sink status bitmap as defined in Table 5-7, and the rest six bytes are MAC address of Coupled peer WFD Sink. If the WFD Device described in this descriptor is not Coupled, these seven octets shall be set to all zeros. If the GO does not know the MAC address of the Coupled sink with that the WFD Sink described in this descriptor, the last six octets shall be set to all zeros.

Table 5-30 : WFD Device Info Descriptor field

The GO may set WFD Session Availability bits in the WFD Device Information field of WFD Device Info Descriptor to 0b00 or 0b01. The recipient shall interpret these bits as WFD Session availability "unknown".

5.1.12 Alternative MAC Address Subelement

If the resolved connectivity scheme demands use of an interface different from the one used during device discovery phase, the Alternate MAC Address subelement is used to communicate the alternate P2P device address or the WLAN interface address to be used for the WFD Connection. The MAC address required for forthcoming connection establishment is then included into this subelement as an Alternative MAC address field by the WFD Device while transmitting (tunneled) Probe Response frame.

The format of the Alternate MAC Address subelement is as shown in Table 5-31.

Field	Size (octets)	Value	Description
Subelement ID	1	10	Identifying the type of WFD subelement. The specific value is defined in Table 5-3.
Length	2	6	Length of the following fields of the subelement.
Alternative MAC address	6	Valid MAC address	Address of WLAN interface or P2P Device address.

Table 5-31 : Alternative MAC Address subelement

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5.2 Management Frames

This section defines extensions to the P2P management frames specified in [7] in support of WFD Capabilities.

5.2.1 Beacon Frame Format

If a WFD Device acts as a P2P Group Owner, the WFD Device shall insert one or more WFD IEs after the other information elements in the Beacon frames it transmits. WFD subelements for a WFD IE that are included in the Beacon frame are shown in Table 5-32.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the Beacon frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD device shall include the Associated BSSID subelement in the WFD IE in the Beacon frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation and if the WFD Sink is the P2P GO, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the Beacon frames it transmits.

Table 5-32 : WFD Subelements in a Beacon Frame

5.2.2 Probe Request Frame Format

The Probe Request frames are transmitted by any WFD Device.

A WFD Device shall insert one or more WFD IEs after the other information elements in the Probe Request frames it transmits. WFD subelements for a WFD IE that are included in the Probe Request frame are shown in the Table 5-33.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the Probe Request frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the Probe Request frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the Probe Request frames it transmits.
WFD Extended Capability	7	If a WFD Device intends to advertise its TDLS persistent capability to other WFD Devices during the discovery process, the WFD Device shall include the WFD Extended Capability subelement in the WFD IE in the Probe Request frames it transmits.

Table 5-33 : WFD Subelements in a Probe Request Frame

5.2.2.1 Tunneled Probe Request/Response

Probe Request frames and Response frames are tunneled via

1. The AP to which the WFD Source and Sink are associated if the TDLS Prohibited field of the Extended Capability element included in the Beacon frame from the AP is not set to one, or

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2. The GO to which the WFD Source and Sink are associated if the Intra-BSS Distribution field of the Group Capability bitmap of the P2P Capability attribute in the beacon frame from the GO is not set to zero.

Field in the Frame	Value (Hexadecimal)	Length (octets)	Requirement
802.11 MAC Header		Depends on the data frame	MAC header corresponding to a data frame
LLC	AA-AA-03	3	
SNAP	00-00-00-89-0D	5	
Payload Type	2	1	TDLS
Category	7F	1	Vendor Specific
OUI	50-6F-9A	3	WFA OUI
Frame Body Type	4 or 5	1	4 for Probe Request, 5 for Probe Response; other values are reserved. Corresponds to the Management Frame subtype as defined in [13]
Other fields		variable	Information Elements that are included in the encapsulated Probe Request/Response payload

Table 5-34 : Tunneled Probe Request/Response

5.2.3 Probe Response Frame

The Probe Response frames are transmitted by any WFD Device as per the rules specified in [7].

When a WFD Device responds to the Probe Request frame that is transmitted by other WFD Device and contains a WFD IE, the WFD Device shall insert one or more WFD IEs after the other information elements in the Probe Response frames it transmits. WFD subelements for a WFD IE that are included in the Probe Response frame are shown in Table 5-35.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the Probe Response frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the Probe Response frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the Probe Response frames it transmits.
WFD Extended Capability	7	If a WFD Device intends to advertise its TDLS persistent capability to other WFD Devices during the discovery process, the WFD Device shall include the WFD Extended Capability subelement in the WFD IE in the Probe Response frames it transmits.

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WFD Session Information	9	If a WFD Capable GO has at least one associated client that is WFD capable, the WFD capable GO shall include the WFD Session Information subelement in the WFD IE in the Probe Response frames it transmits.
Alternative MAC Address	10	If a WFD Device intends to use a different interface for the forthcoming WFD Connection from the one on which the (tunneled) Probe Request Frame was received, the WFD Device shall include the Alternate MAC Address subelement in the WFD IE in the (tunneled) Probe Response frames it transmits.

Table 5-35 : WFD Subelements in a Probe Response Frame

5.2.4 Association/Reassociation Request Frame

When a WFD Device becomes a P2P client, an Association/Reassociation Request frame is transmitted by the WFD Device.

When a WFD Device tries to establish a P2P connection for a WFD Session with another WFD Device, the WFD Device shall insert one or more WFD IEs after the other information elements in the Association/Reassociation Request frames it transmits. WFD subelements for a WFD IE that is included in the Association/Reassociation Request frame are shown in Table 5-36.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the Association/Reassociation Request frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the Association/Reassociation Request frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the Association/Reassociation Request frames it transmits.

Table 5-36 : WFD Subelements in an Association/Reassociation Request Frame

5.2.5 Association/Reassociation Response Frame

Upon receiving an Association/Reassociation Request frame, an Association/Reassociation Response frame is transmitted by a WFD Device acting as a P2P GO.

When a WFD Device responds to the Association/Reassociation Request frame that is transmitted by other WFD Device and contains a WFD IE, the WFD Device shall insert one or more WFD IEs after the other information elements in the Association/Reassociation Response frames it transmits. WFD subelements for a WFD IE that are included in the Association/Reassociation Response frame are shown in Table 5-37.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement shall be present in the WFD IE in the Association/Reassociation frames it transmit.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the

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		Associated BSSID subelement in the WFD IE in the Association/Reassociation Response frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the Association/Reassociation Response frames it transmits.
WFD Session Information	9	If a WFD Capable GO has at least one associated client that is WFD capable, the WFD capable GO shall include the WFD Session Information subelement in the WFD IE in the Association/Reassociation Response frames it transmits.

Table 5-37 : WFD Subelements in an Association/Reassociation Response Frame

5.2.6 P2P Public Action Frames

5.2.6.1 GO Negotiation Request Frame

The GO Negotiation Request frames are transmitted by any WFD Device.

When a WFD Device tries to establish a P2P connection to initiate a WFD Session with another WFD Device, the WFD Device shall insert one or more WFD IEs after the other information elements in the GO Negotiation Request frames it transmits. WFD subelements for a WFD IE that are included in the GO Negotiation Request frame are shown in Table 5-38.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the GO Negotiation Request frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the GO Negotiation Request frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the GO Negotiation Request frames it transmits.

Table 5-38 : WFD Subelements in a GO Negotiation Request Frame

5.2.6.2 GO Negotiation Response Frame

Upon receiving the GO Negotiation request frame, The GO Negotiation Response frame is transmitted by a WFD Device.

When a WFD Device responds to the GO Negotiation Request frame that is transmitted by another WFD Device and contains a WFD IE, the WFD Device shall insert one or more WFD IEs after the other information elements in the GO Negotiation Response frame that it transmits. WFD subelements for a WFD IE that are included in the GO Negotiation Response frame are shown in Table 5-39.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the GO Negotiation Response frame.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the

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		Associated BSSID subelement in the WFD IE in the GO Negotiation Response frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the GO Negotiation Response frames it transmits.

Table 5-39 : WFD Subelements in a GO Negotiation Response Frame

5.2.6.3 GO Negotiation Confirmation Frame

Upon receiving the GO Negotiation response frame, the GO Negotiation Confirmation frame is transmitted by a WFD Device acting as a P2P GO.

When a WFD Device responds to the GO Negotiation Response frame that is transmitted by another WFD Device and contains a WFD IE, the WFD Device shall insert one or more WFD IEs after the other information elements in the GO Negotiation Confirmation frame that it transmits. WFD subelements for a WFD IE that are included in the GO Negotiation Response frame are shown in Table 5-40.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the GO Negotiation Confirmation frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the GO Negotiation Confirmation frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the GO Negotiation Confirmation frames it transmits.

Table 5-40 : WFD Subelements in a GO Negotiation Confirmation Frame

5.2.6.4 P2P Invitation Request Frame

The P2P Invitation Request frames are transmitted by any WFD Device.

When a WFD Device tries to establish P2P connection for a WFD Session with another WFD Device, the WFD Device shall insert one or more WFD IEs after the other information elements in the P2P Invitation Request frames it transmits. WFD subelements for a WFD IE that are included in the P2P Invitation Request frame are shown in Table 5-41.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the P2P Invitation Request frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the P2P Invitation Request frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the P2P Invitation Request frames it transmits.

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WFD Session Information	9	If a WFD Capable GO has at least one associated client that is WFD capable, the WFD capable GO shall include the WFD Session Information subelement in the WFD IE in the P2P Invitation Request frames it transmits.

Table 5-41 : WFD Subelements in a P2P Invitation Request Frame

5.2.6.5 P2P Invitation Response Frame

Upon receiving the P2P Invitation request frame, the P2P Invitation Response frame is transmitted by a WFD Device.

When a WFD Device responds to the P2P Invitation Request frame that is transmitted by another WFD Device and contains a WFD IE, the WFD Device shall insert one or more WFD IEs after the other information elements in the P2P Invitation Response frame that it transmits. WFD subelements for a WFD IE that are included in the P2P Invitation Response frame are shown in Table 5-42.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement shall be present in the WFD IE in the P2P Invitation Response frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the P2P Invitation Response frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the P2P Invitation Response frames it transmits.
WFD Session Information	9	If a WFD Capable GO has at least one associated client that is WFD capable, the WFD capable GO shall include the WFD Session Information subelement in the WFD IE in the P2P Invitation Response frames it transmits.

Table 5-42 : WFD Subelements in a P2P Invitation Response Frame

5.2.6.6 Provision Discovery Request Frame

The Provision Discovery Request frames are transmitted by a WFD Device, to establish P2P connection for WFD Session with another WFD Device, using Wi-Fi Simple Configuration.

When a WFD Device tries to establish P2P connection for a WFD Session with another WFD Device using Wi-Fi Simple Configuration, the WFD Device shall insert one or more WFD IEs after the other information elements in the Provision Discovery Request frames it transmits. WFD subelements for a WFD IE that are included in the Provision Discovery Request frame are shown in Table 5-43.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the Provision Discovery Request frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the Provision Discovery Request frames it transmits.

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Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the Provision Discovery Request frames it transmits.

Table 5-43 : WFD Subelements in a Provision Discovery Request Frame

5.2.6.7 Provision Discovery Response Frame

Upon receiving the Provision Discovery Request frames, the Provision Discovery Response frames are transmitted by a WFD Device.

When a WFD Device responds to the Provision Discovery Request frame that is transmitted by another WFD Device and contains a WFD IE, the WFD Device shall insert one or more WFD IEs after the other information elements in the Provision Discovery Response frames it transmits. WFD subelements for a WFD IE that are included in the Provision Discovery Response frame are shown in Table 5-44.

Subelements	Subelement ID	Requirement
WFD Device Information	0	A WFD Device shall include the WFD Device Information subelement in the WFD IE in the Provision Discovery Response frames it transmits.
Associated BSSID	1	If a WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in WFD Device Information subelement, the WFD Device shall include the Associated BSSID in the WFD IE in the Provision Discovery Response frames it transmits.
Coupled Sink Information	6	If a WFD Sink supports the Coupled Sink Operation, the WFD Sink shall include the Coupled Sink Information subelement in the WFD IE in the Provision Discovery Response frames it transmits.
WFD Session Information	9	If a WFD Capable GO has at least one associated client that is WFD capable, the WFD capable GO shall include the WFD Session Information subelement in the WFD IE in the Provision Discovery Response frames it transmits.

Table 5-44 : WFD Subelements in a Provision Discovery Response Frame

5.2.7 Service Discovery Action Frames

5.2.7.1 WFD Service Discovery

If WFD Service Discovery is supported, the WFD Device shall make use of the Service Discovery action frames defined in [7], except as noted in the following.

A WFD Device shall set the following fields within a Service Discovery Action Frame;

- OI field to the WFA OUI 0x50 6F 9A
- OUI subtype field to 0x09
- Service protocol type to 0x04.

The query data field of the WFD Service Discovery Query frame transmitted by a WFD Device shall be comprised of a single Service Request TLV for each requested device role with each indicating information for which the requestor seeks response data. For example, if a WFD Device uses a Service Discovery Action Frame to query information from a WFD Device which can function as a WFD Source and a WFD Sink, then the WFD Device can include two TLVs within the same action frame. The query data format encapsulated in the Query Data field in Service TLV field for a WFD Service Discovery Query is specified in Table 5-45.

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The allowed sets of requested information for a WFD Service Discovery Query frame are identified in Table 5-3.

Field	Size (octets)	Description
Requested Device Role	1	0x00: WFD Source 0x01: Primary Sink 0x02: Secondary Sink 0x03: dual role of WFD Source and Primary Sink
List of WFD subelement IDs	Variable	Requested WFD Subelements as an array of subelement IDs as per Table 5-3

Table 5-45 : Query data format for a WFD Service Discovery Query frame

The response data field of the Service Discovery Response frame transmitted by a WFD Device in response to a received Service Discovery Query frame shall be comprised of the requested Service Response TLVs, where each contains response data specifying the respective information subelements. The Service Transaction ID in the Service Response TLV shall match the Service Transaction ID in the Query Data for the specific device role.

Subelements to be included in the WFD IE for WFD Service Discovery action frames are listed in Table 5-46.

Subelement name	Requirements
WFD Device Information	If requested, the WFD Device Information subelement shall be present in the WFD IE in the WFD Service Discovery Response action frames it transmits.
Associated BSSID	If requested and if the responding WFD Device is associated with an infrastructure AP or a GO and the WFD Device sets its PC bit to 0b1 in the WFD Device Information subelement, the WFD Device shall include the Associated BSSID subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
WFD Audio Formats	If requested and if the responding WFD Device has audio capability, the WFD Device shall include the WFD Audio Formats subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
WFD Video Formats	If requested and if the responding WFD Device has video capability, the WFD Device shall include the WFD Video Formats subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
WFD 3D Video Formats	If requested and if the responding WFD Device has 3D video capability over WFD, the WFD Device shall include the WFD Video Formats subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
WFD Content Protection	If requested and if the responding WFD Device supports Content Protection, the WFD Device shall include the WFD Content Protection subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
Coupled Sink Information	If requested and if the responding WFD Sink supports Coupled Sink Operation, the WFD Device shall include the Coupled Sink Information

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	subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
WFD Extended Capability	If requested and if the responding WFD Device supports at least one of UIBC, Remote I2C Read/Write, Preferred Display mode and TDLS as a preferred connectivity scheme for WFD, the WFD Device shall include the WFD Extended Capability subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
Local IP Address	If requested and if the responding WFD Device supports TDLS as a preferred connectivity scheme for WFD, the WFD Device shall include the Local IP address subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
WFD Session Information	If requested and if the WFD Device is acting as a GO and has WFD Session(s) with other WFD Device(s), the WFD Device shall include the WFD Session information subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.
Alternate MAC Address	If requested and if the responding WFD Device supports TDLS as a preferred connectivity scheme for WFD, the WFD Device shall include the Alternate MAC Address subelement in the WFD IE in the WFD Service Discovery Response action frames it transmits.

Table 5-46 : Information Subelement in WFD IE at WFD Service Discovery Response

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6 RTSP Based WFD Control Plane

This chapter defines the methods and messages that are used to establish, maintain, manage and teardown WFD Sessions.

A WFD Sink shall establish a layer 3 connection with a WFD Source before beginning WFD Session establishment and management. WFD Session management shall use RTSP [23] (RFC2326) over TCP as the communication protocol. The WFD Sink shall use the WFD Session management Control Port value (contained in the WFD IE) for all session management communication.

Since the RTSP specification [23] does not allow an RTSP server to initiate the SETUP, PLAY, PAUSE or TEARDOWN methods, this Specification uses SET_PARAMETER messages with a `wfd-trigger-method` parameter to enable the RTSP server to trigger the client into initiating control operations while still maintaining compliance with [23].

6.1 RTSP Data Structures

This section (and sub-section) defines the data structures used by the WFD control plane. The data structures are WFD specific RTSP parameters. All definitions are in Augmented Backus-Naur Form (ABNF).

6.1.1 ABNF Definitions

The data structure definitions below use ABNF as defined in RFC 2234 [28] to define some elements. Some common ABNF elements used in this Specification are summarized here.

```
DIGIT          = %x30-39                    ; 0-9
HEXDIG         = DIGIT / %x41-46
SP             = %x20                       ; space
CR             = %x0D                       ; carriage return
LF             = %x0A                       ; linefeed
CRLF           = CR LF
IPADDRESS      = 1*3(DIGIT) “.” 1*3(DIGIT) “.” 1*3(DIGIT) “.” 1*3(DIGIT)
IPPORT         = 1*5(DIGIT)                 ; must be between 0 and 65535
```

6.1.2 wfd-audio-codecs

The `wfd-audio-codecs` parameter specifies the audio formats supported in the WFD Session. Valid audio codecs are listed in section 3.4.1.

```
wfd-audio-codecs  = “wfd_audio_codecs:” SP sink-audio-cap CRLF
sink-audio-cap    = “none” / sink-audio-list; “none” if not supported at a
                    Primary Sink
sink-audio-list   = audio-format SP modes SP latency *(“,” SP sink-audio-
                    list)
audio-format      = “LPCM” / “AAC” / “AC3”
modes             = 8*8HEXDIG; see Table 5-21, Table 5-22 and Table 5-23
latency           = 2*2HEXDIG; decoder latency in units of 5 msecs, see
                    LPCM decoder latency field for LPCM, see AAC decoder
                    latency field for AAC and see AC3 decoder latency field
                    in Table 5-20 for more detail
```

The `sink-audio-list` is a list of one or more <`audio-format`, `modes`, `latency`> tuples for each audio CODEC supported when included in RTSP M3 response messages. The sink-audio-list is just one <`audio-format`, `modes`, `latency`> tuple when included in RTSP M4 request messages.

Tuples for LPCM, AAC and/or AC-3 can appear in any order, in an RTSP M3 response message.

