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(54) SYSTEM AND METHOD FOR UNIVERSAL SERIAL BUS HUB PORT REVERSAL

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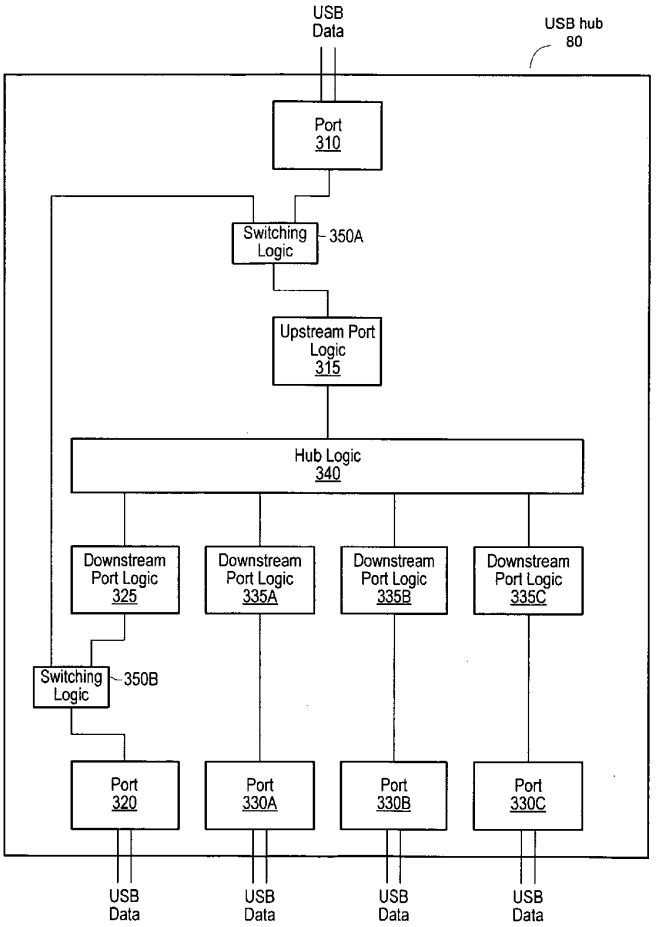
(52) **U.S. Cl.** **710/316**

(57) **ABSTRACT**

System and method for switching logic in a Universal Serial Bus hub. The USB hub may include upstream logic and downstream logic for sending and receiving information from a host controller and a USB device respectively. The USB hub may include a plurality of ports operable to couple to a plurality of devices, including a first port coupled to the upstream logic and a second port coupled to the downstream logic. The USB hub may also include switching logic operable to switch the upstream and the downstream logic with respect to the first port and the second port respectively. The switching logic may switch the upstream and downstream logic by decoupling the first port from the upstream logic, decoupling the second port from the downstream logic, and coupling the second port to the upstream logic. Additionally, the first port may be coupled to the downstream logic.



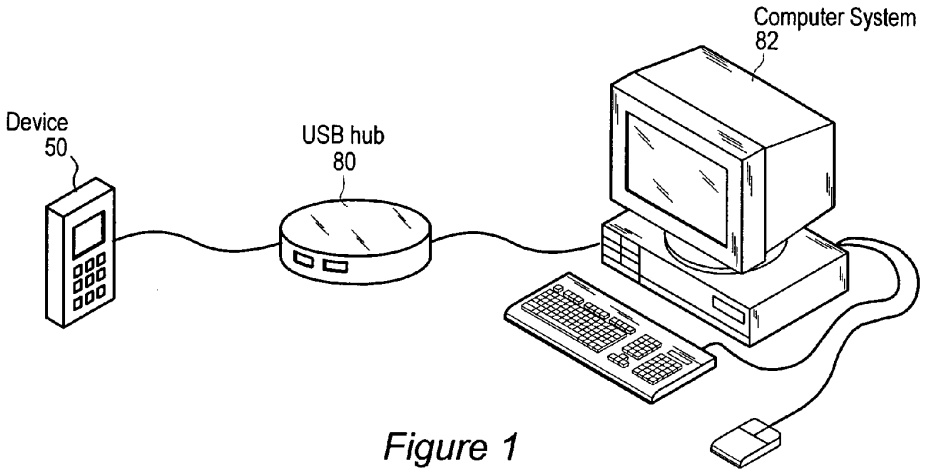


Figure 1

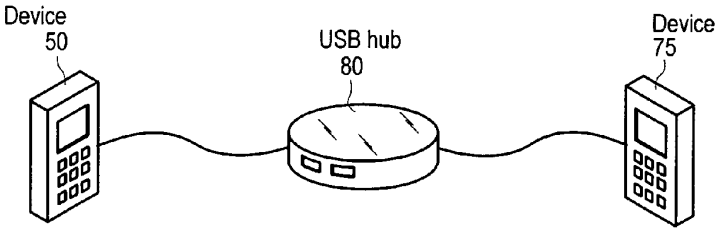
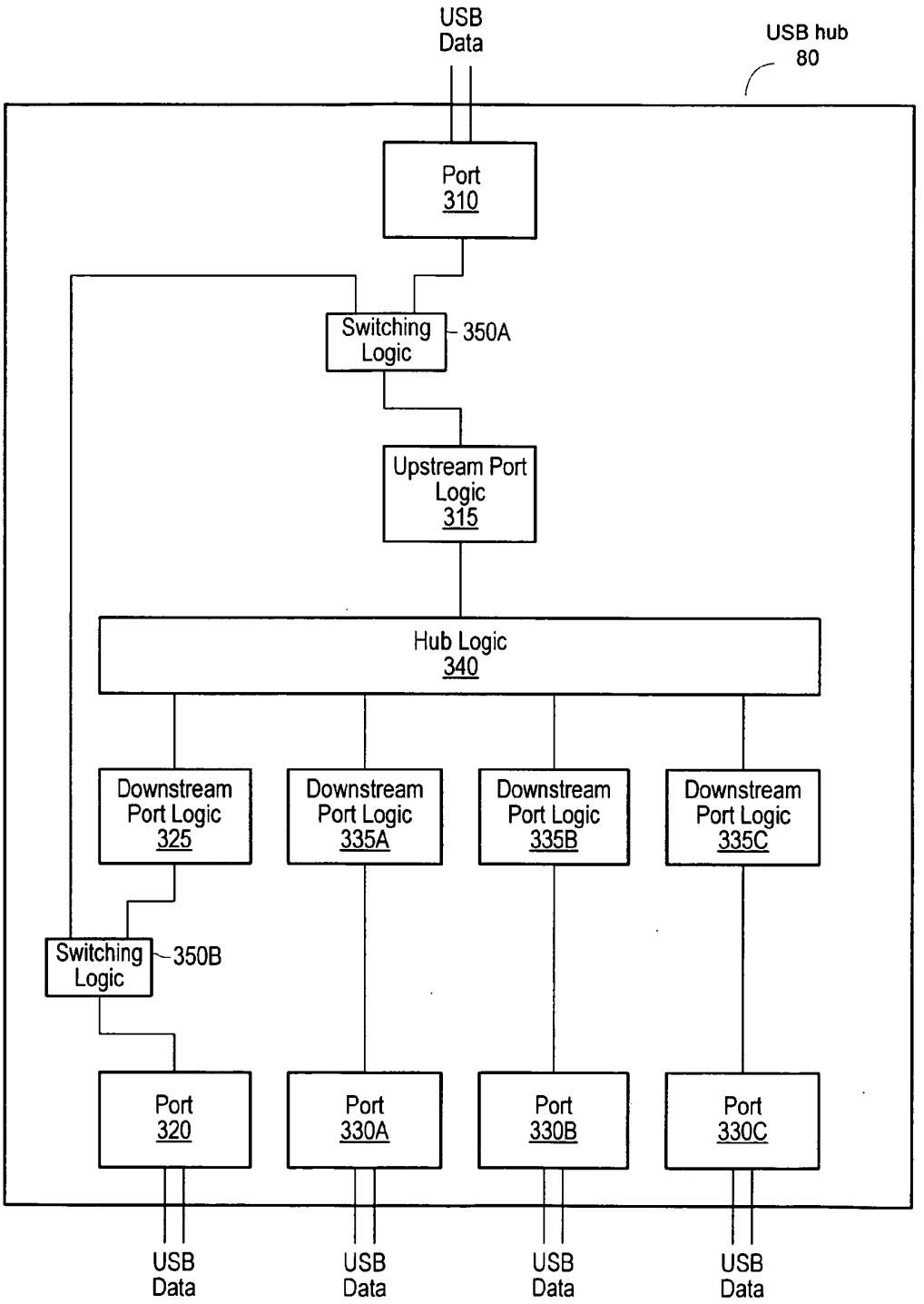


