Wi-Fi CERTIFIED Miracast™
Technical Overview

July 2017

Introduction

The exponential growth in multimedia traffic, especially for streaming video and gaming, is accompanied by a fundamental shift in how, when and where users access content. Users expect to access multimedia content on a wide range of Wi-Fi® devices, such as smartphones, tablets, laptops, TVs, as well as auto infotainment systems. Whether in the home or in a mobile environment, users interact with multiple Wi-Fi devices, some of which store content locally and some of which are better suited for displaying content. For example, users may want to stream a high-definition (HD) movie from the internet to a tablet, and display it on a television in their living room.

The Wi-Fi CERTIFIED Miracast™ certification program was developed with the support of a wide ecosystem of silicon, mobile device, and consumer electronics vendors to make sharing of screens including HD graphical, video, and audio content across Wi-Fi devices seamless. With Miracast®, devices can identify and connect to each other, manage the connection, and optimize the transmission of content based on device capabilities and network conditions, even without a Wi-Fi network. Miracast-certified devices bring a user experience that rivals wired connections, with the added advantage of portability within the Wi-Fi coverage area at home, at work, and in mobile situations such as automobiles with infotainment system displays.

Miracast is a certification program for devices capable of supporting video, such as TVs, set-top boxes, cameras, projectors, smartphones, tablets, and laptops. After initially pairing two Miracast devices, users can choose to stream content or mirror a display from one device (the source) to a second device (the display). Miracast allows users to establish a direct Wi-Fi connection between two devices, eliminating the need for an existing network when content to be shared is locally stored on a source device.

To enjoy Miracast, both the display and the source devices must be Miracast-certified. Miracast may be used on devices without embedded Wi-Fi® through the use of a Miracast-certified adapter that supports an interface such as High-Definition Multimedia Interface (HDMI).
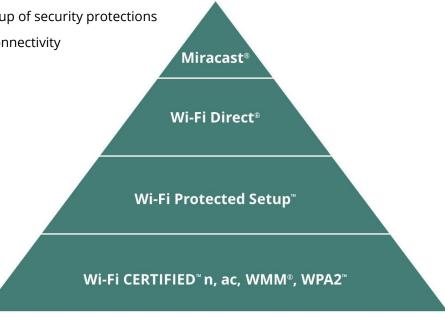
This paper gives a technical overview of the Miracast program. A list of devices certified for Miracast is available on the Wi-Fi Alliance® Product Finder (http://www.wi-fi.org/product-finder).

Miracast underlying technology requirements

Miracast utilizes Wi-Fi to give users the freedom to display content on the device of their choice, while retaining the ease of use, interoperability among vendors, and security that all Wi-Fi CERTIFIED™ products share. Miracast operates at 802.11n and 802.11ac data rates. The technology supports the most widely used codecs and video formats, including HD and 4K Ultra High-Definition (Ultra HD) video, to enable users to view the audio and video content they want on the devices they choose.

Miracast employs many of the building blocks that have enriched the user experience and increased their trust in Wi-Fi for years. To attain Miracast certification, devices must also be certified for the following:

- Core Wi-Fi functionality: Wi-Fi CERTIFIED ac or Wi-Fi CERTIFIED n
- Wi-Fi Multimedia™ (WMM®) – multimedia traffic management
- Wi-Fi Protected Setup™ – easy setup of security protections
- Wi-Fi Direct® – device-to-device connectivity
- WPA2™ security

