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Lavian

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(54) **NETWORK APPARATUS WITH JAVA CO-PROCESSOR**

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(73) Assignee: **Nortel Networks Limited**, Montreal (CA)

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(52) **U.S. Cl.** **709/232**; 709/223; 709/224; 709/235; 709/238
(58) **Field of Search** 709/220, 221, 709/223, 224, 225, 230, 232, 233, 234, 235, 238, 242, 250

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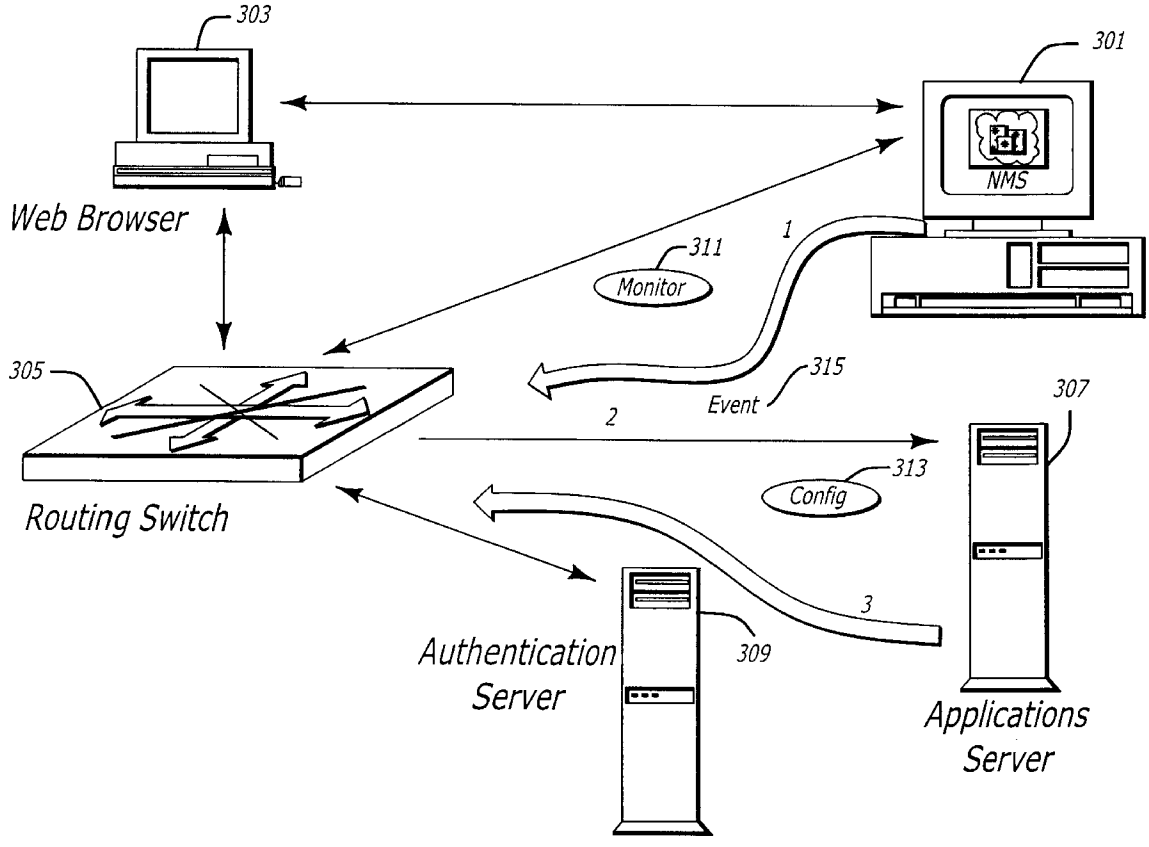
(57) **ABSTRACT**

A method and apparatus for automatically configuring a network switch having external network data ports, a processor, memory, data bus, and coprocessor. Network data is monitored on the external network data port. Information about the network data traffic is compared to one or more threshold conditions. The network switch is automatically configured by the coprocessor if the network data meets one of the threshold conditions. The monitor and configuration functions can be performed by software running on the coprocessor which has been downloaded from an external network maintenance station through a maintenance data port. Information about the network data traffic can be uploaded to the external network maintenance station through a maintenance data port.

