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Kumar

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(54) **METHOD AND SYSTEM FOR HARDWARE BASED IMPLEMENTATION OF USB 1.1 OVER A HIGH SPEED LINK**

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Related U.S. Application Data

(63) Continuation of application No. 13/355,735, filed on Jan. 23, 2012, now Pat. No. 8,225,020, which is a continuation of application No. 11/304,358, filed on Dec. 15, 2005, now Pat. No. 8,103,813.

(60) Provisional application No. 60/697,571, filed on Jul. 8, 2005.

(51) **Int. Cl.**
G06F 13/42 (2006.01)

(52) **U.S. Cl.** **710/106**; 710/65

(58) **Field of Classification Search** 710/62, 710/64–65, 106, 313, 315
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0045037 A1 3/2006 Nomura
2006/0123166 A1 6/2006 Toebes et al.

OTHER PUBLICATIONS

U.S. Appl. No. 11/304,358 entitled "Method and System for Hardware Based Implementation of USB 1.1 Over a High Speed Link," which was filed Dec. 15, 2005.
U.S. Appl. No. 61/697,571 entitled "Method and System for Hardware Based Implementation of USB 1.1 Over a High Speed Link," which was filed Jul. 8, 2005.

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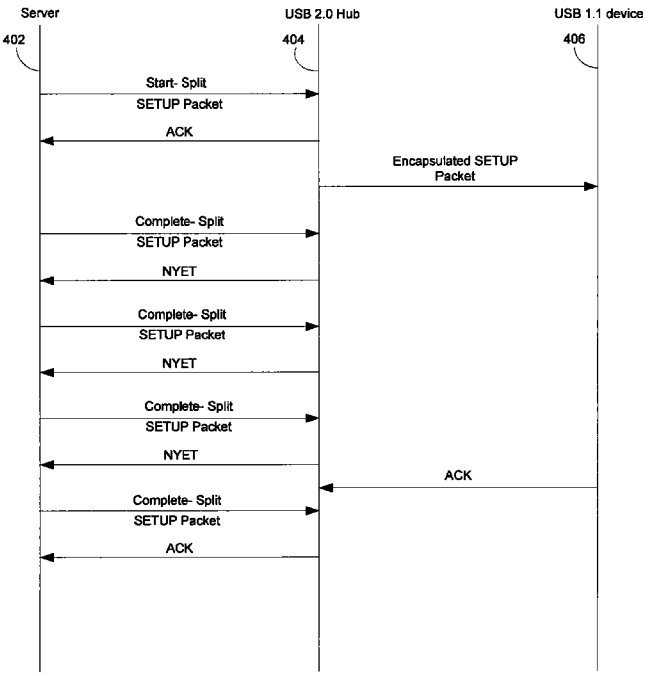
(57) **ABSTRACT**

Certain aspects of a method and system for a hardware-based implementation of USB 1.1 over a high-speed link may comprise translating at a client side of a client server communication system, USB protocol messages comprising a first USB standard to corresponding encapsulated USB protocol messages, wherein the USB protocol messages comprising the first USB standard are received from a client device at the client side of the client server communication system. The translated corresponding encapsulated USB protocol messages may be communicated from the client side to a server at a server side of the client server communication system.

20 Claims, 6 Drawing Sheets



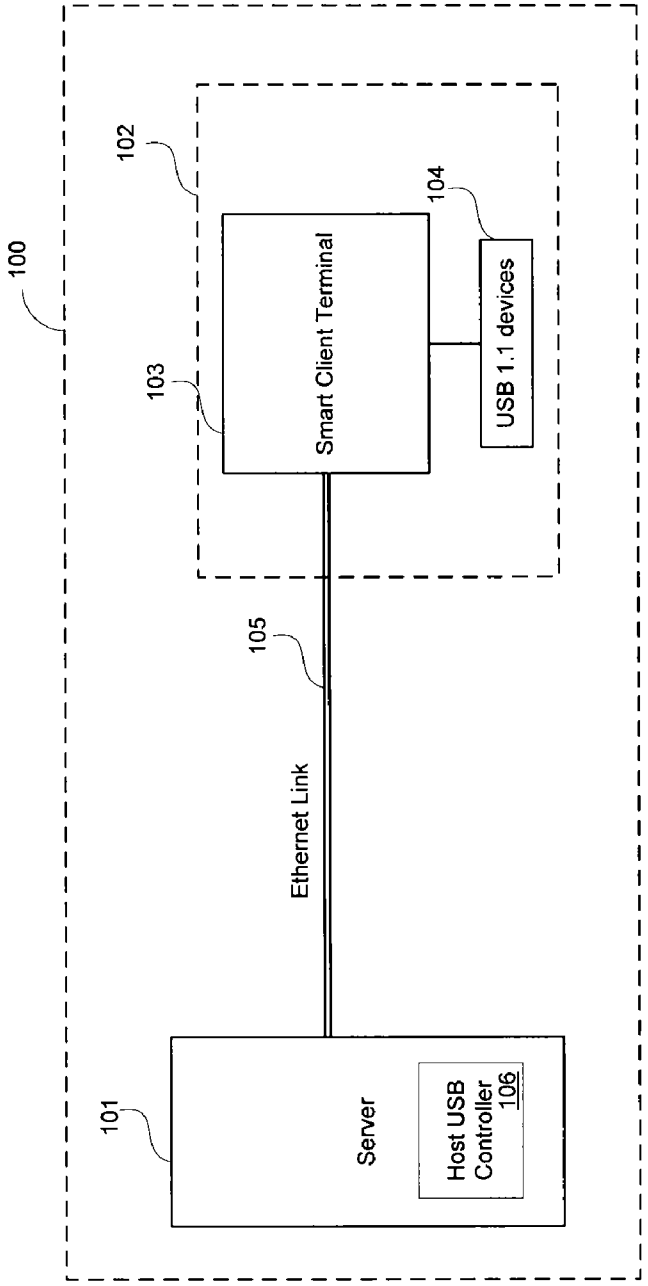

100
102
103
Smart Client Terminal
104
USB 1.1 devices
105
Ethernet Link
101
Server
Host USB Controller 106

