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(54) APPARATUS AND METHOD FOR WIRELESS/WIRED COMMUNICATIONS INTERFACE

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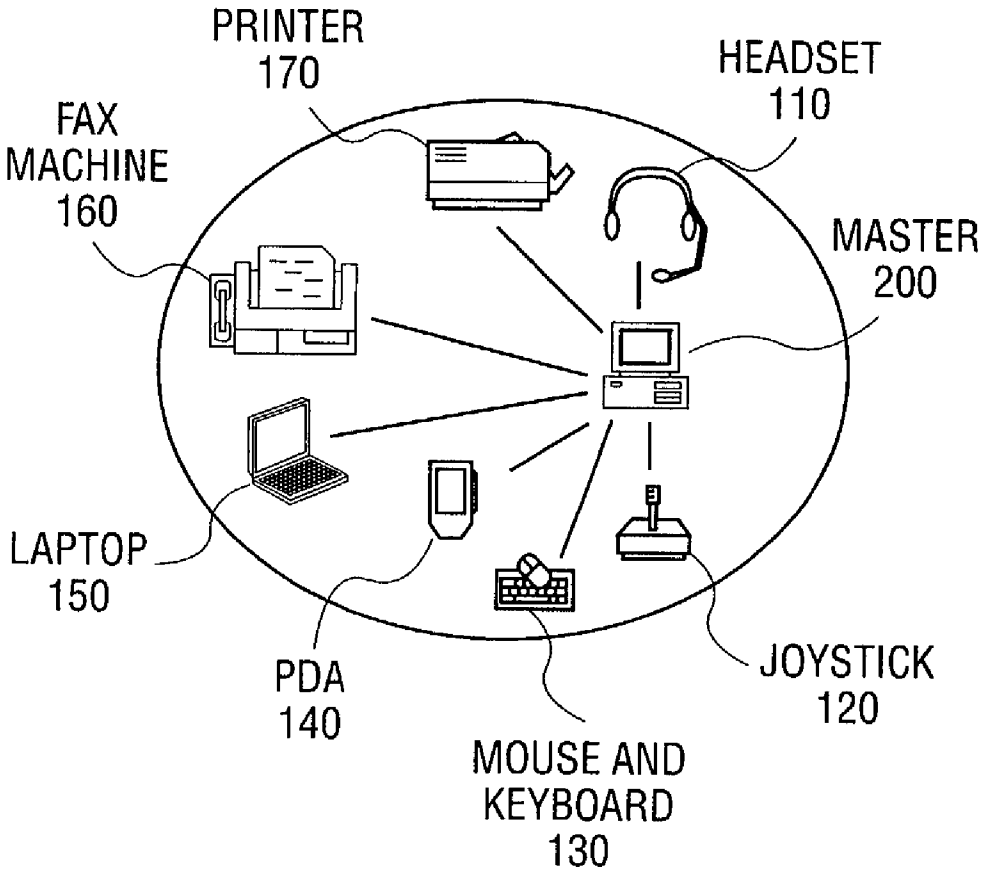
(57) ABSTRACT

An apparatus and method for wireless/wired Bluetooth™ communications interface are described. The method includes detection of a communications configuration of a device as one of a wireless communications interface and a wireless/wired communications interface. Once detected, it is determined whether a wired/wireless communications interface is the communications interface of the device. When such is the case, a data transmission error rate of the device is determined during operation of the device in a wireless communications mode. Next, the device is switched from the wireless communications mode to a wired communications mode when the data transmission error rate caused by wireless radio interference of the device exceeds a pre-determined threshold. As such, the present invention allows Bluetooth™ wireless communications devices to utilize a wired communications mode when transmission error rate exceeds a pre-determined threshold.



BLUETOOTH PICONET 100

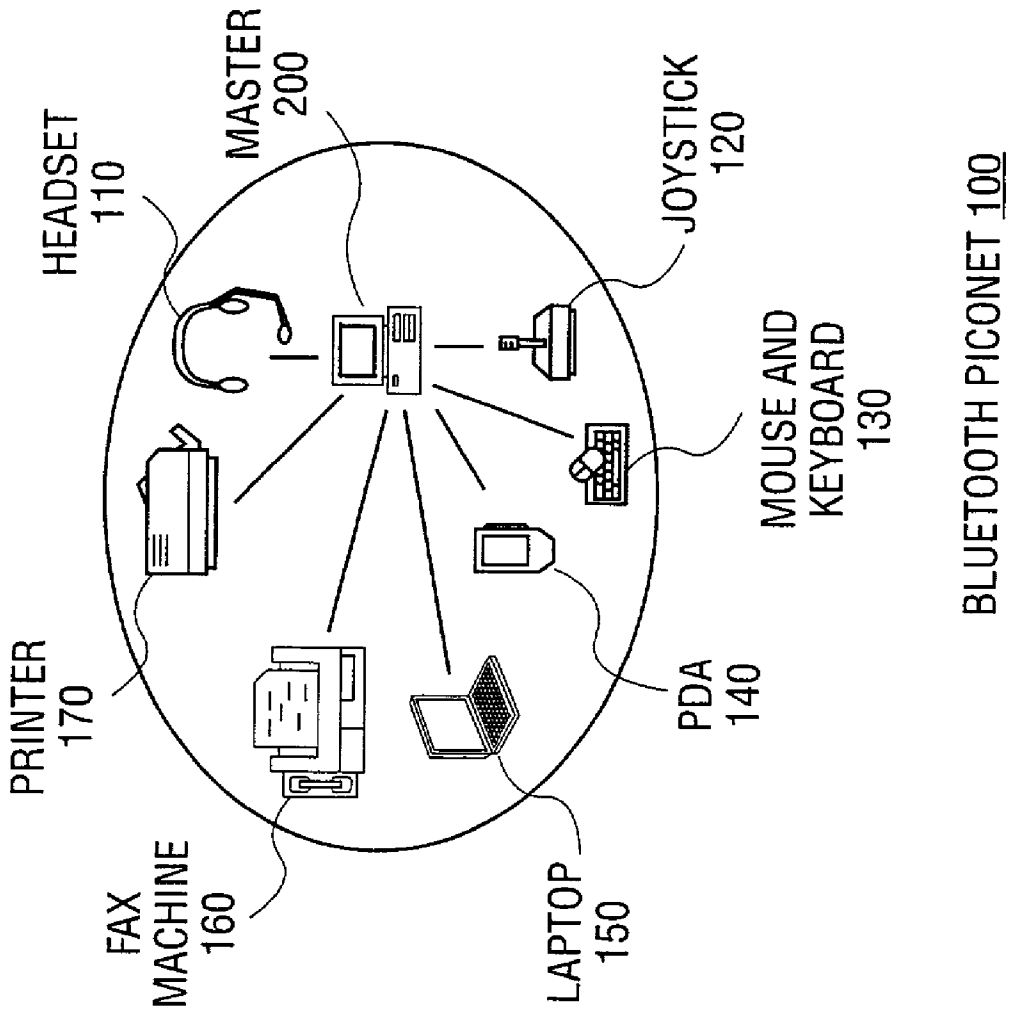

HEADSET
110
MASTER
200
JOYSTICK
120
MOUSE AND
KEYBOARD
130
PDA
140
LAPTOP
150
FAX
MACHINE
160
PRINTER
170
BLUETOOTH PICONET 100

FIG. 1

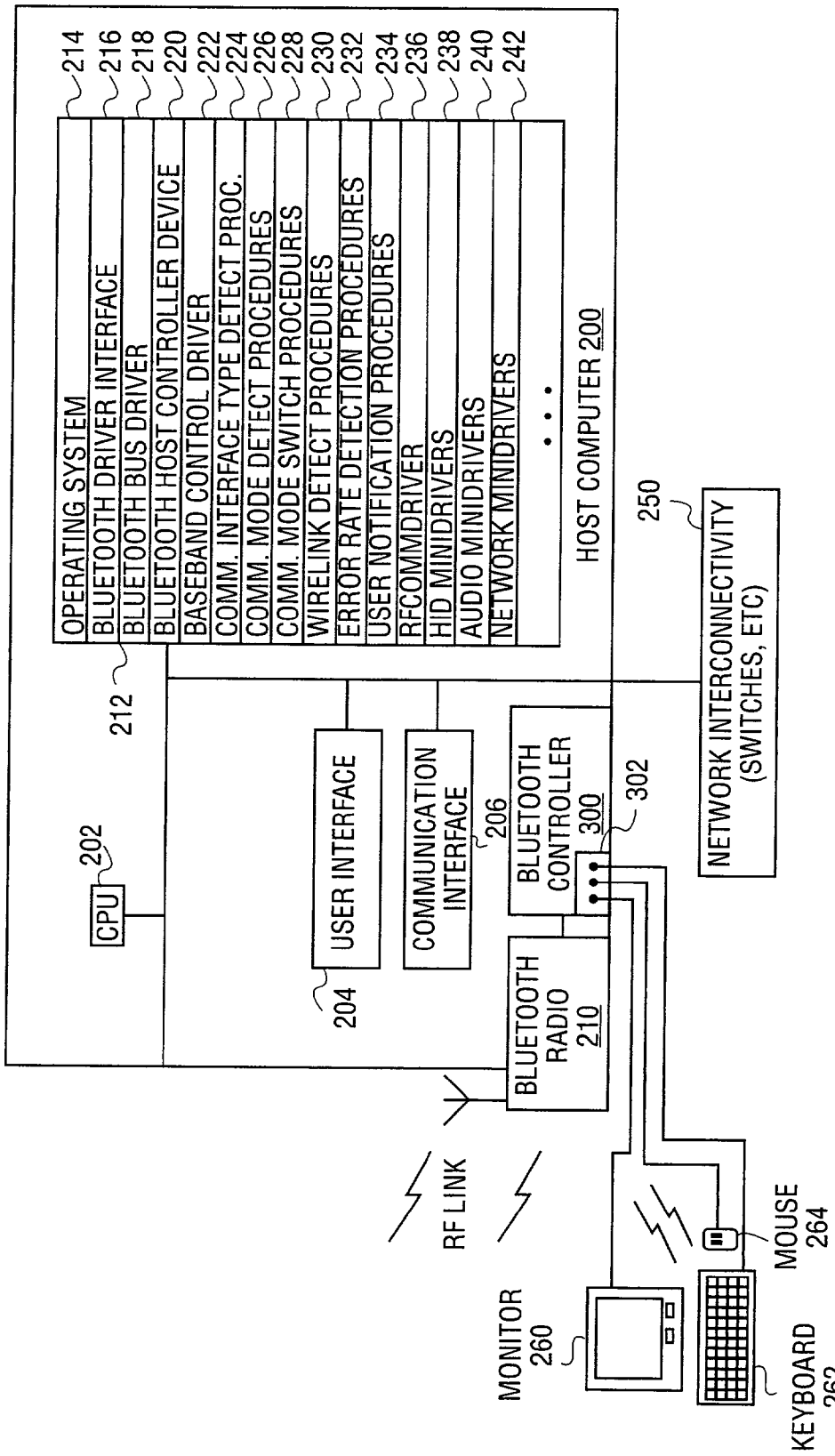

214
216
218
220
222
224
226
228
230
232
234
236
238
240
242
OPERATING SYSTEM
BLUETOOTH DRIVER INTERFACE
BLUETOOTH BUS DRIVER
BLUETOOTH HOST CONTROLLER DEVICE
BASEBAND CONTROL DRIVER
COMM. INTERFACE TYPE DETECT PROC.
COMM. MODE DETECT PROCEDURES
COMM. MODE SWITCH PROCEDURES
WIRELINK DETECT PROCEDURES
ERROR RATE DETECTION PROCEDURES
USER NOTIFICATION PROCEDURES
RFCOMMDRIVER
HID MINIDRIVERS
AUDIO MINIDRIVERS
NETWORK MINIDRIVERS
• • •
212
HOST COMPUTER 200
250
NETWORK INTERCONNECTIVITY (SWITCHES, ETC)
202
CPU
USER INTERFACE
204
COMMUNICATION INTERFACE
206
BLUETOOTH CONTROLLER
300
302
BLUETOOTH RADIO
210
RF LINK
MONITOR
260
MOUSE
264
KEYBOARD
262

