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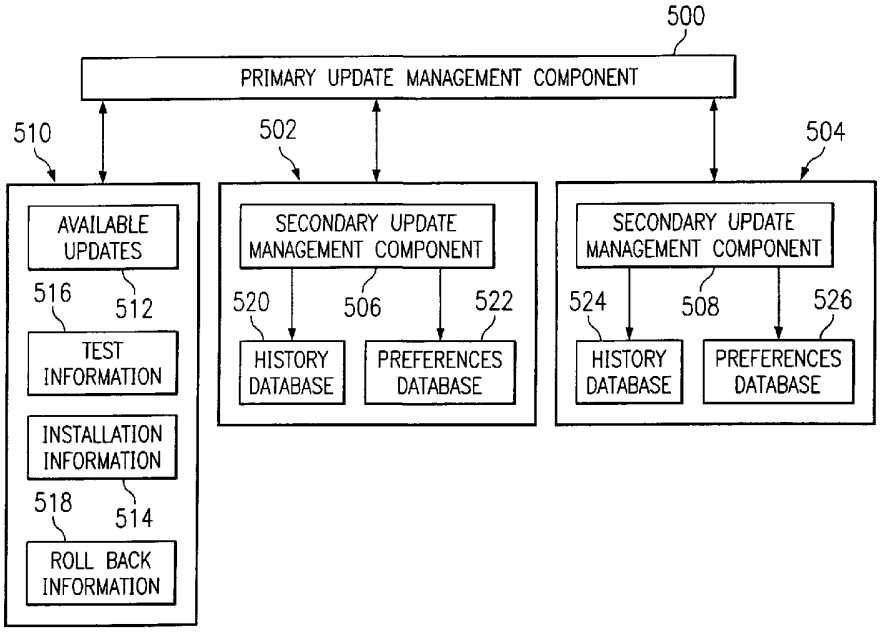
(54) Title: METHOD AND APPARATUS FOR AUTOMATIC UPDATING AND TESTING OF SOFTWARE



(57) Abstract: A method, apparatus, and computer instructions for updating a software component. A determination is made as to whether to update the software component (602). The software component is updated to form an updated software component in response to a determination to update the software component (606). The updated software component is automatically tested (612). A corrective action is performed in response to a failure in testing of the updated component (620).

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METHOD AND APPARATUS FOR AUTOMATIC UPDATING AND TESTING OF SOFTWARE

CROSS REFERENCE TO RELATED APPLICATIONS

The present invention is related to the following applications entitled: "Method and Apparatus for Publishing and Monitoring Entities Providing Services in a Distributed Data Processing System", serial no. 10/252,816, attorney docket no. YOR920020173US1; "Composition Service for Autonomic Computing", serial no. 10/252,324, attorney docket no. YOR920020176US1; "Self-Managing Computing System", serial no. 10/252,247, attorney docket no. YOR920020181US1; and "Adaptive Problem Determination and Recovery in a Computer System", serial no. 10/252,979, attorney docket no. YOR920020194US1; all filed even date hereof, assigned to the same assignee, and incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Technical Field:

The present invention relates generally to an improved data processing system, and in particular, to a method and apparatus for managing software components. Still more particularly, the present invention provides a method and apparatus for automatically updating software components.

2. Description of Related Art:

Modern computing technology has resulted in immensely complicated and ever-changing environments. One such environment is the Internet, which is also referred to as an "internetwork". The Internet is a set of computer networks, possibly dissimilar, joined together by means of gateways that handle data transfer and the conversion of messages from a protocol of the sending network to a protocol used by the receiving network. When capitalized, the term "Internet" refers to the collection of networks and gateways that use the TCP/IP suite of protocols. Currently, the most commonly employed method of transferring data over the Internet is to employ the World Wide Web environment, also called simply "the Web". Other Internet resources exist for transferring information, such as File Transfer Protocol (FTP) and Gopher, but have not achieved the popularity of the Web. In the Web environment, servers and clients effect data transaction using the Hypertext Transfer Protocol (HTTP), a known protocol for handling the transfer of

various data files (e.g., text, still graphic images, audio, motion video, etc.). The information in various data files is formatted for presentation to a user by a standard page description language, the Hypertext Markup Language (HTML). The Internet also is widely used to transfer applications to users using browsers. Often times, users of software packages may search for and obtain updates to those software packages through the Internet.

Other types of complex network data processing systems include those created for facilitating work in large corporations. In many cases, these networks may span across regions in various worldwide locations. These complex networks also may use the Internet as part of a virtual product network for conducting business. These networks are further complicated by the need to manage and update software used within the network.

Such environments, made up of many loosely connected software components, are typically somewhat fragile. Within these environments, deploying a new version of one of the software components involved in the network data processing system is problematic, and may well have far-reaching and unforeseen effects on parts of the overall system that are only tangentially connected to the component being replaced. Even less obviously risky changes are often prone to cause unpredictable and undesirable side effects. Thus, system administrators are often extremely wary of performing updates, such as component upgrades or minor configuration changes, due to these far-reaching effects. When information systems are so critical to modern business, even seconds of downtime can be a serious problem, and tracing that downtime can take far more than seconds. For example, email servers provide a critical component for many businesses because these servers facilitate communications between users inside and outside of the business or organization. An update to an email server that results in errors in delivery of email messages can cause loss in productivity and loss of business for a company or organization.

As software changes to become increasingly "autonomic", the task of updating, configuring, and patching software will, more and more, be performed by the computers themselves, as opposed to being performed by administrators. The current updating mechanisms are moving towards an "autonomic" process. For example, many operating systems and software packages will automatically look for updates based on some event, such as a timer or a particular set of actions by a user. The update mechanisms often connect to the Internet at a preselected location to see whether an update is present. If an update is present, the message is presented to the user in which the message asks the user whether to download and install the update. A next step towards "autonomic" computing involves identifying and downloading the updates without

requiring user intervention. Therefore, it would be advantageous to have an improved method, apparatus, and computer instructions to deal with the effects, be they undesired or merely unexpected, that such updating, reconfiguring, and patching of software could cause.

SUMMARY OF THE INVENTION

The present invention provides a method, apparatus, and computer instructions for updating a software component. A determination is made as to whether to update the software component. The software component is updated to form an updated software component in response to a determination to update the software component. The updated software component is automatically tested. A corrective action is performed in response to a failure in testing of the updated component.

BRIEF DESCRIPTION OF THE DRAWINGS

The novel features believed characteristic of the invention are set forth in the appended claims. The invention itself, however, as well as a preferred mode of use, further objectives and advantages thereof, will best be understood by reference to the following detailed description of an illustrative embodiment when read in conjunction with the accompanying drawings, wherein:

Figure 1 is a pictorial representation of a network of data processing systems in which the present invention may be implemented;

Figure 2 is a block diagram of a data processing system that may be implemented as a server in accordance with a preferred embodiment of the present invention;

Figure 3 is a block diagram illustrating a data processing system in which the present invention may be implemented;

Figure 4 is a diagram illustrating components used in updating a software component in accordance with a preferred embodiment of the present invention;

Figure 5 is a diagram illustrating components used in autonomic updates in accordance with a preferred embodiment of the present invention;

Figure 6 is a flowchart of a process used for performing an autonomic update in accordance with a preferred embodiment of the present invention;

Figure 7 is a flowchart of a process used for performing an autonomic update in accordance with a preferred embodiment of the present invention;

Figure 8 is a flowchart of a process used for performing an autonomic update in accordance with a preferred embodiment of the present invention; and

Figure 9 is a flowchart of a process used for modifying autonomic updates in accordance with a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

With reference now to the figures, **Figure 1** depicts a pictorial representation of a network of data processing systems in which the present invention may be implemented. Network data processing system **100** is a network of computers in which the present invention may be implemented. Network data processing system **100** contains a network **102**, which is the medium used to provide communications links between various devices and computers connected together within network data processing system **100**. Network **102** may include connections, such as wire, wireless communication links, or fiber optic cables.

In the depicted example, server **104** is connected to network **102** along with storage unit **106**. In addition, clients **108**, **110**, and **112** are connected to network **102**. These clients **108**, **110**, and **112** may be, for example, personal computers or network computers. In the depicted example, server **104** provides data, such as boot files, operating system images, and applications to clients **108-112**. Clients **108**, **110**, and **112** are clients to server **104**. Server **104** may provide a source of updates for clients, such as clients **108**, **110**, and **112**. In these examples, network data processing system **100** contains autonomic computing features, such as those for updating software components used within network data processing system **100**. In particular, updates may be made to software components without requiring user intervention to obtain and install the updates. These updates may include, for example, updates to executable files for a software component, new executable or data files for a software component, or even a change in a configuration file for a software component. Network data processing system **100** may include additional servers, clients, and other devices not shown.

In the depicted example, network data processing system **100** is the Internet with network **102** representing a worldwide collection of networks and gateways that use the Transmission Control Protocol/Internet Protocol (TCP/IP) suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers, consisting of thousands of commercial, government, educational and other computer systems that route data and messages. Of course, network data processing system **100** also may be implemented as a number of different types of networks, such as for example, an intranet, a local area network (LAN), or a wide area network (WAN). **Figure 1** is intended as an example, and not as an architectural limitation for the present invention.

Referring to **Figure 2**, a block diagram of a data processing system that may be implemented as a server, such as server **104** in **Figure 1**, is depicted in accordance with a

preferred embodiment of the present invention. Data processing system **200** may be a symmetric multiprocessor (SMP) system including a plurality of processors **202** and **204** connected to system bus **206**. Alternatively, a single processor system may be employed. Also connected to system bus **206** is memory controller/cache **208**, which provides an interface to local memory **209**. I/O bus bridge **210** is connected to system bus **206** and provides an interface to I/O bus **212**. Memory controller/cache **208** and I/O bus bridge **210** may be integrated as depicted.