FIG. 1

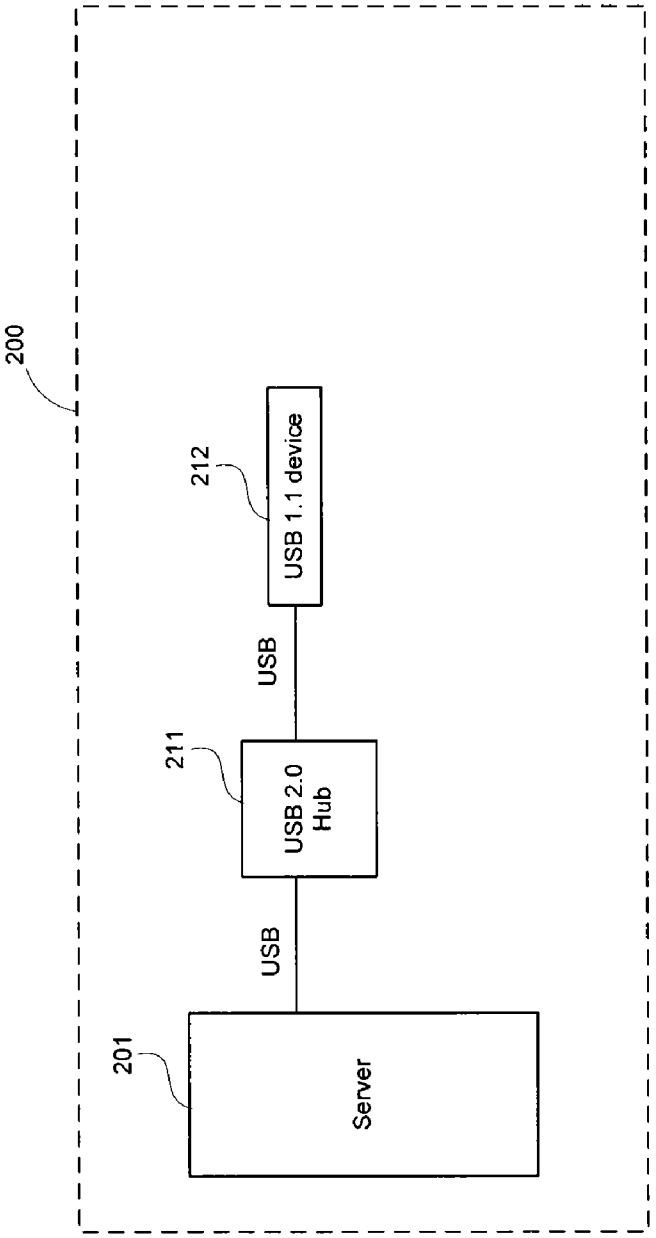


FIG. 2

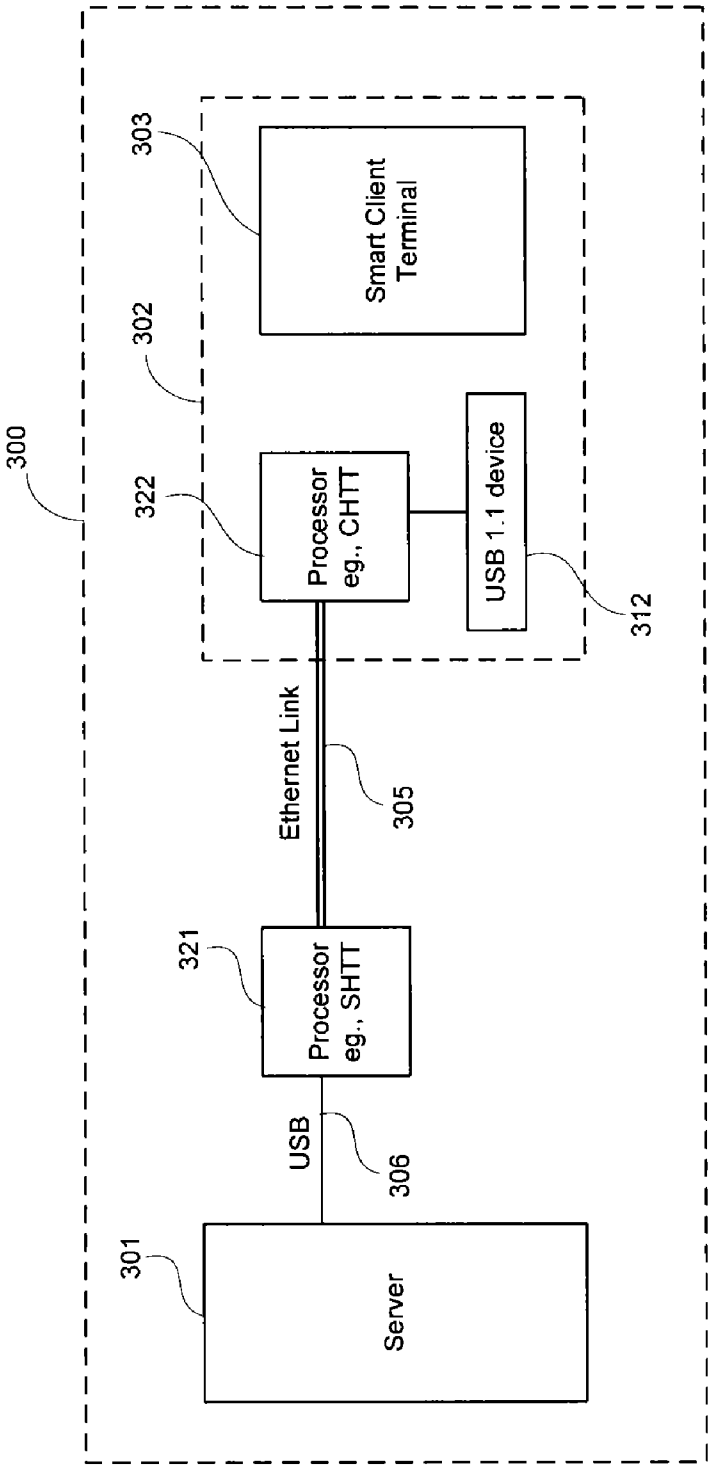

300
303
Smart Client Terminal
302
322
Processor eg., CHTT
USB 1.1 device
312
Ethernet Link
305
321
Processor eg., SHTT
USB
306
301
Server