FIG. 2

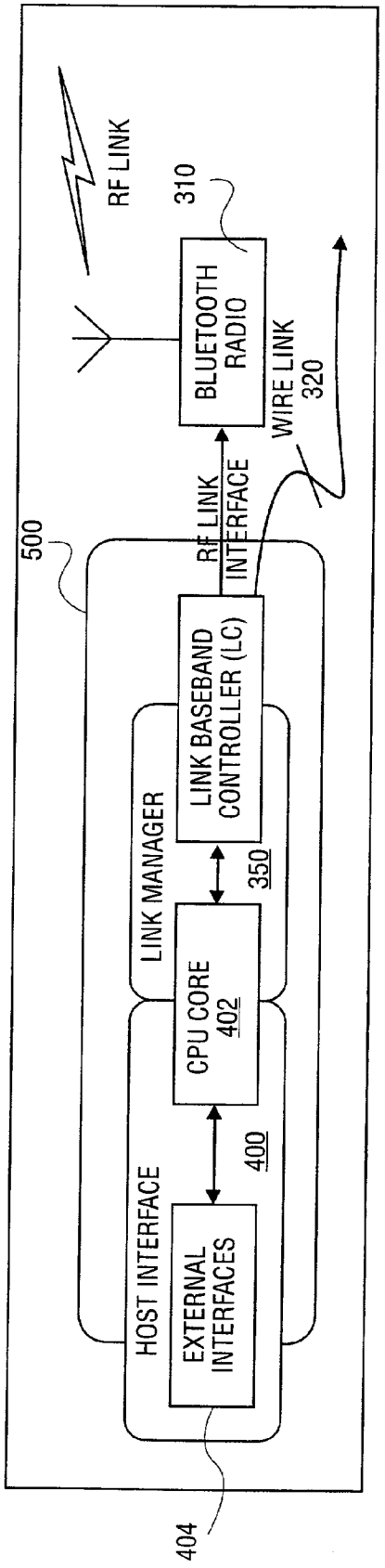

RF LINK
310
BLUETOOTH RADIO
WIRE LINK 320
RF LINK INTERFACE
500
LINK BASEBAND CONTROLLER (LC)
LINK MANAGER
350
CPU CORE 402
400
HOST INTERFACE
EXTERNAL INTERFACES
404
BLUETOOTH CONTROLLER 300

FIG. 3

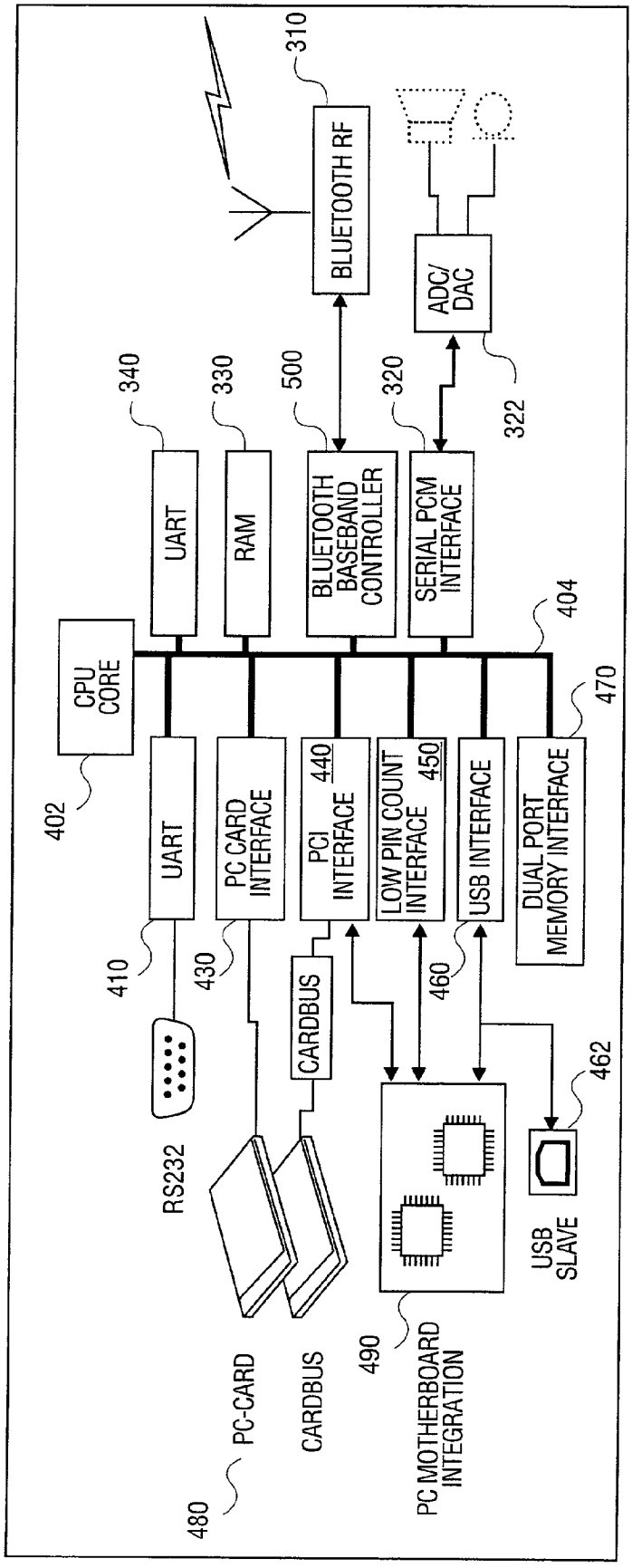

310
BLUETOOTH RF
ADC/
DAC
322
340
330
500
320
UART
RAM
BLUETOOTH
BASEBAND
CONTROLLER
SERIAL PCM
INTERFACE
404
CPU
CORE
402
UART
PC CARD
INTERFACE
PCI
INTERFACE
440
LOW PIN COUNT
INTERFACE
450
USB INTERFACE
DUAL PORT
MEMORY INTERFACE
470
410
430
460
CARDBUS
462
RS232
USB
SLAVE
490
PC MOTHERBOARD
INTEGRATION
PC-CARD
CARDBUS
480
HOST INTERFACE 400

FIG. 4

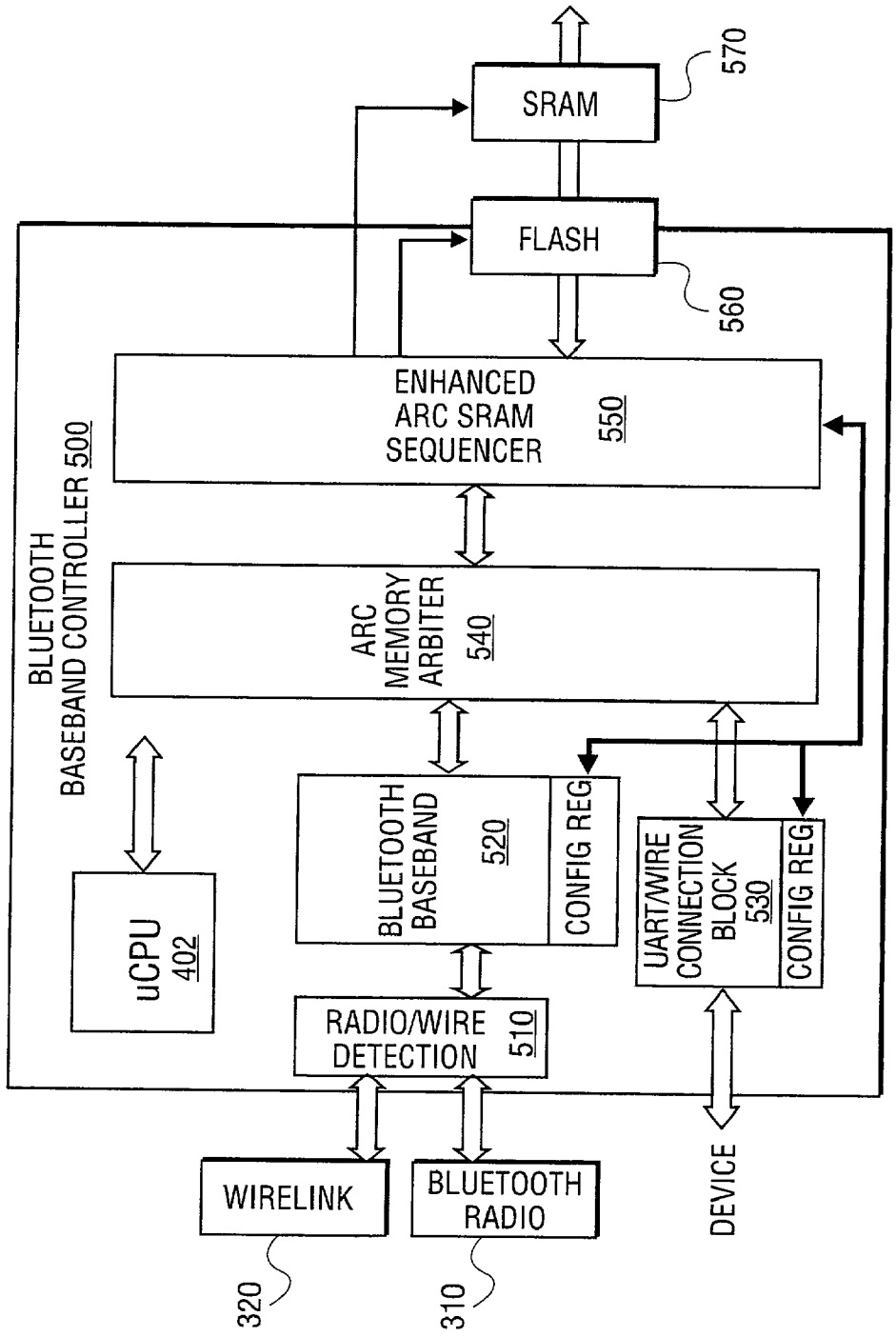

SRAM
570
FLASH
560
ENHANCED ARC SRAM SEQUENCER 550
BLUETOOTH BASEBAND CONTROLLER 500
ARC MEMORY ARBITER 540
uCPU 402
BLUETOOTH BASEBAND 520
CONFIG REG
UART/WIRE CONNECTION BLOCK 530
CONFIG REG
RADIO/WIRE DETECTION 510
WIRELINK
BLUETOOTH RADIO
DEVICE
320
310