Peripheral component interconnect (PCI) bus bridge **214** connected to I/O bus **212** provides an interface to PCI local bus **216**. A number of modems may be connected to PCI local bus **216**. Typical PCI bus implementations will support four PCI expansion slots or add-in connectors. Communications links to clients **108-112** in **Figure 1** may be provided through modem **218** and network adapter **220** connected to PCI local bus **216** through add-in boards.

Additional PCI bus bridges **222** and **224** provide interfaces for additional PCI local buses **226** and **228**, from which additional modems or network adapters may be supported. In this manner, data processing system **200** allows connections to multiple network computers. A memory-mapped graphics adapter **230** and hard disk **232** may also be connected to I/O bus **212** as depicted, either directly or indirectly.

Those of ordinary skill in the art will appreciate that the hardware depicted in **Figure 2** may vary. For example, other peripheral devices, such as optical disk drives and the like, also may be used in addition to or in place of the hardware depicted. The depicted example is not meant to imply architectural limitations with respect to the present invention.

The data processing system depicted in **Figure 2** may be, for example, an IBM eServer pSeries system, a product of International Business Machines Corporation in Armonk, New York, running the Advanced Interactive Executive (AIX) operating system or LINUX operating system.

With reference now to **Figure 3**, a block diagram illustrating a data processing system is depicted in which the present invention may be implemented. Data processing system **300** is an example of a client computer. Data processing system **300** employs a peripheral component interconnect (PCI) local bus architecture. Although the depicted example employs a PCI bus, other bus architectures such as Accelerated Graphics Port (AGP) and Industry Standard Architecture (ISA) may be used. Processor **302** and main memory **304** are connected to PCI local bus **306** through PCI bridge **308**. PCI bridge **308** also may include an integrated memory controller and cache memory for processor **302**. Additional connections to PCI local bus **306** may be made through direct component interconnection or through add-in boards. In the depicted

example, local area network (LAN) adapter **310**, SCSI host bus adapter **312**, and expansion bus interface **314** are connected to PCI local bus **306** by direct component connection. In contrast, audio adapter **316**, graphics adapter **318**, and audio/video adapter **319** are connected to PCI local bus **306** by add-in boards inserted into expansion slots. Expansion bus interface **314** provides a connection for a keyboard and mouse adapter **320**, modem **322**, and additional memory **324**. Small computer system interface (SCSI) host bus adapter **312** provides a connection for hard disk drive **326**, tape drive **328**, and CD-ROM drive **330**.

An operating system runs on processor **302** and is used to coordinate and provide control of various components within data processing system **300** in **Figure 3**. The operating system may be a commercially available operating system, such as Windows XP, which is available from Microsoft Corporation. An object oriented programming system such as Java may run in conjunction with the operating system and provide calls to the operating system from Java programs or applications executing on data processing system **300**. "Java" is a trademark of Sun Microsystems, Inc. Instructions for the operating system, the object-oriented operating system, and applications or programs are located on storage devices, such as hard disk drive **326**, and may be loaded into main memory **304** for execution by processor **302.**

Those of ordinary skill in the art will appreciate that the hardware in **Figure 3** may vary depending on the implementation. Other internal hardware or peripheral devices, such as flash read-only memory (ROM), equivalent nonvolatile memory, or optical disk drives and the like, may be used in addition to or in place of the hardware depicted in **Figure 3**. Also, the processes of the present invention may be applied to a multiprocessor data processing system.

The depicted example in **Figure 3** and above-described examples are not meant to imply architectural limitations. For example, data processing system **300** also may be a notebook computer or hand held computer in addition to taking the form of a PDA. Data processing system **300** also may be a kiosk or a Web appliance.

Turning now to **Figure 4**, a diagram illustrating components used in updating a software component is depicted in accordance with a preferred embodiment of the present invention. These components may be located within a single data processing system, or one or more of these components may be located in one or more other data processing systems.

Update management component **400** employs database **402** in performing autonomic updates. The use of the term "autonomic update" means that an update to a software component is performed automatically using a software process without any user intervention. This update may include, for example, changes to an executable file, changes to a data file, an addition of a

new executable file, an addition of a new data file, or changes to a configuration. Database **402** includes available updates **404**, test information **406**, installation information **408**, and roll back information **410**. Available updates **404** contains information on updates for different software components, which may be managed by update management component **400**. This information may include, for example, presently available updates identified by version numbers, locations or paths on which updates may be identified, or the actual update files themselves. This information also may include an identification of different data processing systems participating in autonomic updates. If an update is located externally to available updates **404**, these updates may be located through a path or location information. For example, update information within available updates **404** may point to storage medium **412**, which is accessible by update management component **400**. Storage medium **412** may be located on the same data processing system as update management component **400** or may be located on a remote data processing system. This storage medium may take many forms, such as, for example, a hard disk drive, a magnetic tape, or a CD-ROM.

Database **402** also includes test information for each update listed in available updates **404**. Test information **406**, in these examples, specifies zero or more tests that are to be performed following the autonomic deployment of an update. The use of the term "autonomic deployment" is interchangeable with the term "autonomic update". The tests performed after the autonomic update will vary depending on the particular implementation. Tests may include tests other than those used to determine whether the update has been properly installed. For example, in some cases the testing may involve performance testing, unit testing, compatibility testing, or on-the-fly regression testing. Unit testing involves testing a small section of a larger whole. For example, software unit tests are performed on individual objects for the particular software being developed to verify that these objects behave correctly in response to different inputs and outputs. In these examples, unit testing involves testing one or more components specifically related to the update that was applied. The update may be, for example, a new program file, a modified program file, or a configuration change. This type of testing is low cost in terms of time and impact and verifies on a course level that the updates are performing sufficiently to some standard or benchmark. Performance testing is employed to insure that the performance of the system after the update is acceptable. Various thresholds and benchmarks may be used as part of the performance testing. Compatibility testing may be employed to ensure that the updated component performs in a manner acceptable to other components with which the updated component communicates. Regression testing is another test that may be employed to

determine whether the updated component performs equivalently to the old component. With performance testing, if the software component does not meet some metric or threshold, the test fails even though the update has been successfully deployed on the software component. The different types of testing performed are referred to as "autonomic" testing because the testing is performed automatically after an update has been performed. No user input is required to perform these tests. In these examples, autonomic tests are performed by update management component **400**. An "autonomic" test is a test that is initiated and performed without requiring user input or intervention. In other words, an autonomic test is initiated in response to an update having just occurred without requiring a user to provide user input to a data processing system to select or initiate the test. Whether to perform a test and what test to perform are based on policies within test information **406**. For example, the policy may specify that if the update is to an email server, performance testing is to be performed after the update has been deployed. Additionally, corrective actions to be taken may be included in test information **406**. Corrective actions may include, for example, rolling back the update, installing an entirely different software component, or reinstalling the update with different parameters or options.

Further, database **402** also contains installation information **408**. In these examples, this installation information specifies a procedure used by update management component **400** in installing or updating a software component with a particular update. Roll back information **410** specifies a procedure that is to occur if an update is to be rolled back. A roll back of an update involves removing the update and placing the software component back into its previous state prior to the update. Such a procedure is performed in accordance with a preferred embodiment of the present invention if testing of an updated software component yields a failure or some particular error. In some cases, an error may be minor, resulting in the update remaining without a roll back. In other cases, the error may be serious, resulting in update management component **400** performing a roll back of the update.

Installation database **414** is a database of software components and updates installed on a particular data processing system. Installation database **414** may contain information for one data processing system or for many data processing systems. Installation database **414** may be used by update management component **400** to cross-reference information in this database with available updates **404** to identify updates applicable to a particular data processing system. Next, history database **416** contains a history of updates made to a data processing system. For example, this history information includes an identification of updates from available updates **404** that have been deployed to a data processing system, when each update was deployed, as

well as test results for testing performed on an update. This database also may track the status for more than one computer. Further, decisions made subsequent to testing of updates as well as any actions taken as a result of testing may be stored in history database **416**. With history database **416**, update management component **400** may make decisions on updates, such as, for example, which updates to install and when to install an update. Another database used by update management component **400** is preferences database **418**. This database contains additional information used to control the operation of update management component **400**. For example, preferences database **418** may specify that for a particular software component, the most recent update should never be installed. As a result, that particular software component will always run using an update prior to the currently available update.

In these examples, installation database **414**, history database **416**, and preferences database **418** may contain information relating to more than one client data processing system. For example, preferences database **418** may specify that for a particular software component and a particular data processing system, the most recent update should never been installed. As a result, that particular data processing system will always run using an update prior to the currently available update for that particular software component. Update management component **400** also may track other types of information other than that illustrated in database **402**. For example, information relating to the past status of computers and updates may be stored in database **402**.

With reference now to **Figure 5**, a diagram illustrating components used in autonomic updates is depicted in accordance with a preferred embodiment of the present invention. In this example, updates are performed using a central or primary update component, such as primary update management component **500**, to manage updates on a number of different clients, such as client **502** and **504**. These clients contain secondary update management components, such as, for example, secondary update management components **506** and **508**. Primary update management component **500** may be located on a server, such as server **104** in **Figure 1**, while secondary update management components **506** and **508** may be located on clients, such as clients **108** and **110** in **Figure 1**. Each of these secondary update management components manages software components on the client on which it is located.

In this example, database **510** is accessed by primary update management component **500** to control autonomic updates, testing, and roll backs of available updates. Available updates are located in available updates **512** in these examples. The information used to install updates on clients **502** and **504** is located in installation information **514**, while tests to be performed after

the install are located in test information **516**. If testing fails, the procedure used to roll back an update is located in roll back information **518**.

