[MS-MICE]:

Miracast over Infrastructure Connection Establishment Protocol

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Revision Summary

Date	Revision History	Revision Class	Comments
3/16/2017	1.0	New	Released new document.
6/1/2017	1.1	Minor	Clarified the meaning of the technical content.
3/16/2018	2.0	Major	Significantly changed the technical content.

Table of Contents

1 Introduction

The Miracast over Infrastructure Connection Establishment Protocol specifies a connection negotiation sequence that is used to connect and disconnect from a Miracast over Infrastructure device.

This protocol uses a Wi-Fi Simple Configuration (WSC) information element (IE) Vendor Extension attribute to advertise a receiver (Sink) that can support Miracast over infrastructure sessions.

Sections 1.5, 1.8, 1.9, 2, and 3 of this specification are normative. All other sections and examples in this specification are informative.

1.1 Glossary

This document uses the following terms:

802.11 Access Point (AP): Any entity that has IEEE 802.11 functionality and provides access to the distribution services, via the wireless medium for associated stations (STAs).

ASCII: The American Standard Code for Information Interchange (ASCII) is an 8-bit character-encoding scheme based on the English alphabet. ASCII codes represent text in computers, communications equipment, and other devices that work with text. ASCII refers to a single 8-bit ASCII character or an array of 8-bit ASCII characters with the high bit of each character set to zero.

basic service set identifier (BSSID): A 48-bit structure that is used to identify an entity such as the access point in a wireless network. This is typically a MAC address.

Beacon: A management frame that contains all of the information required to connect to a network. In a WLAN, Beacon frames are periodically transmitted to announce the presence of the network.

big-endian: Multiple-byte values that are byte-ordered with the most significant byte stored in the memory location with the lowest address.

Domain Name System (DNS): A hierarchical, distributed database that contains mappings of domain names to various types of data, such as IP addresses. DNS enables the location of computers and services by user-friendly names, and it also enables the discovery of other information stored in the database.

friendly name: A name for a user or object that can be read and understood easily by a human.

globally unique identifier (GUID): A term used interchangeably with universally unique identifier (UUID) in Microsoft protocol technical documents (TDs). Interchanging the usage of these terms does not imply or require a specific algorithm or mechanism to generate the value. Specifically, the use of this term does not imply or require that the algorithms described in [RFC4122] or [C706] must be used for generating the **GUID**. See also universally unique identifier (UUID).

information element (IE): In a Wi-Fi Protected Setup (WPS) scenario, descriptive information consisting of informative type-length-values that specify the possible and currently deployed configuration methods for a device. The IE is transferred and added to the Beacon and Probe Response frames, and optionally to the Probe Request frame and associated request and response messages.

Internet Protocol version 4 (IPv4): An Internet protocol that has 32-bit source and destination addresses. IPv4 is the predecessor of IPv6.

Internet Protocol version 6 (IPv6): A revised version of the Internet Protocol (IP) designed to address growth on the Internet. Improvements include a 128-bit IP address size, expanded routing capabilities, and support for authentication and privacy.

organizationally unique identifier (OUI): A unique 24-bit string that uniquely identifies a vendor, manufacturer, or organization on a worldwide l basis, as specified in [IEEE-OUI]. The OUI is used to help distinguish both physical devices and software, such as a network protocol, that belong to one entity from those that belong to another.

peer to peer (P2P): An Internet-based networking option in which two or more computers connect directly to each other to communicate and share files without use of a central server.

Probe Request: A frame that contains the advertisement IE for a device that is seeking to establish a connection with a proximate device. The Probe Request frame is defined in the Wi-Fi Peer-to-Peer (P2P) Specification v1.2 [WF-P2P1.2] section 4.2.2.

Probe Response: A frame that contains the advertisement IE for a device. The Probe Response is sent in response to a Probe Request. The Probe Response frame is defined in the Wi-Fi Peer-to-Peer (P2P) Specification v1.2 [WF-P2P1.2] section 4.2.3.

Real-Time Streaming Protocol (RTSP): A protocol used for transferring real-time multimedia data (for example, audio and video) between a server and a client, as specified in [RFC2326]. It is a streaming protocol; this means that **RTSP** attempts to facilitate scenarios in which the multimedia data is being simultaneously transferred and rendered (that is, video is displayed and audio is played).

Stock Keeping Unit (SKU): A unique code that refers to a particular manufactured object or source of revenue. A **SKU** can refer to a retail product (software in a box that is sold through a channel), a subscription program (such as MSDN), or an online service (such as MSN).

subnet: A logical division of a network. Subnets provide a multilevel hierarchical routing structure for the Internet. On TCP/IP networks, subnets are defined as all devices whose IP addresses have the same prefix. Subnets are useful for both security and performance reasons. In general, broadcast messages are scoped to within a single subnet. For more information about subnets, see [RFC1812].

Transmission Control Protocol (TCP): A protocol used with the Internet Protocol (IP) to send data in the form of message units between computers over the Internet. TCP handles keeping track of the individual units of data (called packets) that a message is divided into for efficient routing through the Internet.

type-length-value (TLV): A property of a network interface, so named because each property is composed of a Type field, a Length field, and a value.

UTF-16: A standard for encoding Unicode characters, defined in the Unicode standard, in which the most commonly used characters are defined as double-byte characters. Unless specified otherwise, this term refers to the UTF-16 encoding form specified in [UNICODE5.0.0/2007] section 3.9.

virtual private network (VPN): A network that provides secure access to a private network over public infrastructure.

Wi-Fi Direct (WFD): A standard that allows Wi-Fi devices to connect to each other without requiring a **wireless access point (WAP)**. This standard enables WFD devices to transfer data directly among each other resulting in significant reductions in setup.

Wi-Fi Protected Setup (WPS): A computing standard that attempts to allow easy establishment of a secure wireless home network. This standard was formerly known as Wi-Fi Simple Config.

wireless access point (WAP): A wireless network access server (NAS) that implements 802.11.

MAY, SHOULD, MUST, SHOULD NOT, MUST NOT: These terms (in all caps) are used as defined in [RFC2119]. All statements of optional behavior use either MAY, SHOULD, or SHOULD NOT.

1.2 References

Links to a document in the Microsoft Open Specifications library point to the correct section in the most recently published version of the referenced document. However, because individual documents in the library are not updated at the same time, the section numbers in the documents may not match. You can confirm the correct section numbering by checking the Errata.

1.2.1 Normative References

We conduct frequent surveys of the normative references to assure their continued availability. If you have any issue with finding a normative reference, please contact dochelp@microsoft.com. We will assist you in finding the relevant information.

[IANA-DNS] IANA, "Domain Name System (DNS) Parameters", April 2009, http://www.iana.org/assignments/dns-parameters

[IANAPORT] IANA, "Service Name and Transport Protocol Port Number Registry", http://www.iana.org/assignments/service-names-port-numbers/service-names-port-numbers.xhtml

[IEEE802.11-2012] IEEE, "Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications", ANSI/IEEE Std 802.11-2012, http://standards.ieee.org/getieee802/download/802.11-2012.pdf

Note There is a charge to download this document.