FIG. 3

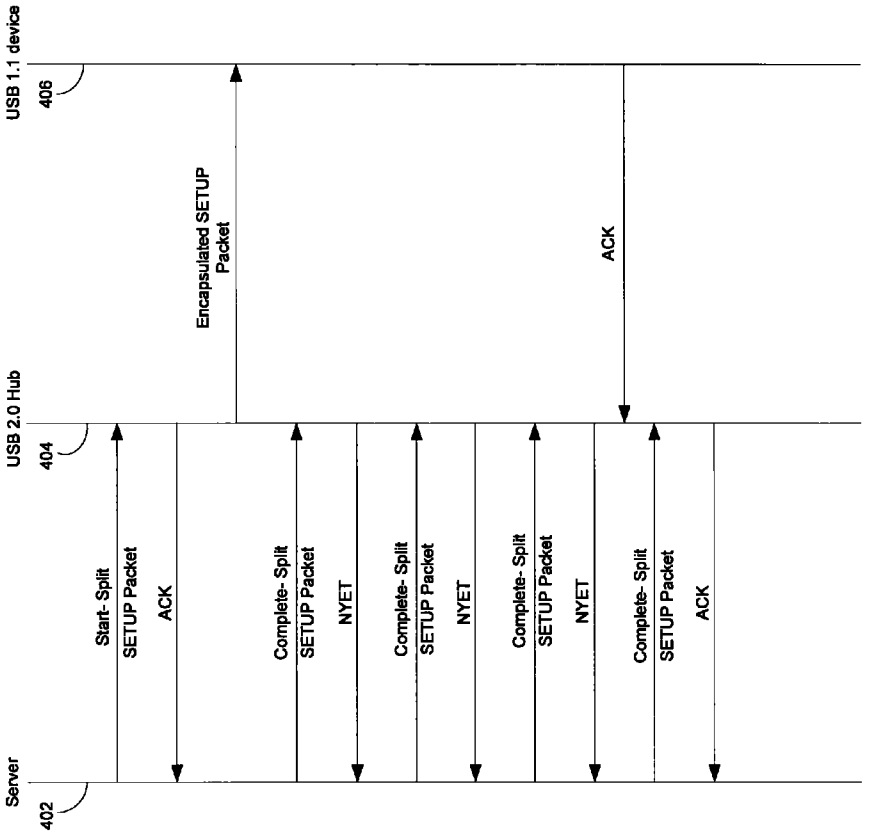

USB 1.1 device
406
USB 2.0 Hub
404
Server
402
Encapsulated SETUP Packet
ACK
Start- Split
SETUP Packet
ACK
Complete- Split
SETUP Packet
NYET
Complete- Split
SETUP Packet
NYET
Complete- Split
SETUP Packet
NYET
Complete- Split
SETUP Packet
ACK

FIG. 4

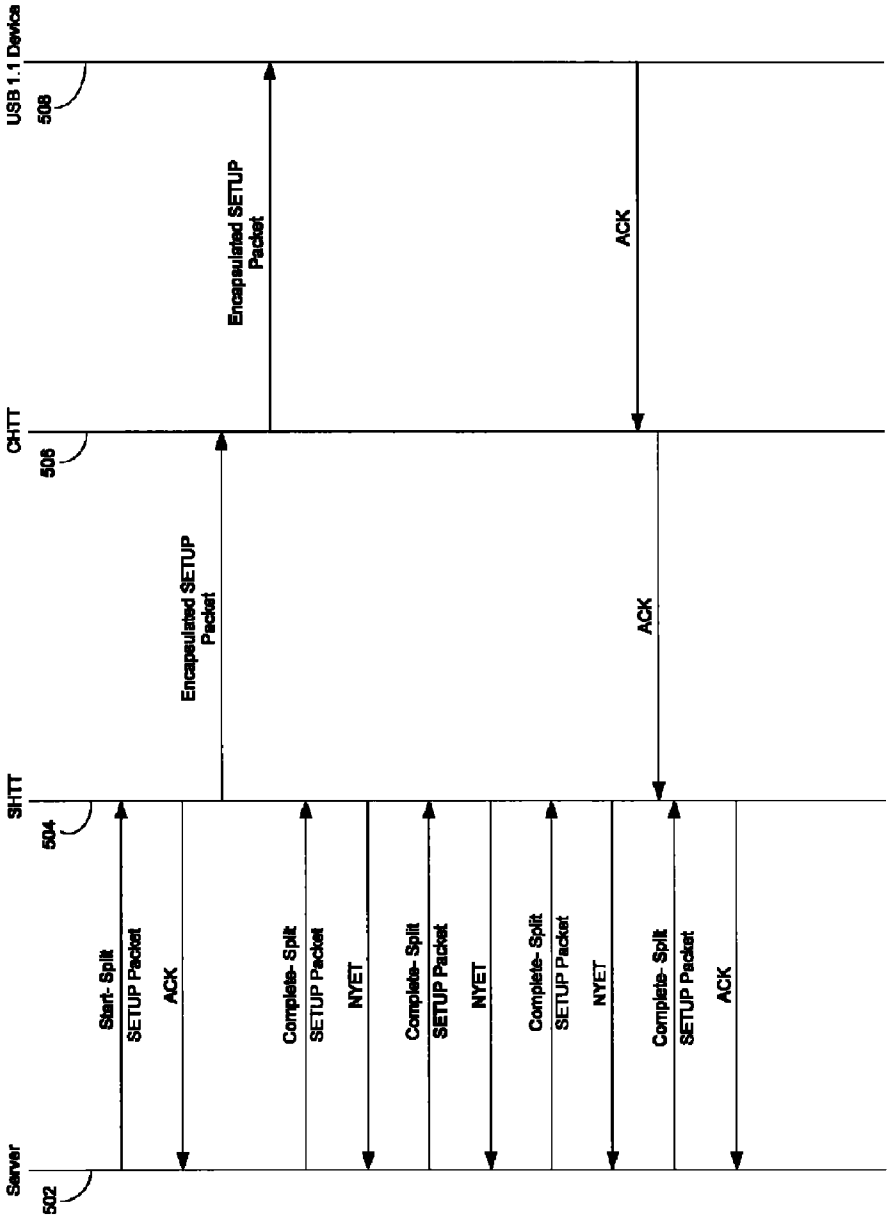

USB 1.1 Device
508
CHTT
506
SHTT
504
Server
502
Encapsulated SETUP Packet
ACK
Encapsulated SETUP Packet
ACK
Start- Split
SETUP Packet
ACK
Complete- Split
SETUP Packet
NYET
Complete- Split
SETUP Packet
NYET
Complete- Split
SETUP Packet
NYET
Complete- Split
SETUP Packet
ACK

