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**Linetsky**

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(54) **SECURITY SYSTEM WITH METHODOLOGY FOR DEFENDING AGAINST SECURITY BREACHES OF PERIPHERAL DEVICES**

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| *H04N 7/16* | (2011.01) |
| *G06F 12/14* | (2006.01) |

(52) **U.S. Cl.** ..... **713/2**; 726/2; 726/22; 726/26; 710/15

(58) **Field of Classification Search** ..... None
See application file for complete search history.

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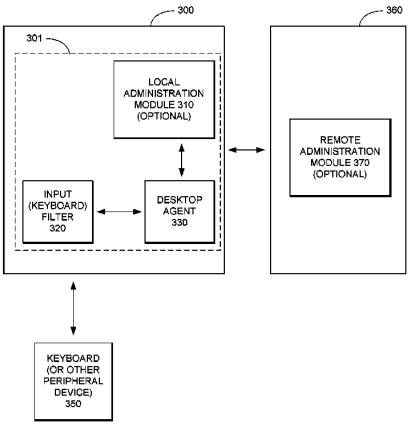
(57) **ABSTRACT**

A security system with methodology for defending against security breaches of peripheral devices is described. In one embodiment, for example, a method is described for protecting a computer from security breaches involving devices that may be attached to the computer, the method comprises steps of: when a device is first attached to the computer, specifying authorization information indicating that the device is allowed to communicate with the computer; detecting detachment of the device from the computer; updating the authorization information to indicate that the device is no longer authorized to communicate with the computer; and upon reattachment of the device, blocking communication with the device while the device remains unauthorized, thereby preventing a security breach involving the device.

**42 Claims, 6 Drawing Sheets**



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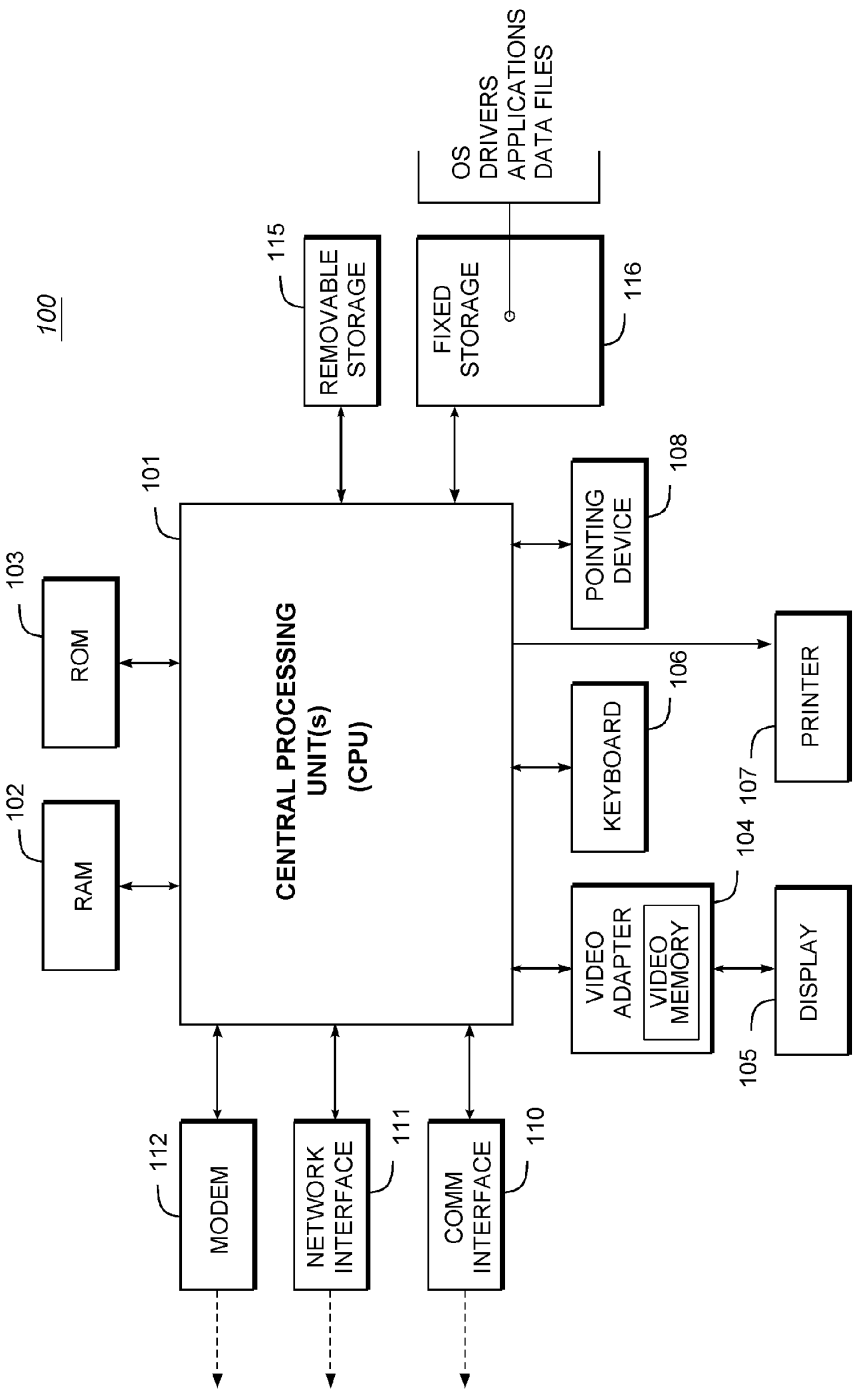


FIG. 1
(PRIOR ART)

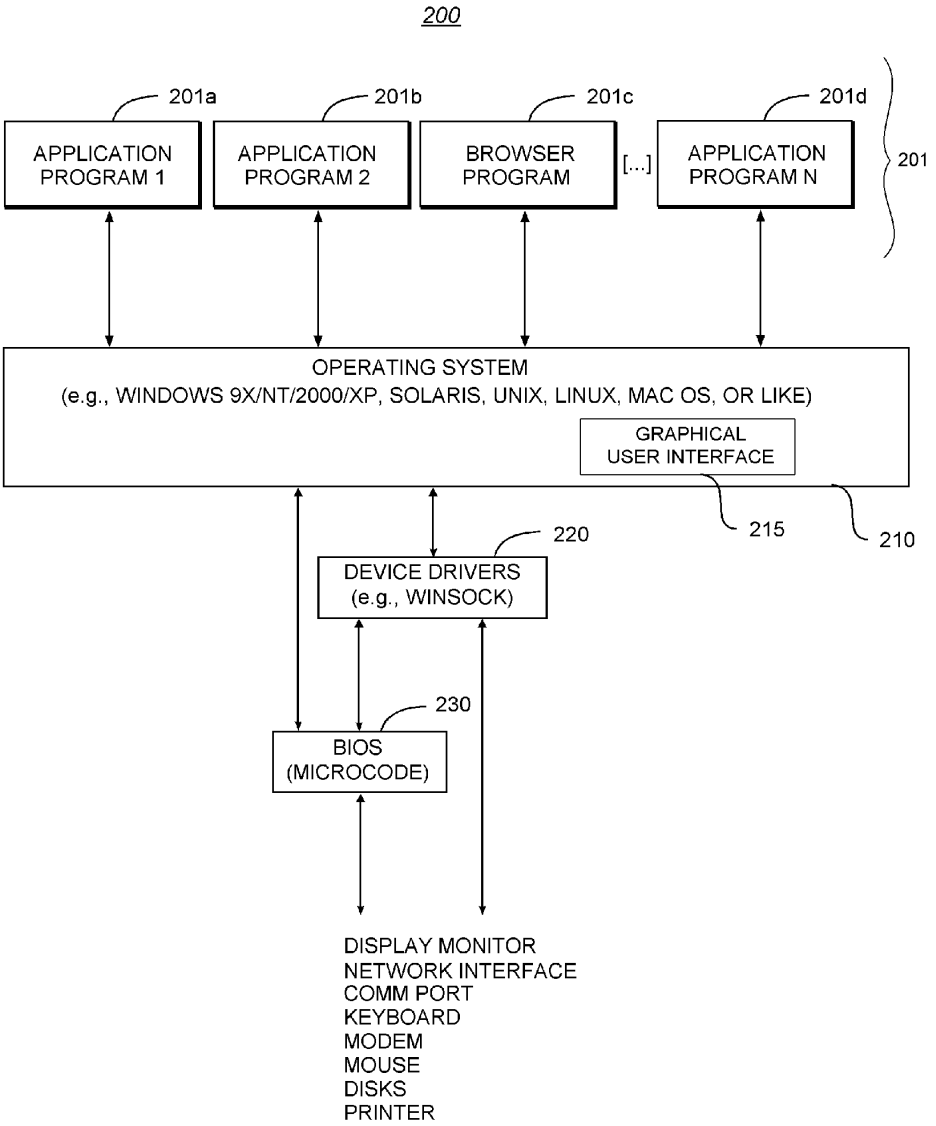
200
201a
201b
201c
201d
APPLICATION PROGRAM 1
APPLICATION PROGRAM 2
BROWSER PROGRAM
[...]
APPLICATION PROGRAM N
201
OPERATING SYSTEM
(e.g., WINDOWS 9X/NT/2000/XP, SOLARIS, UNIX, LINUX, MAC OS, OR LIKE)
GRAPHICAL USER INTERFACE
215
210
220
DEVICE DRIVERS
(e.g., WINSOCK)
230
BIOS
(MICROCODE)
DISPLAY MONITOR
NETWORK INTERFACE
COMM PORT
KEYBOARD
MODEM
MOUSE
DISKS
PRINTER