16 Claims, 9 Drawing Sheets



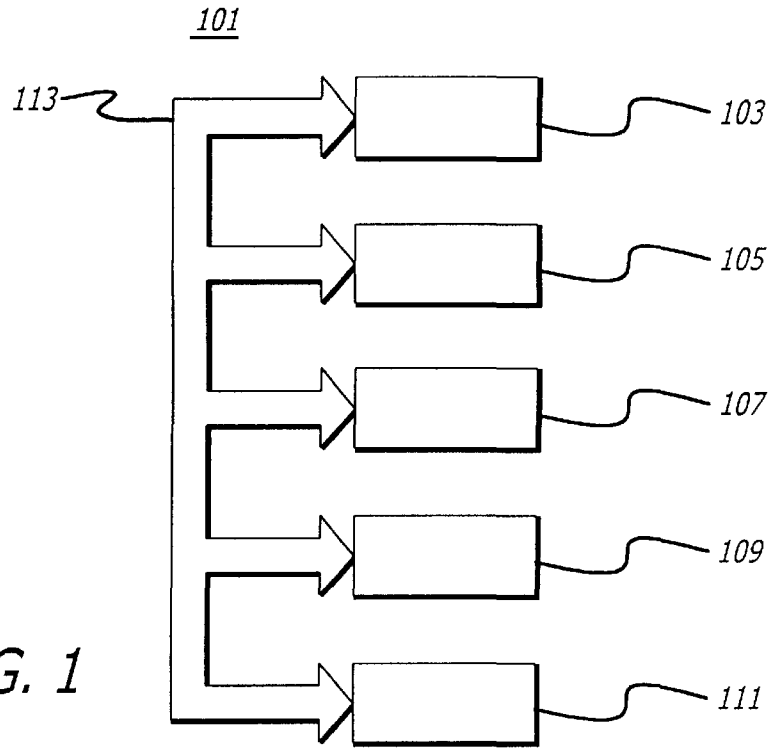

101
113
103
105
107
109
111

FIG. 1

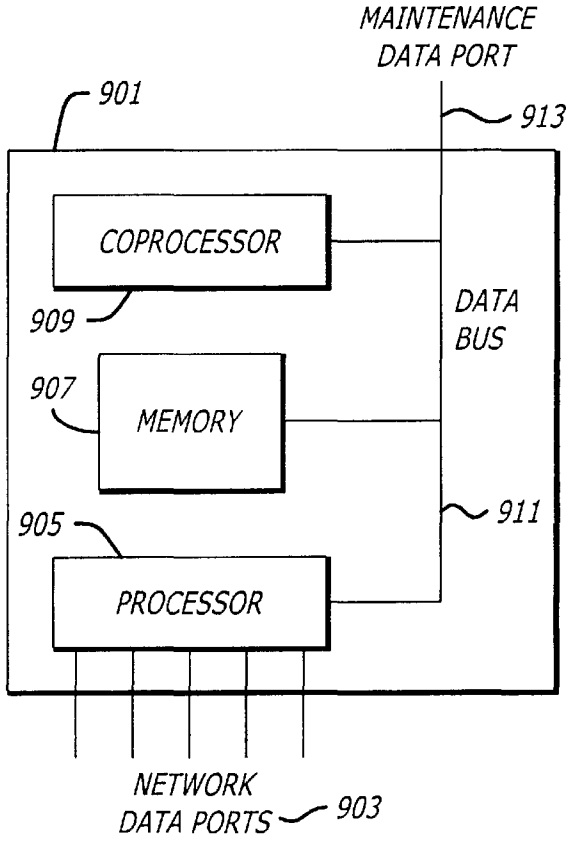

MAINTENANCE
DATA PORT
901
913
COPROCESSOR
909
DATA
BUS
907
MEMORY
911
905
PROCESSOR
NETWORK
DATA PORTS
903

FIG. 9

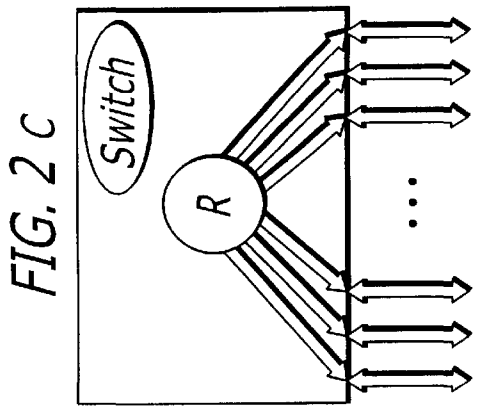


FIG. 2 C

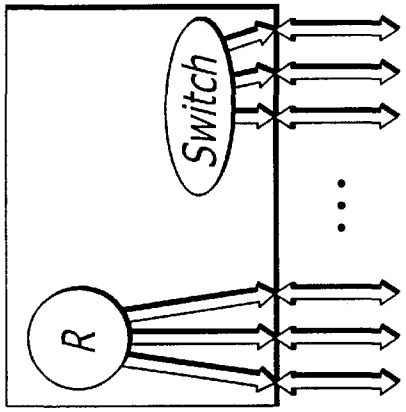


FIG. 2 B

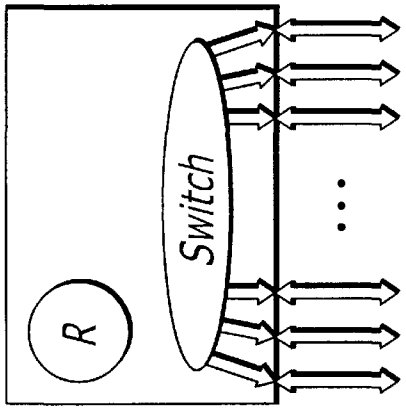


FIG. 2 A

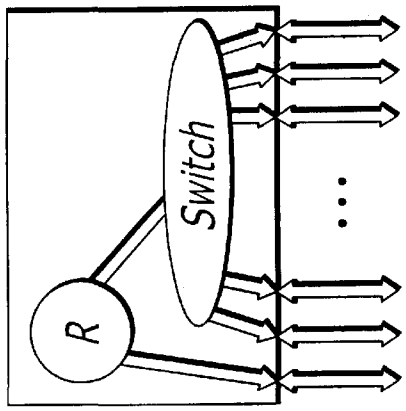


FIG. 2 F

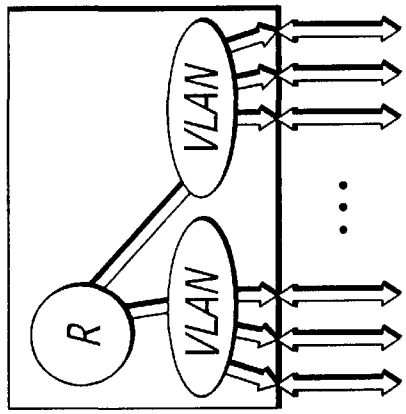