[RFC1034] Mockapetris, P., "Domain Names - Concepts and Facilities", STD 13, RFC 1034, November 1987, http://www.ietf.org/rfc/rfc1034.txt

[RFC1123] Braden, R., "Requirements for Internet Hosts - Application and Support", RFC 1123, October 1989, http://www.ietf.org/rfc/rfc1123.txt

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997, http://www.rfc-editor.org/rfc/rfc2119.txt

[RFC2181] Elz, R., and Bush, R., "Clarifications to the DNS Specification", RFC 2181, July 1997, http://www.ietf.org/rfc/rfc2181.txt

[RFC2326] Schulzrinne, H., Rao, A., and Lanphier, R., "Real Time Streaming Protocol (RTSP)", RFC 2326, April 1998, http://www.ietf.org/rfc/rfc2326.txt

[RFC4291] Hinden, R. and Deering, S., "IP Version 6 Addressing Architecture", RFC 4291, February 2006, http://www.ietf.org/rfc/rfc4291.txt

[RFC6762] Krochmal, M. and Cheshire, S., "Multicast DNS", http://www.rfc-editor.org/rfc/rfc6762.txt

[RFC6763] Cheshire, S. and Krochmal, M., "DNS-Based Service Discovery", RFC 2326, April 1998, https://www.rfc-editor.org/rfc/rfc6763.txt

[RFC793] Postel, J., Ed., "Transmission Control Protocol: DARPA Internet Program Protocol Specification", RFC 793, September 1981, http://www.rfc-editor.org/rfc/rfc793.txt

[WF-DTS1.1] Wi-Fi Alliance, "Wi-Fi Display Technical Specification v1.1", April 2014, https://www.wi-fi.org/file/wi-fi-display-technical-specification-v11

Note There is a charge to download the specification.

[WF-P2P1.2] Wi-Fi Alliance, "Wi-Fi Peer-to-Peer (P2P) Technical Specification v1.2", https://www.wi-fi.org/wi-fi-peer-to-peer-p2p-technical-specification-v12

Note There is a charge to download the specification.

[WF-WSC2.0.2] Wi-Fi Alliance, "Wi-Fi Simple Configuration Technical Specification v2.0.2", August 2011, https://www.wi-fi.org/wi-fi-simple-configuration-technical-specification-v202

Note There is a charge to download the specification.

1.2.2 Informative References

[IEEE-OUI] IEEE Standards Association, "IEEE OUI Registration Authority", February 2007, http://standards.ieee.org/regauth/oui/oui.txt

[WF-DTS2.1] Wi-Fi Alliance, "Wi-Fi Display Technical Specification v2.0", April 2016, https://www.wi-fi.org/file/wi-fi-display-technical-specification-v21

1.3 Overview

The Miracast over Infrastructure protocol provides the ability to transmit a multimedia data stream over a local wireless network instead of **Wi-Fi Direct (WFD)**. The process of such transmission is called "projection".

A Miracast over Infrastructure session involves the following principals.

Miracast Source: A device that sends audio and video streams to the Miracast Sink. This device is sometimes called a "sender". Optionally, this device can also receive input signals from the Miracast Sink.

Miracast Sink: A device that receives audio and video streams from the Miracast Source. This device is sometimes called a "receiver". Optionally, this device can also send input signals back to the Miracast Source.

The following diagram illustrates the logical flow of establishing a Miracast over Infrastructure session, including successful and unsuccessful outcomes. For further details, see Protocol Details (section 3).

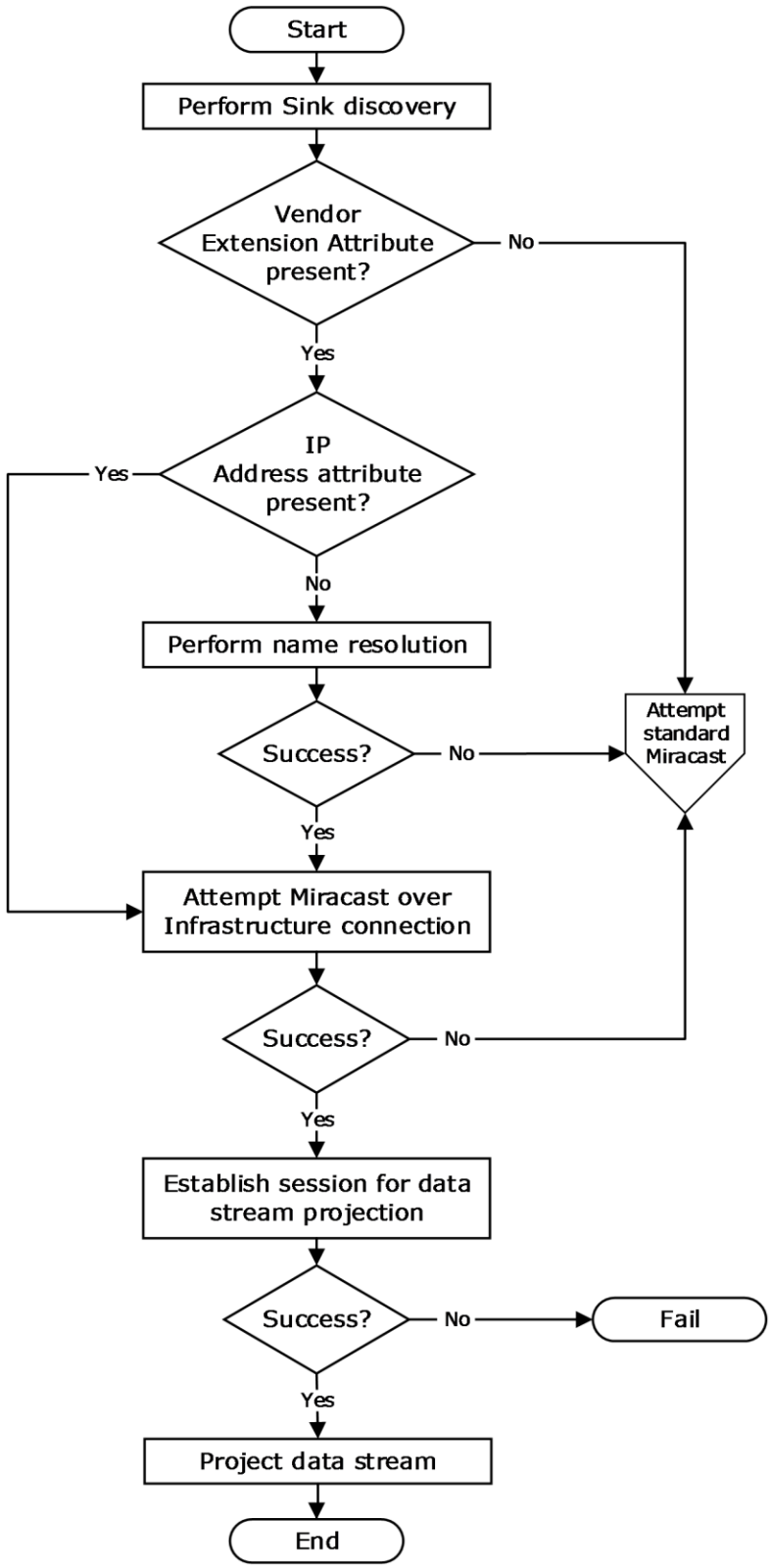


Figure 1: A Miracast over Infrastructure session

A Miracast over Infrastructure session consists of three phases: device discovery, host name resolution, and projection.

The device discovery phase starts with a Miracast Source trying to find devices capable of performing the role of Miracast Sink. Each Sink advertises its capabilities by transmitting **Beacon** and **Probe Response** frames that might include WSC IE Vendor Extension attributes (section 2.2.4).

