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(54) **SYSTEM AND METHOD FOR SUPPORTING DATA COMMUNICATION IN A HETEROGENEOUS ENVIRONMENT**

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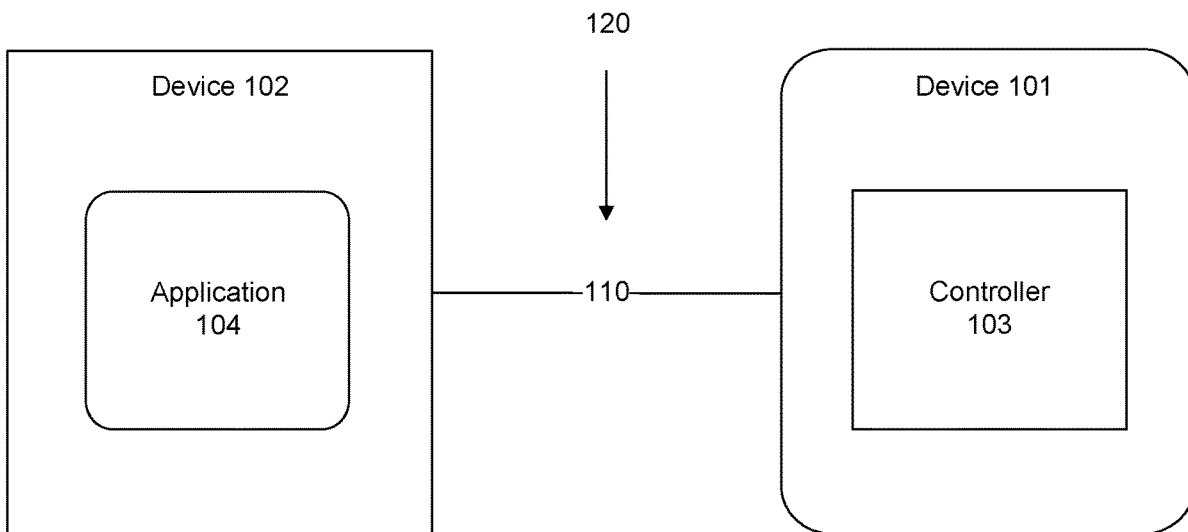
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(57) **ABSTRACT**

Systems and methods for supporting data communication in a heterogeneous environment, the method including receiving, by a first device, an identifier value from a second device that is associated with a software platform installed on the second device; identifying the software platform based on the identifier value; determining a device type of the second device based on the identified software platform; configuring the first device to be in a host mode or an accessory mode based on the determined device type of the second device; and establishing data communication between the first device and the second device via a communication interface associated with the determined device type of the second device.

