Wi-Fi CERTIFIED Miracast™: Extending the Wi-Fi experience to seamless video display

Wi-Fi Alliance
September 19, 2012

Executive summary

The stunning growth in multimedia traffic, especially for video and gaming, is accompanied by a fundamental shift in how, when and where users access content. Now more than ever, users have a wide range of Wi-Fi-capable devices, such as smartphones, tablets, laptops, TVs, and gaming consoles. 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 movie from the internet to a tablet, but display it on a television in their living room.

The Wi-Fi Alliance has launched a new certification program, Wi-Fi CERTIFIED Miracast™, developed with the support of a wide ecosystem of silicon, mobile device and consumer electronics (CE) vendors, to make sharing of screens including graphical, video and audio content across Wi-Fi devices seamless. After initially pairing two Wi-Fi 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.

Miracast builds upon 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 supports the most widely used codecs and video formats, to enable users to view the audio and video content they want on the devices they choose.

Miracast uses many of the building blocks that, over the years, have enriched the user experience and increased their trust in Wi-Fi, including Wi-Fi CERTIFIED n (improved throughput and coverage), Wi-Fi Direct™ (device-to-device connectivity), Wi-Fi Protected Access® 2 (WPA2™) (security), Wi-Fi Multimedia™ (WMM®) (traffic management) and Wi-Fi Protected Setup™. Some Miracast devices will also support Tunneled Direct Link Setup (TDLS), which allows them to connect via an infrastructure network. TDLS enables more efficient data transfer and the use of more advanced Wi-Fi capabilities than those supported by the legacy infrastructure network through which the devices are connected.

Miracast is an optional certification program for client devices capable of supporting video, such as TVs, over-the-top set-top boxes, cameras, projectors, smartphones, tablets, and laptops. To enjoy Miracast, both the display and the source devices must be certified for Miracast. 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) or Universal Serial Bus (USB).

The list of devices certified for Miracast is available in the online database of Wi-Fi CERTIFIED products on the Wi-Fi Alliance website (www.wi-fi.org).

Contents

Introduction: Wi-Fi in the connected home

The intersection of wireless connectivity and streamed audio/video content is one of the hottest growth areas in CE devices. In North America, real-time entertainment now dominates data traffic, both in the fixed (64.5%) and mobile (51.6%) domains (Figure 1)[1]. Other regions are also rapidly approaching the 50% mark for video content, and are expected to surpass it in the coming years. Video dominates real-time entertainment (in North America, Netflix alone accounts for 33% and YouTube 14% of fixed traffic; in mobile networks, YouTube captures 27% of traffic).

The growth in real-time video entertainment is coupled with a trend towards devices that are easy to carry, with smaller form factors that maximize the screen areas (e.g., tablets) and encourage interactivity and sharing among family members or friends. And users are no longer satisfied using one connected device. According to a survey by Juniper, mobile users have on average three Internet-connected devices and 18% of them own five or more[2].

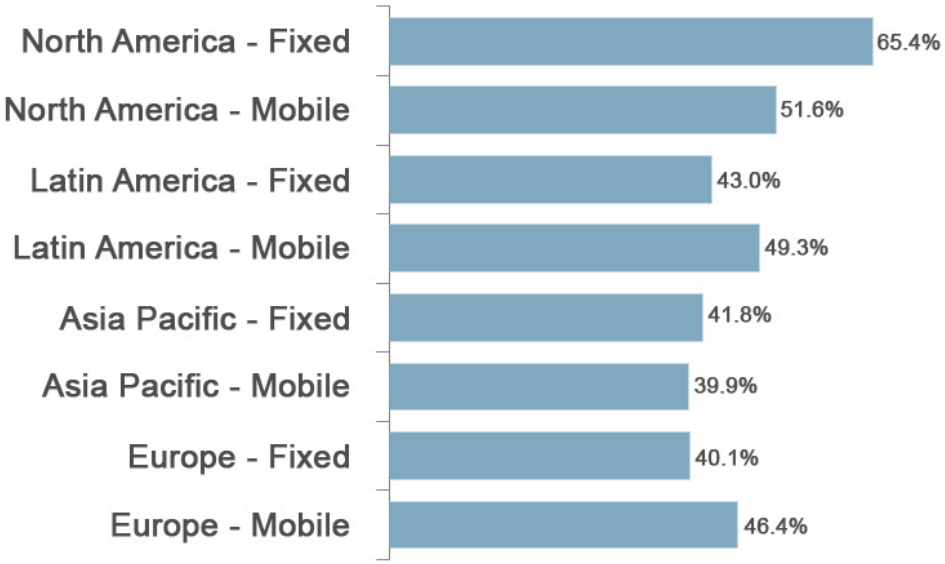


Figure 1. Real-time entertainment traffic as percentage of download traffic.

Used by an estimated 17% of the world population[3], Wi-Fi is at the epicenter of growth in wireless video and other real-time entertainment, because it is the most widely used wireless networking technology in the home, workplace, and public areas, and in both fixed and mobile user devices.