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6.1.3 wfd-video-formats

The `wfd-video-formats` parameter specifies the supported video resolutions (Table 5-10, Table 5-11, Table 5-12), H.264 codec profile (Table 5-14), level (Table 5-15), decoder latency, minimum slice size, slice encoding parameters and support for video frame rate control (including explicit Frame Rate Change and implicit video frame skipping). Valid H.264 codec configurations supported in this Specification are listed in Table 3-3.

```
wfd-video-formats  = “wfd_video_formats:” SP sink-video-list CRLF
sink-video-list    = “none” / (native SP preferred-display-mode-supported
                     SP H.264-codec);the Secondary Sink shall return
                     “none”
native             = 2*2HEXDIG; see Table 5-13
preferred-display-mode-supported = 2*2HEXDIG; 0-not supported, 1-
                     supported, 2-255 reserved
H.264-codec        = profile SP level SP misc-params SP max-hres SP max-
                     vres *(“,” SP H.264-codec)
profile            = 2*2HEXDIG; see Table 5-14, only one bit set
level              = 2*2HEXDIG; see Table 5-15, only one bit set
max-hres           = “none” / (4*4HEXDIG); in M3 response and if
                     preferred-display mode-supported is 0, then “none”.
                     in M3 response and if preferred-display-mode-
                     supported is 1, specifies the maximum horizontal
                     resolution that the H.264 decoder supports in pixels.
                     in M4 request, it is “none” and the recipient shall
                     ignore this subparameter
max-vres           = “none” / (4*4HEXDIG); in M3 response and if
                     preferred-display mode-supported is 0, then “none”.
                     in M3 response and if preferred-display-mode-
                     supported is 1, specifies the maximum vertical
                     resolution that the H.264 decoder supports in pixels.
                     in M4 request, it is “none” and the recipient shall
                     ignore this subparameter
misc-params        = CEA-Support SP VESA-Support SP HH-Support SP latency
                     SP min-slice-size SP slice-enc-params SP frame-rate-
                     control-support
CEA-Support        = 8*8HEXDIG; see Table 5-10. when used inside preferred
                     display mode in M4 request, this subfield should be
                     set to 0x00000000 and the recipient shall ignore this
                     subfield.
VESA-Support       = 8*8HEXDIG; see Table 5-11. when used inside preferred
                     display mode in M4 request, this subfield should be
                     set to 0x00000000 and the recipient shall ignore this
                     subfield.
HH-Support         = 8*8HEXDIG; see Table 5-12. when used inside preferred
                     display mode in M4 request, this subfield should be
                     set to 0x00000000 and the recipient shall ignore this
                     subfield.
latency            = 2*2HEXDIG; decoder latency in units of 5 msecs, see
                     latency field in Table 5-9 for more detail
min-slice-size     = 4*4HEXDIG; number of macroblocks
slice-enc-params   = 4*4HEXDIG; see Table 5-16
frame-rate-control-support   = 2*2HEXDIG; see Table 5-17
```

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The H.264-codec is a list of one or more <profile, level, misc-params, max-hres, max-vres> tuples for each H.264 profile, corresponding maximum level, miscellaneous parameters, maximum horizontal resolution, and maximum vertical resolution supported when included in RTSP M3 response messages. In this case, level indicates the maximum level support for the specified profile. Tuples for CBP and CHP can appear in any order, in an RTSP M3 response message.

A WFD Sink shall set the Video Frame Rate Change Support bit in the frame-rate-control-support field to one, in the RTSP M3 response message, if it supports this functionality. If the Sink has not set this bit to one, then the WFD Source shall not set this bit to one in the RTSP M4 request message. If the WFD Source does not support the functionality, it shall set this bit to zero.

The H.264-codec is just one <profile, level, misc-params, max-hres, max-vres> tuple when included in an RTSP M4 request message. In this case level refers to the actual level to be used with the selected profile.

The min-slice-size field is expressed in number of macroblocks. WFD Devices that do not support slice encoding in which a picture is constructed by multiple slices shall set this field to 0x00 00.

A WFD Source shall set the min-slice-size value to zero in the RTSP M4 request message and shall not transmit an encoded picture constructed by multiple slices to a WFD Sink that does not support decoding picture constructed by multiple slices (i.e., the WFD Sink sets the min-slice-size value to zeto in the RTSP M3 response message).

A WFD Sink sets the min-slice-size value to the smallest slice size it can decode. Slices smaller than the min-slice-size value may not reduce latency. A WFD Source sets this value to the smallest encoded slice it may transmit.

Note that the actual realizable maximum horizontal resolution and maximum vertical resolutions are a function of horizontal resolution, vertical resolution and required macro block rate and may be smaller than the max-hres and/or the max-vres values indicated in this parameter.

6.1.4 wfd-3d-formats

The wfd-3d-formats parameter specifies the support for stereoscopic video capabilities. Valid 3D stereoscopic configurations supported in this Specification are listed in Table 3-5.

```
wfd-3d-formats     = “wfd_3d_video_formats:” SP 3d-cap CRLF
3d-cap             - “none” / 3d-cap-list; if not supported then “none”
3d-cap-list        = native SP preferred-display-mode-supported SP H.264-
                     codec
native             = 2*2HEXDIG; see Table 5-13
preferred-display-mode-supported = 2*2HEXDIG; 0-not supported, 1-
                     supported, 2-255 reserved
H.264-codec        = profile SP level SP misc-params SP max-hres SP max-
                     vres * (“,” SP H.264-codec)
profile            = 2*2HEXDIG; see Table 5-14, only one bit set
level              = 2*2HEXDIG; see Table 5-15, only one bit set
max-hres           = “none” / (4*4HEXDIG); in M3 response and if
                     preferred-display mode-supported is 0, then “none”.
                     in M3 response and if preferred-display-mode-
                     supported is 1, specifies the maximum horizontal
                     resolution that the H.264 decoder supports in pixels.
                     in M4 request, it is “none” and the recipient shall
                     ignore this subparameter
max-vres           = “none” / (4*4HEXDIG); in M3 response and if
                     preferred-display mode-supported is 0, then “none”.
                     in M3 response and if preferred-display-mode-
                     supported is 1, specifies the maximum vertical
                     resolution that the H.264 decoder supports in pixels.
```

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```
                    in M4 request, it is “none” and the recipient shall
                    ignore this subparameter
misc-params       = 3d-video-capability SP latency SP min-slice-size SP
                    slice-enc-params SP frame-rate-control-support
3d-video-capability= 16*16HEXDIG; see Table 5-19.
latency           = 2*2HEXDIG; decoder latency in units of 5 msecs, see
                    latency field in Table 5-9 for more detail
min-slice-size    = 4*4HEXDIG; number of macroblocks
slice-enc-params  = 4*4HEXDIG; see Table 5-16
frame-rate-control-support   = 2*2HEXDIG; see Table 5-17
```

The H.264-codec is a list of one or more <profile, level, misc-params, max-hres, max-vres> tuples for each H.264 profile, corresponding maximum level, miscellaneous parameters, maximum horizontal resolution, and maximum vertical resolution supported when included in RTSP M3 response messages. Tuples for CBP and CHP can appear in any order, in an RTSP M3 response message.

The H.264-codec is just one <profile, level, misc-params, max-hres, max-vres> tuple when included in an RTSP M4 request message.

See section 6.1.3 for details on the max-hres, max-vres and min-slice-size fields.

6.1.5 wfd-content-protection

The wfd-content-protection parameter specifies whether the WFD Sink supports the HDCP system 2.x[10] for content protection. If content protection is not supported or is not currently possible for any reason, the parameter is set to “none”. If the WFD Sink supports HDCP 2.0 only, the parameter is set to “HDCP2.0” (Supporting HDCP 2.0 only is prohibited due to transition period has been expired). If the WFD Sink supports HDCP 2.0 and 2.1, the parameter is set to “HDCP2.1”. If the WFD Sink supports HDCP 2.0. 2.1 and higher version, the parameter is set to “HDCP 2.1”[12]

If the WFD Sink supports HDCP system 2.x, the TCP port number to be used on the WFD Sink for the HDCP 2.x AKE connection is included. The port number shall be between 1 and 65535.

```
wfd-content-protection      = “wfd_content_protection:” SP cp-spec CRLF
cp-spec                     = “none” / hdcp2-spec
hdcp2-spec                  = (“HDCP2.0” / “HDCP2.1”) SP “port=” IPPORT ;
                              TCP port
```

6.1.6 wfd-display-edid

The wfd-display-edid parameter specifies the EDID of the display on which the content will be rendered.

EDID data comes in multiples of 128-byte blocks as shown in Figure 6-1.

Display devices may contain 1 to 256 128-byte blocks of EDID data depending on the EDID structure that it supports.

[10] After transition period from the HDCP system 2.0 to the HDCP system 2.1 defined by DCP LLC has expired, “HDCP 2.0” shall not be used by the WFD Devices seeking WFD certification. Refer to section 5.2 of [35] and its addendum [36] for more detail.

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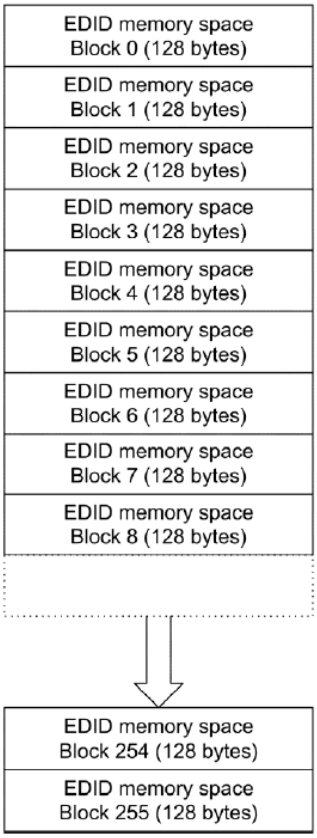

Figure 6-1 : Block Structure of EDID data

The content and format of the EDID are not defined in this Specification. Refer to the following standards for EDID structure:

- VESA Enhanced Extended Display Identification Data Standards (E-EDID) (e.g., E-EDID 1.4 [10])
- The various VESA E-EDID extension block standards
- The CEA E-EDID extension defined in the CEA-861 standard [11].

The WFD Sink shall follow the procedure for EDID access specified in VESA E-DDC v1.2 [12] (and later version if exists).When a WFD Sink responds to the query of `wfd-display-edid` parameter in an RTSP GET_PARAMETER request message, the following rules are applied.

If a WFD Sink reports `wfd-connector-type` as HDMI or DP or UDI, the WFD Sink should return the EDID of the display that renders the streamed video.

A WFD Sink that supports the `wfd-display-edid` parameter shall include the entire EDID data structure that is available from the display device in a `edid-payload` field with indicating its length by a `edid-count` field in a unit of a number of 128-bytes block(s).A WFD Sink that does not support `wfd-display-edid` parameter shall set the `edid` field of the `wfd-display-edid` parameter to “none”, except for a WFD Sink dongle without an integrated display or with an integrated display that is not being used to render streamed video.

The WFD Sink dongle without an integrated display or with an integrated display that is not being used to render streamed video shall not set the `edid` field of the `wfd-display-edid` parameter to “none” regardless of whether an external display device is attached or not.

If EDID data is not available at the WFD Sink dongle without an integrated display or with an integrated display that is not being used to render streamed video, the `edid-block-count` field shall be set to 0x00 00 and the `edid-payload` field shall be “none”, instead of EDID data.

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If EDID data is available at the WFD Sink dongle without an integrated display or with an integrated display that is not being used to render streamed video, the `edid-block-count` field and the `edid-payload` field shall be set to include entire EDID structure. In this case, The WFD Sink dongle without an integrated display or with an integrated display that is not being used to render streamed video should pass the EDID blocks from the connected external display device to the WFD Source as is, regardless of checksum failure and other error conditions.

```
wfd-display-edid            = "wfd_display_edid:" SP edid CRLF
edid                        = "none" / (edid-block-count SP edid-payload)
edid-block-count            = 4*4HEXDIG;
                              0: if EDID is not available at the time that
                                 the WFD Sink responses to the parameter
                                 request.
                              1-256: number of 128-byte EDID blocks in
                              edid-payload
                              Other values: reserved
edid-payload                = "none" / 256*65536HEXDIG;
                              "none" if edid-block-count is 0. Otherwise,
                              edid-payload contains the entire EDID data
                              structure available from the display device.
                              Length of edid-payload shall be a multiple
                              of 128 bytes. (length of edid-payload =
                              edid-block-count * 128-byte)
```

6.1.7 wfd-coupled-sink

The `wfd-coupled-sink` parameter is used by a WFD Sink to convey its Coupled status and if Coupled to another WFD Sink, the Coupled WFD Sink's MAC address.

```
wfd-coupled-sink = "wfd_coupled_sink:" SP coupled-sink-cap CRLF
coupled-sink-cap = "none" /(status SP sink-address); "none" if Coupled
                           Sink Operation is not supported
status           = 2*2HEXDIG; see Table 5-8
sink-address     = "none" / (12*12HEXDIG); WFD Sink's MAC address if
                           status is Coupled otherwise "none".
```

6.1.8 wfd-trigger-method

The `wfd-trigger-method` parameter is used by a WFD Source to trigger the WFD Sink to initiate an operation with the WFD Source.

```
wfd-trigger-method = "wfd_trigger_method:" SP ("SETUP" / "PAUSE" /
                     "TEARDOWN" / "PLAY") CRLF
```

6.1.9 wfd-presentation-url

The `wfd-presentation-url` parameter describes the Universal Resource Identifier (URI) to be used in the RTSP Setup (RTSP M6) request message in order to setup the WFD Session from the WFD Sink to the WFD Source. The `wfd-url0` and `wfd-url1` values indicated in this parameter correspond to the `rtp-port0` and `rtp-port1` values from the `wfd-client-rtp-ports` parameter in the RTSP M4 request message from the WFD Source to the WFD Sink at the end of the WFD Capability Negotiation phase.

```
wfd-presentation-url    = "wfd_presentation_URL:" SP wfd-url0 SP wfd-url1
                          CRLF
wfd-url0                = "none" / ("rtsp://" source-ip-address
                          "/wfd1.0/streamid=0")
wfd-url1                = "none" / ("rtsp://" source-ip-address
                          "/wfd1.0/streamid=1")
```

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```
source-ip-address       = IPADDRESS
```

The values for `wfd-url0` and `wfd-url1` in the `wfd-presentation-url` in the RTSP M4 request message are determined by Table 6-1.

Type of WFD Session	Type of sink(s)	wfd-client-rtp-ports in RTSP M4 request		wfd-presentation-url in RTSP M4 request	
		rtp-port0	rtp-port1	wfd-url0 specified?	wfd-url1 specified?
No Secondary Sink in WFD Session Single (audio only, or video only, or audio and video multiplexed) MPEG2_TS to a Primary Sink.	Primary Sink	Non zero	0	Yes	"none"
No Primary Sink in WFD Session Single (audio only) MPEG2_TS to a Secondary Sink.	Secondary Sink	0	Non zero	"none"	Yes
Two independent MPEG2_TS, one for video destined to the Primary Sink and one for audio destined to the Secondary Sink.	Primary Sink	Non zero	0	Yes	"none"
	Secondary Sink	0	Non zero	"none"	Yes
Other combinations are reserved.					

Table 6-1 : wfd-url0 and wfd-url1 values in wfd-presentation-url

6.1.10 wfd-client-rtp-ports

The `wfd-client-rtp-ports` parameter is used by a WFD Sink to convey the RTP port(s) that the WFD Sink is listening on and by the a WFD Source to indicate how audio, video or both audio and video payload will be encapsulated in the MPEG2-TS stream transmitted from the WFD Source to the WFD Sink.

```
wfd-client-rtp-ports= "wfd_client_rtp_ports:" SP profile SP rtp-port0 SP
                                rtp-port1 SP mode CRLF
profile             = "RTP/AVP/UDP;unicast"
rtp-port0           = IPPORT ; UDP port
rtp-port1           = IPPORT ; UDP port
mode                = "mode=play"
```

Note : MPEG2-TS (MP2T) described at section 5.7 in RFC3551 [6] is used with the AVP/ profile in this Specification. Other profiles described at other sections in [6] are not relevant to this Specification.

When a WFD Sink receives an M3 request message querying the `wfd-client-ports` parameter, the WFD Sink shall set the `rtp_port0` and `rtp_port1` values in the `wfd-client-rtp-ports` parameter in the RTSP M3 response message as shown in Table 6-2.

rtp_port0	rtp_port1	Description
Non-zero	Non-zero	This combination is reserved.
Non-zero	0	Primary Sink that supports a single MPEG2-TS stream.

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0	Non-zero	Secondary Sink that supports a single MPEG2-TS stream
0	0	This combination is reserved.

Table 6-2 : wfd-client-rtp-ports parameter values in M3 response message

When a WFD Source sends a RTSP M4 request message that includes the `wfd-client-rtp-ports` parameter as a part of WFD Capability Negotiation, the `rtp-port0` and `rtp-port1` values in the `wfd-client-rtp-ports` parameter shall be set as shown in Table 6-3. In addition, the client-port value in Transport header line of an RTSP M6 request message shall be set as shown in Table 6-3.

Received RTSP M3 response		Possible RTSP M4 request		Possible RTSP M6 request	Description
rtp-port0	rtp-port1	rtp-port0	rtp-port1	client-port	
Non-zero	0	Non-zero	0	rtp-port0	WFD Source transmits an MPEG2-TS stream to the Primary Sink. Audio and video session, audio-only or video-only session. WFD Source streams corresponding content to rtp-port0.
0	Non-zero	0	Non-zero	rtp-port1	WFD Source transmits an MPEG2-TS stream containing audio only to the Secondary Sink.
					Other combinations are reserved.

Table 6-3 : wfd-client-rtp-ports parameter values in M3 response message and corresponding values in the subsequent M4/M6 request message

6.1.11 wfd-route

The `wfd-route` parameter provides a mechanism to specify the destination to which the audio stream is to be routed.

```
wfd-route          = "wfd_route:" SP destination CRLF
destination        = "primary" / "secondary"
```

6.1.12 wfd-I2C

The `wfd-I2C` parameter is used by a WFD Source to inquire whether a WFD Sink supports remote I2C Read/Write function or not.

If the WFD Sink does not support remote I2C Read/Write function, it shall set the value of this parameter to "none" when responding to the query of this parameter.

If the WFD Sink supports remote I2C Read/Write function, it shall set the value of this parameter to the TCP port number to be used by the WFD Source to exchange remote I2C Read/Write messaging transactions with the WFD Sink.

Refer to section 7 for details of Remote I2C Read/Write Messaging Transactions.

```
wfd-I2C            = "wfd_I2C:" SP I2C-port CRLF
I2C-port           = "none" / IPPORT; port where the device listens for I2C
                     commands, "none" if not supported
```

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6.1.13 wfd-av-format-change-timing

The wfd-av-format-change-timing parameter is used to signal the actual AV format change timing of the streaming data to the WFD Sink. It shall not be included in an RTSP M4 request message for the first WFD Capability Negotiation before the establishment of RTSP connection. It shall be included in an RTSP M4 request message for WFD Capability Re-negotiation after a WFD Session has been established.

The PTS field represents PTS values that are included in the PES header of the PES corresponding to AV format change. The DTS field represents the DTS values that are included in the PES header of the PES corresponding to AV format change. The least-significant 7 bits of the PTS and DTS fields are reserved and are set to all zeros.

```
wfd-av-format-change-timing = “wfd_av_format_change_timing:” SP PTS SP DTS
                              CRLF
PTS = 10*10HEXDIG; most-significant 33 bits indicating PTS value
DTS = 10*10HEXDIG; most-significant 33 bits indicating DTS value
```

6.1.14 wfd-preferred-display-mode

Refer to chapter 8 for the overview and operation details of the Preferred Display mode.

Support of the wfd-preferred-display-mode parameter is optional.

The preferred-display-mode-supported field in a wfd-video-formats parameter and/or in a wfd-3d-formats parameter in an RTSP M3 response message indicates whether a WFD Sink supports the Preferred Display mode operation or not.

Once a WFD Source has ascertained that the WFD Sink supports the Preferred Display mode operation, the WFD Source may send an RTSP SET_PARAMETER request message that only contains the wfd-preferred-display-mode parameter to the WFD Sink. The WFD Sink shall respond with appropriate RTSP status code:

- RTSP OK: the proposed wfd-preferred-display-mode is acceptable to the WFD Sink.

  In this case, the WFD Source shall send an RTSP M4 request message that includes a wfd-preferred-display-mode parameter that contains exactly same values indicated in the last SET_PARAMETER request message and a wfd-presentation-url parameter but does not include a wfd-video-formats parameter or a wfd-3d-formats parameter to the WFD Sink..
- Otherwise: the proposed wfd-preferred-display-mode is not acceptable to the WFD Sink.

  In this case, the WFD Source shall send one of the following to the WFD Sink;

  (a) an RTSP M4 request message that includes a wfd-presentation-url parameter and either one of a wfd-video-formats parameter or a wfd-3d-formats parameter.

  (b) an RTSP SET_PARAMETER request message that includes a wfd-presentation-url parameter and a wfd-preferred-display-mode parameter that contains another set of values from those in the previous RTSP SET_PARAMETER request message.

The following flow diagram illustrates the messages exchange that includes a preferred-display-mode-supported field and wfd-preferred-display-mode parameter.