100



100

120



110

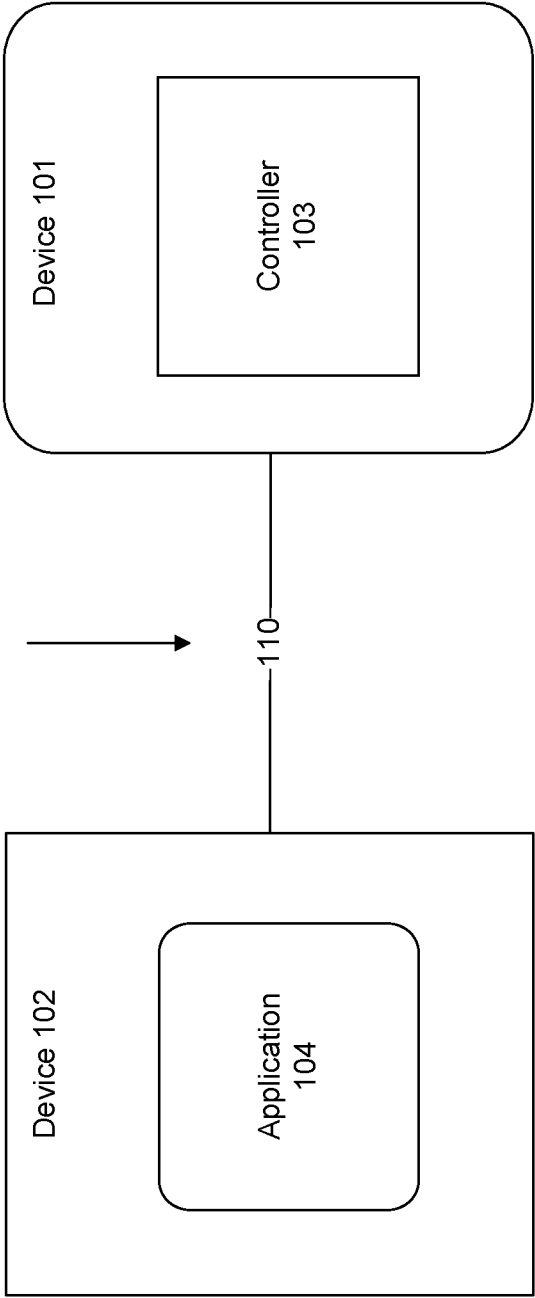


FIG. 1

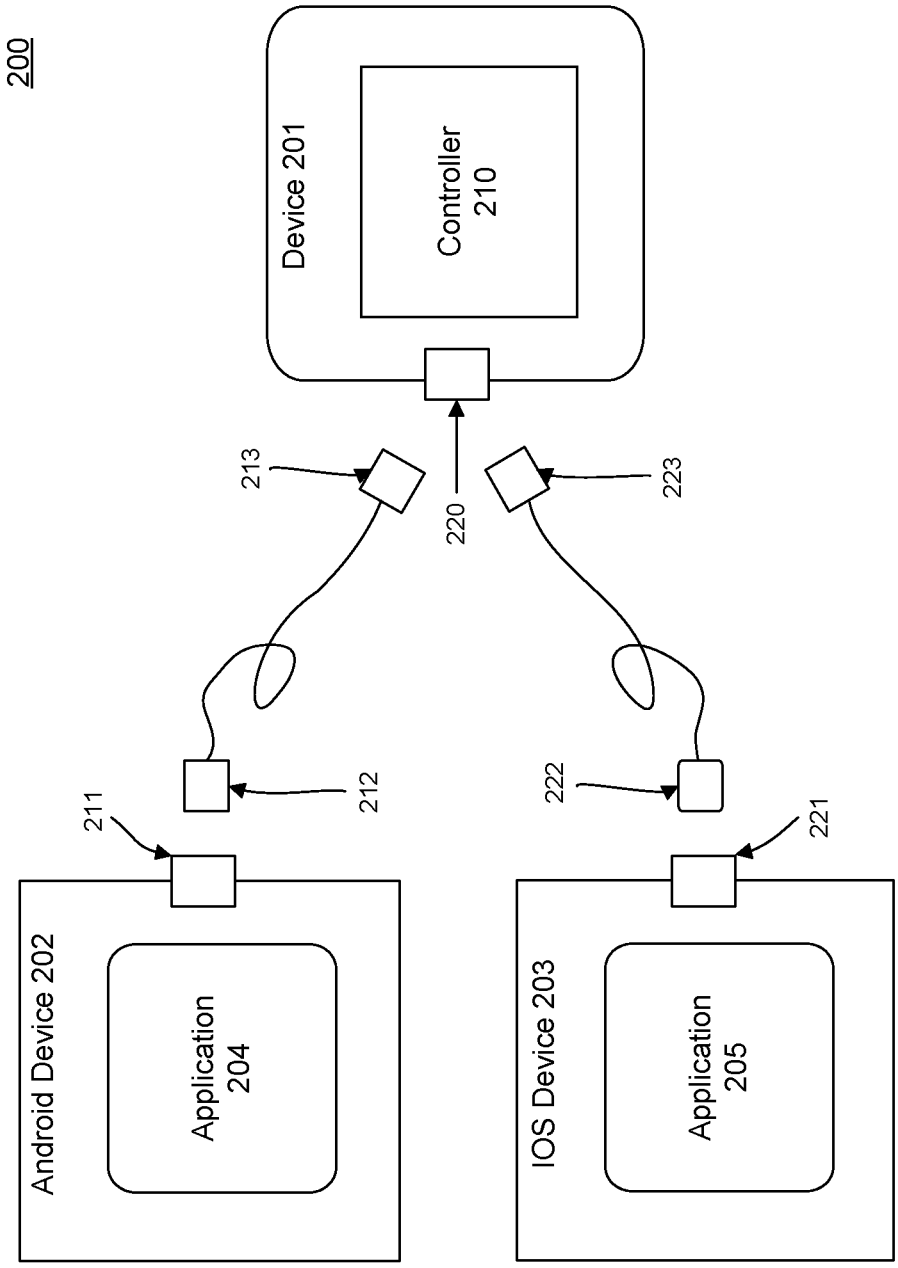


FIG. 2

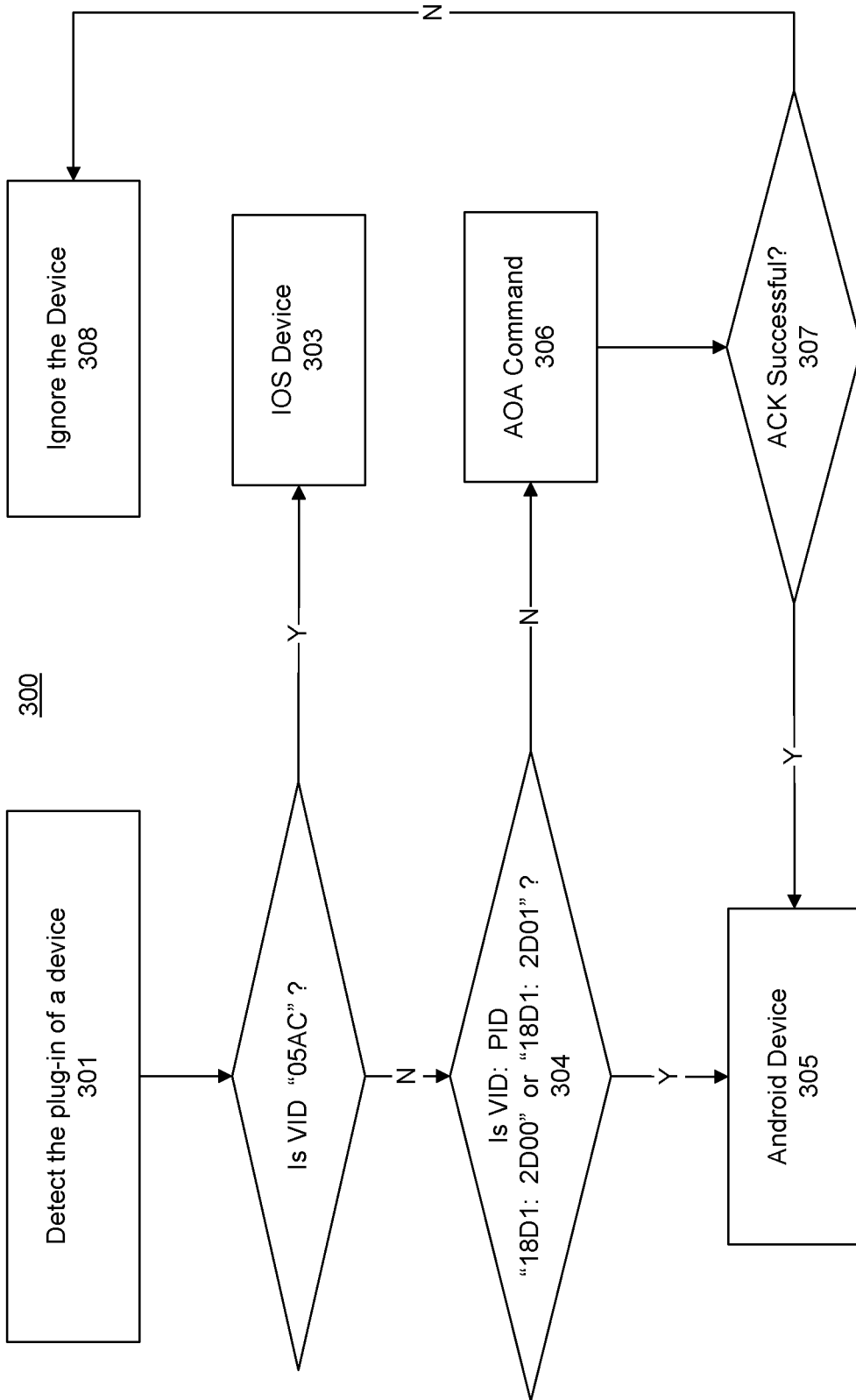


FIG. 3

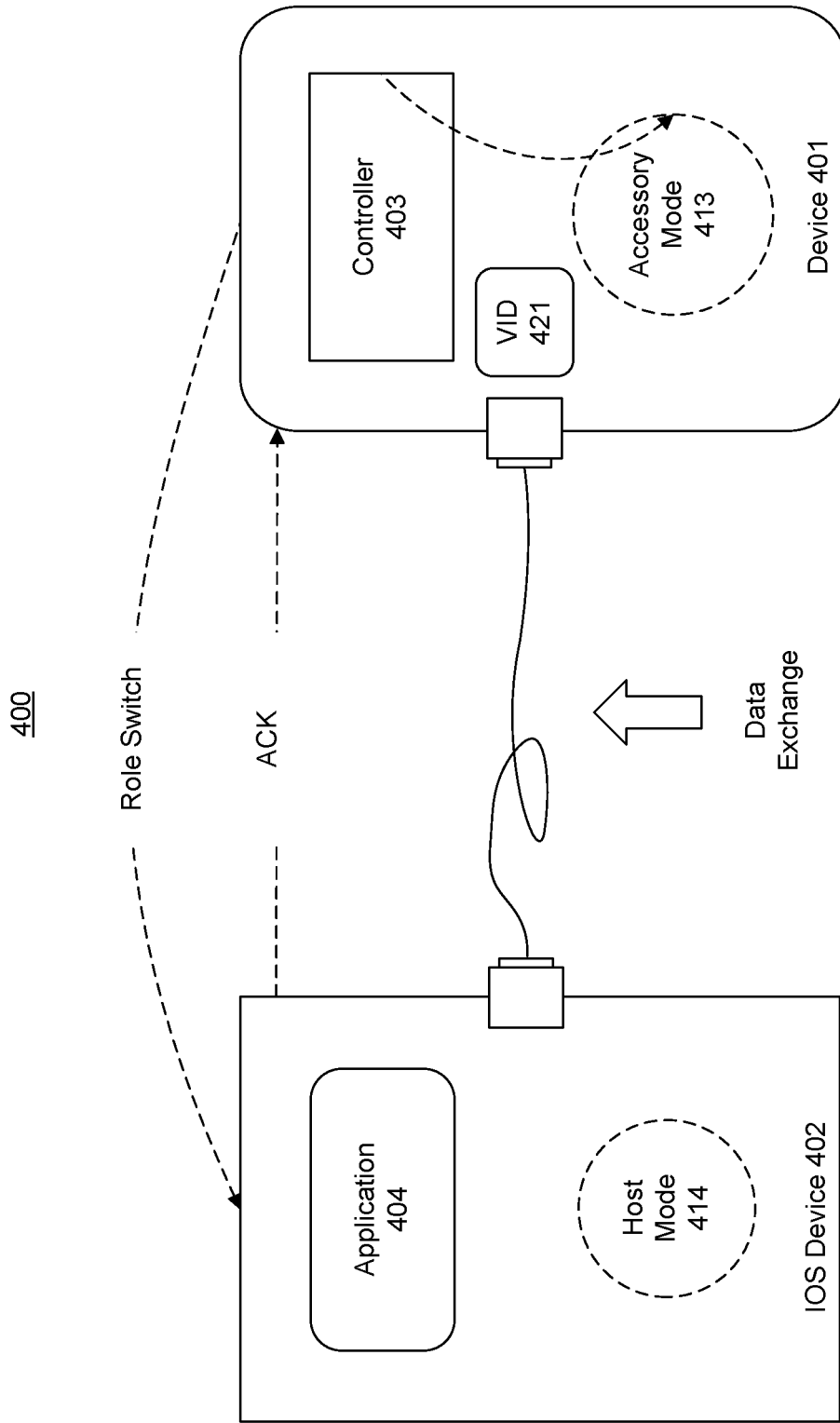


FIG. 4

500

Control
Command

ACK

Data
Exchange

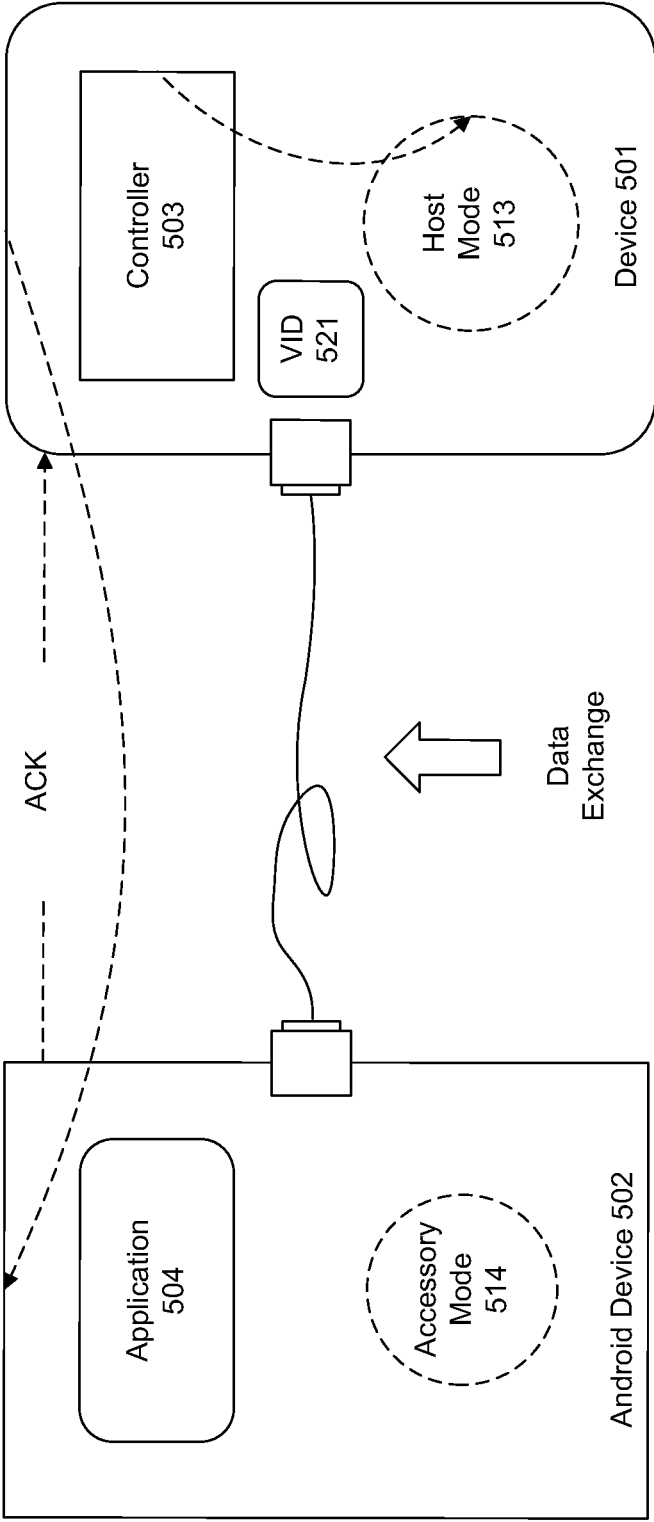


FIG. 5

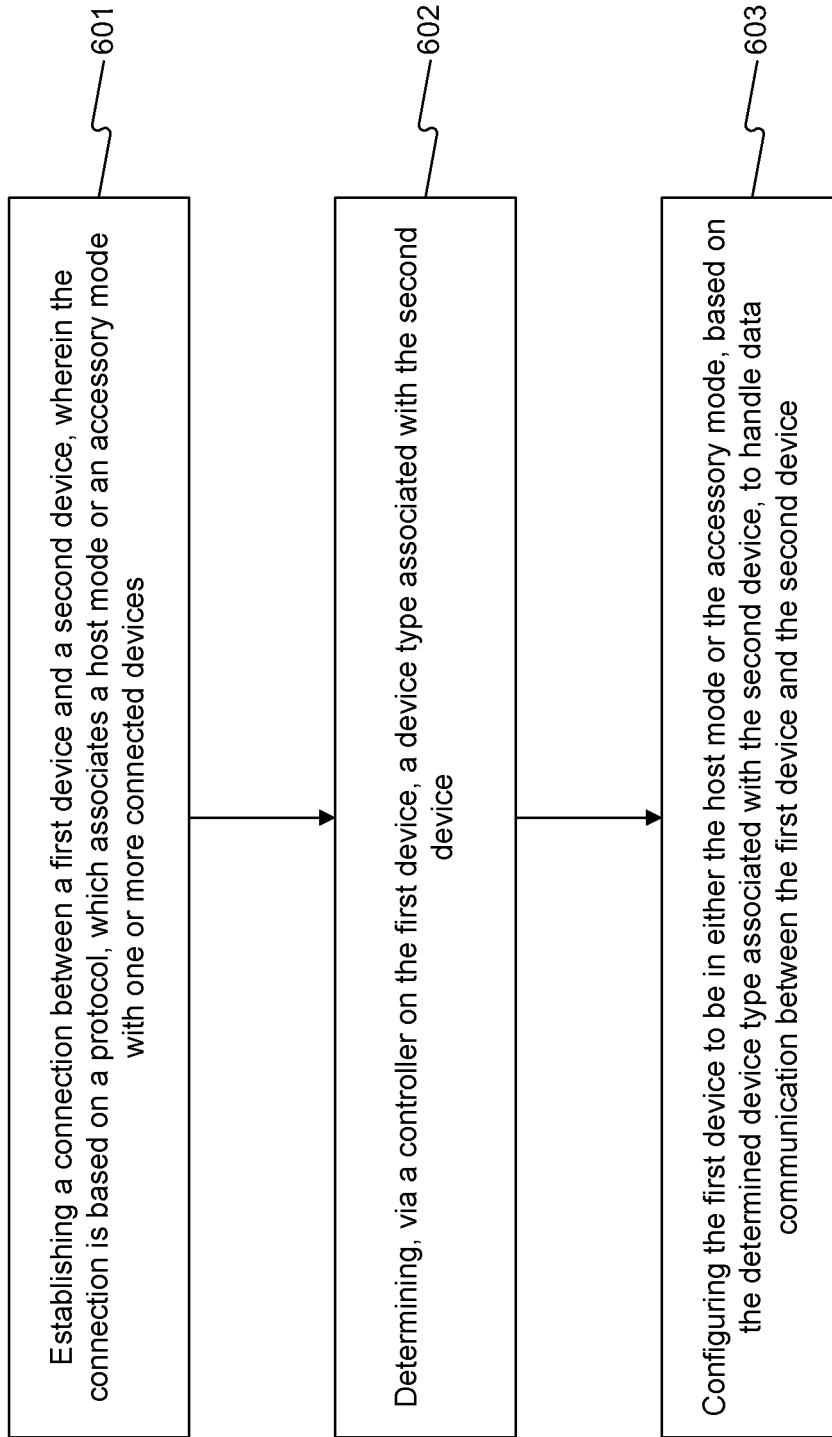


FIG. 6

SYSTEM AND METHOD FOR SUPPORTING DATA COMMUNICATION IN A HETEROGENEOUS ENVIRONMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application of International Application No. PCT/CN2015/086991 filed on Aug. 14, 2015, the content of which is hereby incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

[0002] The disclosed embodiments relate generally to information technologies and more particularly, but not exclusively, to data communication.

[0003] The success of mobile technologies such as the smart phone and tablet leads to the explosive development of new technologies, e.g. smart hardware and the Internet of Things (IoT). For example, smart hardware, which includes the smart home appliances, smart monitoring devices and unmanned aerial vehicles (UAVs), can be used along with the different mobile platforms to achieve better user experience.

[0004] Various wireless technologies can be used for connecting devices to a network resource such as the Internet. The communication link may be established using Wi-Fi technology, e.g. via a wireless network access point. The Wi-Fi link, which is based on a client/server model, is easy to develop and can provide sufficient bandwidth that is enough for supporting a large variation of applications. For example, the communication can be established over a network with external routers using standard sockets based on the Wi-Fi technology.