FIG. 5

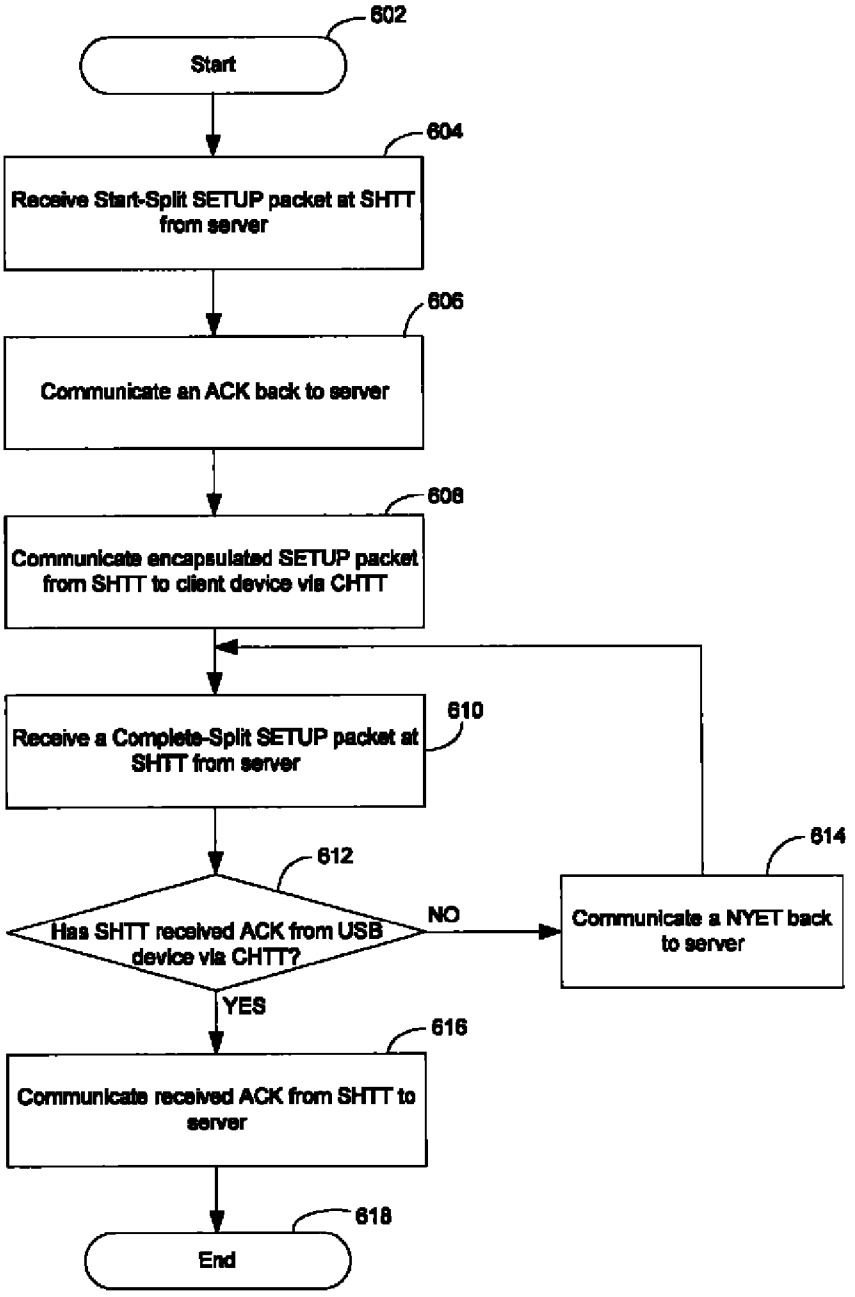

602
Start
604
Receive Start-Split SETUP packet at SHTT from server
606
Communicate an ACK back to server
608
Communicate encapsulated SETUP packet from SHTT to client device via CHTT
610
Receive a Complete-Split SETUP packet at SHTT from server
612
Has SHTT received ACK from USB device via CHTT?
NO
614
Communicate a NYET back to server
YES
616
Communicate received ACK from SHTT to server
618
End

FIG. 6

METHOD AND SYSTEM FOR HARDWARE BASED IMPLEMENTATION OF USB 1.1 OVER A HIGH SPEED LINK

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

This application is a continuation of U.S. patent application Ser. No. 13/355,735, filed Jan. 23, 2012, which is a continuation of U.S. patent application Ser. No. 11/304,358, filed Dec. 15, 2005 which makes reference to, claims priority to, and claims the benefit of U.S. Provisional Patent Application Ser. No. 60/697,571, filed Jul. 8, 2005.

The above stated applications are hereby incorporated herein by reference in their entireties.

FIELD OF THE INVENTION

Certain embodiments of the invention relate to communication interfaces. More specifically, certain embodiments of the invention relate to a method and system for a hardware based implementation of USB 1.1 over a high speed link.

BACKGROUND OF THE INVENTION

The Universal Serial Bus was originally developed in 1995 by a consortium of companies. The major goal of USB was to define an external expansion bus, which makes adding peripherals to a PC as easy as hooking up a telephone to a wall-jack. The ease-of-use and low cost made USB successful in the marketplace, with most peripheral vendors around the globe developing products to its specification.

One role of system software is to provide a uniform view of the system for all applications software. The system software may be adapted to hide hardware implementation details so that application software is more portable. The system software may manage the dynamic attach and detach of peripherals. This phase, called enumeration, involves communicating with the peripheral to discover the identity of a device driver that it should load, if not already loaded. A unique address is assigned to each peripheral during enumeration to be used for run-time data transfers. During run-time the host PC initiates transactions to specific peripherals, and each peripheral accepts its transactions and responds accordingly. Additionally, the host PC software incorporates the peripheral into the system power management scheme and may manage overall system power without user interaction.

The hub may provide additional connectivity for USB peripherals and managed power to attached peripherals. The hub may recognize dynamic attachment of a peripheral and provide device power for peripheral operation. A newly attached hub may be assigned its unique address, and hubs may be cascaded up to five levels deep, for example. During run-time a hub may operate as a bi-directional repeater and may repeat USB signals as required on upstream cables towards the host and downstream cables towards the device.

The USB peripherals may be adapted to request transactions sent from the host PC. The peripheral may respond to control transactions that, for example, request detailed information about the device and its configuration. The peripheral may transmit and receive data to/from the host using a standard USB data format. This standardized data movement to/from the PC host and interpretation by the peripheral gives USB enormous flexibility with little PC host software changes. The USB 1.1 peripherals may operate at 12 Mb/s or 1.5 Mb/s.

USB 2.0 is an evolution of the USB 1.1 specification, providing a higher performance interface. The USB 1.1 connectors and full-speed cables may support the higher speeds of USB 2.0 without any changes. The higher transmission speed may be negotiated on a device-by-device basis and if the higher speed is not supported by a peripheral, then the link operates at a lower speed of 12 Mb/s or 1.5 Mb/s as determined by the peripheral. The external USB 2.0 hub may have different signaling rates on its ports. Using a 40× multiplier for USB 2.0, the USB 2.0 hub may have an input rate of 480 Mb/s and output rates of 480 Mb/s, for example, for attached high speed USB 2.0 peripherals, and 12 Mb/s or 1.5 Mb/s, for example, for attached USB 1.1 peripherals. The USB 2.0 hub may match the data rates sent out of its downstream ports to the data rate appropriate to the attached device. The higher data rate of USB 2.0 may open up the possibilities of new peripherals, for example, video-conferencing cameras may perform better with access to higher bandwidth.

