Car Connectivity Consortium

MirrorLink®

Connectivity

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TERMS AND ABBREVIATIONS

AP	Access Point
ARP	Address Resolution Protocol
CDC	Communications Device Class; specified from USB Device Working Group
CE	Consumer Electronics; CE devices are referred to as mobile devices within this specification
DHCP	Dynamic Host Configuration Protocol
HMI	Human Machine Interface
HU	Head-unit (this term is used interchangeably with the MirrorLink Client)
HS	Head-set
IP	Internet Protocol
NCM	Network Control Model; part of the CDC device class
Pointer Event	Pointer events are used to describe touch screen action in which the user touches the screen with one (virtual) finger only at a single location.
RFB	Remote Framebuffer
RTP	Real-time Transport Protocol
TCP	Transmission Control Protocol
Touch Event	Touch events are used to describe touch screen action in which the user touches the screen with two or more separate fingers at different locations. Touch events are used to describe more complex touch action, like pinch-open or pinch-close.
UDP	User Datagram Protocol
UI	User Interface
UPnP	Universal Plug and Play
USB	Universal Serial Bus
VNC	Virtual Network Computing

1 ABOUT

This document is part of the MirrorLink specification which specifies an interface for enabling remote user interaction of a mobile device via another device. This specification is written having a vehicle head-unit to interact with the mobile device in mind, but it will similarly apply for other devices, which provide a color display, audio input/output and user input mechanisms.

The document will focus on the interface functionality, its parameters and protocols only. It does not provide any guidelines for implementing the protocol. If there is a reference towards an implementation, this is of an informative nature only.

The specification lists a series of requirements, either explicitly or within the text, which are mandatory elements for compliant solutions. Recommendations are given, to ensure optimal usage and to provide suitable performance. All recommendations are optional.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are following the notation as described in RFC 2119 [3].

1. MUST: This word, or the terms "REQUIRED" or "SHALL", means that the definition is an absolute requirement of the specification.
2. MUST NOT: This phrase, or the phrase "SHALL NOT", means that the definition is an absolute prohibition of the specification.
3. SHOULD: This word, or the adjective "RECOMMENDED", means that there may exist valid reasons in particular circumstances to ignore a particular item, but the full implications must be understood and carefully weighed before choosing a different course.
4. SHOULD NOT: This phrase, or the phrase "NOT RECOMMENDED" means that there may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
5. MAY: This word, or the adjective "OPTIONAL", means that an item is truly optional. One vendor may choose to include the item because a particular marketplace requires it or because the vendor feels that it enhances the product while another vendor may omit the same item. An implementation which does not include a particular option MUST be prepared to interoperate with another implementation which does include the option, though perhaps with reduced functionality. In the same vein an implementation which does include a particular option MUST be prepared to interoperate with another implementation which does not include the option (except, of course, for the feature the option provides.)

2 INTRODUCTION

The connectivity between the MirrorLink Server and client is the basis to provide interoperability between both. The Connectivity stack is specified in the following, starting from the low layer and going up the protocol stack.

It is not the objective of this specification to provide a detailed overview of the different protocols. Instead this document highlights the components and parameters required to ensure proper connectivity. The connectivity solution is built purely on existing wireless and wired standards. Therefore detailed information is available in the respective documents.

3 PHYSICAL & LINK LAYER

In principle this specification does not intend to limit the use of any wireless and wired technology. Nevertheless the connectivity solution SHOULD provide reasonable high bandwidth. Minimum bandwidth on link layer cannot be given, as the user experience depends on the networking & transport layer performance, as well as on the parameters of the display (resolution and color format).

The following table gives some indication of the required bandwidth on the display level, i.e. on top of any transport mechanism. These values assume non-incremental, uncompressed updates.

Full Display Update / s	Example: QVGA 320 x 240 x 4	Example: QHD 640 x 360 x 4	Example: WVGA 800 x 480 x 2	Example: WVGA 800 x 480 x 4
2	614 000 Byte/s	1 843 200 Byte/s	1 536 000 Byte/s	3 072 000 Byte/s
5	1 536 000 Byte/s	4 608 000 Byte/s	3 840 000 Byte/s	7 680 000 Byte/s
10	3 072 000 Byte/s	9 216 000 Byte/s	7 680 000 Byte/s	15 360 000 Byte/s
20	6 144 000 Byte/s	18 432 000 Byte/s	15 360 000 Byte/s	30 720 000 Byte/s

Table 1: Bandwidth Requirements vs. Display Update Rate

Wired technologies have advantages with regard to achievable bandwidth and security over wireless technologies. In addition wired USB provides charging capabilities and is the preferred charging interface in the mobile industry.