Figure 2


USB
Data
USB hub
80
Port
310
Switching
Logic
350A
Upstream Port
Logic
315
Hub Logic
340
Downstream
Port Logic
325
Downstream
Port Logic
335A
Downstream
Port Logic
335B
Downstream
Port Logic
335C
Switching
Logic
350B
Port
320
Port
330A
Port
330B
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330C
USB
Data
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USB
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Data

Figure 3

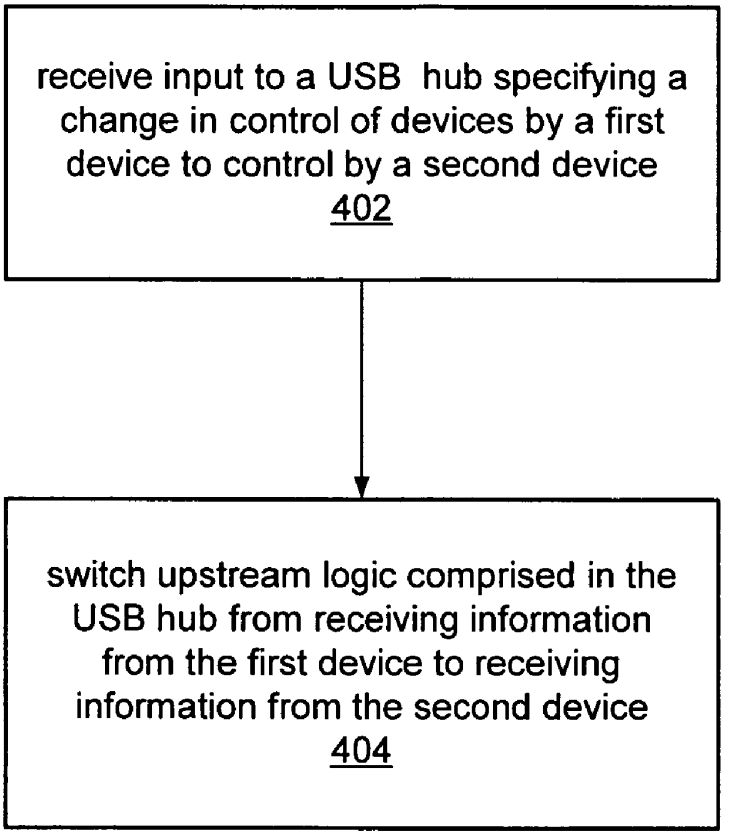

receive input to a USB hub specifying a change in control of devices by a first device to control by a second device
402
switch upstream logic comprised in the USB hub from receiving information from the first device to receiving information from the second device
404