Wi-Fi is not only a required feature in laptops, netbooks, tablets, and smartphones (Figure 2), but also the dominant transport technology for traffic from those devices. In the US, more than 90% of tablet traffic is carried

[1] Sandvine, 2012.
[2] "Trusted mobility index", Juniper, 2012.
[3] ABI Research, 2012.

over Wi-Fi, according to comScore[4], and a large portion of this traffic originates in the home. Cisco VNI estimates that by 2016, Wi-Fi will carry 51% of the global fixed/mobile IP traffic.

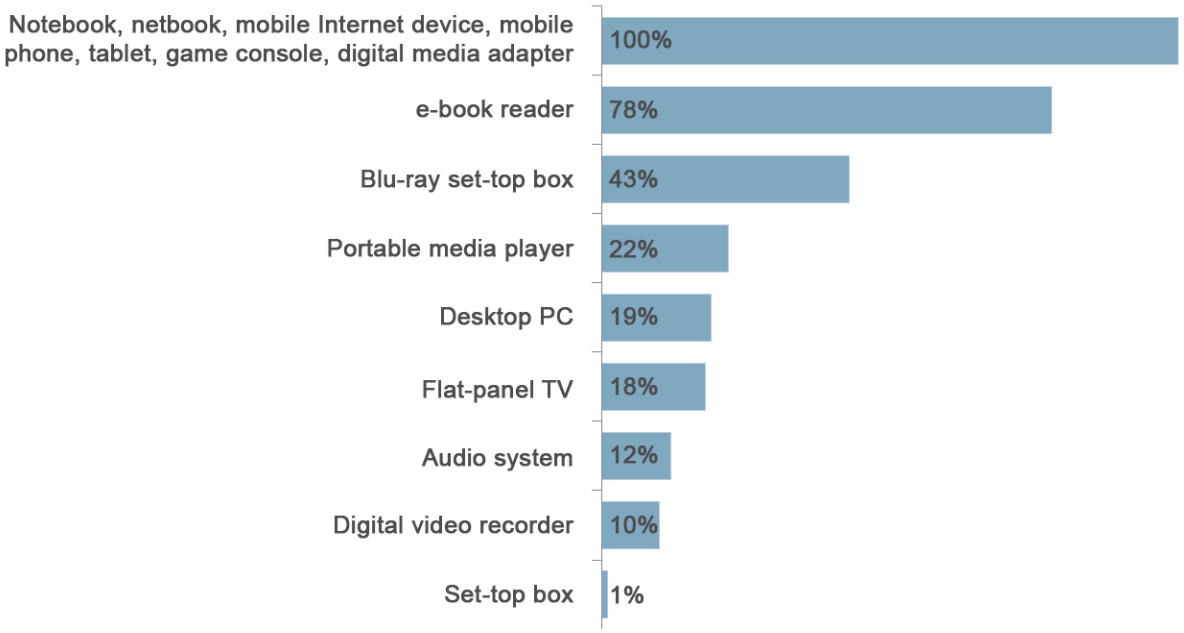


Figure 2. Percentage of CE devices with embedded Wi-Fi sold in 2012.[5]

Wireless connectivity allows users to access content wherever they are, but the home is where they spend much of their time watching and sharing content, listening to music, or playing games. Today's homes are sophisticated environments, buzzing with an increasing number of connected devices, each optimized for some specific usage scenario or content type. Content is less likely to be stored in a centralized location such as a home desktop PC, but is distributed across many devices.

The ability to display content across the devices that populate the home, in a seamless way that works regardless of vendor, form factor, or content type, and that does not involve onerous setup or configuration requirements is crucial for users, and this ability has emerged as a key driver for interoperable real-time entertainment solutions built on Wi-Fi.

Wi-Fi CERTIFIED Miracast™ expands the role of Wi-Fi in interactive video and audio entertainment. It enables seamless mirroring of entire displays across devices or sharing of any type of content that a source could display.

This paper introduces the Miracast program. It provides an overview of the Miracast approach to wireless streaming and display mirroring of real-time video and audio content between Miracast devices, the technology that drives it, the features that will make it valuable to vendors, content providers and users, and the certification program that will ensure interoperability across vendors.

[4] comScore, "Digital Omnivores: How Tablets, Smartphones and Connected Devices Are Changing U.S. Digital Media Consumption Habits," 2011.
[5] Strategy Analytics, 2012.