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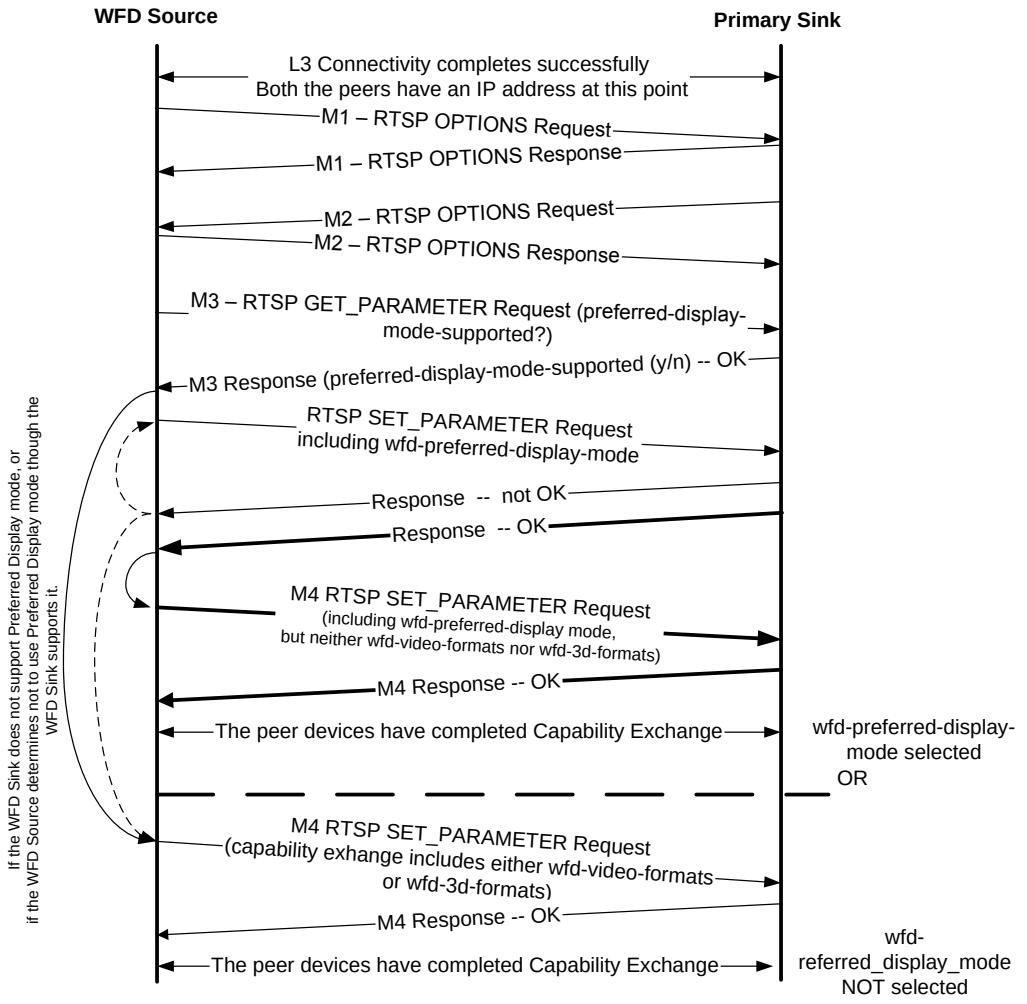

Figure 6-2 : Capability Exchange and Preferred-Display-mode

```
wfd-preferred-display-mode = “wfd_preferred_display_mode:” SP dinfo CRLF
dinfo                      = p-clock SP H SP HB SP HSPOL-HSOFF SP HSW SP
                             V SP VB SP VSPOL-VSOFF SP VSW SP VBS3D SP
                             2d-s3d-modes SP p-depth SP H.264-codec
p-clock                    = 6*6HEXDIG; pixel clock in 10kHz units
H                          = 4*4HEXDIG; horizontal active resolution in
                             units of pixels
HB                         = 4*4HEXDIG; horizontal blanking period in
                             units of pixels
HSPOL-HSOFF                = 4*4HEXDIG; b15: horizontal sync polarity (0
                             negative, 1 positive) b14:b0 horizontal sync
                             offset in units of pixels
HSW                        = 4*4HEXDIG; horizontal sync width in units of
                             pixels
V                          = 4*4HEXDIG; vertical active resolution in
                             units of lines
VB                         = 4*4HEXDIG; vertical blanking period in units
                             of lines
```

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```
VSPOL-VSOFF              = 4*4HEXDIG; b15: vertical sync polarity (0
                           negative, 1 positive) b14:b0 vertical sync
                           offset in units of lines
VSW                      = 4*4HEXDIG; vertical sync width in units of
                           lines
VBS3D                    = 2*2HEXDIG; vertical blanking interval in
                           units of lines (only used in stereoscopic 3D
                           Frame Packing mode)
2d-s3d-modes             = 2*2HEXDIG; 2D/Stereoscopic 3D Modes (refer
                           to Table 6-4)
P-depth                  = 2*2HEXDIG; pixel depth (refer to Table 6-5).
                           This is the pixel depth of the display
                           output which is different from the codec
                           pixel depth.
H.264-codec              ; see section 6.1.3
```

Attribute	Description
2d-s 3d-modes	Only one bit is set by the WFD Source to indicate the selected mode. More than one bit can be set by the WFD Sink to indicate its capabilities. Specifies the 2D and stereoscopic 3D display modes. 0b0 in bit field: Mode not supported. 0b1 in bit field: Mode supported. [B0] Progressive 2D mode: • H x V x R [B1] Top & Bottom Half (Stereoscopic 3D): • H x (V/2 + V/2) x R [B2] Frame Sequential(Stereoscopic 3D): • H x V x (R x 2) [B3] Frame Packing(Stereoscopic 3D): • H x (V + VBS3D + V) x R [B4] Side by side Half(Stereoscopic 3D): • (H/2 + H/2) x V x R [B7:B5] Reserved.

Table 6-4 : Preferred Display mode 2d-s3d-modes field descriptions

Attribute	Description
P-depth	Only one bit is set to indicate the selected pixel depth 0b0 in bit field: pixel depth is not supported 0b1 in bit field: pixel depth is supported [B0] 24 bit per pixel [B1] 30 bits per pixel [B2] 36 bits per pixel [B3] 48 bits per pixel [B7:B4] Reserved

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Table 6-5: Preferred Display mode P-depth field description

Figure 6-3 illustrates the definition of some of the display timing parameters specified in the `dinfo` field.

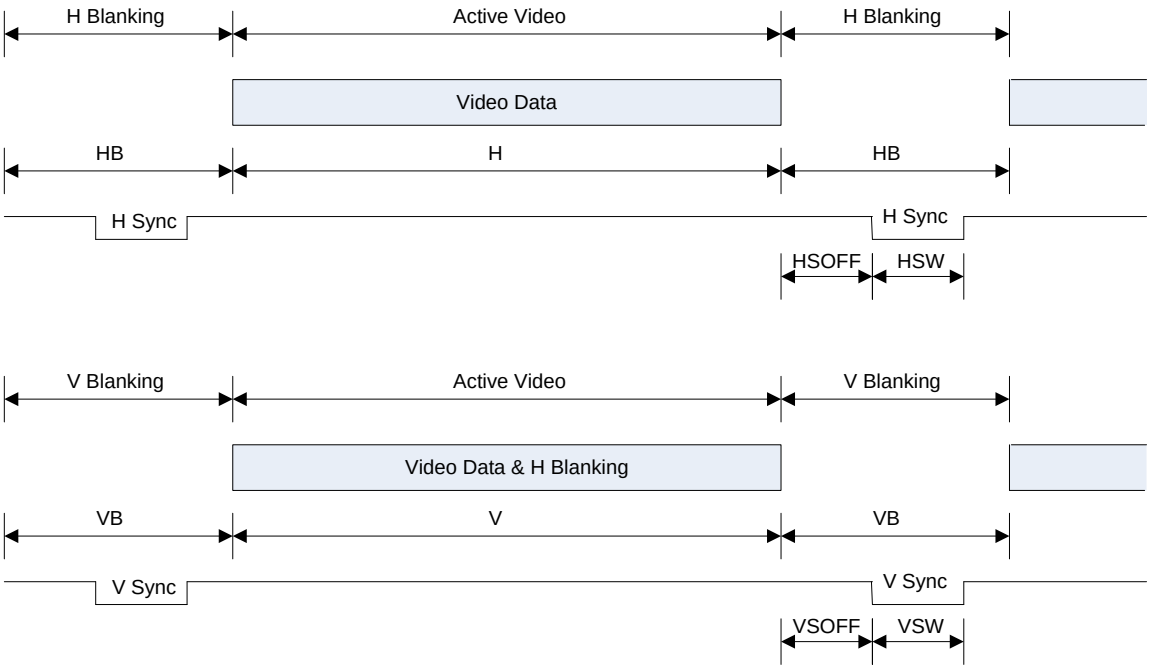

Figure 6-3 : Display Timing Parameters

6.1.15 wfd-uibc-capability

The `wfd-uibc-capability` parameter describes support for the user input back channel (UIBC) and related attributes. Support for UIBC is indicated using the UIBC Support bit (B0) of the WFD Extended Capability bitmap in the WFD Extended Capability subelement. Note that "none" indicates that the corresponding sub-parameter value is not supported.

```
wfd-uibc-capability         = "wfd_uibc_capability:" SP ("none" / (input-
                              category-val ";" generic-cap-val ";" hidc-
                              cap-val ";" tcp-port)) CRLF; "none" if not
                              supported
input-category-val          = "input_category_list=" ("none" / input-
                              category-list)
input-category-list         = input-cat * ("," SP input-category-list)
input-cat                   = "GENERIC" / "HIDC"
generic-cap-val             = "generic_cap_list=" ("none" / generic-cap-
                              list)
generic-cap-list            = inp-type *("," SP generic-cap-list)
inp-type                    = "Keyboard" / "Mouse" / "SingleTouch" /
                              "MultiTouch" / "Joystick" / "Camera" /
                              "Gesture" / "RemoteControl"
hidc-cap-val                = "hidc_cap_list=" ("none" / hidc-cap-list)
hidc-cap-list               = detailed-cap *("," SP hidc-cap-list)
detailed-cap                = inp-type "/" inp-path
inp-path                    = "Infrared" / "USB" / "BT" / "Zigbee" / "Wi-
                              Fi" / "No-SP"; "No-SP" means vendor specific
tcp-port                    = "port=" ("none" / IPPORT)
```

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The WFD Source indicates the TCP port number to be used for UIBC in the `tcp-port` field of the `wfd-uibc-capability` parameter in RTSP M4 and/or M14 request messages. The WFD Sink uses "none" for the `tcp-port` field of the `wfd-uibc-capability` parameter, in RTSP M3 response and M14 request messages.

6.1.16 wfd-uibc-setting

The `wfd-uibc-setting parameter` is used to enable and disable the UIBC.

```
wfd-uibc-setting          = "wfd_uibc_setting:" SP uibc-setting CRLF
uibc-setting              = "disable" / "enable"
```

The `wfd-uibc-setting` parameter may be included in the first RTSP M4 request message during the WFD Capability Negotiation, provided that the RTSP M4 request message contains the `wfd-uibc-capability` parameter.

6.1.17 wfd-standby-resume-capability

The `wfd-standby-resume-capability` parameter describes support of both standby control using a `wfd-standby` parameter and resume control using PLAY and using triggered-method setting PLAY.

```
wfd-standby-resume-capability = "wfd_standby_resume_capability:" SP
                                standby-resume-cap CRLF
standby-resume-cap = "none" / "supported"; "none" if not supported
```

6.1.18 wfd-standby

The `wfd-standby` parameter is used to indicate that the sender of this parameter in an RTSP SET_PARAMETER request message is entering WFD Standby mode.

```
wfd-standby = "wfd_standby" CRLF
```

6.1.19 wfd-connector-type

A WFD Source may send an RTSP GET_PARAMETER request message to a WFD Sink with the `wfd-connector-type` parameter to inquire about the connector type that is currently active in the WFD Sink.

After a change of the active connector type, the WFD Sink may send an RTSP SET_PARAMETER request message to the WFD Source with the `wfd-connector-type` parameter. This is to inform the WFD Source about the new active connector type now in use by the WFD Sink. A WFD Sink shall not send an RTSP SET_PARAMETER request message to the WFD Source with the `wfd-connector-type` parameter unless the WFD Source supports this parameter. Support of this parameter by the WFD Source is indicated when the WFD Source sends an RTSP GET_PARAMETER request message with the `wfd-connector-type` parameter at least once after the successful RTSP M1 and M2 message exchanges.

This mechanism allows 0 or 1 active connector to be reported by the WFD Sink.

Handling of multiple connector types simultaneously is implementation specific and is out of the scope of this Specification.

```
wfd-connector-type        = "wfd_connector_type:" SP connector-type CRLF
connector-type            = "none" / (2*2HEXDIG); specifies the active
                            display connector type (see Table 6-6),
                            "none" if the WFD Sink dongle that is not
                            acting as a WFD Sink with an integrated
                            display is not connected to an external
                            display
```

The connector-type field is used to indicate the Display Connector Type currently in use by the WFD Sink. When a WFD Sink responds to a query of the `wfd-connector-type` parameter in an RTSP GET_PARAMETER request message or when a WFD Sink sends this parameter in an RTSP SET_PARAMETER request message, the following rules apply.

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The WFD Sink dongle that is not connected to an external display and it is not acting as a WFD Sink with embedded display (to render streamed content) shall return a value of "none".

Otherwise, the WFD Sink shall choose a non-reserved value from Table 6-6.

Value	Description
0	Video Graphics Array (VGA) Connector
1	S-Video connector
2	Composite video connector
3	Component video connector
4	Digital Video Interface (DVI) connector
5	High-Definition Multimedia Interface (HDMI) connector
6	Reserved
7	Wi-Fi Display
8	Japanese D connector. (A connector conforming to the EIAJ RC-5237 standard)
9	Serial Digital Image (SDI) connector
10	A Display Port connector (DP)
11	Reserved
12	A Unified Display Interface (UDI)
13-254	Reserved
255[11]	Indicates a type of physical connector that is not listed from value 0 to 254

Table 6-6 : Display Connector Type field

6.1.20 wfd-idr-request

The `wfd-idr-request` parameter is used by the WFD Sink to request an IDR picture from the WFD Source.

```
wfd-idr-request = “wfd_idr_request” CRLF
```

6.2 WFD RTSP methods

The table below lists RTSP methods (including OPTIONS) from RFC2326 [23] that WFD Devices shall support.

- A WFD Device shall be able to send and respond to the OPTIONS, SET_PARAMETER, GET_PARAMETER, and org.wfa.wfd1.0 RTSP methods.
- A WFD Sink shall be able to send the SETUP, PLAY, PAUSE and TEARDOWN RTSP methods.
- A WFD Source shall be able to respond to the SETUP, PAUSE, PLAY, and TEARDOWN RTSP method. Note that a PLAY after a PAUSE may have different behavior from the typical usage in RTSP. See underneath Table 6-7 for detail.

[11] If the value 255 as `connector-type` is reported from the WFD Sink, WFD Sources may not be able to unambiguously identify the connector type that is in use. Due to this reason, some WFD Sources may not be able to recognize the WFD Sink at all or may interoperate in a sub-optimal manner.

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- A WFD Source shall use “rtsp://localhost/wfd1.0” as the URI for requests sent to a WFD Sink. This does not correspond to a stream as per usual RTSP convention, but instead is used to indicate that the request is for the capabilities of the WFD Sink.
- A WFD Sink shall use the `wfd-presentation-url` value (see section 6.1.9) as the URI for requests sent to a WFD Source.
- A WFD Device should ignore any parameter not specified in Table 6-9, in GET_PARAMETER or SET_PARAMETER.

6.2.1 WFD RTSP OPTIONS

The RTSP OPTIONS request is used by a WFD Device to verify that the WFD peer supports the required methods. A WFD Device shall abort the RTSP M1 and/or M2 message exchange(s) if any of the required methods are missing.

Note: There is no need for to explicitly communicate that the RTSP M1 and/or M2 message exchange(s) has been terminated. If a WFD Device aborts the RTSP M1 and/or M2 message exchange(s) on receipt of a response from the peer WFD Device, future RTSP requests from the peer WFD Device will result in RTSP responses with a status code indicating error.

A WFD Device shall use the tag “org.wfa.wfd1.0” to query a peer WFD Device for the options that the peer WFD Device supports.

In response to an OPTIONS request, a WFD Sink shall respond indicating support for org.wfa.wfd1.0, SET_PARAMETER, and GET_PARAMETER.

In response to an OPTIONS request, a WFD Source shall respond indicating support for org.wfa.wfd1.0, SET_PARAMETER, GET_PARAMETER, SETUP, PLAY, PAUSE and TEARDOWN.

The Table 6-7 summarizes the requirements for support of each RTSP method. For example, when it is marked as “Required” in “WFD Source->WFD Sink direction”, it means that the WFD Source shall support transmission of this method and the WFD Sink shall support reception of this method. Note that listed methods in RTSP messages shown in the example are lists of supported methods at reception, as specified in [23].

RTSP Method	From WFD Source to WFD Sink	From WFD Sink to WFD Source	From Primary Sink to Secondary Sink	From Secondary Sink to Primary Sink
OPTIONS	Required	Required	Required	Required
org.wfa.wfd1.0	Required	Required	Required	Required
SET_PARAMETER	Required	Required	Required	Required
GET_PARAMETER	Required	Required	Required	Required
SETUP	Not Allowed**	Required	Not Allowed**	Not used***
PLAY	Not Allowed	Required	Not Allowed	Not used***
TEARDOWN	Not Allowed	Required	Not Allowed	Required
PAUSE	Not Allowed	Required*	Not Allowed	Not used***
RECORD	Not Allowed	Not Allowed	Not Allowed	Not Allowed
DESCRIBE	Not Allowed	Not Allowed	Not Allowed	Not Allowed
REDIRECT	Not Allowed	Not Allowed	Not Allowed	Not Allowed
ANNOUNCE	Not Allowed	Not Allowed	Not Allowed	Not Allowed

*When streaming content encoded in real-time, the definition of PAUSE is different from what it is in RTSP. When real-time content is rendered using Wi-Fi Display, PAUSE causes the WFD Source to stop streaming. When the session is resumed streaming does not continue from the point where it

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was paused but from the ‘current’ content. The WFD Source does not cache the real-time content from the point where the stream was paused.

** Not allowed during RTSP procedures to establish a WFD Session, if the WFD Device is acting as specified in the column.

*** SETUP, PAUSE, and PLAY are optional in an RTSP M2 response message from a Secondary Sink to the Primary Sink during a coupling procedure. These SETUP, PAUSE and PLAY methods are not used from a Secondary Sink to a Primary Sink.

Table 6-7 : RTSP methods that the WFD Source and/or WFD Sink can invoke

Example: The following RTSP exchange shows a WFD Source querying its peer WFD Sink to verify that it has WFD support.

```
Source->Sink  OPTIONS * RTSP/1.0
    CSeq: 0
    Require: org.wfa.wfd1.0

Sink->Source RTSP/1.0 200 OK
    CSeq: 0
    Public: org.wfa.wfd1.0, SET_PARAMETER, GET_PARAMETER
```

Conversely, below is an example of a WFD Sink querying its peer WFD Source to verify that it has WFD support.

```
Sink->Source  OPTIONS * RTSP/1.0
    CSeq: 0
    Require: org.wfa.wfd1.0
Source->Sink  RTSP/1.0 200 OK
    CSeq: 0
    Public: org.wfa.wfd1.0, SET_PARAMETER, GET_PARAMETER, SETUP, PLAY, PAUSE,
TEARDOWN
```

6.2.2 GET_PARAMETER

In response to a GET_PARAMETER request from a WFD Source, a WFD Sink shall respond with the current value of the requested parameter or parameters. A WFD Device shall be able to parse RTSP parameters in any order. A WFD Sink shall support responding to a GET_PARAMETER request at any time after a successful RTSP M2 message exchange.

A GET_PARAMETER without body can be used for keep-alive function. See section 6.5.1 and 6.4.16.

The GET_PARAMETER response may include responses to the parameters in a different order from that which was requested in the corresponding GET_PARAMETER request. In addition, the responder may ignore parameters in the request that the responder does not recognize.

6.2.3 SET_PARAMETER

In response to a SET_PARAMETER request from a WFD Device, a peer WFD Device shall either:

(a) update all of the values of the specified parameters to the provided values and respond with an RTSP SET_PARAMETER response message containing a status code of RTSP OK, or

(b) respond with an RTSP SET_PARAMETER response message containing a status code “303 See Other” in the message header. The SET_PARAMETER response message body shall contain the parameter or parameters that were not set successfully, followed by a separator of “: ” and one or more reason codes, which inform the sender of the RTSP SET_PARAMETER request of the reason for the failure. The reason code shall be separated by “, ”.

The ABNF of the response is as follows:

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```
line-at-message-body   = "name-of-failed-parameter:" SP reason-code
                         *("," SP reason-code) CRLF
Reason-code            = 3*3DIGIT; see Table 6-8
```

For example, if the `wfd-video-formats` cannot be set at the Primary Sink because the WFD Source requested both an unsupported resolution and an unsupported codec profile, the message body of the response is as follows;

```
Wfd_video_formats: 415, 457
```

The reason codes to be used in the message body are specified in Table 6-8. These reason codes are WFD specific and are not identical to the status code specified in RTSP.