[0005] However, the Wi-Fi technology may require a full-fledged operating system for supporting the TCP/IP transport protocol. Thus, the device based on the Wi-Fi technology may need to have a processor with high performance capability for supporting this operating system, which may consume substantial amount of resource available to the device.

[0006] Additionally, the Wi-Fi technology is not ideal for application with high security requirements. Using the Wi-Fi technology, the devices may be exposed on the network, which is prone to malicious attacks. Also, the Wi-Fi technology may not be suitable for transporting large amount of data in real time (e.g. performing video broadcasting), since the wireless protocols (like other wireless protocols) is easy to be interfered and may suffer delay in data transport. Moreover, the high energy consumption by the Wi-Fi technology may significant reduce the battery life of the smart devices.

[0007] Alternatively, the Bluetooth technology can be used for supporting short-range low-volume data communication. The Bluetooth communication connection is simple to implement and easy to establish network. Also, the Bluetooth technology consumes relatively lower power and enjoys high communication security.

[0008] However, the Bluetooth technology is not suitable for performing real-time high-volume data transmission, since the bandwidth is small (e.g. around 1 Mbit). Also, the Bluetooth protocol stack is complex and difficult to handle, usually requires the purchase of a Bluetooth module (i.e. involving extra hardware cost). In addition, the user experience for the Bluetooth technology is not ideal, since the devices need to be paired before the actual usage.

[0009] Hence, there is a need for easily, reliably and securely connecting the smart devices with different mobile platforms to achieve better user experience. This is the general area that embodiments of the invention are intended to address.

