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BRIDGE DEVICES FOR WIRELESS PROJECTION OF VEHICLE OPERATING SYSTEMS

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ABSTRACT

Vehicles may provide an infotainment experience that is hosted by a head unit or other computing device. The head unit may execute a native operating system that provides an execution environment in which an operating system client may execute to support execution of a different operating system hosted by another computing device (e.g., a smartphone, laptop computer, tablet computer, etc.). The head unit may require that the computing device physically interconnect with the head unit as the head unit may not support wireless connections (or only support limited wireless connections in the form of bandwidth limited connection – e.g., personal area network connections, such as Bluetooth® connections). Techniques described in this disclosure provide a bridge device for enabling wireless connections between the head unit and the computing devices for wireless projection of the different operating system, where the bridge device provides the physical interconnection required by the head unit while maintaining the wireless connection with the computing device to support wireless projection of the different operating system.

DESCRIPTION

Techniques are described that provide for a bridge device 10 that facilitates wireless projection of a vehicle operating system by a computing device 12 to a vehicle head unit 14 that would otherwise only support wired projection of the vehicle operating system. In other words, vehicle head unit 14 may not support wireless projection of the vehicle operating system, as the vehicle head unit 14 may not include full wireless communication in accordance with the Institute of Electrical and Electronics Engineers (IEEE) 802.11 family of standards.

Rather vehicle head unit 14 may only include limited support of wireless communication, such as supporting personal area networks (PAN – e.g., Bluetooth®, or other PAN protocols). In some examples, vehicle head unit 14 may support full wireless communication but may not be certified to support such full wireless communication for the purposes of wireless projection of the vehicle operating system as the vehicle in which head unit 14 resides was sold prior to such certification being performed. In any event, a large number of vehicles may not provide for certified wireless projection of the vehicle operating system, but may allow for a wired projection of the vehicle operating system in which computing device 12 is physically coupled to head unit 14 via a wired connection to project the vehicle operating system.

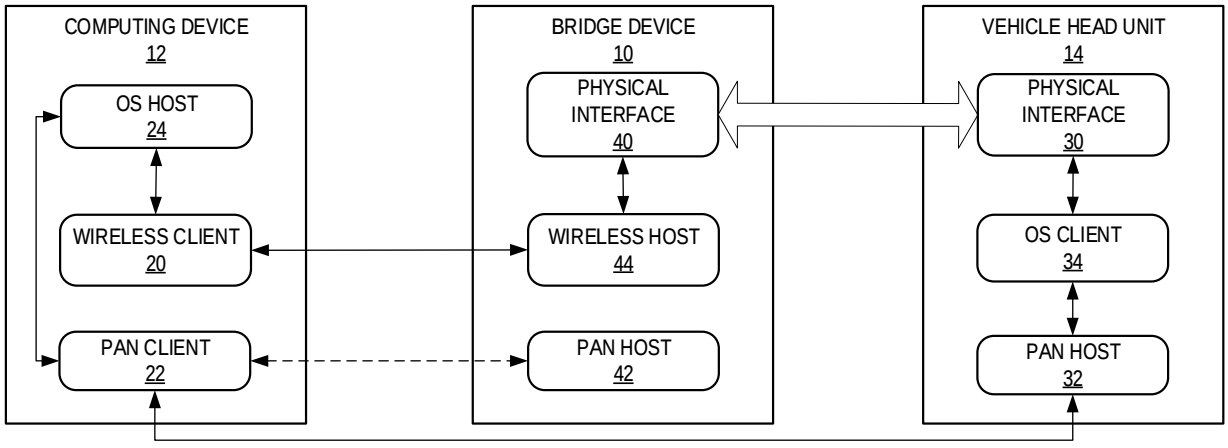

FIG. 1

As shown in the example of FIG. 1, bridge device 10 may facilitate the wireless projection of the vehicle operating system by computing device 12 to head unit 14. Computing device 12 may represent any computing device capable of wireless projection of a vehicle operating system. Examples of computing device 12 may include a cellular phone (including a so-called “smartphone”), a smartwatch, smart glasses, a smart television (such as a portable

television), a gaming system (including portable gaming systems), a smart vehicle adapter (which may support a digital assistant), and the like.