Figure 4

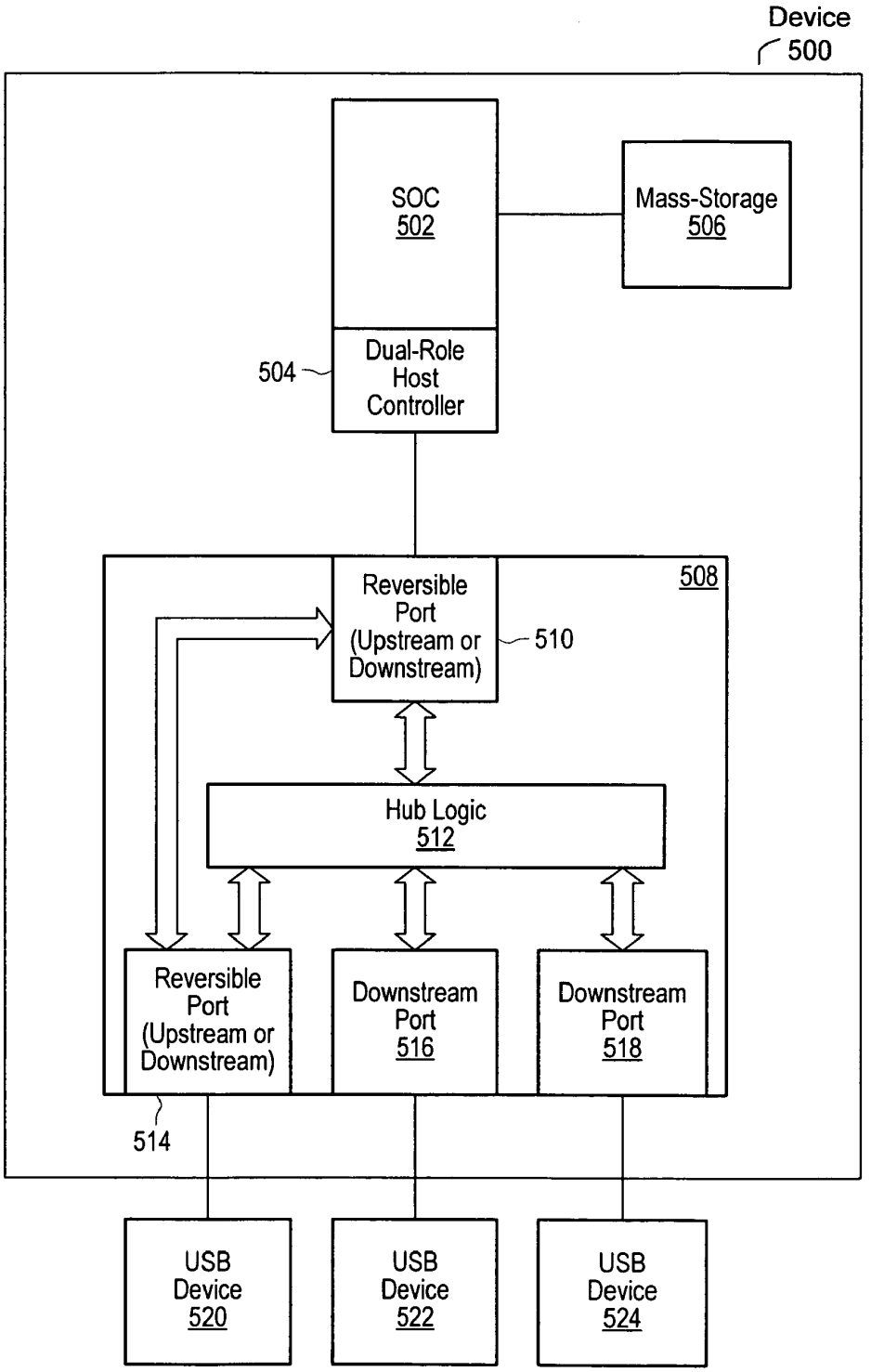
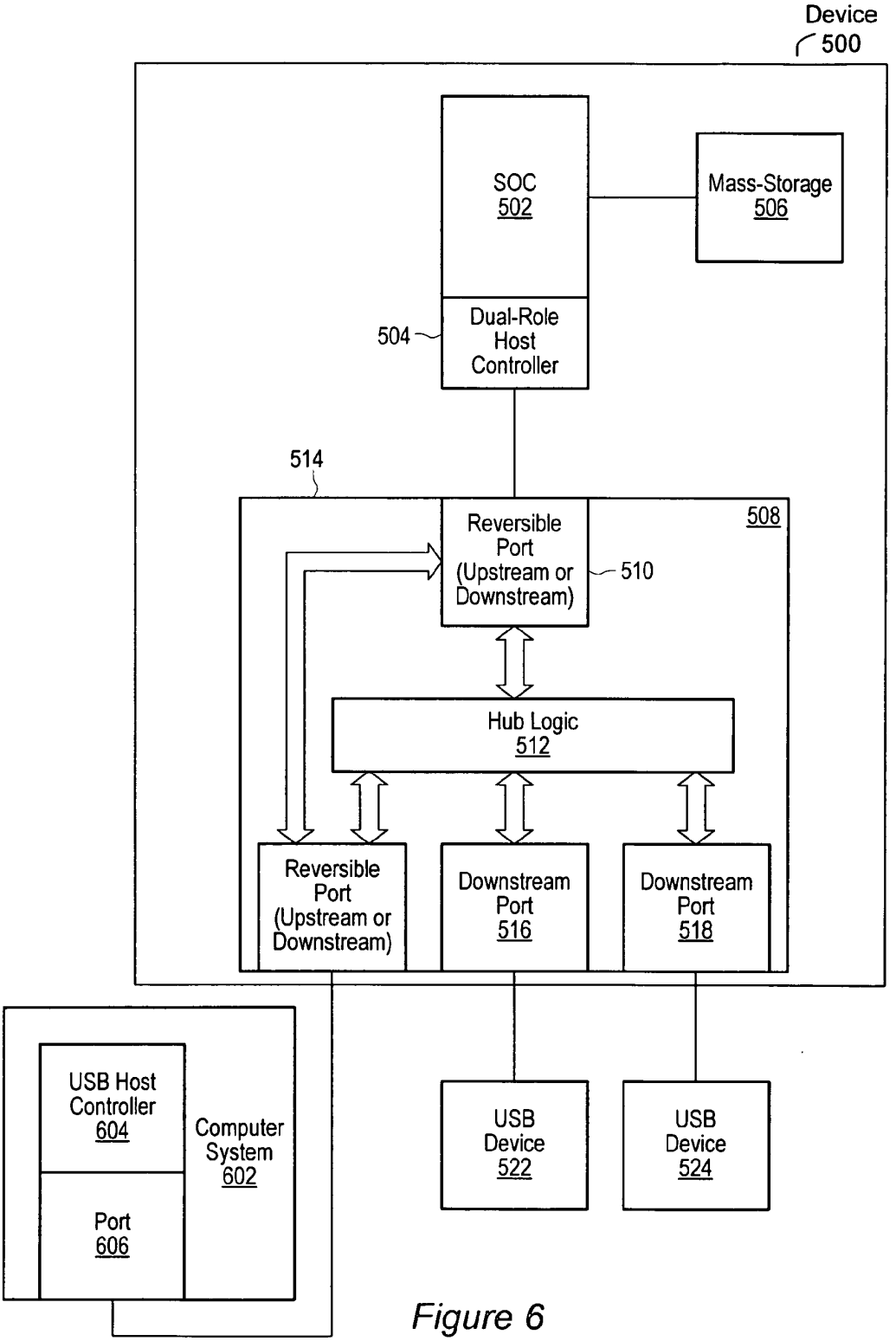

Device
500
SOC
502
Mass-Storage
506
504
Dual-Role
Host
Controller
508
Reversible
Port
(Upstream or
Downstream)
510
Hub Logic
512
Reversible
Port
(Upstream or
Downstream)
Downstream
Port
516
Downstream
Port
518
514
USB
Device
520
USB
Device
522
USB
Device
524

Figure 5


Device
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Hub Logic
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(Upstream or
Downstream)
Downstream
Port
516
Downstream
Port
518
USB Host
Controller
604
Computer
System
602
Port
606
USB
Device
522
USB
Device
524

Figure 6

SYSTEM AND METHOD FOR UNIVERSAL SERIAL BUS HUB PORT REVERSAL

FIELD OF THE INVENTION

[0001] The present invention relates to the field of Universal Serial Bus (USB) hubs and more particularly to a system and method for reversing logic in USB hubs.

DESCRIPTION OF THE RELATED ART

[0002] In recent years, the electronics marketplace has seen a proliferation of Universal Serial Bus (USB) electronics and devices. These devices and electronics have given the common user access to a plethora of devices, e.g., that connect to a computer, including, as an exemplary list, keyboards, mice, audio devices, digital cameras, digital video-recorders, cell phones, digital music players, power supplies, storage devices, recording equipment, and signal converters, among others. Because of the widespread use of USB electronics and methods, direct communication between devices, without the need of a host computer, has been implemented using the USB 2.0 On-The-Go (OTG) specification. However, when two USB devices communicate using the OTG specification, a first device must act as a host controller and the other device must act as a USB (peripheral) device. Because OTG devices have this dual-role capability, an ambiguity as to which device will act as the host controller results. For example, it may be desirable for a given device, e.g., a cell phone, to be a host in one situation, e.g., printing a picture taken on the cell phone, and a peripheral in another, e.g., downloading music from a host computer. To deal with this issue, the OTG supplement has defined a host negotiation protocol (HNP) as well as a default configuration based on the connecting cable, i.e., the connecting pins of the cable designates a default host and peripheral device.

[0003] However, the OTG supplement does not define a protocol for using dual-role devices in a USB hub, i.e., circuitry that allows USB communication among multiple devices. USB hubs, in general, have upstream logic associated with a port for communicating with a host or host controller, and downstream logics associated with ports for communicating with a plurality of USB devices. One prior art approach allows one of the USB devices to act as a host to the previous host controller (now acting as a device). However, this method does not allow dual-role devices to act as hosts to the other devices connected to the hub. In other words, the USB hub becomes a two-way communication path between the new host and the old host, and ignores communication to the other connected devices.