FIG. 5

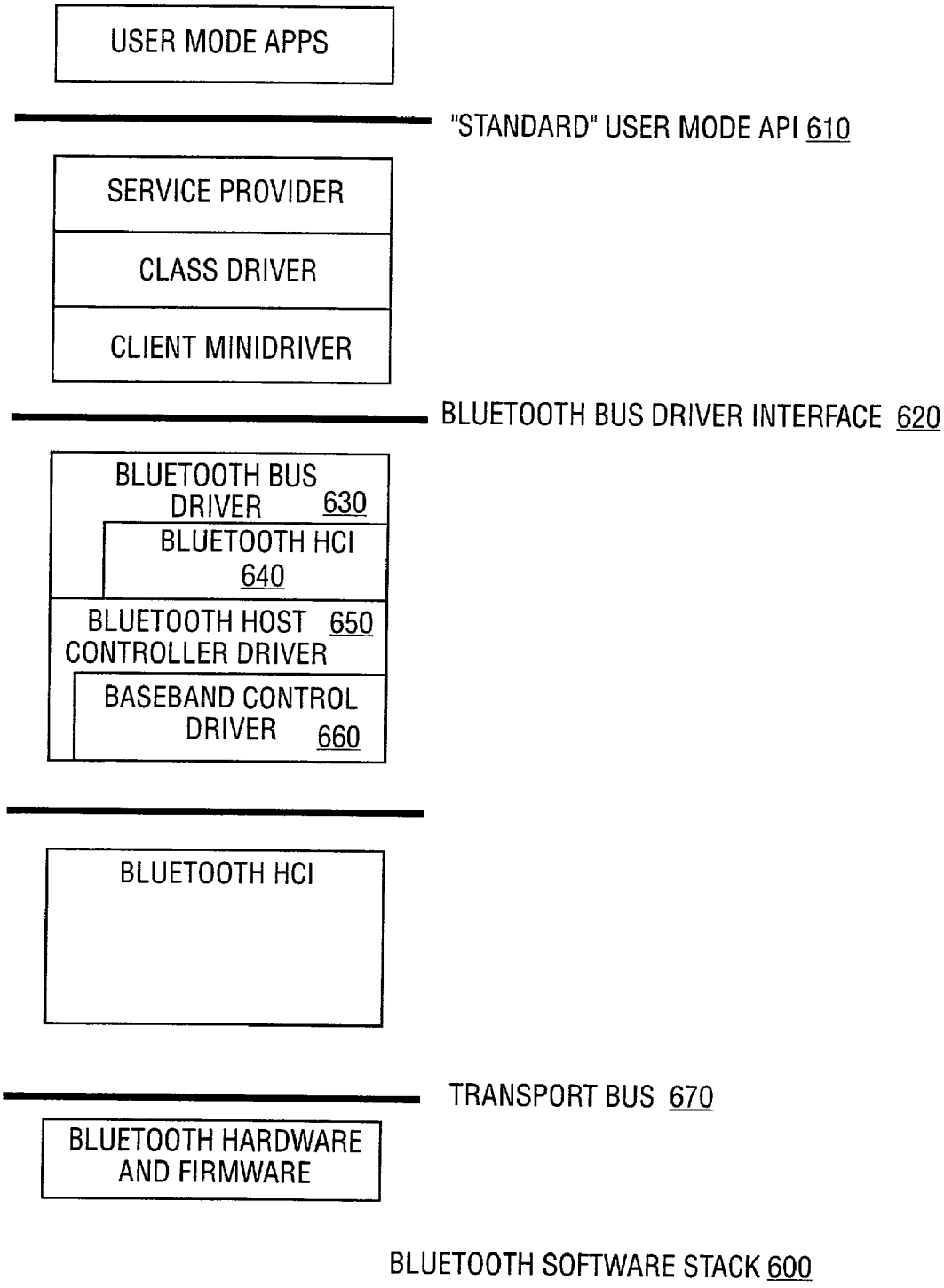

USER MODE APPS
"STANDARD" USER MODE API 610
SERVICE PROVIDER
CLASS DRIVER
CLIENT MINIDRIVER
BLUETOOTH BUS DRIVER INTERFACE 620
BLUETOOTH BUS DRIVER 630
BLUETOOTH HCI 640
BLUETOOTH HOST CONTROLLER DRIVER 650
BASEBAND CONTROL DRIVER 660
BLUETOOTH HCI
TRANSPORT BUS 670
BLUETOOTH HARDWARE AND FIRMWARE
BLUETOOTH SOFTWARE STACK 600

FIG. 6

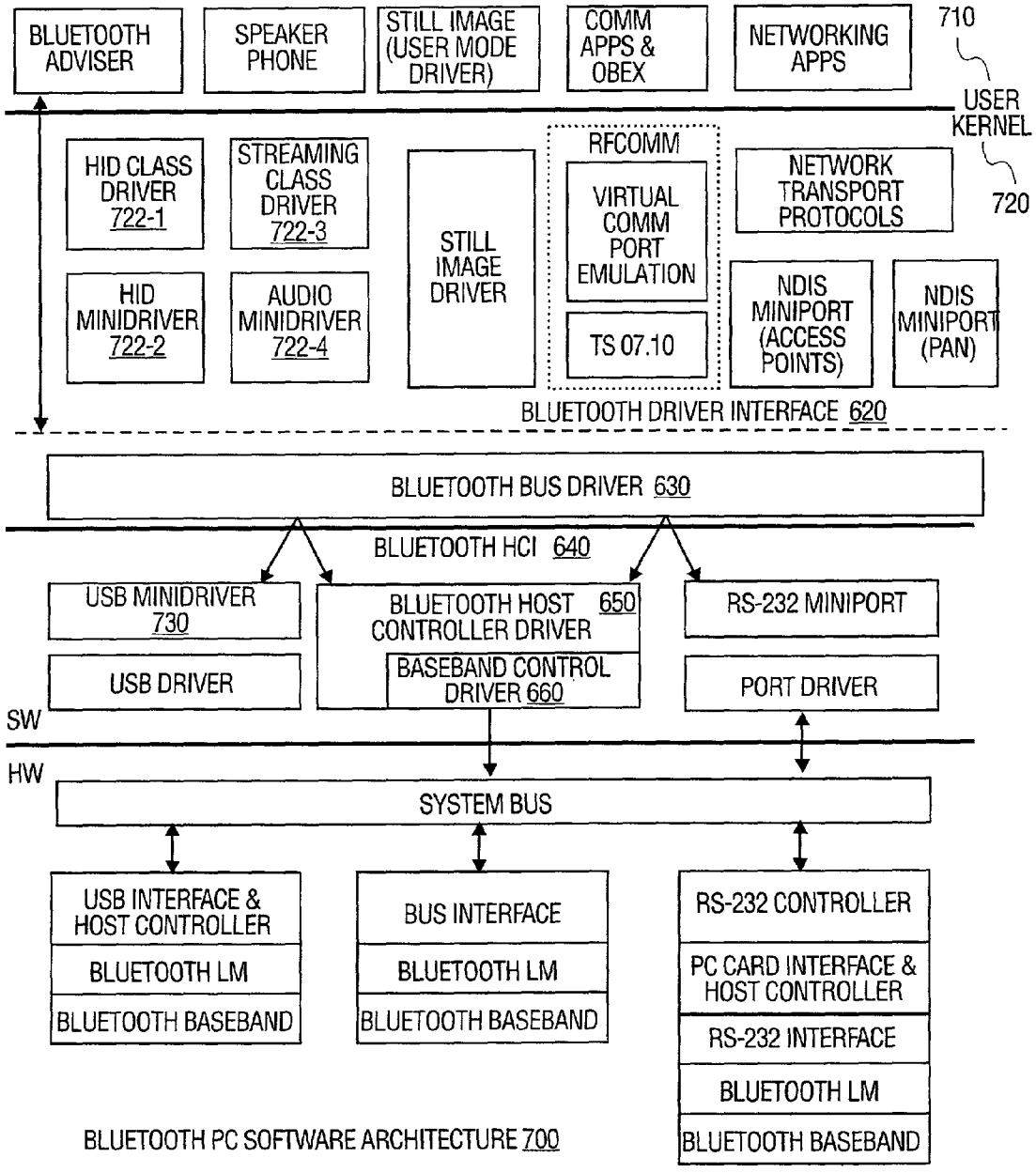

BLUETOOTH ADVISER
SPEAKER PHONE
STILL IMAGE (USER MODE DRIVER)
COMM APPS & OBEX
NETWORKING APPS
710
USER
KERNEL
720
HID CLASS DRIVER 722-1
STREAMING CLASS DRIVER 722-3
HID MINIDRIVER 722-2
AUDIO MINIDRIVER 722-4
STILL IMAGE DRIVER
RFCOMM
VIRTUAL COMM PORT EMULATION
TS 07.10
NETWORK TRANSPORT PROTOCOLS
NDIS MINIPORT (ACCESS POINTS)
NDIS MINIPORT (PAN)
BLUETOOTH DRIVER INTERFACE 620
BLUETOOTH BUS DRIVER 630
BLUETOOTH HCI 640
USB MINIDRIVER 730
USB DRIVER
BLUETOOTH HOST CONTROLLER DRIVER 650
BASEBAND CONTROL DRIVER 660
RS-232 MINIPORT
PORT DRIVER
SW
HW
SYSTEM BUS
USB INTERFACE & HOST CONTROLLER
BLUETOOTH LM
BLUETOOTH BASEBAND
BUS INTERFACE
BLUETOOTH LM
BLUETOOTH BASEBAND
RS-232 CONTROLLER
PC CARD INTERFACE & HOST CONTROLLER
RS-232 INTERFACE
BLUETOOTH LM
BLUETOOTH BASEBAND
BLUETOOTH PC SOFTWARE ARCHITECTURE 700

FIG. 7

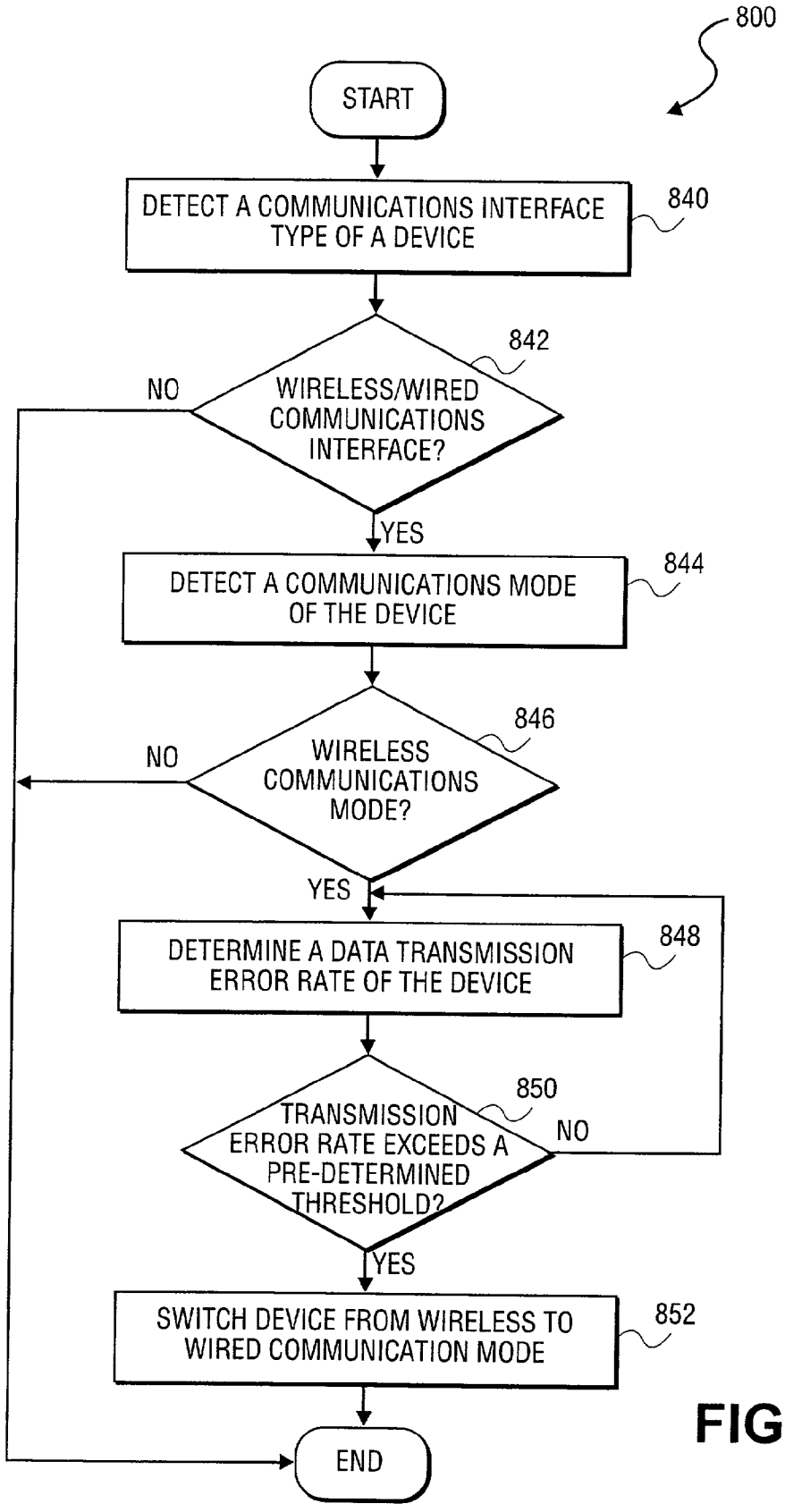

800
START
DETECT A COMMUNICATIONS INTERFACE TYPE OF A DEVICE
840
842
WIRELESS/WIRED COMMUNICATIONS INTERFACE?
NO
YES
DETECT A COMMUNICATIONS MODE OF THE DEVICE
844
846
WIRELESS COMMUNICATIONS MODE?
NO
YES
DETERMINE A DATA TRANSMISSION ERROR RATE OF THE DEVICE
848
850
TRANSMISSION ERROR RATE EXCEEDS A PRE-DETERMINED THRESHOLD?
NO
YES
SWITCH DEVICE FROM WIRELESS TO WIRED COMMUNICATION MODE
852
END