*FIG. 2*

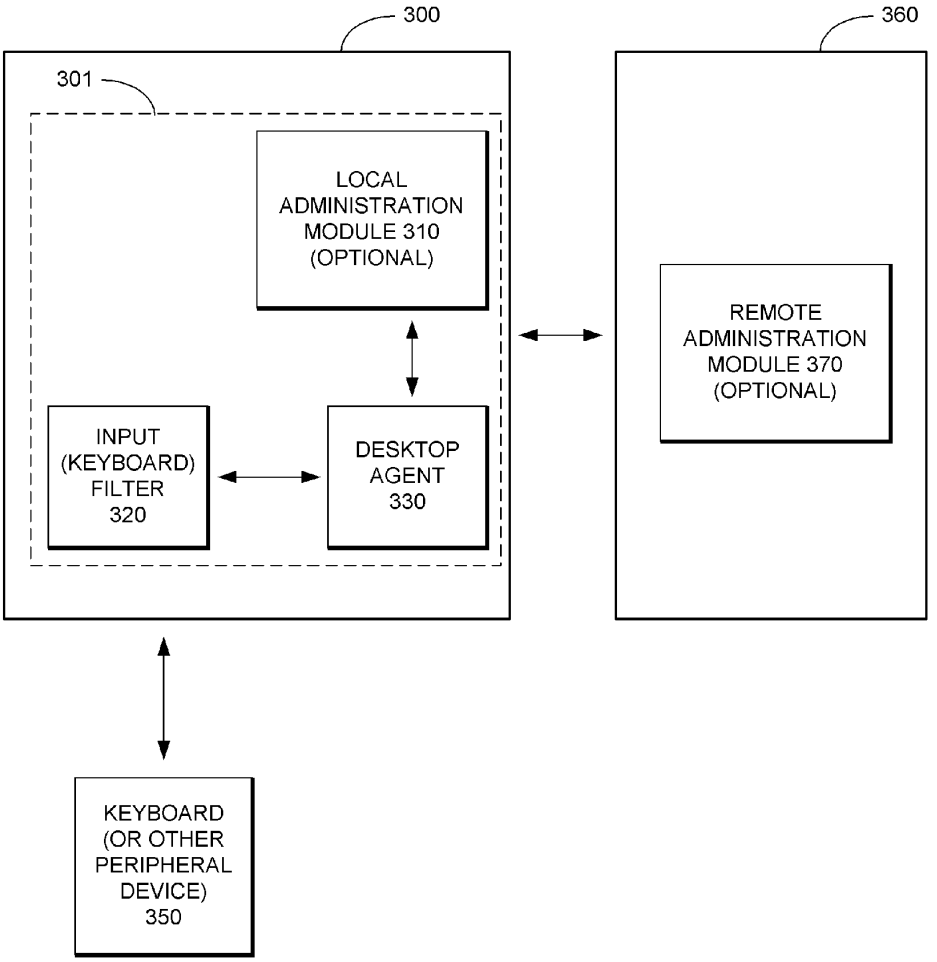
300
360
301
LOCAL ADMINISTRATION MODULE 310 (OPTIONAL)
REMOTE ADMINISTRATION MODULE 370 (OPTIONAL)
INPUT (KEYBOARD) FILTER 320
DESKTOP AGENT 330
KEYBOARD (OR OTHER PERIPHERAL DEVICE) 350

*FIG. 3*

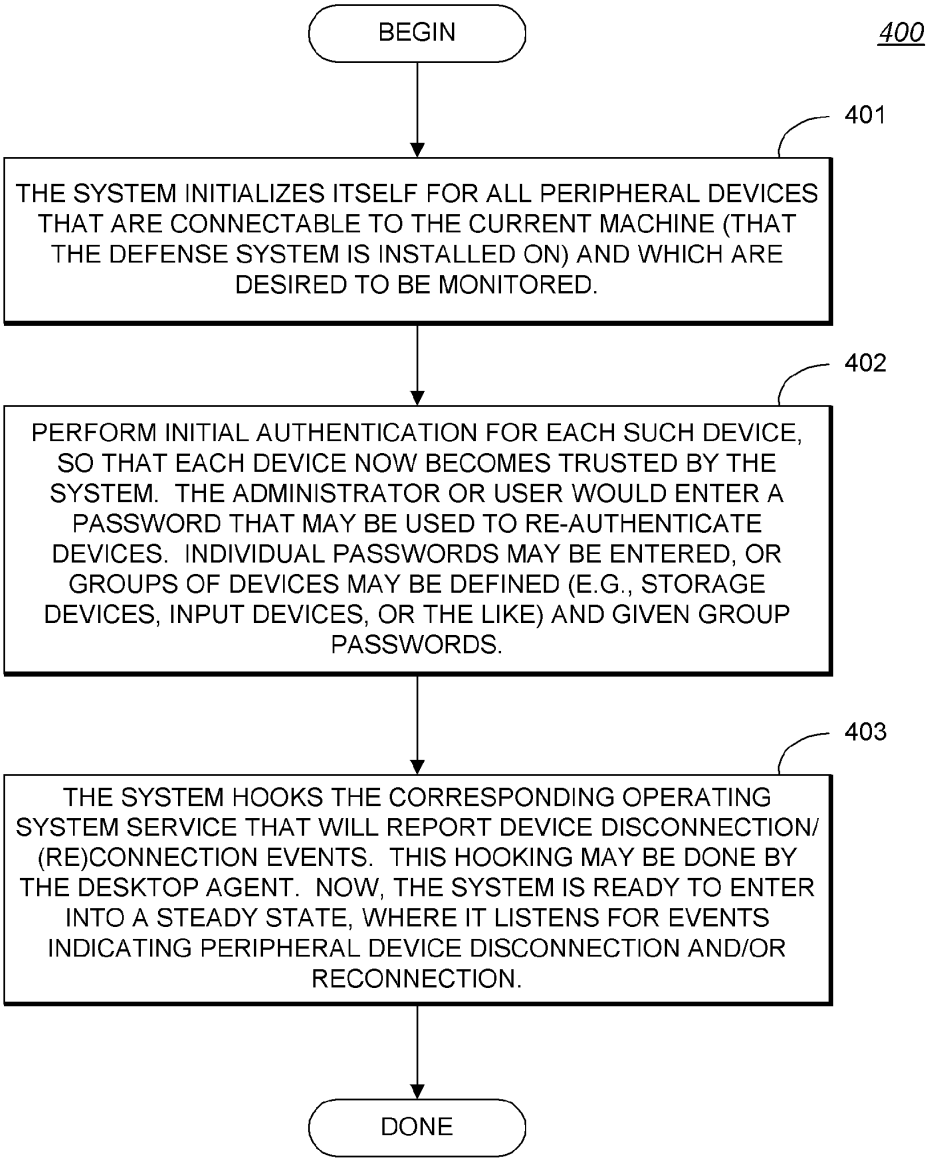
400
BEGIN
401
THE SYSTEM INITIALIZES ITSELF FOR ALL PERIPHERAL DEVICES THAT ARE CONNECTABLE TO THE CURRENT MACHINE (THAT THE DEFENSE SYSTEM IS INSTALLED ON) AND WHICH ARE DESIRED TO BE MONITORED.
402
PERFORM INITIAL AUTHENTICATION FOR EACH SUCH DEVICE, SO THAT EACH DEVICE NOW BECOMES TRUSTED BY THE SYSTEM. THE ADMINISTRATOR OR USER WOULD ENTER A PASSWORD THAT MAY BE USED TO RE-AUTHENTICATE DEVICES. INDIVIDUAL PASSWORDS MAY BE ENTERED, OR GROUPS OF DEVICES MAY BE DEFINED (E.G., STORAGE DEVICES, INPUT DEVICES, OR THE LIKE) AND GIVEN GROUP PASSWORDS.
403
THE SYSTEM HOOKS THE CORRESPONDING OPERATING SYSTEM SERVICE THAT WILL REPORT DEVICE DISCONNECTION/ (RE)CONNECTION EVENTS. THIS HOOKING MAY BE DONE BY THE DESKTOP AGENT. NOW, THE SYSTEM IS READY TO ENTER INTO A STEADY STATE, WHERE IT LISTENS FOR EVENTS INDICATING PERIPHERAL DEVICE DISCONNECTION AND/OR RECONNECTION.
DONE