Secondary update management component **506** accesses history database **520** and preferences database **522**, while secondary update management component **508** accesses history database **524** and preferences database **526**. Each of these secondary update management components will contact primary update management component **500** to determine whether an update is available for each particular client. In checking for an available update, preference information and history information on installed updates may be sent to primary update management component **500** from secondary update management component **506** and secondary update management component **508**. This check may be made based on some event, such as a periodic event, like the expiration of a timer or some other non-periodic event, such as the starting of the software component. The availability of updates is stored in available updates **512**.

If an update is available, the procedure for installing the update is obtained from installation information **514** by primary update management component **500** and sent to secondary update management components **506** and **508**. In response to receiving the installation information, secondary update management component **506** and secondary update management component **508** will perform the autonomic update using the procedures received from primary update management component **500**. After installation of the update, secondary update management component **506** and secondary update management component **508** will perform testing of the update using test information from test information **516**, received through primary update management component **500**. If the tests are successful, the software components continue to operate. If the tests are unsuccessful, a roll back procedure is received from roll back information through primary update management component **500**. Data and other statistical information regarding updates, testing, and roll backs are stored in history database **520** and history database **524**.

In this particular example, primary update management component **500** may track additional information, such as that about computers participating in autonomic updates, an identification of a data processing system to perform testing, an identification of versions of each software component and configurations currently installed in the computers, as well as information about versions and configurations for software components available for installation. Additionally, primary update management component **500** also may track other information relating to updates and tests currently underway on clients. This information may include, for

example, software components currently being updated and the state or stage of any testing being performed.

In the case of a critical software component, installation of that software component may be performed on a new client having a similar or identical configuration. For example, client **502** may be an email server forming a critical component of a network data processing system. When secondary update management component **506** identifies an available update to the email server component, another client is identified on which the update is to be performed. Specifically, an update may be made to client **504** by secondary update management component **508**, while no updates are made by client **502**. After the updates are made and testing is performed on the email server component on client **504**, users may be transferred or migrated from client **502** to client **504**. If no failures or errors occur, then client **502** may be phased out and client **504** may provide email services to the users. If an error occurs, then users may be moved back to client **502**. This procedure provides for additional failsafe mechanisms in the case of some error or failure after an update has occurred. By performing the update on a second data processing system, while maintaining the first data processing system in a state without the update, the first data processing system may be brought back into service quickly in case of failure on the second data processing system. Of course, this procedure may be performed through a single management component directing updates and migration of use of a software component, as illustrated in **Figure 4**, rather than employing the distributed structure illustrated in **Figure 5**.

Turning now to **Figure 6**, a flowchart of a process used for performing an autonomic update is depicted in accordance with a preferred embodiment of the present invention. The process illustrated in **Figure 6** may be implemented in an update management component, such as update management component **400** in **Figure 4**.

The process begins by selecting a software component (step **600**). Selection of a component may vary depending on the particular implementation. In these examples, the component selected may be identified by accessing an installation database, such as installation database **414** in **Figure 4**. The installation database may identify software components installed on a particular data processing system. Alternatively, software components may be identified dynamically at a particular time, such as when an update is to be performed. A determination is made as to whether an update is available for the software component (step **602**). This update may be made by checking a database, such as database **402** in **Figure 4** for information. If an update is available for the component, a determination is made as to whether the update is

desired (step **604**). This decision may be made with the aid of preference and history information, which may be found in databases, such as history database **416** and preferences database **418** in **Figure 4**. If the update is desired, the update is deployed (step **606**). After deployment of the update, a determination is made as to whether the deployment was successful (step **608**). If the deployment is successful, a determination is made as to whether to test the update (step **610**). In some cases, no tests may be performed on the update. If the update is to be tested, then one or more specified tests are performed (step **612**). The particular test or tests to run are specified by test information, such as test information **406** found in database **402** in **Figure 4**. After the testing has been performed, a determination is made as to whether the testing performed on the update was successful (step **614**). If the testing was successful, a history database is updated (step **616**). The history database is one, such as history database **416** in **Figure 4**. The information written into the database includes information about the update form, results of the test, and any other data that could be used for determining the application of future updates to the software component. Next, a determination is made as to whether additional unprocessed software components are present (step **618**). If additional unprocessed software components are not present, the process terminates.

Referring again to step **618**, if additional unprocessed software components are present, the process returns to step **600** as described above. Returning to step **614**, if the testing was not successful, a corrective action is performed (step **620**). A roll back of the update to the software component may be performed as the corrective action. Other corrective actions that may be performed include, for example, identifying a different update to apply to the software component or accelerating a roll out of an entirely new software component to take the place of the present one. For example, if an update to a Web server process results in a test failure, a Web server process from a different source may be installed in place of the current one, rather than rolling back the Web server process to its un-updated state. The particular corrective action to take may be included in a database, such as database **402** in **Figure 4**. If a roll back is performed, the process used to roll back the update can be identified from roll back information **410** in database **402** in **Figure 4**. Thereafter, a notification is sent (step **622**). The notifications are typically sent when no more attempts are made to reapply an update. This notification is typically sent to an administrative person. The notification may be sent through various communication mechanisms, such as, for example, email, pager, and simple network management protocol (SNMP) with the process proceeding to step **618** as described above.

Turning back to step **608**, if the deployment was unsuccessful, a determination is made as

to whether to retry the deployment of the update (step **624**). If the update is to be repeated, the process returns to step **606**. Otherwise, the process proceeds to step **622** as described above. In this case, the notification indicates a failure in the deployment. The notification may occur after various types of failures, such as, for example, when a single deployment fails, two or more attempted deployments of the same update to the same target fails, two or more attempted deployments of the same update to different targets fails, or one or more attempted deployments of two or more different updates to the same target fail. These notifications may be logged in a file or sent to administrative personnel depending on the particular implementation. With reference again to step **610**, if testing is not to be performed, the process proceeds to step **618** as described above. In some cases, testing is not performed if metrics indicate that failures are unlikely to occur. The process also proceeds to step **618** from step **604** if the update is not desired. Referring again to step **602**, if an update is not available for the component, the process also proceeds to step **618**.

With reference now to **Figure 7**, a flowchart of a process used for performing an autonomic update is depicted in accordance with a preferred embodiment of the present invention. The process illustrated in **Figure 7** may be implemented in a secondary update management component, such as secondary update management component **506** in **Figure 5**.

The process begins by sending a message to the primary update management component (step **700**). This message includes a query as to whether an update is available and should be performed. The message sent to the primary management component may include information, such as, for example, preference information on updates and history information on the last update performed on the software component. A response to the message is received (step **702**). The message indicates whether an update is to be performed along with an identification of any update that is to be performed. This message also may include information, such as the procedure to install the update, an identification of one or more tests to perform after the update has been installed, and an identification of a roll back process if testing is unsuccessful. A determination is made as to whether an update is to be performed (step **704**). If an update is to be performed, an update is performed on the software component using installation information received from the primary update management component (step **706**). The component is tested (step **708**) and a determination is made as to whether the test was successful (step **710**). If the test was successful, a history database is updated (step **712**) and the process terminates thereafter.

Returning again to step **710**, if the test was not successful, a roll back of the update is performed to remove the update from the software component and place the software component

back into its prior state (step **714**) and the process terminates thereafter. Referring again to step **704**, if an update is not to be performed, the process terminates.

The steps illustrated in **Figure 7** also may be modified to allow for a secondary update management component to be contact by a primary update management component. In this case, the primary update management component tells the secondary update management component what updates are available. Such a configuration is a push model in contrast to the pull model illustrated in these examples in which a secondary update management component queries the primary update management component to determine whether updates are available.

Turning now to **Figure 8**, a flowchart of a process used for performing an autonomic update is depicted in accordance with a preferred embodiment of the present invention. The process illustrated in **Figure 8** may be implemented in an update management component, such as secondary update management component **506** in **Figure 5** and update management component **400** in **Figure 4**. The process in this example is used to perform software updates on software components having critical functions.

The process begins by making a determination as to whether an update is available (step **800**). If an update is available, a determination is made as to whether an update is desired (step **802**). If an update is desired, a new system is identified (step **804**). The new system is another data processing system, which is configured to provide the same function as the software component managed by the update management component. For example, if the software component is an email server, another data processing system containing the software component is selected to be updated. The update is deployed on the new system (step **806**). The update on the new system is tested (step **808**) and a determination is made as to whether the update is successful (step **810**). If the update is successful, clients of the software component are moved to a new system (step **812**). In step **812**, some or all of the clients may be moved to the new system depending on the particular implementation. A determination is made as to whether errors are present after the clients have been moved or transitioned to the new system (step **814**). If errors are present, clients are moved back to the old system (step **816**) and the process terminates thereafter.

With reference again to step **814**, if no errors are present, the old system is phased out (step **818**) and the process terminates thereafter. Turning again to step **810**, if the update is not successful, the process terminates. Of course, additional attempts to implement the update may be performed depending on the particular implementation. With reference again to step **802**, if an update is not desired, the process terminates. Referring again to step **800**, if an update is not

available, the process terminates.

Turning now to **Figure 9**, a flowchart of a process used for modifying autonomic updates is depicted in accordance with a preferred embodiment of the present invention. The process illustrated in **Figure 9** may be implemented in an update management component, such as primary update management component **500** in **Figure 5**.