Reason Code	WFD Detail
400	RTSP syntax violation
401	Unacceptable RTP port being used
404	The requester attempts setting a parameter that the responder did not advertise in Capability Negotiation or cannot find a parameter
415	The requester attempts to use an unsupported A/V format on the responder
451	The receiver of the request does not understand a parameter
453	The responder cannot set a given parameter because expected bit rate for the requested parameter may exceed available bit rate
457	The responder does not support a profile and/or level for a given codec
458	A responder cannot update a requested parameter because it is not allowed in this Specification
465	An unknown reason other than the ones specified here

Table 6-8 : Reason Code for RTSP M4 response in WFD

In this case (b) above, the recipient of the SET_PARAMETER request shall update the parameters that are acceptable. The transmitter of the SET_PARAMETER request may send a second SET_PARAMETER request after modifying parameters based on the error codes returned by the recipient in its SET_PARAMETER response. An example is shown in Table E-2 under Annex-E.2.

6.2.4 SETUP

RTSP M6 request and response messages for SETUP shall include `Transport` header as specified herein.

The RTSP SETUP request shall use the values from the `wfd-client-rtp-ports` parameter (specified in section 6.1.10) for the transport. The ABNF for `Transport` header is:

```
Transport      = "Transport:" SP profile port-numbers CRLF
profile        = "RTP/AVP/UDP;unicast;"
port-numbers   = client-port [";" server-port]; client-port only at M6
                            request message, (client-port ";" server-
                            port) at M6 response message.
client-port    = "client_port=" (rtp-port0 / rtp-port1) ["-" IPPORT]; rtp-
                            port0 from a Primary Sink, rtp-port1 from a
                            Secondary Sink. IPPORT here is rtp-port0 (or
                            rtp-port1) plus 1 to be used for RTCP. ["-"
                            IPPORT] can only appear in M6 request if the
                            WFD Sink wants to use optional RTCP. ["-"
                            IPPORT] can only appear in M6 response if
                            the WFD Source accepts to use optional RTCP.
```