Consumers embrace connected content
Users worldwide watch 4 billion hours each month on YouTube
U.S. Netflix users have streamed more than 2 billion hours from the service
In Japan, Niconico video has 26.48 million subscribers as of March 2012
In Korea, TVing, first launched in 2010, has over 3.5 million users and is the country's biggest multi-screen service for smartphones, tablets, PCs and other screens
Use of apps continues to skyrocket – extending beyond smartphones to tablets, e-book readers, and TVs

Table 1. Consumers embrace connected content

Miracast delivers real-time wireless display of content

The astonishing growth in the adoption of real-time entertainment and other types of video content gives Wi-Fi further opportunity to expand its reach, and to allow users to continue to rely on a technology they know and trust in the devices they already own or plan to purchase. But the high levels of real-time traffic to be exchanged between devices – and the expectation of a high-quality rendering of the received content – create a demanding wireless environment, characterized by:

- High traffic volumes
- A need to connect devices even where a Wi-Fi access point (AP) is not available
- Traffic that requires low latency and jitter
- Multiple devices with different capabilities (ranging from high-definition TVs, to smartphones, to tablets, and more)
- A wide range of applications running on these devices
- A desire to establish transient device pairings across multiple devices to allow flexible content access and screen sharing with family and friends

The Wi-Fi Alliance developed the Miracast certification based on the Wi-Fi Alliance Wi-Fi Display Specification to meet these challenges and to ensure that Wi-Fi remains the technology of choice for real-time wireless content display in the home and enterprise. The technology and certification program were developed in the Wi-Fi Alliance by a diverse group of mobile and consumer electronics device manufacturers and silicon vendors.

Miracast makes the sharing of video content between devices seamless. It simplifies the process of forming direct wireless connections, freeing users from spending time and effort connecting cables or manually establishing a wireless link every time they want to share content between devices. With Miracast, devices identify and connect to each other, manage their connection, and optimize the transmission of content on the basis of their capabilities and network conditions. Miracast brings a user experience that is functionally similar to a wired connection, but with the added advantage of portability within the Wi-Fi coverage area.

With Miracast enabled, users no longer need to find the right cables and connectors, or to identify the appropriate ports to connect devices. Moreover, devices such as smartphones and tablets, which may lack physical ports for various cable solutions, are still able to connect and display. Devices connect to each other, without cables, adapters, or a Wi-Fi network, and without complex configuration – provided that they are Wi-Fi CERTIFIED Miracast.

The main target market for Miracast is users who own multiple devices capable of storing and/or rendering video/audio content and enjoy the ability to interactively direct the content to any device, and share the real-time multimedia experience with family and friends. Miracast gives them the opportunity to easily view or mirror any content on any Miracast CERTIFIED device within the home.

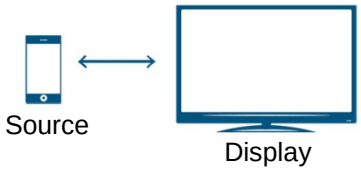
The enterprise is another target market segment, in addition to the home. Miracast allows employees and their customers or partners to share real-time content and business applications between devices. With Miracast they no longer need to physically connect their laptop to the projector; they can instead use either their laptop, smartphone, or tablet as a source that beams all the content to the display – i.e., the projector.

Miracast: Key benefits	
Content support	Miracast can support any type of content that the source device can display, with no restriction of applications or file formats. Available content protection mechanisms promote the participation of premium content providers and encourage their efforts to distribute content while protecting their digital rights.
Cost effectiveness	Miracast uses the Wi-Fi functionality already designed into connected devices. It does not require implementation of an additional wireless technology, or of ports for cabled solutions, in order to provide connectivity.
Demand-driven connectivity	Connectivity between source and display devices can be established through the user's normal interaction with an application or service. This creates an environment where users only need to choose what content to display, without having to establish device-to-device connectivity as a preliminary step.
Ease of use	Users can share video content between devices seamlessly, without a complex setup procedure.
Strong Wi-Fi foundation	Miracast benefits from the advantages of Wi-Fi as the underlying connectivity technology. Miracast delivers Wi-Fi CERTIFIED n performance and Wi-Fi Direct, enabling connectivity across devices even where there is no Wi-Fi AP infrastructure. Miracast will further benefit from continuous advances in Wi-Fi performance.
Proven interoperability	The well-established and proven certification model of the Wi-Fi Alliance is extended to Miracast. Miracast works between any source device and display device, regardless of vendor, as long as they are both certified for Miracast.
Traffic management	Miracast uses channel selection mechanisms from Wi-Fi Direct and TDLS to select an optimal channel, avoiding congestion from nearby networks that might impact video transfer. Quality of service mechanisms enhance the viewing experience by prioritizing latency-sensitive video traffic.
Trusted security	Wi-Fi Protected Access® 2 (WPA2™) security protects users' privacy, as it does in all Wi-Fi CERTIFIED networks.

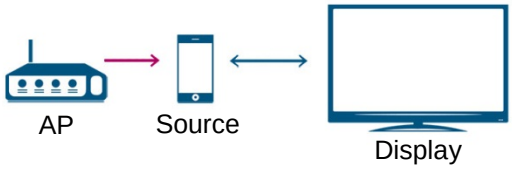
Table 2. Miracast: Key benefits

Miracast does not require a typical Wi-Fi infrastructure network, though many devices will take advantage of network connectivity to access content. Miracast connections are expected to be predominantly established between Wi-Fi devices connected with each other directly, without an AP acting as an intermediary. The direct link between devices is established either through Wi-Fi Direct, a feature that all Miracast devices are required to support, or through TDLS, an optional feature. When two devices connect with each other directly, one fulfills its role as the source (the transmitting device) and the other functions as a display (the device receiving and rendering the content to the user). Topologies supported by Miracast are shown in Figure 3.