The process begins by retrieving metrics on an update (step **900**). These metrics may be retrieved from a history database, such as history database **520** or history database **524** in **Figure 5**. These metrics may be pulled from a single client or node or from multiple clients or nodes in a network data processing system. These metrics include data, such as, for example, the date and clients on which roll outs were performed, the data and clients on which roll backs occurred, and any testing and test results related to the updates. The metrics are analyzed (step **902**). This analysis may take various forms depending on the particular implementation. For example, the metrics may be analyzed to identify patterns and correlations between occurrences of faults between specific types or sets of software entities, users, types of hardware, and operating systems. The deployment of the update is modified using the analysis (step **904**) and the process terminates thereafter. This modification may take various forms. For example, deployment of an update may be avoided on data processing systems on which an update is likely to fail. This modification also may include accelerated deployment of an update to data processing systems on which a successful deployment is likely. The modification also may include ceasing deployment of the update or modifying the update. The analysis may result in a modification in which additional updates are deployed or made to improve on the success of previous updates. Further, depending on the particular correlation or pattern identified in step **902**, administrative personnel may be provided a notification of the correlation or pattern.

Thus, the present invention provides an improved method, apparatus, and computer instructions for an autonomic update of a software component. The mechanism of the present invention updates the software component, automatically tests the software component to determine whether faults or errors occur, and may roll back the update to a prior version or take some other corrective action in the event of a fault or error identified in testing. It will be evident that the update management component of the present invention is able to receive information about the progress and status of updates, and make decisions based on that information. These decisions can range from the simple (for example, a decision to roll back the upgrade and to not attempt a redeployment) to the complex (for example, a decision to partially roll back the upgrade -- to roll it back from a subset of the upgraded computers -- and to not attempt to deploy

the upgrade to computers similar -- by some relevant metric -- to those on which the upgrade failed testing). It can therefore be seen that the presence of the update management component allows much more complex decisions to be made automatically, based on a much wider set of available data, than is possible without the update management component.

To elaborate, in another preferred embodiment, the dramatic success of the update (by one or more appropriate metrics) may accelerate the deployment of the update to other machines. In yet another embodiment, analysis of the metrics may indicate that the software update works well in some environments but not in others, and analysis may indicate similarities between the environments in which the update does not work -- the update roll out may then continue to machines that do not share the similarity with the environments on which the update failed. In another embodiment, upon encountering problems with a component deployment, it may be decided to accelerate the deployment of another software component that is believed to resolve, or in some other way deal with, the problems detected. Another possible embodiment has the update management component performing the same update to many computers, and deciding, after the update and tests have succeeded on a number of those computers, to skip some or all of the tests on subsequent deployments of that update to the remaining computers.

Additionally, the mechanism of the present invention may maintain metrics of all the software updates, roll outs, roll backs, and testing to identify patterns of occurrences of faults between specific types of software entities, specific types of users, specific types of data processing systems, and/or operating systems. These patterns may be identified through different statistical analysis normally used to identify patterns. Some examples of overall behavior of multiple updates on multiple data processing systems include a pattern in which an update fails every time an update is attempted on a machine running a particular operating system. In this case, updates on that specific operating system should not be performed in the future. Another example is if an update fails every time it is installed on a data processing system of a particular manufacturer. An example of another pattern is when a third update installs, but fails to pass testing whenever it is installed after the first update. Another pattern may be, for example, a fourth update never installs unless the second update has been installed first. Finer grained pattern detection also may be used to detect other patterns, such as, for example, patterns in performance or compatibility. These patterns may be used to adaptively modify the course of updates or other factors in the update process to decrease the incidence of faults and required roll backs in deployment. For example, a specific pattern may indicate a change in the manner in which an installation occurs or the selection of options for an update if particular steps or options

are identified as causing more faults or failure in testing. In this manner, deployment or updates may be avoided on systems that are likely to fail testing. Further, these identifications may accelerate the deployment of software to update other computers. This is especially true in the instance in which the patterns identified show that an update is unlikely to cause any failures. Also, the deployment of updates may be ceased or terminated when the patterns indicate that many failures will occur. In other cases, the patterns may indicate that additional updates should be employed to improve the success of previous updates. This mechanism also may be used to identify modifications for updates in a manner to increase the likelihood that subsequent updates will be successful. An update procedure may be employed that automatically detects and responds to patterns, such as patterns in which certain installs fail or do not successfully occur based on what prior updates have or have not been performed. The update process may be adapted by changing the process to avoid failures in testing or installation of updates.

It is important to note that while the present invention has been described in the context of a fully functioning data processing system, those of ordinary skill in the art will appreciate that the processes of the present invention are capable of being distributed in the form of a computer readable medium of instructions and a variety of forms and that the present invention applies equally regardless of the particular type of signal bearing media actually used to carry out the distribution. Examples of computer readable media include recordable-type media, such as a floppy disk, a hard disk drive, a RAM, CD-ROMs, DVD-ROMs, and transmission-type media, such as digital and analog communications links, wired or wireless communications links using transmission forms, such as, for example, radio frequency and light wave transmissions. The computer readable media may take the form of coded formats that are decoded for actual use in a particular data processing system.

The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

CLAIMS

What is claimed is:

1. A method in a data processing system for updating a software component, the method comprising the computer implemented steps of:

determining whether to update the software component;

responsive to a determination to update the software component, updating the software component to form an updated software component;

automatically testing the updated software component; and

responsive to a failure in testing the updated component, performing a corrective action.

2. The method of claim 1, wherein the determining step comprises:

determining whether an update is present for the software component;

responsive to the update being present for the software component, determining whether the update should be applied to the software component; and

responsive to a determination to apply the update to the software component, applying the update to the software component to form the updated software component.

3. The method of claim 1, wherein the corrective action includes rolling back the updated software component to a state prior to the update being made.

4. The method of claim 1, wherein the corrective action includes at least one of identifying an alternative update, rolling back the updated software component to the

software component without the update, installing a different software component, and installing the alternative update.

5. The method of claim 1, wherein the testing step comprises:

identifying a test to perform from a database of tests to form an identified test; and

performing the identified test of the updated component.

6. The method of claim 1, wherein the update is a new parameter for a configuration file.

7. The method of claim 1, wherein the update is to an executable file for the software component.

8. The method of claim 1 further comprising:

storing data on at least one of updates, roll backs, test results from testing of the updated component, occurrences of faults between sets of users, occurrences of faults between specific types of software components, and occurrences of faults between sets of operating systems.

9. The method of claim 1, wherein the automatically testing step uses at least one of performance testing, on-the-fly-regression testing, unit testing, and compatibility testing.

10. The method of claim 1, wherein a first party is a source of the software update and a second party provides a policy used in determining whether to update the software component.

11. The method of claim 1, wherein the determining step comprises:

determining whether the update is available; and

if the update is available, determining whether to apply the update using a pattern of occurrences of faults correlating to at least one of specific types of software sources, users, types of operating systems, and types of data processing systems.

12. The method of claim 1 further comprising:

determining whether the software component was successfully updated to form the updated software component; and

responsive to a failure to successfully update the software component, sending a notification of the failure.

13. The method of claim 1 further comprising:

determining whether the software component was successfully updated to form the updated software component; and

responsive to a failure to successfully update the software component, reattempting updating of the software component.

14. The method of claim 13, wherein the notification is sent after at least two attempted updates to the software component have failed.

15. A computer process in a data processing system for deploying an update to a plurality of nodes in a network data processing system, the computer process comprising:

identifying nodes within the plurality of nodes in the network data processing system having a software component requiring an update to form a set of identified nodes;

initiating updating of the set of identified nodes with the update to generate a set of updated nodes;

automatically testing the set of updated nodes; and

responsive to a test failure in a node in the set of updated nodes, performing a corrective action.

16. The computer process of claim 15, wherein the corrective action is at least one of sending a notification of the test failure, reattempting updating of nodes having the test failure, rolling back the update, and installing a different software component.

17. The computer process of claim 15 further comprising:

determining whether a failure occurred in a node when updating the software component in the set of identified nodes; and

responsive to a failure in updating the software component in at least two nodes in the set of nodes, sending a notification of the failure.

18. The computer process of claim 15, further comprising:

determining whether a failure occurred in a node when updating the software component in the set of identified nodes; and

responsive to a failure in updating the software component in the node, reattempting updating of the software component in the node.

19. The computer process of claim 18 further comprising:

responsive to a second failure to update the software component in the node, sending a notification of the failure.

20. The computer process of claim 15 further comprising:

storing data on metrics of at least one of successful deployments of updates in the plurality of nodes and results from testing of updates.

21. The computer process of claim 20 further comprising:

analyzing the data to identify patterns of test failures in the plurality of nodes.

22. The computer process of claim 21 further comprising:

modifying an identification of nodes within the plurality of nodes to receive future updates in a manner reducing test failures, wherein the identification is based on the patterns of test failures.

23. The computer process of claim 21 further comprising:

modifying an identification of nodes within the plurality of nodes to receive future updates in a manner in which some nodes in the plurality of nodes cease to receive updates for the software component, wherein the identification is based on the patterns of test failures.

24. The computer process of claim 21 further comprising:

modifying an identification of nodes within the plurality of nodes to receive future updates in a manner in which some nodes in the plurality of nodes cease to receive updates for the software component, wherein the some nodes are nodes in which failures are likely to occur and wherein the identification is based on the patterns of test failures.

25. The computer process of claim 21 further comprising:

modifying an identification of nodes within the plurality of nodes to receive future updates in a manner in which some nodes in the plurality of nodes receive the update at an accelerated rate, wherein the identification is based on the patterns of test failures.

26. A computer implemented process in a computer for updating a software component, the computer implemented process comprising:

determining whether to update the software component, wherein the software component is executing on the computer;

responsive to a determination to update the software component, identifying a second

computer also containing the software component for deployment of an update to the software component;

initiating means for initiating an update of the software component on the second computer to generate an updated software component on the second computer, wherein the computer continues to execute the software component;

automatically testing the updated software component on the second computer; and

responsive to a failure in testing the updated component, performing a corrective action.

27. The method of claim 26, wherein the testing step includes:

migrating clients of the software component executing on the computer to the updated software component on the second computer.

28. The method of claim 27 further comprising:

responsive to successful testing of the software component, removing the software component on the computer from service.