FIG. 2 E

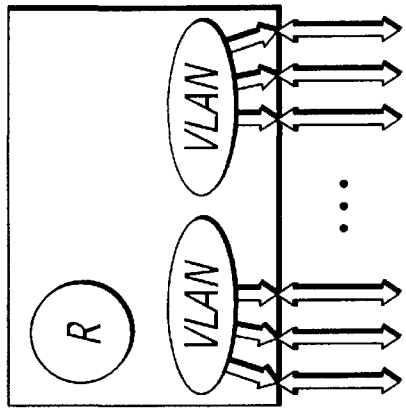


FIG. 2 D

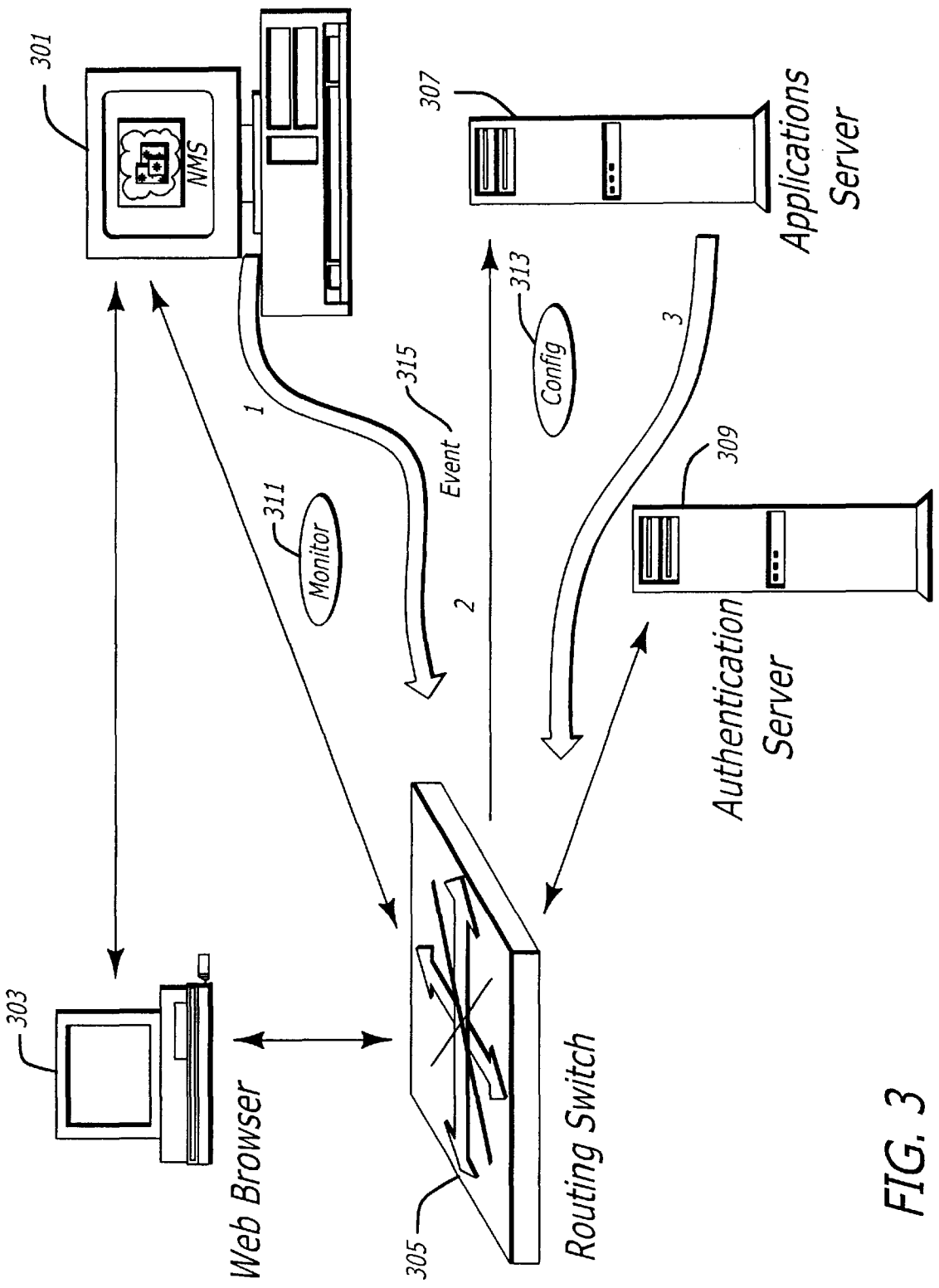

301
NMS
307
Applications Server
313
Config
315
Event
311
Monitor
1
2
3
309
Authentication Server
303
Web Browser
305
Routing Switch

FIG. 3

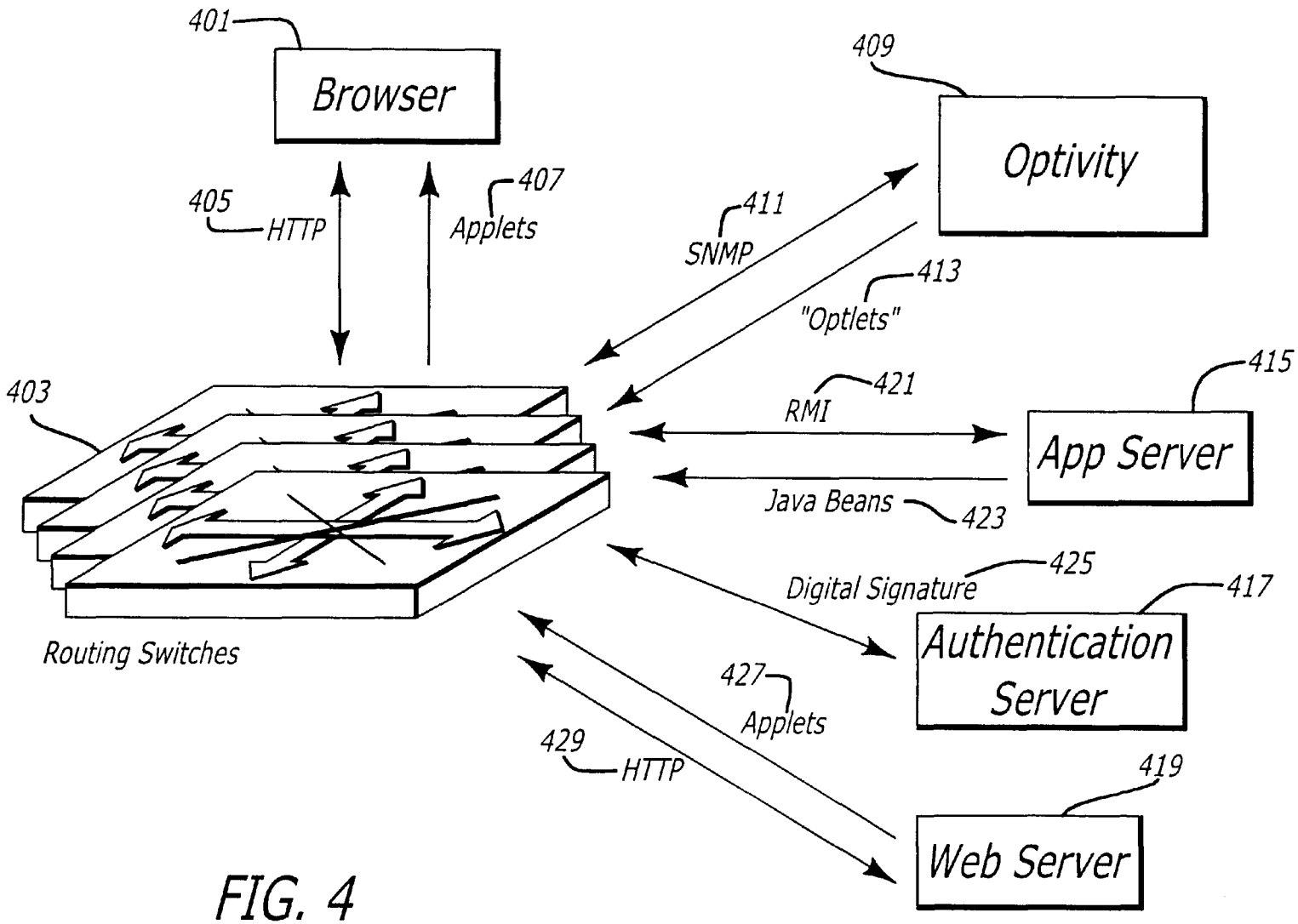

401
Browser
409
Optivity
405
HTTP
407
Applets
411
SNMP
413
"Optlets"
403
415
RMI
421
App Server
Java Beans
423
425
Digital Signature
417
Authentication Server
427
Applets
429
HTTP
419
Web Server
Routing Switches