FIG. 8

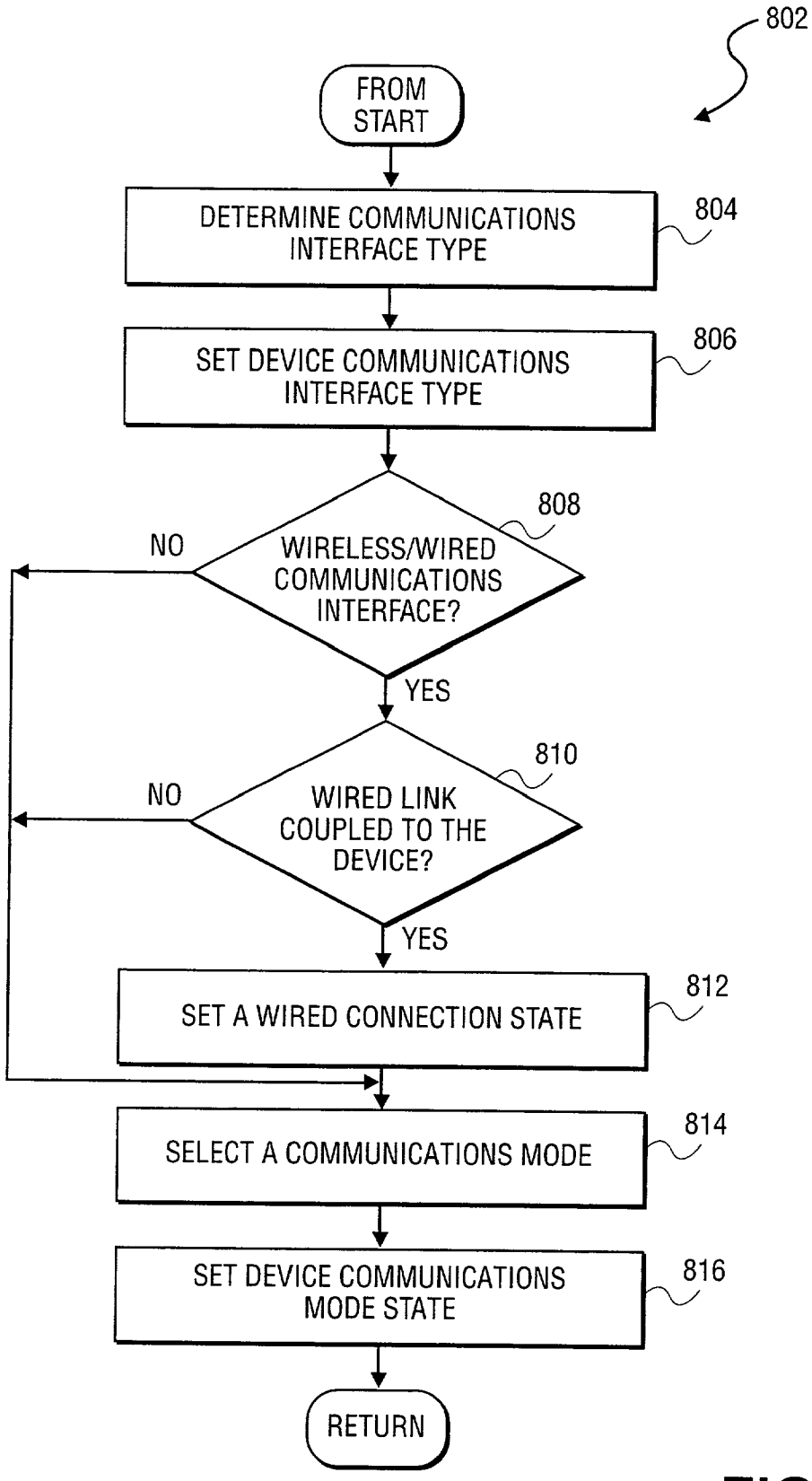

802
FROM START
DETERMINE COMMUNICATIONS INTERFACE TYPE
804
SET DEVICE COMMUNICATIONS INTERFACE TYPE
806
808
WIRELESS/WIRED COMMUNICATIONS INTERFACE?
NO
YES
810
WIRED LINK COUPLED TO THE DEVICE?
NO
YES
SET A WIRED CONNECTION STATE
812
SELECT A COMMUNICATIONS MODE
814
SET DEVICE COMMUNICATIONS MODE STATE
816
RETURN

FIG. 9

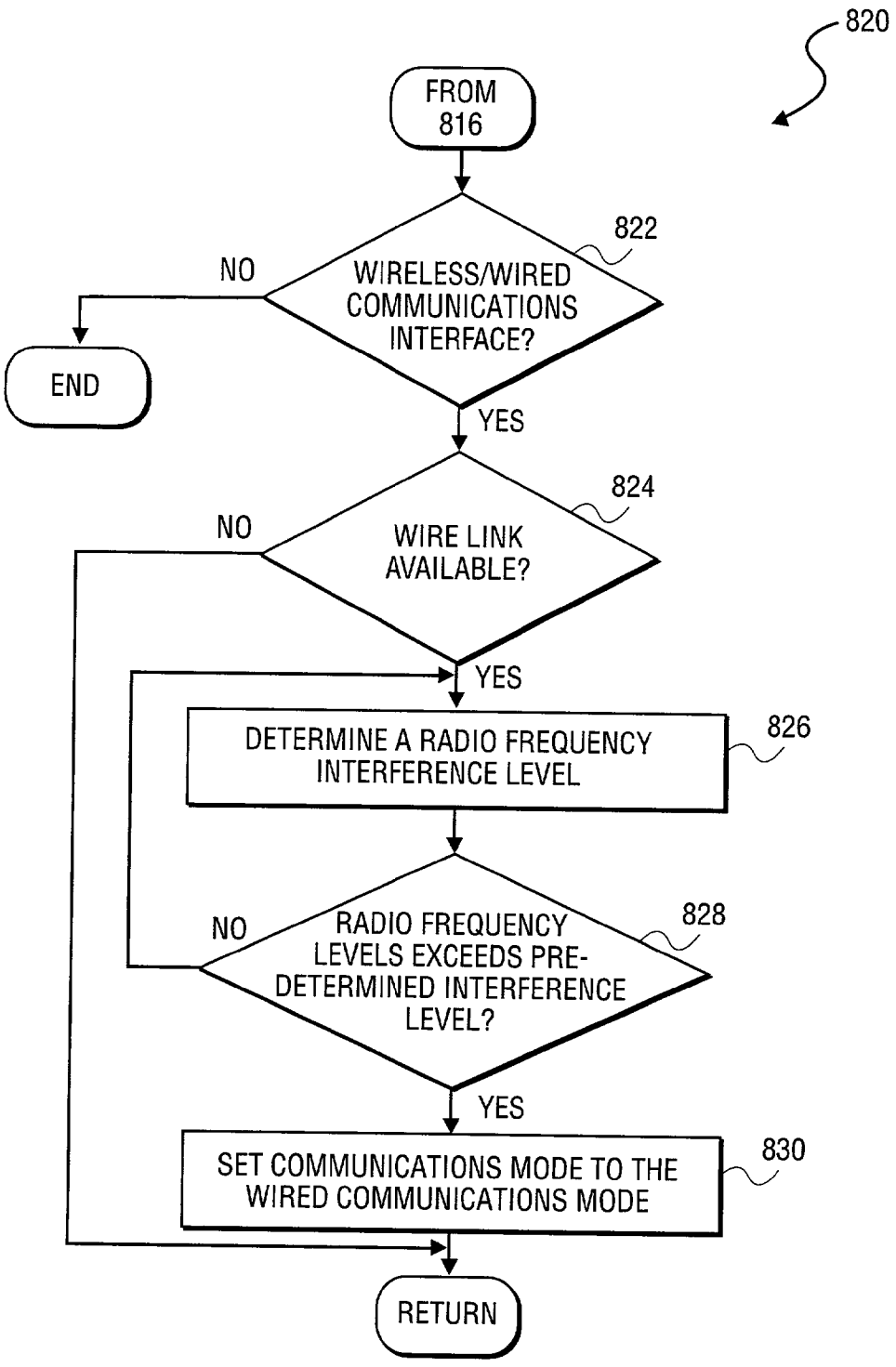

820
FROM 816
822
WIRELESS/WIRED COMMUNICATIONS INTERFACE?
NO
END
YES
824
WIRE LINK AVAILABLE?
NO
YES
DETERMINE A RADIO FREQUENCY INTERFERENCE LEVEL
826
828
RADIO FREQUENCY LEVELS EXCEEDS PRE-DETERMINED INTERFERENCE LEVEL?
NO
YES
SET COMMUNICATIONS MODE TO THE WIRED COMMUNICATIONS MODE
830
RETURN