29. A data processing system for updating a software component, the data processing system comprising:

a bus system;

a communications unit connected to the bus system;

a memory connected to the bus system, wherein the memory includes a set of instructions; and

a processing unit connected to the bus system, wherein the processing unit executes the set of instructions to determine whether to update the software component;

update the software component to form an updated software component in response to a determination to update the software component; automatically test the updated software component; and perform a corrective action in response to a failure in testing the updated component.

30. A data processing system for deploying an update to a plurality of nodes in a network data processing system, the data processing system comprising:

a bus system;

a communications unit connected to the bus system;

a memory connected to the bus system, wherein the memory includes a set of instructions; and

a processing unit connected to the bus system, wherein the processing unit executes the set of instructions to identify nodes within the plurality of nodes in the network data processing system having a software component requiring an update to form a set of identified nodes; initiate an updating of the set of identified nodes with the update to generate a set of updated nodes; automatically test the set of updated nodes; and perform a corrective action in response to a test failure in a node in the set of updated nodes.

31. A data processing system for updating a software component, the data processing system comprising:

a bus system;

a communications unit connected to the bus system;

a memory connected to the bus system, wherein the memory includes a set of instructions; and

a processing unit connected to the bus system, wherein the processing unit executes the set of instructions to determine whether to update the software component in which the software component is executing on the computer; identify a second computer also containing the software component for deployment of an update to the software component in response to a determination to update the software component; initiate an update of the software component on the second computer to generate an updated software component on the second computer in which the computer continues to execute the software component; automatically test the updated software component on the second computer; and perform a corrective action in response to a failure in testing the updated component.

32. A data processing system for updating a software component, the data processing system comprising:

determining means for determining whether to update the software component;

updating means, responsive to a determination to update the software component, for updating the software component to form an updated software component;

testing means for automatically testing the updated software component; and

performing means, responsive to a failure in testing the updated component, for performing a corrective action.

33. The data processing system of claim 32, wherein the determining means is a first determining means and further comprises:

second determining means for determining whether an update is present for the software component;

third determining means, responsive to the update being present for the software component, for determining whether the update should be applied to the software component; and

applying means, responsive to a determination to apply the update to the software component, for applying the update to the software component to form the updated software component.

34. The data processing system of claim 32, wherein the corrective action includes rolling back the updated software component to a state prior to the update being made.

35. The data processing system of claim 32, wherein the corrective action includes at least one of identifying an alternative update, rolling back the updated software component to the software component without the update, installing a different software component, and installing the alternative update.

36. The data processing system of claim 32, wherein the performing means is a first performing means and wherein the testing means comprises:

identifying means for identifying a test to perform from a database of tests to form an identified test; and

second performing means for performing the identified test of the updated component.

37. The data processing system of claim 32, wherein the update is a new parameter for a configuration file.

38. The data processing system of claim 32, wherein the update is to an executable file for the software component.

39. The data processing system of claim 32 further comprising:

storing means for storing data on at least one of updates, roll backs, test results from

testing of the updated component, occurrences of faults between sets of users, occurrences of faults between specific types of software components, and occurrences of faults between sets of operating systems.

40. The data processing system of claim 32, wherein the automatically testing means uses at least one of performance testing, on-the-fly-regression testing, unit testing, and compatibility testing.

41. The data processing system of claim 32, wherein a first party is a source of the software update and a second party provides a policy used in determining whether to update the software component.

42. The data processing system of claim 32, wherein the determining means comprises:

first means for determining whether the update is available; and

second means, responsive to the update being available, for determining whether to apply the update using a pattern of occurrences of faults correlating to at least one of

specific types of software sources, users, types of operating systems, and types of data processing systems.

43. The data processing system of claim 32, wherein the determining means is a first determining means and further comprising:

second determining means for determining whether the software component was successfully updated to form the updated software component; and

sending means, responsive to a failure to successfully update the software component, for sending a notification of the failure.

44. The data processing system of claim 32, wherein the determining means is a first determining means and the updating means is a first updating means, further comprising:

second determining means for determining whether the software component was successfully updated to form the updated software component; and

second updating means, responsive to a failure to successfully update the software component, for reattempting updating of the software component.

45. The data processing system of claim 44, wherein the notification is sent after at least two attempted updates to the software component have failed.

46. A data processing system for deploying an update to a plurality of nodes in a network data processing system, the data processing system comprising:

identifying means for identifying nodes within the plurality of nodes in the network data processing system having a software component requiring an update to form a set of identified nodes;

initiating means for initiating updating of the set of identified nodes with the update to generate a set of updated nodes;

testing means for automatically testing the set of updated nodes; and

performing means, responsive to a test failure in a node in the set of updated nodes, for performing a corrective action.

47. The data processing system of claim 46, wherein the corrective action is at least one of sending a notification of the test failure, reattempting updating of nodes having the test failure, rolling back the update, and installing a different software component.

48. The data processing system of claim 46 further comprising:

determining means for determining whether a failure occurred in a node when updating the software component in the set of identified nodes; and

sending means, responsive to a failure in updating the software component in at least two nodes in the set of nodes, for sending a notification of the failure.

49. The data processing system of claim 46, wherein the updating means is a first updating means and further comprising:

determining means for determining whether a failure occurred in a node when updating the software component in the set of identified nodes; and

second updating means, responsive to a failure in updating the software component in the node, for reattempting updating of the software component in the node.

50. The data processing system of claim 49 further comprising:

sending means, responsive to a second failure to update the software component in the node, for sending a notification of the failure.

51. The data processing system of claim 46 further comprising:

storing means for storing data on metrics of at least one of successful deployments of updates in the plurality of nodes and results from testing of updates.

52. The data processing system of claim 51 further comprising:

analyzing means for analyzing the data to identify patterns of test failures in the plurality of nodes.

53. The data processing system of claim 52 further comprising:

modifying means for modifying an identification of nodes within the plurality of nodes to receive future updates in a manner reducing test failures, wherein the identification is based on the patterns of test failures.

54. The data processing system of claim 52 further comprising:

modifying means for modifying an identification of nodes within the plurality of nodes to receive future updates in a manner in which some nodes in the plurality of nodes cease to receive updates for the software component, wherein the identification is based on the patterns of test failures.

55. The data processing system of claim 52 further comprising:

modifying means for modifying an identification of nodes within the plurality of nodes to receive future updates in a manner in which some nodes in the plurality of nodes cease to receive updates for the software component, wherein the some nodes are nodes in which failures are likely to occur and wherein the identification is based on the patterns of test failures.

56. The data processing system of claim 52 further comprising:

modifying means for modifying an identification of nodes within the plurality of nodes to receive future updates in a manner in which some nodes in the plurality of nodes receive the update at an accelerated rate, wherein the identification is based on the patterns of test failures.

57. A data processing system for updating a software component, the data processing system

comprising:

determining means for determining whether to update the software component, wherein the software component is executing on the computer;

identifying means, responsive to a determination to update the software component, for identifying a second computer also containing the software component for deployment of an update to the software component;

iniating means for initiating an update of the software component on the second computer to generate an updated software component on the second computer, wherein the computer continues to execute the software component;

testing means for automatically testing the updated software component on the second computer; and

performing means, responsive to a failure in testing the updated component, for performing a corrective action.

58. The data processing system of claim 57, wherein the testing means includes:

migrating means for migrating clients of the software component executing on the computer to the updated software component on the second computer.

59. The data processing system of claim 58 further comprising:

removing means, responsive to successful testing of the software component, for removing the software component on the computer from service.

60. A computer program product in a computer readable medium for updating a software component, the computer program product comprising:

first instructions for determining whether to update the software component;

second instructions, responsive to a determination to update the software component, for updating the software component to form an updated software component;

third instructions for automatically testing the updated software component; and

fourth instructions, responsive to a failure in testing the updated component, for performing a corrective action.

61. A computer program product in a computer readable medium for deploying an update to a plurality of nodes in a network data processing system, the computer program product comprising:

first instructions for identifying nodes within the plurality of nodes in the network data processing system having a software component requiring an update to form a set of identified nodes;

second instructions for initiating updating of the set of identified nodes with the update to generate a set of updated nodes;

third instructions for automatically testing the set of updated nodes; and

fourth instructions, responsive to a test failure in a node in the set of updated nodes, for performing a corrective action.

62. A computer program product in a computer readable medium for updating a software component, the computer program product comprising:

first instructions for determining whether to update the software component, wherein the software component is executing on the computer;

second instructions, responsive to a determination to update the software component, for identifying a second computer also containing the software component for deployment of an update to the software component;

third instructions for initiating an update of the software component on the second computer to generate an updated software component on the second computer, wherein the computer continues to execute the software component;

fourth instructions for automatically testing the updated software component on the second computer; and

fifth instructions, responsive to a failure in testing the updated component, for performing a corrective action.