The system software may comprehend the increased capabilities of USB 2.0 peripherals so that it can optimize performance and detect sub-optimal configurations, for example, a USB 2.0 peripheral attached to a USB 1.1 hub, and recommends a better configuration for attaching the peripherals. A USB 2.0 hub may be adapted to accept high-speed transactions at the faster frame rate and deliver them to high-speed USB 2.0 peripherals and USB 1.1 peripherals. This data rate matching responsibility may require increased hub complexity and temporary buffering of the incoming high-speed data. In the case of communicating with an attached USB 2.0 peripheral, the hub repeats the high speed signals on appropriate USB 2.0 upstream and downstream cables. This allows USB 2.0 peripherals to utilize the majority of USB 2.0 bandwidth.

To communicate with USB 1.1 peripherals, a USB 2.0 hub may comprise a mechanism that supports the concept of matching the data rate with the capabilities of the downstream device. The hub may be adapted to manage the transition of the data rate from the high speed of the host controller to the lower speed of a USB 1.1 device.

A USB device may be serviced by a local USB host controller and appropriate host software to configure, operate, monitor and manage the USB devices. However, in order to enable a host with limited local intelligence to support some USB devices, the USB processing may be executed in a remote location based on a local entity sending the signals to that remote location. For example, in a client/server setup, where the client is a smart terminal with limited local processing but would like to offer the flexibility of supporting peripherals, for example, USB 1.1 peripherals such as keyboard, mouse and printer.

Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

A method and system for a hardware based implementation of USB 1.1 over a high speed link, substantially as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated

embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a block diagram of an exemplary client/server configuration for a USB system that may be utilized in connection with an embodiment of the invention.

FIG. **2** is a block diagram of a single computer USB system with a USB 2.0 hub that may be utilized in connection with an embodiment of the invention.

FIG. **3** is a block diagram of a single computer USB 2.0 system with a server side hub transaction translator (SHTT) and a client side hub transaction translator (CHTT), in accordance with an embodiment of the invention.

FIG. **4** is a flow diagram illustrating an exemplary USB 1.1 setup packet transaction over a USB 2.0 hub, in accordance with an embodiment of the invention.

FIG. **5** is a flow diagram illustrating an exemplary USB 1.1 setup packet transaction over a USB 2.0 system with a server side hub transaction translator (HTT) and a client side HTT, in accordance with an embodiment of the invention.

FIG. **6** is a flow chart illustrating exemplary steps for a hardware-based implementation of USB 1.1 over a high-speed link, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Certain aspects of a method and system for a hardware-based implementation of USB 1.1 over a high-speed link may comprise translating at a client side of a client server communication system, USB protocol messages comprising a first USB standard to corresponding encapsulated USB protocol messages, wherein the USB protocol messages comprising the first USB standard are received from a client device at the client side of the client server communication system. The translated corresponding encapsulated USB protocol messages may be communicated from the client side to a server at a server side of the client server communication system. The client device may receive the USB protocol messages comprising the first USB standard from the server, wherein the USB protocol messages comprising the first USB standard that were received from the server were translated from the second USB standard at the server side of the client server communication system prior to being received at the client device.

At least a first packet of data may be received from a server. The first packet of data may be a start-split SETUP packet, for example. The received start-split SETUP packet may be encapsulated and transmitted to a client side hub transaction translator (CHTT). The received first packet of data, for example, the SETUP packet may be transmitted to at least one universal serial bus (USB) 1.1 device by the CHTT. At least a second packet of data may be received from the server. At least a first acknowledgement (ACK) packet may be received from at least one USB 1.1 device by the CHTT. The first ACK packet may be received from the CHTT and the received first ACK packet may be transmitted to the server.

In an embodiment of the invention, a transparent hardware connection may be provided in a client/server setup over a high-speed link between USB 1.1 devices attached to the client and a USB 2.0 host system integrated with the server. For illustrative purposes, an exemplary high-speed link may comprise an Ethernet link, although the invention is not limited in this regard. Ethernet is based on carrier sense multiple access with collision detection (CSMA/CD) media access control mechanism. In this regard, each device such as a network interface card (NIC) that is coupled to the physical medium listens to the medium prior to transmitting a packet. If the medium is clear, then a device wishing to transmit information may begin transmitting. If a collision occurs, then the computers may retransmit the information at a random interval.

FIG. **1** is a block diagram of an exemplary client/server configuration for a USB system that may be utilized in connection with an embodiment of the invention. Referring to FIG. **1**, there is shown a USB system **100** that comprises a server **101**, a client device **102** and an Ethernet link **105**. The client device **102** comprises a smart client terminal **103** coupled to a USB 1.1 devices block **104**. The Ethernet link **105** couples the server **101** to the smart client terminal **103**. The server **101** comprises a host USB controller **106**.

The server **101** may comprise suitable logic, circuitry and/or code that may be adapted to handle various kinds of requests from a client, for example, printing, or controlling access to voice mail, electronic mail and facsimile services. The server **101** may also be adapted to handle large amounts of data. The server **101** comprises a host USB controller **106**. The host USB controller **106** may comprise suitable logic, circuitry and/or code that may be adapted to be coupled to a plurality of USB devices. The USB system **100** comprises a host controller and multiple client devices connected in a tree-like fashion using special hub devices. Based on USB specification, there is a limit of 5 levels of branching hubs per controller. Up to 127 devices may be connected to a single host controller **106**.

The client device **102** may comprise suitable logic, circuitry and/or code that may be adapted to request information or applications from the server **101**. The client device **102** comprises a smart client terminal **103** coupled to a USB 1.1 devices block **104**. The smart client terminal **103** may comprise suitable logic, circuitry and/or code that may be adapted to allow the USB 1.1 devices **104** to access the server **101** via a communication protocol, for example, the Ethernet link **105**. The USB 1.1 devices block **104** may comprise a plurality of USB 1.1 devices, for example, a flash storage device, a webcam, a digital camera, a modem, a printer, a scanner, a mouse, a keyboard, or a telephone.