Miracast®

Wi-Fi Direct®

Wi-Fi Protected Setup™

Wi-Fi CERTIFIED™ n, ac, WMM®, WPA2™

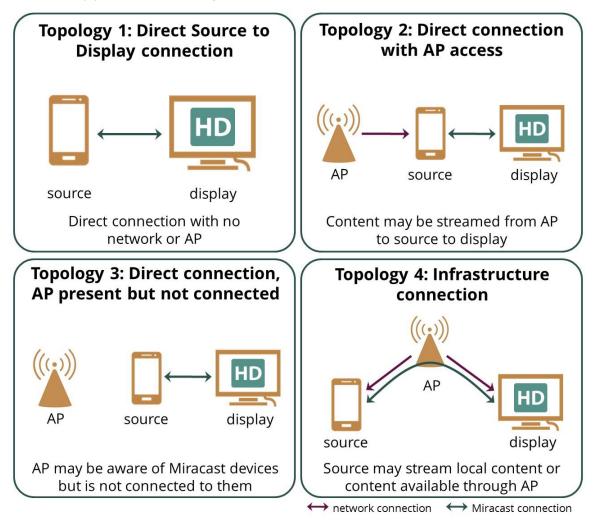## Connectivity overview

Miracast does not require a typical Wi-Fi infrastructure network, though many devices will take advantage of network connectivity to access content. Miracast connections may be peer-to-peer without requiring an access point (AP) acting as an intermediary, or negotiated through existing Wi-Fi network infrastructure.

When two devices connect with each other, one is the source (the transmitting device) and the other functions as a display (the device receiving and rendering the content to the user). While many devices can act as a source in some usage contexts and a display in others, their capabilities will largely determine their role. Devices that can generate, transcode, or store content, such as laptops, smartphones, and cameras, are more likely to be sources; devices such as digital TVs and projectors are more likely to be displays. Tablets may function as both sources and displays, depending on whether they are used to generate, transcode, or store content (source) or to present content (display) transmitted wirelessly by the source.

Peer-to-peer connection: A direct link between devices may be established through Wi-Fi Direct based on the Wi-Fi Peer-to-Peer (P2P) Specification. All Miracast devices are required to support Wi-Fi Direct. Optionally, P2P connectivity can be established through Tunneled Direct Link Setup (TDLS).

Infrastructure connection: A Miracast session may also occur through existing infrastructure (i.e. an AP) connection. Multicast Domain Name System/Domain Name System-Service Discovery (nDNS/DNS-SD) is utilized for discovery prior to establishing a Miracast session.

Operation and supported formats

A Miracast session starts with a request from the user either from the source or from the display device. The content must be present on the source device, and may be acquired through streaming, copying, or downloading the content, or generated by the source device itself, as in the case of screen mirroring, business applications, or gaming.

Once the content is available for transmission, the source device identifies available display devices and their respective capabilities, and asks the user to select which device should act as the display. At this point, the source device establishes a link with the chosen display device in preparation for transmission. Once the connection is established, the source device encodes the content, taking into account display device capabilities and channel conditions to optimize transmission over the Wi-Fi interface. Supported formats are

listed in Table 1. Finally, the display device receives the content, decodes it, and renders it. Miracast supports a wide range of audio and video formats wthout transcoding, extending the battery life in mobile devices.
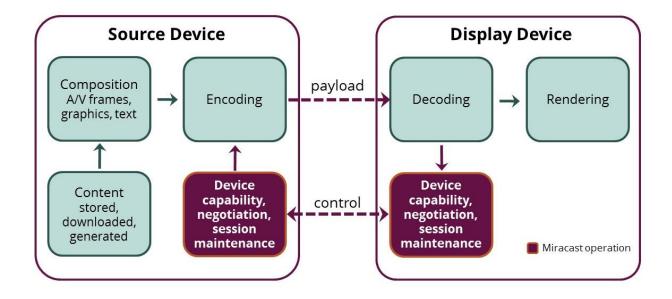