[0004] Thus, improved systems and methods for device communications in USB hubs are desirable.

SUMMARY OF THE INVENTION

[0005] Various embodiments of a system and method for reversing logic in USB hubs are presented herein.

[0006] According to one embodiment of the present invention, a USB hub may include upstream logic for sending and receiving information to and from a host controller, downstream logic for sending and receiving information to and from a USB device, a plurality of ports each operable to couple to upstream or downstream logic and one or more USB devices, and switching logic operable to switch upstream and downstream logic between a first port and a second port. In some embodiments, input may be received to the USB hub specifying a change in control of one or more devices coupled to the USB hub by a first device, e.g., coupled to a first port, to control by a second device, e.g., coupled to a second port. For example, if one of the devices is an on-the-go (OTG) or dual-role device, it may request, or be instructed, to act as the host controller of the USB hub. In this example, the input may be received from any of a variety of sources, and may set or invoke a switching condition, which may then be detected by the USB hub.

[0007] In some embodiments, the switching condition may be invoked mechanically, such as, for example, by flipping, i.e., switching on or off, a mechanical switch on the USB hub, or, alternatively, if the USB hub is included in a device, a switch on the device. In one embodiment, the switching condition may include a change in orientation of the connecting cables. More specifically, in the current USB OTG specification, the USB connecting cable may have a default host controller connection (on one end) and a default device connection (on the other end). In this case, the switching condition may be invoked by reversing these two connections, e.g., via the change in pins associated with each of the connectors on each end of the cable may invoke the switching condition.

[0008] Alternatively, or additionally, a user or other system may invoke the switching condition via electronic means; for example, the user may choose from a plurality of possible buttons or options, e.g., depending on the number of devices coupled to the USB hub. For example, if the USB hub is included in a peripheral device, e.g., a cell phone, PDA, and/or a digital music player, among others, the user may be presented with a plurality of options on the display of the peripheral device and may invoke the switching condition by selecting one or more of the available options. More specifically, the peripheral device may include a menu associated with the USB hub; the user may select this menu, e.g., via a stylus, voice activation, and/or a keypad, among others means, and select from one or more options to invoke a specific change in host, e.g., by invoking the switching condition. Alternatively, the user may invoke the switching condition, e.g., similar to methods described above, among others, from a device coupled to the USB hub.

[0009] In some embodiments, the USB hub may automatically detect the switching condition. For example, the USB hub may have a sensing mechanism, e.g., present in the physical layer (PHY) of connections to the USB hub, specifically for detecting the switching condition. In one embodiment, the switching condition may include a change of impedance in one or more pins of one of the connections to the USB hub, e.g., one or more of the ports. For example, in one embodiment, the invoked switching condition, e.g., via the means described above, may include a change in impedance on the D+ and D− pins of the USB cable, e.g., connected to the peripheral device that is requesting logic reversal. As a specific example, normally two of the pins in the PHY may have an impedance of 15 kOhms, and after tying, for example, two pins together, the impedance may decrease to 7.5 kOhms. Correspondingly, the USB hub may detect this change in impedance as the switching condition. Thus, the USB hub may receive input invoking a switching condition indicating a change in logic in the hub.

[0010] It should be noted that in various embodiments where there are a plurality of upstream logics with associated host controllers, the input may also specify which of the coupled devices are to be controlled by the second device. In other words, as indicated above, the USB hub may have a plurality of host controllers, each controlling a respective subset of the coupled devices, possibly overlapping, and the input may specify that one or more of the coupled devices become host controllers for controlling other coupled devices, possibly including the old host controllers. In some embodiments, the input may specify a change in subsets of devices that are controlled by the new host controllers. Said another way, the input may specify that control of the plurality of coupled devices be changed to a new set of host controllers, and each of the new and/or old host controllers may control a new respective subset of the coupled devices.

[0011] Note that the input, the methods, and the switching conditions described herein may also apply to the above description regarding the multiple host controllers. For example, the input may be received mechanically, e.g., similar to above, via a switch, but in this case, the switch may have a plurality of options each associated with the new and old host controller(s) and the new controlled subset(s) of the coupled devices. Alternatively, or additionally, the input may be received electronically using the menus and methods described above. Note further that the above described switching conditions, and invoking thereof, are exemplary only and that other methods and switching conditions are envisioned. Thus, the USB hub may receive input specifying a change in control of the plurality of devices coupled to the USB hub from one or more host controllers to one or more other host controllers, e.g., previously acting as peripheral devices.

[0012] In one embodiment, the upstream logic included in the USB hub may be switched from receiving information from the first port, i.e., coupled to the old host controller, to receiving information from the second port, i.e., coupled to the new host controller. In other words, the USB hub may change control of the devices coupled to the hub from one device to another in response to the received input, e.g., the inputs described above. In one embodiment, the hub may perform this change by decoupling the first port from the upstream logic, decoupling the second port from the downstream logic, and coupling the second port to the upstream logic. In some embodiments, the hub may also allow the old host controller to act as a peripheral device to the new host controller; in other words, the hub may couple the downstream logic, e.g., the downstream logic that was used by the second port, to the first port. Thus, the upstream and downstream logic may be effectively switched between a host controller and a device. Correspondingly, in various embodiments, the new host controller may act as host to other devices, e.g., possibly including the old host controller, coupled to the hub, e.g., each with associated downstream logic.

[0013] It should be noted that the above described switching is not limited to any particular two ports included in the hub, and, in fact, any of a plurality of logics associated with various ports may be switched according to methods described above, among others. Thus, in one embodiment, any downstream logic, upstream logic, and/or other logics included in the USB hub may be switched.

[0014] Thus, using the methods described herein, the USB hub may switch the upstream and downstream logic(s) according to the received input.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered in conjunction with the following drawings, in which:

[0016] FIGS. **1** and **2** illustrate exemplary systems suitable for implementing various embodiments of the invention;

[0017] FIG. **3** is an exemplary block diagram illustrating one embodiment of a USB hub;

[0018] FIG. **4** is a flowchart diagram illustrating one embodiment of a method for switching logic in a USB Hub, according to one embodiment of the invention;

[0019] FIG. **5** is an exemplary block diagram illustrating one embodiment of a USB hub included in a USB device; and

[0020] FIG. **6** is an exemplary block diagram illustrating one embodiment of a USB hub included in a USB device which is coupled to a computer system.

[0021] While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof are shown by way of example in the drawings and are herein described in detail. It should be understood, however, that the drawings and detailed description thereto are not intended to limit the invention to the particular form disclosed, but on the contrary, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the present invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

Incorporation by Reference:

[0022] The following references are hereby incorporated by reference in their entirety as though fully and completely set forth herein:

[0023] U.S. patent application Ser. No. 10/940,406, titled "Universal Serial Bus Switching Hub," filed Sep. 14, 2004, whose inventors are Henry Wurzburg, James E. Bowles, Robert E. Hollingsworth, Mark R. Bohm, and Drew J. Dutton; and

[0024] U.S. patent application Ser. No. 11/100,299, titled "Peripheral Sharing USB Hub," filed Mar. 6, 2005, whose inventors are Mark R. Bohm, Mark Fu, Henry Wurzburg, James E. Bowles, Robert E. Hollingsworth and Drew J. Dutton.