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```
server-port    = "server_port=" IPPORT ["-" IPPORT]; server's UDP port
                                number for RTP. Optional IPPORT is server's
                                UDP port number for RTP plus 1 to be used
                                for optional RTCP. ["-" IPPORT] can only
                                appear in M6 response if the WFD Source
                                accepts to use optional RTCP.
```

Note : MPEG2-TS (MP2T) described at section 5.7 in RFC3551 [6] is used with the AVP/ profile in this Specification. Other profiles described at other sections in [6] are not relevant to this Specification.

The WFD Source can determine and inform the timeout value to the WFD Sink. In the RTSP M6 response message, the WFD source may set a timeout value in units of 1 second. See section 6.5.1 for more detail.

6.2.5 PLAY

The RTSP PLAY request shall not include a "Range" parameter.

6.2.6 PAUSE

The RTSP PAUSE request shall not include a "Range" parameter.

6.2.7 TEARDOWN

The RTSP TEARDOWN request has no additional WFD specific requirements.

6.3 RTSP Parameters

This section defines WFD specific parameters that are used within RTSP SET_PARAMETER and GET_PARAMETER methods. All parameters referenced are those that describe or control capabilities of the WFD Sink, except for the `wfd-connector-type`, `wfd-standby`, `wfd-idr-request`, `wfd-uibc-capability` and `wfd-uibc-setting`, which may be sent by the WFD Sink to set parameter in the WFD source.

The URL specified by the WFD Source in GET_PARAMETER and SET_PARAMETER for accessing WFD Sink parameters shall be "rtsp://localhost/wfd1.0". Conversely, the WFD Sink shall always reference the WFD Source in RTSP messages using the URL given to it by the WFD Source in the `wfd-presentation-url` parameter.

Table 6-9 contains a summary of RTSP parameters used in this Specification:

Parameter name	Parameter description	Method	Definition	Usage
`wfd-audio-codecs`	Audio format(s) supported by the WFD Sink.	GET	6.1.2	Mandatory in RTSP M3 request and response.
	Audio format selected for the WFD Session.	SET		Mandatory in RTSP M4 request if the stream includes audio.
`wfd-video-formats`	video format(s) support by the WFD Sink.	GET	6.1.3	Mandatory in RTSP M3 request and response.
	Video format selected for WFD Session.	SET		Mandatory in RTSP M4 request if the stream includes 2D video and if the `wfd-preferred-display-mode` parameter is not included.
`wfd-3d-formats`	3D formats supported by the WFD Sink.	GET	6.1.4	Optional in RTSP M3 request. Mandatory in RTSP M3 response if

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				RTSP M3 request includes it.
	3D format selected for the WFD Session.	SET		Mandatory in RTSP M4 request if the stream includes 3D video and if the `wfd-preferred-display-mode` parameter is not included.
`wfd-content-protection`	The HDCP system 2.x support/control port.	GET	6.1.5	Mandatory in RTSP M3 request if the WFD Device supports HDCP system 2.x. Mandatory in RTSP M3 response if RTSP M3 request includes it.
`wfd-display-edid`	Available EDID information of display attached to the WFD Sink.	GET	6.1.6	Optional in RTSP M3 request. Mandatory in RTSP M3 response if RTSP M3 request includes it.
`wfd-coupled-sink`	Coupled WFD Sink information.	GET	6.1.7	Optional in RTSP M3 request. Mandatory in RTSP M3 response if RTSP M3 request includes it.
`wfd-trigger-method`	Trigger to cause a SETUP, PLAY, PAUSE or TEARDOWN message to be initiated by WFD Sink to WFD Source.	SET	6.1.8	Mandatory in RTSP M5 request.
`wfd-presentation-url`	Accompanies `wfd-trigger-method` for SETUP trigger. Defines the URI that shall be used for SETUP request from the WFD Sink.	SET	6.1.9	Mandatory in RTSP M4 request when WFD Session has not been established.
`wfd-client-rtp-ports`	RTP port(s) the WFD Sink(s) listen on.	GET	6.1.10	Mandatory in RTSP M3 request when WFD Session has not been established.
		SET		Mandatory in RTSP M4 request when WFD Session has not been established.
`wfd-route`	Route audio from Primary Sink to Secondary Sink or vice-versa.	SET	6.1.11	Mandatory in RTSP M10 request if RTSP M10 is supported.
`wfd-I2C`	Supports I2C commands and port number.	GET	6.1.12	Optional in RTSP M3 request. Mandatory in M3

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				response if RTSP M3 request includes it.
wfd-av-format-change-timing	Signals timing related to AV format change to the WFD Sink.	SET	6.1.13	Mandatory in RTSP M4 request when it is sent during WFD Session.
wfd-preferred-display-mode	The Preferred Display mode that is selected for use in the WFD Session.	SET	6.1.14	Optional in RTSP M4 request. Mandatory in RTSP M4 response if RTSP M4 request includes it.
wfd-uibc-capability	UIBC capability supported.	GET	6.1.15	Optional in RTSP M3 request. Mandatory in RTSP M3 response if RTSP M3 request includes it.
	Select UIBC to be used.	SET		Optional in RTSP M4 request. Mandatory in RTSP M14 request if RTSP M14 is supported.
wfd-uibc-setting	Enable or disable the UIBC.	SET	6.1.16	Optional in RTSP M4 request. Mandatory in RTSP M15 request if RTSP M15 is supported.
wfd-connector-type	WFD Source uses this parameter to obtain the connector type currently active on the WFD Sink.	GET	6.1.19	Optional in RTSP M3 request. Mandatory in RTSP M3 response if RTSP M3 request includes it.
	The WFD Sink uses this parameter to inform the WFD Source of a connector type change and report the currently active connector type.	SET		Mandatory in RTSP M11 request if RTSP M11 is supported.
wfd-standby-resume-capability	Indicate the support for standby and resume control using RTSP.	GET	6.1.17	Optional in RTSP M3 request. Mandatory in RTSP M3 response if RTSP M3 request includes it.
wfd-standby	Sender is entering WFD Standby mode.	SET	6.1.18	Mandatory in RTSP M12 request if RTSP M12 is supported.
wfd-idr-request	WFD Sink requests an IDR picture from the WFD Source.	SET	6.1.20	Mandatory in RTSP M13 request if sending RTSP M13 request is supported by the Primary Sink.

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Table 6-9 : Summary of RTSP Parameters

6.4 RTSP Messages

This section (and sub-section) defines RTSP messages that are exchanged between WFD Devices for WFD Capability Negotiation, Coupling, WFD Session Establishment, and WFD Session Management.

The transmission of an RTSP M1 request message from a WFD Source initiates WFD Capability Negotiation, as described in section 4.6. Upon a successful exchange of RTSP M4 request and response messages, WFD Capability Negotiation is successfully completed.

The transmission of an RTSP M5 request message from a WFD Source initiates a WFD Session Establishment, as described in section 4.8. Upon a successful exchange of RTSP M6 request message and response messages, an RTSP session is established as described in [23]. Upon the first successful exchange of RTSP M7 request message and response messages just after an RTSP session establishment, a WFD Session is established as described in section 4.8. A WFD Session ends when the WFD Sink sends a TEARDOWN, when an RTSP timeout occurs as specified in section 6.5, or when an error condition occurs as described later in this section.

When both a Primary and a Secondary Sink are in a WFD Session with a WFD Source for a Coupled Sink Operation, the WFD Source shall perform the sequence described in section 4.9.6, once with the Primary Sink, and once with the Secondary Sink. A WFD Session is considered as established when the first exchange of RTSP M7 messages between both the WFD Primary Sink and WFD Secondary Sink has been completed successfully with the WFD Source[12].

Upon the establishment of the TCP connection, the WFD Source shall send an RTSP M1 request message to the WFD Sink. The WFD Sink shall respond with an RTSP response message and then shall send an RTSP M2 request message to the WFD Source. The messages shall be transmitted in sequential order as described here.

The RTSP procedures are defined as all RTSP message exchanges listed in this Specification, including RTSP messages before establishing RTSP session. An RTSP message exchange is defined as sending an RTSP request message and receiving a corresponding RTSP response message. A successful RTSP message exchange is one where the corresponding RTSP response message contains a status code of RTSP OK. A failed RTSP message exchange is one where the corresponding RTSP response message contains a status code that is not a status code of RTSP OK. See 7.1.1 in [23] for details.

When the WFD Device is unable to parse a request or unable to accept a request in an RTSP request message, the WFD Device receiving the RTSP request message shall send an RTSP response message that includes a corresponding RTSP status code indicating an associated error.

If the WFD Device that sent the RTSP request message receives an RTSP response message with an RTSP status code indicating an error from the peer WFD Device, the WFD Device shall not execute any behavior that is not accepted by the peer WFD Device as indicated in a parameter (or parameters) in the received RTSP response message. Depending on the returned value of a status code other than RTSP OK, the message exchange may be retried with a different set of parameters or the RTSP procedures may be aborted, and the RTSP session may be aborted if it has been established.

If an RTSP request or RTSP response does not match the syntax specified in this Specification, the recipient of the RTSP message shall ignore the RTSP message and abort the RTSP procedures, and the RTSP session shall be aborted if the RTSP session has been established.

When aborting the RTSP procedures before a successful exchange of an RTSP M6 message exchange (i.e., RTSP session has not been established yet), a WFD Sink should not send an RTSP M8 request message, nor should a WFD Source send an RTSP M5 request message containing `wfd-trigger-method` parameter with the trigger method set to TEARDOWN.

[12] RTSP sessions are individually established, i.e., the RTSP session between the WFD Source and the Primary Sink is established when the exchange of RTSP M6 request and response messages between them is completed, and the RTSP session between the WFD Source and the Secondary Sink is established when the exchange of RTSP M6 request and response messages between them is completed.

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If the RTSP procedures are aborted before establishing an RTSP session, the WFD Source and the WFD Sink stay in an RTSP Init state, and the WFD Source may send an RTSP M1 request message to a WFD Sink. When aborting the RTSP procedures after a successful exchange of RTSP M6 messages (i.e., RTSP session has been established), a WFD Sink shall send an RTSP M8 request message, or a WFD Source shall send an RTSP M5 request message containing `wfd-trigger-method` parameter with the trigger method set to TEARDOWN.

Timeout rules are specified in section 6.5.

Examples of RTSP messages are shown in Annex-E.

Table 6-10 lists the RTSP messages and their identifiers defined in this Specification.

Id	Requester	Payload	Behavior	Description	RTSP State
M1	WFD Source	6.2.1	6.4.1	Query WFD Sink's options	Init
M2	WFD Sink	6.2.1	6.4.2	Query WFD Source's options	Init
M3	WFD Source	6.1.2-6.1.7, 6.1.10	6.4.3	Query WFD Sink's capabilities	Init (for WFD Capability Negotiation) Playing (for WFD Capability Re-negotiation)
M4	WFD Source	6.1.2-6.1.7	6.4.4	Set WFD Sink's parameters	Init (for WFD Capability Negotiation) Playing (for WFD capability Re-negotiation)
M5	WFD Source	6.1.8	6.4.5	Trigger WFD Sink to issue a SETUP, PLAY, TEARDOWN, or PAUSE request.	Init (for SETUP) Ready (for PLAY and TEARDOWN) Playing (for PAUSE and TEARDOWN)
M6	WFD Sink	6.2.4	6.4.6	Send SETUP request to WFD Source.	Ready
M7	WFD Sink		6.4.7	Send PLAY request to WFD Source. WFD Source begins audio and/or video streaming.	Ready (for initiating streaming and for returning from pause or WFD Standby)
M8	WFD Sink		6.4.8	Send TEARDOWN request to WFD Source	Playing
M9	WFD Sink		6.4.9	Send PAUSE request to WFD Source. WFD Source pauses the audio video stream(s)	Playing
M10	WFD Sink	6.1.11	6.4.10	Send RTSP SET_PARAMETER with `wfd-route` to change the WFD Sink at which audio is rendered. Applies only when both a Primary and a Secondary Sinks are in WFD Session with a WFD Source.	Playing (optional)
M11	WFD Sink	6.1.19	6.4.11	Send RTSP SET_PARAMETER with `wfd-connector-type` to indicate change of active connector type, when the WFD Source and the WFD Sink support content protection.	Playing (optional)

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M12	WFD Source WFD Sink	6.1.18	6.4.12	Send RTSP SET_PARAMETER with `wfd-standby` to indicate that the sender is entering WFD Standby mode.	Playing (optional)
M13	WFD Sink	6.1.20	6.4.13	Send RTSP SET_PARAMETER with `wfd-idr-request` to request IDR refresh	Playing (optional at the Primary Sink to send request, and mandatory at the WFD Source to respond)
M14	WFD Source WFD Sink	6.1.15	6.4.14	Send RTSP SET_PARAMETER with `wfd-uibc-capability` to select UIBC to be used.	Playing (optional)
M15	WFD Source WFD Sink	6.1.16	6.4.15	Send RTSP SET_PARAMETER with `wfd-uibc-setting` to enable or disable the UIBC.	Playing (optional)
M16	WFD Source		6.4.16	Send GET_PARAMETER to confirm active RTSP session	Ready Playing

Table 6-10 : List of defined RTSP messages and their identifiers

6.4.1 RTSP M1 Message

A WFD Source shall send an RTSP M1 request to a WFD Sink to begin the RTSP procedures and a WFD Capability Negotiation. The RTSP M1 request shall contain an RTSP OPTIONS request. A WFD Sink shall respond with an RTSP M1 response message indicating an appropriate status code specified in section 7.1.1 of [23]. If the RTSP M1 response message contains a status code of RTSP OK, the RTSP M1 response message shall contain an RTSP OPTIONS response.

6.4.2 RTSP M2 Message

After sending an RTSP M1 response including a status code of RTSP OK to the WFD Source, the WFD Sink shall send an RTSP M2 request to the WFD Source. The RTSP M2 request shall contain an RTSP OPTIONS request. The WFD Source shall respond with an RTSP M2 response indicating an appropriate status code specified in section 7.1.1 of [23]. If the RTSP M2 response message contains a status code of RTSP OK, the RTSP M2 response message shall contain an RTSP OPTIONS response.

6.4.3 RTSP M3 Message

After sending an RTSP M2 response including a status code of RTSP OK to the WFD Sink, the WFD Source shall send an RTSP M3 request to the WFD Sink to query the WFD Sink's attributes and capabilities. The RTSP M3 request shall contain an RTSP GET_PARAMETER request (see section 6.2.2). The parameters that may be requested are listed in section 6.3. The WFD Sink shall respond with an RTSP M3 response indicating an appropriate status code specified in section 7.1.1 of [23]. If the RTSP M3 response message contains a status code of RTSP OK, the RTSP M3 response shall contain the values of the requested parameters.

When an optional parameter is included in the RTSP M3 Request message from the WFD Source, it implies that the WFD Source supports the optional feature corresponding to the parameter.

The WFD Sink shall be able to parse all the RTSP parameters that are listed in section 6.1 in the RTSP M3 request message. If the WFD Sink receives an RTSP M3 request including any of these parameters, it shall respond to them in the RTSP M3 response.

The WFD Sink shall support responding to an RTSP M3 request at any time after a successful RTSP M2 message exchange. The WFD Source may query all parameters at once with a single RTSP M3 request message or may send separate RTSP M3 request messages.

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The WFD Sink shall only respond with formats and settings that it can accept in the following RTSP M4 message exchange.

If the WFD Sink has indicated support for the HDCP system 2.x (see section 6.1.5) in the most recent RTSP M3 response message and if the HDCP 2.x authentication key exchange has not been successfully completed for a WFD Session, the WFD Source and the WFD Sink shall start the HDCP 2.x authentication key exchange upon successful completion of the RTSP M3 message exchange. The WFD Sink should start listening upon transmission of an RTSP M3 response message, and the WFD Source should start sending AKE_Init upon receipt of the RTSP M3 response message.

The WFD Sink shall only respond with formats and settings that the WFD Sink can accept in the following RTSP M4 message exchange.

6.4.4 RTSP M4 Message

If a WFD Session has not been established, after receiving an RTSP M3 response including a status code of RTSP OK, the WFD Source shall send an RTSP M4 request to the WFD Sink to set parameters for the WFD Sink. The WFD Sink shall respond with an RTSP M4 response indicating an appropriate status code specified in section 7.1.1 of [23].

The WFD Sink shall support responding to an RTSP M4 request at any time after a successful RTSP M3 message exchange. The WFD Source may set parameters all at once with a single RTSP M4 request message or may send separate RTSP M4 request messages.

The format of the M4 request message varies depending on the WFD Session:

(a) If the WFD Source is trying to initiate the establishment of an audio-only WFD Session with the WFD Sink, the RTSP M4 request message (or a series of RTSP M4 request messages) shall include a `wfd-audio-codecs` parameter and shall not include any of the following parameter: `wfd-video-formats`, `wfd-3d-formats`, or `wfd-preferred-display-mode`.

(b) If the WFD Source is trying to initiate the establishment of a video-only WFD Session with the WFD Sink, the RTSP M4 request message (or a series of RTSP M4 request messages) shall not include a `wfd-audio-codecs` parameter and shall include only one of the following parameters: `wfd-video-formats`, `wfd-3d-formats`, or `wfd-preferred-display-mode`.

(c) If the WFD Source is trying to initiate the establishment of an audio and video WFD Session with a Primary Sink, the RTSP M4 request message (or a series of RTSP M4 request messages) shall include a `wfd-audio-codecs` parameter and only one of the following parameters: `wfd-video-formats`, `wfd-3d-formats`, or `wfd-preferred-display-mode`.

(d) if the WFD Source is trying to initiate the establishment of an audio and video WFD Session with a Primary Sink and a Secondary Sink during a Coupled Sink Operation:

   i. If both audio and video payloads are destined for the Primary Sink, the RTSP M4 request message (or a series of RTSP M4 request messages) to the Primary Sink shall include a `wfd-audio-codecs` parameter and only one of the following parameters: `wfd-video-formats`, `wfd-3d-formats`, or `wfd-preferred-display-mode`.

   ii. If video payload is destined for the Primary Sink and audio payload is destined for the Secondary Sink, then:

      (1) The RTSP M4 request message (or a series of RTSP M4 request messages) to the Primary Sink shall not include a `wfd-audio-codecs` parameter and shall include one of the following parameters: `wfd-video-formats`, `wfd-3d-formats`, or `wfd-preferred-display-mode`.
      (2) The RTSP M4 request message (or a series of RTSP M4 request messages) to the Secondary Sink shall include a `wfd-audio-codecs` parameter and shall not include any of the following parameters: `wfd-video-formats`, `wfd-3d-formats`, or `wfd-preferred-display-mode`.

The RTSP M4 request message may include a `wfd-uibc-setting` parameter during the WFD Capability Negotiation if the RTSP M4 request message contains a `wfd-uibc-capability` parameter.

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If a WFD Sink has indicated unsupported for feature(s) in its RTSP M3 response message, then the WFD Source shall not include RTSP parameter(s) that are related to those unsupported feature(s). It is highly recommended that the WFD Sink should ignore an RTSP parameter that is unknown or is not supported.

Based on the `wfd-client-rtp-ports` parameter in the M3 response and depending on the WFD Session being setup, the WFD Source determines the configuration of the MPEG2-TS stream(s) to be used in the WFD Session and the WFD Source shall include the corresponding `wfd-client-rtp-ports` parameter in the RTSP M4 request message sent to the WFD Sink. How to set this parameter is defined in Table 6-3 under section 6.1.10.

The RTSP M4 request message that is for WFD Capability Negotiation shall contain the `wfd-presentation-url` parameter (specified in section 6.1.9) that describes the Universal Resource Identifier (URI) to be used in the RTSP Setup request (RTSP M6 request) in order to setup the WFD Session. The `wfd-presentation-url` specifies the URI that a WFD Sink shall use in an RTSP M6 request message to a WFD Source. The values of `wfd-url0` and `wfd-url1` fields specified in this parameter correspond to the values of `rtp-port0` and `rtp-port1` field in the `wfd-client-rtp-ports` parameter in the RTSP M4 request message from the WFD Source to the WFD Sink at the end of the Capability Negotiation. The WFD Sink uses information in this parameter in RTSP SETUP request (RTSP M6 request) message.

If the RTSP M4 request message is sent to the WFD Sink to change one or more parameters in `wfd-audio-codec`, `wfd-video-formats`, `wfd-3d-formats`, and/or `wfd-preferred-display-mode` parameter(s) used in the WFD Session, it shall include a `wfd-av-format-change-timing` (specified in section 6.1.13) parameter.

6.4.5 RTSP M5 Message

The M5 request message is used by a WFD Source to trigger an RTSP session establishment when an RTSP session has not been established, or to trigger play, pause, or teardown during an RTSP session.

If an RTSP session has not been established, after receiving an RTSP M4 response with a status code of RTSP OK, the WFD Source shall send an RTSP M5 request message containing `wfd-trigger-method` parameter with the trigger method set to SETUP to the WFD Sink to indicate that the WFD Sink is requested to send an RTSP M6 request message. The WFD Sink shall respond with an RTSP M5 response indicating an appropriate status code specified in section 7.1.1 of [23].

Once an RTSP session has been established, the WFD Source may send an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PLAY to the WFD Sink to indicate that the WFD Sink is requested to send an RTSP M7 request message. The WFD Sink shall respond with an RTSP M5 response message indicating an appropriate status code specified in section 7.1.1 of [23]. The WFD Source in an RTSP Playing state should not send an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PLAY to the WFD Sink.

Once a WFD Session has been established, the WFD Source may send an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PAUSE to the WFD Sink to indicate that the WFD Sink is requested to send an RTSP M9 request message. The WFD Sink shall respond with an RTSP M5 response message indicating an appropriate status code specified in section 7.1.1 of [23]. The WFD Source in an RTSP Ready state should not send an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to PAUSE to the WFD Sink.

Once an RTSP session has been established, the WFD Source may send an RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to TEARDOWN to the WFD Sink to indicate that the WFD Sink is requested to send an RTSP M8 request message. The WFD Sink shall respond with an RTSP M5 response message indicating an appropriate status code specified in section 7.1.1 of [23].