*FIG. 4*

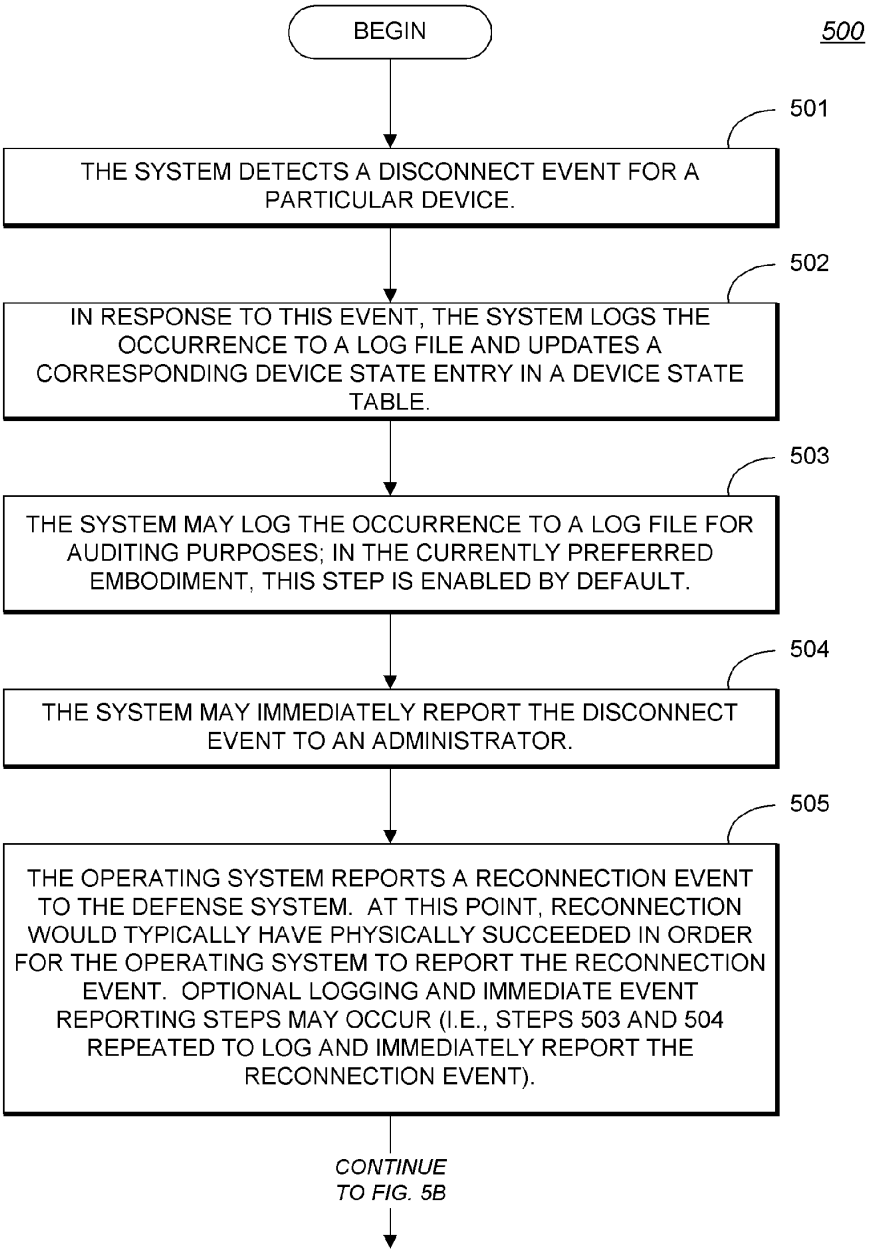
BEGIN
500
501
THE SYSTEM DETECTS A DISCONNECT EVENT FOR A PARTICULAR DEVICE.
502
IN RESPONSE TO THIS EVENT, THE SYSTEM LOGS THE OCCURRENCE TO A LOG FILE AND UPDATES A CORRESPONDING DEVICE STATE ENTRY IN A DEVICE STATE TABLE.
503
THE SYSTEM MAY LOG THE OCCURRENCE TO A LOG FILE FOR AUDITING PURPOSES; IN THE CURRENTLY PREFERRED EMBODIMENT, THIS STEP IS ENABLED BY DEFAULT.
504
THE SYSTEM MAY IMMEDIATELY REPORT THE DISCONNECT EVENT TO AN ADMINISTRATOR.
505
THE OPERATING SYSTEM REPORTS A RECONNECTION EVENT TO THE DEFENSE SYSTEM. AT THIS POINT, RECONNECTION WOULD TYPICALLY HAVE PHYSICALLY SUCCEEDED IN ORDER FOR THE OPERATING SYSTEM TO REPORT THE RECONNECTION EVENT. OPTIONAL LOGGING AND IMMEDIATE EVENT REPORTING STEPS MAY OCCUR (I.E., STEPS 503 AND 504 REPEATED TO LOG AND IMMEDIATELY REPORT THE RECONNECTION EVENT).
CONTINUE TO FIG. 5B

*FIG. 5A*

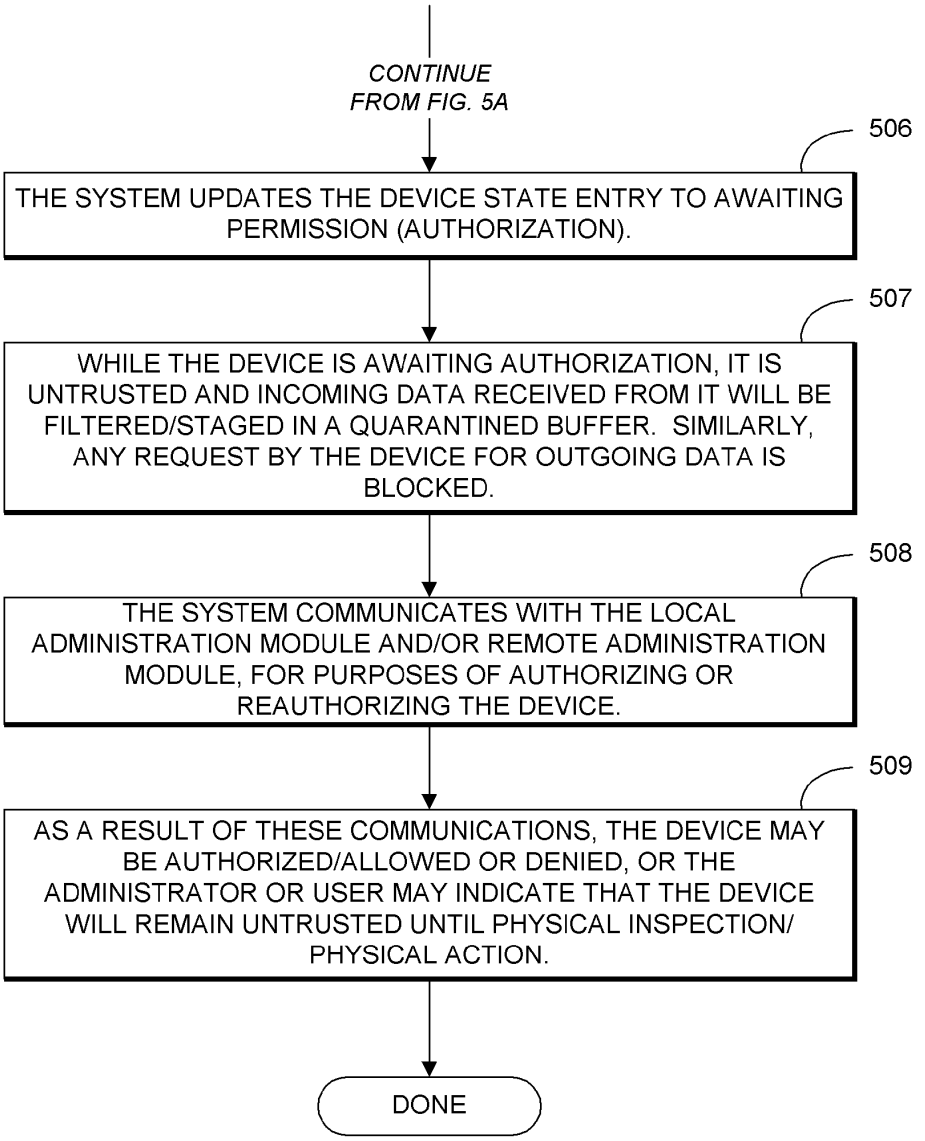
CONTINUE
FROM FIG. 5A
506
THE SYSTEM UPDATES THE DEVICE STATE ENTRY TO AWAITING PERMISSION (AUTHORIZATION).
507
WHILE THE DEVICE IS AWAITING AUTHORIZATION, IT IS UNTRUSTED AND INCOMING DATA RECEIVED FROM IT WILL BE FILTERED/STAGED IN A QUARANTINED BUFFER. SIMILARLY, ANY REQUEST BY THE DEVICE FOR OUTGOING DATA IS BLOCKED.
508
THE SYSTEM COMMUNICATES WITH THE LOCAL ADMINISTRATION MODULE AND/OR REMOTE ADMINISTRATION MODULE, FOR PURPOSES OF AUTHORIZING OR REAUTHORIZING THE DEVICE.
509
AS A RESULT OF THESE COMMUNICATIONS, THE DEVICE MAY BE AUTHORIZED/ALLOWED OR DENIED, OR THE ADMINISTRATOR OR USER MAY INDICATE THAT THE DEVICE WILL REMAIN UNTRUSTED UNTIL PHYSICAL INSPECTION/ PHYSICAL ACTION.
DONE

*FIG. 5B*

# SECURITY SYSTEM WITH METHODOLOGY FOR DEFENDING AGAINST SECURITY BREACHES OF PERIPHERAL DEVICES

## COPYRIGHT STATEMENT

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## BACKGROUND OF INVENTION

1. Field of the Invention

The present invention relates generally to defending computer systems against security breaches and, more particularly, to defending such systems against security breaches involving peripheral devices.