Terms

[0025] The following is a glossary of terms used in the present application:

[0026] Memory Medium—Any of various types of memory devices or storage devices. The term "memory medium" is intended to include an installation medium, e.g., a CD-ROM, floppy disks **104**, or tape device; a computer system memory or random access memory such as DRAM,

DDR RAM, SRAM, EDO RAM, Rambus RAM, etc.; or a non-volatile memory such as a magnetic media, e.g., a hard drive, or optical storage. The memory medium may comprise other types of memory as well, or combinations thereof. In addition, the memory medium may be located in a first computer in which the programs are executed, or may be located in a second different computer which connects to the first computer over a network, such as the Internet. In the latter instance, the second computer may provide program instructions to the first computer for execution. The term "memory medium" may include two or more memory mediums which may reside in different locations, e.g., in different computers that are connected over a network.

[**0027**] Carrier Medium—a memory medium as described above, as well as signals such as electrical, electromagnetic, or digital signals, conveyed via a communication medium such as a bus, network and/or a wireless link.

[**0028**] Medium—includes one or more of a memory medium, carrier medium, and/or programmable hardware element; encompasses various types of mediums that can either store program instructions/data structures or can be configured with a hardware configuration program. For example, a medium that is "configured to perform a function or implement a software object" may be 1) a memory medium or carrier medium that stores program instructions, such that the program instructions are executable by a processor to perform the function or implement the software object; 2) a medium carrying signals that are involved with performing the function or implementing the software object; and/or 3) a programmable hardware element configured with a hardware configuration program to perform the function or implement the software object.

[**0029**] Computer System—any of various types of computing or processing systems, including a personal computer system (PC), mainframe computer system, workstation, network appliance, Internet appliance, personal digital assistant (PDA), television system, grid computing system, or other device or combinations of devices. In general, the term "computer system" can be broadly defined to encompass any device (or combination of devices) having at least one processor that executes instructions from a memory medium.

FIGS. **1** and **2**—Exemplary USB Systems

[**0030**] FIG. **1** illustrates an exemplary system suitable for implementing various embodiments of the current invention. As shown, a device, e.g., device **50**, may be coupled to a Universal Serial Bus (USB) hub, e.g., USB hub **80**, which may in turn be coupled to a host computer system, e.g., computer system **82**. In some embodiments, the device and/or the computer system may be coupled to each other, e.g., via the hub, via a network. For example, the computer system **82** and/or the device **50** may be at remote location(s) and may couple to the USB hub **80** via a network, e.g., an intranet network, a wide-area network (WAN), the Internet, etc.

[**0031**] The device **50** may be any of numerous devices capable of USB communication; for example, the device **50** may be or include a personal digital assistant (PDA), a portable digital music player, e.g., an IPOD™ as provided by Apple Computer Corporation, a cell phone, a printer, a digital camera, a video player, an audio device, a recording device, e.g., a digital voice recorder, a personal video recorder (PVR), a set-top box, an uninterrupted power supply (UPS), a mass-storage device, e.g., a hard drive, a zip drive, etc., a memory medium, e.g., flash memory, a thumb drive, etc., a keyboard, a mouse, a joystick, a communication device, e.g., a Bluetooth device, an Ethernet device, etc., a communication converter device, e.g., for converting signal formats, an additional USB hub, a computer system, and a monitor, among others. In preferred embodiments, the device may be a dual-role device, e.g., a USB OTG device. Note that the above list of devices and types of devices is exemplary only, and that other devices are also envisioned.

[**0032**] Additionally, the computer system **82** may be any of various computer types. For example, the computer system **82** include at least one memory medium on which one or more computer programs or software components may be stored. The memory medium may also store operating system software, as well as other software for operation of the computer system. Various embodiments further include receiving or storing instructions and/or data implemented in accordance with the foregoing description upon a carrier medium. As shown, the computer system **82** may include one or more coupled input devices, e.g., a keyboard and mouse, as well as other input devices, and a display device for displaying graphics associated with software components executing on the computer system **82**.

[**0033**] In various embodiments, the USB hub **80** may be any of various hubs. For example, the USB hub **80** may be an external hub, e.g., one whereby a host, such as the device **50** and/or the computer system **82**, may control one or more other devices coupled to the hub. In one embodiment, the USB hub **80** may be a root hub. Additionally, or alternatively, the USB hub **80** may be included in the device **50** or the computer system **82**. For example, the device may connect directly to a hub included in the computer system **82**. Additionally, or alternatively, the device may itself include a USB hub for connecting to other USB devices, e.g., the computer system **82** or a hub in each of the device **50** and the computer system **82**. In one embodiment, the USB hub may include or be a portion of a USB composite or compound device, e.g., similar to above where the USB hub **80** may be included in the device or computer system. Exemplary USB hubs and systems will be described in more detail below.

[**0034**] FIG. **2** illustrates another exemplary system suitable for implementing various embodiments of the current invention. As shown in FIG. **2**, the device **50** may be coupled to the USB hub **80**, which may in turn be coupled to another device, e.g., device **75**. Similar to above, the USB hub may be included in one or both of the device **50** and the device **75**, i.e., one of the devices may include the USB hub, and the other device may also include a similar USB hub; additionally, the device **75** may be or include any of the above enumerated devices capable of USB communication, among others.

[**0035**] Furthermore, in one embodiment, the device **75** and the USB hub **80** may be internal to the device **50**. For example, the device **50** may be a peripheral device such as a cell phone, a PDA, and/or a portable music player, among others, that includes the USB hub **80** for communication with internal and external devices. The cell phone, for example, may have any of numerous internal devices that

may be coupled to the USB hub such as a camera, a hard drive or another memory medium, a Bluetooth device, a digital music file player, or any of various appropriate devices such as those described above, among others. Following this example, the cell phone may couple to an external system, such as a PDA, and an internal device, such as a digital camera, via the USB hub housed inside of the cell phone. Note that the above-described system(s) are exemplary only, and other devices and systems are envisioned such as those described herein, among others.

FIG. **3**—Exemplary USB Hub

[**0036**] FIG. **3** illustrates a block diagram of an exemplary USB hub, e.g., the USB hub **80**, according to one embodiment of the present invention. In some embodiments, peripheral device(s) may couple to the USB hub through interface(s). For example, the USB hub may include physical (PHY) interfaces, and/or other interfaces, e.g. USB 2.0 Transceiver Macrocell Interface (UTMI) or UTMI+ Low Pin Interface (ULPI), among others. In one embodiment, the USB hub may include a plurality of ports, e.g., ports **310**, **320**, **330**A, **330**B, and **330**C as shown in FIG. **3**, for coupling to one or more devices, e.g., the device **50**, the device **75**, and/or other device(s), e.g., using the interfaces described above, among others. Each port may be coupled to logic for interpreting and transmitting signals to and from the devices. For example, a host controller may be coupled to upstream logic, e.g., upstream port logic **315**, which may be operable to transmit and receive information specific to devices acting as hosts. Conversely, a device may be coupled to downstream logic, e.g., downstream port logics **325**, **335**A, **335**B, and **335**C, which may be operable to transmit and receive information specific to devices acting as peripheral devices. It should be noted that the hub may include one or more of each of these logics, among others. For example, in one embodiment, the USB hub may have a plurality of upstream logics associated with one or more host controllers, each of which may have separate or overlapping control over the USB devices coupled to the USB hub. Additionally, as indicated above, the USB hub may have a plurality of downstream logics associated with one or more peripheral devices.