FIG. 4

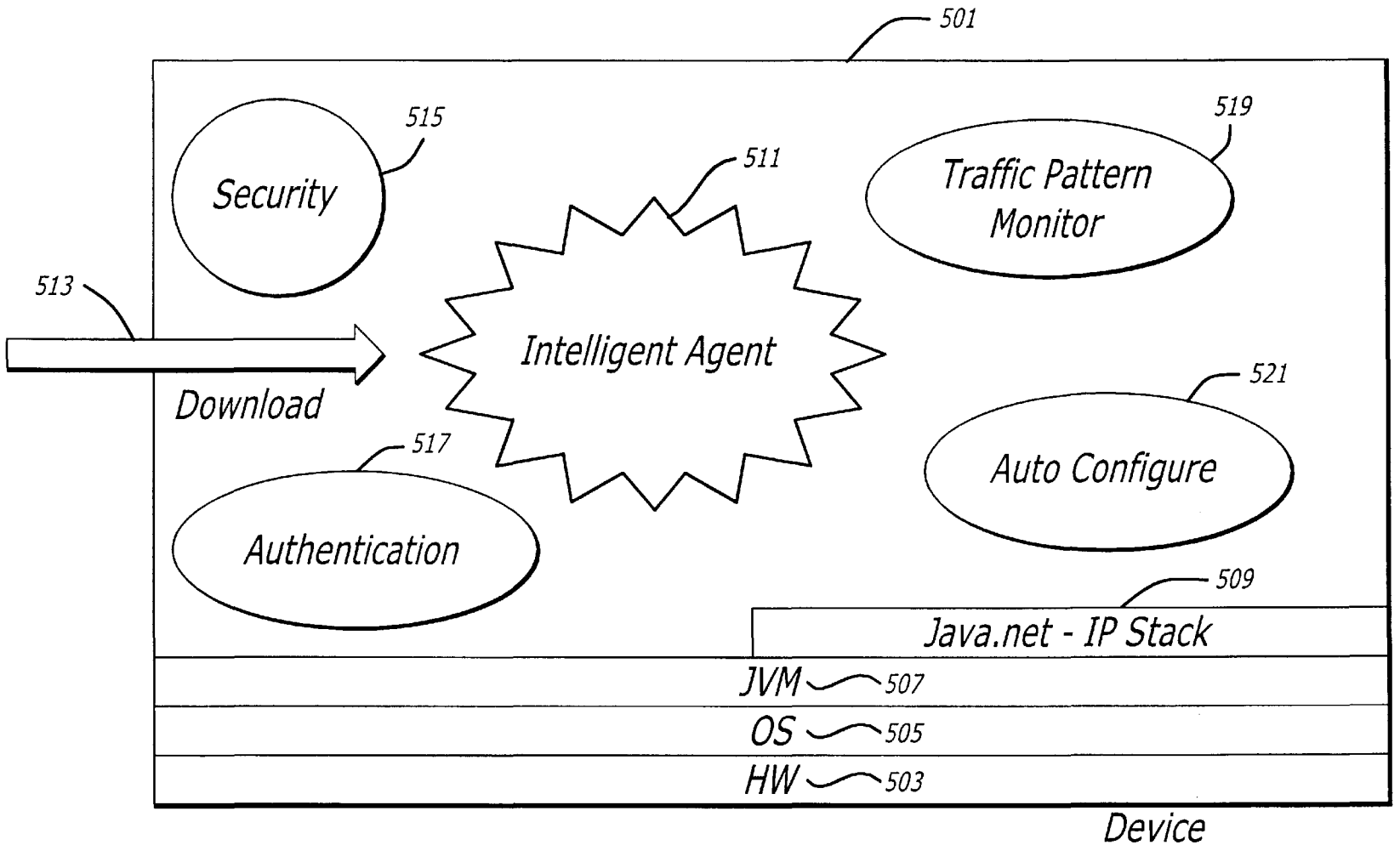

501
515
Security
511
519
Traffic Pattern Monitor
513
Intelligent Agent
Download
521
Auto Configure
517