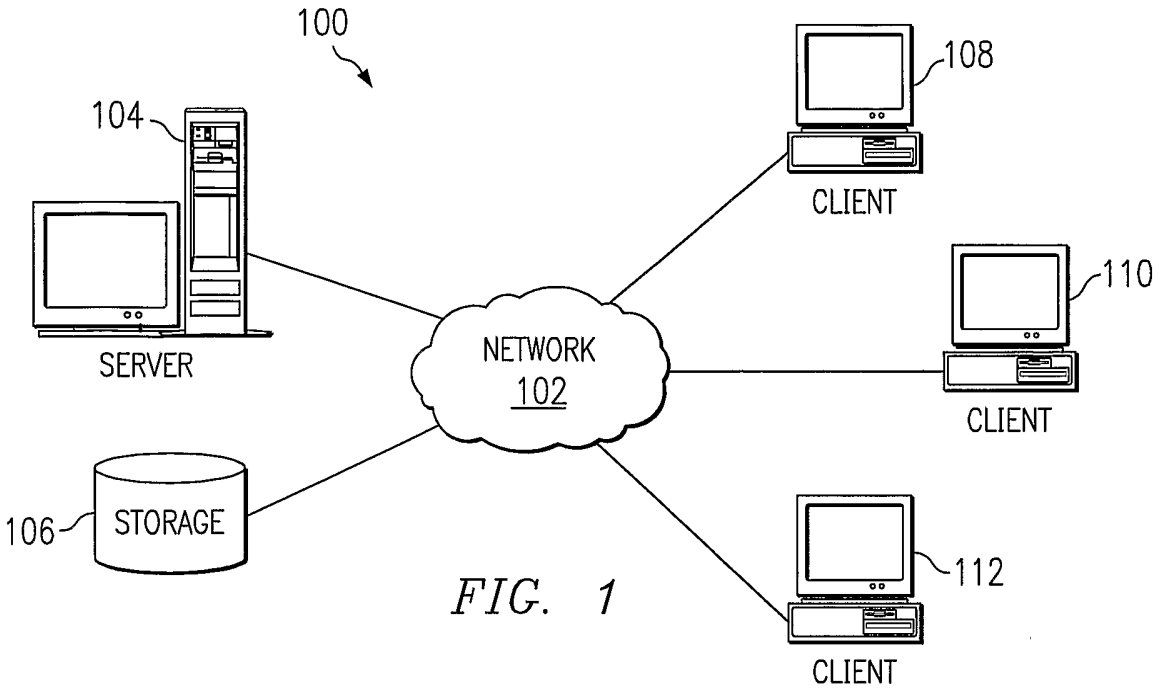

100
104
SERVER
108
CLIENT
110
CLIENT
NETWORK
102
106
STORAGE
112
CLIENT

FIG. 1

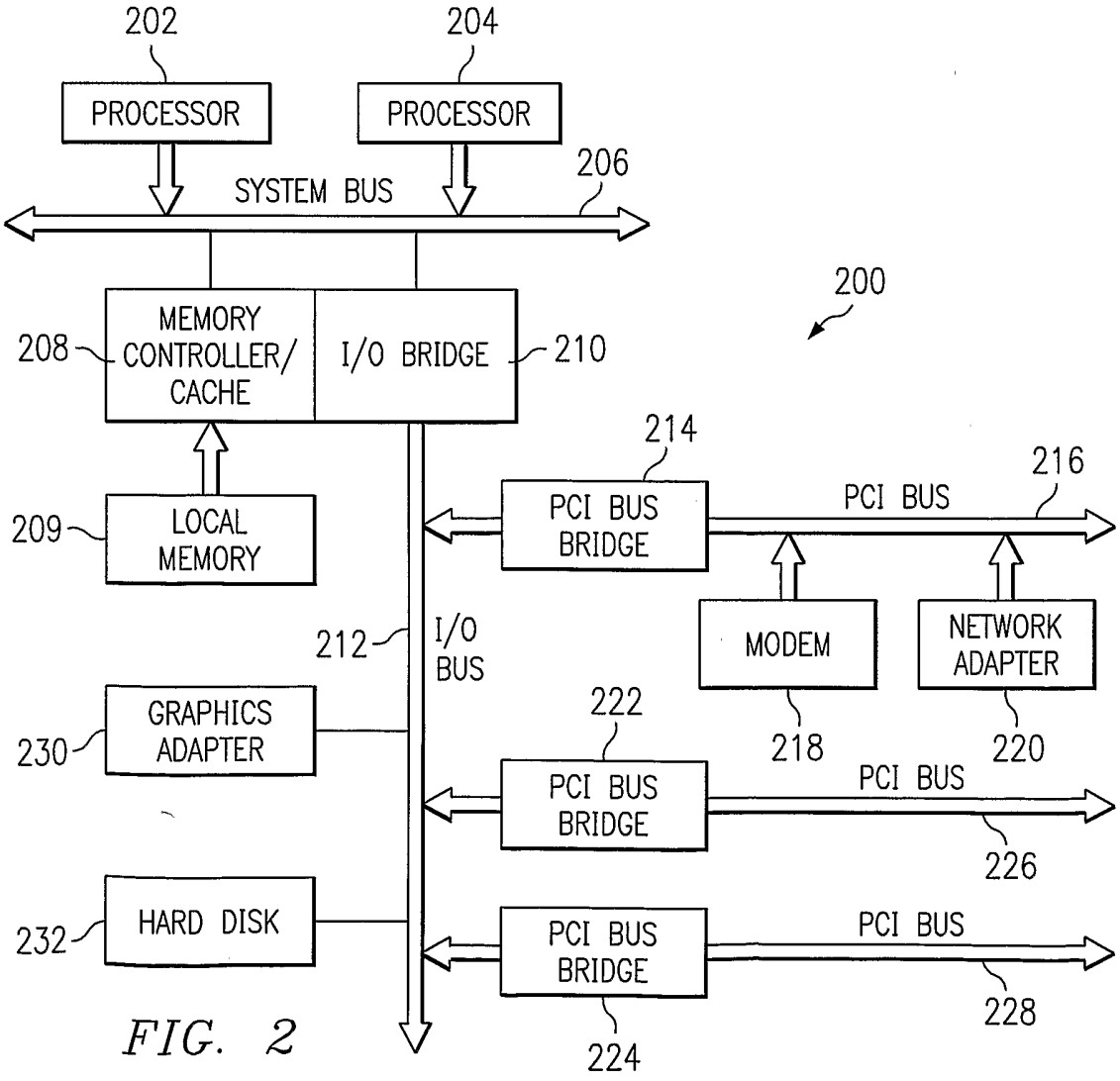

202
204
PROCESSOR
PROCESSOR
206
SYSTEM BUS
200
208
MEMORY CONTROLLER/ CACHE
I/O BRIDGE
210
214
216
PCI BUS BRIDGE
PCI BUS
209
LOCAL MEMORY
212
I/O BUS
MODEM
NETWORK ADAPTER
218
220
222
230
GRAPHICS ADAPTER
PCI BUS BRIDGE
PCI BUS
226
232
HARD DISK
PCI BUS BRIDGE
PCI BUS
228
224

FIG. 2

FIG. 3

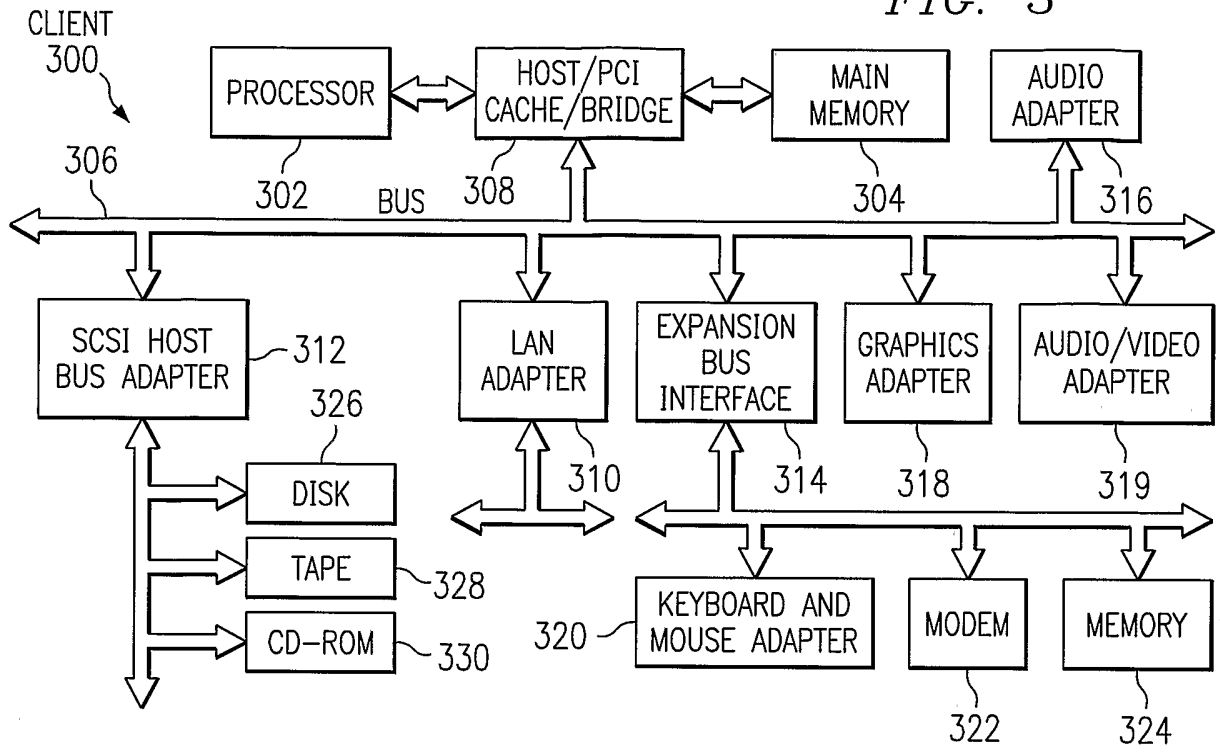

CLIENT
300
PROCESSOR
HOST/PCI
CACHE/BRIDGE
MAIN
MEMORY
AUDIO
ADAPTER
306
302
BUS
308
304
316
SCSI HOST
BUS ADAPTER
312
326
LAN
ADAPTER
EXPANSION
BUS
INTERFACE
GRAPHICS
ADAPTER
AUDIO/VIDEO
ADAPTER
DISK
310
314
318
319
TAPE
328
CD-ROM
330
320
KEYBOARD AND
MOUSE ADAPTER
MODEM
MEMORY
322
324