Computing device 12 may include one or more processors, a memory (which may be part of an overall storage architecture in which a solid state drive – SSD – or other non-volatile memory, such as flash memory or a platter-based hard drive, operates in conjunction with volatile memory, such as random access memory (RAM), static RAM (SRAM), dynamic RAM (DRAM), etc., to store data), and wired and wireless interfaces. Computing device 12 may include a wireless interface that supports execution of a wireless client 20 that conforms to the IEEE 802.11 family of standards, and a personal area network interface that supports execution of PAN client 22 that conforms to PAN standards, such as the Bluetooth® standards.

Although described in the context of a PAN interface, various aspects of the techniques described in this disclosure may be performed with respect to various profiles of the Bluetooth® standard or other types of communication standards. For example, PAN client 22 may operate according to a serial port profile, a or according to Bluetooth® low energy (BLE) profile (such as a BLE generic attribute profile (GATT)), of the Bluetooth® standard to act as the control channel. As such the PAN client 22 may be referred to as a serial port client or as a BLE client.

Vehicle head unit 14 may represent any type of computing device certified for operation within a vehicle, such as a car, a motorcycle, a truck, a service utility vehicle, an airplane, farm equipment, a military vehicle, etc. In the example of a car, vehicle head unit 14 may be integrated into a dashboard of the vehicle, where vehicle head unit 14 may include a display (such as a presence sensitive display), one or more processors and some form of user interface (which may include the presence sensitive display, buttons, and/or other input/output – I/O – components) along with physical interface 30 and wireless interfaces, such as a PAN interface

that conforms to various PAN standards and supports execution of a PAN host 32. Vehicle head unit 14 may also include a storage architecture similar to that described above with respect to computing device 12.

Vehicle head unit 14 may however not support, and/or be certified to support, vehicle operation system projection via full wireless communication in conformance with the family of standards defined by IEEE 802.11 (or in other words WiFi™). Upgrading vehicle head unit 14 to support full wireless communication in accordance with WiFi™ may be expensive and may result in potential for damage to the vehicle (as removing integrated head units may be difficult and result in damage to the dashboard and surrounding area).

As such, computing device 12 may execute, via the one or more processors, an operating system (OS) host 24 that is configured to project a vehicle operating system to vehicle head unit 14, where vehicle head unit 14 executes, via the one or more processors, an OS client 34 to facilitate wired communication with OS host 24. While OS host 24 may support wireless projection of the OS to OS client 24, vehicle head unit 24 may be unable to support such wireless projection, as vehicle head unit 14 may not support such wireless communication (e.g., WiFi™ may be disabled, absent, or uncertified for wireless projection – but certified for wired projection).

In accordance with various aspects of the techniques described in this publication, bridge device 10 may facilitate wireless projection of the vehicle operating system by computing device 12 to vehicle head unit 14. Bridge device 10 may represent any computing device that is capable of wired communication with vehicle head unit 14 and wireless communication with computing device 12. Bridge device 10 may include one or more processors configured to support execution of a lightweight operating system (such as a lightweight Linux operating system) and a

memory (configured to store the lightweight operating system), which may form part of a storage architecture similar to that described above with respect to computing device 12.

Bridge device 10 may include a wired interface in the form of physical interface 40 and a wireless interface configure to support execution of PAN host 42 and wireless host 44. Physical interface 40 may include any type of wired interface, including a universal system bus (USB) interface, an Ethernet physical interface, a high definition multimedia interface (HDMI), and the like. Likewise, physical interface 30 may include any type of wired interface, where physical interface 30 may conform to the same or similar type as that of physical interface 40 (although it should be understood that any incompatibilities may be overcome through use of convertible cables that are well known in the art for conversion between two differing, but similar, physical interfaces).

In operation, bridge device 10 may by physically coupled to vehicle head unit 14 in which a cord or cable is physically connected in physical interface 40 and physical interface 30, creating a physical communication coupling between physical interface 40 and physical interface 30. Vehicle head unit 14 may power bridge device 10 via the physical connection between physical interface 30 and physical interface 40. Upon activation (or, in other words, starting or powering) of vehicle head unit 14, vehicle head unit 14 may output power (e.g., a certain voltage) over the physical connection to bridge device 10, thereby powering bridge device 10 to operate in the manner described below in more detail.