3.1 Universal Serial Bus (USB)

USB provides a high-bandwidth connection while allowing charging of the mobile device at the same time. The MirrorLink Client MUST provide a USB host. The MirrorLink Server MUST provide USB device functionality.

The USB host and device MUST at least support USB 2.0 high-speed.

3.1.1 MirrorLink USB Command

To simplify the user intervention on the MirrorLink Server, it MAY set the right USB personality automatically[1], once connected to the MirrorLink Client. To inform the MirrorLink Server about the client's MirrorLink support, the USB host SHOULD send a specific identification message to the USB device, prior to configuring the device, according the following format.

```
bmRequestType = 0x40
bRequest      = 0xF0
wValue[1]     = MirrorLink major version
wValue[2]     = MirrorLink minor version
wIndex        = USB Host vendorID
wLength       = 0
Data          = None
```

USB uses little endian. Therefore the MirrorLink minor version is in the high byte and the MirrorLink major version in the low byte of wValue.

```
MirrorLink 1.0:  wValue = 0x0001 (0x01, 0x00)
MirrorLink 1.1:  wValue = 0x0101 (0x01, 0x01)
```

[1] A USB personality MAY include multiple USB device classes, which can be then used from the USB host simultaneously.

A MirrorLink Server SHOULD apply a received MirrorLink version 0.1 as a 1.0 version (for backward compatibility reasons).

The USB device MUST recognize MirrorLink USB command message. The USB device SHOULD select the respective USB personality, if in line with the user preferences. If the MirrorLink Client does not send the described identification message or the user has different preferences, the mobile device MUST allow for manual or semi-manual selection of the USB CDC/NCM profile.

The MirrorLink specification does not specify, whether USB CDC/NCM is provided as an individual device class or within a USB personality. In latter case, it is up to the USB device implementation, which other USB device classes MAY be available under the same personality, where USB CDC/NCM is provided. The USB Host MUST support CDC/NCM within a USB personality and as an individual device class.

3.1.2 Managing USB Personalities using the MirrorLink USB Command

If a MirrorLink Client wants to use MirrorLink immediately upon physical connection of the USB port, the client SHOULD send the MirrorLink USB command before the end of the USB enumeration, to ask the MirrorLink Server to provide a USB personality supporting MirrorLink (i.e. allowing a USB-CDC/NCM).

If a MirrorLink Client wants to change to MirrorLink from other USB personalities at a later time, the MirrorLink Client SHOULD send the MirrorLink USB command at a later time. Alternatively, the MirrorLink Client MAY reset the USB connection[2].

If the MirrorLink Server is not able to switch to USB CDC/NCM functionality in response to the MirrorLink USB command, e.g. as the user has a different preference, the USB device MUST respond with a STALL PID. If the MirrorLink Server responds with a STALL PID (refer to [1], section 9.2.7), it MUST provide a mechanism for the user to switch to MirrorLink.

Using the MirrorLink USB command, the MirrorLink Client is able to detect an operating MirrorLink Server connected to it, if all of the following conditions are true:

1. The MirrorLink USB command does not return with STALL PID
2. The USB device descriptor has USB CDC/NCM
3. A MirrorLink device is advertised over UPnP

If the MirrorLink Client wants to switch from MirrorLink to another USB personality or device class, it MUST reset the USB connection. It will be up to the MirrorLink Server to select a different USB personality; therefore the MirrorLink Server MAY still provide MirrorLink functionality.

If the MirrorLink Server wants to switch from MirrorLink to another USB personality or device class, it MUST reset the USB connection and provide a new USB personality or device class.

3.1.3 Interoperability Issues using the MirrorLink USB Command

USB devices, not supporting MirrorLink USB command, will return STALL PID in compliance with USB 2.0 core specification [1].

Nevertheless, the MirrorLink Client MAY recognize that a connected USB device is not working, after sending the MirrorLink USB command, e.g. the USB host is not able to read the USB device descriptor. This might be the case, if the connected USB device has not been certified from USB-IF. To resolve this issue, the MirrorLink Client SHOULD reset the USB connection and SHOULD NOT send the MirrorLink USB command again after reset.