2. Description of the Background Art

The first computers were largely stand-alone units with no direct connection to other computers or computer networks. Data exchanges between computers were mainly accomplished by exchanging magnetic or optical media such as floppy disks. Over time, more and more computers were connected to each other using Local Area Networks or "LANs". In both cases, maintaining security and controlling what information a computer user could access was relatively simple because the overall computing environment was limited and clearly defined.

With the ever-increasing popularity of the Internet, however, more and more computers are connected to larger networks. Providing access to vast stores of information, the Internet is typically accessed by users through Web "browsers" (e.g., Microsoft® Internet Explorer or Netscape Navigator) or other Internet applications. Browsers and other Internet applications include the ability to access a URL (Uniform Resource Locator) or "Web" site. In the last several years, the Internet has become pervasive and is used not only by corporations, but also by a large number of small business and individual users for a wide range of purposes.

As more and more computers are now connected to the Internet, either directly (e.g., over a dial-up or broadband connection with an Internet Service Provider or "ISP") or through a gateway between a LAN and the Internet, a whole new set of challenges face LAN administrators and individual users alike: these previously closed computing environments are now open to a worldwide network of computer systems. A particular set of challenges involves attacks by perpetrators (hackers) capable of damaging the local computer systems, misusing those systems, and/or stealing proprietary data and programs.

The software industry has, in response, introduced a number of products and technologies to address and minimize these threats, including "firewalls", proxy servers, and similar technologies—all designed to keep malicious users (e.g., hackers) from penetrating a computer system or corporate network. Firewalls are applications that intercept the data traffic at the gateway to a Wide Area Network ("WAN") and check the data packets (i.e., Internet Protocol packets or "IP packets") being exchanged for suspicious or unwanted activities.

Another security measure that has been utilized by many users is to install an end point security (or personal firewall) product on a computer system to control traffic into and out of



the system. An end point security product can regulate all traffic into and out of a particular computer. One such product is assignee's ZoneAlarm® product that is described in detail in U.S. Pat. No. 5,987,611, the disclosure of which is hereby incorporated by reference. For example, an end point security product may permit specific "trusted" applications to access the Internet while denying access to other applications on a user's computer. To a large extent, restricting access to "trusted" applications is an effective security method. However, despite the effectiveness of end point security products, issues remain in protecting computer systems against attack by malicious users and applications.

One particular problem that remains is how to secure computers with detachable peripheral devices, particularly input devices such as keyboard and mouse input devices. These input devices, which are connected to computers having access to the Internet, are vulnerable to security breaches or attacks, such as "sniffing." For example, malicious software may be installed on an input device that looks for user names and passwords and, upon discovery, sends them to a potential attacker via the Internet. Although the foregoing problem most commonly occurs with keyboard and mouse input devices, the problem also extends to other peripheral devices or mechanisms that are detachable or transferable. This would include, for example, a peripheral storage device such as a detachable USB disk drive. Even though that device is not a classic input device, it nevertheless is vulnerable to the same types of attacks.

Software key loggers are a form of sniffing that have always been a favorite hacker tool. Recently in New York, for example, an individual plead guilty in federal court to two counts of computer fraud and one charge of unauthorized possession of access codes for a scheme in which the individual planted a copy of a commercial keyboard sniffing program on computers at a well-known copy service firm. Using his makeshift surveillance mechanism, the individual captured over 450 on-line banking passwords and user names from unsuspecting customers. He then used the victims' financial information to open new accounts under their names, and then siphon money from their legitimate accounts into the new, fraudulent ones. Apart from the criminal activities of the individual, the copy service firm itself is potentially open to liability for failure to adequately protect its equipment from such activities. Given the increasing popularity of Internet cafes, the risk for this type of fraud can be expected to grow.

Recently, in response to considerable advances in the detection and removal of software key loggers, several hardware-based key loggers have appeared on the market. Consider, for example, the dongle-style sniffer/logger device that may be ordered off of the Internet today. KEYKatcher is one of the more popular ones. To use the device, a malicious user secretly attaches it to a keyboard by placing it in-line with the keyboard cord. The dongle includes memory that allows the device to record all of the keystrokes of other unsuspecting users. Later, the malicious user removes the device and extracts all of the recorded keystrokes from the dongle memory using custom software (e.g., dumps the recorded keystrokes to a text file). In this manner, a malicious user may easily use the device to "sniff" all of the keyboard input of other unsuspecting users. Unlike software-based key loggers, once a hardware-based key logger is installed, it is very difficult to detect in software.

Stated generally, the problem applies to any device or mechanism that transmits data or information into a given computer system. However, the problem is most severe with detachable devices. Since detachable devices lack the degree

of physical security that non-detachable devices enjoy, they present a greater opportunity for an unauthorized and undetected entity or actor to intervene in the communication channel or even replace the communication channel. In contrast, non-detachable devices have at least some degree of protection. For example, a built-in internal hard drive in a laptop computer is probably relatively safe, given the physical barrier that must be breached in order to gain physical access to that device. All told, detachable devices or mechanisms pose the greater security risk because they lack this protective physical barrier. The peripheral devices that pose this risk include any detachable device or mechanism capable of providing a data feed, including such common devices as detachable keyboards, pointing/mouse devices, microphones, memory cards, USB storage devices, web cameras, and the like.

With these types of devices or mechanisms, two major threats are posed. First, communications between the peripheral device and a given computer may be intercepted in an unauthorized manner. This would include, for example, the above-mentioned "sniffing" approach. Second, the peripheral device may be impersonated. Here, the computer will mistakenly authenticate the impersonator as legitimate, when in fact it is not.

Although these threats are now recognized, the only solution offered to date has been in terms of some type of physical security that prevents individuals from plugging in peripheral devices. The most commonly proposed defense against installing hardware key loggers has been to physically secure the keyboard and mouse cables so that the hacker cannot easily insert the hardware key logger. For example, a keyboard/mouse input jack may be secured with some type of physical locking device. These mechanical barriers only provide a limited solution. In a large organization, for example, the burden of tending to a large number of mechanical locks makes the approach impractical (especially if existing hardware needs to be retrofitted). Further, size limitations about what is practical for locking computer sockets and plugs would dictate using a relatively small locking device, one which would likely be easily defeated (e.g., using a bolt cutter). As yet another problem, such physical locks are not easily monitored. This is particularly a problem if the locks needed to be monitored at a remote site. A breach would likely only be detected very much after the fact. Given all these deficiencies, a better solution is sought.

In the current computing environment, computers (e.g., PCs) are configured to always trust all peripheral devices by default. Further, there is no existing infrastructure in any of the commercially available operating systems today that requires re-authentication of every single peripheral device each time it is attached to a computer. What is needed is a system implementing methodology that solves the basic problem of establishing and maintaining trust between a computer and all of the peripheral devices that may be plugged into it. In this manner, a growing source of security problems may be solved.

## SUMMARY OF INVENTION

A security system with methodology for defending against security breaches of peripheral devices is described. In one embodiment, for example, a method of the present invention is described for protecting a computer from security breaches involving devices that may be attached to the computer, the method comprises steps of: when a device is first attached to the computer, specifying authorization information indicating that the device is allowed to communicate with the computer; detecting detachment of the device from the computer; updating the authorization information to indicate that the device is no longer authorized to communicate with the computer; and upon reattachment of the device, blocking communication with the device while the device remains unauthorized, thereby preventing a security breach involving the device.

In another embodiment, for example, a system of the present invention is described for protecting a computer from security breaches involving devices that may be attached to the computer, the system comprises: an agent module for specifying authorization information indicating that the device is allowed to communicate with the computer when a device is first attached to the computer; for detecting detachment of the device from the computer; and for updating the authorization information to indicate that the device is no longer authorized to communicate with the computer; and a filter module for blocking communication with the device while the device remains unauthorized, thereby preventing a security breach involving the device.

In yet another embodiment, for example, a method of the present invention is described for securing a computer from security breaches involving peripheral devices, the method comprises steps of: specifying a password to be supplied for authorizing a peripheral device to communicate with the computer; detecting each attachment of the peripheral device to the computer; upon each attachment, blocking communications with the peripheral device until the password is supplied; and if the password is supplied, permitting the peripheral device to communicate with the computer.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a very general block diagram of a computer system (e.g., an IBM-compatible system) in which software-implemented processes of the present invention may be embodied.

FIG. **2** is a block diagram of a software system for controlling the operation of the computer system.

FIG. **3** is a high-level block diagram of a software-based security system, which may be embodied on a computer system running the Microsoft Windows operating system (e.g., such as the above-described system).

FIG. **4** is a flowchart illustrating overall operation of the defense system of the present invention.

FIGS. **5**A-B comprise a single flowchart illustrating operation of the system upon receipt of an event indicating disconnection/detachment of a peripheral device.