FIG. 4

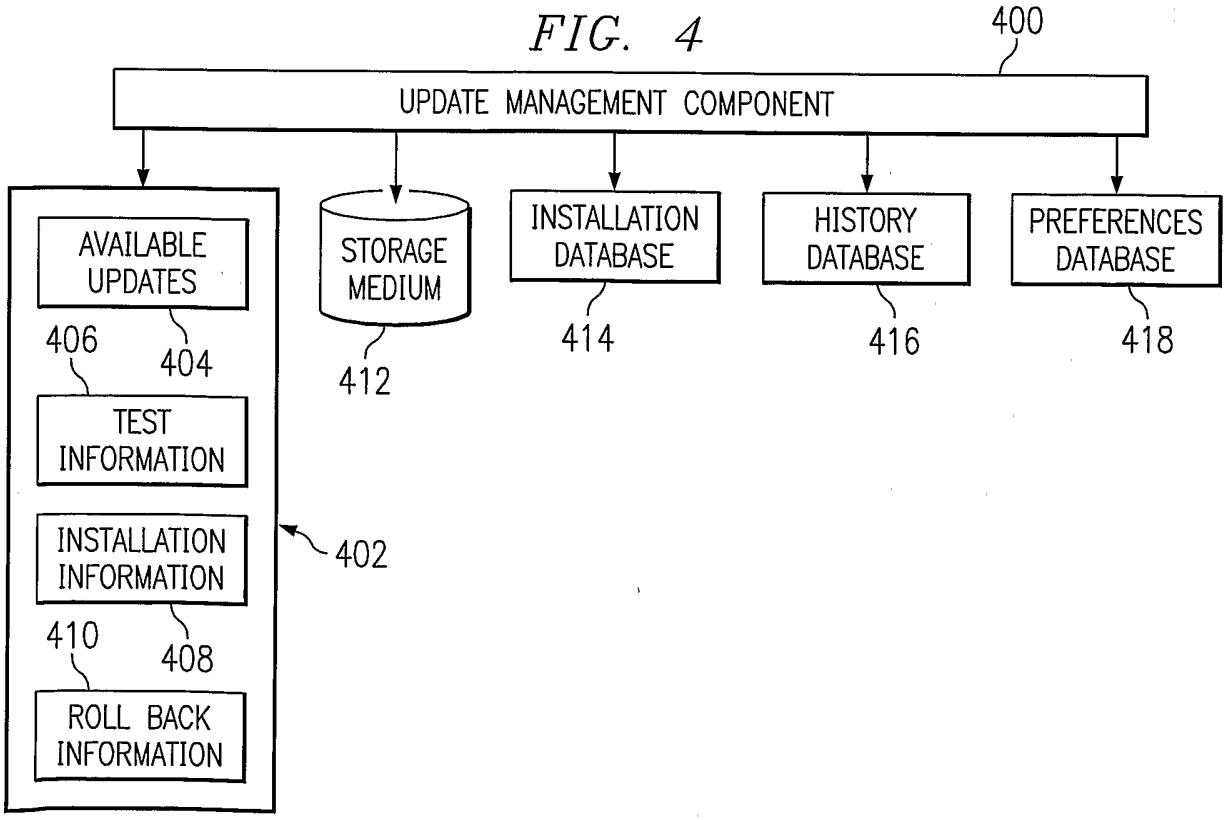

400
UPDATE MANAGEMENT COMPONENT
AVAILABLE
UPDATES
406
404
TEST
INFORMATION
INSTALLATION
INFORMATION
410
408
ROLL BACK
INFORMATION
402
STORAGE
MEDIUM
412
INSTALLATION
DATABASE
414
HISTORY
DATABASE
416
PREFERENCES
DATABASE
418

FIG. 5

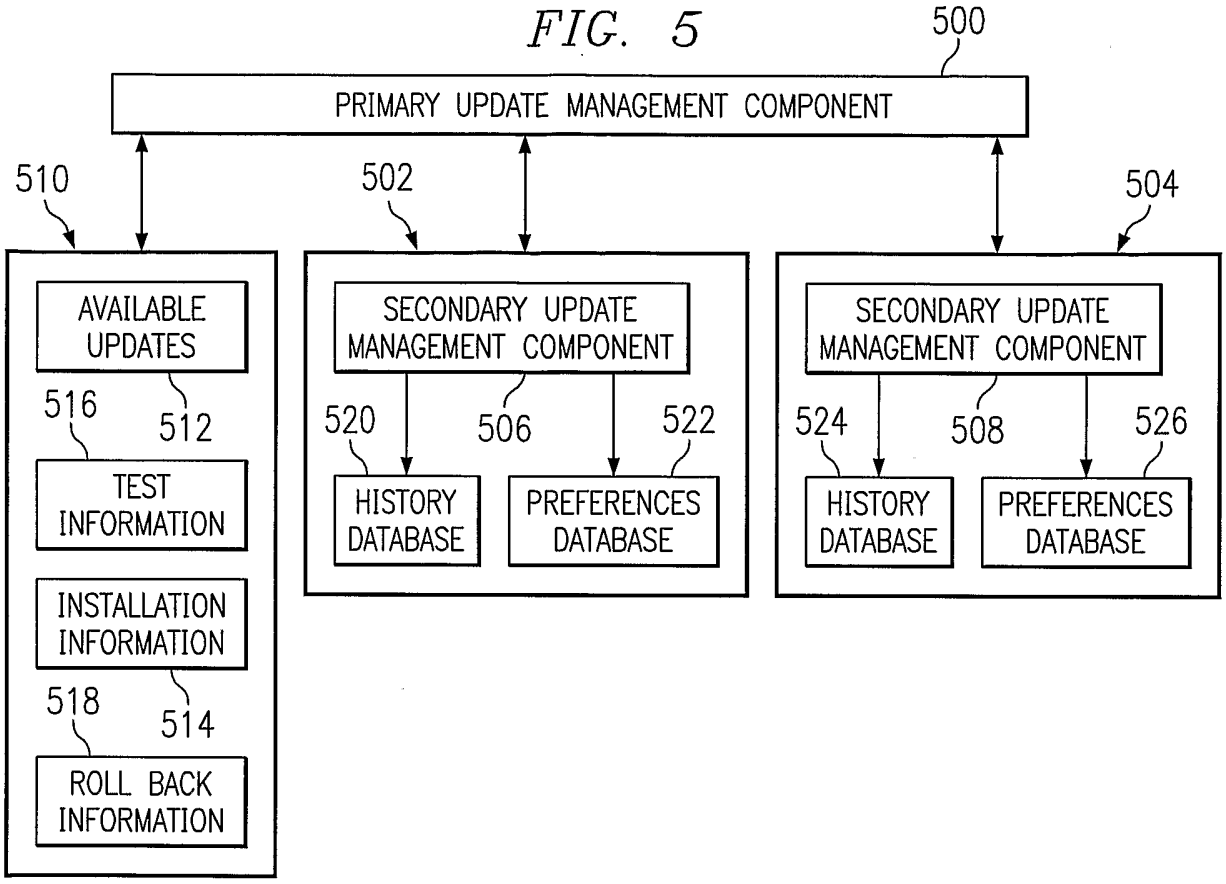
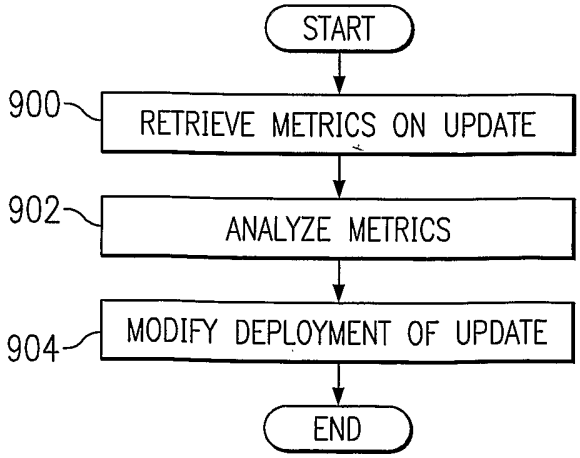

500
PRIMARY UPDATE MANAGEMENT COMPONENT
510
502
504
AVAILABLE UPDATES
516
512
TEST INFORMATION
INSTALLATION INFORMATION
518
514
ROLL BACK INFORMATION
SECONDARY UPDATE MANAGEMENT COMPONENT
520
506
522
HISTORY DATABASE
PREFERENCES DATABASE
SECONDARY UPDATE MANAGEMENT COMPONENT
524
508
526
HISTORY DATABASE
PREFERENCES DATABASE