FIG. 10

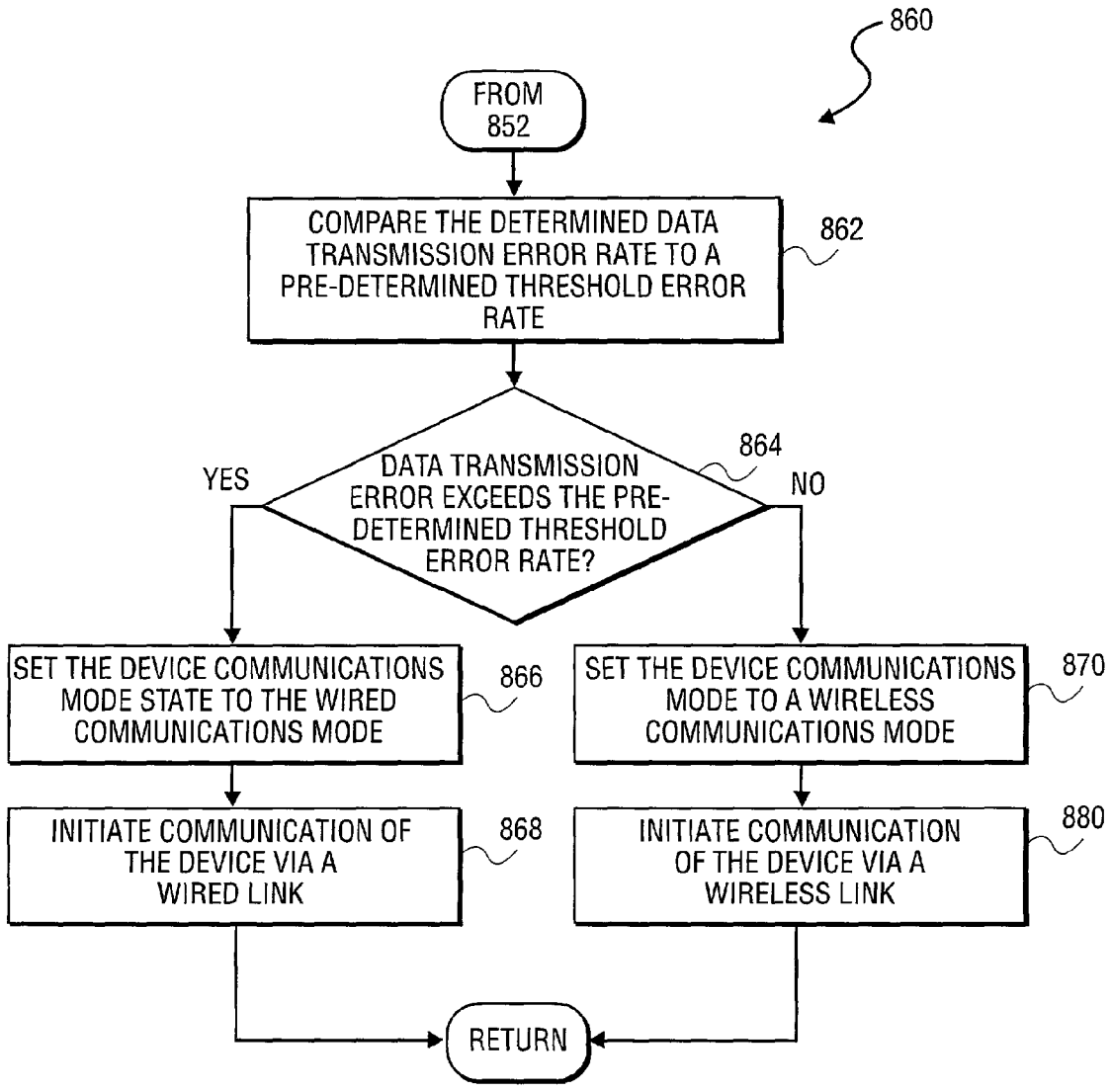

860
FROM 852
COMPARE THE DETERMINED DATA TRANSMISSION ERROR RATE TO A PRE-DETERMINED THRESHOLD ERROR RATE
862
DATA TRANSMISSION ERROR EXCEEDS THE PRE-DETERMINED THRESHOLD ERROR RATE?
864
YES
NO
SET THE DEVICE COMMUNICATIONS MODE STATE TO THE WIRED COMMUNICATIONS MODE
866
SET THE DEVICE COMMUNICATIONS MODE TO A WIRELESS COMMUNICATIONS MODE
870
INITIATE COMMUNICATION OF THE DEVICE VIA A WIRED LINK
868
INITIATE COMMUNICATION OF THE DEVICE VIA A WIRELESS LINK
880
RETURN

FIG. 11

APPARATUS AND METHOD FOR WIRELESS/WIRED COMMUNICATIONS INTERFACE

FIELD OF THE INVENTION

[0001] The invention relates generally to the field of wireless communications devices. More particularly, the invention relates to a method and apparatus for when a wireless/wired communications interface is detected as the communications configuration.

BACKGROUND OF THE INVENTION

[0002] The Bluetooth™ radio system is defined by a specification for a wireless, cable replacement solution based on radio frequency (RF) technology. In addition, Bluetooth™ has been specified and designed with emphasis on robustness and low cost. Implementations of Bluetooth™ are based on high performance, yet low-cost integrated radio transceivers. Accordingly, Bluetooth™ is defined as a protocol with a wireless interface. The frequency assignment that is utilized by Bluetooth™ within the United States is in the same radio frequency range as 802.11 wireless LAN (local area network), high end portable home phones, medical devices, as well as microwave ovens. As a result, the required nominal range of Bluetooth™ radio devices is set to approximately 10 meters, although distances may vary according to the power output of the radio.

[0003] Bluetooth™ is targeted at mobile and business users who need to establish a link or small network between their computers, cellular phones or other peripherals. To fill this communications need, a Bluetooth™ radio in a phone, PDA (personal digital assistant), headset, notebook computer or other device enables the devices to communicate with each other. As a result, Bluetooth™ is gaining in popularity as a wireless cable replacement technology. Moreover, Bluetooth™ provides a new market segment and devices to solve an age old problem of excessive number of wires used to connect personal computers (PCs) and other mobile devices. Unfortunately, devices in various environments cause radio traffic as well as interference problems in the radio frequencies utilized by Bluetooth™ devices.

[0004] As a result, communication information interference can become a problem when utilizing Bluetooth™-enabled devices. In addition, Bluetooth™ devices may cause interference problems with other devices. As described above, the frequency assignment to Bluetooth™ devices is in the same radio frequency range as 802.11 wireless LANs, high-end portable home phones, medical devices, as well as microwave ovens. Consequently, these other devices may cause interference with Bluetooth™-enabled devices. Conversely, Bluetooth™-enabled devices may affect the proper functioning of LANs, portable phones, medical devices, microwave ovens or the like.

[0005] Consequently, although Bluetooth™ devices may offer users the ability to replace the myriad of cables for attaching to various devices, the Bluetooth™ device is not immune to radio frequency interference. Hence, Bluetooth™ devices, when operated in the presence of significant radio frequency interference, will often perform poorly or even malfunction, which may lead to dissatisfaction of users of such Bluetooth™-enabled devices. This dissatisfaction may reach the point where users decline usage of Bluetooth™ devices and opt for standard wired connections, as are currently available in various devices described above. Therefore, there remains a need to overcome one or more of the limitations in the above-described existing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The present invention is illustrated by way of example, and not by way of limitation, in the figures of the accompanying drawings and in which:

[0007] **FIG. 1** depicts a block diagram illustrating a Bluetooth™ piconet utilizing a host computer configured to implement a wireless/wired Bluetooth™ communications interface, in accordance with one embodiment of the present invention.

[0008] **FIG. 2** depicts a block diagram further illustrating the host computer, as depicted in **FIG. 1**, in accordance with the further embodiment of the present invention.

[0009] **FIG. 3** depicts a block diagram illustrating the Bluetooth™ controller, as illustrated in **FIG. 2**, in accordance with one embodiment of the present invention.

[0010] **FIG. 4** depicts the host interface, as depicted in **FIG. 3**, in accordance with a further embodiment of the present invention.

[0011] **FIG. 5** depicts a block diagram further illustrating the Bluetooth™ baseband controller, as depicted in **FIG. 3**, in accordance with the further embodiment of the present invention.

[0012] **FIG. 6** depicts a Bluetooth™ software stack, implementing a Bluetooth™ baseband controlled driver to provide a wired/wireless Bluetooth™ communications interface, in accordance with an exemplary embodiment of the present invention.

[0013] **FIG. 7** depicts a block diagram illustrating a Bluetooth™ software architecture utilizing the Bluetooth™ baseband control driver, as depicted in **FIG. 6**, and in accordance with a further embodiment of the present invention.

[0014] **FIG. 8** depicts a flowchart illustrating a method for implementing a wired/wireless Bluetooth™ communications interface, in accordance with one embodiment of the present invention.

[0015] **FIG. 9** depicts a flowchart illustrating an additional method, which is performed prior to detection of a device communications type, in accordance with a further embodiment of the present invention.

[0016] **FIG. 10** depicts a flowchart illustrating an additional method for selecting a communications mode of the wireless device, in accordance with a further embodiment of the present invention.

[0017] **FIG. 11** depicts a flowchart illustrating a method for switching a device communications mode from one of a wired communications mode to a wireless communications mode, in accordance with an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[0018] A method and apparatus for wireless communications devices are described. The method includes detection of a communications configuration of a device as one of a

wireless communications interface and a wireless/wired communications interface. Once detected, it is determined whether a wired/wireless communications interface is the communications interface of the device. When such is the case, a data transmission error rate of the device is determined during operation of the device in a wireless communications mode. Next, the device is switched from the wireless communications mode to a wired communications mode when the data transmission error rate of the device exceeds a pre-determined threshold. As such, the present invention allows Bluetooth™ wireless communications devices to utilize a wired communications mode when transmission error rate exceeds a pre-determined threshold.

[0019] In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent, however, to one skilled in the art that the present invention may be practiced without some of these specific details. In addition, the following description provides examples, and the accompanying drawings show various examples for the purposes of illustration. However, these examples should not be construed in a limiting sense as they are merely intended to provide examples of the present invention rather than to provide an exhaustive list of all possible implementations of the present invention. In other instances, well-known structures and devices are shown in block diagram form in order to avoid obscuring the details of the present invention.

[0020] Portions of the following detailed description may be presented in terms of algorithms and symbolic representations of operations on data bits. These algorithmic descriptions and representations are used by those skilled in the data processing arts to convey the substance of their work to others skilled in the art. An algorithm, as described herein, refers to a self-consistent sequence of acts leading to a desired result. The acts are those requiting physical manipulations of physical quantities. These quantities may take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. Moreover, principally for reasons of common usage, these signals are referred to as bits, values, elements, symbols, characters, terms, numbers, or the like.

[0021] However, these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise, it is appreciated that discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's devices into other data similarly represented as physical quantities within the computer system devices such as memories, registers or other such information storage, transmission, display devices, or the like.

[0022] The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the required method. For example, any of the methods according to the present invention can be implemented in hard-wired circuitry, by programming a general-purpose processor, or by any combination of hardware and software.

[0023] One of skill in the art will immediately appreciate that the invention can be practiced with computer system configurations other than those described below, including hand-held devices, multiprocessor systems, microprocessor-based or programmable consumer electronics, digital signal processing (DSP) devices, network PCs, minicomputers, mainframe computers, and the like. The invention can also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. The required structure for a variety of these systems will appear from the description below.

[0024] It is to be understood that various terms and techniques are used by those knowledgeable in the art to describe communications, protocols, applications, implementations, mechanisms, etc. One such technique is the description of an implementation of a technique in terms of an algorithm or mathematical expression. That is, while the technique may be, for example, implemented as executing code on a computer, the expression of that technique may be more aptly and succinctly conveyed and communicated as a formula, algorithm, or mathematical expression.

[0025] Thus, one skilled in the art would recognize a block denoting "C=A+B" as an additive function whose implementation in hardware and/or software would take two inputs (A and B) and produce a summation output (C). Thus, the use of formula, algorithm, or mathematical expression as descriptions is to be understood as having a physical embodiment in at least hardware and/or software (such as a computer system in which the techniques of the present invention may be practiced as well as implemented as an embodiment).

[0026] In an embodiment, the methods of the present invention are embodied in machine-executable instructions. The instructions can be used to cause a general-purpose or special-purpose processor that is programmed with the instructions to perform the steps of the present invention. Alternatively, the steps of the present invention might be performed by specific hardware components that contain hardwired logic for performing the steps, or by any combination of programmed computer components and custom hardware components.

[0027] In one embodiment, the present invention may be provided as a computer program product which may include a machine or computer-readable medium having stored thereon instructions which may be used to program a computer (or other electronic devices) to perform a process according to the present invention. Accordingly, the computer-readable medium includes any type of media/machine-readable medium suitable for storing electronic instructions. Moreover, the present invention may also be downloaded as a computer program product. As such, the program may be transferred from a remote computer (e.g., a server) to a requesting computer (e.g., a client). The transfer of the program may be by way of data signals embodied in a carrier wave or other propagation medium via a communication link (e.g., a modem, network connection or the like).

[0028] System Architecture

[0029] Referring now to **FIG. 1**, **FIG. 1** depicts a Bluetooth™ piconet **100**, including a master, host computer **200**, which implements a wired/wireless Bluetooth™ communications interface. As known to those skilled in the art, a piconet describes a collection of devices connected via Bluetooth™ technology in an ad hoc fashion. A piconet is initialized with two connective devices, such as for example, a portable personal computer and a mobile phone. The number of devices which can participate in a piconet is limited to eight units. Accordingly, as illustrated in **FIG. 1**, the various devices, including headset **110**, joystick **120**, mouse keyboard **130**, personal digital assistant (PDA) **140**, laptop computer **150**, fax machine **160** and printer **170**, may participate in a piconet with host computer **200**.

[0030] As described above, piconets, such as piconet **100** as depicted in **FIG. 1**, are designed as wire replacement technologies for implementing such networks as depicted in **FIG. 1** without the need of wires for interconnecting devices. As such, a host computer would merely await page requests from the various devices in order to establish a connection between the host computer **200** and an authorized device, such as for example, headset **110**. Unfortunately, Bluetooth™ enabled devices, such as for example, headset **110**, are subject to various interference problems. As interference occurs, the host device may lose its connection with the Bluetooth™ device. Furthermore, interference problems may result in lost or dropped data packets from the Bluetooth™ connection between devices. In the case of a Bluetooth™ audio headset connected to a portable computer, the lost or dropped data packets would result in crackle or pops or gaps in the audio stream received at the headset.