Bridge device 10 may, responsive to receiving power, activate physical interface 40 to establish communication with vehicle head unit 14 via physical interface 30. Bridge device 10, upon being powered, may invoke PAN host 42 to establish a PAN to which computing device 12 may connect. Computing device 12 may execute PAN client 22 to couple to a PAN presented by

vehicle head unit 14 via PAN host 32 and a PAN presented by bridge device 10 via PAN host 42. Computing device 12 may maintain the PAN connection with vehicle head unit 14 but the PAN connection with bridge device 10 may be temporary as the PAN connection with bridge device 10 may be disabled once the wireless connection with bridge device 10 in accordance with WiFi™ is established (hence, the dashed lines for the PAN connection between computing device 12 and bridge device 10).

Bridge device 10 may interface, via PAN host 42, with computing device 12 to establish a wireless connection via WiFi™. As such, computing device 12 may negotiate, via PAN client 22, the wireless connection over WiFi™ to bridge device 10, thereby establishing the wireless connection between wireless client 20 of computing device 12 and wireless host 44 of bridge device 10. OS host 24 of computing device 12 may interface with PAN client 22 and wireless client 20 to establish the wireless communication session.

Bridge device 10 may present bridge device 10 as vehicle head unit 14 during negotiation of the wireless communication with computing device 12, while also presenting bridge device 10 as computing device 12 during negotiation of the wired connection to vehicle head unit 14. As such, bridge device 10 may act as a proxy for vehicle head unit 14 during negotiation of the wireless connection, and (possibly concurrently) as a proxy for computing device 12 during negotiation of the wired connection. Bridge device 10 may be considered as a shim device that facilitates seamless wireless interconnection between computing device 12 and vehicle head unit 14 when vehicle head unit 14 does not support (or is not certified to support) such wireless communication (via WiFi™ or other high bandwidth wireless connections).

Upon establishing the wireless communication between computing device 12 and bridge device 10, OS host 24 of computing device 12 may begin projecting the OS to bridge device 12,

where such projection may include a number of commands and other data to specify how OS client 34 should present the data. In other words, OS host 24 may support execution of the OS via a separate display of vehicle head unit 14, where OS client 34 may support the presentation of the separate display, performing formatting or other operations to ensure the display of the OS (graphically) occurs in a format compatible with the display of vehicle head unit 14. In this respect, OS host 24 may support formal execution of the vehicle OS, while OS client 34 may support basic functionality to ensure proper presentation of the OS interface via the display of vehicle head unit 14.

In any event, bridge device 10 may receive the commands and data via wireless host 44 and translate the commands and data to conform to the wired communication session protocols supported by physical interface 40. In this respect, bridge device 10 decapsulates the wireless communications received by wireless host 44 to obtain the commands and data and then encapsulates the commands and data according to the physical interface protocols supported by physical interface 40. Again, bridge device 10 acts as a proxy (or, in other words, as a bridge) between computing device 12 and vehicle head unit 14 to enable wireless communication between computing device 12 and vehicle head unit 14.

Vehicle head unit 14 may output commands and data via physical interface 30 to bridge device 10, which bridge device 10 decapsulates and then encapsulates as a wireless communication that is supported by wireless host 44 and understood by OS host 24. In this manner, bridge device 10 may translate both wired communications received via physical interface 40 to wireless communications sent via wireless host 44, and wireless communications received via wireless host 44 to wired communications sent via physical interface 40. As such, bridge device 10 may operate as a bilateral proxy with respect to each of computing device 12

and vehicle head unit 14 to enable wireless communication between computing device 12 and vehicle head unit 14.

It is noted that the techniques of this disclosure may be combined with any other suitable technique or combination of techniques. As an example, the techniques of this disclosure may be combined with the techniques described in U.S. Patent Application Publication No. 2016/0197782A1, entitled "METHOD AND APPARATUS FOR CONNECTING A MOBLE COMMUNICATION DEVICE TO A HEAD UNIT OF A VEHICLE," and/or an webpage, entitled "[Android 4.1+] Proxy/GateWay for Android Auto," available at https://forum.xda-developers.com/general/paid-software/android-3-0-proxy-gateway-android-auto-t3813163.