A Sink is selected from those discovered; for example, by asking a user to pick one. If the Vendor Extension attribute from the selected Sink does not indicate support for Miracast over Infrastructure, the Source falls back to using standard Miracast [WF-WSC2.0.2].

If the Vendor Extension attribute contains one or more IP Address attributes (section 2.2.4.5), the Source optionally skips the host name resolution phase and proceeds to the projection phase.

In the host name resolution phase, name resolution is performed on the name in a Host Name attribute (section 2.2.4.2) in the Vendor Extension attribute. If name resolution is unsuccessful, the Source again falls back to using standard Miracast.

In the projection phase, the Source attempts a connection to the Sink for sending Miracast over Infrastructure messages (section 2.2). Finally, the Sink establishes a connection with the Source for streaming multimedia data. If that connection cannot be established, the entire process fails.

1.4 Relationship to Other Protocols

The Miracast over Infrastructure protocol builds upon the following standard technologies.

- **Domain Name System (DNS)** [IANA-DNS] [RFC1034] [RFC2181]
- Multicast DNS (mDNS) [RFC6762]
- **Real-Time Streaming Protocol (RTSP)** [RFC2326]
- **Transmission Control Protocol (TCP)** [RFC793]
- Wi-Fi Display Protocol [WF-DTS1.1]
- Wi-Fi Peer-to-Peer (P2P) Protocol [WF-P2P1.2]
- Wi-Fi Simple Configuration (WSC) Protocol [WF-WSC2.0.2]

1.5 Prerequisites/Preconditions

Miracast over Infrastructure has the following prerequisites and preconditions.

- The Miracast Source and Miracast Sink endpoints are on the same logical IP network, so they can establish a local network connection.
- Either the Sink is on the same logical IP **subnet** as the Source, or the Sink's name is registered in a **DNS** server that the Source can resolve to.

1.6 Applicability Statement

Miracast over Infrastructure is applicable to streaming audio and video content from one device to another, such as PC to large-screen TV, PC to PC, phone to PC, and so on.

The protocol functions in a configuration in which Miracast Source and Miracast Sink devices share a common logical IP network and determine they can project content across that network.

1.7 Versioning and Capability Negotiation

Versioning and capability negotiation are performed by using Vendor Extension attributes (section 2.2.4).

1.8 Vendor-Extensible Fields

None.

1.9 Standards Assignments

The Miracast over Infrastructure protocol uses the following standard port assignments.

Parameter	Value	Reference
TCP port	7250	[IANAPORT]

2 Messages

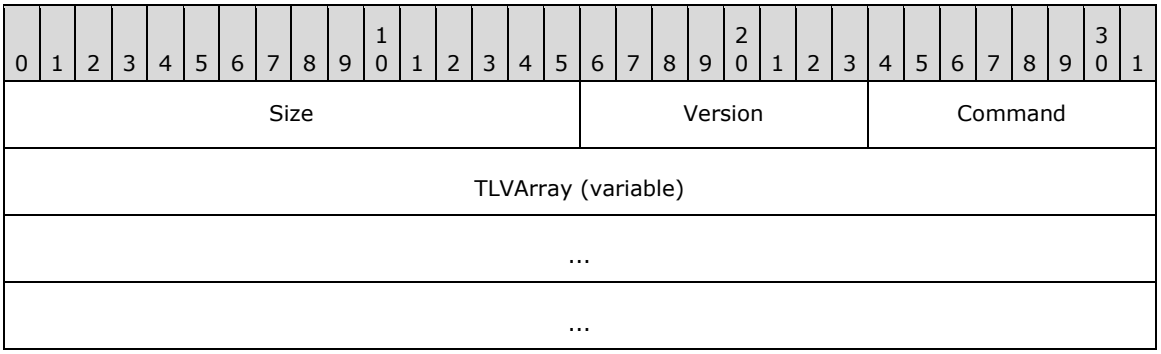
2.1 Transport

Miracast over Infrastructure messages (section 2.2) are sent over **TCP** port 7250 to manage the multimedia stream.

2.2 Message Syntax

In the structures defined in this section, multi-byte field values are ordered in **big-endian** format, unless specified otherwise, and string values do not include NUL terminators.

This section defines the messages used for starting and stopping Miracast over Infrastructure sessions. This is the general format for Miracast messages.



Size (2 bytes): The size of the message, in bytes.

Version (1 byte): The version of this protocol, which is 0x01.

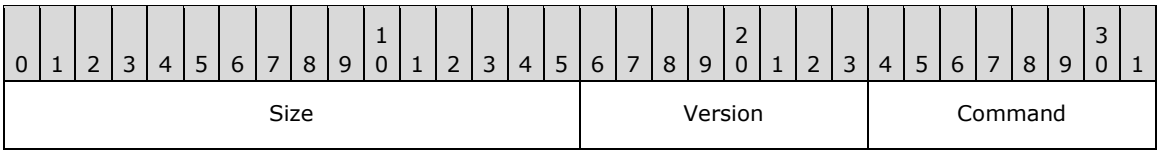
Command (1 byte): The type of message, which determines the **TLVs** passed in the **TLVArray** field. The following messages are defined in the sections listed.

Message type	Section	Description
SOURCE_READY 0x01	2.2.1	Indicates the Miracast Source is ready to accept a connection on the **RTSP** port.
STOP_PROJECTION 0x02	2.2.2	Indicates the end of the projection.

TLVArray (variable): An array of one or more Miracast TLVs (section 2.2.3), which specify information for the message.

2.2.1 Source Ready Message

The Source Ready message is sent by the Miracast Source to the Miracast Sink when the Source has started listening on the **RTSP** port and is ready to accept an incoming connection on it.



TLVArray (variable)
...
...

Size (2 bytes): The size of the entire message, in bytes.

Version (1 byte): The version of this protocol, which is 0x01.

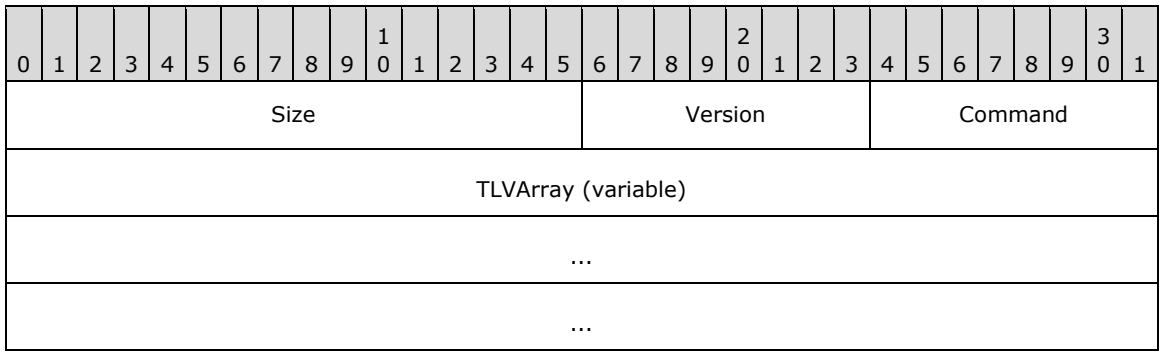
Command (1 byte): The type of message, which is 0x01 for **SOURCE_READY**.