Authentication
509
Java.net - IP Stack
JVM
507
OS
505
HW
503
Device

FIG. 5

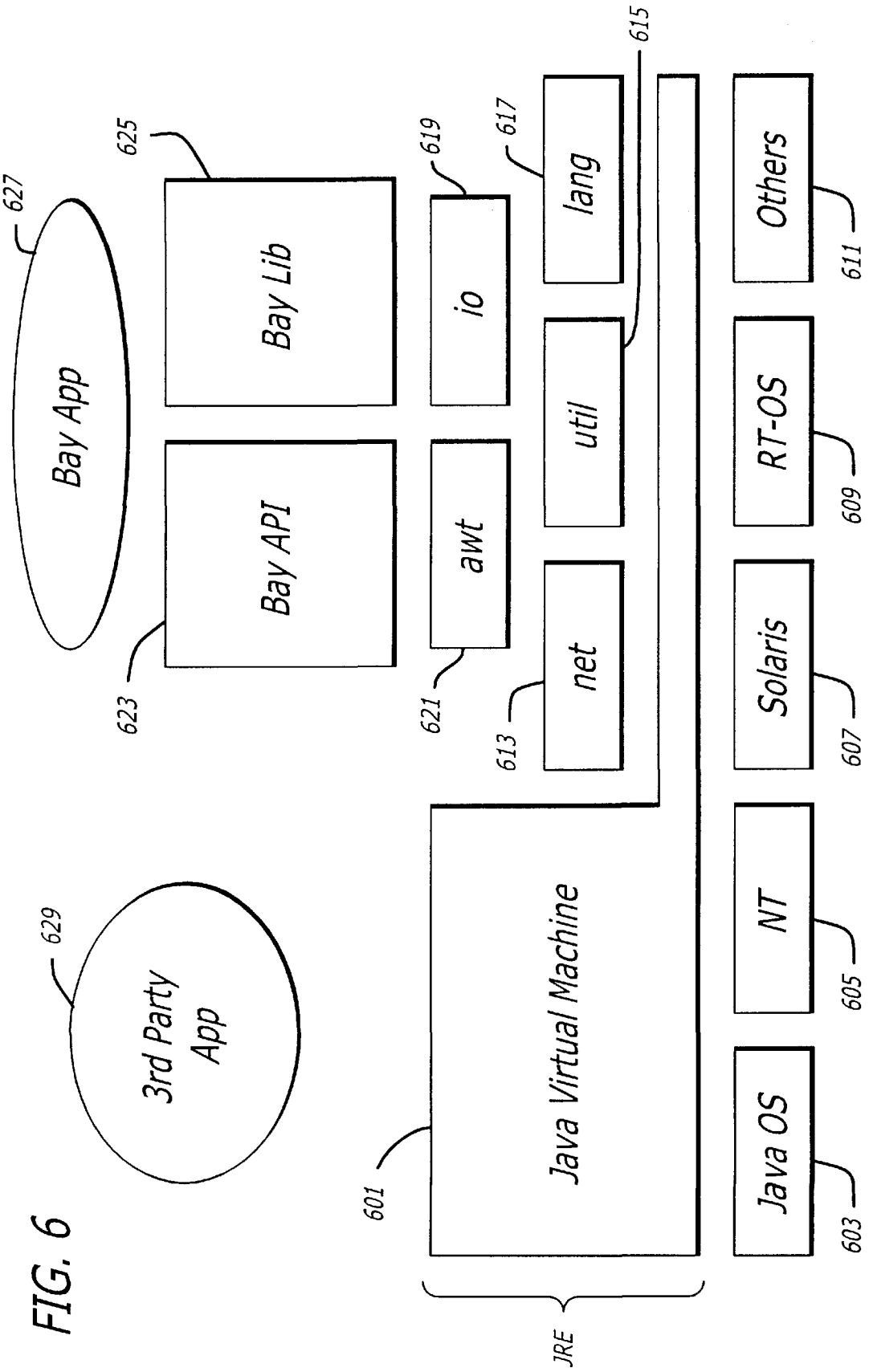
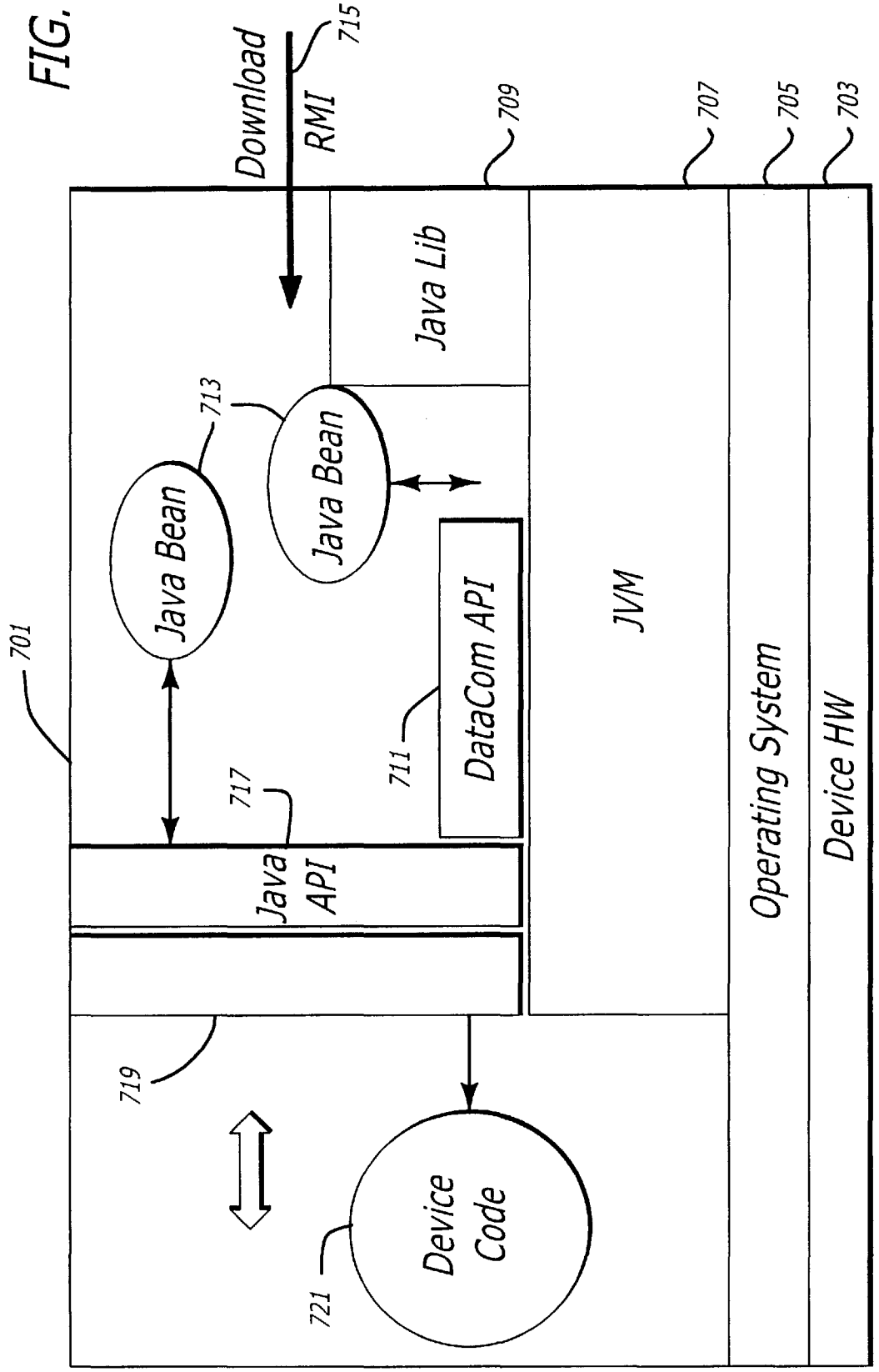