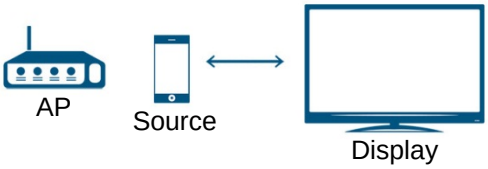
Topology 1: Direct Source to Display
No AP present



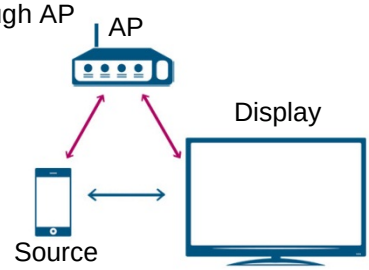
Topology 2: Source with access to AP and direct connection to Display
Content may be streamed from AP to Source to Display



Topology 3: Direct Source to Display, AP present, but not connected
AP may be aware of Wi-Fi Miracast devices, but it is not connected to them



Topology 4: Source and Display connected to each other and to AP
Source may stream content from itself or through AP



⟷ = Miracast Connection

Figure 3. Miracast topologies

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 (DTVs) and projectors are more likely to be displays. Devices like tablets may act 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.

The Miracast user experience

To start using Miracast, the user has to:

- Power on both the source (transmitting) and display (receiving) devices, and enable Miracast if not enabled by default
- If using the user interface on a display device:
  - Request the device to discover all the compatible source devices
  - Browse the source devices that have been discovered or previously paired
  - Select the source device to be paired
- If using the user interface in a source device:
  - Request the device to discover all the compatible display devices
  - Browse the display devices that have been discovered or previously paired
  - Select the display device to be paired
- Begin playing the content on the source

Wi-Fi Direct is used to complete these initial steps to connect the two devices. In subsequent sessions, the two devices recognize that they are paired without repeating these steps.

The user can initiate a new session from either the source device or the display device. A source device and a display device can be involved in only one active session at a time. The session can be ended by either device.

Leveraging Wi-Fi technology for wireless display

Miracast builds upon the foundation provided by several other Wi-Fi Alliance certification programs (Figure 4):

- **Connectivity**: Wi-Fi CERTIFIED n provides a transmission channel designed to support multimedia content.
- **Device-to-device connectivity:** Wi-Fi Direct™ allows devices to connect directly to each other, without the need for a Wi-Fi AP, and often requiring just the push of a button. TDLS allows devices that are associated to the same Wi-Fi network to establish a direct link with each other.
- **Security:** WPA2™ makes the transport of multimedia content safe, protecting both the source and the display.
- **Quality of service (QoS) :** Wi-Fi Multimedia™ (WMM®) gives real-time content, such as voice and audio, priority where appropriate over best-effort traffic, to support a good user experience.
- **Battery life:** WMM Power Save extends the battery life of mobile devices like smartphones or tablets by minimizing the time the device is actively connected to the AP during idle time. Power save mechanisms in Wi-Fi Direct provide similar benefits when connecting devices without an AP.
- **Ease of installation:** Wi-Fi Protected Setup™ helps users to automatically configure Wi-Fi networks, enable WPA2 security, and add new devices.