Table 1. Miracast-supported display, video and audio formats	
Display resolution	27 Consumer Electronics Association (CEA) formats, from 640 x 480 up to 4096 x 2160 pixels, and from 24 to 60 frames per second (fps)
	34 Video Electronics Standards Association (VESA) formats, from 800 x 600 up to 2560 x 1600 pixels, and from 30 to 60 fps
	12 handheld formats, from 640 x 360 up to 960 x 540 pixels, and from 30 to 60 fps
	Mandatory: 1280 x 720p30 (HD) Optional: 3840 x 2160p60 (4K Ultra HD)
Video	Mandatory: ITU-T H.264 (Advanced Video Coding [AVC]) for HD and Ultra HD video; supports several profiles in transcoding and non-transcoding modes, including Constrained Baseline Profile (CBP), at levels ranging from 3.1 to 5.2
	Optional: ITU-T H.265 (High Efficiency Video Coding [HEVC]) for HD and Ultra HD video; supports several profiles in transcoding and non-transcoding modes, including Main Profile, Main 444, SCC-8 bit 444, Main 444 10, at levels ranging from 3.1 to 5.1
Audio	Mandated audio codec: Linear Pulse-Code Modulation (LPCM) 16 bits, 48 kHz sampling, 2 channels
	Optional audio codecs, including: • LPCM mode 16 bits, 44.1 kHz sampling, 2 channels • Advanced Audio Coding (AAC) modes • Dolby Advanced Codec 3 (AC3) modes • E-AC-3 • Dolby TrueHD, Dolby MAT modes • AC-4

	• DTS-HD mode
	• MPEG-4 AAC and MPEG-H 3D Audio modes
	• AAC-ELDv2

All source devices are required to support video and video plus audio content. Display devices may support video only, or audio and video content.

Principal mechanisms

Miracast uses the Wi-Fi medium access control (MAC) and physical (PHY) layers as its foundation. It relies on the vendor-specific user interface (UI) to manage the user inputs and preferences. Further, vendor session policy management is relied upon to initiate device discovery and selection, authorize the link between the source and the display devices, store the user profile, and manage the traffic. Table 2 describes the session management stages in Miracast.

Table 2. Miracast session management	
Device discovery	Source and display devices discover each other prior to connection setup. The Device discovery mechanism is defined in the Wi-Fi Peer-to-Peer Specification or through existing AP connections as defined in the Wi-Fi Display Technical Specification 2.0. Device discovery over an existing infrastructure connection utilizes mDNS/DNS-SD.
Service discovery (optional)	Service discovery is only used for infrastructure connections and in conjunction with device discovery utilizing mDNS/DNS–SD.
Device selection	A remote device is selected for connection setup. User input and local policies may be used to decide which device is a display and which is a source.
Connection setup	Connection setup selects a method to manage the connections, either through P2P or network AP connection.
	Upon the establishment of connectivity between the source and display devices, the display initiates a Transmission Control Protocol (TCP) connection, with a control port using Real-Time Streaming Protocol (RTSP) to create and manage the sessions between source and display devices.
Capability negotiation	Source and display devices determine the parameters for the Miracast session.
Content protection setup (optional)	If the devices support content protection and are streaming content requiring protection, session keys for link content protection are derived using High-bandwidth Digital Content Protection (HDCP). HDCP session keys are established before the Real-Time Protocol (RTP) session is initiated. This feature is designed to protect the digital rights of content owners and to encourage their efforts to make their content available.
Session establishment and streaming	Upon completion of capability negotiation, the source and display devices set up the Miracast session prior to streaming content.
	The audio and video content available on the source device is packetized using Moving Picture Experts Group 2 Transport Stream (MPEG2-TS) coding and encapsulated by RTP User Datagram Protocol (UDP) and Internet Protocol (IP). Finally, IEEE 802.11 packetization enables the source device to send content to the display device. Switching from UDP to TCP is supported to provide dynamic network optimization.

User input back channel setup (optional)	A User Interface Back Channel (UIBC) for transmitting control and data information related to user interaction with the user interface is set up. User inputs at a display are packetized using a UIBC packet header and transported using Transmission Control Protocol/Internet Protocol (TCP/IP).
	Two user input categories are available, i.e., Human Interface Device Class (HIDC) and Generic input.
Payload control	When the payload transfer starts, devices may adapt transmission parameters on the basis of channel conditions and power consumption. Adaptation can be achieved by:
	▪ Compression ratio change and macroblock skipping (using the H.264 standard)
	▪ Frame skipping (if the display device supports this functionality, the source device may skip some of the frames to be transmitted according to the current resolution)
	▪ Format change
Display session teardown	Either the source or the display terminates the Miracast session.