## DETAILED DESCRIPTION

Glossary

The following definitions are offered for purposes of illustration, not limitation, in order to assist with understanding the discussion that follows.

FireWire (IEEE 1394): This is a very fast external bus standard that supports data transfer rates of up to 400 Mbps (in 1394a) and 800 Mbps (in 1394b).

IDE: Abbreviation for Integrated Drive Electronics. An IDE interface is an interface for mass storage devices, in which the controller is integrated into the disk or CD-ROM drive. IDE is increasingly becoming subsumed by ATA, "Advanced Technology Attachment," a disk drive implementation that integrates the controller on the disk drive itself.

Parallel port: A parallel port is an interface for connecting an external device such as a printer. On PCs, the parallel port uses a 25-pin connector (type DB-25) and is used to connect

printers, computers, and other devices that need relatively high bandwidth. Newer types of parallel port include the EPP (Enhanced Parallel Port) and the ECP (Extended Capabilities Port). Both of these parallel ports support bi-directional communication and transfer rates up to ten times faster than traditional parallel ports.

RS-232: Short for recommended standard 232C, a standard interface approved by the Electronic Industries Alliance (EIA) for connecting serial devices. In 1987, the EIA released a new version of the standard and changed the name to EIA-232-D.

SCSI: Acronym for small computer system interface. Pronounced "scuzzy," SCSI is a parallel interface standard used by Apple Macintosh computers, PCs, and many UNIX systems for attaching peripheral devices to computers. Nearly all Apple Macintosh computers come with a SCSI port for attaching devices such as disk drives and printers. Users can attach many devices to a single SCSI port, so that the SCSI port functions really as an I/O bus rather than simply as an interface.

USB: Short for Universal Serial Bus, an external bus standard that supports data transfer rates of 12 Mbps. A single USB port can be used to connect up to 127 peripheral devices, such as mice, modems, and keyboards. USB also supports Plug-and-Play (PnP) installation and hot plugging.

Introduction

Referring to the figures, exemplary embodiments of the invention will now be described. The following description will focus on the presently preferred embodiment of the present invention, which is implemented in desktop and/or server software (e.g., driver, application, or the like) operating in an Internet-connected environment running under an operating system, such as the Microsoft Windows operating system. The present invention, however, is not limited to any one particular application or any particular environment. Instead, those skilled in the art will find that the system and methods of the present invention may be advantageously embodied on a variety of different platforms, including Macintosh, Linux, Solaris, UNIX, FreeBSD, and the like. Therefore, the description of the exemplary embodiments that follows is for purposes of illustration and not limitation. The exemplary embodiments are primarily described with reference to block diagrams or flowcharts. As to the flowcharts, each block within the flowcharts represents both a method step and an apparatus element for performing the method step. Depending upon the implementation, the corresponding apparatus element may be configured in hardware, software, firmware or combinations thereof.

Computer-Based Implementation

Basic System Hardware (e.g., For Desktop and Server Computers)

The present invention may be implemented on a conventional or general-purpose computer system, such as an IBM-compatible personal computer (PC) or server computer. FIG. **1** is a very general block diagram of a computer system (e.g., an IBM-compatible system) in which software-implemented processes of the present invention may be embodied. As shown, system **100** comprises a central processing unit(s) (CPU) or processor(s) **101** coupled to a random-access memory (RAM) **102**, a read-only memory (ROM) **103**, a keyboard **106**, a printer **107**, a pointing device **108**, a display or video adapter **104** connected to a display device **105**, a removable (mass) storage device **115** (e.g., floppy disk, CD-ROM, CD-R, CD-RW, DVD, or the like), a fixed (mass) storage device **116** (e.g., hard disk), a communication (COMM) port(s) or interface(s) **110**, a modem **112**, and a network interface card (NIC) or controller **111** (e.g., Ethernet). Although not shown separately, a real time system clock is included with the system **100**, in a conventional manner.

CPU **101** comprises a processor of the Intel Pentium family of microprocessors. However, any other suitable processor may be utilized for implementing the present invention. The CPU **101** communicates with other components of the system via a bi-directional system bus (including any necessary input/output (I/O) controller circuitry and other "glue" logic). The bus, which includes address lines for addressing system memory, provides data transfer between and among the various components. Description of Pentium-class microprocessors and their instruction set, bus architecture, and control lines is available from Intel Corporation of Santa Clara, Calif. Random-access memory **102** serves as the working memory for the CPU **101**. In a typical configuration, RAM of sixty-four megabytes or more is employed. More or less memory may be used without departing from the scope of the present invention. The read-only memory (ROM) **103** contains the basic input/output system code (BIOS)—a set of low-level routines in the ROM that application programs and the operating systems can use to interact with the hardware, including reading characters from the keyboard, outputting characters to printers, and so forth.

Mass storage devices **115**, **116** provide persistent storage on fixed and removable media, such as magnetic, optical or magnetic-optical storage systems, flash memory, or any other available mass storage technology. The mass storage may be shared on a network, or it may be a dedicated mass storage. As shown in FIG. **1**, fixed storage **116** stores a body of program and data for directing operation of the computer system, including an operating system, user application programs, driver and other support files, as well as other data files of all sorts. Typically, the fixed storage **116** serves as the main hard disk for the system.

In basic operation, program logic (including that which implements methodology of the present invention described below) is loaded from the removable storage **115** or fixed storage **116** into the main (RAM) memory **102**, for execution by the CPU **101**. During operation of the program logic, the system **100** accepts user input from a keyboard **106** and pointing device **108**, as well as speech-based input from a voice recognition system (not shown). The keyboard **106** permits selection of application programs, entry of keyboard-based input or data, and selection and manipulation of individual data objects displayed on the screen or display device **105**. Likewise, the pointing device **108**, such as a mouse, track ball, pen device, or the like, permits selection and manipulation of objects on the display device. In this manner, these input devices support manual user input for any process running on the system.

The computer system **100** displays text and/or graphic images and other data on the display device **105**. The video adapter **104**, which is interposed between the display **105** and the system's bus, drives the display device **105**. The video adapter **104**, which includes video memory accessible to the CPU **101**, provides circuitry that converts pixel data stored in the video memory to a raster signal suitable for use by a cathode ray tube (CRT) raster or liquid crystal display (LCD) monitor. A hard copy of the displayed information, or other information within the system **100**, may be obtained from the printer **107**, or other output device. Printer **107** may include, for instance, an HP LaserJet printer (available from Hewlett Packard of Palo Alto, Calif.), for creating hard copy images of output of the system.

The system itself communicates with other devices (e.g., other computers) via the network interface card (NIC) **111** connected to a network (e.g., Ethernet network, Bluetooth

wireless network, or the like), and/or modem **112** (e.g., 56K baud, ISDN, DSL, or cable modem), examples of which are available from 3Com of Santa Clara, Calif. The system **100** may also communicate with local occasionally-connected devices (e.g., serial cable-linked devices) via the communication (COMM) interface **110**, which may include a RS-232 serial port, a Universal Serial Bus (USB) interface, or the like. Devices that will be commonly connected locally to the interface **110** include laptop computers, handheld organizers, digital cameras, and the like.

IBM-compatible personal computers and server computers are available from a variety of vendors. Representative vendors include Dell Computers of Round Rock, Tex., Hewlett-Packard of Palo Alto, Calif., and IBM of Armonk, N.Y. Other suitable computers include Apple-compatible computers (e.g., Macintosh), which are available from Apple Computer of Cupertino, Calif., and Sun Solaris workstations, which are available from Sun Microsystems of Mountain View, Calif.

Basic System Software

FIG. **2** is a block diagram of a software system for controlling the operation of the computer system **100**. As shown, a computer software system **200** is provided for directing the operation of the computer system **100**. Software system **200**, which is stored in system memory (RAM) **102** and on fixed storage (e.g., hard disk) **116**, includes a kernel or operating system (OS) **210**. The OS **210** manages low-level aspects of computer operation, including managing execution of processes, memory allocation, file input and output (I/O), and device I/O. One or more application programs, such as client application software or "programs" **201** (e.g., **201***a*, **201***b*, **201***c*, **201***d*) may be "loaded" (i.e., transferred from fixed storage **116** into memory **102**) for execution by the system **100**. The applications or other software intended for use on the computer system **100** may also be stored as a set of downloadable computer-executable instructions, for example, for downloading and installation from an Internet location (e.g., Web server).

System **200** includes a graphical user interface (GUI) **215**, for receiving user commands and data in a graphical (e.g., "point-and-click") fashion. These inputs, in turn, may be acted upon by the system **100** in accordance with instructions from operating system **210**, and/or client application module (s) **201**. The GUI **215** also serves to display the results of operation from the OS **210** and application(s) **201**, whereupon the user may supply additional inputs or terminate the session. Typically, the OS **210** operates in conjunction with device drivers **220** (e.g., "Winsock" driver—Windows' implementation of a TCP/IP stack) and the system BIOS microcode **230** (i.e., ROM-based microcode), particularly when interfacing with peripheral devices. OS **210** can be provided by a conventional operating system, such as Microsoft Windows 9×, Microsoft Windows NT, Microsoft Windows 2000, or Microsoft Windows XP, all available from Microsoft Corporation of Redmond, Wash. Alternatively, OS **210** can also be an alternative operating system, such as the previously mentioned operating systems.