BRIEF SUMMARY OF THE INVENTION

[0010] Described herein are systems and methods that can support data communication in a heterogeneous environment. The system can establish a connection between a first device and a second device, wherein the connection is based on a protocol, which associates a host mode or an accessory mode with one or more connected devices. Furthermore, a controller on the first device can determine a device type associated with the second device, and can configure the first device to be in either the host mode or the accessory mode, based on the determined device type associated with the second device, to handle data communication between the first device and the second device.

[0011] Other objects and features of the present invention will become apparent by a review of the specification, claims, and appended figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The novel features of the invention are set forth with particularity in the appended claims. A better understanding of the features and advantages of the present invention will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the invention are utilized, and the accompanying drawings briefly described herein.

[0013] FIG. 1 is an exemplary illustration of establishing data communication between different devices, in accordance with various embodiments of the present invention.

[0014] FIG. 2 is an exemplary illustration of supporting data communication in a heterogeneous environment, in accordance with various embodiments of the present invention.

[0015] FIG. 3 is an exemplary illustration of determining a device type for a connected device, in accordance with various embodiments of the present invention.

[0016] FIG. 4 is an exemplary illustration of a third party device using an accessory mode for connecting with an IOS device in a heterogeneous environment, in accordance with various embodiments of the present invention.

[0017] FIG. 5 is an exemplary illustration of a third party device using a host mode for connecting with an ANDROID device in a heterogeneous environment, in accordance with various embodiments of the present invention.

[0018] FIG. 6 shows a flowchart of supporting data communication in a heterogeneous environment, in accordance with various embodiments of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0019] The invention is illustrated, by way of example and not by way of limitation, in the figures of the accompanying drawings in which like references indicate similar elements. It should be noted that references to “an” or “one” or “some” embodiment(s) in this disclosure are not necessarily to the same embodiment, and such references mean at least one.

[0020] The description of the invention as following uses a universal serial bus (USB) protocol as example for a data communication protocol. It will be apparent to those skilled in the art that other types of data communication protocols can be used without limitation.

[0021] In accordance with various embodiments of the present invention, the system and method can handle the connection between a device, e.g. a third party smart hardware, with devices based on different mobile platforms, such as the Android platform and the IOS platform.

[0022] FIG. 1 is an exemplary illustration of establishing data communication between different devices, in accordance with various embodiments of the present invention. As shown in FIG. 1, a data communication environment 100 includes a device 101 and a device 102, which can exchange data via a connection 110.