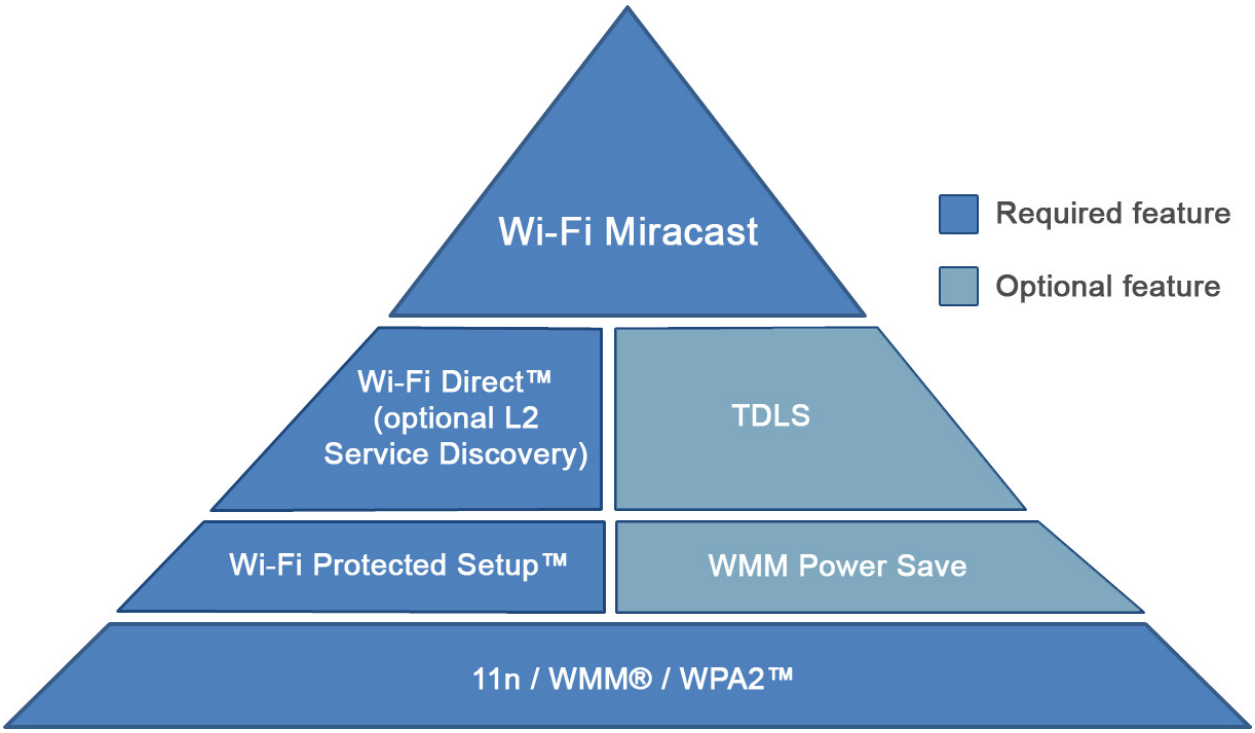


Figure 4. Miracast benefits from multiple Wi-Fi Alliance certification programs

Miracast devices may support as an option Tunneled Direct Link Setup (TDLS), a Wi-Fi Alliance certification program that enables a direct link between client devices connected to the same Wi-Fi AP so they can communicate directly. TDLS is based on Institute of Electrical and Electronics Engineers (IEEE) 802.11z and defines a device-to-device network within an existing basic service set (BSS). When supported, TDLS allows two devices on the same network to establish a Miracast session between them so that they can transmit to each

other directly without having to route the traffic through the AP. In this scenario, the link between the devices is not provided by Wi-Fi Direct.

The Wi-Fi CERTIFIED Miracast approach to wireless streaming of multimedia content

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 transmitting, 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 (Figure 5). 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 3. Finally, the display device receives the content, decodes it, and renders it.

Miracast: Supported formats	
Display Resolution	• 17 Consumer Electronics Association (CEA) formats, from 640 x 480 up to 1920 x 1080 pixels, and from 24 to 60 frames per second[6] (fps) • 29 Video Electronics Standards Association (VESA) formats, from 800 x 600 up to 1920 x 1200 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
Video	• ITU-T H.264 (also known as Advanced Video Coding [AVC]) for high-definition (HD) video, supporting the Constrained Baseline Profile (CBP) and the Miracast-specific Constrained High Profile (CHP), at levels ranging from 3.1 to 4.2.

Audio	• Mandated codec: Linear Pulse-Code Modulation (LPCM) 16 bits, 48 kHz sampling, 2 channels
	• Optional audio codecs, based on:
	  • LPCM mode 16 bits, 44.1 kHz sampling, 2 channels
	  • Advanced Audio Coding (AAC) modes
	  • Dolby Advanced Codec 3 (AC3) modes