[0031] Accordingly, as interference levels are detected, they can eventually reach the limit of intolerable interference within the Bluetooth™ devices, such that even the frequency hopping and error correction algorithms enabled by Bluetooth™ devices is not sufficient to overcome the interference problems. As a result, the present invention describes Bluetooth™ devices which implements a baseband controller, which enables a wired/wireless Bluetooth™ communications interface. Consequently, the various Bluetooth™ devices may either communication in a wireless fashion with a host device or be connected with the host device via a wired link.

[0032] As such, the wire link may be used whenever desired and is, in fact, required when a transmission data error rate between the host device and the various Bluetooth™ devices exceeds a pre-determined level. For example, in the case of a Bluetooth™ device transmitting audio data, an error rate of <1% may be established as the threshold error rate. Error rates in data traffic result in slowed performance of the Bluetooth™ link as it retransmits data until errors are corrected. In one embodiment, performance drops of >20% may necessitate switching from a wireless link to a wired link.

[0033] However, the various baseband controllers within the devices utilize the same communication methodology as conventional Bluetooth™ devices. Nevertheless, communication of voice and data is now provided between the devices using a wired link. In certain embodiments, the Bluetooth™ device may encounter excessive network interference requiring switching to a wired communications mode. When a wire is not currently being utilized, the devices may either direct themselves or require the host device to notify a user to connect a wire link between the devices to enable the wired communications mode. However, once the communication interference has subsided, the user can be notified to remove the wired link, if desired, and return to wireless (radio frequency (RF)) communication between the devices. In one embodiment, the configuration change may be done automatically by the system according to predefined preference settings.

[0034] Referring now to **FIG. 2**, **FIG. 2** further illustrates the host computer **200**, as depicted in **FIG. 1**, in accordance with a further embodiment of the present invention. As depicted, the host computer **200** includes a CPU **302**, a user interface **204**, a communications interface **206**, as well as a memory **212**. However, the host computer **200** is implemented utilizing a Bluetooth™ controller **300**, which includes a wire link connection port **302** in order to implement a wired/wireless interface, either via wire link port **302** or Bluetooth™ radio **310**.

[0035] Although the host computer **200** is illustrated using the Bluetooth™ controller **300**, those skilled in the art will recognize that each of the Bluetooth™ enabled devices, such as monitor **260**, keyboard **262** and mouse **264** also include a Bluetooth™ control and Bluetooth™ radio as depicted in **FIG. 2**. Accordingly, the Bluetooth™ enabled monitor **260**, keyboard **262** and mouse **264** can be utilized by the host control in order to provide a user interface without the need for interconnected wires between the host computer **200** and the Bluetooth™ devices. However, for the reasons described above, data transmission errors may be incurred during times of high interference levels.

[0036] Consequently, when interference levels exceed a pre-determined level, it may be necessary for a user to interconnect the various Bluetooth™ devices with a wired link to the wired link port **302** of the Bluetooth™ controller **300**. The various devices may themselves determine when excessive interference levels are detected and notify the user to make the wired connection. Alternatively, the Bluetooth™ controller **300** may make such determinations and notify the user to interconnect the wire link devices. In other embodiments, the detection of excessive error conditions resulting in a switch from wireless to wired transmission can be made automatically by either the device or the Bluetooth™ controller. As a result, the Bluetooth™ enabled devices will switch to a wired communications mode once notified by the Bluetooth™ controller **300** of a host device **200**.

[0037] Referring again to **FIG. 2**, the memory **212** of the host computer **200** may be implemented as RAM (random access memory), SRAM (synchronous random access memory), SDRAM (synchronous data random access memory) or a combination of RAM and non-volatile memory, such as one or more memory modules, storage volumes or magnetic disc storage units. The memory can contain any of the following:

[0038] an operating system **214**, which includes for example, windows driver model (WDM drivers) such as the human interface device (HID) class driver, streaming media windows drivers model, as well as the network driver interface specification

supported by the operating system, such as for example, Winsock, transmission communication protocol (TCP), Internet protocol (IP) (TCP/IP);

[0039] Bluetooth™ driver interface **216**;

[0040] Bluetooth™ host controller driver **220**;

[0041] base band control driver **222**;

[0042] communications interface type detection procedures **224**;

[0043] communications mode detection procedures **226**;

[0044] communications mode switch procedures **228**;

[0045] wire link detection procedures **230**;

[0046] error rate detection procedures **232**;

[0047] user notification procedures **234**;

[0048] RF.com driver **236**;

[0049] human interface device (HD) mini-drivers **238**;

[0050] audio mini-drivers **240**;

[0051] network mini-drivers **242**; and

[0052] other procedures and files.

[0053] Accordingly, the various procedures and drivers included in the host computer memory **212** will be described in further detail below within the Software Architecture description.

[0054] Referring now to **FIG. 3**, **FIG. 3** further illustrates the Bluetooth™ controller **300**, as depicted in **FIG. 2**, in accordance with a further embodiment of the present invention. As depicted, the Bluetooth™ controller **300** includes an analog portion as the Bluetooth™ radio **310**, which is utilized to communicate with the various Bluetooth™ enabled devices, as well as the digital portion, the link controller (Bluetooth™ baseband controller) **500**. Accordingly, the Bluetooth™ baseband controller **500** performs the digital signal processing functions of the Bluetooth™ controller using various signal processing hardware. The Bluetooth™ controller **300** further includes a CPU (central processing unit) core **360**, which is optional, but is however beneficial, in order to avoid interface problems with a personal computer CPU. The CPU core **402** is further utilized to interface between external interfaces **404**, which provide a host interface **400** to the various additional devices of the host computer **200**.

[0055] As such, the baseband controller **500** includes hardware for performing baseband processing and basic protocols close to the physical layer, such as for example, ARQ (automatic request repeat) protocol and FEC (forward error control) coding. Hence, the baseband controller **500** incorporates all hardware required to interface the Bluetooth™ controller **300** to the Bluetooth™ radio environment. Generally, command responses and data are transferred between Bluetooth™ units across the radio interface in packet format. In addition, the baseband controller **500** is generally responsible for quality of service parameters, asynchronous transfers with guaranteed delivery, synchronous transfers audio coding and encryption.

[0056] Referring again to **FIG. 3**, the link manager **350** is a software entity which carries out protocols, such as link set-up, authentication link configuration and the like. The link manager discovers other remote link managers and communicates with them via the link management protocol to perform service provider role and uses the services of the underlying baseband controller. The service provided includes name requests, which may be up to 16 characters in length, link address inquiries, connection set-up, authentication, link mode negotiation and set-up, such as for example, data or data invoice, setting devices in sniff mode, hold mode, park mode and active mode.

[0057] Referring now to **FIG. 4**, **FIG. 4** depicts host interface **400**, as depicted in **FIG. 3**, in accordance with one embodiment of the present invention. The host interface (HF) **400** includes hardware and software, which interfaces the Bluetooth™ controller **300** to a host, such as for example, host device **200**, as depicted in **FIG. 2**. The primary function of HIF **400** is to provide services of the lower layers (via the link manager) in a format suitable for the host device.

[0058] Accordingly, the various external interfaces are depicted in **FIG. 4**, which may include for example, PC card interface **430**, PCI (peripheral component interconnect) interface **440**, low pin out pin count interface **450**, USB interface **460** and dual port memory interface **470**. These devices may implement and support PC card bus RS **232**, PC mother board integration, as well as USB slave **462**. As such, the Bluetooth™ controller firmware implements the baseband link management protocol. The drivers control the radio **310** using the Bluetooth™ host controller interface **400**, which is accessed through an appropriate transport interface, as will be described in further detail below.

[0059] Referring now to **FIG. 5**, **FIG. 5** further illustrates the Bluetooth™ baseband controller, as depicted in **FIG. 4**. The Bluetooth™ baseband controller includes a processor **402** along with memory arbiter **540**, SRAM sequencer **550**, flash memory **560** and SRAM **570**. However, in contrast to conventional baseband controllers, the Bluetooth™ baseband controller **500** includes Bluetooth™ baseband **520**, which utilizes radio/wire detection block **510** in order to determine a communications mode of the respective device and to determine whether a wire link between a host device and the Bluetooth™ device is connected. As such, the Bluetooth™ baseband **520** includes firmware for performing the radio/wire detection functionality in order to perform the baseband control driver procedures **222-230**, as depicted in **FIG. 2**.

[0060] Accordingly, wire connection block **530** is utilized by the Bluetooth™ baseband controller **500** in order to provide a physical wire link to a slave device. Therefore, when interference levels exceeds a pre-determined level, a host device can notify a user to connect a wire link between the device and a host device via wire connection block **530**. Consequently, using wire link Bluetooth™ devices can avoid unduly interference levels and communicate via the wire link until the interference levels have subsided. Once interference levels have subsided, the various devices can notify the user to remove the wire link and resume wireless communication between the various devices. Alternatively, switching between modes is performed automatically according to the detected interference levels.

[0061] Software Architecture

[0062] The software architecture for implementing Bluetooth™ devices is based on the concept of treating the short range radio, such as for example, Bluetooth™ RF **310**, as depicted in FIGS. **2-4**, as a bus driver. Treating the local radio **310** as a bus controller enables the loading of appropriate device drivers on detection and identification of other Bluetooth™ compliant devices within range. As such, Bluetooth™ devices fall under the following three classes—telephone related devices, traditional PC peripherals and communication/network devices.

[0063] In order to support Bluetooth™ peripherals, the software model **600** utilizes the windows driver model (WDMS) human interface (HID) class driver. The HID class driver comes standard from, for example, Microsoft's NT™ 5.0 and 98 operating systems, and provides support for all human interface devices, such as bus list mechanisms. The HID driver is capable of identifying the HID peripheral and loading the corresponding HID mini drivers in a way that is bus independent. The HID class driver must be pointed to a WDM bus driver. Accordingly, by means of the Bluetooth™ WDM bus driver and an HID to Bluetooth™ bus mini driver, the HID class driver can be used to support all human interface devices, such as mice, keyboard, joysticks or the like.

[0064] Support for real time voice has been implemented using digital audio hooks in the PC via the streaming media Windows driver model (WDM) defined by Microsoft Corporation of Redmond, Wash. In addition, the network driver interface specification has connection orientation channels at the (NDIS) layer, which targets telephone applications. Finally, in networking applications are implemented by utilizing the Bluetooth™ controller interface as a network interface card (NIC), utilizing a mini driver to interface the NDIS class driver with the Bluetooth™ WDM bus driver.

[0065] Referring now to **FIG. 6**, **FIG. 6** depicts the Bluetooth™ software stack **600**. As illustrated, the core of the Bluetooth™ software stack **600** essentially includes the Bluetooth™ bus driver **630**, the Bluetooth™ host control interface (HCI) **640** and the Bluetooth™ host controller driver **650**. Accordingly, each function class typically includes a client driver that is loaded by the Bluetooth™ bus driver. These client drivers utilize the Bluetooth™ bus driver interface **620** to communicate with the Bluetooth™ bus driver **630** for data and control transfer purposes.

[0066] However, in contrast to conventional Bluetooth™ software stacks, Bluetooth™ software stack **600** includes a Bluetooth™ or link manager control driver **660**, which is utilized to implement the wired/wireless communications interface, as described herein. However, those skilled in the art will recognize that the wired/wireless interface communications methods described herein may be implemented anywhere within the Bluetooth™ bus driver interface **620** software stack **600**, as well as within the Bluetooth™ controller firmware, depending on the desired implementation specific details of the system designer.

[0067] As such, a Bluetooth™ software stack **600**, as depicted in **FIG. 6**, is further illustrated in the Bluetooth™ software architecture **700**, as depicted in **FIG. 7**. As illustrated, user mode **710** programs interact with the kernel **720** using a variety of programmer interfaces, including, for example, WIN32™ , Winsock™, RealTime™ applications server (RAS) and telephone application program interface (TAPI). As such, Bluetooth™ kernel mode drivers **720** fit into the framework exposed by Windows 98™ and Windows 2000™ for third party drivers. Although the Bluetooth™ software architecture **700**, as depicted in **FIG. 7**, is illustrated with reference to application programming interfaces specific to Windows 98™ and Windows 2000™, those skilled in the art will recognize that various third party drivers available in computing operating systems, such as for example, Unix, Linix or the like, may be provided in order to provide and implement Bluetooth™ device specific interfaces.