FIG. 9


START
900
RETRIEVE METRICS ON UPDATE
902
ANALYZE METRICS
904
MODIFY DEPLOYMENT OF UPDATE
END

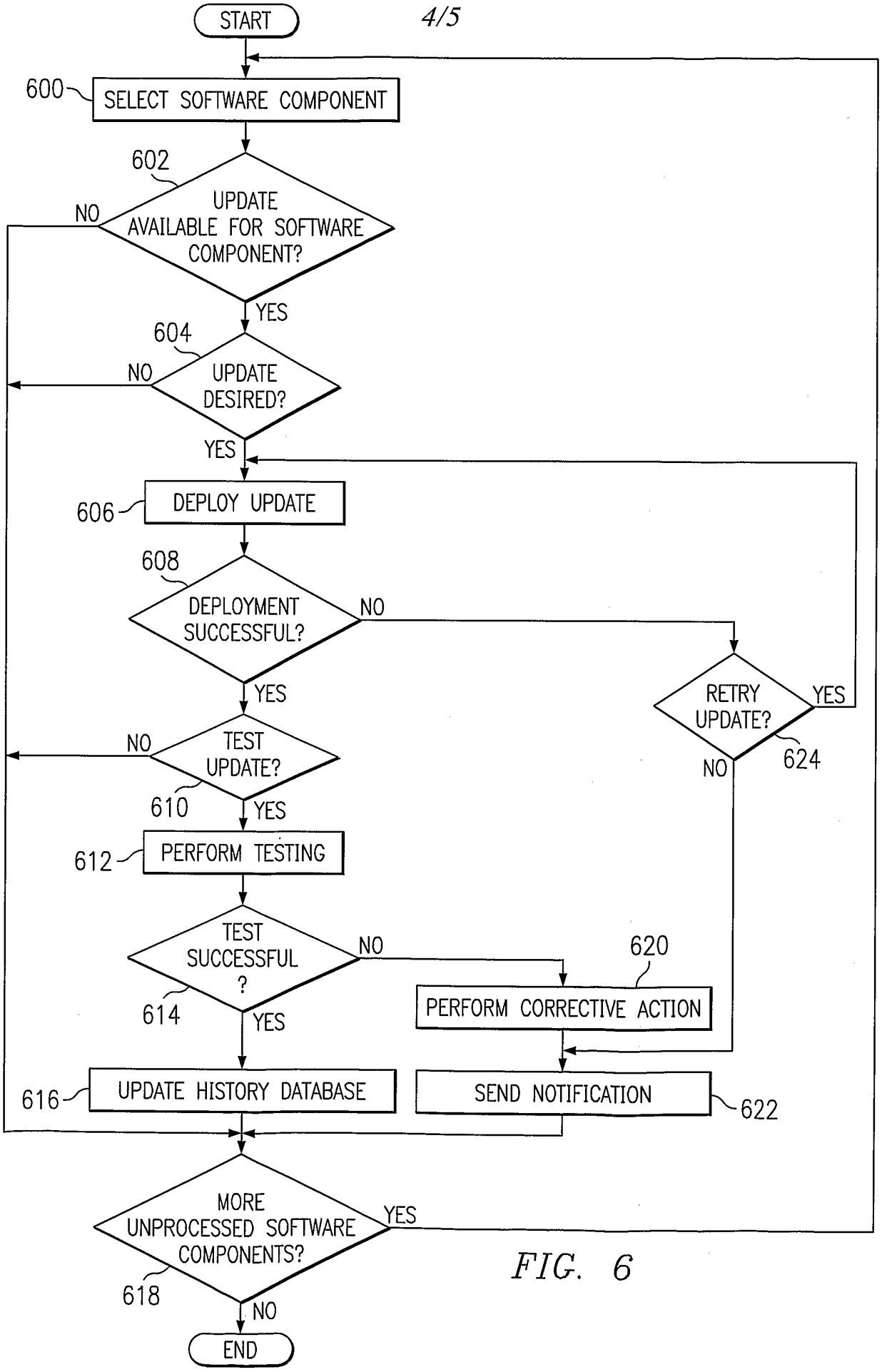

START
600
SELECT SOFTWARE COMPONENT
602
UPDATE AVAILABLE FOR SOFTWARE COMPONENT?
NO
YES
604
UPDATE DESIRED?
NO
YES
606
DEPLOY UPDATE
608
DEPLOYMENT SUCCESSFUL?
NO
YES
RETRY UPDATE?
YES
NO
624
TEST UPDATE?
NO
610
YES
612
PERFORM TESTING
TEST SUCCESSFUL ?
NO
620
614
YES
PERFORM CORRECTIVE ACTION
616
UPDATE HISTORY DATABASE
SEND NOTIFICATION
622
MORE UNPROCESSED SOFTWARE COMPONENTS?
YES
618
NO
END

FIG. 6

FIG. 7

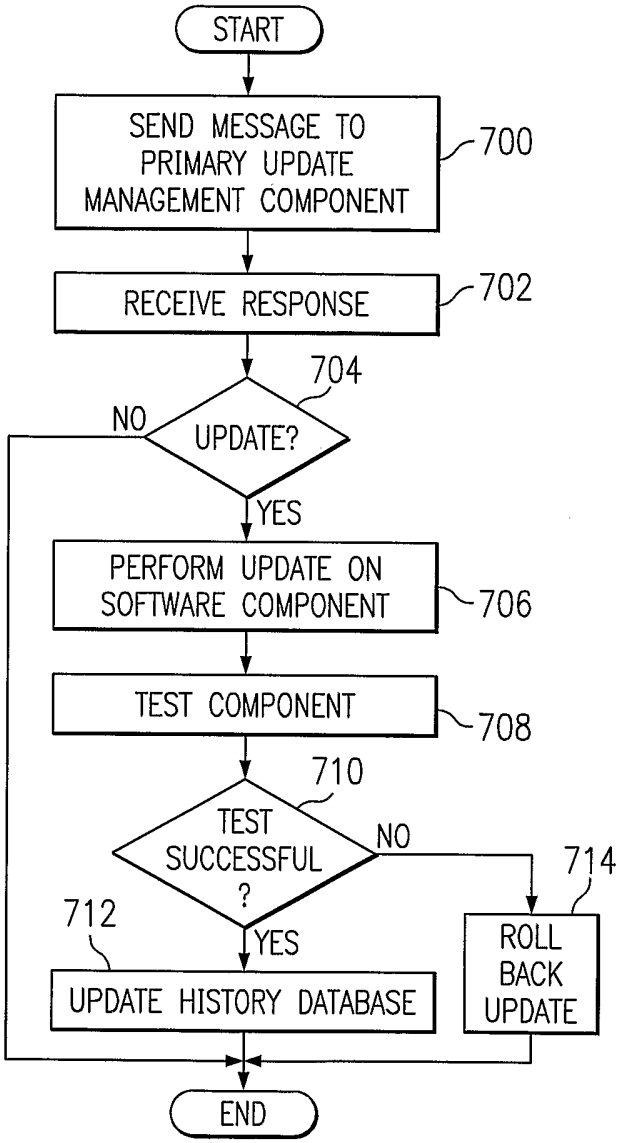
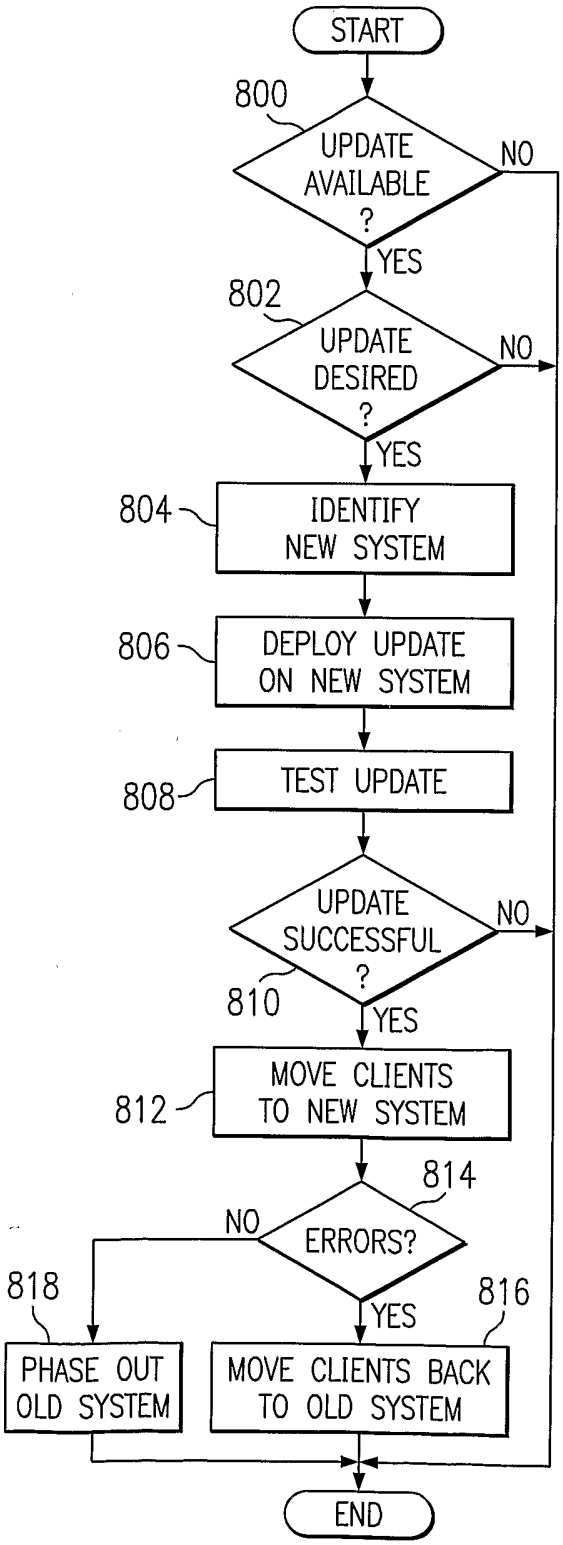

START
SEND MESSAGE TO PRIMARY UPDATE MANAGEMENT COMPONENT
700
RECEIVE RESPONSE
702
704
UPDATE?
NO
YES
PERFORM UPDATE ON SOFTWARE COMPONENT
706
TEST COMPONENT
708
710
TEST SUCCESSFUL ?
NO
YES
712
714
UPDATE HISTORY DATABASE
ROLL BACK UPDATE
END

FIG. 8


START
800
UPDATE AVAILABLE ?
NO
YES
802
UPDATE DESIRED ?
NO
YES
804
IDENTIFY NEW SYSTEM
806
DEPLOY UPDATE ON NEW SYSTEM
808
TEST UPDATE
UPDATE SUCCESSFUL ?
NO
810
YES
812
MOVE CLIENTS TO NEW SYSTEM
814
ERRORS?
NO
YES
818
816
PHASE OUT OLD SYSTEM
MOVE CLIENTS BACK TO OLD SYSTEM
END