TLVArray (variable): The following **TLVs**, included in any order:

- Friendly Name TLV (section 2.2.3.1)
- RTSP Port TLV (section 2.2.3.2)
- Source ID TLV (section 2.2.3.3)

2.2.2 Stop Projection Message

The Stop Projection message is sent by the Miracast Source to notify the Miracast Sink that the projection is being stopped.



Size (2 bytes): The size of the entire message, in bytes.

Version (1 byte): The version of this protocol, which is 0x01.

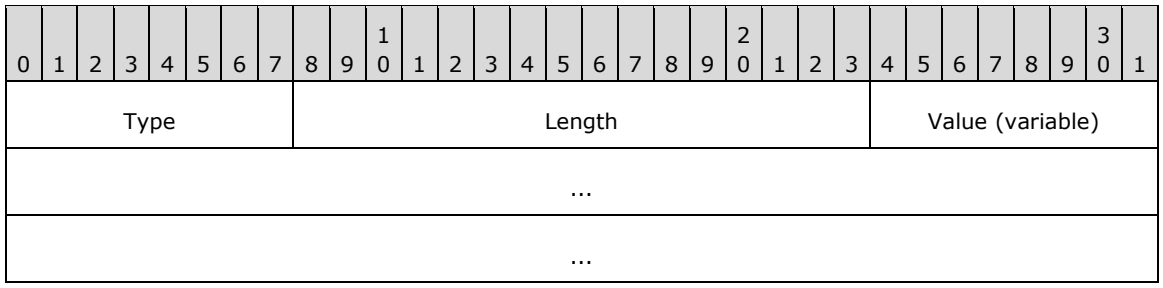
Command (1 byte): The type of message, which is 0x02 for **STOP_PROJECTION**.

TLVArray (variable): The following **TLVs**, included in any order:

- Friendly Name TLV (section 2.2.3.1)
- Source ID TLV (section 2.2.3.3)

2.2.3 Miracast TLVs

This section defines common **type-length-value (TLV)** structures that are used to pass information in messages during a Miracast session. This is the general format for the TLVs:



Type (1 byte): The type of TLV, which determines the information passed in the **Value** field. The following TLVs are defined in the sections listed.

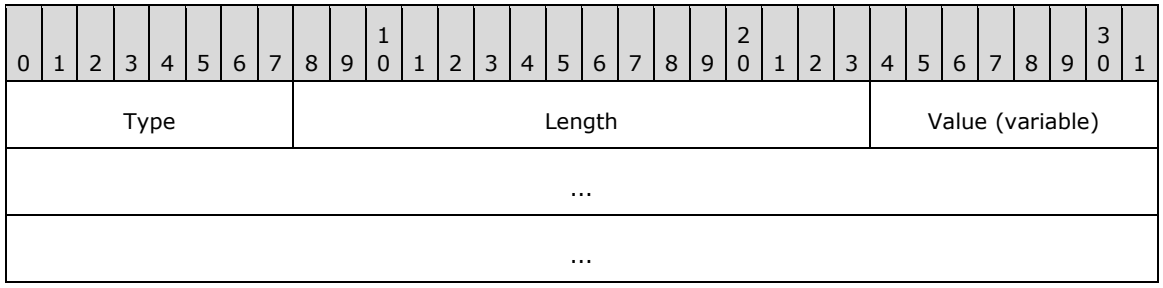
TLV type	Section	Description
FRIENDLY_NAME 0x00	2.2.3.1	Specifies the **friendly name** of the Miracast Source.
RTSP_PORT 0x02	2.2.3.2	Specifies the port on which the Source is listening for **RTSP** connections.
SOURCE_ID 0x03	2.2.3.3	Specifies an identifier for the Source, which is used for all messages sent during a Miracast session.

Length (2 bytes): The length of the **Value** field, in bytes. This value MUST be greater than or equal to 0x0001.

Value (variable): One or more bytes, which specify information for the TLV.

2.2.3.1 Friendly Name TLV

The Friendly Name **TLV** specifies the **friendly name** of the Miracast Source in messages to the Miracast Sink.



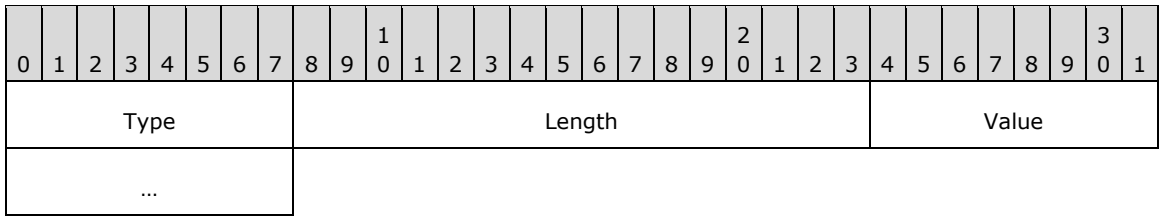
Type (1 byte): The type of TLV, which is 0x00 for the Friendly Name TLV.

Length (2 bytes): The length of the **Value** field, in bytes.

Value (variable): The friendly name string of the Source, encoded in **UTF-16**.

2.2.3.2 RTSP Port TLV

The RTSP Port **TLV** specifies the port on which the Miracast Source is listening. The port is used in messages for connecting sessions over **RTSP**.



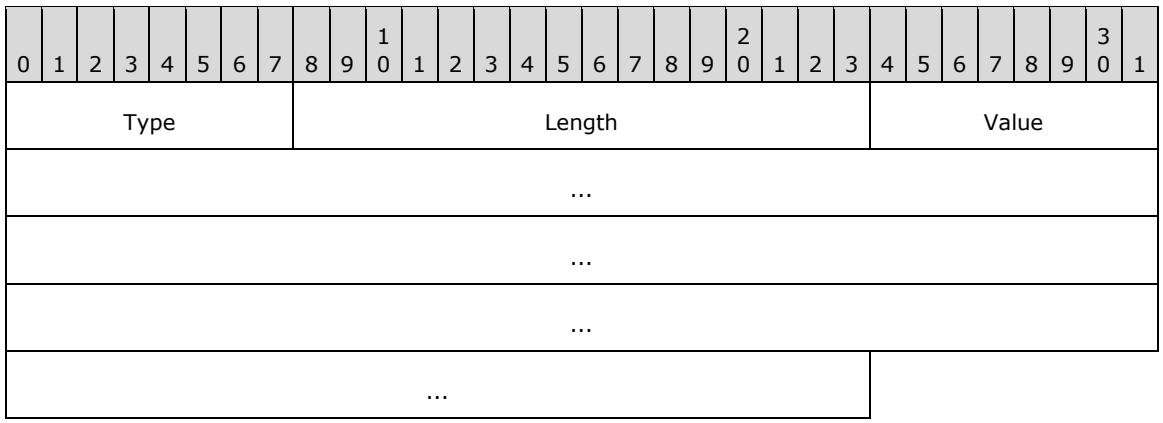
Type (1 byte): The type of TLV, which is 0x02 for the RTSP Port TLV.

Length (2 bytes): The length of the **Value** field, in bytes, which is 0x0002.

Value (2 bytes): The RTSP port on which the Source is listening (7236 by default).

2.2.3.3 Source ID TLV

The Source ID **TLV** specifies a unique identifier for the Miracast Source. That identifier is used in all messages sent during a session.



Type (1 byte): The type of TLV, which is 0x03 for the Source ID TLV.