Bay App
627
Bay API
623
Bay Lib
625
awt
621
io
619
net
613
util
lang
617
615
Java Virtual Machine
601
JRE
Java OS
603
NT
605
Solaris
607
RT-OS
609
Others
611
3rd Party App
629

FIG. 6

FIG. 7


Download
RMI
715
709
707
705
703
Java Lib
713
Java Bean
Java Bean
701
DataCom API
711
JVM
Operating System
Device HW
717
Java API
719
Device Code
721

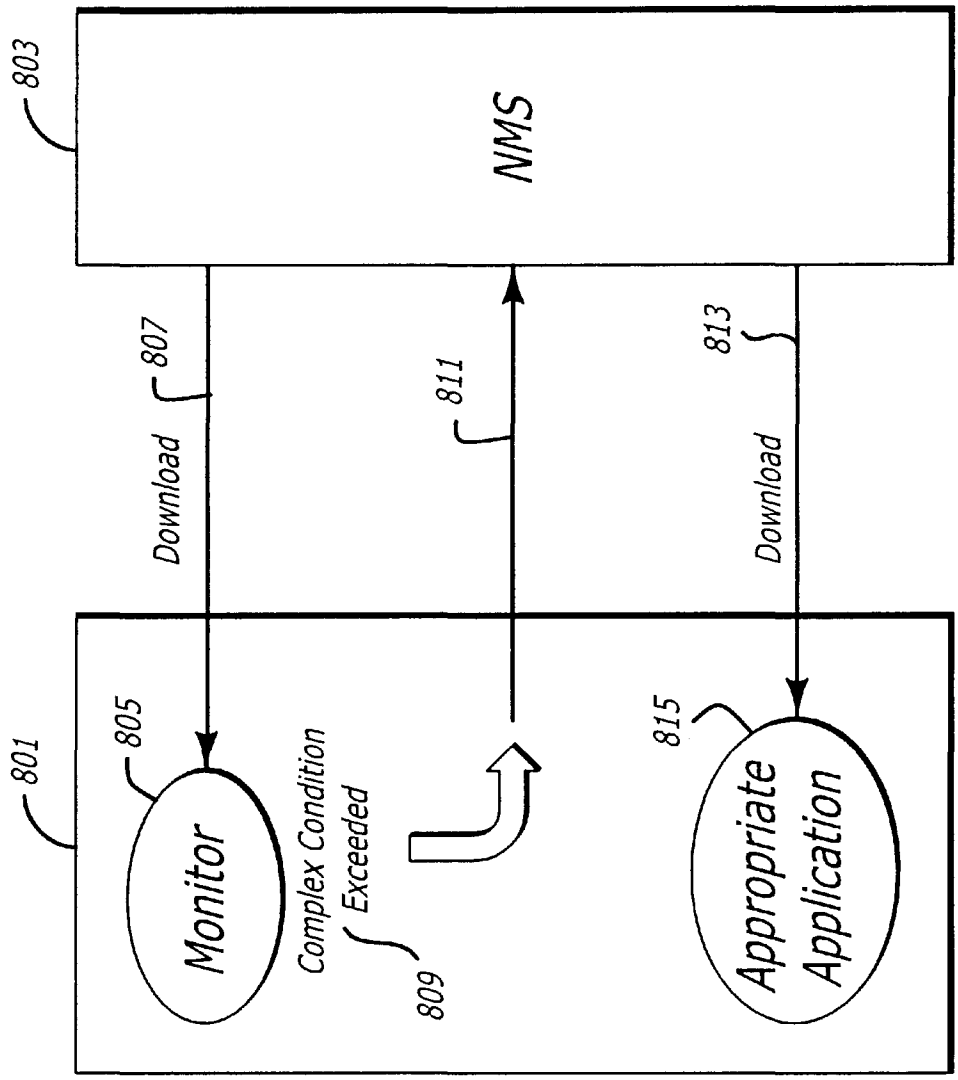

803
NMS
807
Download
811
813
Download
801
805
Monitor
Complex Condition Exceeded
809
815
Appropriate Application

FIG. 8

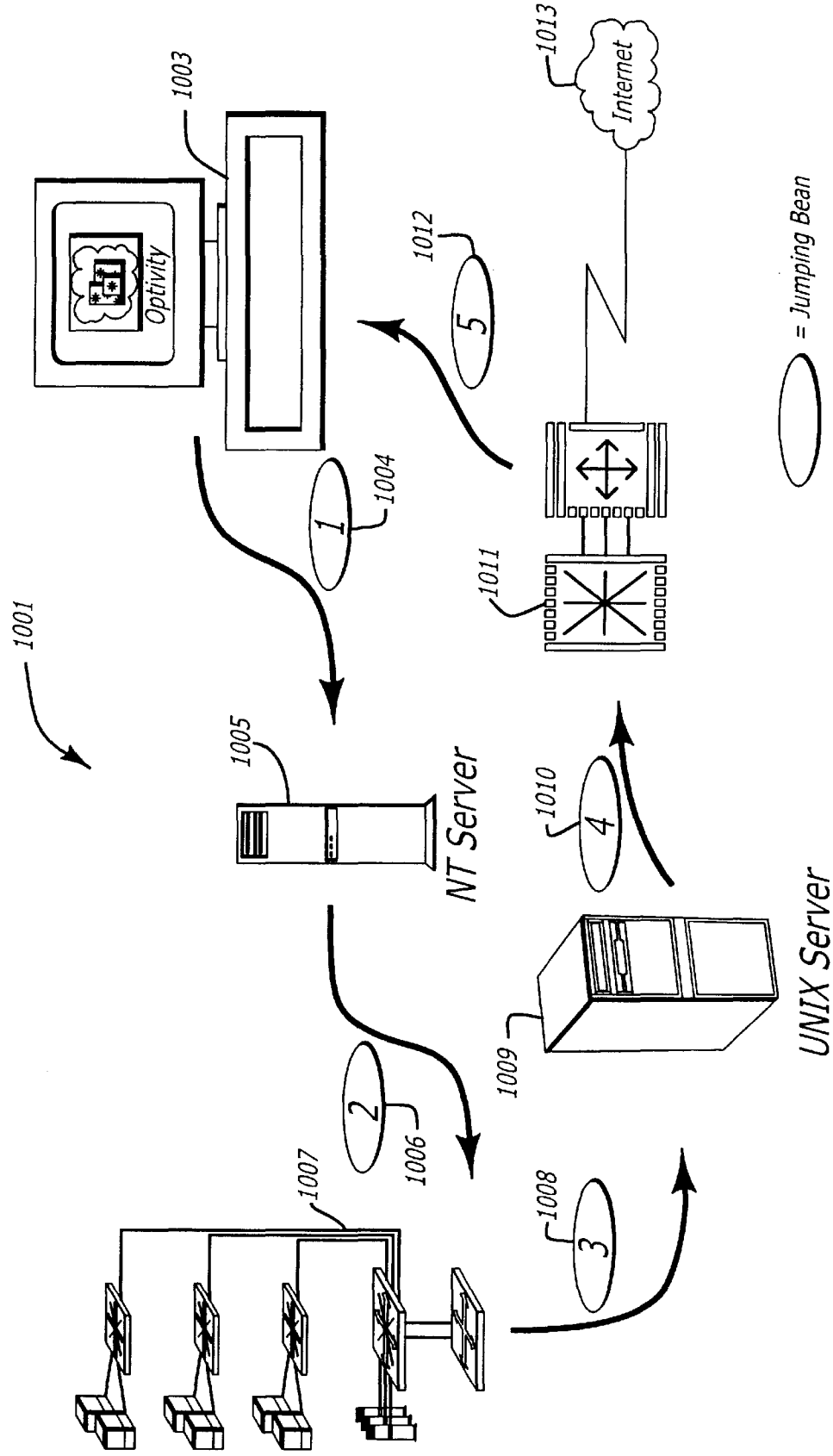

1001
1003
Optivity
1004
1
1005
NT Server
1006
2
1007
1008
3
1009
UNIX Server
1010
4
1011
1012
5
1013
Internet
= Jumping Bean

FIG. 10

NETWORK APPARATUS WITH JAVA CO-PROCESSOR

FIELD OF THE INVENTION

This invention relates generally to data communications networks, and more particularly, to a method and apparatus for automatically configuring a network switch with a coprocessor.

BACKGROUND OF THE INVENTION

Computer networks are used to interconnect many computing resources, including computers, workstations, servers, printers, modems, and storage devices. For example, two or more computers may be connected together through a network. Network users are able to share files, printers and other resources, send messages and run applications on remote computers. An important part of any computer network includes the physical components or network communications devices used to interconnect the computing resources.

One network communications device used to interconnect multiple computing resources is a chassis-based system designed to accommodate a number of internal cards. The computing resources such as computers are coupled to the internal cards of the chassis-based system. Once the computers are coupled to the internal cards, the computers are coupled to the network. To accommodate network growth, additional internal cards may be purchased and added to the chassis-based system. With the additional internal cards installed, additional computing resources may be added to the network. A disadvantage of these chassis-based systems is that there is a relatively large initial investment when purchasing the chassis because of the large amount of overhead associated with chassis-based systems.

An alternative to expensive chassis-based systems is the use of less expensive standalone network communications devices or units that have a fixed number of ports for connecting computing resources or stations to the network. Such standalone network communications devices include stackable switches or the like. Although additional ports can not be added to each individual standalone unit, separate standalone units can be stacked, cascaded or coupled to accommodate network growth. As a result, there is a lower startup cost when establishing a computer network with the standalone units in comparison with chassis-based systems. Furthermore, network administrators still have the flexibility to increase the size of the network with the less-expensive standalone units.

FIG. **1** illustrates multiple network communications devices **103**, **105**, **107**, **109** and **111** coupled together to form a computer network **101**. Multiple computing resources (not shown) are coupled to each network communications device **103**, **105**, **107**, **109** and **111**. In one embodiment, network communications devices **103**, **105**, **107**, **109** and **111** are stackable switches coupled together through bus **113**. Bus **113** is used to tie together the switch network fabric of computer network **101**. It are noted by one of ordinary skill in the art that the utilization of bus **113** is an extension of the chassis-based designs discussed earlier. The internal cards of the chassis-based systems are commonly coupled to high speed buses within the chassis-based systems.

The use of stackable switches allows network administrators to build systems having multiple physical ports to various computing resources on the network. Different types of network use patterns may typically be handled most efficiently by different configurations of a network switch.

Currently, a network administrator must manually monitor and analyze network traffic patterns, and also manually make any changes to the configuration of a network switch through the use of an external network maintenance station (NMS). Although some network switches may have data gathering and reporting capabilities, a network administrator must still take a considerable amount of time to analyze the network traffic pattern and manually reconfigure the switch. Delays in rerouting network traffic are directly related to the time required to analyze network traffic and reconfigure a network switch by a network administrator.