In a client/server model, the client **102** may make a service request from the server **101**, which fulfills the request. In a network, the client/server model may provide a convenient way to interconnect programs that are distributed across different network locations. For example, to check a bank account from a computer, a client program in the computer forwards the request to a server program at the bank. The client program may be, for example, an accounting application or Web Browser. Notwithstanding, the client program may in turn forward the request to its own client program that sends a request to a database server at another bank computer to retrieve the account balance. The balance may be returned back to the bank data client, which in turn may serve it back to the client in the personal computer. In a client/server model, the server **101**, sometimes called a daemon, may be activated and awaits client **102** requests. A plurality of USB 1.1 client devices **104** may share the services of a common server **101**. Both client **102** and server **101** may be a part of a larger program or application.

A virtual connection may be present between the USB devices block **104** coupled to the client device **102** and the USB host controller **106** residing on the server **101** at the remote location. There may be a challenge dealing with signaling due to additional latency when maintaining the flex-

ibility of the local entity supporting multiple devices with different capabilities without having local intelligence to support it and handling the host stack issues on the remote location.

In a software approach, the USB 1.1 devices **104** may communicate with a local USB 1.1 host controller in the client **102** and the device data may be relayed over the Ethernet link **105** by software to a special driver on the host server **101**. In a hardware approach, the USB 1.1 devices **104** may be virtually connected to the USB host controller **106** via a special hardware. If the client functionality is independent of the USB 1.1 device, the server USB stack may not require any changes over the support provided for a local USB device.

FIG. **2** is a block diagram of a single computer USB system with a USB 2.0 hub that may be utilized in connection with an embodiment of the invention. Referring to FIG. **2**, there is shown a server **201**, a USB 2.0 hub **211** and a USB 1.1 device **212**. The server **201** may comprise suitable logic, circuitry and/or code that may be adapted to handle various kinds of requests from a client, for example, printing, or controlling access to voice mail, electronic mail and facsimile services. The server **201** may also be adapted to handle large amounts of data. The USB 2.0 hub **211** may comprise suitable logic, circuitry and/or code that may be adapted to increase the number of USB ports on a personal computer (PC). The USB 1.1 device block **212** may be, for example, a flash storage device, a webcam, a digital camera, a modem, a printer, a scanner, a mouse, a keyboard, or a telephone.

The USB system **200** may be adapted to connect several USB devices **212** to a host controller on the server **201** through a chain of USB 2.0 hubs **211**. The USB devices and hubs have associated pipes or logical channels, which are connections from the host controller on the server **201** to a logical entity on the device named an endpoint.

Each endpoint may transfer data in one direction only, either into or out of the device, so each pipe is uni-directional. All USB devices have at least two such pipes/endpoints, namely endpoint 0 which is used to control the device on the bus. There an inward and an outward pipe numbered 0 on each device. The pipes may be divided into four different categories by way of their transfer type, for example, control transfers, isochronous transfers, interrupt transfers and bulk transfers. The control transfers may be used for short, simple commands to the device, and a status response by the bus control pipe number 0. The isochronous transfers may be used at some guaranteed speed but with possible data loss, for example, realtime audio or video. The interrupt transfers may be used for devices that need guaranteed quick responses or bounded latency, for example, pointing devices and keyboards. The bulk transfers may be used for large sporadic transfers using all remaining available bandwidth but with no guarantees on bandwidth or latency, for example, file transfers.

The USB device **212** connected to the bus has one device descriptor and one or more configuration descriptors. Each configuration descriptor in turn has one or more interface descriptors, which describe certain aspects of the device, so that it may be used for different purposes, for example, a camera may have both audio and video interfaces. These interface descriptors in turn have one default interface setting and possibly more alternate interface settings which in turn have endpoint descriptors. An endpoint may be reused among several interfaces and alternate interface settings.

The hi-speed devices may fall back to the slower data rate of full speed when plugged into a full speed hub. The hi-speed hubs may have a special function called the transaction translator that segregates full speed and low speed bus traffic from hi-hpeed traffic. The transaction translator in a hi-speed hub may function as a completely separate full speed bus to full speed and low speed devices attached to it.

FIG. **3** is a block diagram of a single computer USB 2.0 system with a server side hub transaction translator (SHTT) and a client side hub transaction translator (CHTT), in accordance with an embodiment of the invention. Referring to FIG. **3**, there is shown a USB system **300**. The USB system **300** comprises a server **301**, a client **302**, a processor which may be referred to as a server side hub transaction translator (SHTT) **321**, and an Ethernet link **305**. The client **302** comprises a processor, which may be referred to as a client side hub transaction translator (CHTT) **322**, a smart client terminal **303** and a USB 1.1 devices block **312**. The server **301** is coupled to the SHTT **321** via a USB connection **306**. The SHTT **321** is coupled to the CHTT **322** via an Ethernet link **305**. In accordance with an embodiment of the invention, the SHTT **321** device may be located on a plug-in card inside the server **301**.

A hub transaction translator (HTT) may be utilized when a USB 1.1 device **312** is coupled to a USB 2.0 host server **301** through an external high-speed (HS) hub. In this regard, the HTT provides the capability to bridge USB 1.1 data traffic between a USB 2.0 host server **301** and a USB 1.1 device **312** by using a split transaction protocol. The split transaction protocol allows full speed and low speed devices to be attached to hubs operating at high speed. These transactions involve host controllers and hubs and are not visible to devices. This prevents a USB 1.1 device **312** from adversely affecting operation of the USB 2.0 host server's **301** high-speed bandwidth by isolating the two signaling environments of USB 1.1 and USB 2.0.

In an embodiment of the invention, the functionality of the HTT may be split into server and client sections. The server section may be referred to as the SHTT **321** and the client section may be referred to as the CHTT **322**. The server side hub transaction translator (SHTT) **321** may comprise suitable logic, circuitry and/or code that may be enabled to receive an encapsulated SETUP packet from the server **301** and transmit the received encapsulated SETUP packet to the CHTT **322** over the network link.

The client side hub transaction translator (CHTT) **322** may comprise suitable logic, circuitry and/or code that may be enabled to transmit the received encapsulated SETUP packet to at least one universal serial bus (USB) 1.1 device **312**. The CHTT **322** may be adapted to receive at least a first acknowledgement (ACK) packet from at least one USB 1.1 device **312**. The SHTT **321** may be adapted to receive the first ACK packet from the CHTT **322** and the SHTT **321** transmits the received first ACK packet to the server **301**.

The USB 2.0 bus timing and protocol requirements at the server **301** end may be handled by the SHTT **321**. The USB 1.1 bus timing and protocol requirements at the client device **302** end may be handled by the CHTT **322**. The USB 1.1 protocol data between the SHTT **321** and CHTT **322** is encoded and transmitted over a high-speed link, for example, the Ethernet link **305**.