[0023] The connection 110 can be based on a data communication protocol 120, e.g. the Universal Serial Bus (USB) protocol. The USB protocol, which uses a USB bus, allows only one device on the USB bus to be in the host mode, and the device in the host mode powers the bus and enumerates other devices that connect with the device in the host mode.

[0024] The USB protocol has the advantage of high-bandwidth, low-latency, and low-cost. Thus, the USB protocol can be used for supporting high-volume real-time data transmission, such as real-time video broadcasting. Additionally, the USB bus supports hot-plug and flexible power supply, and can be used for supporting processor peripherals

[0025] Furthermore, the connection 110 can be based on other communication protocols, such as the Wi-Fi protocol and the Bluetooth protocol. Also, the USB interface can be used as a charging interface

[0026] As shown in FIG. 1, the device 101 can include a controller 103, which controls the state of the connection 110 that is related to the device 101. For example, the state can be either a host mode (e.g. the HOST mode as prescribed by the USB protocol) or an accessory mode (e.g. the DEVICE mode) that can be associated with the connected devices 101-102.

[0027] In accordance with various embodiments of the present invention, once the device 102 is physically connected with the device 101, the controller 103 can determine a device type associated with the device 102. For example, the controller 103 can determine the device type associated with a device based on a device descriptor, such as a vendor identifier (VID) and/or a product identifier (PID).

[0028] Based on the determined device type associated with the device 102, the controller 103 can configure the device 101 in either a host mode or an accessory mode for handling data communication between the first device and the second device. For example, the device 101 can be configured in a host mode (e.g. the USB HOST MODE) as default.

[0029] Then, via the connection 110, the device 101 can send one or more video data to an application 104 on the device 102, and receive one or more commands from the application 104 on the device 102.

[0030] FIG. 2 is an exemplary illustration of supporting data communication in a heterogeneous environment, in accordance with various embodiments of the present invention. As shown in FIG. 2, a device 201 can be connected with different types of devices in a heterogeneous environment 200.

[0031] In accordance with various embodiments of the present invention, these different types of devices (or terminals) may use different USB interfaces. Due to the differences between the various USB interfaces, a third-party hardware may need to provide different types of connectors for connecting to the different types of devices (or terminals), which increases the difficulty for industrial design and causes more hardware cost.

[0032] For example, the ANDROID devices may use the sockets based on the MICRO USB standard, while the IOS devices use the sockets based on the LIGHTNING standard. In order to support both the MICRO USB interface and the LIGHTNING interface, a third-party hardware may need to provide different sockets: a MICRO USB socket for connecting to the ANDROID devices and a LIGHTNING socket for connecting to the IOS devices.

[0033] In accordance with various embodiments of the present invention, the system can use the same socket for connecting a device 201 with different types of devices in the heterogeneous environment 200.

[0034] As shown in FIG. 2, the device 201 can use a socket 220 for connecting with an IOS device 203 and an Android device 202. For example, the device 201 can be a third-party accessory that provides an external physical interface, e.g. a USB TYPE A socket. Also, the device 201 can have a processor with USB On-The-Go (OTG) peripheral, with the USB OTG be configured in the USB HOST MODE.

[0035] A USB cable can be used for connecting the ANDROID device 202 with the device 201, with a connector 212 plugged into a MICRO USB socket 211 and a connector 213 plugged into a USB TYPE A socket 220. Alternatively, a different USB cable can be used for connecting the IOS device 203 with the device 201, with a connector 222 plugged into a LIGHTNING type socket 211 and a connector 223 plugged into the USB TYPE A socket 220.

[0036] Additionally, it is beneficial for a third-party device 201 to use a socket, such as the USB TYPE A socket 220, which may also be used as a charging interface, since a user can use an original charging cable for connecting the different mobile devices 202-203 with the third-party device 201.

[0037] After the device 201 is connected with the Android device 202, the device 201 can use a communication interface, e.g. an Android Open Accessory (AOA) interface, for exchanging data with the application 204 on the Android device 202. Also, the device 201 can use a communication interface, e.g. a Made for IOS (MFI) interface, for exchanging data with the application 205 on the IOS device 202, after the device 201 is connected with the IOS device 202.

[0038] FIG. 3 is an exemplary illustration of determining a device type for a connected device, in accordance with various embodiments of the present invention. As shown in FIG. 3, a controller for a third party device can detect the device type associated with a connected device in a heterogeneous environment 300, e.g. determining whether the connected device is an android device or an IOS device.

[0039] At step 301, a third party device can detect the plugging-in of a connector into a socket on the third party device. The controller on the third party device can (request and) obtain a device descriptor for the device, such as a vendor identifier (VID) and/or a product identifier (PID) for the device.

[0040] At step 302, the controller can check whether the detected descriptor matches the IOS descriptor (e.g. whether the VID is "05AC"). At step 303, the controller can determine that the device is an IOS device when the detected descriptor matches IOS descriptor (i.e. the VID is 05AC).

[0041] In accordance with various embodiments of the present invention, the system can check whether a connected device is associated with a closed system, before checking whether the connected device is associated with an open system. The reason is that a device for a closed system, such as an IOS system, is likely to have one or more unique descriptor(s), while the same reasoning may not always be true for an open system such as the ANDROID system.

[0042] In other words, a connected device with a device descriptor other than the IOS descriptor is not an IOS device. On the other hand, there is a chance that a connected device with a device descriptor other than the ANDROID descriptor may actually be an ANDROID device.

[0043] At step 304, when the detected descriptor does not match the IOS descriptor (i.e. the VID is not "05AC"), the controller can check whether the detected descriptor matches the ANDROID descriptor (e.g. whether the VID:PID is "18D1:2D00" or "18D1:2D01").