[2] Resetting the USB connection does not inform the MirrorLink Server, that the MirrorLink Client supports MirrorLink.

3.2 Wireless Local Area Networks (WLAN)

Support for Wireless LAN is OPTIONAL and MirrorLink WLAN connectivity is implemented by Wi-Fi technology of Wi-Fi Alliance. In order to meet the required bandwidth described in Table 1, only IEEE 802.11a, IEEE 802.11g and IEEE 802.11n are used for MirrorLink. The IEEE802.11n is RECOMMENDED to provide more stable and enough user experience.

Both, MirrorLink Server and MirrorLink Client can be Access Point (AP) and Client. Which entity is taking which role, depends on the configuration of the MirrorLink Client and Server. The decision making is out of scope of MirrorLink.

Link-Layer authentication mechanisms, like WPA, MUST be used, if mandated from the MirrorLink Server or from the MirrorLink Client.

3.2.1 Wi-Fi P2P connection

If a MirrorLink Server and Client want Wi-Fi P2P connection, it MUST proceed Wi-Fi connection setup as defined at Wi-Fi P2P specification [2].

If a MirrorLink Client is setup to connect in this mode and the MirrorLink Server is set to operate in same mode, the two devices find each other over Wi-Fi technology and negotiate the AP and client role in autonomous way by exchanging Group Owner negotiation procedure defined in the Wi-Fi P2P specification.

The AP role negotiation is performed as following, as defined in [2],

1) The Wi-Fi interface turns on at both of MirrorLink Server and Client
2) If the Wi-Fi mode is set to P2P mode, it proceed to Wi-Fi Device discovery as defined in [2]
3) After Wi-Fi Device discovery, both sides MAY perform Wi-Fi Service discovery to find each other.
4) The MirrorLink Server and Client exchange Group Owner negotiation messages to negotiate AP role by checking GO Intent value in the message.
5) The device sends higher value of GO Intent value field takes Group Ownership and starts AP mode

4 NETWORKING AND TRANSPORT LAYER

Networking mechanisms are used to abstract the different physical transport mechanisms. The Internet Protocol is a well-established and known networking solution.

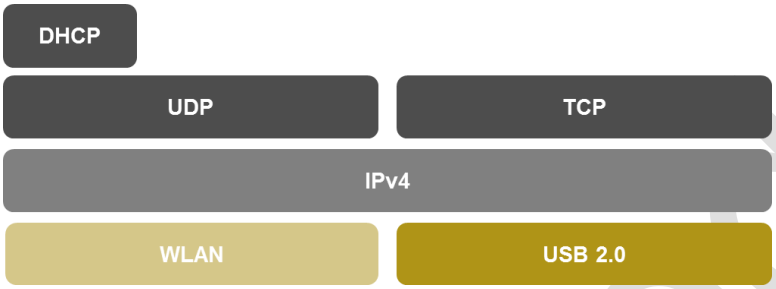

Figure 1: MirrorLink Networking and Transport Stack

This specification anticipates only USB and WLAN networking, as shown in Figure 1. Other wired or wireless links MAY be supported, as long as they carry IP packets.

4.1 USB Networking

Support for USB Networking is mandatory.

The USB networking MUST follow CDC/NCM device class, revision 1.0 specification[3]. The host and client SHOULD support a Maximum Transmission Unit (MTU) size bigger than 1,500 Bytes. It is recommended they support MTU sizes up to 9000 Byte. The USB host MUST follow the maximum Ethernet frame size supported from the USB device as discovered from the value `wMaxSegmentSize` in the Ethernet Networking Functional Descriptor (For details refer to [1]) and supported from the host.

4.2 WLAN Networking

Support for Wireless Local Area Network (WLAN) is OPTIONAL. IP packets are carried over WLAN connections, using the Ethernet LLC/SNAP framing. On network types other than Ethernet, LLC and SNAP headers are REQUIRED to multiplex different protocols on the link layer.

4.3 IP Configuration

The networking layer MUST support IPv4. It MAY support IPv6.

4.3.1 IPv4 Configuration

MirrorLink Server and MirrorLink Client MAY support IPv4 only or both IPv4 and IPv6. For IP connection IP addressing is a fundamental functionality of both side devices.

For IP addressing, MirrorLink Server and MirrorLink Client MUST support Dynamic Host Configuration Protocol (DHCP) which is standardized as IETF RFC 2131 and the role of DHCP server and DHCP client is decided by each connectivity technology and use cases.