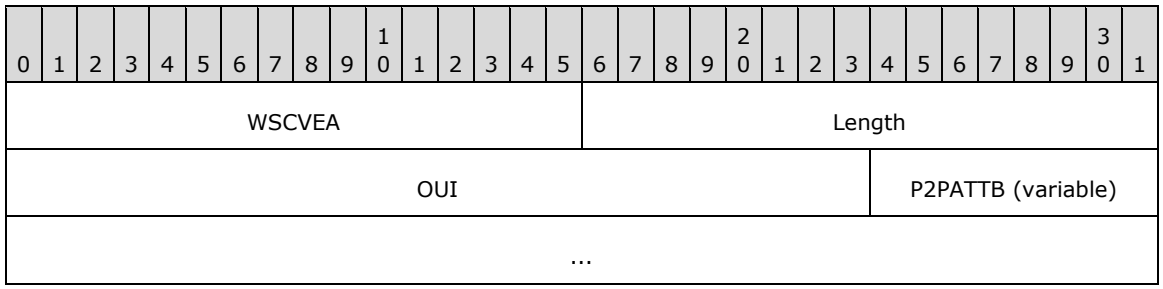
Length (2 bytes): The length of the **Value** field, in bytes, which is 0x0010.

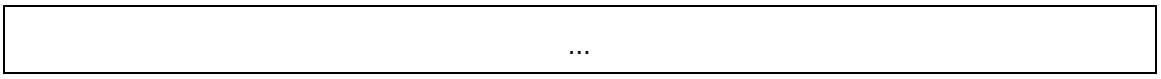
Value (16 bytes): An implementation-defined value that identifies the Source.

2.2.4 Vendor Extension Attribute

The **Vendor Extension a**ttribute is a WSC **information element (IE)** structure that is used by a Miracast Sink to publish **peer to peer (P2P)** attribute structures defined by the Miracast over Infrastructure protocol.

As specified in [WF-WSC2.0.2], the Vendor Extension attribute has the following general format.





WSCVEA (2 bytes): The value is 0x1049 to indicate that this attribute is a WSC vendor extension.

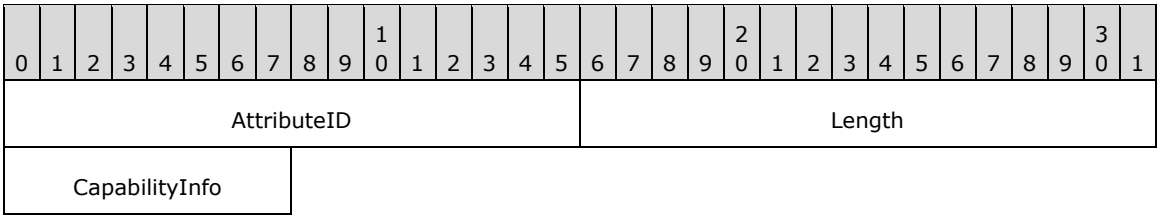
Length (2 bytes): The length of the following fields in bytes.

OUI (3 bytes): A **Wi-Fi Protected Setup (WPS) organizationally unique identifier (OUI)** [IEEE-OUI]. The value is 0x000137 for messages defined by this specification.

P2PATTB (variable): One or more of the P2P attribute structures defined in the sections that follow. Attributes can be included in any order.

2.2.4.1 Capability Attribute

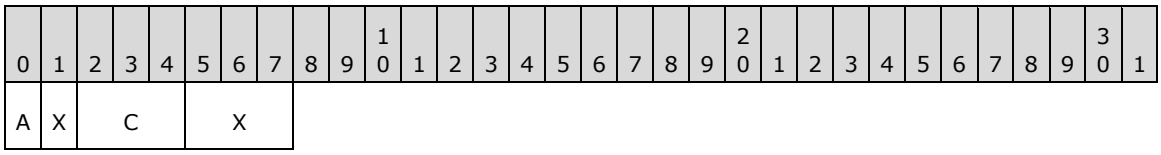
The **Capability** attribute indicates whether a connection over Miracast over Infrastructure is possible. This attribute MUST be present in the Vendor Extension attribute.



AttributeID (2 bytes): The Capability attribute ID, which is 0x2001.

Length (2 bytes): The length of the **CapabilityInfo** field, in bytes, which is 0x0001.

CapabilityInfo (1 byte): A bit field table with capability information, which has the following structure:



A - MiracastOverInfrastructureSupport (1 bit): 0 = not supported, 1 = supported.

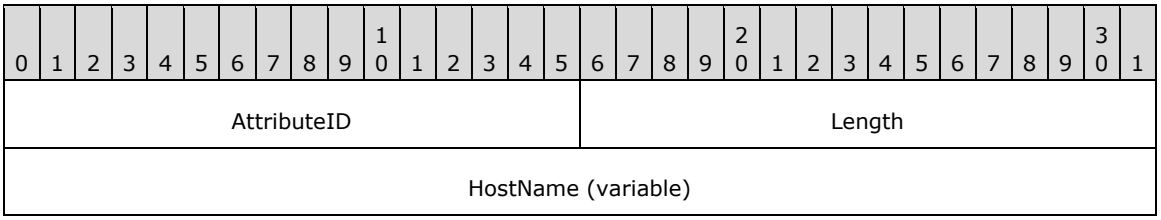
X - Reserved (1 bit): Reserved.

C - Version (3 bits): The version of this protocol, which is 0x1.

X - Reserved (3 bits): Reserved.

2.2.4.2 Host Name Attribute

The **Host Name** attribute specifies the Miracast Sink host name. This attribute MUST be present exactly once in the Vendor Extension attribute.



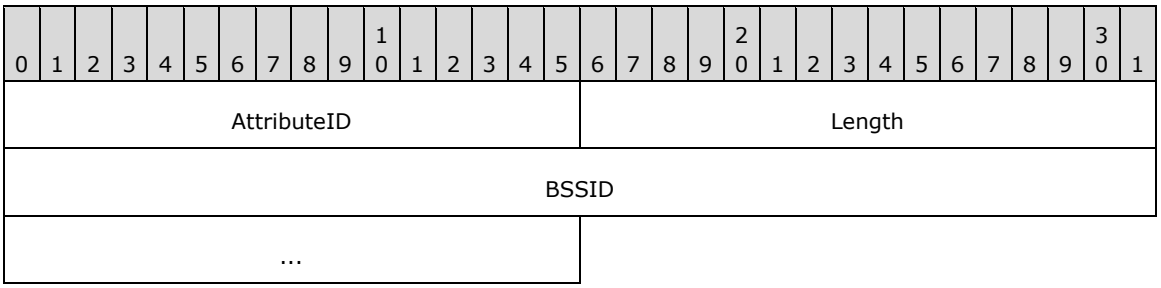
AttributeID (2 bytes): The Host Name attribute ID, which is 0x2002.

Length (2 bytes): The length of the **HostName** field, in bytes.

HostName (variable): The Miracast Sink host name string, encoded in **ASCII**. The host name is not fully qualified. A Sink having a host name that contains the period ('.') character MUST NOT be used for Miracast over Infrastructure connections.

2.2.4.3 BSSID Attribute

The **BSSID** attribute specifies the **basic service set identifier (BSSID)** for the **802.11 Access Point (AP)** [IEEE802.11-2012] associated with the wireless network. This attribute is optional in the Vendor Extension attribute, but it MUST NOT appear more than once.