[**0037**] Furthermore, in some embodiments, the USB hub may include hub logic, e.g., hub logic **340**, for receiving, transmitting, and interpreting information to and from at least one host controller and the devices. For example, the hub logic **340** may be operable to intelligently route information from the host controller to the appropriate target device and vice-versa; additionally, the hub logic may be operable to resolve signal conflicts and collisions, e.g., signals sent from multiple devices at substantially the same time. In one embodiment, the USB hub may include one or more switches and/or switching logic(s), e.g., switching logics **350**A and **350**B, operable to couple and/or switch upstream or downstream logics associated with two or more devices as will be described in more detail below. Note that the switching logic may be separated into multiple components, such as, for example, the two components shown in FIG. **3**, or combined into a single switching logic component. Alternatively, the switching logic may be stored in a memory medium and/or distributed throughout the USB hub. Note that, as shown in FIG. **3**, the switching logic may be associated with a first port, e.g., the port **310**, and a second port, e.g., the port **320**; however, this configuration is exemplary only, and, in fact, other systems and designs are contemplated. For example, the switching logic may be associated with any or all of the ports included in the USB hub thus allowing any of the included logics to be switched, e.g., during operation.

[**0038**] As an example, in some embodiments, the USB hub may include a first port coupled to a host controller with associated upstream logic and a second port coupled to a USB device with associated downstream logic. As indicated above, there may be one or more additional devices coupled to one or more additional ports included in the USB hub. Thus, the host controller may control a plurality of USB devices, e.g., by using the hub logic described above. If one of the USB devices is a dual-role device, it may request or be requested to become the host controller of the hub, e.g., to control the other USB devices coupled to the USB hub as described below.

FIG. **4**—Exemplary Method for Switching Logic in a USB Hub

[**0039**] FIG. **4** illustrates an exemplary method for switching logic in a USB hub, such as the USB hub of FIG. **3**. The method shown in FIG. **4** may be used in conjunction with any of the computer systems or devices described herein, among others. In various embodiments, some of the method elements shown may be performed concurrently, in a different order than shown, or may be omitted. Additional method elements may also be performed as desired. As shown, this method may operate as follows.

[**0040**] In **402**, input may be received to the USB hub, e.g., USB hub **80**, specifying a change in control of one or more devices coupled to the USB hub **80** (e.g., via ports **330**A-**330**C) by a first device, e.g., coupled to the first port **310**, to control by a second device, e.g., coupled to the second port **320**. For example, following the descriptions above, if one of the devices is an OTG or dual-role device, it may request, or be instructed, to act as the host controller of the USB hub. In this example, the input may be received from any of a variety of sources, and may set or invoke a switching condition, which may then be detected by the USB hub.

[**0041**] In some embodiments, the switching condition may be invoked mechanically, such as, for example, by flipping, i.e., switching on or off, a mechanical switch on the USB hub, or, alternatively, if the USB hub is included in a device, a switch on the device. In one embodiment, the switching condition may include a change in orientation of the connecting cables. More specifically, as indicated above, in the current USB OTG specification, the USB connecting cable may have a default host controller connection (on one end) and a default device connection (on the other end). In this case, the switching condition may be invoked by reversing these two connections, e.g., via the change in pins associated with each of the connectors on each end of the cable may invoke the switching condition.

[**0042**] Alternatively, or additionally, a user or other system may invoke the switching condition via electronic means; for example, the user may choose from a plurality of possible buttons or options, e.g., depending on the number of devices coupled to the USB hub. For example, if the USB hub is included in a peripheral device, e.g., a cell phone, PDA, and/or a digital music player, among others, the user may be presented with a plurality of options on the display

of the peripheral device and may invoke the switching condition by selecting one or more of the available options. More specifically, the peripheral device may include a menu associated with the USB hub; the user may select this menu, e.g., via a stylus, voice activation, and/or a keypad, among others means, and select from one or more options to invoke a specific change in host, e.g., by invoking the switching condition. Alternatively, the user may invoke the switching condition, e.g., similar to methods described above, among others, from a device coupled to the USB hub.

[0043] In some embodiments, the USB hub may automatically detect the switching condition. For example, the USB hub may have a sensing mechanism, e.g., present in the physical layer (PHY) of connections to the USB hub, specifically for detecting the switching condition. In one embodiment, the switching condition may include a change of impedance in one or more pins of one of the connections to the USB hub, e.g., one or more of the ports. For example, in one embodiment, the invoked switching condition, e.g., via the means described above, may include a change in impedance on the D+ and D− pins of the USB cable, e.g., connected to the peripheral device that is requesting logic reversal. As a specific example, normally two of the pins in the PHY may have an impedance of 15 kOhms, and after tying, for example, two pins together, the impedance may decrease to 7.5 kOhms. Correspondingly, the USB hub may detect this change in impedance as the switching condition. Thus, the USB hub may receive input invoking a switching condition indicating a change in logic in the hub.

[0044] It should be noted that in various embodiments where there are a plurality of upstream logics with associated host controllers, the input may also specify which of the coupled devices are to be controlled by the second device. In other words, as indicated above, the USB hub may have a plurality of host controllers, each controlling a respective subset of the coupled devices, possibly overlapping, and the input may specify that one or more of the coupled devices become host controllers for controlling other coupled devices, possibly including the old host controllers. In some embodiments, the input may specify a change in subsets of devices that are controlled by the new host controllers. Said another way, the input may specify that control of the plurality of coupled devices be changed to a new set of host controllers, and each of the new and/or old host controllers may control a new respective subset of the coupled devices.

[0045] For example, the USB hub may first include two host controllers, such as a computer and a PDA, and a plurality of peripheral devices, such as a cell phone, a printer, and a digital camera. In this example, the computer may control the printer and the cell phone, and the PDA may control the digital camera. Subsequently, the USB hub may receive input specifying that the cell phone become a new host controller, e.g., taking the place of the PDA, e.g., in order to print a picture. In this case, the input may specify that the new host controller, i.e., the cell phone, control the printer and the digital camera, and that the computer control the PDA. Thus, the input may specify a change in control from one or more host controllers, in this case, the. PDA, to one or more of the peripheral devices, in this case, the cell phone. Additionally, the input may specify a new control set for each of the new controllers, e.g., the cell phone controlling the printer and the digital camera, and the computer controlling the PDA.

[0046] As a simple example, the USB hub may couple to a host controller and a plurality of USB devices, e.g., a dual-role digital music player device controlling a dual-role PDA, a keyboard, and a digital video recorder. In this example, the USB hub may receive input specifying that upstream logic for controlling the keyboard be coupled to the PDA, and that the digital music player continue to control the digital video recorder coupled to the USB hub. Thus, in some embodiments, the input may specify that the original host controller may control a new subset of the coupled devices, e.g., only the digital video recorder, and the new host controller control another subset, e.g., the keyboard.