Table 3. Display, Video and audio formats supported by Miracast

[6] 30 fps for 1920x1200

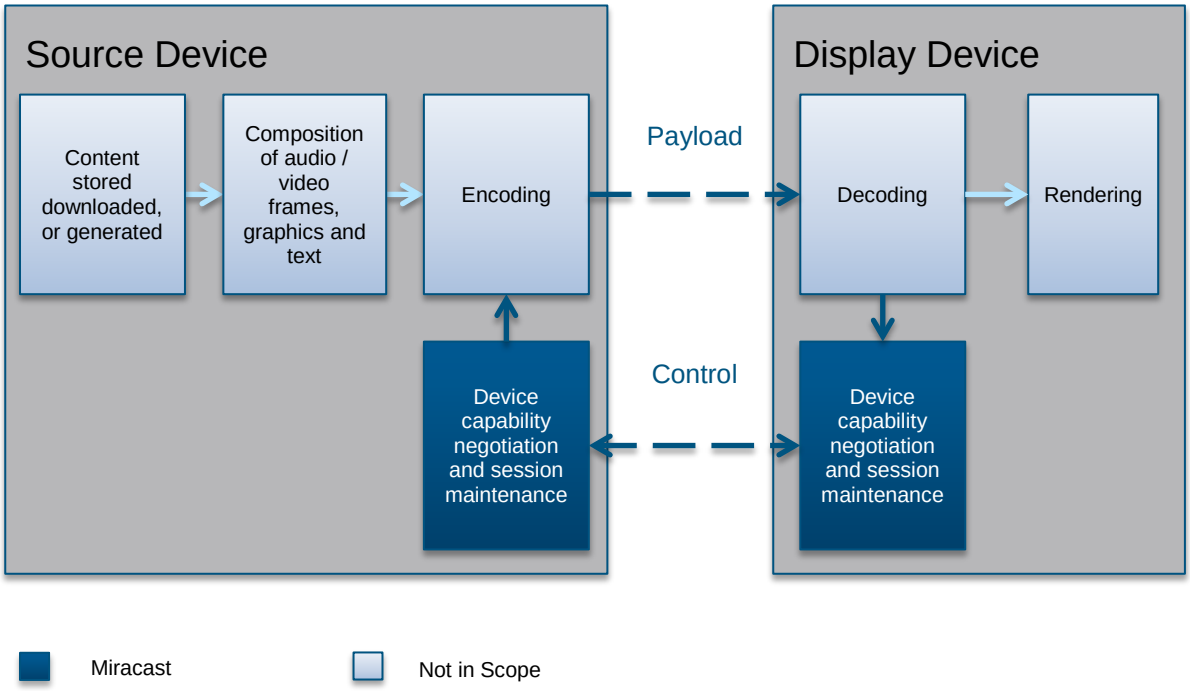


Figure 5. Wireless streaming in Miracast

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 3 describes the session management stages in Miracast.

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 (P2P) Specification.
Service discovery (optional)	Source and display devices discover each other's Miracast capabilities prior to connection setup. The Service discovery mechanism is defined in the Wi-Fi P2P specification.
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 (Wi-Fi Direct or TDLS) to manage the connection. Wi-Fi Direct sets up a group owner and client to initiate a device-to-device link. A WPA2 single-hop link with selected devices is established. 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) 2.0/2.1. HDCP session keys are established before the 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 setup 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 Real-Time Protocol (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.
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.
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.

Table 4. Miracast session management

Certification Program Testing Overview

Miracast is an optional certification program, directed mostly to equipment that is 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 retains the interoperability approach common to all Wi-Fi Alliance CERTIFIED programs, which ensures that Miracast-certified equipment retains backwards compatibility with previously certified equipment. As a result, a Miracast-certified display device will work with a newly purchased Miracast-certified source device, even if this 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 program will support the functionality. Miracast works only when both source and display are certified.

The Miracast certification is limited to non-infrastructure devices. Infrastructure equipment such as APs do not require any additional certification to participate in a network with active Miracast sessions – even if, as in Figure 3, the source device is connected to the AP (topology 2) or both the source and display devices are (topology 4).

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

- Wi-Fi CERTIFIED n
- WPA2
- Wi-Fi Direct
- WMM
- Wi-Fi Protected Setup

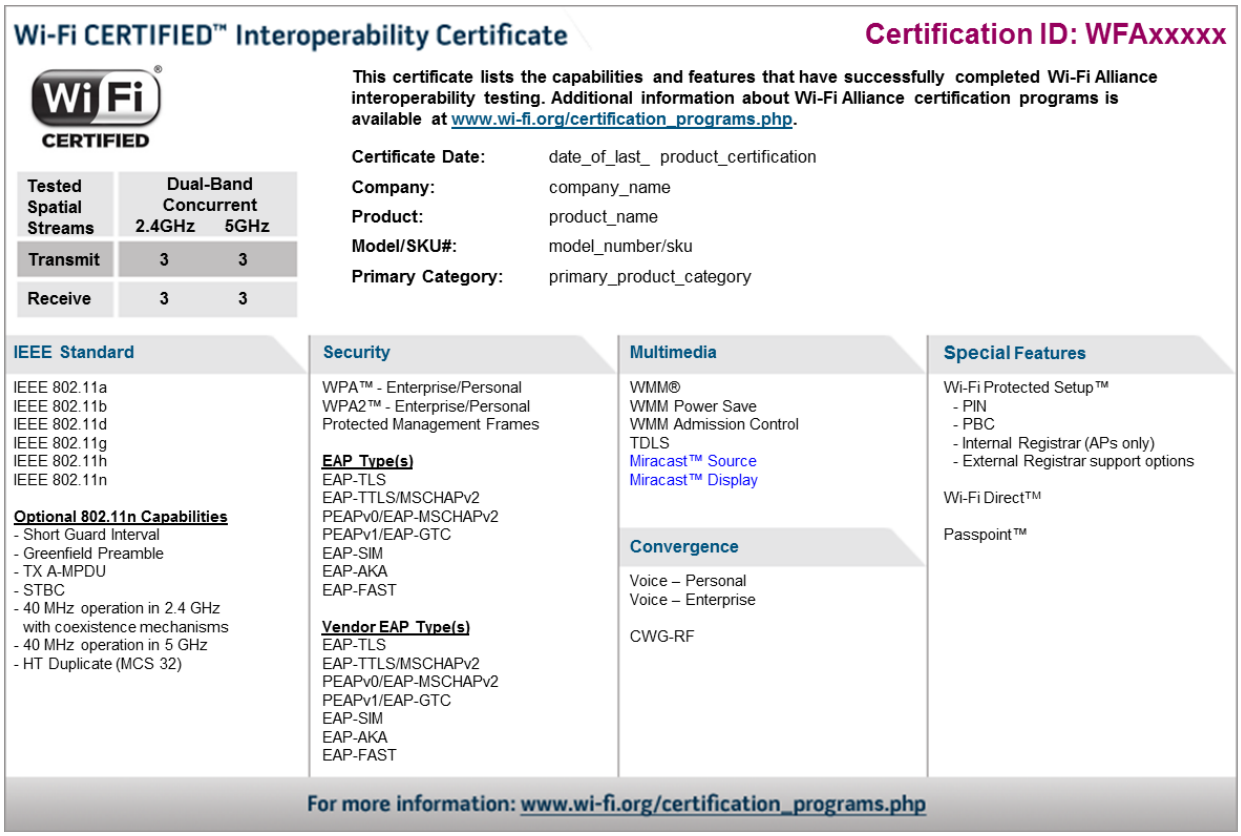
While it is expected that TDLS certification will be commonly pursued for Miracast–certified devices, it is an optional component of the Miracast certification process. Miracast and TDLS are complementary, and vendors seeking Miracast certification for their products have the flexibility to choose whether they want to support TDLS.