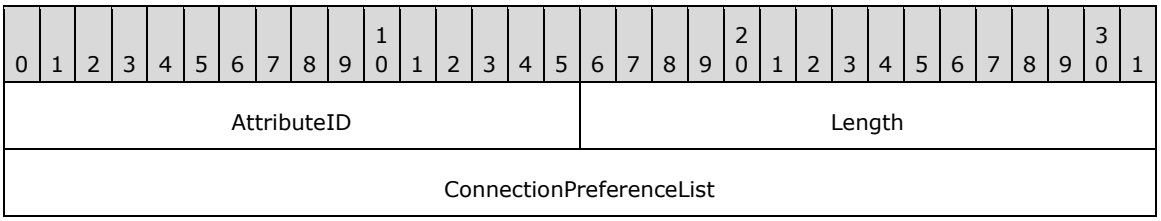
AttributeID (2 bytes): The BSSID attribute ID, which is 0x2003.

Length (2 bytes): The length of the **BSSID** field, in bytes, which is 0x0006.

BSSID (6 bytes): The BSSID for the associated **WAP**.

2.2.4.4 Connection Preference Attribute

The **Connection Preference** attribute indicates the preference of transports for the connection of the Miracast Sink to the Miracast Source. The Sink MAY include a Connection Preference attribute in the Vendor Extension attribute, but it MUST NOT appear more than once.



AttributeID (2 bytes): The Connection Preference attribute ID, which is 0x2004.

Length (2 bytes): The length of the **ConnectionPreferenceList** field, in bytes, which is 0x0004.

ConnectionPreferenceList (4 bytes): A packed array with room for 8 connection transport IDs, in descending order of preference. The following IDs are defined.

Transport ID	Transport
0x1	Miracast over Infrastructure
0x2	**Wi-Fi Direct (WFD)**

The following is an example of a preference list buffer with Miracast over Infrastructure preferred over WFD.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
0x1				0x2				0				0				0				0				0				0			

2.2.4.5 IP Address Attribute

The **IP Address** attribute specifies an IP address of the Miracast Sink. This attribute can occur zero or more times in the Vendor Extension attribute. The set of IP addresses included in the Vendor Extension attribute SHOULD<1> be the same set as the Sink's mDNS responder would provide to an mDNS requester.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
AttributeID																Length															
IPAddress (variable)																															
...																															
...																															

AttributeID (2 bytes): The IP Address attribute ID, which is 0x2005.

Length (2 bytes): The length of the **IPAddress** field, in bytes.

IPAddress (variable): An IP address string, encoded in **ASCII**. The supported address formats are **IPv4** in dotted decimal notation ([RFC1123] section 2.1) and **IPv6** ([RFC4291] section 2.2).

3 Protocol Details

A Miracast over Infrastructure session consists of three phases: device discovery, host name resolution, and projection, as shown in the following diagram.

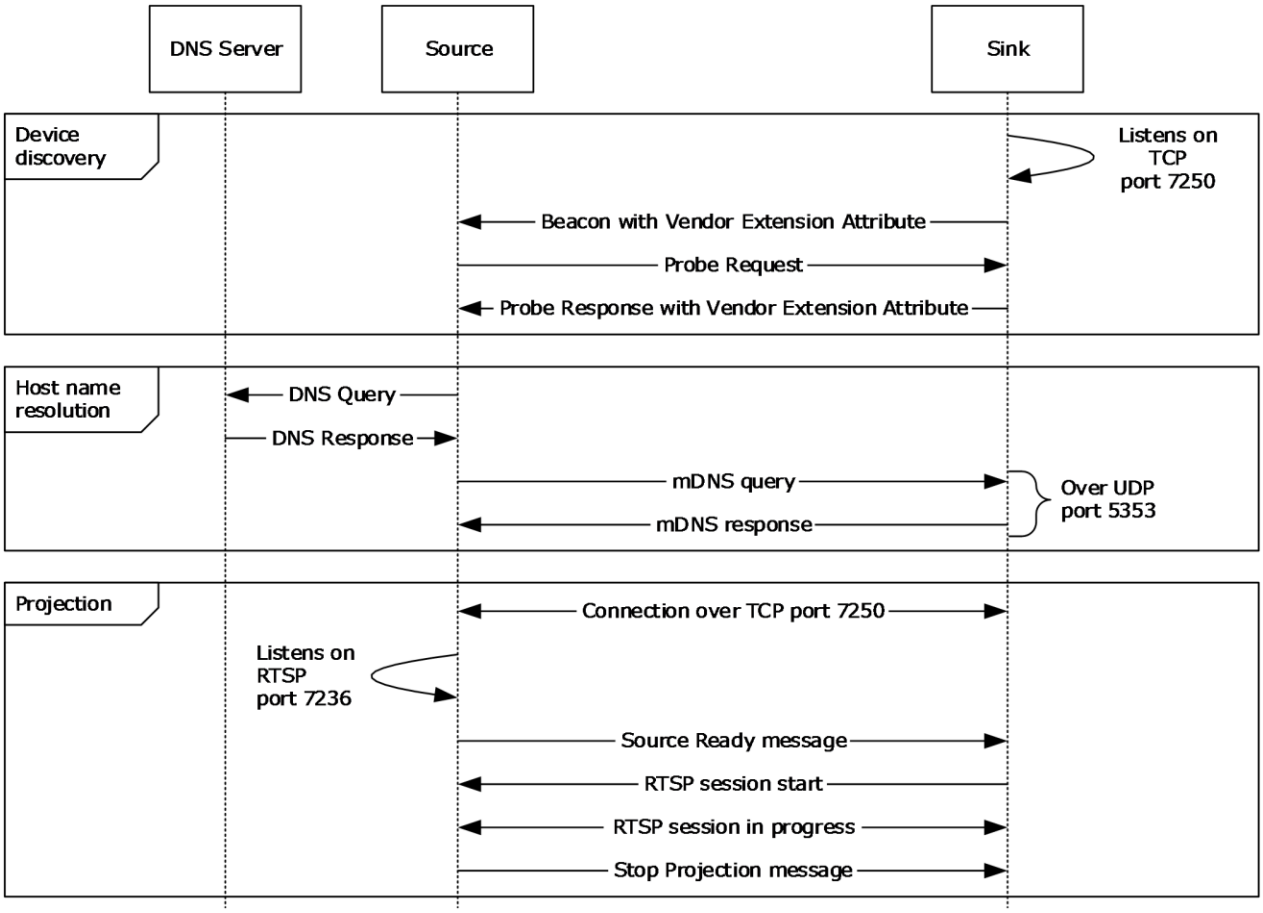


Figure 2: A Miracast over Infrastructure session

Device discovery

The Miracast over Infrastructure session starts with **peer to peer (P2P)** device discovery ([WF-P2P1.2] section 3.1.2), which a Miracast Source uses to find a device capable of performing the functions of a Miracast Sink. This includes the Source sending **Probe Request** frames ([WF-P2P1.2] section 4.2.2) and listening for **Probe Response** frames ([WF-P2P1.2] section 4.2.3) and **Beacon** frames ([WF-P2P1.2] section 4.2.1).

Beacon frames are unsolicited broadcasts that advertise P2P devices. Probe Response frames are sent by a Sink in response to Probe Request frames sent by the Source. If the Source receives a Beacon or Probe Response that contains a WSC **IE** [WF-WSC2.0.2] Vendor Extension attribute (section 2.2.4), the Source checks the Capability attribute (section 2.2.4.1) for Miracast over Infrastructure support.