[0047] Note that the input, the methods, and the switching conditions described herein may also apply to the above descriptions regarding the multiple host controllers. For example, the input may be received mechanically, e.g., similar to above, via a switch, but in this case, the switch may have a plurality of options each associated with the new and old host controller(s) and the new controlled subset(s) of the coupled devices. Alternatively, or additionally, the input may be received electronically using the menus and methods described above. Note further that the above described switching conditions, and invoking thereof, are exemplary only and that other methods and switching conditions are envisioned. Thus, the USB hub may receive input specifying a change in control of the plurality of devices coupled to the USB hub from one or more host controllers to one or more other host controllers, e.g., previously acting as peripheral devices.

[0048] In **404**, the upstream logic included in the USB hub may be switched from receiving information from the first port, i.e., coupled to the old host controller, to receiving information from the second port, i.e., coupled to the new host controller. In other words, the USB hub may change control of the devices coupled to the hub from one device to another in response to the received input, e.g., the inputs described above. In one embodiment, the hub may perform this change by decoupling the first port from the upstream logic, decoupling the second port from the downstream logic, and coupling the second port to the upstream logic. In some embodiments, the hub may also allow the old host controller to act as a peripheral device to the new host controller; in other words, the hub may couple the downstream logic, e.g., the downstream logic that was used by the second port, to the first port. Thus, the upstream and downstream logic may be effectively switched between a host controller and a device. Correspondingly, in various embodiments, the new host controller may act as host to other devices, e.g., possibly including the old host controller, coupled to the hub, e.g., each with associated downstream logic. Further examples of this switching will be described in more detail below.

[0049] It should be noted that the above described switching is not limited to any particular two ports included in the hub, and, in fact, any of a plurality of logics associated with various ports may be switched according to methods described above, among others. Thus, in one embodiment, any downstream logic may be switched with any upstream logic and/or other logics included in the USB hub.

[0050] Following the example above regarding the computer, the PDA, and the cell phone, the USB hub may switch

the upstream and downstream logic associated with the PDA and the cell phone respectively. The USB hub may also switch the control of the peripherals, e.g., the printer being controlled by the computer to being controlled by the cell phone, by rerouting the signals from the upstream logic of the computer to the upstream logic of the cell phone. In other words, the downstream logic associated with the printer may be switched from receiving signals from the computer to receiving signals from the cell phone. Thus, after the logic is switched, the cell phone may control the printer and the digital camera, and the computer may control the PDA. Further details regarding the changing of controlled subsets of devices in USB hubs can be found in U.S. application Ser. Nos. 10/940,406 and 11/100,299 which were incorporated by reference above.

[**0051**] Thus, using the methods described herein, the USB hub may switch the upstream and downstream logic(s) according to the received input.

FIGS. **5** and **6**—Exemplary USB Hub Included in a USB Device

[**0052**] FIGS. **5** and **6** illustrate exemplary block diagrams of a USB hub included in a USB device, e.g., device **500**. The device may be or include any of the above-described devices, e.g., as described with respect to the above described Figures, among others. Similar to above, the USB hub **508** may include a plurality of ports, e.g., reversible ports **510** and **514** and downstream ports **516** and **518**, for coupling to at least one host controller and one or more peripheral devices. As also described above, the coupled devices may be internal or external to the USB device. The USB device may include logic for controlling devices and for acting as a peripheral device, e.g., dual-role host controller block **504**, which may be coupled to or included in a system-on-a-chip (SoC) **502** that controls the peripheral device. In some embodiments, the peripheral device may include a mass-storage device, e.g., mass-storage **506**, e.g., a hard drive, for storing information. As shown, the mass storage device may be coupled to the SoC **502** outside of the USB hub **508**; alternatively, the mass storage device may be coupled to the USB hub as an internal or external device, e.g., USB device **520**, **522**, or **524**. Furthermore, similar to above, the USB hub may include hub logic **512**, e.g., for routing signals between the host controller and the coupled devices.

[**0053**] As also shown, the USB hub may reverse at least two of the ports, e.g., reversible ports **510** and **514**, e.g., using switching logic methods and conditions described above, among others. Note that, this particular system is exemplary only, and, in fact, further embodiments are envisioned where any of the ports included in the USB hub may be reversible.

[**0054**] FIG. **6** illustrates the USB device, e.g., the device **500**, coupled to a computer system, e.g., computer system **602**, e.g., similar to the computer system **82** described above. The computer system may include a USB host controller, e.g., USB host controller **604**, for managing and/or communicating with devices (e.g., USB devices **522** and **524**) coupled to the computer system. The computer system may also include a port for coupling to other USB devices, e.g., port **606**. Thus, as shown, the computer system may couple to the peripheral device via the USB hub and may alternate as host controller of the coupled devices and device with the host controller included in the peripheral device. In other words, the computer system and/or the SoC **502** may control respective subsets (or all) of the devices coupled to the USB hub. In one embodiment, the computer system may act as a host, and may control the mass storage device via the SoC. In other words, the computer system may control the mass storage device by sending commands through the SoC. In one embodiment, the SoC may interpret the commands and send corresponding commands to the mass storage device for the computer system. In embodiments where the mass storage device is coupled to the USB hub directly, the computer system may control the mass storage device without using the SoC.

[**0055**] As an example, the peripheral device may be a cell phone including an associated hard drive, e.g., the mass storage device **506** as well as a digital camera and a Bluetooth device. The cell phone may have a USB port for coupling to other devices, in this case, the computer system. Thus, when the SoC acts as the host controller of the USB hub, the cell phone may control each of the coupled devices and communicate information to the host computer as a host controller. Upon receiving input specifying a change in control, the USB hub may switch respective upstream and downstream logics associated with the cell phone and the host computer. Subsequently, the host computer may control respective devices in the cell phone. For example, the host computer may update files on the hard drive, e.g., via the SoC, take pictures using the digital camera, and communicate using the Bluetooth device. Alternatively, as described above, the host controller may control a subset of these devices, and the SoC may continue to control another subset.

[**0056**] Thus, using the systems and methods described herein, a USB hub may change control of a plurality of coupled devices from a first device acting as a host controller to a second device, which was previously a peripheral device.

[**0057**] Although the embodiments above have been described in considerable detail, numerous variations and modifications will become apparent to those skilled in the art once the above disclosure is fully appreciated. It is intended that the following claims be interpreted to embrace all such variations and modifications.

We claim:

1. A Universal Serial Bus (USB) hub, comprising:

upstream logic for sending and receiving information to and from a host controller;

downstream logic for sending and receiving information to and from a USB device;

a plurality of ports operable to couple to a plurality of devices, including a first port of the plurality of ports coupled to the upstream logic, and a second port of the plurality of ports coupled to the downstream logic; and

switching logic operable to switch the upstream logic and the downstream logic with respect to the first port and the second port respectively.

2. The USB hub of claim 1,

wherein to switch the upstream and downstream logics, the switching logic is operable to decouple the first port

from the upstream logic, decouple the second port from the downstream logic, and couple the second port to the upstream logic.