In general, an RTSP M5 request message is used to trigger the recipient to send an RTSP message corresponding to the parameter contained in the RTSP M5 request message. Figure 6-4 illustrates the message exchange between WFD Devices.

In the event that a WFD Source receives an RTSP message requesting the WFD Source to perform an action that contradicts a previously initiated TRIGGER operation by the WFD Source, then the WFD Source shall obey the action indicated in the RTSP request message from the WFD Sink.

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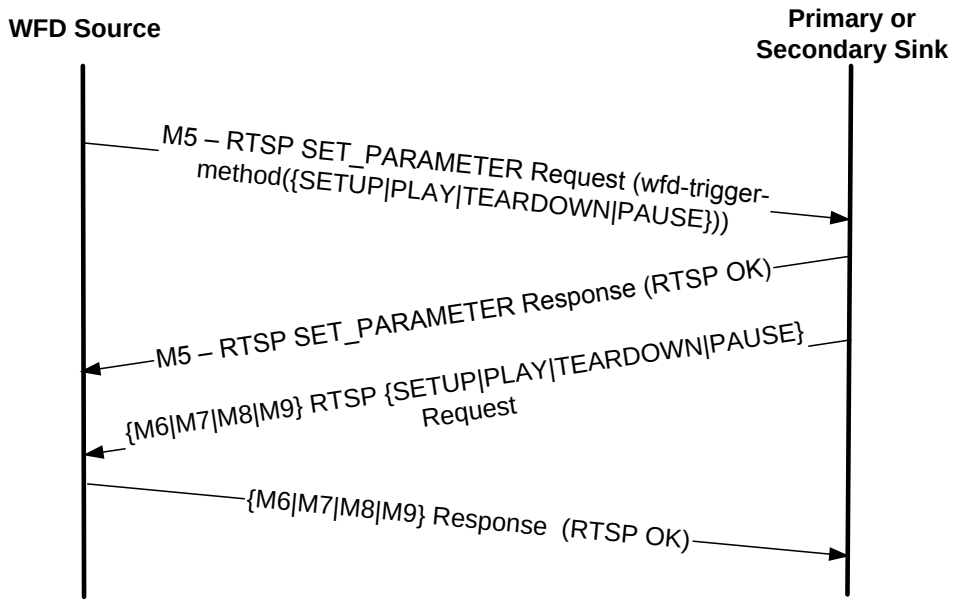

Figure 6-4 : Triggering the WFD Sink to send an RTSP request message

6.4.6 RTSP M6 Message

After sending an RTSP M5 response message with a status code of RTSP OK as a response to the RTSP M5 request message containing a `wfd-trigger-method` parameter with the trigger method set to SETUP, the WFD Sink shall send an RTSP M6 request message to the WFD Source. The RTSP M6 request message shall contain an RTSP SETUP request. The request shall use information indicated in a `wfd-presentation-url` (specified in section 6.1.9) in the RTSP M4 request message as an URI for SETUP[13]. The WFD Source shall respond with an RTSP M6 response message indicating an appropriate status code specified in section 7.1.1 of [23]. When the WFD Source sends the RTSP M6 response message indicating a status code of RTSP OK, a session id shall be included.

RTSP M6 request and response messages include `Transport` header as specified in section 6.2.4.

To apply HDCP 2.x encryption from the beginning of the stream after verifying that the WFD Source and the WFD Sink support the HDCP system 2.0/2.1 or higher version in the RTSP M3 request/response messages (see section 6.1.5), the WFD Sink shall transmit an RTSP M7 request message only after successful completion of the HDCP 2.x authentication and key exchange as specified in clause 2 of the corresponding specification references indicated in Annex-F that maps to the HDCP version in use. For higher version than HDCP 2.2, refer to corresponding specification released by DCP LLC.

6.4.7 RTSP M7 Message

A WFD Sink sends an RTSP M7 request message to the WFD Source in the following cases:

(a) While in the process of establishing a WFD Session, after receiving an RTSP M6 response message with a status code of RTSP OK, the WFD Sink shall send an RTSP M7 request message to the WFD Source.

(b) Once a WFD Session has been established, in response to the receipt of an RTSP M5 request message from the WFD Source containing a `wfd-trigger-method` parameter with the trigger method set to PLAY, the WFD Sink sends an RTSP M5 response message to the WFD Source. If the RTSP M5 response message included a status code of RTSP OK, the WFD Sink shall send an RTSP M7 request message to the WFD Source.

[13] It does not mean that the RTSP M6 request shall include identical text string in the `wfd-presentation-url` parameter in an RTSP M4 request message.

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(c) Once a WFD Session has been established, if the WFD Sink intends to resume streaming from the WFD Source, the WFD Sink sends an RTSP M7 request message to the WFD Source.

The RTSP M7 request message contains an RTSP PLAY request.

The WFD Source shall respond with an RTSP M7 response message indicating an appropriate status code specified in section 7.1.1 of [23].

If the RTSP M7 response message includes a status code of RTSP OK, the WFD Source shall start/resume transmitting the audio/video stream to the RTP client port numbers specified in the RTSP M6 request message. If the WFD Source starts/resumes transmitting an MPEG2-TS that contains a video elementary stream, the first video frame shall be an IDR picture with SPS and PPS. Also, if the WFD Source starts/resumes transmitting an MPEG2-TS that contains an audio elementary stream, the first Access Unit (AU) for audio shall be a new AU, and the first audio frame shall be a new frame if the audio format is not LPCM[14].

If the WFD Source in an RTSP Playing state receives an RTSP M7 request message, the WFD Source should send the RTSP M7 response message with status code "406" (means "not acceptable") and reason phrase of "in-play-state".

6.4.8 RTSP M8 Message

A WFD Sink sends an RTSP M8 request message to the WFD Source in the following cases:

(a) Once the RTSP session has been established, in response to the receipt of an RTSP M5 request message from the WFD Source containing `wfd-trigger-method` parameter with the trigger method set to TEARDOWN, the WFD Sink sends an RTSP M5 response message to the WFD Source. If the RTSP M5 response message included a status code of RTSP OK, the WFD Sink shall send an RTSP M8 request message to the WFD Source.

(b) Once the RTSP session has been established, if the WFD Sink intends to end the RTSP session with the WFD Source, the WFD Sink sends an RTSP M8 request message to the WFD Source.

The RTSP M8 request message contains an RTSP TEARDOWN request.

If an RTSP M8 request message is received during the RTSP procedures, the WFD Source shall send an RTSP M8 response message indicating an appropriate status code specified in section 7.1.1 of [23].

If the WFD Source sends an RTSP M8 response message with a status code of RTSP OK, the WFD Source shall abort the RTSP procedures, and shall stop the audio/video streaming and terminate the corresponding RTP session(s) if exists.

If the RTSP M8 request and response messages are correctly exchanged with a status code of RTSP OK, the WFD Source and WFD Sink shall release corresponding resources committed to the RTP session (if exists) and RTSP procedures. After the teardown, in order to establish a new WFD Session, the WFD Devices shall start with WFD Capability Negotiation (See section 4.6) and WFD Session establishment (See section 4.8) procedures.

6.4.9 RTSP M9 Message

Once a WFD Session has been established and the WFD Sink has started decoding the corresponding stream received from the WFD Source, the WFD Sink sends the RTSP M9 request message to the WFD Source in the following cases:

(a) In response to the receipt of an RTSP M5 request message from the WFD Source containing `wfd-trigger-method` parameter with the trigger method set to PAUSE, the WFD Sink sends an RTSP M5 response message to the WFD Source. If the RTSP M5 response message included a status code of RTSP OK, the WFD Sink shall send an RTSP M9 request message to the WFD Source.

(b) If the WFD Sink intends to pause the current stream being received from the WFD Source, the WFD Sink sends an RTSP M9 request message to the WFD Source.

[14] In LPCM case, a WFD Sink can start rendering form any point and it is not necessary to consider frame boundary.

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The RTSP M9 request message contains an RTSP PAUSE request.

If an RTSP M9 request message is received during the WFD Session with "PLAY" state, the WFD Source shall respond with an RTSP M9 response message indicating an appropriate status code specified in section 7.1.1 of [23].

If the WFD Source sends an RTSP M9 response message with a status code of RTSP OK, the WFD Source shall stop transmission of the content stream to the RTP client port numbers specified in the RTSP M6 response message.

If the WFD Source in an RTSP Ready state receives an RTSP M9 request message, the WFD Source should send an RTSP M9 response message with status code "406" (means "not acceptable") and reason phrase if "in-pause-state".

6.4.10 RTSP M10 Message

During a WFD Session for Coupled Sink Operation (see section 4.9), the Primary Sink may send an RTSP M10 request message to the WFD Source in order to change the WFD Sink where the audio stream corresponding to the WFD Session is rendered (see section 4.10.4).

During a WFD Session for Coupled Sink Operation (see section 4.9), the Secondary Sink may send an RTSP M10 request message to the WFD Source in order to change the WFD Sink where the audio stream corresponding to the WFD Session is rendered (see section 4.10.4).

The RTSP M10 request message is an RTSP SET_PARAMETER request containing a `wfd-route` parameter. The `destination` field in the `wfd-route` parameter identifies the WFD Sink where the audio stream is to be rendered.

If an RTSP M10 request message is received during the WFD Session, the WFD Source shall respond with an RTSP M10 response message indicating an appropriate status code specified in section 7.1.1 of [23] to the WFD Sink that sent an RTSP M10 request message.

If the WFD Source sends an RTSP M10 response message with a status code of RTSP OK, the WFD Source shall switch the destination of the audio stream to the WFD sink identified in the M10 request message.

6.4.11 RTSP M11 Message

During a WFD Session, only if the WFD Source had indicated support for this feature by querying a `wfd-connector-type` parameter (specified in section 6.1.19) in the RTSP M3 request message and the WFD Sink had indicated the support of this feature in the RTSP M3 response message, the WFD Sink may send an RTSP M11 request message to the WFD Source in order to inform the change of active connector type,.

The RTSP M11 request message is an RTSP SET_PARAMETER request containing the `wfd-connector-type` parameter.

If an RTSP M11 request message is received during the WFD Session, the WFD Source shall respond with an RTSP M11 response message indicating an appropriate status code specified in section 7.1.1 of [23].

6.4.12 RTSP M12 Message

During a WFD Session, a WFD Device may send an RTSP M12 request message to indicate that the WFD Device is trying to enter into a WFD Standby mode. The RTSP M12 request message shall only be sent if the paired WFD Device had indicated the support for this feature in an exchange of the RTSP M3 request and response messages.

The RTSP M12 request message is an RTSP SET_PARAMETER request containing the `wfd-standby` parameter.

If an RTSP M12 request message is received during the WFD Session, the WFD Device shall respond with an RTSP M12 response message indicating an appropriate status code specified in section 7.1.1 of [23].

If the WFD Device receives the RTSP M12 response message including a status code of RTSP OK, the WFD Device shall enter into a WFD Standby mode.

The WFD Device should not send an RTSP M12 request message when it is in a WFD Standby mode.

See section 4.15 for more detail.

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6.4.13 RTSP M13 Message

During a WFD Session with streaming video content, the WFD Sink may send an RTSP M13 request message to the WFD Source in order to request the IDR picture.

The RTSP M13 request message is an RTSP SET_PARAMETER request containing the `wfd-idr-request` parameter.

If an RTSP M13 request message is received during the WFD Session with streaming video content, the WFD Source shall respond with an RTSP M13 response message indicating an appropriate status code specified in section 7.1.1 of [23].

See section 4.10.5 for more detail.

6.4.14 RTSP M14 Message

During the WFD Session, the WFD Device may send an RTSP M14 request message to establish the UIBC. The RTSP M14 request message shall only be sent if the paired WFD Device had indicated the support for UIBC in an exchange of the RTSP M3 request and response messages.

The RTSP M14 request message is an RTSP SET_PARAMETER request containing the `wfd-uibc-capability` parameter.

During the WFD Session and when the WFD Source tries to establish a UIBC, the WFD Source sends an RTSP M14 request message to establish the UIBC. If the RTSP M14 request message is received, the WFD Sink shall respond with an RTSP M14 response message indicating an appropriate status code specified in section 7.1.1 of [23]. If the exchange of RTSP M14 request and response messages is successfully completed with a status code of RTSP OK in the RTSP M14 response message, then the UIBC is established.

During the WFD Session and when the UIBC had been established, the WFD Device may send an RTSP M14 request message to update parameters in the UIBC. If the RTSP M14 request message is received, the paired WFD Device shall respond with an RTSP M14 response message indicating an appropriate status code specified in section 7.1.1 of [23]. If the exchange of RTSP M14 request and response messages is successfully completed with a status code of RTSP OK in the RTSP M14 response message, then the parameters in the UIBC are updated.

The WFD Sink shall not update any UIBC parameter(s) now in use, before the next exchange of RTSP M14 request and response messages is successfully completed with a status code of RTSP OK in the RTSP M14 response message, independent on which side transmits the RTSP M14 request message.

When the WFD Source attempts to update the UIBC parameter, the `wfd-uibc-capability` parameter in the RTSP M14 request message shall be compliant with the capability of the WFD Sink indicated in the most recent RTSP M3 response message.

During a WFD Session, if previously the WFD Sink had received the RTSP M14 response message with a status code other than RTSP OK on the RTSP M14 request message, the WFD Sink should not send the RTSP M14 request message that includes same UIBC parameter (e.g., input category or input type to be used) setting with previously unaccepted UIBC parameter setting by the WFD Source.

To reduce one RTSP M14 message exchange, an RTSP M4 message exchange before establishing an RTSP session may be used for establishing UIBC. The RTSP M4 request message to establish the UIBC may contain the `wfd-uibc-capability` parameter. If an RTSP M4 request message containing `wfd-uibc-capability` parameter is received, the WFD Sink shall respond with an RTSP M4 response message including `wfd-uibc-capability` parameter indicating an appropriate status code specified in section 7.1.1 of [23]. If the exchange of RTSP M4 request and response messages is successfully completed with a status code of RTSP OK in the RTSP M14 response message, then the UIBC is established.

See section 4.11 and 6.1.15 for more detail.

6.4.15 RTSP M15 Message

During a WFD Session and after a successful establishment of the UIBC by an exchange of RTSP M4 or M14 request and response messages, a WFD Source may send an RTSP M15 request message to enable/disable the UIBC. During a WFD Session and after a successful establishment of the UIBC by an

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exchange of RTSP M4 or M14 request and response messages, a WFD Sink may send an RTSP M15 request message to enable/disable the UIBC.

The RTSP M15 request message is an RTSP SET_PARAMETER request containing the `wfd-uibc-setting` parameter.

On receipt of the RTSP M15 request message, the WFD Sink shall respond with an RTSP M15 response message indicating an appropriate status code specified in section 7.1.1 of [23]. On receipt of the RTSP M15 request message, the WFD Source shall respond with an RTSP M15 response message indicating an appropriate status code specified in section 7.1.1 of [23].

If the exchange of the RTSP M15 request and response messages is successfully completed with a status code of RTSP OK in the RTSP M15 response message, then the UIBC is enabled or disabled as the parameter value indicates.

See section 4.11 and 6.1.16 for more detail.

6.4.16 RTSP M16 Message

During a WFD Session, a WFD Source shall send RTSP M16 messages to the WFD Sink in order to confirm that the RTSP session is active.

The RTSP M16 request message is an RTSP GET_PARAMETER request without a body.

If an RTSP M16 request message is received during a WFD Session, the WFD Sink shall respond with an RTSP M16 response message indicating an appropriate status code specified in section 7.1.1 of [23].

See section 6.5.1 for usage of an RTSP M16 message.

6.5 RTSP Timeout

During RTSP procedures, timeout rules are applied to ensure the completion of a specific operation (e.g., WFD Capability Negotiation, WFD Session establishment, session management, coupling, etc) in a timely manner. This section (and sub-section) defines timeout rules.

The following are RTSP timeout rules:

1. Upon the successful establishment of a TCP connection between a WFD Source and a WFD Sink, the WFD Source shall send an RTSP M1 request message to the WFD Sink within 6 second.
2. The timeout for an RTSP message exchange (i.e. between a request message and a corresponding response message) by a WFD Device is 5 seconds (e.g., time between an RTSP M1 request message and an RTSP M1 response message), except for an RTSP M16 message exchange. The timeout rules for an RTSP M16 message exchange are described in section 6.5.1.
3. Until a WFD Session has been established, the timeout between the receipt of a response message and the transmission of a successive request is 6 seconds (e.g. time between upon receiving an RTSP M3 response message and sending an RTSP M4 request message).
4. Until a WFD Session has been established, the timeout between the transmission of a previous response message and the transmission of a successive request is 6 seconds (e.g. between sending an RTSP M2 response message and sending an RTSP M3 request message).
5. The timeout between the receipt of an RTSP M6 response message and the transmission of an RTSP M7 request message takes two values depending on the support of link content protection (see section 4.7):
   - If link content protection is not supported, the timeout value is 6 seconds (same as rule #3).
   - If link content protection is supported, the timeout value is 9 seconds in order to accommodate the HDCP locality check (including retries) and key negotiation that shall be done before transmitting an RTSP PLAY.
6. After a WFD Session establishment, the timeout between the transmission of an RTSP M5 response message and the transmission of the corresponding RTSP M7, M8, or M9 request message is 6 seconds.

If any of the RTSP timeout rules is not satisfied, the RTSP procedures (and RTSP session if it has been established) shall be aborted, and a WFD Source and a WFD Sink returns to an RTSP Init state.

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6.5.1 WFD keep-alive

The WFD keep-alive function is used to periodically ensure the status of WFD Session. This WFD keep-alive function has following steps, and this timeout rule is applied to both a WFD Source and a WFD Sink (WFD Sinks in the case of Coupled Sink Operation).

1. A WFD Source indicates the timeout value via the "Session:" line in the RTSP M6 response message.
2. A WFD Source shall send RTSP M16 request messages and the time interval of two successive RTSP M16 request messages shall be smaller than the timeout value set by the RTSP M6 response message minus 5 seconds.
3. A WFD Sink shall respond with an RTSP M16 response message upon successful receiving the RTSP M16 request message.
4. If the WFD Source does not receive at least one RTSP M16 response message within the period of the assigned timeout, the WFD Source shall abort the RTSP session and RTP session. The WFD Source recognizes that the WFD Sink is still alive as far as any RTSP M16 response from that WFD Sink is received, independent on the RTSP status code.
5. If the WFD Sink does not receive at least one RTSP M16 request message from the WFD Source within the period of the assigned timeout, the WFD Sink shall abort the RTSP session and RTP session.

The timeout value shall not be smaller than 10 seconds. The default value is 60 seconds when the value is not specified in the RTSP M6 (SETUP) response message (refer to RFC 2326 [23] "12.37 session").

6.5.2 Timeout before RTSP Procedure

If Wi-Fi P2P is used as WFD Connectivity, the WFD Device shall successfully establish a TCP connection with the peer WFD Device for the purpose of RTSP procedures within 90 seconds of a successful transmission of the M4 Message of the Four-Way WPA2 handshake.

If TDLS is used as WFD Connectivity, the WFD Device shall successfully establish a TCP connection with the peer WFD Device for the purpose of RTSP procedure within 90 seconds of a successful transmission of the TDLS Setup Confirm message.

A successful TCP connection establishment constitutes the following steps;

- For Wi-Fi P2P case, a WFD Device shall assign itself or obtain an IP address depending on its role in the P2P Group. For TDLS case, IP address assignment shall occur prior to TDLS link establishment.
- The WFD Source (or the Primary Sink in the case of initiating RTSP procedure for Coupling) shall start the RTSP server.
- In the event of an unsuccessful attempt at establishing the TCP connection, the WFD Sink shall retry the TCP connection attempt at regular intervals until the expiration of the 90 seconds timeout period.

In the event of an unsuccessful TCP connection within 90 seconds, then the WFD Devices may teardown the Wi-Fi P2P or TDLS link.

6.6 RTSP Syntax remark

This subsection describes additional rules and clarification for RTSP syntax.

6.6.1 CSeq

The CSeq number in each RTSP header shall be assigned by the sender of the RTSP request message, i.e., separate counters for WFD Source requested messages and for WFD Sink requested messages. Same rule is applied during a Coupling procedure, i.e., separate counters for Primary Sink requested messages and for Secondary Sink requested messages). The CSeq number shall be incremented by one as specified in [23]. The initial value of CSeq at the WFD Source and the initial value of CSeq at the WFD Sink may not be identical.

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6.6.2 Delimiter for parameters

In GET_PARAMETER requests, each parameter name shall have “CRLF” at the end of the name.

A new line, i.e., an additional CRLF after the CRLF of the last body line, is not required at the end of the content of the RTSP message. If a new line, i.e., additional CRLF, exists at the end of the content of the RTSP message, the Content-Length shall be calculated to incorporate this. As a result, the recipient parses the received message body correctly. At the end of the header section, two CRLF (one is a delimiter for the last header line) shall be inserted, i.e., one blank line exists.

6.6.3 Message header

In the RTSP message header, the message header field shall be separated from the message header value by one colon (“:”) and one space (e.g., “`CSeq: 1`” or “`Session: ABCDEF`”)[15].

6.6.4 Content-Encoding

Although the RTSP specification [23] requires inclusion of the Content-Encoding header for SET_PARAMETER requests, the default encoding in this Specification is UTF8 and it is not mandatory to include Content-Encoding header when using default encoding.

6.6.5 Case Sensitivity

In all RTSP messages, all alphabet characters are case insensitive, except for the RTSP methods, such as GET_PARAMETER, PLAY and so on, as specified in [23] (RFC 2326) and its referring document of HTTP 1.1.

6.6.6 Content-Length and Content-Type

The Content-Type and the Content-Length header lines can appear in any order.

If an RTSP message carries a message body, both the Content-Type and the Content-Length header lines shall be included in the header of the RTSP message.

The ABNF for the `Content-Type` header line is:

```
Content-Type                = “Content-Type:” SP “text/parameters”
```

[15] HTTP 1.1 specification allows multiple spaces (and/or Linear White Space : LWS), but we use one space in this Specification for easier implementation for parsing.

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7 Remote I2C Read/Write Messaging Transaction

A WFD Source and a WFD Sink exchange Remote I2C Read/Write messaging transactions using the TCP port for I2C Read/Write.

The TCP port number to be used at the WFD Sink for I2C Read/Write message transaction is included in the `wfd-I2C` parameter (specified in section 6.1.12) in the RTSP M3 response message. The WFD Sink shall be ready to accept incoming connections from the WFD Source at the TCP port for I2C Read/Write before replying to the RTSP M3 request message containing the `wfd-I2C` parameter.

Once established, the WFD Devices shall use a single TCP connection for the duration of the WFD Session for all Remote I2C requests and replies between them.

There are two types of messaging transactions:

- Remote I2C Request sent by a WFD Source
- Remote I2C Reply sent by a WFD Sink.

A Request-and-Reply Message Transaction pair defines the remote I2C message transaction sequence.

Two types of requests from a WFD Source to a WFD Sink for remote I2C Read/Write message transaction are defined:

- Remote_I2C_Read_Request
- Remote_I2C_Write_Request

Four types of responses from a WFD Sink to a WFD Source for remote I2C read/Write message transaction are defined:

- Remote_I2C_Read_Reply_Ack
- Remote_I2C_Read_Reply_Nak
- Remote_I2C_Write_Reply_Ack
- Remote_I2C_Write_Reply_Nak

Remote I2C Read/Write requests consist of high-level data structures that are described in section 7.1 and 7.2. A Remote I2C Write Request includes one or more Write Transactions. A Remote I2C Read Request includes one Read Transaction and one or more Write Transactions.

One remote I2C Write Transaction in a Remote I2C Read/Write Request may be mapped into one or more actual I2C bus write transactions. One remote I2C Read Transaction in a Remote I2C Read Request may be mapped into one or more actual I2C bus read transactions. Whether a WFD Sink translates the Remote I2C Read/Write Requests into actual I2C bus transactions or not is implementation specific and is out of scope of WFD specification.

The I2C bus writes are required to set up the address for the I2C bus reads.

Figure 7-1 shows the case of a discrete WFD Sink dongle mapping the Remote I2C data structure into one or more I2C bus transactions.

If a WFD Sink indicates support of Remote I2C Read/Write function at a `wfd-I2C` parameter in an RTSP M3 response message, the WFD Sink shall support the reception of a Remote_I2C_Read_Request and a Remote_I2C_Write_Request message and the transmission of a Remote_I2C_Read_Reply_Ack, a Remote_I2C_Read_Reply_Nak, a Remote_I2C_Write_Ack and a Remote_I2C_Write_Nak messages. If a WFD Source indicates support of Remote I2C Read/Write function by including a `wfd-I2C` parameter in an RTSP M3 request message, the WFD Source shall support the transmission of a Remote_I2C_Read_Request and a Remote_I2C_Write_Request message and the reception of a Remote_I2C_Read_Reply_Ack, a Remote_I2C_Read_Reply_Nak, a Remote_I2C_Write_Ack and a Remote_I2C_Write_Nak messages.

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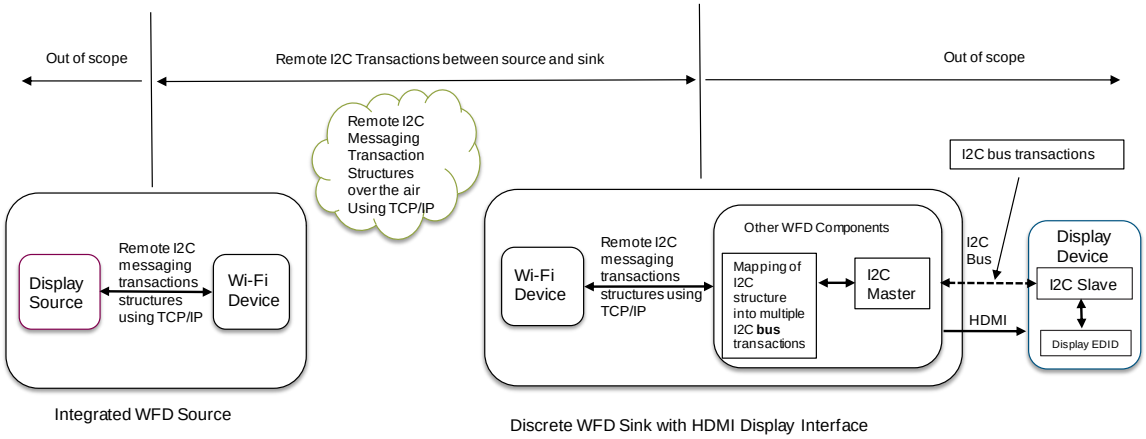

Figure 7-1 : Remote I2C Transaction Example

7.1 Remote_I2C_Read_Request

A WFD Source sends a Remote_I2C_Read_Request to a WFD Sink using the TCP port number assigned, to initiate I2C read(s) from remote display device(s).

The data structure of Remote_I2C_Read_Request is defined in Table 7-1.

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Field	Size (Octets)	Description
Request identifier	1	This field should be set to 0x00 to indicate Remote_I2C_Read_Request.
Number_Of_I2C_Write_Transactions	1	The total number of I2C write transactions to be sent in this message transaction.
For (i=0; i <Number_Of_I2C_Write_Transactions - 1; i++) {		
Write_I2C_Device_Identifier[i]	1	The I2C device identifier to receive the write request
Number_of_Bytes_To_Write[i]	1	The number of data bytes to write to the I2C device
for (j=0; j < Number_of_Bytes_To_Write; j++) I2C_Data_To_Write[i][j]	Number_of_Bytes_To_Write[i]	The I2C write data for the write device. Total number of bytes to write for each write transaction is equal to Number_of_Bytes_To_Write[i]
No_Stop_Bit[i]	1	When set to a 0x01, a stop bit is not sent at the end of the I2C transaction; otherwise when set to a 0x00, a stop will be generated at the end of the I2C transaction.
I2C_Transaction_Delay[i]	1	The amount of delay to insert between this and the next I2C transaction. The delay unit is 10ms. The delay range is 0 to 150 ms.
}		
Read_I2C_Device_Identifier	1	The I2C device identifier to receive the read request.
Number_Of_Bytes_To_Read	1	The number of data bytes requested to read from the I2C device.

Table 7-1 : Remote_I2C_Read_Request

7.2 Remote_I2C_Write_Request

The WFD Source sends a Remote_I2C_Write_Request to the WFD Sink using the TCP port number assigned, to initiate I2C write(s) to remote display device(s).

The data structure of Remote_I2C_Write_Request is defined in Table 7-2.

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Field	Size (Octets)	Description
Request Identifier	1	Field set to 0x01 to indicate Remote_I2C_Write_Request.
Write_I2C_Device_Identifier	1	The I2C device identifier to receive the write request.
Number_of_Bytes_To_Write	1	The number of data bytes to write to the I2C device.
For (j=0; j < Number_of_Bytes_To_Write; j++) I2C_Data_To_Write[j]	Number_of_Bytes_To_Write	The I2C write data for the write device Total number of bytes to write is equal to Number_of_Bytes_To_Write.

Table 7-2 : Remote_I2C_Write_Request

7.3 Remote_I2C_Read_Reply_Ack

The WFD Sink sends a Remote_I2C_Read_Reply_Ack to the WFD Source in response to a Remote_I2C_Read_Request using the TCP port number assigned, to indicate that successful I2C reads are performed and read data are presented.

The data structure of Remote_I2C_Read_Reply_Ack is defined in Table 7-3.

Field	Size (Octets)	Description
Reply Identifier	1	Field set to 0x00 to indicate Remote_I2C_Read_Reply_Ack.
Number_of_Bytes_To_Read	1	The number of data bytes read from the I2C device.
For (j=0; j < Number_of_Bytes_Read; j++) I2C_Device_Byte_Read[j]	Number_of_Bytes_To_Read	A data byte read from the I2C device

Table 7-3 : Remote_I2C_Read_Reply_Ack

7.4 Remote_I2C_Read_Reply_Nak

The WFD Sink sends a Remote_I2C_Read_Reply_Nak to the WFD Source in response to a Remote_I2C_Read_Request using the TCP port number assigned, to indicate I2C read failure.

The data structure of Remote_I2C_Read_Reply_Nak is defined in Table 7-4.

Field	Size (Octets)	Description
Reply Identifier	1	Field set to 0x80 to indicate Remote_I2C_Read_Reply_Nak.

Table 7-4 : Remote_I2C_Read_Reply_Nak

7.5 Remote_I2C_Write_Reply_Ack

The WFD Sink sends a Remote_I2C_Write_Reply_Ack to the WFD Source in response to a Remote_I2C_Write_Request using the TCP port number assigned, to indicate successful I2C Writes are performed.

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The Data structure of Remote_I2C_Write_Reply_Ack is defined in Table 7-5.

Field	Size (Octets)	Description
Reply Identifier	1	Field set to 0x01 to indicate Remote_I2C_Write_Reply_Ack.

Table 7-5 : Remote_I2C_Write_Reply_Ack

7.6 Remote_I2C_Write_Reply_Nak

The WFD Sink sends a Remote_I2C_Write_Reply_Nak to the WFD Source in response to a Remote_I2C_Write_Request using the TCP port number assigned, to indicate I2C Write failure.

The data structure of Remote_I2C_Write_Reply_Nak is defined in Table 7-6.

Field	Size (Octets)	Description
Reply Identifier	1	Field set to 0x81 to indicate Remote_I2C_Write_Reply_Nak.

Table 7-6 : Remote_I2C_Write_Reply_Nak

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8 Preferred Display Mode

8.1 Overview

Table 5-10, Table 5-11, Table 5-12 and Table 5-19 list all the pre-defined display modes that are supported by this Specification. During capability exchange (at an RTSP M3 response message), a Primary Sink indicates to a WFD Source the list of supported display modes among pre-defined display modes (as described in section 6.1.3 and 6.1.4) within this Specification. If a WFD Source wants to support a display mode that is not one of the pre-defined display modes of this Specification and if a Primary Sink supports the optional `wfd-preferred-display-mode` parameter data structure, the WFD Source may use the `wfd-preferred-display-mode` parameter (specified in section 6.1.14) to set that particular display mode.

In addition, the WFD Source may also use the `wfd-preferred-display-mode` parameter to set a display resolution that is supported by this Specification. Using this method, the WFD Source is able to control the display timing parameters of the display device (e.g. horizontal/vertical sink width, horizontal/vertical blank time, etc.). If a WFD Source uses a SET_PARAMETER method with a `wfd-video-formats` parameter (instead of a `wfd-preferred-display-mode` parameter) in an RTSP M4 request message to select a display resolution, the display timing parameters are determined by the WFD sink. In this case, the WFD source has no control over the display timing parameters.

A determined display mode with detail of parameters to be used, by exchanging `wfd-preferred-display-mode` parameter in RTSP, is called as Preferred Display mode herein, and the procedure to determine a Preferred Display mode is called as Preferred Display mode operation.

8.2 Preferred Display Mode Operation

If a WFD Source supports Preferred Display mode operation, the WFD Source shall check the `preferred-display-mode-supported` bit at an RTSP M3 response message to find out whether the Primary Sink supports Preferred Display mode operation or not.

If a WFD Source supports preferred display mode, the WFD Source shall support the `wfd-display-edid` parameter (defined in section 6.1.6) to transmit a query in an RTSP M3 request message and to parse data in an RTSP M3 response message. If a Primary Sink supports preferred display mode, the WFD Sink shall support the `wfd-display-edid` parameter to transmit an EDID data in an RTSP M3 response message.

Once it is confirmed that both the WFD Source and the Primary Sink support the Preferred Display mode operation, then the following information are used to make the decision as to whether a certain Preferred Display mode can be supported:

a. Capability of the display device.
   The capability of the display device is obtained by reading the EDID data of the display device. A WFD Source may use the `wfd-display-edid` parameter to obtain the display EDID data from a WFD Sink. Alternatively, a WFD Source may use the `wfd-I2C` parameter (defined in section 6.1.12) to obtain the display EDID data from a WFD Sink.
b. Capability of the decoder.
   The following data structures are required for the WFD Source to verify the decoder capability:
   `profile`, `level`, `max-hres`, `max-vres`.
   These data structures are sent from the Primary Sink to the WFD Source at the RTSP M3 response message (refer to section 6.1.3).
   The `max-hres` and `max-vres` data structures are required because the resolution of the Preferred Display mode to be used may be higher than the maximum resolution of the display mode in this Specification.

Based on the capability of the display device and the codec, it is possible to set a display mode that is not currently specified in this Specification. This can be done using the RTSP M4 (SET_PARAMETER) request message with the `wfd-preferred-display-mode` parameter.

Figure 8-1 shows the operation flow of a typical implementation of the Preferred Display mode operation.

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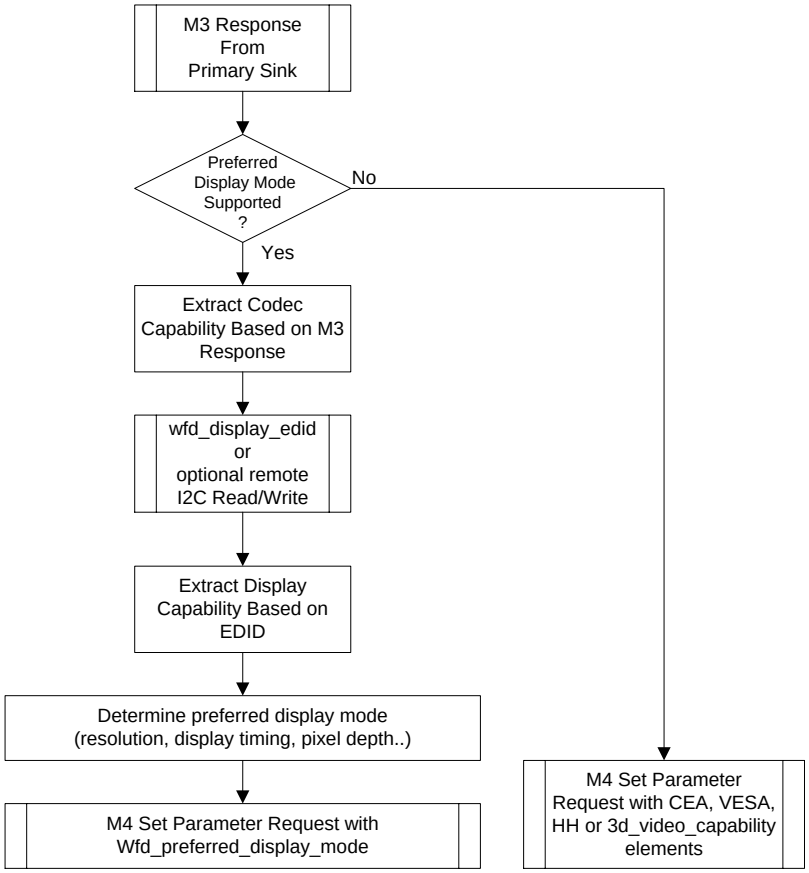

Figure 8-1 : Typical Operation Flow to determine the Preferred Display mode

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Annex-A. MPEG System Layer (informative)

This annex provides an overview of MPEG System Layer specified in ITU-T Rec. H.222.0 [2]. The following basic functions are provided therein:

- synchronization of multiple compressed streams on decoding
- interleaving of multiple compressed streams into a single stream
- initializing of buffering for decoder start up
- continuous buffer management
- time identification
- multiplexing and identification of various components in a system stream

MPEG2-TS multiplexing is used for transport over the RTP/UDP/IP layers for Wi-Fi Display.

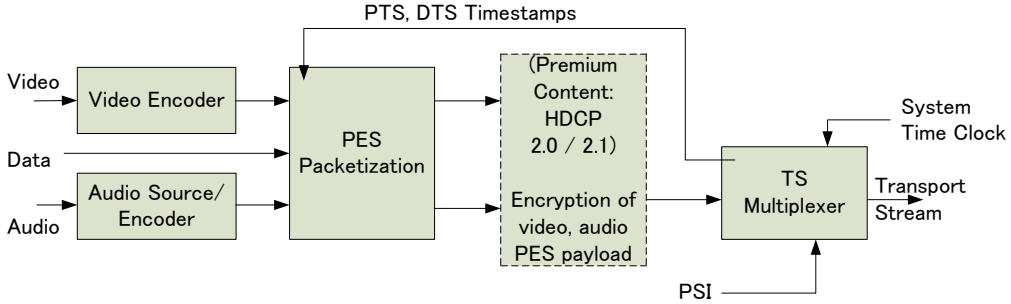

Figure A- 1 Overview of the H.222.0 Systems Layer – Transmission, Multiplexing and Synchronization

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Annex-B. MPEG-TS Parameters for Audio and Video Elementary Streams (normative)

This annex specifies MPEG2-TS parameters and encapsulation of MPEG2-TS into RTP packets.

The parameters necessary to be specified in order to include the different supported audio and video formats in the MPEG-TS bit stream are described in [2].

AV Format	*Stream_id* (PES header)	*Stream_type* (MPEG-TS PMT section)	Descriptor tag (if present) (MPEG-TS PMT section)	Usage Classifier, Reference
H.264 video	0xE0-0xEF	0x1B	0x28 [AVC descriptor]	Tables 2-22, 2-34, 2-45 of [2]
LPCM	0xBD	0x83	0x83 [LPCM audio stream descriptor]	Table 2-22 of [2], Table 4.6.3-1 of [5], Table 4.6.6.1-1 of [5]
Dolby AC-3	0xBD	0x81	0x81 [AC-3 audio descriptor]	Table 2-22 of [2], Table 4.6.3-1 of [5]
AAC	0xC0-0xDF	0x0F	0x2B [MPEG2 AAC audio descriptor]	Tables 2-22, 2-34, 2-45 of [2]

Table B- 1 MPEG-TS parameters for supported video formats

When using the audio formats listed in section 3.4.1, audio format, PES payload usage and H.222 parameter settings (e.g., stream_type signaled in Stream Program map section in Program Map Table within TS packets, and PES header setting such as stream_id, PTS, PES_extension_flag and so on) shall be compliant with the referred document indicated in the table, except with the following additional/modified rules.

- When referring to [5], ISO/IEC 13818-1 (The system part of the MPEG-2 standard) is replaced with [2] (ITU-R Rec. H.222)
- When referring to [5], section 4.6.1, 4.6.5-4.6.5.4.2, 4.6.6.2-4.6.6.4 and 4.6.6.6 are not referred.
- When referring to [5] for LPCM, following modifications are used.
  - Known errata in it are fixed as follows;
    - "1536 bytes" in Table 4.5.2.1-1 is replaced by "1920 bytes".
    - "0000 0100b" for number_of_frame_headers in Table 4.5.2.1-2 and in its explanation is replaced by "0000 0110b".
  - for 48ksps 16bits 2ch LPCM, the following parameters are used;
    - Number of audio sample data per one Access Unit : 80 samples as specified in [5].
    - One audio Access Unit length : 1/600 second as calculated from above.
    - Substream_id : 1010 0000b.
  - for 44.1ksps 16bits 2ch LPCM, the following parameters are used;
    - Number of audio sample data per one Access Unit : 80 samples as specified in [5].
    - One audio Access Unit length : 4/2205 second as calculated from above.
    - Substream_id : 1010 0000b.
  - PES structure and field values are specified in Table B-2 to allow the HDCP system 2.x operation. When the HDCP 2.x encryption is not used, this table is identical to Table 4.5.2.1-2 in [5].
- LPCM audio samples are in network byte order (big-endian) using two's complement integers, as specified in [5]. The order of output of bytes is in network byte order. As a result, the order of the bits in one mono-audio sample is from MSB to LSB, i.e., b15b14b13....b2b1b0.

	Field	Number of bits	Number of bytes	Value
PES Header	packet_start_code_prefix	24	3	0x00 00 01
	stream_id	8	1	0b10111101 [private stream1]

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		PES_packet_length	16	2	0x07 8E : if HDCP 2.x is not used 0x07 9F : if HDCP 2.x is used
		'10'	2	1	0b10
		PES_scrambling_control	2		0b00 [not scrambled]
		PES_priority	1		0b0 [no priority]
		data_alignment_indicator	1		0b0 [not defined]
		copyright	1		0b0 [not defined]
		original_or_copy	1		0b1 [original] or 0b0 [copy]
		PTS_DTS_flag	2	1	10b [present]
		ESCR_flag	1		0b0 [not present]
		ES_rate_flag	1		0b0 [not present]
		DSM_trick_mode_flag	1		0b0 [not present]
		additional_copy_info_flag	1		0b0 [not present]
		PES_CRC_flag	1		0b0 [not present]
		PES_extension_flag	1		0b0 : if HDCP 2.x is not used 0b1 : if HDCP 2.x is used
		PES_header_data_length	8	1	0x07 : if HDCP 2.x is not used 0x18 : if HDCP 2.x is used
		'0010'	4	5	0b0010
		PTS[32…30]	3		shall be set to correct value
		marker_bit	1		0b1
		PTS[29…15]	15		shall be set to correct value
		marker_bit	1		0b1
		PTS[14…0]	15		shall be set to correct value
		marker_bit	1		0b1
		PES_private_data_flag	1	1	0b1 [present] (note-1)
		pack_header_field_flag	1		0b0 [not present] (note-1)
		program_packet_sequence_counter_flag	1		0b0 [not present] (note-1)
		P-STD_buffer_flag	1		0b0 [not present] (note-1)
		Reserved	3		0b111 (note-1)
		PES_extension_flag_2	1		0b0 [not present] (note-1)
		PES_private_data	128	16	HDCP 2.x counter values and marker_bit. See [21]. (note-1)
		stuffing bytes	16	2	0xFF FF
PES Payload	Private	sub_stream_id	8	1	0b10100000 [0th sub stream]
		number_of_frame_header	8	1	0b00000110 [6 AUs]

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		reserved	7	1	0b0000000
		audio_emphasis_flag	1		See Table 4.5.2.1-3 of [5]
		quantization_word_length	2	1	See Table 4.5.2.1-4 of [5]
		audio_sampling_frequency	3		See Table 4.5.2.1-5 of [5]
		number_of_audio_channel	3		See Table 4.5.2.1-6 of [5]
	data	Audio Data (LPCM)	15360	1920	

(note-1) These fields will appear only when PES_extension_flag=1 when using the HDCP 2.x encryption.

Table B-2 : PES structure and field values for 48ksps/44.1ksps 16bits 2-ch LPCM

- When referring to [5] for Dolby AC-3, the following modifications are used.
  - Reference to "DVD-Video specification ([R1])" in [5] is not to be referred.
  - "Max. 2-ch/Dolby AC-3" for "Number of channels" at Table 4.5.1-1 in [5] is replaced by "Max. 6-ch/Dolby AC-3".
  - "between 64k and 448 kbps" for "Bit rate" at Table 4.5.3-1 in [5] is replaced by "between 64k and 640 kbps".
  - As Table 4.6.3-1 in [5] specifies that stream_type=0x81, AC-3 here uses System-A defined in reference [R11] within [5].
  - PES structure and field values are specified in Table B-3 as below. This is consistent with the description in [5].

	Field	Number of bits	Number of bytes	Value
PES Header	packet_start_code_prefix	24	3	0x00 00 01
	stream_id	8	1	0b10111101 [private stream1]
	PES_packet_length	16	2	variable
	'10'	2	1	0b10
	PES_scrambling_control	2		0b00 [not scrambled]
	PES_priority	1		0b0 [no priority]
	data_alignment_indicator	1		0b0 [not defined]
	copyright	1		0b0 [not defined]
	original_or_copy	1		0b1 (original) or 0b0 (copy)
	PTS_DTS_flag	2	1	10b [present]
	ESCR_flag	1		0b0 [not present]
	ES_rate_flag	1		0b0 [not present]
	DSM_trick_mode_flag	1		0b0 [not present]
	additional_copy_info_flag	1		0b0 [not present]
	PES_CRC_flag	1		0b0 [not present]
	PES_extension_flag	1		0b0 : if HDCP 2.x is not used 0b1 : if HDCP 2.x is used
	PES_header_data_length	8	1	0x07 : if HDCP 2.x is not used 0x18 : if HDCP 2.x is used

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	'0010'	4	5	0b0010
	PTS[32…30]	3		shall be set to correct value
	marker_bit	1		0b1
	PTS[29…15]	15		shall be set to correct value
	marker_bit	1		0b1
	PTS[14…0]	15		shall be set to correct value
	marker_bit	1		0b1
	PES_private_data_flag	1	1	0b1 [present] (note-1)
	pack_header_field_flag	1		0b0 [not present] (note-1)
	program_packet_sequence _counter_flag	1		0b0 [not present] (note-1)
	P-STD_buffer_flag	1		0b0 [not present] (note-1)
	Reserved	3		0b111 (note-1)
	PES_extension_flag_2	1		0b0 [not present] (note-1)
	PES_private_data	128	16	HDCP 2.x counter values and marker_bit. See [21]. (note-1)
	stuffing bytes	16	2	0xFF FF
PES Payload	Audio Data (Dolby AC-3)	variable	variable	1 byte or more, and 2560 bytes or less

(note-1) These fields will appear only when PES_extension_flag=1 when using the HDCP 2.x encryption.

Table B-3 : PES structure and field values for Dolby AC-3

- When referring to [5] for AAC-LC, following modifications are used.
  - Reference to "DVD-Video specification ([R1])" in [5] is to not to be referred.
  - "04_{16} | MPEG2 audio (ISO/IEC 13818-3)" at Table 4.6.3-1 in [5] is replaced by "$0F_{16}$ | MPEG2 audio (ISO/IEC 13818-7)".
  - Description in section 4.5.5 is read as "For MPEG2 audio the audio stream shall comply with ISO/IEC 13818-7".
  - At the Wi-Fi Display Technical Specification, only base stream is used and extension stream is not used, and description related to extension stream in [5] is to be neglected.
  - PES structure and field values are specified in Table B-4 as below. This is consistent with the description in [5].

	Field	Number of bits	Number of bytes	Value
PES Header	packet_start_code_prefix	24	3	0x00 00 01
	stream_id	8	1	0b11000000 to 0b11011111 [MPEG2 AAC]
	PES_packet_length	16	2	variable
	'10'	2	1	0b10

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	PES_scrambling_control	2		0b00 [not scrambled]
	PES_priority	1		0b0
	data_alignment_indicator	1		0b0
	copyright	1		0b0
	original_or_copy	1		0b1 (original) or 0b0 (copy)
	PTS_DTS_flag	2		10b
	ESCR_flag	1		0b0
	ES_rate_flag	1		0b0
	DSM_trick_mode_flag	1	1	0b0
	additional_copy_info_flag	1		0b0
	PES_CRC_flag	1		0b0
	PES_extension_flag	1		0b0 : HDCP 2.x is not used 0b1 : HDCP 2.x is used
	PES_header_data_length	8	1	0x07 : HDCP 2.x is not used 0x18 : HDCP 2.x is used
	'0010'	4		0b0010
	PTS[32…30]	3		shall be set to correct value
	marker_bit	1		0b1
	PTS[29…15]	15	5	shall be set to correct value
	marker_bit	1		0b1
	PTS[14…0]	15		shall be set to correct value
	marker_bit	1		0b1
	PES_private_data_flag	1		0b1 (note-1)
	pack_header_field_flag	1		0b0 (note-1)
	program_packet_sequence _counter_flag	1	1	0b0 (note-1)
	P-STD_buffer_flag	1		0b0 (note-1)
	Reserved	3		0b111 (note-1)
	PES_extension_flag_2	1		0b0 (note-1)
	PES_private_data	128	16	HDCP 2.x counter values and marker_bit. See [21]. (note-1)
	stuffing bytes	16	2	0xFF FF
PES Payload	Audio Data (AAC-LC)	variable	variable	1 byte or more, and 2020 bytes or less

(note-1) These fields will appear only when PES_extension_flag=1 when using the HDCP 2.x encryption.

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Table B-4 : PES structure and field values for AAC-LC

- When referring to [2] for AAC-LC, following modification are used.
  - MPEG-2_AAC_channel_configuration can have value 7 also, i.e., not limited from 1 to 6, to indicate 8ch (7.1ch) as specified in [20].
  - When using AAC-LC for 2ch to 7.1ch, stream shall use 1 ADTS.

A WFD Source shall generate only audio and video formats (and associated MPEG2-TS metadata parameters above) that the WFD Sink has already been discovered to support during the discovery phase.

In turn, a WFD Sink shall decode audio and video formats as indicated by MPEG2-TS metadata parameters above. If the WFD Source changes audio or video formats in the middle of an streaming and this format changes are indicated by transmitted MPEG2-TS metadata parameters, the WFD Sink should continue processing audio and video elementary streams as indicated formats".

B.1 Encapsulation of MPEG2-TS into RTP Packets