If the Capability attribute specifies that Miracast over Infrastructure is not supported, the Source falls back to standard Miracast [WF-WSC2.0.2].

If one or more IP Address attributes (section 2.2.4.5) are included, the Source can skip host name resolution.

Host name resolution

The host name received by the Source during device discovery specifies the unqualified host name of the target Sink. The Source tries to resolve this host name by using **DNS** [IANA-DNS] [RFC1034] [RFC2181] and/or mDNS [RFC6762].

When host name resolution is complete, the session proceeds to the Projection phase.

The Source uses a **Discovery timer** (section 3.2.2) to limit the time it spends on host name resolution. If this timer reaches its timeout, the host name resolution fails, and the Source falls back to standard Miracast.

Projection

When the Source finds a device that can perform as the Sink, the Source attempts a connection to it over **TCP** port 7250, which it will use for sending Miracast over Infrastructure messages (section 2.2) to the Sink. These messages include starting and stopping the projection.

If the connection fails, the Source falls back to standard Miracast.

The Sink is expected to be listening for a Source Ready message (section 2.2.1) on TCP port 7250. When the Source is ready to project, it listens on **Real-Time Streaming Protocol (RTSP)** control port 7236 for a connection request, then it sends the Source Ready message. In turn, the Sink connects to the specified RTSP Source port to establish the link.

To pause or stop the projection, the Source sends a Stop Projection message (section 2.2.2) to notify the Sink. Upon receipt of that message, the Sink stops displaying the stream, and a disconnection follows from the Source on the socket that is connected on port 7250. The Source resumes projection by sending another Source Ready message to the Sink.

3.1 Miracast Sink Details

3.1.1 Abstract Data Model

None.

3.1.2 Timers

None.

3.1.3 Initialization

Upon initialization, the Miracast Sink SHOULD register the following service instance name ([RFC6763] section 4.1) with the Sink's local mDNS implementation.

```
<instance name>._display._tcp.local
```

The <instance name> is the **friendly name** of the Sink, which will be associated with both port 7250 and the following TXT key-value pair ([RFC6763] section 6).

Key: container_id

Value: A **GUID** that identifies the Sink.

This service instance name is also used in [WF-DTS2.1] section 4.4.1.

After registering the service instance name, the Sink MUST start listening on **TCP** port 7250 for an inbound connection.

Finally, the Sink MUST begin being discoverable by **Beacons** and/or **Probe Requests** as in standard Miracast [WF-WSC2.0.2], except that every Beacon and **Probe Response** the Sink sends MUST include a Vendor Extension attribute (section 2.2.4).

3.1.4 Higher-Layer Triggered Events

None.

3.1.5 Message Processing Events and Sequencing Rules

3.1.5.1 Receive Probe Request

When a Miracast Sink receives a **Probe Request** message, the Sink MUST send a **Probe Response** message [WF-P2P1.2] and include a WSC IE [WF-WSC2.0.2] Vendor Extension attribute (section 2.2.4) with a Capability Attribute (section 2.2.4.1) that indicates support for Miracast over Infrastructure.

3.1.5.2 Receive Connection Request

When a Miracast Sink receives a new **TCP** connection attempt on port 7250, but it already has a TCP connection established, the Sink SHOULD reject the new connection request, but it MAY close the existing TCP connection instead and accept the new one.<2>

3.1.5.3 Receive Source Ready Message

When a Miracast Sink receives a Source Ready message (section 2.2.1), it MUST connect back to the Source over **TCP** on the **RTSP** port specified in the message.

3.1.5.4 Receive Stop Projection Message

When a Miracast Sink receives a Stop Projection message (section 2.2.2), it MUST stop displaying the stream.

3.1.6 Timer Events

None.

3.1.7 Other Local Events

If the **RTSP** connection receives a teardown message as it does in standard Miracast, or if the connection to the Source is lost, or if the TCP port 7250 connection is lost, the Sink MUST close its session.

3.2 Miracast Source Details

3.2.1 Abstract Data Model

This section describes a conceptual model of possible data organization that an implementation maintains to participate in this protocol. The described organization is provided to facilitate the explanation of how the protocol behaves. This document does not mandate that implementations adhere to this model, provided their external behavior is consistent with that described in this document.

A Source ID **TLV** (section 2.2.3.3) is maintained throughout the lifetime of the Miracast session. It is included in all Miracast messages (section 2.2) to identify the Miracast Source.

3.2.2 Timers

This Miracast Source uses the following timers.

Discovery timer: This timer is used to limit the time the Source spends on host name resolution before giving up and falling back to standard Miracast.

Control channel connection timer: This timer is used to limit the time the Source spends waiting for the Sink to connect to it before giving up and falling back to standard Miracast.

3.2.3 Initialization

The Source ID **TLV** (section 2.2.3.3) of the abstract data model (section 3.2.1) is initialized to an implementation-dependent value.

3.2.4 Higher-Layer Triggered Events

When a higher-layer application requests discovery of Miracast Sinks, the Miracast Source MUST send a standard **Probe Request** to Miracast Sinks within range, as specified in [WF-P2P1.2].

When the higher-layer application or protocol requests to disconnect the Miracast connection, the Source MUST send the Stop Projection message (section 2.2.2) to the Sink to stop the projection of the multimedia data stream. After sending this message, the Source MUST close the TCP session.

3.2.5 Message Processing Events and Sequencing Rules

3.2.5.1 Receive Beacon with Vendor Extension Attribute

When a Miracast Source receives a **Beacon** message that includes a Vendor Extension Attribute (section 2.2.4), it MUST check the **MiracastOverInfrastructureSupport** bit in the Capability attribute (section 2.2.4.1), which indicates whether the Sink supports Miracast over Infrastructure.

If Miracast over Infrastructure is supported by the Sink, the Source MUST do the following.

1. If one or more IP Address attributes (section 2.2.4.5) are present in the message, the Source SHOULD<3> skip name resolution and treat the addresses as the result of host name resolution, by proceeding as specified in section 3.2.5.3; however, the Source MAY instead ignore them and continue as if they were not present.

2. If host name resolution was not skipped, the Source MUST do the following.

    1. Start its **Discovery timer** (section 3.2.2) to expire after an implementation-specific<4> period of time if host name resolution does not complete.

    2. Begin host name resolution on the name in the Host Name Attribute (section 2.2.4.2), using DNS and/or mDNS, the choice of which is implementation-specific.<5>

3.2.5.2 Receive Probe Response with Vendor Extension Attribute

When a Miracast Source receives a **Probe Response** message that includes a Vendor Extension Attribute (section 2.2.4), the Source MUST check the **MiracastOverInfrastructureSupport** bit in the Capability attribute (section 2.2.4.1), which indicates whether a Sink supports Miracast over Infrastructure.

If Miracast over Infrastructure is supported by the Sink, the Source MUST perform the actions specified in section 3.2.5.1, as if it had received a **Beacon** message indicating that the Sink supports Miracast over Infrastructure.

3.2.5.3 Host Name Resolution Complete

When a Miracast Source obtains a set of one or more IP addresses of the Miracast Sink, the Source MUST do the following.