FIG. **4** is a flow diagram illustrating an exemplary USB 1.1 setup packet transaction over a USB 2.0 hub, in accordance with an embodiment of the invention. Referring to FIG. **4**, there is shown a server **402**, a USB 2.0 hub **404** and a USB 1.1 device **406**. The server **402** may comprise suitable logic, circuitry and/or code that may be adapted to handle various kinds of requests from a client, for example, printing, or controlling access to voice mail, electronic mail and facsimile services. The USB 2.0 hub **404** may comprise suitable logic, circuitry and/or code that may be adapted to increase the

number of USB ports on a personal computer (PC). The USB 1.1 device **406** may be, for example, a flash storage device, a webcam, a digital camera, a modem, a printer, a scanner, a mouse, a keyboard, or a telephone.

The host server **402** transmits a start-split SETUP packet to the USB 2.0 hub **404**, which transmits an acknowledgement (ACK) packet back to the server **402**. The USB 2.0 hub **404** relays an encapsulated SETUP packet to the USB 1.1 device **406** that is connected to its downstream port. The host server **402** now sends a complete-split SETUP packet to the USB 2.0 hub **404**, which may respond in one of two ways. When the USB 1.1 device **406** responds to the USB 2.0 hub **404** with an ACK packet for the received encapsulated SETUP packet, the USB 2.0 hub **404** will relay that ACK packet back to the host server **402**. Until then the USB 2.0 hub **404** transmits a not yet (NYET) acknowledgement packet back to the host server **402**. After the USB 2.0 hub **404** transmits the ACK packet to the server **402** in response to the next received complete-split SETUP packet, the split-SETUP transaction is completed.

FIG. **5** is a flow diagram illustrating an exemplary USB 1.1 setup packet transaction over a USB 2.0 system with a server side hub transaction translator (SHTT) and a client side hub transaction translator (CHTT), in accordance with an embodiment of the invention. Referring to FIG. **5**, there is shown a server **502**, a SHTT **504**, a CHTT **506** and a USB 1.1 device **508**. The server **502** may comprise suitable logic, circuitry and/or code that may be adapted to handle various kinds of requests from a client, for example, printing, or controlling access to voice mail, electronic mail and facsimile services. The server **502** is coupled to the SHTT **504** via a USB connection. The SHHT **504** is coupled to the CHHT **506** via an Ethernet link, for example. The USB 1.1 device **508** may be, for example, a flash storage device, a webcam, a digital camera, a modem, a printer, a scanner, a mouse, a keyboard, or a telephone.

The host server **502** transmits a start-split SETUP packet to the SHTT **504**, which transmits an acknowledgement (ACK) packet back to the server **502**. The SHTT **404** relays an encapsulated SETUP packet over a high speed link to the CHTT **506**. The CHTT **506** relays the encapsulated SETUP packet to the USB 1.1 device **508** that is connected to its downstream port. The host server **502** now sends a complete-split SETUP packet to the SHTT **504**, which may respond with a not yet (NYET) acknowledgement packet back to the host server **502**. When the USB 1.1 device **508** transmits an ACK packet to the CHTT **506** in response to receiving the encapsulated SETUP packet, the CHTT **506** will relay that ACK packet back to the SHTT **504**. Until then the SHTT **504** transmits a not yet (NYET) acknowledgement packet back to the host server **502**. After the SHTT **504** transmits the ACK packet to the server **502** in response to the next received complete-split SETUP packet, the split-SETUP transaction is completed. The latency issues due to the high-speed link may be handled by the split transaction protocol that isolates the host to SHTT signaling from the CHTT to device signaling.

FIG. **6** is a flow chart illustrating exemplary steps for a hardware-based implementation of USB 1.1 over a high-speed link, in accordance with an embodiment of the invention. Referring to FIG. **6**, exemplary steps may begin at step **602**. In step **604**, a hub transaction translator located on the server side (SHTT) may receive a start-split SETUP packet from the server. In step **606**, the SHTT communicates an acknowledgement (ACK) packet back to the server in response to the received start-split SETUP packet from the server. In step **608**, an encapsulated SETUP packet may be communicated from the SHTT to a client device via a hub transaction translator located on the client side (CHTT). In step **610**, the SHTT may receive a complete-split SETUP packet from the server. In step **612**, it may be determined whether the SHTT has received an ACK packet from the client device via the CHTT in response to the communicated encapsulated SETUP packet. If the SHTT has not received the ACK packet from the client device via the CHTT in response to the communicated encapsulated SETUP packet, control passes to step **614**. In step **614**, the SHTT may communicate a not yet (NYET) packet to the server indicating that the SHTT has not yet received the ACK packet from the client device via the CHTT in response to the communicated encapsulated SETUP packet. If the SHTT has received the ACK packet from the client device via the CHTT in response to the communicated encapsulated SETUP packet, control passes to step **616**. In step **616**, the SHTT may communicate the received ACK packet to the server indicating the completion of the split-SETUP transaction. Control then passes to end step **618**.

Another embodiment of the invention may provide a machine-readable storage, having stored thereon, a computer program having at least one code section executable by a machine, thereby causing the machine to perform the steps as described above for hardware based implementation of USB 1.1 over a high speed link.

In accordance with an embodiment of the invention, a system for communicating via a bus interface in a network may comprise a transaction translator at a client side of a client server communication system **300**, for example, CHTT **322** that translates USB protocol messages comprising a first USB standard to corresponding encapsulated USB protocol messages, wherein the USB protocol messages comprising the first USB standard are received from a client device at the client side of the client server communication system **300**. The transaction translator at the client side of the client server communication system **300**, for example, CHTT **322** communicates the translated corresponding encapsulated USB protocol messages from the client side to a server, for example, server **301** at a server side of the client server communication system **300**.

At least one client device, for example, USB 1.1 device **312** may be adapted to receive the USB protocol messages comprising the first USB standard from the server, for example, server **301**, wherein the USB protocol messages comprising the first USB standard that are received from the server, for example, server **301** were translated from the second USB standard at the server side of the client server communication system **300** prior to being received at the client device, for example, USB 1.1 device **312**. The first USB format may be USB 1.1. The second USB format may be USB 2.0.