Therefore, there is a need for a way to automatically monitor and configure a network switch according to changes in network traffic. There is a further need to automatically configure a network switch which does not reduce the flow of data through the switch.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for automatically configuring a network switch having external network data ports, a processor, memory, data bus, and coprocessor. Network data is monitored on the external network data port. Information about the network data traffic is compared to one or more threshold conditions. The network switch is automatically configured by the coprocessor if the network data meets one of the threshold conditions. The monitor and configuration functions can be performed by software running on the coprocessor which has been downloaded from an external network maintenance station through a maintenance data port. Information about the network data traffic can be uploaded to the external network maintenance station through a maintenance data port.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated by way of example and may be better understood by referring to the following description in conjunction with the accompanying drawings, in which like references indicate similar elements and in which:

FIG. **1** shows a computer network coupled together with a bus architecture compatible with the present invention;

FIG. **2A–2F** show alternative network switch configurations compatible with the present invention;

FIG. **3** shows a block diagram of a high level system architecture compatible with the present invention;

FIG. **4** shows a block diagram of a system architecture and protocol relationships compatible with the present invention;

FIG. **5** shows a block diagram of downloading intelligent agents compatible with the present invention;

FIG. **6** shows a block diagram of a Java application environment compatible with the present invention;

FIG. **7** shows a block diagram of an open system architecture compatible with the present invention;

FIG. **8** shows an auto-configuring network switch compatible with the present invention;

FIG. **9** shows a network switch with coprocessor compatible with the present invention;

FIG. **10** shows a system diagram of Java mobile agents compatible with the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT OF THE PRESENT INVENTION

In the following description of a preferred embodiment, reference is made to the accompanying drawings which

form a part hereof, and in which is shown by way of illustration a specific embodiment in which the invention may be practiced. It is to be understood that other embodiments may be utilized and structural changes may be made without departing from the scope of the present invention.

The present invention provides for a method and apparatus for automatically configuring a network switch having external network data ports, a processor, memory, data bus, and coprocessor. Network data is monitored on the external network data port. Information about the network data traffic is compared to one or more threshold conditions. The network switch is automatically configured by the coprocessor if the network data meets one of the threshold conditions. The monitor and configuration functions can be performed by software running on the coprocessor which has been downloaded from an external network maintenance station through a maintenance data port. Information about the network data traffic can be uploaded to the external network maintenance station through a maintenance data port.

For the purpose of illustration, one embodiment of present invention is described below in the context of a Java virtual machine in a Java development environment. Information and specifications relating to the Java development environment are described in the document "Java Virtual Machine Specification", October, 1997, Sun Microsystems. It will be recognized by one of ordinary skill in the art that the present invention may be used with other development environments without loss of generality, such as Microsoft Visual C/C++.

Java is a programming language similar to the object-oriented language C++, and consists of runtime libraries. These libraries provide a standard set of facilities for manipulating the user interface, communicating across a network, etc. Two Java runtime libraries, remote method invocation (RMI) and and Java native interface (JNI) allow a single application to run on multiple hardware platforms without modification.

Java preferably isolates applications from both hardware and operating systems. Unlike traditional computer programs, which are almost always compiled for a hardware platform using tools that preclude their running on anything else, Java applications can be designed to run on any system that has a Java Virtual Machine (VM), also known as a Java Runtime Engine. The VM takes Java byte code and transforms it on the fly into instructions that can be executed by the PC. The same byte code can be interpreted as hardware-level instructions for any other platform with a VM implementation.

Java can be used to create two types of programs: applications and applets. Java applications, like those written in other languages, are standalone programs. They require a VM to run, but this runtime environment may be separate, embedded in the OS or in the application itself. Applets rely on a Web browser with a VM (such as Microsoft Internet Explorer or Netscape Communicator). Since applets are designed to be downloaded, they are also typically much smaller than applications.

In addition to platform independence, Java applications offer several other advantages. First, Java was designed for network computing and makes hiding the differences between local and remote resources easy. This allows Java to be used with thin-client computing, in which most of the processing and storage is handled by a server, while the client is used largely for display and interaction. Typical thin clients include network computers (NCs), which are low-cost personal computers typically connected to a private or public network. Second, the Java programming language has a rigorous object-oriented model that makes it possible to build modular applications. An end user need only download a particular feature of a Java word processor when needed, for example. This dynamic design also lets developers create custom desktop environments that display only those applications required by each end user.

The Java platform or runtime environment is the platform that enables Java applications and applets to run on any system regardless of the operating system and underlying hardware. Rather than compiling code into a format designed for a specific platform, developers compile Java source code into an intermediate form, bytecode, which can be executed on any system with a runtime environment. A Class Loader transfers the Java bytecode to the Java Virtual Machine (JVM). As the heart of the Java platform, the JVM is basically a software CPU that sits between applications and the platform consisting of the operating system and hardware. The JVM interprets bytecode for the platform or uses a just-in-time JIT) compiler to convert the bytecode to machine code for that specific platform. Java class libraries, which are files that make up the standard application programming interface (API) for applications and applets, are also loaded dynamically as needed.

The runtime system, which manages threads, memory, and other system resources, preferably executes the interpreted or machine code on the end platform. The program may be run within a browser as an applet, or as a standalone application.

JavaBeans are reusable building blocks that make up object-oriented Java programs. JavaBeans are defined by an API specification for a visual component architecture based on the Java language. Preferably, any Java components conforming to the JavaBeans component model can be reused in any other JavaBean-compliant application.

The present invention is used to configure a network switch or other apparatus having a processor and memory which can be modified through software. FIGS. **2**A–**2**F show alternative network switch configurations typically chosen by a network administrator, and which may be automatically configured by the present invention. FIG. **2**A shows a L**2** switch configuration; FIG. **2**B shows a configuration which routes or switches on any port; FIG. **2**C shows a configuration which routes on all ports; FIG. **2**D shows a configuration which creates virtual local area networks (VLANs) by policy or port; FIG. **2**E shows a configuration which routes between VLANs with simple software configurations; FIG. **2**F shows a configuration which demonstrates arbitrary network routing and switching. It will be recognized by one of ordinary skill in the art that configurations shown in FIGS. **2**A–**2**F are for illustration purposes only, and that other configurations may be implemented with the present invention without loss of generality. Different applications or users may be assigned different priorities. For example, high level network applications such as real-time network monitoring and two-way voice and video may be given a low priority, equivalent to that of non-critical email or internet browsing. Alternatively, an important user such as a corporate CEO may be given a higher network priority than other employees.

FIG. **3** shows a block diagram of a high level system architecture compatible with the present invention. A network maintenance station (NMS) **301** may be coupled to a network routing switch **305** via a maintenance data port on the network switch **305**. A preferred personal computer **303**

running browser software may optionally communicate with both the NMS **301** and network switch **305**. Network monitor software **311** may preferably be downloaded from the NMS **301** to a processor in the network switch **305** for monitoring network data traffic. The monitor software **311** is downloaded through a control data channel, preferably through the maintenance data port on the network switch **305**, and not as network traffic being routed through the network switch **305**. The use of a control channel preferably does not impact the flow of network traffic through the network switch **305**. Once the network monitor software **311** has been downloaded to the network switch **305**, events and information **315** relating to network traffic can be uploaded to either the NMS **301** or an applications server **307**. Analysis of the network events **315** may be performed either by the processor on the network switch **305** or by the NMS **301** or applications server **307**. Analysis of the network events **315** preferably involves monitoring the events **315** to see if they meet one or more of a set of predefined threshold conditions. If so, network configuration software **313** can be downloaded either from the NMS **301** or applications server **307** in reconfigure the network switch **305**. An authentication server **309** may optionally be used to authenticate data and actions taking place on the network switch **305**.