1. Cancel its **Discovery timer** (section 3.2.2).
2. Start its **Control Channel Connection timer**, which will expire after an implementation-specific<6> time unless it receives a connection over the **RTSP** control channel.
3. Attempt a connection to one of the IP addresses over **TCP** port 7250. The method of choosing a Sink IP address is implementation-specific.<7>

3.2.5.4 Miracast Connection Complete

When the connection to the Sink over **TCP** port 7250 fails, the Source MUST do the following:

1. Abandon its attempt to start a Miracast over Infrastructure session.
2. Fall back to using standard Miracast [WF-WSC2.0.2].

If the connection attempt succeeds, the Source MUST do the following.

1. Begin listening on **RTSP** control port 7236 for a connection request.
2. Send a Source Ready message (section 2.2.1) over the TCP session.

3.2.5.5 RTSP Connection Accepted

When a Miracast Sink accepts an **RTSP** connection, the Miracast Source MUST do the following.

- Cancel the **Control Channel Connection** timer (section 3.2.2).
- Perform standard RTSP behavior.

3.2.6 Timer Events

If either of the Miracast Source timers (section 3.2.2) reaches its timeout, the Source MUST do the following.

1. Abandon its attempt to start a Miracast over Infrastructure session.
2. Fall back to using standard Miracast [WF-WSC2.0.2].

3.2.7 Other Local Events

None.

4 Protocol Examples

The following sections describe examples of Miracast over Infrastructure structures, which were taken from network captures of the protocol.

4.1 Vendor Extension Attribute Example

This is an example of the Vendor Extension attribute (section 2.2.4).

```
10 49       // WSC Vendor Extension attribute
00 19       // Length (25 bytes)
00 01 37    // OUI (WPS ID)

20 01       // Capability attribute
00 01       // Length (1 byte)
88          // Capability info

20 02       // Host Name attribute
00 0F       // Length (15 bytes)
44 75 6D 6D 79 31 2D 4B 61 62 79 6C 61 6B 65 // "Dummy1-Kabylake"
```

4.2 Source Ready Message Example

This is an example of the Source Ready message (section 2.2.1).

```
00 3D       // Length (61 bytes)
01          // Version
01          // SOURCE READY

00          // Friendly Name TLV
00 1E       // Length (30 bytes)
44 00 75 00 6D 00 6D 00 79 00 31 00 2D 00 4B 00 // "Dummy1-Kabylake"
61 00 62 00 79 00 6C 00 61 00 6B 00 65 00

02          // RTSP Port TLV
00 02       // Length (2 bytes)
1C 44       // Port (7236)

03          // Source ID TLV
00 10       // Length (16 bytes)
91 F4 AB E9 EF F5 46 4A AE E2 69 72 2A ED 11 B5 // Source ID
```

4.3 Stop Projection Message Example

This is an example of the Stop Projection message (section 2.2.2).

```
00 38       // Size (56 bytes)
01          // Version
02          // STOP PROJECTION

00          // Friendly Name TLV
00 1E       // Length (30 bytes)
44 00 75 00 6D 00 6D 00 79 00 31 00 2D 00 4B 00 // "Dummy1-Kabylake"
61 00 62 00 79 00 6C 00 61 00 6B 00 65 00

03          // Source ID TLV
00 10       // Length (16 bytes)
91 F4 AB E9 EF F5 46 4A AE E2 69 72 2A ED 11 B5 // Source ID
```

5 Security Considerations

Because a Miracast over Infrastructure session has no security of its own, use it only when security is provided at another layer, such as link layer security (WPA2) on a wireless network, or physical security on a wired network.<8>

6 Appendix A: Product Behavior

The information in this specification is applicable to the following Microsoft products or supplemental software. References to product versions include updates to those products.

- Windows 10 v1703 operating system

Exceptions, if any, are noted in this section. If an update version, service pack or Knowledge Base (KB) number appears with a product name, the behavior changed in that update. The new behavior also applies to subsequent updates unless otherwise specified. If a product edition appears with the product version, behavior is different in that product edition.

Unless otherwise specified, any statement of optional behavior in this specification that is prescribed using the terms "SHOULD" or "SHOULD NOT" implies product behavior in accordance with the SHOULD or SHOULD NOT prescription. Unless otherwise specified, the term "MAY" implies that the product does not follow the prescription.

<1> Section 2.2.4.5: The Windows Sink implementation adds a single IP Address attribute with an **IPv4** address.

<2> Section 3.1.5.2: The Windows Sink implementation rejects new connections except on the Surface Hub **SKU**, where the new connection replaces the existing one.

<3> Section 3.2.5.1: The IP Address attribute (section 2.2.4.5) is not supported in Windows 10 v1709 operating system and earlier implementations.

<4> Section 3.2.5.1: The Windows implementation uses a period of 1.5 second for the **Discovery timer**.

<5> Section 3.2.5.1: The Windows implementation attempts both DNS and mDNS in parallel and uses the first one to respond; however, when connected to a **virtual private network (VPN)**, mDNS is preferred, so if the Windows implementation gets DNS results, it still waits for mDNS to complete or time out.

<6> Section 3.2.5.3: The Windows implementation uses a period of 5 seconds for the **Control Channel Connection timer**.

<7> Section 3.2.5.3: The Windows implementation of the Source chooses the first IP address in the set.

<8> Section 5: The Windows implementation does not attempt a Miracast over Infrastructure connection over a wireless network, if the wireless network it is connected to does not employ link layer security (WPA2).

7 Change Tracking

This section identifies changes that were made to this document since the last release. Changes are classified as Major, Minor, or None.

The revision class **Major** means that the technical content in the document was significantly revised. Major changes affect protocol interoperability or implementation. Examples of major changes are:

- A document revision that incorporates changes to interoperability requirements.
- A document revision that captures changes to protocol functionality.

The revision class **Minor** means that the meaning of the technical content was clarified. Minor changes do not affect protocol interoperability or implementation. Examples of minor changes are updates to clarify ambiguity at the sentence, paragraph, or table level.

The revision class **None** means that no new technical changes were introduced. Minor editorial and formatting changes may have been made, but the relevant technical content is identical to the last released version.

The changes made to this document are listed in the following table. For more information, please contact dochelp@microsoft.com.

Section	Description	Revision class
1.3 Overview	8371 : Added support for skipping source name resolution.	Major
2.2.3.1 Friendly Name TLV	8371 : Defined the maximum length of the friendly name string.	Major
2.2.4.5 IP Address Attribute	8371 : Added the IP Address vendor extension attribute.	Major
3 Protocol Details	8371 : Added a detailed diagram and summary of the behavior of a Miracast over Infrastructure session.	Major
3.1.5.1 Receive Probe Request	8371 : Added Receive Probe Request section.	Major
3.1.5.2 Receive Connection Request	8371 : Added Receive Connection Request section.	Major
3.2.5 Message Processing Events and Sequencing Rules	8317 : Added support for skipping source name resolution.	Major
3.2.5.1 Receive Beacon with Vendor Extension Attribute	8371 : Added Receive Beacon with Vendor Extension Attribute section.	Major
3.2.5.2 Receive Probe Response with Vendor Extension Attribute	8371 : Added Receive Probe Response with Vendor Extension Attribute section.	Major
3.2.5.3 Host Name Resolution Complete	8371 : Added Host Name Resolution Complete section.	Major
3.2.5.4 Miracast Connection Complete	8371 : Added Miracast Connection Complete section.	Major
3.2.5.5 RTSP Connection Accepted	8371 : Added RTSP Connection Accepted section.	Major

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