The above-described computer hardware and software are presented for purposes of illustrating the basic underlying computer components that may be employed for implementing the present invention. For purposes of discussion, the following description will present certain examples in which it will be assumed that one computer system may communicate with another computer system, such as a desktop computer ("client") computer system that communicates with a remote computer system offering at least one service ("server"). The present invention, however, is not limited to any particular environment or device configuration. In particular, a client/server distinction is not necessary to the invention, but is used to provide a framework for discussion. Instead, the present invention may be implemented in any type of system architecture or processing environment capable of supporting the methodologies of the present invention presented in detail below, including peer-to-peer configurations or the like.

Overview of Defending Against Security Breaches of Peripheral Devices

Detection of Detachment and Reattachment

Given the limitations of current hardware/physical lock security approaches, a software-based defense would clearly be preferable. In accordance with the present invention, a software agent works in conjunction with a computer's underlying operating system to detect the attachment or the detachment/reattachment of any security-sensitive peripheral device, especially including an input device such as a keyboard, mouse, microphone, webcam, or the like. More particularly, the agent effectively "locks down" (i.e., blocks) the peripheral device when it is initially attached or when it is detached and then plugged back in, and requires an authorized party to supply a password in order to enable (or re-enable) the device. Of course, the password will only be known to such authorized individuals as the system administrator or authorized user. Optionally, a system administrator may be notified of the occurrence of a peripheral device disconnection event and reconnection event, and have the ability to re-enable the input device(s) remotely (or allow the device to remain blocked).

The approach of the present invention takes advantage of the fact that, in many modern operating systems, it is possible to detect in software in real-time that a given peripheral device has been attached, or even reattached. Microsoft Windows, for example, includes a "plug and play" interface layer that handles all modern peripheral devices in a Windows environment. Other operating systems, such as Linux or Mac OS-X, have similar interfaces. In fact, all of the interfaces (PS/2, USB, COM ports) most commonly used in computer systems today allow some sort of software process to detect the loss of peripheral device connection. If necessary or desired for a particular deployment, however, a special input device driver or a custom driver I/O filter may be employed.

Given these peripheral device interfaces that exist in modern operating systems, a peripheral device security monitoring module constructed in accordance with the present invention may watch or monitor such an interface for the occurrence of an attachment event. An attachment event may consist of initial attachment of a new device or detachment/reattachment of a previously-seen peripheral device. As soon as a peripheral device is detached, the security module may revert or default to no longer trusting the peripheral device. In particular, the security module no longer trusts the peripheral device once it is reattached since, during its detachment, someone could have installed something on the device or otherwise modified it in a manner that compromises the trustworthiness of the device (e.g., such as installing a sniffer on a keyboard device). While the discussion which follows will focus on securing peripheral devices against attack, those skilled in the art will readily appreciate that the present invention can easily be adapted to securing network cables against similar types of attacks, such as preventing installation of hardware Ethernet sniffers, as well as protecting other device input/output (I/O) ports or interfaces of computer systems (e.g., parallel (printer) ports, RS-232 ports, FireWire (IEEE 1394) ports, Ethernet ports, SCSI ports, IDE bus interfaces, or the like).

Operating systems such as Microsoft Windows do not detect attachment/detachment of peripheral devices when a given computer is powered down. Note, however, that when the computer is next powered up, the operating system requires an administrator or user password. Therefore, by default, a re-powered computer will not be accessible and its peripheral devices cannot be used until such time as the appropriate administrator or user password is entered. In a public setting, such as a public kiosk or a publicly-accessible service center, the appropriate password will not be available for an unauthorized party to reboot the operating system upon powering up a computer. In effect, in order for one to power cycle a computer, that individual must have appropriate access privileges and, thus, effectively becomes the appropriate agent for re-authenticating any peripheral devices attached at the time of computer system power up. In particular, the operating system has to authenticate the user that is attempting to power up the computer system.

Device Authorization

The safest course of action, with an untrusted device, is prevent any data input from that device after it has been reattached, until such time (if any) that an authorized party reactivates the peripheral device. In the currently preferred embodiment, the security system of the present invention maintains a basic flag for each attached peripheral device indicating whether a given device is trusted or not. As soon as the device is disconnected, it becomes untrusted, whereupon its corresponding flag is set. In order to re-enable trust, the security system includes a mechanism, which may be implemented locally and/or remotely, to exclude or reallow data input from the device.

After a peripheral device is attached (i.e., attached initially or reattached), authorization is required. It should be noted that in the following discussion references to the term "attachment" include both initial attachment and reattachment of a device. Similarly, unless otherwise indicated the term "authorization" refers to either initial authorization of a device or any subsequent reauthorization of the device (e.g., after the device has been detached and then reattached). When a device is attached an appropriate user or entity (e.g., network administrator or authorized user) is alerted that the particular device has just been attached and that it needs to be authorized. In the case of a local user, the security system of the present invention may prompt the user for a device-specific password. At this point, the user may type in the password, and the security module, which is monitoring the keystroke input, will be able to recognize input of a correct password. As soon as the correct password is entered, the security module may unlock the device—that is, reactivate the data stream for the peripheral device (coming from the device into the computer).

In the case of a remote user or entity, the above authorization/re-authorization sequence happens remotely. For example, the network administrator may be alerted remotely of the occurrence (e.g., via network alert, e-mail, a pager, or the like). The administrator has the option of either reactivating the device from the remote location, or he or she may decide to leave the device deactivated until such time that the device may be physically inspected for security breach by the administrator or other authorized user. In this matter, remote re-authorization operates like home burglar alarm monitoring systems. When an alarm is tripped, the alarm monitoring company may attempt to verify whether the event is a false alarm or not. In the instance that the alarm monitoring company cannot verify that the alarm event is false (i.e., is unable to resolve the alarm state), the company notifies the police to go out to the site for physical inspection of any security breach.

System Components

FIG. **3** is a high-level block diagram of a software-based security system **301**, which may be embodied on a computer system running the Microsoft Windows operating system (e.g., such as the above-described system **100**). As shown, the security (defense) system **301** includes an input filtering module **320** and a desktop agent module **330**, typically operated on a single computer (e.g., computer **300**). Locally, the system **301** may (optionally) include a local administration module **310** also residing on the computer **300**. The system **301** may be extended to include an optional remote administration module **370**, running on a remote machine **360** (e.g., server computer, or another peer computer). In operation, the system **301** serves to protect the computer **300** from security breaches occurring via peripheral devices, such as keyboard device **350**.

In the configuration shown, computer **300** is the "protected computer" and thus is running the desktop agent **330** and the input filter **320**. The agent **330** is watching for events of disconnection and reconnection of peripheral devices, such as the keyboard device **350** illustrated in FIG. **3**. The input filter **320** will collect all of the peripheral device input (e.g., keystrokes from the keyboard **350**) in an isolated buffer, when the system is operating in an untrusted mode (e.g., when the keyboard **350** is untrusted). Thus, the buffer serves as a staging area that allows the local administration module **310** to determine whether the user or administrator has entered an appropriate password for re-authenticating a given peripheral device. During this time (i.e., untrusted mode), all other input from the untrusted peripheral device is otherwise blocked. Upon receiving the appropriate password input, the local administration module **310** will re-authenticate the peripheral device and allow its input to pass through the filter and on into the computer **300**. Thus, for example, upon receiving the appropriate password for reauthorizing the keyboard **350**, the filter will allow keyboard input (keystrokes) to pass through and on into the computer **300**.

The above example describes a situation in which the keyboard is the peripheral device that is disconnected and reconnected to the computer **300**. When the keyboard is reconnected, the input filter collects the keystrokes in a buffer to look for the appropriate password amongst (potentially) untrusted input. It should be noted, however, that in the event that the peripheral device that is reconnected to the computer is a device other than the keyboard (e.g., a mouse input device), then the input from the keyboard itself (e.g., to type in the password) does not necessarily need to be filtered or quarantined. For example, the keyboard may remain connected and in a "trusted" status while the mouse input device is disconnected and reconnected. In this case keyboard input from the "trusted" keyboard does not need to be filtered.

In certain deployments, it may not be desirable or even possible to locally reactivate/re-authorize peripheral devices. In those instances, the remote administration module **370** is employed as part of the security system **301**. In this configuration, events about the disconnection and reconnection of peripheral devices (i.e., attachment events) are reported to the remote administration module **370** via a connection between the computer **300** and the computer **360** (e.g., via Internet connectivity or the like). Preferably, the communication of the attachment events (i.e., the disconnection and reconnection of peripheral devices) is done in a secure manner. The actual technique used for secure communication depends on the underlying network that the system is deployed on. In a deployment with Internet connectivity, for example, SSL (Secure Socket Layer) or VPN (Virtual Private Network) mechanisms may be used to establish secure communication with

the remote administration module **370**. In a closed network, on the other hand, a private line of communication may be employed. At the remote administration module **370**, the network administrator will have the option of reactivating the peripheral device access remotely or initiating physical inspection of the device (e.g., device **350**) and the computer (e.g., computer **300**) before reactivating the device.