[0068] Bluetooth™ kernel mode drivers **720** fall into two categories: one set of drivers provide the infrastructure on which the second set of client Bluetooth™ drivers are layers. Infrastructure drivers are the ones below the Bluetooth™ driver interface. Bluetooth™ client drivers interface to the main specific interfaces in the operating system. As illustrated, **FIG. 7** depicts the software architecture for support, including networking communications, TAPI, HID, still image and audio. However, those skill in the art will recognize that this is not an exhaustive list. In addition, the Bluetooth™ host controller implements a baseband controlled driver, as illustrated in **FIG. 6**.

[0069] Accordingly, as illustrated in **FIG. 2**, within the memory of the host device **200**, the baseband control driver procedures **222** enable the wireless/wired communications interface, as referred to above, within Bluetooth™ enabled devices. As such, the communication interface type detection procedures **224** are utilized by the baseband control driver procedures **222** in order to determine whether the slave device is configured with a wired/wireless communications interface. When such is the case, the procedures can use the communications mode detection procedures **226** to determine whether a wire link is being used for communication between the devices.

[0070] As such, when a wireless mode is detected, the error rate detection procedures **232** will monitor packet error rates to determine interference levels. When the interference levels exceed a pre-determined level, the user notification procedures **234** will be utilized to notify a user to connect a wire link between the devices. Once a connection is made, the baseband control driver procedures **222** will invoke the communicator mode switch procedures **228** to switch communication from the wireless mode to the wired mode via wire link **320**.

[0071] In addition, the host device **200** includes a variety of mini drivers (**232-240**) for implementing the Bluetooth™ specific devices. In addition, the user mode applications include a Bluetooth™ advisor, as provided as a single point of control for all Bluetooth™ devices. It is generally targeted to be the end user visible application for Bluetooth™ related configurations. Within the infrastructure drivers described, the USB mini driver **730**, is a client of Microsoft's USB stack and communicates using the USB driver interface (USBDI). Accordingly, the driver provides a transport mechanism for access to the Bluetooth™ host controller interface **640**. The Bluetooth™ HCI **640** abstracts driver abstracts the HIC interface from the Bluetooth™ bus driver **630** and publishes a much simplified connection model. The Bluetooth™ bus driver **630** is one of the core components of

the Bluetooth™ stack. For Bluetooth™ purposes, the RF interface is modeled as a peripheral bus on which Bluetooth™ devices come and go.

[0072] The Bluetooth™ bus driver **630** is the bus driver for the RF bus and is responsible for the following functions: device enumeration, connection maintenance, client driver loading, implementation, segmentation, reassembly and protocol multiplexing, support for RF bus driver interface (RFBDI) management of radio transmissions and management of power states in the Bluetooth™ device. RF communication driver is a client of the Bluetooth™ bus and is responsible for implementing comport import immolation over Bluetooth™. It is generally used for dial-up networking and speech applications. It can also be used as a transport for objects exchange (OBEX) insert and implementations. OBEX enables synchronization applications between various Bluetooth™ devices, such as between a notebook computer and a phone.

[0073] The HID mini drivers **722** provide support for RD via the phone through an HID mini driver that interfaces with the HID class driver and the Bluetooth™ bus driver **630**. These interfaces are also utilized in order to enable support for other HID devices in Bluetooth™, including keyboards, joysticks, mice and game pads. An audio mini driver is also provided that interfaces with the streaming class driver from the Microsoft operating system. It is utilized as a capacitor from the system audio devices to the Bluetooth™ interface, where it will be transported to a headset, cellular phone or another notebook computer. Network mini drivers also are provided in order to provide LAN access points, as well as conference table functions. Accordingly, the procedural methods for implementing the wired/wireless communications interface as described herein are now provided.

[0074] Operation

[0075] Referring now to **FIG. 8**, **FIG. 8** depicts a method **800** for implementing a wired/wireless Bluetooth™ communications interface within, for example, the Bluetooth™ devices as depicted in **FIGS. 1 and 2**. As described above, the various wired/wireless interface procedures, as described herein, may be implemented utilizing the baseband control driver **222**, as depicted in **FIGS. 2, 6** and **7**. Alternatively, the wired/wireless interface procedures may be implemented utilizing software procedures within the link manager **350**, as depicted in **FIG. 3**. Otherwise, the interface procedures may be implemented utilizing baseband controller firmware within baseband controller **500**, as depicted in **FIG. 5**.

[0076] Accordingly, utilizing the wired/wireless interface techniques describes herein, Bluetooth™ enabled devices may utilize a wire link to communicate with a Bluetooth™ host device when environment interference exceeds a predetermined level, which prohibits wireless communication between the various devices. However, as described herein, communication continues via the Bluetooth™ baseband controller, with the exception that the Bluetooth™ radio is no longer utilized as the various information packets of data invoice information are transmitted through a wire link that connects the various devices.

[0077] Referring again to **FIG. 8**, at process block **840**, a communications interface type of a device is detected. In the embodiments described, the communications interface type is one of a wireless communications interface and a wired/wireless communications interface. As described herein, the wireless communications interface refers to conventional Bluetooth™ baseband controllers, which are limited to a wireless interface. However, Bluetooth™ enabled devices utilizing baseband controllers, as described herein, will implement a wireless/wired communications interface.

[0078] Accordingly, at process block **842**, when a wired/wireless communications interface is detected, at process block **844**, a communications mode of the device is detected. In one embodiment, the interface type and the communications mode of the device are determined by querying a communications interface type state field and a wired link state field, which are set during, for example, start-up of the device. As described herein, the communications mode of the device includes wireless communications mode and a wired communications mode for dual wired/wireless communications interfaces.

[0079] Next, at process block **846**, it is determined whether the device is functioning in a wireless communications mode. When such is the case, at process block **848**, a data transmission error rate of the device is determined. Once determined, at process block **850**, it is determined whether the data transmission error rate exceeds a predetermined threshold error rate. As such, process block **848** is repeated until the error rate exceeds a pre-determined threshold. Accordingly, at process block **852**, when the data transmission error rate exceeds the pre-determined threshold error rate, the wireless communications mode of the device is switched from the wireless communications mode to a wired communications mode. Alternatively, an environment interference level may be determined in order to decide whether to initiate communication in a wired communications mode.

[0080] As such, the device will now communicate using the baseband controller via a wired link interconnecting device with a host device. As indicated, the various procedural methods may either be implemented solely within the Bluetooth™ device or within a host device, such that a host device could send a broadcast packet to the various Bluetooth™ devices to begin functioning in the wired communications mode. In addition, when a wire link is not present, the host device could notify a user to plug in the required wired link.

[0081] Alternatively, such notification could be provided via the devices, themselves, such that the host device begins functioning in a wired communications mode upon notification from a device or when plugin of the wired link is detected. The various baseband controlled driver procedures are described with reference to **FIG. 2** and include communications interface procedures **224**, communications mode detection procedures **226**, communications mode switch procedures **228**, wire link detection procedures **230**, error rate (interference level) detection procedures **232** and user notification procedures **234**, which may be implemented solely in the host computers as well as in the various Bluetooth™ enabled devices utilizing the Bluetooth™ software stack or baseband controller firmware.

[0082] Referring now to **FIG. 9**, **FIG. 9** illustrates a method **802** which is performed prior to detection of the device communications interface type. Accordingly, at process block **804**, a device communications interface type is

determined. Once the interface type of the device is determined, a device communications interface state is set according to the determined communications interface type. Next, at process block **808**, it is determined whether a wired/wireless communications interface is detected as the communications configuration of the device. When such is the case, at process block **810**, it is determined whether a wired link couples the device to a host device. When such is the case, at process block **812**, a wired connection state is set. Next, at process block **814**, a communications mode of the device is selected according to the device communications configuration state, the wired connections state and a radio frequency interference level.

[**0083**] Finally, at process block **816**, a device communications mode state is set according to the selected communications mode. As described above, the communications mode will be selected as a wireless communications mode when interference levels are at a normal level. However, when interference levels exceed a pre-determined threshold error level, the device will switch to a wired communications mode assuming a dual wired/wireless interface is supported. As will be described in detail below, when a wire link is not present during times of excessive interference, a user of a dual wired/wireless interface device will be notified to connect the device to a host device via a wire link.

[**0084**] Referring now to **FIG. 10**, **FIG. 10** depicts a flowchart illustrating an additional method **816** for selecting the communications mode of process block **816**, as depicted in **FIG. 10**. At process block **822**, it is determined whether a wireless/wired communications interface of the device is detected. When such is the case, at process block **824**, it is determined whether a wire link couples the device to a host device. When such is the case, at process block **826**, a radio frequency interference level is determined. Once determined, at process block **828**, it is determined whether the radio frequency interference level exceeds a pre-determined interference level. As such, process block **826** is repeated until the radio frequency interference level exceeds the pre-determined interference level. As such, once this case is determined, the communications mode of the device is set to the wired communications mode at process block **830**.

[**0085**] In one embodiment, process blocks **826** and **828** are optional. In this embodiment, when a wire link is detected, the device will continually function in the wired communications mode. However, in the embodiment described with reference to **FIG. 10**, the device can automatically switch between communication modes (wired/wireless), as dictated by the interference levels, without notifying the user. Alternatively, the user may be notified to disconnect the wire link and enjoy wireless freedom provided by the wireless communications mode.

[**0086**] Referring now to **FIG. 11**, **FIG. 11** depicts a flowchart illustrating a method for switching the device communications mode. At process block **862**, the determined data transmission error rate is compared to a pre-determined threshold error rate. Next, at process block **824**, it is determined whether the data transmission error rate exceeds the pre-determined threshold error rate. When such is the case, the device communications mode is set to the wired communications mode. Once set to the wired communications mode, at process block **868**, communication of the device is initiated via a wire link between the device and a host device. Otherwise, at process block **870**, the device communications mode is set to a wireless communications mode. Finally, at process block **880**, communication of the device is initiated via a wireless link, such as for example, Bluetooth™ radio **310**.

[**0087**] In alternate embodiments, during communication of the device according to the wired communications mode, one of the device or the host device will continue monitoring of the device interference levels or transmission error rates in order to determine when interference levels leading to increased transmission error rates have subsided. As such, once interference levels and corresponding data transmission error rates have fallen within an accepted threshold level, a user may be notified to disconnect the wire link between the device and the host device. Consequently, once the wire link is removed, the devices can resume functioning in a wireless communications mode, thereby enabling a user of the device to move around freely without being constricted by wires. As a result, this process may be continually repeated as interference levels are encountered by the user.

[**0088**] In a further alternate embodiment, a wire link is continuously connected between the wireless device and the host device. In such an embodiment, one of the host device or the wire device determines the interference levels within the environment and selects the communications mode accordingly. As indicated above, during times of excess interference levels, either of the devices will switch to the wired communications mode. However, when the interference level returns to an acceptable range, the devices may return to a wireless communications mode automatically, without alerting the user. This embodiment is provided in order to enable the user to have continued, uninterrupted communication.

[**0089**] Nonetheless, the user is restricted to having a wire link in place at all times during communications between the devices. However, the user can, at their option, remove the wire links and function in a wireless communications mode until an excessive interference level is detected, at which time the user may be requested to connect the wire link. As recognized by those skilled in the art, the various implementation details are up to the respective system designers and will include considerations relative to user preference for eliminating wire connections, as well as considerations for continuous communications and uninterrupted communication between the various devices.

[**0090**] As such, the process described herein will be repeated, requiring connecting a wire link and removing the wire link as necessary, in order to provide continued communication according to either a wired communications mode or a wireless communications mode. Moreover, voice/data communication between devices simply is performed by transmitting voice/data via either a wire link or a radio frequency transmitter within devices without requiring modification to device communication protocols or packet processing. Therefore, a user may continue communication without being subject to inoperable wireless devices during times of excessive interference levels leading to untenable error transmission rates.