[0044] At step 305, the controller can determine that the device is an ANDROID device, when the detected descriptor matches the ANDROID descriptor (i.e. when the VID:PID is "18D1:2D00" or "18D1:2D01").

[0045] Furthermore, since there are chances that the connected device may actually be an ANDROID device even when the detected descriptor does not match the ANDROID descriptor. At step 306, the controller can send an AOA control command to the connected device to explicitly initiating the communication. Then, at step 307, the controller can check whether a successful acknowledgment (ACK) is received from the connected device. If a successful acknowledgment (ACK) is received, the controller can determine that the device is an ANDROID device. Otherwise, at step 308, the controller may ignore the device, and consider the type of the device is unknown.

[0046] FIG. 4 is an exemplary illustration of a third party device using an accessory mode for connecting with an IOS device in a heterogeneous environment, in accordance with various embodiments of the present invention. As shown in FIG. 4, a device 401 can connect with a device 402 in a heterogeneous environment 400.

[0047] Furthermore, once the device 402 connects with the device 401, the controller 403 on the device 401 can detect a vendor identifier (VID) 421 for the device 402. For example, if the VID is "05AC," then the device 402 is in an IOS device. The IOS device 402 can provide a MFI connection interface for connecting with the third-party accessory, such as the device 401. The MFI interface may include several modes: such as DEVICE MODE, HOST MODE, and ROLE SWITCH.

[0048] The controller 403 on the device 401 can send a ROLE SWITCH command to the IOS device 402 for instructing the IOS device 402 to entering into the HOST MODE. Also, the controller 403 on the device 401 can configure the device 401 to be in an accessory mode. For example, the controller 403 on the device 401 can reverse the USB OTG role from the default USB HOST MODE to the USB DEVICE MODE. Then, the device 401 can wait for a host node (i.e. the IOS device 402) to initiate a data communication.

[0049] Thus, the IOS device 402 in the USB HOST MODE can establish a data connection with the device 401 by taking advantage of the MFI interface. For example, the IOS application 404 can take advantage of the MFI EA NATIVE TRANSPORT API interface for exchanging data with the third-party accessories, such as the device 401.

[0050] FIG. 5 is an exemplary illustration of a third party device using a host mode for connecting with an ANDROID device in a heterogeneous environment, in accordance with various embodiments of the present invention. As shown in FIG. 5, a device 501 can connect with a device 502 in a heterogeneous environment 500.

[0051] Furthermore, once the device 502 connects with the device 501, the controller 503 can detect a vendor identifier (VID) 521 for the device 502. For example, if the VID:PID is "18D1:2D00" or "18D1:2D01," then the device 502 is identified as an Android device.

[0052] The ANDROID device 502 provides an AOA connection interface for connecting with the third-party accessories. Also, the Android AOA connection interface can be provided in an accessory mode, e.g. using a USB DEVICE mode.

[0053] The device 501, which is in a host mode as default, can send a message to the ANDROID device 502 for establishing the data communication, via an API based on the AOA protocol. For example, the application 504, which is an ANDROID APP, can use the AOA-based API for supporting data exchange with third-party accessories, such as the device 501.

[0054] On the other hand, if the VID 521 is not recognizable, then the device 501 may try to send a control command to the device 502, for instructing the device 502 to enter into the AOA mode explicitly. If the acknowledgment (ACK) is successful, then the controller 503 can assume that the device 502 supports the AOA mode, and the controller can communicate data with the device 502, via an AOA related API.

[0055] If the acknowledgment (ACK) is not successful, e.g. if the device 502 fails to respond to the device 501 or responds with an error message, the device 501 may decide to ignore the device 502.

[0056] FIG. 6 shows a flowchart of supporting data communication in a heterogeneous environment, in accordance with various embodiments of the present invention. As shown in FIG. 6, at step 601, a connection can be established between a first device and a second device, wherein the connection is based on a protocol, which associates a host mode or an accessory mode with one or more connected devices. Then, at step 602, a controller on the first device can determine that a device type associated with the second device. Furthermore, at step 603, the controller on the first device can configure the first device to be in either the host mode or the accessory mode, based on the determined device type associated with the second device, to handle data communication between the first device and the second device.

[0057] Many features of the present invention can be performed in, using, or with the assistance of hardware, software, firmware, or combinations thereof. Consequently, features of the present invention may be implemented using a processing system (e.g., including one or more processors). Exemplary processors can include, without limitation, one or more general purpose microprocessors (for example, single or multi-core processors), application-specific inte-

grated circuits, application-specific instruction-set processors, graphics processing units, physics processing units, digital signal processing units, coprocessors, network processing units, audio processing units, encryption processing units, and the like.

[0058] Features of the present invention can be implemented in, using, or with the assistance of a computer program product which is a storage medium (media) or computer readable medium (media) having instructions stored thereon/in which can be used to program a processing system to perform any of the features presented herein. The storage medium can include, but is not limited to, any type of disk including floppy disks, optical discs, DVD, CD-ROMs, microdrive, and magneto-optical disks, ROMs, RAMs, EPROMs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs), or any type of media or device suitable for storing instructions and/or data.

[0059] Stored on any one of the machine readable medium (media), features of the present invention can be incorporated in software and/or firmware for controlling the hardware of a processing system, and for enabling a processing system to interact with other mechanism utilizing the results of the present invention. Such software or firmware may include, but is not limited to, application code, device drivers, operating systems and execution environments/containers.

[0060] Features of the invention may also be implemented in hardware using, for example, hardware components such as application specific integrated circuits (ASICs) and field-programmable gate array (FPGA) devices. Implementation of the hardware state machine so as to perform the functions described herein will be apparent to persons skilled in the relevant art.

[0061] Additionally, the present invention may be conveniently implemented using one or more conventional general purpose or specialized digital computer, computing device, machine, or microprocessor, including one or more processors, memory and/or computer readable storage media programmed according to the teachings of the present disclosure. Appropriate software coding can readily be prepared by skilled programmers based on the teachings of the present disclosure, as will be apparent to those skilled in the software art.