A useful configuration to deploy is one that employs both the local administration module **310** and remote administration module **370**. With this configuration, the network administrator may easily delegate the re-authentication to an authorized user on site. The authorized user will be given sufficient authorization to reactivate the peripheral device on site. In that instance, the on-site authorized user types in the appropriate password for the peripheral device, whereupon the local administration module **310** receives the password and reactivates the device. This type of deployment is useful in a managed service provider environment, where there is a central administration console for several satellite locations. For example, a photocopy service provider could use a central administrator to control computers at various retail locations. The central administration console allows for the easy consolidation of all information and event reporting. However, this is coupled with on site personnel (e.g., photocopy service provider employees) who are authorized to check the physical state of machines and re-allow connection of peripheral devices.

Detailed Operation

The following description presents method steps that may be implemented using computer-executable instructions, for directing operation of a device under processor control. The computer-executable instructions may be stored on a computer-readable medium, such as CD, DVD, flash memory, or the like. The computer-executable instructions may also be stored as a set of downloadable computer-executable instructions, for example, for downloading and installation from an Internet location (e.g., Web server).

FIG. **4** is a flowchart **400** illustrating overall operation of the defense system of the present invention. The steps are as follows. At step **401**, the system initializes itself for all peripheral devices. As previously stated, this may be extended to include all devices that are "connectable" to the current machine that the security system is installed on and which are desired to be monitored (e.g., devices connected via parallel port, RS 232 port, FireWire (IEEE 1394) port, SCSI port, IDE bus interface, or like). Step **402** indicates that there is an initial authentication for each such device, so that each device now becomes "trusted" by the system. As part of this step, or as part of the previous step, the administrator or user would enter a password that may be used to re-authenticate devices. Individual passwords may be entered, or groups of devices may be defined (e.g., "storage devices," "input devices," or the like) and given group passwords. At step **403**, the system "hooks" the corresponding operating system service that will report device disconnection/(re)connection events. This hooking may be done by the desktop agent **330**, and/or the functionality may be embodied in the input filter **320**. Now, the system is ready to enter into a steady state, where it listens for events indicating peripheral device disconnection and/or reconnection.

Hooks, such as the one referenced above, are used to trap all events in the Windows environment. More particularly, a hook is a mechanism by which a function can intercept events (messages, mouse actions, keystrokes, or the like) before they reach an application. The function can act on events and, in some cases, modify or discard them. The following is a simple function that installs a hook to trap keyboard events and save the keystrokes to a text file.

```
1: BOOL___declspec(dllexport)___stdcall installhook( )
2: {
3:      f1=fopen("c:\\report.txt","w");
4:      fclose(f1);
5:      hkb=SetWindowsHookEx(WH_KEYBOARD,
(HOOKPROC)KeyboardProc,hins,0);
6:
7:      return TRUE;
8: }
```

A callback function, specified in the above hooking call, is to be invoked upon the occurrence of the trapped event.

```
1: LRESULT___declspec(dllexport)___stdcall CALLBACK
KeyboardProc(int
nCode,WPARAM wParam,
2:                                  LPARAM lParam)
3: {
4:      char ch;
5:      if (((DWORD)lParam & 0x40000000) &&(HC_ACTION=
=nCode))
6:      {
7:          if ((wParam==VK_SPACE)||(wParam==VK_RETURN)
||(wParam>=0x2f)
&&(wParam<=0x100))
8:          {
9:              f1=fopen("c:\\report.txt","a+");
10:                 if (wParam==VK_RETURN)
11:                 {
12:                     ch='\n';
13:                     fwrite(&ch,1,1,f1);
14:                 }
15:                 else
16:                 {
17:                         BYTE ks[256];
18:                     GetKeyboardState(ks);
19:
20:                     WORD w;
21:                     UINT scan=0;
22:                     ToAscii(wParam,scan,ks,&w,0);
23:                     ch = char(w);
24:                     fwrite(&ch,1,1,f1);
25:                 }
26:             fclose(f1);
27:             }
28:     }
29:
30:     LRESULT RetVal = CallNextHookEx( hkb, nCode,
wParam, lParam );
31:     return RetVal;
32: }
```

Functions that receive events are called filter functions and are classified according to the type of event they intercept. For example, a filter function might want to receive all keyboard or mouse events. For Windows to call a filter function, the filter function must be installed—that is, attached to a Windows hook, such as a keyboard hook. If a hook has more than one filter function attached, Windows maintains a chain of filter functions. The most recently installed function is at the beginning of the chain, and the least recently installed function is at the end. When a hook has one or more filter functions attached and an event occurs that triggers the hook, Windows calls the first filter function in the filter function chain. This action is known as calling the hook. For example, if a filter function is attached to the Computer Based Training (CBT) hook and an event that triggers the hook occurs, such as a window is about to be created, Windows calls the CBT hook by calling the first function in the filter function chain. To

maintain and access filter functions, one uses the "SetWindowsHookEx" (illustrated above) and the "UnhookWindowsHookEx" Windows API function calls.

The Windows "IoRegisterPlugPlayNotification" routine registers a device driver callback routine to be called when a Plug-and-Play (PnP) event of the specified category occurs. For example, in order to be notified of keyboard disconnects, the desktop agent module **330** defines a notification routine as follows:

```
1: NTSTATUS KeyboardClassPlugPlayNotification
2: (
3:      IN PTARGET__DEVICE__REMOVAL__NOTIFICATION
NotificationStructure,
4:      IN PDEVICE__EXTENSION Port
5: )
6: {
7:      NTSTATUS    status = STATUS__SUCCESS;
8:      PVOID       notify = NULL;
9:
10:      PAGED__CODE ( );
11:
12:      ASSERT (Globals.GrandMaster->Self == Port->True
ClassDevice);
13:
14:      if (IsEqualGUID ((LPGUID)
15: &(NotificationStructure->Event),
(LPGUID)&GUID__TARGET__DEVICE__QUERY__REMOVE
16: ))
17:      {
18:          // react to the disconnect notification, then close the
device
19: port
20:              <...>
21:              // close the handle
22:              status = KeyboardClassEnableGlobalPort (Port,
FALSE);
23:      }
24:      else
25:      if(IsEqualGUID
26: ((LPGUID)&(NotificationStructure->Event),
(LPGUID)&GUID__TARGET__DEVICE__REM
27: OVE__COMPLETE))
28:      {
29:              // handle device disappearance
30:              notify = InterlockedExchangePointer
31: (&Port->TargetNotifyHandle,NULL);
32:              if (NULL != notify)
33:              {
34:                  IoUnregisterPlugPlayNotification (notify);
35:                  status = KeyboardClassEnableGlobalPort (Port,
 FALSE);
36:              }
37:      }
38:      return status;
39: }
```

The agent may then register this routine by calling "IoRegisterPlugPlayNotification" as follows.

```
1: status = IoRegisterPlugPlayNotification
2: (
3:   EventCategoryTargetDeviceChange,
4:       0,
5:       *File,
6:       Port->Self->DriverObject,
7:       KeyboardClassPlugPlayNotification,
8:       Port,
9:       &Port->TargetNotifyHandle
10: );
```

"Port" and "File" were previously obtained from the instance of keyboard device object.

FIGS. **5**A-B comprise a single flowchart **500** illustrating operation of the system upon receipt of an event indicating disconnection/detachment of a peripheral device. The method of operation starts at step **501**, with the system picking up a disconnection event for a particular device. For example, in the embodiment shown in FIG. **3**, every time the peripheral device **350** (e.g., keyboard) is disconnected, the filter module **320** receives notification of the event, which has been trapped by the security system by virtue of hooking the corresponding Windows keyboard driver. In response to this event, the system logs the occurrence to a log file and updates a corresponding device state entry in a device state table, at step **502**. For example, in the embodiment shown in FIG. **3**, the filter **320** notifies the desktop agent **330** that the disconnect event occurred, and in response the desktop agent sets its internal device table state to DISCONNECTED. As an optional step, indicated at step **503**, the system may log the occurrence to a log file for auditing purposes; in the currently preferred embodiment, this step is enabled by default. In a similar manner as an optional step, the system may immediately report the disconnect event to an administrator, as indicated a step **504**. In the embodiment shown in FIG. **3**, for example, the desktop agent **330** notifies the remote administration module **370**, thereby allowing the network administrator to become aware of the occurrence. Typically, this operational step would be employed in instances where the system is configured to communicate with the remote administration module **370**.

The following steps deal with occurrence of a reconnection. At step **505**, the operating system reports a reconnection event to the security (defense) system. At this point, reconnection would typically have physically succeeded in order for the operating system to report the reconnection event. For example, in the embodiment shown in FIG. **3**, the filter **320** notifies the desktop agent **330** when the peripheral device **350** (e.g., keyboard) is reconnected. However, because the desktop agent's internal state for the keyboard device is set to DISCONNECTED, all subsequent keystrokes are intercepted by the keyboard filter and forwarded to protected area for processing by the desktop agent (e.g., to determine entry of a valid password for unlocking the device). Optional logging and immediate event reporting steps may occur (i.e., steps **503** and **504** repeated to log and immediately report the reconnection event).