In addition, to be considered for Miracast certification, devices are required to support the mandatory audio and video formats as defined in Table 2. Display devices without speakers are allowed to support video only.

Since Miracast builds on the latest Wi-Fi functionality, some recently released devices may receive Miracast as a vendor software upgrade after being certified for Miracast. The potential to add Miracast to devices already in the market will accelerate the adoption of Miracast, because it allows users to enjoy the advantages of Miracast without the need to replace their Wi-Fi devices.

Furthermore, 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 High-Definition Multimedia Interface (HDMI), Universal Serial Bus (USB) 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.

Users can identify products that are certified for Miracast either by consulting the online database of Wi-Fi CERTIFIED products on the Wi-Fi Alliance website (www.wi-fi.org) or by checking their interoperability certificate (Figure 6).



Wi-Fi CERTIFIED™ Interoperability Certificate

Certification ID: WFAxxxxx

Wi Fi CERTIFIED

This certificate lists the capabilities and features that have successfully completed Wi-Fi Alliance interoperability testing. Additional information about Wi-Fi Alliance certification programs is available at www.wi-fi.org/certification_programs.php.

Certificate Date: date_of_last_ product_certification
Company: company_name
Product: product_name
Model/SKU#: model_number/sku
Primary Category: primary_product_category

Tested Spatial Streams	Dual-Band Concurrent 2.4GHz	5GHz
Transmit	3	3
Receive	3	3

IEEE Standard

IEEE 802.11a
IEEE 802.11b
IEEE 802.11d
IEEE 802.11g
IEEE 802.11h
IEEE 802.11n

Optional 802.11n Capabilities
- Short Guard Interval
- Greenfield Preamble
- TX A-MPDU
- STBC
- 40 MHz operation in 2.4 GHz with coexistence mechanisms
- 40 MHz operation in 5 GHz
- HT Duplicate (MCS 32)

Security

WPA™ - Enterprise/Personal
WPA2™ - Enterprise/Personal
Protected Management Frames

EAP Type(s)
EAP-TLS
EAP-TTLS/MSCHAPv2
PEAPv0/EAP-MSCHAPv2
PEAPv1/EAP-GTC
EAP-SIM
EAP-AKA
EAP-FAST

Vendor EAP Type(s)
EAP-TLS
EAP-TTLS/MSCHAPv2
PEAPv0/EAP-MSCHAPv2
PEAPv1/EAP-GTC
EAP-SIM
EAP-AKA
EAP-FAST

Multimedia

WMM®
WMM Power Save
WMM Admission Control
TDLS
Miracast™ Source
Miracast™ Display

Convergence

Voice – Personal
Voice – Enterprise

CWG-RF

Special Features

Wi-Fi Protected Setup™
- PIN
- PBC
- Internal Registrar (APs only)
- External Registrar support options

Wi-Fi Direct™

Passpoint™

For more information: www.wi-fi.org/certification_programs.php

Figure 6. Interoperability certificate

Summary

Miracast is a new Wi-Fi Alliance certification program based on the Wi-Fi Alliance Wi-Fi Display Specification. It leverages Wi-Fi technology to support wireless video streaming and display mirroring between Wi-Fi devices for real-time viewing in home and enterprise environments.

The growth in video and audio content availability, in the number of devices that can generate or display high-quality media, and in user demand for real-time entertainment applications has created an environment in which users increasingly rely on Wi-Fi. Wi-Fi is a technology that users trust and is found in most of the mobile and CE devices that they use for multimedia applications. The Wi-Fi Alliance and its member companies developed Miracast to increase the ease of use and quality of the user experience for interactively sharing graphical, text, audio and video content between Wi-Fi devices.

Miracast leverages Wi-Fi Direct to optimize the graphical, textual, audio and video streaming over Wi-Fi by establishing efficient device-to-device connections—in which a source device transmits real-time content to a display device through a direct, peer-to-peer connection—which do not incur the cost of an additional transmission path to an infrastructure AP. Miracast coexists with traditional Wi-Fi networks, but does not need them to establish streaming sessions between Miracast–certified devices.