Certification program testing summary

Miracast is an optional certification program, designed for equipment capable of supporting graphical, text, video, and audio content. Devices such as TVs, cameras, projectors, smartphones, tablets, and laptops are ideal candidates for Miracast certification.

Miracast may be added to existing devices that do not have embedded Wi-Fi. This can be done by using a Miracast-certified dongle that supports HDMI or other interfaces to connect a rendering device. In this scenario, the dongle manages the Miracast pairing and sessions, and it is treated by the device as if it were a cabled input source.

Device interoperability and functionality

Miracast retains the approach common to all Wi-Fi CERTIFIED programs, which ensures that Miracast-certified equipment retains backwards compatibility with previously certified equipment. As a result, Miracast display devices will work with newly purchased Miracast source devices, even if the source device supports additional Wi-Fi functionality that is not available in the display device, such as new PHY layer features, expansion to new spectrum bands, or new codecs.

Because Miracast implements advanced technology, only products which have been certified in the Wi-Fi Alliance certification program will support the functionality. Miracast operation requires both source and display to be certified.

Miracast certification applies to source and display devices. Miracast sessions over infrastructure do not require changes to existing APs.

Certification prerequisites

To be certified for Miracast, a device must also be Wi-Fi CERTIFIED for:

- Wi-Fi CERTIFIED ac or Wi-Fi CERTIFIED n: Leverages 2.4 and 5 GHz bands
- WPA2: Required in all Wi-Fi CERTIFIED devices, provides IEEE 802.1X controlled access, secure Extensible Authentication Protocol (EAP)-based authentication and connectivity through encryption of the over-the-air traffic

- Wi-Fi Direct: Enables direct, peer-to-peer connection of two Wi-Fi devices without network infrastructure
- WMM: Provides quality of service (QoS) functionality to enhance the user experience with real-time applications
- Wi-Fi Protected Setup: Provides for simple setup of security-enabled Wi-Fi networks
- Optional: TDLS support

Audio/Video (A/V) requirements

Miracast supports high-definition graphical and video content. To be considered for Miracast certification, devices are required to support the mandatory audio and video formats as defined in Table 1. Display devices without speakers may support video only.

Devices for Miracast certification will undergo tests for latency, audio/video (A/V) quality, and A/V synchronization offset.

Latency testing: End-to-end latency of the video stream from the source device to the display device should not exceed 250 milliseconds at the highest video resolution and frame rate. "End-to-end delay" is defined as the time it takes for a given video frame to appear on the screen of the display device, measured from the instant the same video frame is displayed on the source device screen.

Quality testing: A/V quality requires that video frame drop is less than 1.5 percent. Dropped video frames occur when frames arrive too late at the display device and miss the deadline by which they are to be rendered. Audio anomalies are caused when audio frames miss the playback deadline, forcing the display device to play different audio (or no audio) instead of the correct audio frame.

Synchronization offset testing: The audio stream should be no more than 45 milliseconds ahead of video and no more than 125 milliseconds behind the video. Incorrect source device time stamps to the audio and/or video frames may cause unacceptable lip synchronization.

About Wi-Fi Alliance®

www.wi-fi.org

Wi-Fi Alliance® is the worldwide network of companies that brings you Wi-Fi®. Members of our collaboration forum come together from across the Wi-Fi ecosystem with the shared vision to connect everyone and everything, everywhere, while providing the best possible user experience. Since 2000, Wi-Fi Alliance has certified more than 35,000 Wi-Fi products. The Wi-Fi CERTIFIED™ seal of approval designates products with proven interoperability, backward compatibility, and the highest industry-standard security protections in place. Today, Wi-Fi carries more than half of the internet's traffic in an ever-expanding variety of applications. Wi-Fi Alliance continues to drive the adoption and evolution of Wi-Fi, which billions of people rely on every day.

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