At step **506**, the security system updates the device's internal state entry to AWAITING_PERMISSION, thereby indicating that the device is awaiting permission or authorization. While the device is awaiting authorization, it is "untrusted" and incoming data received from it will be filtered/staged in a quarantined buffer (accessible by the desktop agent) as shown at step **507**. Similarly, any request by the device for outgoing data is blocked. At step **508**, the system communicates with the local administration module and/or remote administration module, for purposes of authorizing or reauthorizing the device.

In the case of remote administration, the network administrator may choose to dispatch a technician or other authorized user to inspect the affected computer or he or she may decide to grant the permission remotely to restore keyboard input. As soon as the permission is granted, the remote administration module notifies the desktop agent which sets the device's internal state to CONNECTED and notifies the input filter that the keystrokes can now be allowed through the filter to the computer.

If the remote administration module is not present, then the local administration module is employed. Here, the desktop agent notifies the local administration module that the key-

board was reconnected and is awaiting a reactivation signal. Only someone in possession of the appropriate password will now be able to reactivate the peripheral device by typing a password. The quarantine buffer maintained by the desktop agent includes a sliding buffer of the last N keystrokes where N is the length of the password. Every time a new keystroke is received from the keyboard filter, the desktop agent places it into the buffer, calculates the hash value of the buffer and compares it with the stored hash of the password. Upon finding a match, the desktop agent resets the device's internal state to CONNECTED and notifies the input filter that the device's input (e.g., keystrokes from the keyboard) can now be allowed through.

Therefore, as a result of these communications, the device may be authorized/allowed or denied, or the administrator or user may indicate that the device will remain untrusted until physical inspection/physical action, as indicated at step **509**. In a computer system subject to high security, step **509** may be augmented to treat the entire event as a security breach and shut down the computer's network node, thereby preventing access to other systems on the network. In extreme instances, the entire computer network could be shut down if desired, until the security breach is rectified.

While the invention is described in some detail with specific reference to a single-preferred embodiment and certain alternatives, there is no intent to limit the invention to that particular embodiment or those specific alternatives. For instance, apart from the classic USB-connectable peripheral devices, other devices that connected to the computer may be monitored and secured, such as devices connected via parallel port, RS 232 port, FireWire (IEEE 1394) port, SCSI port, IDE bus interface, or the like. Therefore, those skilled in the art will appreciate that modifications may be made to the preferred embodiment without departing from the teachings of the present invention.

What is claimed is:

**1**. A method for protecting a computer from security breaches involving a hardware-based key logger installed between the computer and an attached input device, the method comprising:

when the computer is first powered on, storing authorization information received from an administrative user to indicate that the input device is authorized to communicate with the computer;

detecting a potential tampering attempt by an unauthorized user comprising detachment of the input device from the computer, installation of a hardware-based key logger, and reattachment of the input device, so that the hardware-based key logger is installed between the computer and the input device;

requiring entry of a password for authorizing the input device;

if the required password is entered, authorizing the input device to communicate with the computer and, otherwise, continuing to block communication from the input device to the computer;

storing authorization information indicating whether or not the input device is allowed to communicate with the computer;

detecting detachment of the input device from the computer;

when said potential tampering attempt is detected, updating the authorization information to indicate that the input device is no longer authorized to communicate with the computer; and

upon said reattachment of the input device, blocking communication from the input device to the computer until the input device is again authorized.

**2**. The method of claim **1**, further comprising:

specifying a password for authorizing the device.

**3**. The method of claim **1**, wherein said

input device comprises a keyboard device.

**4**. The method of claim **1**, wherein the input device is attached to the computer via a port.

**5**. The method of claim **4**, wherein the port is a selected one of a USB port, an RS-232 port, a parallel port, a SCSI port, and an IEEE 1394 port.

**6**. The method of claim **1**, wherein said input device comprises a keyboard device and wherein said blocking step includes blocking input from the keyboard device.

**7**. The method of claim **6**, wherein said blocking step includes blocking any request by the keyboard device for outgoing data from the computer.

**8**. The method of claim **7**, further comprising:

upon reattachment of the keyboard device, trapping keystrokes from the keyboard device.

**9**. The method of claim **8**, further comprising:

determining whether keystrokes trapped from the keyboard comprise a password that may be used to authorize the device.

**10**. The method of claim **1**, wherein said input device comprises a detachable storage device and wherein said blocking step includes blocking any data stream from the storage device.

**11**. The method of claim **1**, wherein said blocking step includes:

blocking communication from the computer to the input device while the input device remains unauthorized.

**12**. The method of claim **1**, further comprising:

receiving input of a password to be utilized for authorizing the input device.

**13**. The method of claim **12**, wherein the password comprises an input device specific password input by an authorized user.

**14**. The method of claim **1**, further comprising:

upon detecting detachment of the input device from the computer, generating an alert that reports the detachment.

**15**. The method of claim **14**, wherein the alert is automatically transmitted to a system administrator.

**16**. The method of claim **14**, wherein the alert is automatically transmitted to a remote administration module operating on a different computer.

**17**. The method of claim **16**, further comprising:

receiving authorization from a remote administration module; and thereafter

allowing communication with the input device.

**18**. The method of claim **1**, wherein said detecting step includes:

specifying an operating system hook that allows attachment and detachment of input devices to be detected.

**19**. The method of claim **1**, wherein said updating step includes:

updating the authorization information to indicate that the input device is currently untrusted.

**20**. The method of claim **1**, wherein said updating step includes:

treating the detachment as a security breach and blocking communication with a network node that the computer resides on.

**21**. A non-transitory computer-readable medium having processor-executable instructions for performing the method of claim **1**.

**22**. The method of claim **1**, further comprising:

downloading a set of processor-executable instructions for performing the method of claim **1** on a computer having a processor and a memory.

**23**. A system for protecting a computer from security breaches involving an unauthorized user installing a hardware-based key logger between a computer and an attached peripheral device, the system comprising:

a computer having at least a processor and memory and including an operating system service that monitors connection and disconnection of peripheral devices that may be attached to the computer via an available external port;

a filter module for receiving notification of connection and disconnection events from the operating system service when peripheral devices are attached to and detached from the computer, including connection and disconnection events that occur during installation of a hardware-based key logger on a given peripheral device attached to the computer, reporting such connection and disconnection events, and blocking communication with the given peripheral device attached to the computer until communication with the given peripheral device is authorized; and

a desktop agent that determines, in response to reported connection events relating to a given peripheral device, whether or not the given peripheral device is authorized to communicate with the computer based on obtaining user input as to whether to allow communication with the given peripheral device, and for revoking the authorization of the given peripheral device to communicate with the computer in response to reported connection and disconnection events relating to the given peripheral device.

**24**. The system of claim **23**, wherein the desktop agent includes:

program logic for specifying a password for authorizing the given peripheral device.

**25**. The system of claim **23**, wherein the desktop agent includes:

program logic for specifying at least one user with sufficient privileges to authorize the given peripheral device.

**26**. The system of claim **23**, wherein the given peripheral device is a keyboard device attached to the computer via a port.

**27**. The system of claim **26**, wherein the port is a selected one of a USB port, an RS-232 port, a parallel port, a SCSI port, and an IEEE 1394 port.

**28**. The system of claim **23**, wherein said given peripheral device comprises an input device and wherein the filter module includes program logic for blocking input from the input device.

**29**. The system of claim **28**, wherein said input device is a keyboard device.

**30**. The system of claim **29**, wherein said filter module includes:

program logic for trapping keystrokes from the keyboard device.

**31**. The system of claim **30**, wherein said filter module further includes:

program logic for determining whether keystrokes trapped from the keyboard comprise a password that may be used to authorize the device.

**32**. The system of claim **23**, wherein said given peripheral device comprises a detachable storage device and wherein the filter module includes program logic for blocking any data stream from the storage device.

**33**. The system of claim **23**, wherein the filter module includes:

program logic for blocking communication from the computer to the given peripheral device until the given peripheral device is authorized.

**34**. The system of claim **23**, further comprising:

program logic for receiving user input of a password for authorizing the given peripheral device, and thereafter

program logic for allowing communication with the given peripheral device.

**35**. The system of claim **34**, wherein the password comprises a device specific password provided by an authorized user.

**36**. The system of claim **23**, wherein said desktop agent further comprises:

program logic for generating, in response to reported disconnection events, an alert that reports the detachment.

**37**. The system of claim **36**, wherein the alert is automatically transmitted to a system administrator.

**38**. The system of claim **36**, wherein the alert is automatically transmitted to a remote administration module operating on a different computer.

**39**. The system of claim **23**, further comprising:

program logic for receiving authorization of the given peripheral device from a remote administration module; and thereafter

program logic for allowing communication with the given peripheral device.

**40**. The system of claim **23**, wherein the filter module includes:

program logic for specifying an operating system hook that intercepts connection and disconnection events from the operating system service allowing attachment and detachment of peripheral devices to be detected.

**41**. The system of claim **23**, wherein the desktop agent includes:

program logic for notifying the filter module as to whether or not the given peripheral devices is authorized to communicated with the computer.

**42**. The system of claim **23**, wherein the desktop agent includes:

program logic for treating a disconnection event as a security breach and blocking communication with a network node that the computer resides on.

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