- The Wi-Fi AP MUST have a DHCP server
- A MirrorLink Server providing USB Device functionality MUST have a DHCP server

[3] According to USB CDC/NCM specification, the device and host MUST support 16-bit NTB structures (NTB-16) and MAY also support 32-bit NTB structures (NTB-32).

DHCP use UDP as transport protocol and well known port numbers are used for the communication

- Packets sent from the client have source port 68 and destination port 67.
- Packets sent from the server have source port 67 and destination port 68.

The DHCP server on the MirrorLink Server MUST provide an IP address within the `192.168.x.y` with `x` in the range of 2 to 127 and `y` in the range of 0 to 254. The netmask MUST be `255.255.255.z` with `z` in the range of 0 to 254.

The DHCP server on the MirrorLink Client MUST provide an IP address within the `192.168.x.y` with `x` in the range of 2 to 254 and `y` in the range of 0 to 254. The netmask MUST be `255.255.255.z` with `z` in the range of 0 to 254.

The DHCP client SHOULD use ARP to resolve potential IP conflicts on the MirrorLink interface. If the DHCP client has multiple interfaces via different networks (i.e. Wi-Fi Interface and USB Interface), the DHCP client SHOULD be able to detect IP conflicts between the interfaces. If the DHCP client indicates that an IP conflict occurred, sending a DHCPDECLINE message, the DHCP server MUST offer a new IP address `192.168.x_new.y_new`, where at least `x_new` is different from the previous offered address or it MUST provide a manual mechanism to change the provided IP address to achieve the same IP address change.

The DHCP server MAY provide a default gateway address for the DHCP client. Provisioning of the default gateway address SHOULD NOT be interpreted as if the DHCP server provides Internet connectivity. The MirrorLink specification does not intend to specify the setup of IP routing functionality on the DHCP server.

4.4 Transport Layer

The IP protocol enables two transport mechanisms,

- User Datagram Protocol (UDP) to provide connectionless communication, used for service advertising, multi-casting, and most real-time streaming protocols
- Transmission Control Protocol (TCP) to provide connection-oriented communication

The transport layer MUST support UDP and TCP transport protocols on top of IP.

5 SESSION & APPLICATION LAYER

The MirrorLink application layer consists of three basic session layer components using either UDP or TCP sockets to interact as shown in the figure below.

- Audio, responsible for providing and exchanging audio content, using UDP sockets.
- VNC, responsible for exchanging display and control information, using TCP sockets.
- UPnP, responsible for service negotiation and remote application control, using UDP broadcasting and TCP sockets.
- Device attestation, responsible for confirming the compliancy of the MirrorLink Server software and hardware.

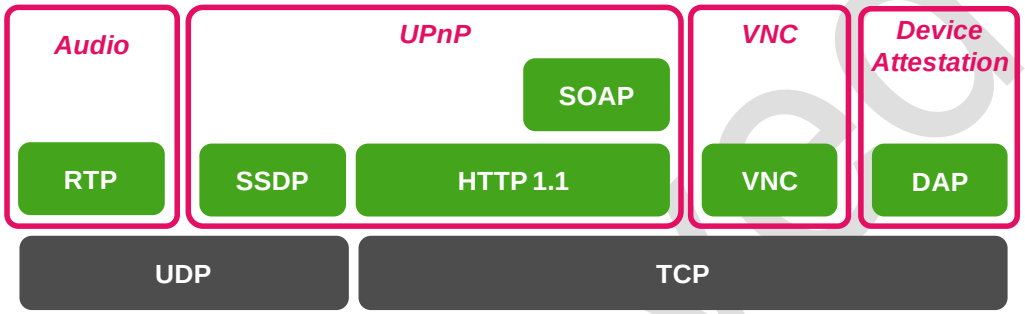

Figure 2: Session Layer

6 REFERENCES

[1] USB 2.0, “Universal Serial Bus Specification”, Revision 2.0, April 27, 2000.

[2] Wi-Fi Alliance Technical Committee, P2P Task Group, “Wi-Fi Peer-to-Peer (P2P) Technical Specification”, Revision 1.1, October 4, 2010

[3] IETF, RFC 2119, “Keys words for use in RFCs to Indicate Requirement Levels”, March 1997. http://www.ietf.org/rfc/rfc2119.txt