A WFD Source shall encapsulate the MPEG2-TS frames in RTP packets following the guidelines on the encapsulation of MPEG systems multiplex streams over RTP [3], [4], and [6]. In particular, MPEG2-TS streams shall be encapsulated in RTP packets as in Section 2 of RFC 2250 [4]. The RTP packet length shall be chosen such that the length of the RTP packet plus the length of the UDP and IP headers is less than or equal to the MTU size. As shown in Figures B-1 and B-2, the RTP payload carries an integral number of MPEG2-TS packets, computed by dividing RTP payload length by the length of an MPEG2-TS packet and rounding the result down. A maximum of 7 MPEG2-TS frames shall be encapsulated in a single RTP packet.

Each RTP packet shall contain a timestamp derived from the sender's 90 kHz clock reference synchronized to the system stream PCR (MPEG2-TS), and represents the target transmission time of the first byte of the packet payload. This RTP timestamp is not passed to the decoder, and is solely used to estimate and reduce network induced jitter and synchronize relative time drift between RTP transmitter and receiver.

When the HDCP 2.x encryption is applied, refer to section 3.6.2 of ref [21] for HDCP 2.0, ref [30] for HDCP 2.1 and ref [38] for HDCP 2.2 to carry an encrypted PES packet in TS packets. For higher version than HDCP 2.2, refer to corresponding specification released by DCP LLC.

Item	Parameter	Usage Classifier, Reference
RTP header PT field	'33'	from [4], [6] for MPEG2-TS
Marker bit (M)	'1' whenever timestamp is discontinuous	from [4]
RTP Timestamp	32-bit timestamp derived from a 90 kHz clock, representing the target transmission time for the first byte of the packet. This clock is synchronized to the system stream PCR (TS) or the SCR (PS), and represents the target transmission time of the first byte of the packet payload.	from [4]

Table B- 5 : RTP encapsulation of MPEG-TS

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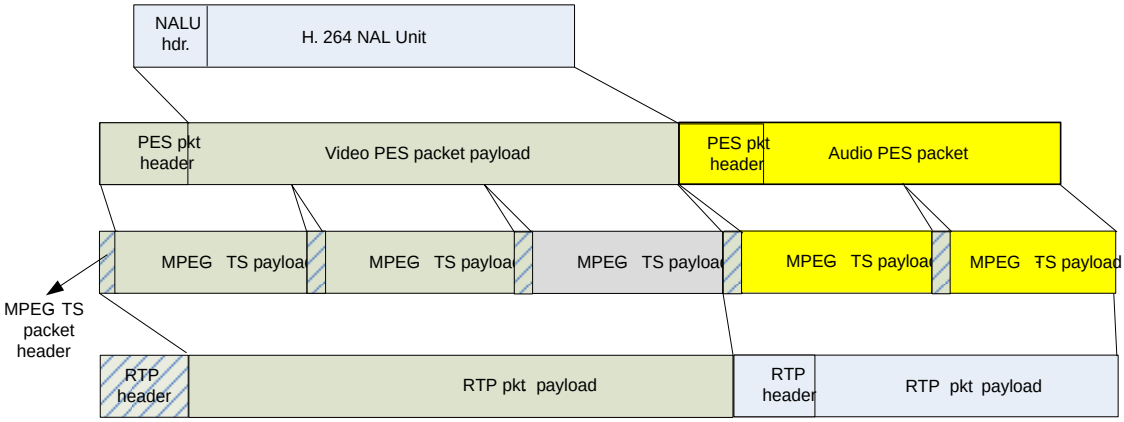

Figure B- 1 : Example of Recommended Encapsulation of MPEG2-TS Packets

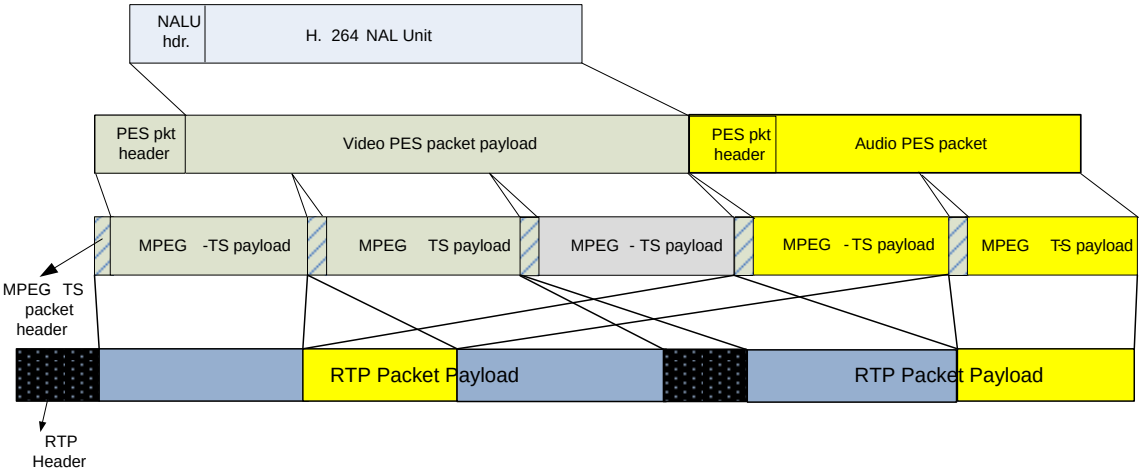

Figure B- 2 : Example of Recommended Encapsulation of MPEG2_TS Packets

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Annex-C. Recommendations for Satisfying the HDCP 2.x Locality Check (informative)

This annex provides a recommended parameter setting at the TCP/IP layer for Locality Check of the HDCP system 2.x (if applicable).

The HDCP system 2.x requires successful completion of Locality Check prior to initiating the Session Key Exchange phase. The Locality Check requires that the round trip time shall be within 7 milliseconds for a WFD Source to transmit a TCP packet containing a 64 bit pseudo random nonce (LC_Init message) to the WFD Sink and to receive a HMAC-SHA256 digest as a corresponding response from the WFD Sink.

The Locality Check is described in Cl.2.3 of [21] and clarified in the second item of the Errata [22] for HDCP system 2.0, it is described in Cl2.3 of [30] for HDCP system 2.1, and it is described in Cl2.3 of [38] for HDCP system 2.2. For higher version than HDCP 2.2, refer to corresponding specification released by DCP LLC. . This section describes a set of recommended optimizations in order to expedite the transit of LC_Init and LC_Send_L_Prime messages between the WFD Source and WFD Sink.

Some of the optimizations are possible in specific implementations of the TCP stack.

A WFD Device should provide expedited processing of the HDCP locality check data [21] for HDCP system 2.0 or [30] for the HDCP system 2.1 or [38] for HDCP system 2.2 at the TCP, IP and MAC layers (for higher version than HDCP 2.2, refer to corresponding specification released by DCP LLC). When the WFD Source transmits the LC_Init message or the WFD Sink transmits the LC_Send_L_prime message without using pre-compute option:

(a) at the TCP layer, the URG and PSH flags should be set to “1”,
(b) at the IP layer, the TOS field of the IP header should be configured to provide expedited forwarding, low delay and low drop probability,
(c) at the MAC layer, WMM access category should be set to AC_VI.
(d) at the PHY/MAC layer, reduced MCS should be used to reduce transmission errors and to provide highest reliability to the locality check data.

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Annex-D. H.264 and H.222 Usage Detail (normative)

This annex specifies rules for H.264 and H.222 usage at this Specification. Restricting rules as specified in this annex shall be applied to H.264 and H.222 specifications.

D.1 Slice Usage

Except as specified in the following section D.1.1, a slice shall be a picture in this Specification.

D.1.1 Multiple Slices in a Picture

If the `min-slice-size` field in the `wfd-video-formats` parameter or the `wfd-3d-formats` parameter transmitted by the targeted WFD Sink has non-zero value, WFD Source may transmit a picture that is constructed by multiple slices. In this case, each slice in a picture shall include the equal number of macroblocks.

The minimum number of macroblocks in a slice shall be greater than or equal to the number of macroblocks indicated in the `min-slice-size` field of the `wfd-video-formats` parameter, the `wfd-3d-formats` or the `wfd-preferred-display-mode` parameter from the WFD Sink.

The maximum number of slices per a picture shall not exceed the limit as specified in [1].

In the Max SliceNum bits (B9:B0) transmitted using an RTSP M4 (RSTP SET_PARAMETER) request message, the WFD Source shall not set a value exceeding the value of Max SliceNum bits (B9:B0) that is informed by the WFD Sink to the WFD Source. In the Max SliceNum bits (B9:B0) transmitted using an RTSP M4 (RSTP SET_PARAMETER) request message, the WFD Source may set a value independent on the value of Max Slice Size Ratio bits (B12:B10) that is informed by the WFD Sink to the WFD Source.

In the Max Slice Size Ratio bits (B12:B10) transmitted using an RTSP M4 (RTSP SET_PARAMETER) request message, the WFD Source shall not set a value exceeding the value of Max Slice Size Ratio bits (B12:B10) that is informed by the WFD Sink to the WFD Source. In the Max Slice Size Ratio bits (B12:B10) transmitted using an RTSP M4 (RTSP SET_PARAMETER) request message, the WFD Source may set a value independent on the value of Max SliceNum bits (B9:B0) that is informed by the WFD Sink to the WFD Source.

If a WFD Source tries to change the video resolution using an RTSP M4 (SET_PARAMETER) request message, the WFD Source should not change the values in Slice encoding parameters from the previously determined values, as far as the new values in Slice encoding parameters are not conflict with the other rules in this Specification.

If a WFD Source transmits video elementary stream where one picture is constructed by multiple slices;

- A picture is constructed by I-slice(s) and/or P-slices(s)
- I-slice includes intra-macroblock only
- P-slice includes inter-macroblock and may include intra-macroblock(s)

A WFD Source should determine averaged encoded video data rate not to exceed the value indicated in the WFD Device Maximum throughput field at WFD Device Information subelement transmitted by the targeted WFD Sink, with taking into account an expected end-to-end latency. As a result, the WFD Sink can buffer/decode the encoded video data at reasonable latency.

D.2 Frame Packing Arrangement SEI

When transmitting 3D video, the WFD Source shall include the Frame packing arrangement SEI within a SEI NAL unit at all first Access Units within a GOP.

If the transmitting 3D video uses frame sequential method (**`frame_packing_arrangement_type`** = 5), the WFD Source shall include the Frame packing arrangement SEI within a SEI NAL unit at all Access Units.

This SEI shall not be included in a video elementary stream that contains 2D video , except for the following case;

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When switching from 3D video to 2D video happens, this SEI shall exist at all Access Units with setting **frame_packing_arrangement_cancel_flag** to one, at least 2 seconds after switching from 3D to 2D. It implies that switching from 2D video to 3D video is disallowed at least 2 seconds after switching 3D video to 2D video. When the switching from 3D video to 2D video happens, the frame that starts carrying 2D video slice data and the frame that switches **frame_packing_arrangement_cancel_flag** value from zero to one in this SEI should be identical.

The syntax element values in this SEI are specified in Table D-1 and other values shall not be used.

Syntax elements	Values
frame_packing_arrangement_id	0 always
frame_packing_arrangement _cancel_flag	0 : frame packing arrangement information follows. When with transmitting 3D video data, it shall be always 0. 1 : cancel the persistence of any previous frame packing arrangement SEI message in output order from decoder. When with transmitting 2D video data and if this SEI exists, this element shall be set to 1.
frame_packing_srrangement _type	[This element exists only when **frame_packing_ arrangement_cancel_flag** = 0] 3 : Side-by-Side 4 : Top & Bottom[16] 5 : Frame Sequential
quincunx_sampling_flag	[This element exists only when **frame_packing_ arrangement_cancel_flag** = 0] 0 always (quincunx sampling is not used)
content_interpretation_type	[This element exists only when **frame_packing_ arrangement_cancel_flag** = 0] 1 always (left half of the frame (frame0) is for left view top half of the picture (frame0) is for left view odd picture (frame0) is for left view)
spatial_flipping_flag	[This element exists only when **frame_packing_ arrangement_cancel_flag** = 0] 0 always (no flipping shall be applied)
frame0_flipping_flag	[This element exists only when **frame_packing_ arrangement_cancel_flag** = 0] 0 always (no flipping shall be applied)
field_views_flag	[This element exists only when **frame_packing_ arrangement_cancel_flag** = 0] 0 always
current_frame_is_frame0_flag	[This element exists only when **frame_packing_ arrangement_cancel_flag** = 0]

[16] To distinguish Top and Bottom [half] and Frame Packing, video format confirmed during the Capability Negotiation and/or **pic_height_in_map_units_minus1** in SPS are used.

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	0 : if **frame_packing_srrangement_type** is 3 or 4, or right view if **frame_packing_srrangement_type** is 5. 1 : left view if **frame_packing_srrangement_type** is 5
frame0_self_contained_flag	[This element exists only when **frame_packing_arrangement_cancel_flag** = 0] 0 always (the samples of constituent frame 0 may or may not refer to samples of some constituent the frame 1.)
frame1_self_contained_flag	[This element exists only when **frame_packing_arrangement_cancel_flag** = 0] 0 always (the samples of constituent frame 1 may or may not refer to samples of some constituent frame 0.)
frame0_grid_position_x	[This element exists only when **frame_packing_arrangement_cancel_flag** = 0, and **frame_packing_srrangement_type** =is 3 or 4.] 0 always (horizontal location of the upper left sample of constituent frame 0)
frame0_grid_position_y	[This element exists only when **frame_packing_arrangement_cancel_flag** = 0, and **frame_packing_srrangement_type** =is 3 or 4.] 0 always (vertical location of the upper left sample of constituent frame 0)
frame1_grid_position_x	[This element exists only when **frame_packing_arrangement_cancel_flag** = 0, and **frame_packing_srrangement_type** =is 3 or 4.] 0 always (horizontal location of the upper left sample of constituent frame 1.)
frame1_grid_position_y	[This element exists only when **frame_packing_arrangement_cancel_flag** = 0, and **frame_packing_srrangement_type** =is 3 or 4.] 0 always (vertical location of the upper left sample of constituent frame 1.)
frame_packing_arrangement_reserved_byte	0 : reserved
frame_packing_arrangement_repetition_period	0 : this SEI message shall be applied to the current decoded frame only. In the case of **frame_packing_srrangement_type** = 5, this value shall be always zero. 1: message persists. See ref [1]
frame_packing_arrangement_extension_flag	0 : reserved

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Table D- 1 Frame packing arrangement SEI syntax element and values at Wi-Fi Display

D.3 SEI and VUI

A WFD Source may include SEIs and VUI that are defined in [1] into Access Unit.

A Primary Sink shall decode video streams with discarding SEIs or VUI that are not supported.

In the case of 3D video, the Frame packing arrangement SEI is used as described in Annex D.2 and the Stereo video information SEI shall not be used.

D.4 H.222 usage

D.4.1 PTS/DTS for video stream

A WFD Source shall not use AVC 24-hour picture, during a WFD Session.

A WFD Source shall use exactly one PES payload to carry one video Access Unit, during a WFD Session.

As a result, a WFD Sink can derive PTS and DTS (if applicable) information from the PES header for each AU.

D.4.2 PAT/PMT

During a WFD Session and if a WFD Source is not in WFD Standby mode, the WFD Source shall transmit PAT/PMT repeatedly with a maximum time interval of 100 msec between repetition.

The following PID values shall be used for Wi-Fi Display:

- program_map_PID in PAT to indicate PID for PMT : 0x01 00
- PCR_PID in PMT to indicate PID for PCR : 0x10 00
- elementary_PID in PMT to indicate PID for video stream : 0x10 11
- elementary_PID in PMT to indicate PID for audio stream : 0x11 00 to 0x11 1F
  - If the transport stream contains one or more audio streams, the PID values of the audio streams shall be numbered consecutively, starting from 0x11 00.

D.4.3 Program and program element descriptors in PMT

D.4.3.1 AVC timing and HRD descriptor

The AVC timing and HRD descriptor provides timing and HRD parameters of the associated AVC video stream. The descriptor_tag for the AVC timing and HRD descriptor is “42” (0x2A) as specified in section 2.6.1 of [2].

A WFD Source shall include the AVC timing and HRD descriptor in PMT when transmitting video stream to the Primary Sink, independent on the inclusion of VUI in SPS.

If a WFD Source sets the HRD_management_valid_flag, it shall set the “initial_cpb_removal_delay” and “cpb_removal_delay” in Buffer period SEI and Picture Timing SEI respectively, as specified in section 2.6.67 of [2].

The WFD Sink may use the information in “initial_cpb_removal_delay” and “cpb_removal_delay” for encoded video removal.

D.4.3.2 other descriptors

Settings of the AVC video descriptor, the AC-3 Audio descriptor and the AAC audio descriptor are described in Table B-1.

If a WFD Source includes a video elementary stream in MPEG2-TS, the WFD Source should include descriptors listed below in the PMT. All of these descriptors are intended to be used together. So, if one of these three descriptors is present, it is recommended that other two descriptors are also present.

- video stream descriptor

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This descriptor is defined in section 2.6.2 and 2.6.3 of [2] and its descriptor_tag is “2” (0x02) as specified in section 2.6.1 of [2]. To allow early display initialization, the values in this descriptor should always match negotiated frame rate indicated in a `wfd-video-formats` parameter as defined in section 6.1.3 (or a `wfd-3d-formats` parameter as defined in section 6.1.4, or a `wfd-preferred-display-mode` parameter as defined in section 6.1.14).

multiple_frame_rate_flag: This 1-bit field is set to '1' to indicate that multiple frame rates may be present in the video stream. This 1-bit field is set to '0' to indicate that only a single frame rate is present.

frame_rate_code: This is a 4-bit field as defined in section 6.3.3 of [34], except that when the multiple_frame_rate_flag is set to a value of '1' the indication of a particular frame rate also permits certain other frame rates to be present in the video stream, as specified in Table 2-47 in [2]. In referred table, the frame_rate_code defines possible frame rates for each frame_rate_code.

MPEG_1_only_flag: A WFD Sink shall ignore the value of this flag.

constrained_parameter_flag: A WFD Sink shall ignore the value of this flag.

still_picture_flag: A WFD Sink shall ignore the value of this flag.

profile_and_level_indication: A WFD Sink shall ignore the value of this flag.

- target background grid descriptor

  This descriptor is defined in section 2.6.12 and 2.6.13 of [2] and its descriptor_tag is “7” (0x07) as specified in section 2.6.1 of [2]. Inclusion of this descriptor allows early display initialization. This descriptor is for the "virtual screen" and the offset where the image should be placed (used for PiP or letterboxing). Basically where to decode the video window in terms of the screen (refer to Figure 2-3 in [2]).

  Note: Usually the offset is zero because the virtual screen is as big as the picture itself

  horizontal_size: The horizontal size of the target background grid in pixels.

  vertical_size: The vertical size of the target background grid in pixels.

  aspect_ratio_information: Specifies the sample aspect ratio or display aspect ratio of the target background grid.

- video window descriptor

  This descriptor is defined in section 2.6.14 and 2.6.15 of [2] and its descriptor_tag is “8” (0x08) as specified in section 2.6.1 of [2]. Inclusion of this descriptor allows early H.264 decoder initialization. The video window descriptor is used to describe the window characteristics of the associated video elementary stream. Values in this descriptor reference the target background grid descriptor for the same stream. Refer to Figure 2-3 in [1] for the horizontal_offset and vertical_offset fields. These fields allow for determining the width x height of the H.264 layer defined in PPS.

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Annex-E. RTSP message examples (informative)

This annex gives examples of RTSP messages.

E.1 From RTSP M1 to M7 without errors

This section gives example of RTSP messages from M1 to M7 without errors and M16 message exchange, between the WFD Source and the Primary Sink. Please note that there is no Secondary Sink in this example.

Also, this is an example for multiplexed video and audio streaming.

<example>

1. `i`: Initial value of CSeq from a WFD Source to a WFD Sink
2. `j`: Initial value of CSeq from a WFD Sink to a WFD Source (`j` may or may not be equal to `i`)
3. Bold letter in an RTSP M3 request message indicates the mandatory parameter in this message.
4. "`Date`" line in the header is optional
5. In this example, time-out value of keep-alive function is set to 30 seconds at an RTSP M6 response.

Message ID	req/res (direction)	RTSP message

M1	request (src →snk)	`OPTIONS * RTSP/1.0`
		`CSeq: i`
		`Require: org.wfa.wfd1.0`

	response (snk→src)	`RTSP/1.0 200 OK`
		`CSeq: i`
		`Date: Sun, Aug 21 2011 04:20:53 GMT`
		`Public: org.wfa.wfd1.0, GET_PARAMETER, SET_PARAMETER`

M2	request (snk →src)	`OPTIONS * RTSP/1.0`
		`CSeq: j`
		`Require: org.wfa.wfd1.0`

	response (src→snk)	`RTSP/1.0 200 OK`
		`CSeq: j`
		`Date: Sun, Aug 21 2011 04:20:53 GMT`
		`Public: org.wfa.wfd1.0, SETUP, TEARDOWN, PLAY, PAUSE,`
		`GET_PARAMETER, SET_PARAMETER`

M3	request (src →snk)	`GET_PARAMETER rtsp://localhost/wfd1.0 RTSP/1.0`
		`CSeq: i+1`
		`Content-Type: text/parameters`
		`Content-Length: 141`
		
		`wfd_video_formats`
		`wfd_audio_codecs`
		`wfd_3d_video_formats`
		`wfd_content_protection`
		`wfd_display_edid`
		`wfd_coupled_sink`
		`wfd_client_rtp_ports`

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	response (snk→src)	RTSP/1.0 200 OK CSeq: i+1 Content-Length: 290 Content-Type: text/parameters wfd_video_formats: 00 00 01 01 00000001 00000000 00000000 00 0000 0000 00 none none wfd_audio_codecs: LPCM 00000003 00 wfd_3d_video_formats: none wfd_content_protection: none wfd_display_edid: none wfd_coupled_sink: none wfd_client_rtp_ports: RTP/AVP/UDP;unicast 1028 0 mode=play
M4	request (src →snk)	SET_PARAMETER rtsp://localhost/wfd1.0 RTSP/1.0 CSeq: i+2 Content-Type: text/parameters Content-Length: 302 wfd_video_formats: 00 00 01 01 00000001 00000000 00000000 00 0000 0000 00 none none wfd_audio_codecs: LPCM 00000002 00 wfd_presentation_URL: rtsp://10.82.24.140/wfd1.0/streamid=0 none wfd_client_rtp_ports: RTP/AVP/UDP;unicast 1028 0 mode=play
	response (snk→src)	RTSP/1.0 200 OK CSeq: i+2
M5	request (src →snk)	SET_PARAMETER rtsp://localhost/wfd1.0 RTSP/1.0 CSeq: i+3 Content-Type: text/parameters Content-Length: 27 wfd_trigger_method: SETUP
	response (snk→src)	RTSP/1.0 200 OK CSeq: i+3
M6	request (snk →src)	SETUP rtsp://10.82.24.140/wfd1.0/streamid=0 RTSP/1.0 CSeq: j+1 Transport: RTP/AVP/UDP;unicast;client_port=1028
	response (src→snk)	RTSP/1.0 200 OK CSeq: j+1 Session: 6B8B4567;timeout=30 Transport: RTP/AVP/UDP;unicast;client_port=1028;server_port=5000
M7	request (snk →src)	PLAY rtsp://10.82.24.140/wfd1.0/streamid=0 RTSP/1.0 CSeq: j+2 Session: 6B8B4567
	response	RTSP/1.0 200 OK

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	(src→snk)	Date: Sun, Aug 21 2011 04:20:53 GMT CSeq: j+2
(there may be other message exchanges)		
M16	request (src →snk)	GET_PARAMETER rtsp://localhost/wfd1.0 RTSP/1.0 CSeq: i+4 Session: 6B8B4567
	response (snk→src)	RTSP/1.0 200 OK Cseq: i+4

Table E-1 : RTSP message example-1

Note that session ID line is not mandatory in the header of RTSP request messages transmitted by the RTSP server (in this case, WFD Source). The example shown above for an RTSP M16 request massage includes session ID line but it is optional.

E.2 RTSP M4 with error case

This section gives an example of RTSP M4 message error case when two parameters (in this case, unsupported audio format and unsupported level for video are requested to set).

The WFD Sink responds in an RTSP M3 response message indicating only formats and settings that it can accept in following RTSP M4 message exchange at that time, as specified in section 6.4.3. While another RTSP M4 attempt is acceptable according to section 6.4.3 that the RTSP M4 request message can be sent at any time, this should generally be treated as a non-recoverable failure to connect and followed up with a teardown trigger from the WFD Source, if the WFD Sink returns an RTSP M4 response message indicating an error even though the selected format and setting in the RTSP M4 request message has been chosen to be consistent with the RTSP M3 response message.

Message ID	req/res (direction)	RTSP message
M4	request (src →snk)	SET_PARAMETER rtsp://localhost/wfd1.0 RTSP/1.0 CSeq: i Content-Type: text/parameters Content-Length: 302 wfd_video_formats: 00 00 01 11 00000001 00000000 00000000 00 0000 0000 00 none none wfd_audio_codecs: LPCM 00000000 00 wfd_presentation_URL: rtsp://10.82.24.140/wfd1.0/streamid=0 none wfd_client_rtp_ports: RTP/AVP/UDP;unicast 1028 0 mode=play
	response (snk→src)	RTSP/1.0 303 See Other CSeq: i Content-Type: text/parameters Content-Length: 47 wfd_video_formats: 457 wfd_audio_codecs: 415

Table E-2 : RTSP message example-2

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Annex-F. HDCP 2.x Notation Mapping to WFD Device HDCP Implementation Revision

The following table provides necessary mapping of the HDCP2.x notation to the appropriate HDCP implementation revision number, allowing the correct specifications release version to be identified. Future releases of HDCP Specifications can be added to this table to facilitate access to relevant specifications.

WFD Device Implementation Revision	**HDCP System 2.x mapping**	**HDCP 2.x mapping**	**Specifications References**
V2.0	HDCP System 2.0	HDCP2.0	[21], [22]
V2.1	HDCP System 2.1	HDCP2.1	[30]
V2.2	HDCP System 2.2	HDCP 2.2	[38]
Future Revisions			

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