FIG. **4** shows a preferred system architecture and protocol. Browser software **401** may preferably communicate with a network switch **403** through a variety of protocols, including HyperText Transfer Protocol (HTTP) **405**, and may also exchange software applets **407** with the switch **403**. Optivity software may preferably communicate with the switch **403** through Simple Network management Protocol (SNMP) **411** or through distributed optivity applications or oplets **409**. An application server **415** may preferably communicate with the switch **403** through Remote Method Invocation (RMI) **421** or Java Beans **423**.

FIG. **5** shows a preferred method of downloading intelligent agents. A network switch or routing device **501** contains a physical hardware layer **503**, preferably including a processor and memory. An operating system **505** runs as a software application on top of the hardware layer **503**. An implementation of a JVM **507** and internet protocol (IP) stack **509** runs on top of the operating system layer **505**. A download channel **513**, typically a maintenance data port, is used to download an intelligent agent **511** to the network switch **501**. The intelligent agent **511** typically performs one or more functions, including but not limited to security **515**, authentication of information **517**, monitoring network data traffic **519**, or automatically configuring **521** the network switch **501**.

FIG. **6** shows a preferred Java application environment. A Java virtual machine **601** may run on top of a number of operating systems, including but not limited to JavaOS 603, Windows NT 605, Solaris 607, RT-OS 609, or others **611**. System functions such as networking **613**, utilities **615**, programming languages **617**, input/output (I/O) **619**, and abstract window toolkit (AWT) **621** are all supported by the JVM **601**. A network switch (API) **623** and network switch libraries **625** are used to support end user applications **627** or third party applications **629** running on the network switch.

FIG. **7** shows a preferred open system architecture compatible with the present invention. A network switch **701** includes a hardware layer **703**, operating system **705**, and a JVM **707**. Java software libraries **709** and a data communications API **711** preferably run on top of the JVM **707**. A download or control channel **715** is used to download applications programs including Java Beans **713**, which communicate with the device **721** through a Java API **717** and a C/C++ API **719**.

FIG. **8** shows an auto-configuring network switch compatible with the present invention. A network switch **801** communicates with a NMS **803** through a download channel **807**. Monitor software **805** may be downloaded from the NMS **803** through the download channel **807**. If a network event or information meets a threshold condition **809**, network information may be optionally uploaded **811** to the NMS **803**. An appropriate application **815** may be downloaded **813** from the NMS **803** in response to the uploaded network information.

FIG. **9** shows a network switch **901** with coprocessor **909** compatible with the present invention. In order not to impact the throughput of data on the network, configuration information is preferably sent through a maintenance port or control channel **913** rather than through the network switch data channel **903**, **905**. In addition, a coprocessor **909** is preferably used to run monitor and configuration software stored in memory **907** in order not to impact the flow of data through network ports **903** and processor **905**. A data bus **911**, preferably a PCI data bus, is used to transfer information between the processor **905**, memory **907**, coprocessor **909**, and the maintenance data port **913**. It will be recognized by one of ordinary skill in the art that changes may be made in the connections between and the types of processor, memory, and network components without loss of generality. For example, the memory may alternatively be connected directly to both the processor and coprocessor, or a data bus other than a PCI data bus, such as an ISA data bus, used to transfer information internally within the network switch **901**.

FIG. **10** shows a system diagram of Java mobile agents compatible with the present invention. A network **1001** containing optivity software running on a NMS **1003** communicates via Java mobile agents **1004** with a file server **1005**, which in turn may communicate via transferred agents **1006** with a network switch **1007**. The network switch **1007** may use transferred agents **1008** to communicate with another file server **1009**, which uses transferred agents **1010** to communicate with a public network **1013** such as the internet via gateway **1011**. Finally, the transferred agents **1012** may be used to communicate with the NMS **1003**.

While the invention is described in terms of preferred embodiments in a specific system environment, those of ordinary skill in the art will recognize that the invention can be practiced, with modification, in other and different hardware and software environments within the spirit and scope of the appended claims.

What is claimed is:

1. A network apparatus comprising:

an external network data port;

a processor coupled to external network data port;

a data bus coupled to the processor;

a memory coupled to the processor and the data bus to store data and program instructions;

a maintenance data port coupled to the data bus; and

a coprocessor coupled to the data bus to monitor a flow of network data through the external network data port, analyze information regarding the flow of network data, and automatically reconfigure the flow of network data supported by the network apparatus in response to the information indicating that a threshold condition, being data prestored within the memory, has been met.

2. The network apparatus of claim **1** wherein the data bus is a Peripheral Component Interconnect bus.

3. A method comprising:

monitoring information related to network traffic data on the external network data port internally within a network switch;

comparing the information with at least one predefined threshold condition; and

automatically reconfiguring the network switch if the information meets or exceeds the at least one predefined threshold condition by transferring information into the internal memory through a maintenance data port.

4. The network apparatus of claim 1 wherein the maintenance data port is coupled to an external network maintenance station.

5. The network apparatus of claim 1 further comprising a set of monitor program instructions stored in the memory and executed by the coprocessor.

6. The network apparatus of claim 5 wherein the set of monitor program instructions comprises program instructions transferred to the memory through the maintenance data port from an external network maintenance station.

7. The network apparatus of claim 1 further comprising a set of network configuator program instructions stored in the memory and executed by the coprocessor.

8. The network apparatus of claim 7 wherein the set of network configuator program instructions comprises program instructions transferred to the memory through the maintenance data port from an external network maintenance station.

9. The network apparatus of claim 1 wherein the processor transfers monitor information through the maintenance data port to an external network maintenance station.

10. A method for configuring a network switch having an external network data port, a maintenance data port, processor, memory, data bus, and coprocessor, the method comprising:

loading software for use by the coprocessor to monitor network data traffic through the maintenance data port;

monitoring network data traffic on the external network data port by the coprocessor;

comparing the network data traffic to at least one predefined threshold condition; and

automatically configuring the network switch with the coprocessor if the network data traffic meets the at least one predefined threshold condition.

11. The method of claim 10, wherein the loading of the software further comprises transferring a set of monitor program instructions to the memory through a maintenance data port from an external network maintenance station.

12. The method of claim 10 further comprising transferring a set of network configuator program instructions to the memory through a maintenance data port from an external network maintenance station.

13. The method of claim 10 further comprising uploading monitor information about the network data to an external network maintenance station through a maintenance data port.

14. The method of claim 10 wherein the act of automatically configuring the network switch comprises configuring the network switch in response to instructions received from the coprocessor.

15. The method of claim 10 wherein the act of automatically configuring the network switch comprises configuring the network switch in response to instructions received from an external network maintenance station through a maintenance data port.

16. The method of claim 3 wherein the reconfiguring of the network switch includes

transferring Java bytecode to a Java Virtual Machine loaded in the network switch; and

converting the Java bytecode into machine code executed by the network switch.

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