[**0091**] Alternate Embodiments

[**0092**] Several aspects of one implementation of the when a wireless/wired communications interface is detected as the

communications configuration for providing wired communication in the event of RF interference have been described. However, various implementations of the when a wireless/wired communications interface is detected as the communications configuration provide numerous features including, complementing, supplementing, and/or replacing the features described above. Features can be implemented as part of the wireless device or as part of a computer system in different implementations. In addition, the foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the invention. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the invention.

[0093] In addition, although an embodiment described herein is directed to a Bluetooth™ device, it will be appreciated by those skilled in the art that the teaching of the present invention can be applied to other systems. In fact, systems for limited distance wireless communication are within the teachings of the present invention, without departing from the scope and spirit of the present invention. The embodiments described above were chosen and described in order to best explain the principles of the invention and its practical applications. These embodiment were chosen to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated.

[0094] It is to be understood that even though numerous characteristics and advantages of various embodiments of the present invention have been set forth in the foregoing description, together with details of the structure and function of various embodiments of the invention, this disclosure is illustrative only. In some cases, certain subassemblies are only described in detail with one such embodiment. Nevertheless, it is recognized and intended that such subassemblies may be used in other embodiments of the invention. Changes may be made in detail, especially matters of structure and management of parts within the principles of the present invention to the full extent indicated by the broad general meaning of the terms in which the appended claims are expressed.

[0095] The present invention provides many advantages over known techniques. The present invention includes the ability to provide a wired interface to a Bluetooth™ device without the necessity to replace the protocol and foundation of the communications device. For example, a Bluetooth™-enabled keyboard can be used in a standard wireless fashion or it can be built such that it connects to a PC via a cable to perhaps a Bluetooth™ to USB connection. In this example, the user can chose either the wireless mode or can also plug the same keyboard into a USB port in cases where radio traffic is a problem. Accordingly, the present invention provides a back-up method of connecting devices where radio frequency traffic is a problem. In addition, devices are provided with a wired or wireless option. There are many circumstances when a user may not want to (or not be able to) use a wireless device, such as for example, battery depletion or the like. Finally, the present invention provides a mechanism for redundant connection or useful so that connectivity is not lost and protocol device connection does not have to ever change.

[0096] Having disclosed exemplary embodiments and the best mode, modifications and variations may be made to the disclosed embodiments while remaining within the scope of the invention as defined by the following claims.

What is claimed is:

1. A method comprising:

detecting a communications interface type of a device as one of a wireless communications interface and a wireless/wired communications interface;

when a wireless/wired communications interface is detected as the device communications interface type, detecting a communications mode of the device as one of a wireless communications mode and a wired communications mode;

when a wired/wireless communications interface type is detected, determining a data transmission error rate of the device during operation of the device in the wireless communications mode; and

switching the device from the wireless communications mode to a wired communication mode when the data transmission error rate of the device exceeds a pre-determined threshold.

2. The method of claim 1, wherein prior to detecting the device communications interface type, the method further comprises:

determining a communications interface type of the device;

setting a device communications interface state according to the determined communications interface type;

when a wireless/wired communications interface is detected as the communications interface type, determining whether a wire link is coupled to the device;

setting a wired connection state according to the determined wired connection;

when a wire link is coupled to the device, selecting a communications mode as one of a wireless communications mode and a wired communications mode according to the device communications configuration state, the wired connection state and a radio frequency interference level; and

setting a device communications mode state according to the selected communications mode.

3. The method of claim 2, wherein selecting the communications mode further comprises:

when the device communications interface state indicates a wireless/wired communications interface and the wired connection state indicates presence of a wire link, determining a radio frequency interference level; and

when the radio frequency interference level exceeds a pre-determined interference level, setting the communications mode to the wired communications mode.

4. The method of claim 1, wherein detecting the communications configuration of the device further comprises:

querying a device communications configuration state to detect the communications interface type of the device; and

when the communications interface type of the device is a wireless/wired communications interface, querying a wired connection state to determine whether a wire link couples the device to a host device.

5. The method of claim 1, wherein determining the data transmission error rate further comprises:

querying a device communications mode state to determine a communications mode of the device; and

when the communications mode of the device is the wired communications mode, determining the data transmission error rate of the device by querying a data transmission error rate state.

6. The method of claim 1, wherein switching the device further comprises:

comparing the determined data transmission error rate to a pre-determined threshold error rate;

when the data transmission error rate exceeds the pre-determined threshold error rate, setting the device communications mode state to the wired communications mode;

initiating communication of the device via a wire link;

otherwise, setting the device communications mode to a wireless communications mode; and

initiating communication of the device via a wireless link.

7. The method of claim 1, wherein switching the device further comprises:

comparing the transmission error rate with a pre-determined threshold error rate;

when the transmission error rate exceeds the pre-determined threshold error rate, querying a wired connection state to determine presence of a wire link coupled to the device;

when a wired connection is coupled to the device, switching the device from the wireless communications mode to the wired communications mode;

otherwise, notifying a device user to couple a wire link between the device and a host device; and

once the user couples a wire link between the device and the host device, switching the device from the wireless communications mode to the wired communications mode.

8. The method of claim 7, further comprising:

comparing the transmission error rate with a pre-determined threshold error rate;

when the transmission error rate is below the pre-determined threshold error rate, notifying the user to disconnect the wire link between the device and the host device; and

once the user disconnects a wire link between the device and the host device, switching the device from the wired communications mode to the wireless communications mode.

9. The method of claim 1, wherein switching the device further comprises:

transmitting data, via a wire link, between the device and a host device, utilizing the wired communication mode; and

receiving data, via the wire link, from the host device, utilizing the wired communications mode.

10. The method of claim 1, wherein switching the device further comprises switching a host device, coupled to the device via a wire link, from the wireless communications mode to the wired communications mode.

11. A computer readable storage medium including program instructions that direct a computer to function in a specified manner when executed by a processor, the program instructions comprising:

detecting a communications interface type of a device as one of a wireless communications interface and a wireless/wired communications interface;

when a wireless/wired communications interface is detected as the device communications interface type, detecting a communications mode of the device as one of a wireless communications mode and a wired communications mode;

when a wired/wireless communications interface type is detected, determining a data transmission error rate of the device during operation of the device in the wireless communications mode; and

switching the device from the wireless communications mode to a wired communication mode when the data transmission error rate of the device exceeds a pre-determined threshold.

12. The computer readable storage medium of claim 11, wherein prior to detecting the device communications interface type, the method further comprises:

determining a communications interface type of the device;

setting a device communications interface state according to the determined communications interface type;

when a wireless/wired communications interface is detected as the communications interface type, determining whether a wire link is coupled to the device;

setting a wired connection state according to the determined wired connection;

when a wire link is coupled to the device, selecting a communications mode as one of a wireless communications mode and a wired communications mode according to the device communications configuration state, the wired connection state and a radio frequency interference level; and

setting a device communications mode state according to the selected communications mode.

13. The computer readable storage medium of claim 12, wherein selecting the communications mode further comprises:

when the device communications interface state indicates a wireless/wired communications interface and the wired connection state indicates presence of a wire link, determining a radio frequency interference level; and

when the radio frequency interference level exceeds a pre-determined interference level, setting the communications mode to the wired communications mode.

14. The computer readable storage medium of claim 11, wherein detecting the communications configuration of the device further comprises:

querying a device communications configuration state to detect the communications interface type of the device; and

when the communications interface type of the device is a wireless/wired communications interface, querying a wired connection state to determine whether a wire link couples the device to a host device.

15. The computer readable storage medium of claim 11, wherein determining the data transmission error rate further comprises:

querying a device communications mode state to determine a communications mode of the device; and

when the communications mode of the device is the wired communications mode, determining the data transmission error rate of the device by querying a data transmission error rate state.

16. The computer readable storage medium of claim 11, wherein switching the device further comprises:

comparing the determined data transmission error rate to a pre-determined threshold error rate;

when the data transmission error rate exceeds the pre-determined threshold error rate, setting the device communications mode state to the wired communications mode;

initiating communication of the device via a wire link;

otherwise, setting the device communications mode to a wireless communications mode; and

initiating communication of the device via a wireless link.

17. The computer readable storage medium of claim 11, wherein switching the device further comprises:

comparing the transmission error rate with a pre-determined threshold error rate;

when the transmission error rate exceeds the pre-determined threshold error rate, querying a wired connection state to determine presence of a wire link coupled to the device;

when a wired connection is coupled to the device, switching the device from the wireless communications mode to the wired communications mode;

otherwise, notifying a device user to couple a wire link between the device and a host device; and

once the user couples a wire link between the device and the host device, switching the device from the wireless communications mode to the wired communications mode.

18. The computer readable storage medium of claim 17, further comprising:

comparing the transmission error rate with a pre-determined threshold error rate;

when the transmission error rate is below the pre-determined threshold error rate, notifying the user to disconnect the wire link between the device and the host device; and

once the user disconnects a wire link between the device and the host device, switching the device from the wired communications mode to the wireless communications mode.

19. The computer readable storage medium of claim 11, wherein switching the device further comprises:

transmitting data, via a wire link, between the device and a host device, utilizing the wired communication mode; and

receiving data, via the wire link, from the host device, utilizing the wired communications mode.

20. The computer readable storage medium of claim 11, wherein switching the device further comprises switching a host device, coupled to the device via a wire link, from the wireless communications mode to the wired communications mode.

21. An apparatus, comprising:

a processor having circuitry to execute instructions;

a communications interface coupled to the processor, the communications interface to transmit data to a host device, and to receive data from the host device;

a connection port coupled to the processor to enable coupling of the apparatus to the host device via a wire link;

a wired/wireless detection unit to detect whether the apparatus is coupled to the host device via the wired link; and

a storage device coupled to the processor, having sequences of instructions stored therein, which when executed by the processor cause the processor to:

determine a data transmission error rate of the apparatus during operation of the apparatus in a wireless communications mode, and

switch the apparatus from the wireless communications mode to a wired communication mode when the data transmission error rate of the apparatus exceeds a pre-determined threshold error rate.

22. The apparatus of claim 21, wherein the instruction to switch the apparatus from the wireless communications mode to the wired communications mode further causes the processor to:

compare the transmission error rate with a pre-determined threshold error rate;

when the transmission error rate exceeds the pre-determined threshold error rate, query the wired/wireless detection unit to determine presence of a wire link coupled to the apparatus connection port;

when the wired link is coupled to the apparatus connection port, switch the apparatus from the wireless communications mode to the wired communications mode;

otherwise, notify an apparatus user to couple the wire link between the apparatus and the host device; and

once the user couples the wire link between the apparatus and the host device, switch the apparatus from the wireless communications mode to the wired communications mode.

23. The apparatus of claim 22, wherein the processor is further caused to

compare the transmission error rate with a pre-determined threshold error rate;

when the transmission error rate is below the pre-determined threshold error rate, notify the user to disconnect the wire link between the apparatus and the host device; and

once the user disconnects the wire link between the apparatus and the host device, switch the device from the wired communications mode to the wireless communications mode.

24. A system comprising:

a host device;

a wireless/wired communication device including:

a communications interface, the communications interface to transmit data to the host device, and to receive data from the host device via a wire link during a wired communications mode and a wireless link during a wireless communications mode,

a connection port coupled to the communications interface to enable coupling of the communication device to the host device via the wire link, and

a wired/wireless detection device coupled to the communications interface to detect whether the communication device is coupled to the host device via the wire link, such that the communication device switches from the wireless communications mode to the wired communication mode when the data transmission error rate of the communication device exceeds a pre-determined threshold.

25. The system of claim 24, wherein the host device comprises:

a host communications interface, the host communications interface to transmit data to the communications device, and to receive data from the communications device via the wire link during the wired communications mode and the wireless link during the wireless communications mode; and

a host connection port coupled to the host communications interface to enable coupling of the host device to the communications device via the wire link.

26. The system of claim 24, wherein the communication device further comprises:

a user interface coupled to the communications interface, the user interface to notify the user to disconnect the wire link between the communication device and the host device when the transmission error rate is below the pre-determined threshold error rate, and once the user disconnects a wire link between the device and the host device, to switch the device from the wired communications mode to the wireless communications mode.

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