The USB protocol messages comprising the first USB standard received from the client device, for example, USB 1.1 device **312** at the client side of the client server communication system **300** comprises an acknowledgement (ACK) packet. The translated corresponding encapsulated USB protocol messages comprising the second USB standard communicated from the client side of the client server communication system **300** to the server, for example, server **301** at the server side of the client server communication system **300** comprises an acknowledgement (ACK) packet. The client device, for example, USB 1.1 device **312** may comprise a USB interface that is USB 1.1 standard compliant. The server, for example, server **301** may comprise a USB interface that is USB 2.0 standard compliant. The transaction translator at the client side of the client server communication system **300**, for example, CHTT **322** may be adapted to communicate the translated corresponding encapsulated USB protocol messages comprising USB 2.0 standard from the client side of the

client server communication system **300** to the server, for example, server **301** at the server side of the client server communication system **300** via an Ethernet link **305**. The client device, for example, USB 1.1 device **312** may be adapted to receive the USB protocol messages comprising USB 1.1 standard from the server, for example, server **301** via an Ethernet link **305**.

In accordance with an embodiment of the invention, a method and system for implementing universal serial bus (USB) communication may comprise a server side hub transaction translator (SHTT), for example, SHTT **321** that receives at least a first packet of data from a server **301**. The first packet of data may be a start-split SETUP packet, for example. The SHTT **321** may enable transmission of an encapsulated SETUP packet to a client side hub transaction translator (CHTT), for example, CHTT **322**. The CHTT **322** may enable transmission of the received encapsulated SETUP packet to at least one universal serial bus (USB) 1.1 device **312**. The SHTT **321** may enable reception of at least a second packet of data from the server **301**. The CHTT **322** may enable reception of at least a first acknowledgement (ACK) packet from at least one USB 1.1 device **312**. The SHTT **321** may be adapted to receive the first ACK packet from the CHTT **322** and the SHTT **321** transmits the received first ACK packet to the server **301**.

The SHTT **321** may enable transmission of at least a second ACK packet in response to the received first packet of data or the encapsulated SETUP packet from the server **301**. The SHTT **321** may enable reception of the second packet of data, for example, the complete-split SETUP packet from the server **301** in response to the transmitting of the second ACK packet. The SHTT **321** may enable transmission of at least one not yet (NYET) ACK packet to the server **301** in response to the received second packet of data, for example, the complete-split SETUP packet. The SHTT **321** may enable reception of the first packet of data or encapsulated SETUP packet from the server over a USB link. The SHTT **321** may enable reception of the second packet of data or the complete-split SETUP packet from the server **301** over a USB link.

The SHTT **321** may enable transmission of the received first ACK packet to the server **301** over a USB link. The CHTT **322** may enable transmission of at least a portion of the received first packet of data to the USB 1.1 device **312** over an Ethernet link, for example. The CHTT **322** may enable reception of the first ACK packet from the USB 1.1 device **312** over an Ethernet link, for example. The SHTT **321** may enable transmission of the received first ACK packet to the server **301** in response to receiving the first ACK packet from the CHTT **322**. The SHTT **321** may enable transmission of at least one not yet (NYET) ACK packet to the server **301** if the first ACK packet is not received from the CHTT **322**.

Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computer system, or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method, comprising the steps of:

communicating, from a server side hub transaction translator, a first acknowledgement packet to a server in response to receiving a start setup packet from said server;

communicating, from the server side hub transaction translator, an encapsulated setup packet to at least one universal serial bus (USB) device; and

communicating, from the server side hub transaction translator, a not yet acknowledgement packet to said server when said server side hub transaction translator has not received a second acknowledgement packet from the at least one USB device.

2. The method according to claim **1**, further comprising receiving one or more complete setup packets from said server based on said communicated first acknowledgement packet.

3. The method according to claim **1**, further comprising communicating, from the server side hub transaction translator, the second acknowledgement packet to the server, the second acknowledgment packet received from the at least one USB device in response to receiving at least one complete-split setup packet from said server in the server side hub transaction translator.

4. The method according to claim **1**, wherein said at least one USB device comprises a USB interface that is USB 1.1 protocol compliant.

5. The method according to claim **1**, wherein said server comprises a USB interface that is USB 2.0 protocol compliant.

6. The method according to claim **1**, comprising communicating said encapsulated setup packet to said at least one USB device in communication with a client side hub transaction translator via an Ethernet link.

7. The method according to claim **6**, comprising receiving said second acknowledgement packet from said at least one USB device via the client side hub transaction translator.

8. The method according to claim **7**, wherein said second acknowledgement packet is received from the client side hub transaction translator via an Ethernet link.

9. A system for communicating packets, the system comprising:

one or more circuits for use in a server side hub transaction translator in a computer system, said one or more circuits being configured to:

communicate a first acknowledgement packet to a server in response to receiving a start setup packet from said server;

communicate an encapsulated setup packet to at least one universal serial bus (USB) device; and

communicate a not yet acknowledgement packet to said server when said server side hub transaction translator has not received a second acknowledgement packet from the at least one USB device.

10. The system according to claim **9**, wherein said one or more circuits are operable to receive at least one complete setup packet from said server based on said communicated first acknowledgement packet.

11. The system according to claim **9**, wherein said one or more circuits are further configured to communicate the second acknowledgement packet to the server, the second acknowledgment packet received from the at least one USB device in response to receiving at least one complete-split setup packet from said server in the server side hub transaction translator.

12. The system according to claim **9**, wherein said at least one USB device comprises a USB interface that is USB 1.1 protocol compliant.

13. The system according to claim **9**, wherein said server comprises a USB interface that is USB 2.0 protocol compliant.

14. The system according to claim **9**, wherein said one or more circuits are further configured to communicate said encapsulated setup packet to said at least one USB device via an Ethernet link.

15. The system according to claim **9**, wherein said one or more circuits are further configured to receive said second acknowledgement packet from said at least one USB device via a client side hub transaction translator executed in a client device.

16. The system according to claim **15**, wherein said second acknowledgement packet is received from the client side hub transaction translator via an Ethernet link.

17. A non-transitory computer-readable medium embodying a program executable in a computing device, the program comprising:

code that communicates a first acknowledgement packet to a server in response to receiving a start setup packet from said server;

code that communicates an encapsulated setup packet to at least one universal serial bus (USB) device; and

code that communicates a not yet acknowledgement packet to said server when said server side hub transaction translator has not received a second acknowledgement packet from the at least one USB device.

18. The non-transitory computer-readable medium of claim **17**, wherein the program further comprises code that receives one or more complete setup packets from said server based on said communicated first acknowledgement packet.

19. The non-transitory computer-readable medium of claim **17**, wherein the program further comprises code that communicates the second acknowledgement packet to the server, the second acknowledgment packet received from the at least one USB device in response to receiving at least one complete-split setup packets from said server in the server side hub transaction translator.

20. The non-transitory computer-readable medium of claim **17**, wherein the program further comprises code that communicates said encapsulated setup packet to said at least one USB device in communication with a client side hub transaction translator via an Ethernet link.

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