3. The USB hub of claim 2,

wherein to switch the upstream and downstream logics, the switching logic is further operable to couple the first port to the downstream logic.

4. The USB hub of claim 1, wherein the switching logic is further operable to:

automatically detect a switching condition with respect to the upstream logic and/or the downstream logic; and

switch the upstream logic and/or the downstream logic in response to the automatic detection.

5. The USB hub of claim 4,

wherein the automatic detection is based on a change in impedance at one or more of the plurality of ports.

6. The USB hub of claim 1, wherein the switching logic is operable to switch the upstream logic and/or the downstream logic in response to a user-user invoked switching condition.

7. The USB hub of claim 1,

wherein after the upstream logic is switched from the first port to the second port, a device of the plurality of devices coupled to the second port is operable to control other devices of the plurality of devices coupled to respective other ports of the USB hub, wherein each of respective other ports is coupled to respective downstream logic.

8. The USB hub of claim 1,

wherein the hub comprises a plurality of downstream logics, wherein the plurality of downstream logics comprises the downstream logic, wherein each of the plurality of downstream logics are associated with a port of the plurality of ports, and wherein the switching logic is further operable to switch the upstream logic and downstream logic between any two ports of the plurality of ports.

9. The USB hub of claim 1,

wherein the USB hub is comprised in a peripheral device.

10. The USB hub of claim 8,

wherein a subset of the plurality of devices comprise one or more of:

one or more devices internal to the peripheral device; and

one or more devices external to the peripheral device.

11. The USB hub of claim 1,

wherein the USB hub is comprised in a cell phone.

12. The USB hub of claim 1,

wherein the USB hub is comprised in a portable music player device.

13. The USB hub of claim 1,

wherein the USB hub is comprised in an external housing, and wherein the USB hub is operable to attach to a system as a first device of the plurality of devices to provide USB communication between the system and the plurality of devices.

14. The USB hub of claim 1, wherein the plurality of devices comprises one or more of:

one or more cell phones;

one or more portable music player devices;

one or more computers;

one or more printers;

one or more hard-drives;

one or more digital cameras;

one or more memory mediums;

one or more audio devices;

one or more keyboards;

one or more mice;

one or more joysticks;

one or more uninterrupted power supplies (UPS);

one or more additional USB hubs;

one or more Ethernet devices;

one or more Bluetooth devices;

one or more storage devices;

one or more video devices; and

one or more communication converter devices.

15. The USB hub of claim 1,

wherein the USB hub further comprises one or more additional upstream logics coupled to one or more respective ports of the plurality of ports for sending and receiving information to and from one or more respective host controllers, and wherein the USB hub is configurable to allow the one or more host controllers to control respective subsets of the plurality of devices; and

wherein the switching logic is further operable to change the configuration of the USB hub to allow the one or more host controllers to control other respective subsets of the plurality of devices.

16. The USB hub of claim 15,

wherein the USB hub further comprises one or more additional downstream logics coupled to another one or more respective ports of the plurality of ports for sending and receiving information to and from one or more respective USB devices coupled to the other one or more respective ports,

wherein the switching logic is further operable to switch any of the one or more additional upstream logics and/or the upstream logic with a respective any of the one or more downstream logics to switch control relationships among the plurality of devices.

17. A Universal Serial Bus (USB) hub, comprising:

a plurality of ports operable to couple to a plurality of devices; and

switching logic operable to couple a port of the plurality of ports to upstream logic for controlling devices coupled to other ports of the plurality of ports.

18. The USB hub of claim 17,

wherein the switching logic is further operable to switch upstream logic and downstream logic between any two respective ports of the plurality of ports.

19. The USB hub of claim 17,

wherein the USB hub is comprised in a peripheral device.

20. The USB hub of claim 17,

wherein the switching logic is further operable to:

automatically detect a switching condition with respect to the upstream logic and/or the downstream logic; and

switch the upstream logic and/or the downstream logic in response to the automatic detection.

21. The USB hub of claim 17,

wherein the USB hub is comprised in an external housing, and wherein the USB hub is operable to attach to a system as a first device of the plurality of devices to provide USB communication between the system and the plurality of devices.

22. The USB hub of claim 17, wherein the plurality of devices comprises one or more of:

one or more cell phones;

one or more portable music player devices;

one or more computers;

one or more printers;

one or more hard-drives;

one or more digital cameras;

one or more memory mediums;

one or more audio devices;

one or more keyboards;

one or more mice;

one or more joysticks;

one or more uninterrupted power supplies (UPS);

one or more additional USB hubs;

one or more Ethernet devices;

one or more Bluetooth devices;

one or more storage devices;

one or more video devices; and

one or more communication converter devices.

23. The USB hub of claim 1,

wherein the USB hub is a root USB hub.

24. A method, comprising:

receiving input to a Universal Serial Bus (USB) hub, wherein the USB hub comprises a plurality of ports for connecting to a plurality of devices, and wherein the input specifies a change in control of at least a subset of the plurality of devices by a first device coupled to a first port to control of the at least a subset of the plurality of devices by a second device coupled to a second port; and

switching upstream logic comprised in the USB hub from sending and receiving information to and from the first device via the first port as a host controller to sending and receiving information to and from the second device via the second port as the host controller.

25. The method of claim 24, wherein said switching the upstream logic composes:

decoupling the upstream logic from the first port;

decoupling downstream logic for sending and receiving information to and from the second device via the second port as a USB device; and

coupling the upstream logic to the second port.

26. The method of claim 24, further comprising:

coupling the downstream logic to the first port for sending and receiving information to and from the first device via the first port as the USB device.

27. The method of claim 24,

wherein the USB hub is comprised in a peripheral device.

28. The method of claim 24, further comprising:

automatically detecting a switching condition with respect to the upstream logic and/or the downstream logic; and

wherein said switching the upstream logic and/or the downstream logic is performed in response to the automatic detection.

29. The method of claim 24,

wherein the USB hub is an external USB hub.

30. The method of claim 24, wherein the plurality of devices comprise one or more of:

one or more cell phones;

one or more portable music player devices;

one or more computers;

one or more printers;

one or more hard-drives;

one or more digital cameras;

one or more memory mediums;

one or more audio devices;

one or more keyboards;

one or more mice;

one or more joysticks;

one or more Uninterrupted Power Supplies (UPS);

one or more additional USB hubs;

one or more Ethernet devices;

one or more Bluetooth devices;

one or more storage devices;

one or more video devices; and

one or more communication converter devices.

31. The method of claim 24,

wherein the USB hub further comprises one or more additional upstream logics coupled to one or more respective ports of the plurality of ports for sending and

receiving information to and from one or more respective host controllers, and wherein the USB hub is configurable to allow the one or more host controllers to control respective subsets of the plurality of devices; and

wherein the method further comprises changing the configuration of the USB hub to allow the one or more host controllers to control other respective subsets of the plurality of devices.

32. The method of claim 31,

wherein the USB hub further comprises one or more downstream logics coupled to another one or more respective ports of the plurality of ports for sending and receiving information to and from one or more respective USB devices coupled to the other one or more respective ports,

wherein the method further comprises switching one of the one or more additional upstream logics and/or the upstream logic with a respective other of the one or more downstream logics to switch control relationships among the plurality of devices.

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