Miracast is an optional Wi-Fi Alliance certification program that is open to devices that support multimedia capabilities. Among its target devices are TVs, STBs, projectors, and other CE Wi-Fi devices, as well as smartphones, tablets, and laptops, which today almost invariably have embedded Wi-Fi. With Miracast, vendors can add a powerful and attractive feature to their products that will further accelerate the consumption of real-time content over multiple devices. Users will welcome Miracast and the freedom from wires and adapters that it brings, allowing them to enjoy seamless, interactive wireless streaming of their favorite audio and video content.

Acronyms

AAC	Advanced Audio Coding
AC3	Advanced Codec 3
AP	Access point
AVC	Advanced Video Coding
BSS	Basic service set
CBP	Constrained Baseline Profile
CE	Consumer electronics
CEA	Consumer Electronics Association
CHP	Constrained High Profile
DRM	Digital rights management
DTV	Digital TV
EAP	Extensible Authentication Protocol
fps	Frames per second
HDCP	High-bandwidth Digital Content Protection
HD	High-definition
HDMI	High-Definition Multimedia Interface
HIDC	Human interface device class
IEEE	Institute of Electrical and Electronics Engineers
IP	Internet Protocol
LPCM	Linear Pulse-Code Modulation
MAC	Medium access control (layer)
P2P	Peer to peer
PHY	Physical (layer)
PMF	Protected Management Frames
QoS	Quality of service
RTP	Real-Time Protocol
RTSP	Real-Time Streaming Protocol
STB	Set-top box
TCP	Transmission Control Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
TDLS	Tunneled Direct Link Setup
UDP	User Datagram Protocol
UI	User interface

UIBC	User Interface Back Channel
USB	Universal Serial Bus
VESA	Video Electronics Standards Association
WMM®	Wi-Fi Multimedia™
WMM-Power Save	Wi-Fi Multimedia Power Save
WPA2™	Wi-Fi Protected Access® 2

Further information resources

An up-to-date list of certified products can be found in the Wi-Fi CERTIFIED products database on the Wi-Fi Alliance website (www.wi-fi.org), where users can search for Wi-Fi CERTIFIED equipment by multiple criteria, including product category, manufacturer, certification date and features supported, and can view the interoperability certificate for certified products.

For further information on Wi-Fi Alliance certification programs and for white papers on Wi-Fi–related topics, please visit the Knowledge Center on the Wi-Fi Alliance website (www.wi-fi.org).

The Wi-Fi CERTIFIED logo makes it easy to identify certified Wi-Fi products

About the Wi-Fi Alliance

The Wi-Fi Alliance is a global non-profit industry association of hundreds of leading companies devoted to seamless connectivity. With technology development, market building, and regulatory programs, the Wi-Fi Alliance has enabled widespread adoption of Wi-Fi worldwide.

The Wi-Fi CERTIFIED™ program was launched in March 2000. It provides a widely-recognized designation of interoperability and quality and it helps to ensure that Wi-Fi-enabled products deliver the best user experience. The Wi-Fi Alliance has completed more than 15,000 product certifications, encouraging the expanded use of Wi-Fi products and services in new and established markets.

Appendix: Wi-Fi Alliance programs to promote seamless connectivity

From its inception, the Wi-Fi Alliance has promoted interoperability across vendors through its Wi-Fi CERTIFIED™ program, which certifies client devices and infrastructure equipment that meets the specifications and the performance requirements established by the Wi-Fi Alliance, and based on the IEEE 802.11 standard. Users' confidence that Wi-Fi CERTIFIED devices can connect to any Wi-Fi CERTIFIED AP to deliver a reliable connection and a high-quality experience has made Wi-Fi ubiquitous in PCs, laptops, tablets and smartphones, and increasingly available in other CE devices.

With effortless interoperability as its core target, the Wi-Fi Alliance certification program has expanded to include the building blocks that support a richer and safer user experience with mobile devices:

- **Wi-Fi Protected Access® 2 (WPA2™)** is required in all Wi-Fi CERTIFIED devices and infrastructure equipment and provides IEEE 802.1X controlled access, secure Extensible Authentication Protocol (EAP)-based authentication and connectivity through encryption of the over-the-air traffic.
- **WPA2™ with Protected Management Frames (PMF)** provides a WPA2-level of protection for unicast and multicast management action frames, strengthening privacy protection for data frames with mechanisms that improve the resiliency of mission-critical networks.
- **Wi-Fi Multimedia™ (WMM®)** provides quality-of-service (QoS) functionality to enhance the user experience with real-time applications, such as streaming video and voice applications.
- **Wi-Fi Multimedia™ – Power Save (WMM®-PS)** minimizes power consumption in mobile devices.
- **Wi-Fi CERTIFIED™ n** leverages multiple-in, multiple-out (MIMO) technology in IEEE 802.11n Wi-Fi CERTIFIED products to enhance performance and capacity in Wi-Fi networks.