[0062] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example, and not limitation. It will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention.

[0063] The present invention has been described above with the aid of functional building blocks illustrating the performance of specified functions and relationships thereof. The boundaries of these functional building blocks have often been arbitrarily defined herein for the convenience of the description. Alternate boundaries can be defined so long as the specified functions and relationships thereof are appropriately performed. Any such alternate boundaries are thus within the scope and spirit of the invention.

[0064] The foregoing description of the present invention has been provided for the purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. The breadth and

scope of the present invention should not be limited by any of the above-described exemplary embodiments. Many modifications and variations will be apparent to the practitioner skilled in the art. The modifications and variations include any relevant combination of the disclosed features. The embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the art to understand the invention for various embodiments and with various modifications that are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the following claims and their equivalence.

1-30. (canceled)

31. A method for supporting data communication in a heterogeneous environment, the method comprising:

receiving, by a first device, an identifier value from a second device, wherein the identifier value is associated with a software platform installed on the second device;

identifying, by the first device, the software platform installed on the second device based on whether the identifier value matches a predetermined value corresponding to the software platform;

determining, by the first device, a device type of the second device based on the identified software platform;

configuring the first device to be in a host mode or an accessory mode based on the determined device type of the second device for handling a data communication between the first device and the second device; and

establishing the data communication between the first device and the second device via a communication interface associated with the determined device type of the second device.

32. The method of claim **31**, further comprising: transmitting a message from the first device to the second device to initiate the data communication, when the first device is configured to be in the host mode.

33. The method of claim **32**, further comprising: exchanging data via the communication interface, when an acknowledgement message in response to the message is received from the second device; or

ignoring the second device, when the acknowledgement message is not received from the second device or an error message is received from the second device.

34. The method of claim **31**, further comprising: switching the first device from the host mode into the accessory mode, when the first device is configured to be in the host mode and the second device is determined to be in a particular device type.

35. The method of claim **34**, further comprising: sending a role switching message from the first device to the second device; and

receiving, by the first device, a message from the second device to initiate the data communication.

36. The method of claim **31**, further comprising: connecting the first device to the second device using a socket of the first device, wherein the socket supports connections with different types of devices associated with different installed software platforms.

37. The method of claim **36**, wherein the socket is adapted to serve as a charging interface that is associated with different types of devices.

38. The method of claim **31**, wherein the identifier value is a device descriptor including at least one of a vendor identifier (VID) or a product identifier (PID).

39. An apparatus for supporting data communication in a heterogeneous environment, the apparatus comprising:

a controller; and

a memory associated with the controller, wherein the memory stores instructions and the controller is configured to execute the instructions to:

receive an identifier value from a device connected to the apparatus, wherein the identifier value is associated with a software platform installed on the device;

identify the software platform installed on the device based on whether the identifier value matches a predetermined value stored in the memory corresponding to the software platform;

determine a device type of the device based on the identified software platform;

configure the apparatus in a host mode or an accessory mode based on the determined device type of the device for handing a data communication between the apparatus and the device; and

establish the data communication between the apparatus and the device via a communication interface associated with the determined device type of the device.

40. The apparatus of claim **39**, wherein the controller is configured to execute the instructions to:

transmit a message to the device to initiate the data communication, when the apparatus is configured to be in the host mode.

41. The apparatus of claim **40**, wherein the controller is configured to execute the instructions to:

exchange data via the communication interface, when an acknowledgement message in response to the message is received from the device; or

ignore the device, when the acknowledgement message is not received from the device or an error message is received from the device.

42. The apparatus of claim **39**, wherein the controller is configured to execute the instructions to:

switch the apparatus from the host mode into the accessory mode, when the apparatus is configured to be in the host mode and the device is determined to be in a particular device type.

43. The apparatus of claim **42**, wherein the controller is configured to execute the instructions to:

send a role switching message to the device; and
receive a message from the device to initiate the data communication.

44. The apparatus of claim **39**, further comprising:

a socket configured to be connected to the device, wherein the socket supports connections with different types of devices associated with different installed software platforms.

45. The apparatus of claim **44**, wherein the socket is adapted to serve as a charging interface that is associated with different types of devices.

46. The apparatus of claim **39**, wherein the identifier value is a device descriptor including at least one of a vendor identifier (VID) or a product identifier (PID).

47. A non-transitory computer-readable medium with instructions stored thereon, that when executed by a processor, perform steps comprising:

receiving, by a first device, an identifier value from a second device, wherein the identifier value is associated with a software platform installed on the second device;

identifying, by the first device, the software platform installed on the second device based on whether the identifier value matches a predetermined value corresponding to the software platform;

determining, by the first device, a device type of the second device based on the identified software platform;

configuring the first device to be in a host mode or an accessory mode based on the determined device type of the second device for handing the data communication between the first device and the second device; and

establishing a data communication between the first device and the second device via a communication interface associated with the determined device type of the second device.

48. The non-transitory computer-readable medium of claim **47**, when executed by the processor, further perform the steps comprising:

transmitting a message from the first device to the second device to initiate the data communication, when the first device is configured to be in the host mode.

49. The non-transitory computer-readable medium of claim **48**, when executed by the processor, further perform the steps comprising:

exchanging data via the communication interface, when an acknowledgement message in response to the message is received from the second device; or

ignoring the second device, when the acknowledgement message is not received from the second device or an error message is received from the second device.

50. The non-transitory computer-readable medium of claim **47**, when executed by the processor, further perform the steps comprising:

switching the first device from the host mode into the accessory mode, when the first device is configured to be in the host mode and the second device is determined to be in a particular device type; and

sending a role switching message from the first device to the second device.

* * * * *