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(54) **SYSTEM AND METHODOLOGY PROVIDING AUTOMATION SECURITY ANALYSIS, VALIDATION, AND LEARNING IN AN INDUSTRIAL CONTROLLER ENVIRONMENT**

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USPC **726/22**

(57) **ABSTRACT**

The present invention relates to a system and methodology facilitating automation security in a networked-based industrial controller environment. Various components, systems and methodologies are provided to facilitate varying levels of automation security in accordance with security analysis tools, security validation tools and/or security learning systems. The security analysis tool receives abstract factory models or descriptions for input and generates an output that can include security guidelines, components, topologies, procedures, rules, policies, and the like for deployment in an automation security network. The validation tools are operative in the automation security network, wherein the tools perform security checking and/or auditing functions, for example, to determine if security components are in place and/or in suitable working order. The security learning system monitors/learns network traffic patterns during a learning phase, fires alarms or events based upon detected deviations from the learned patterns, and/or causes other automated actions to occur.

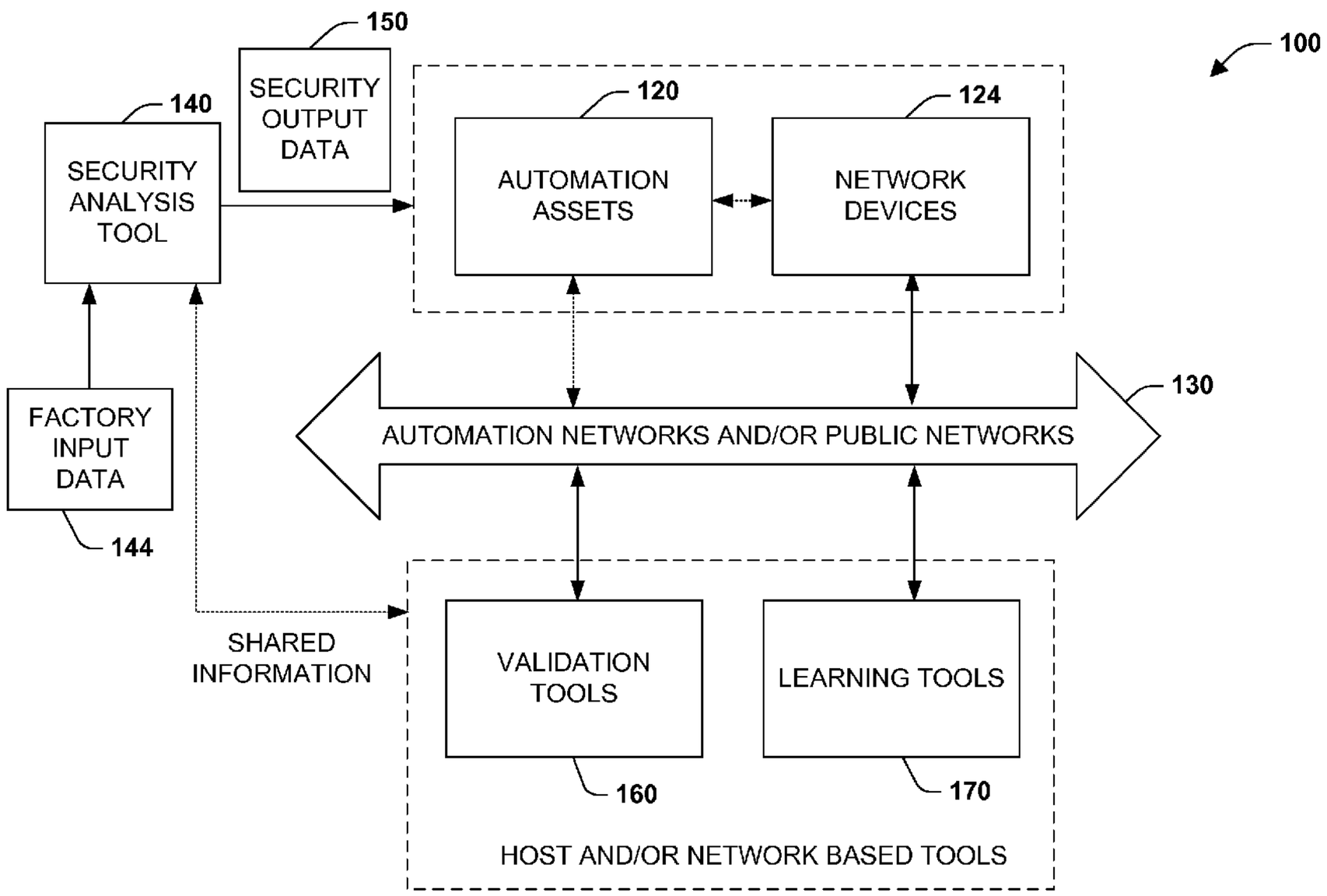
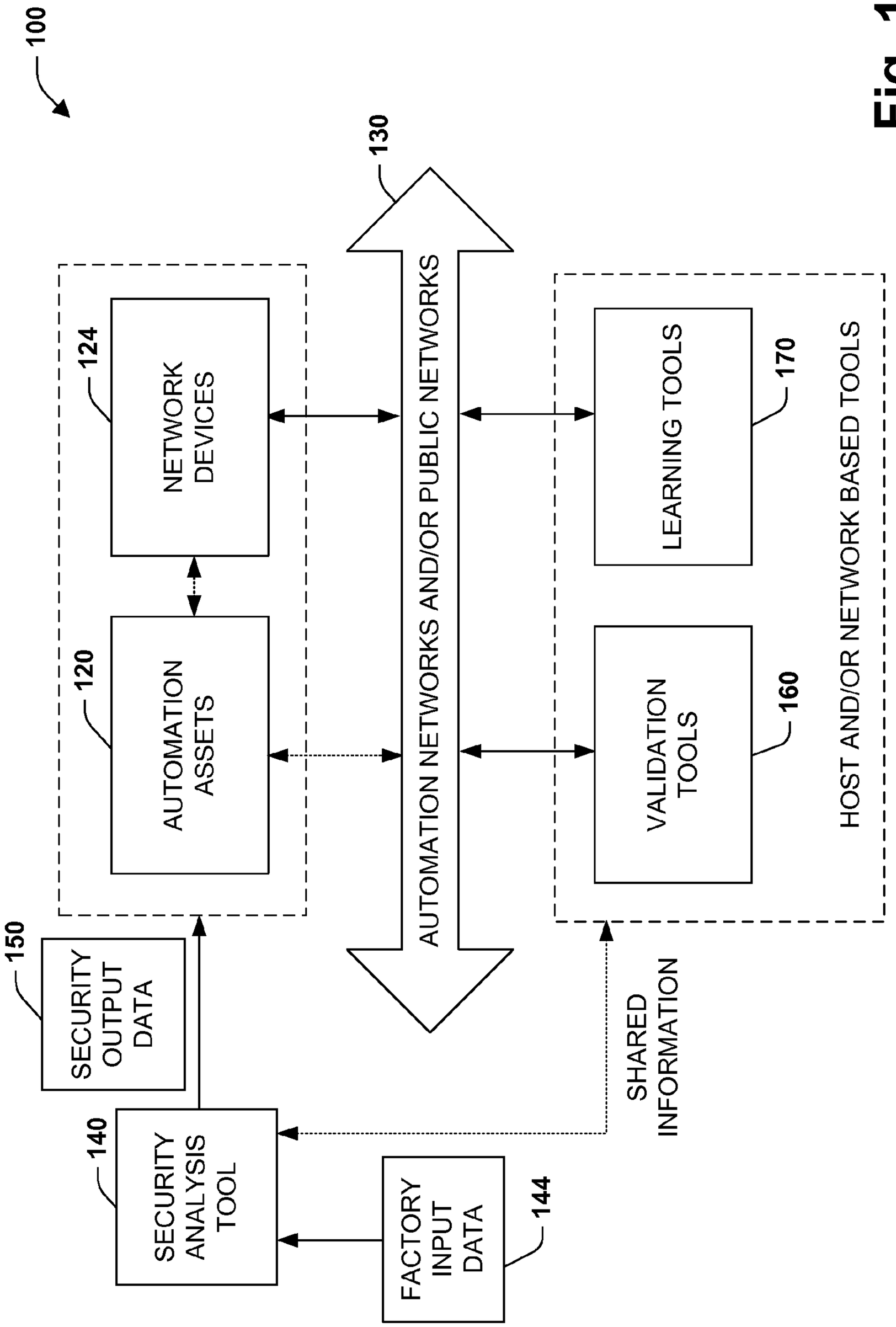
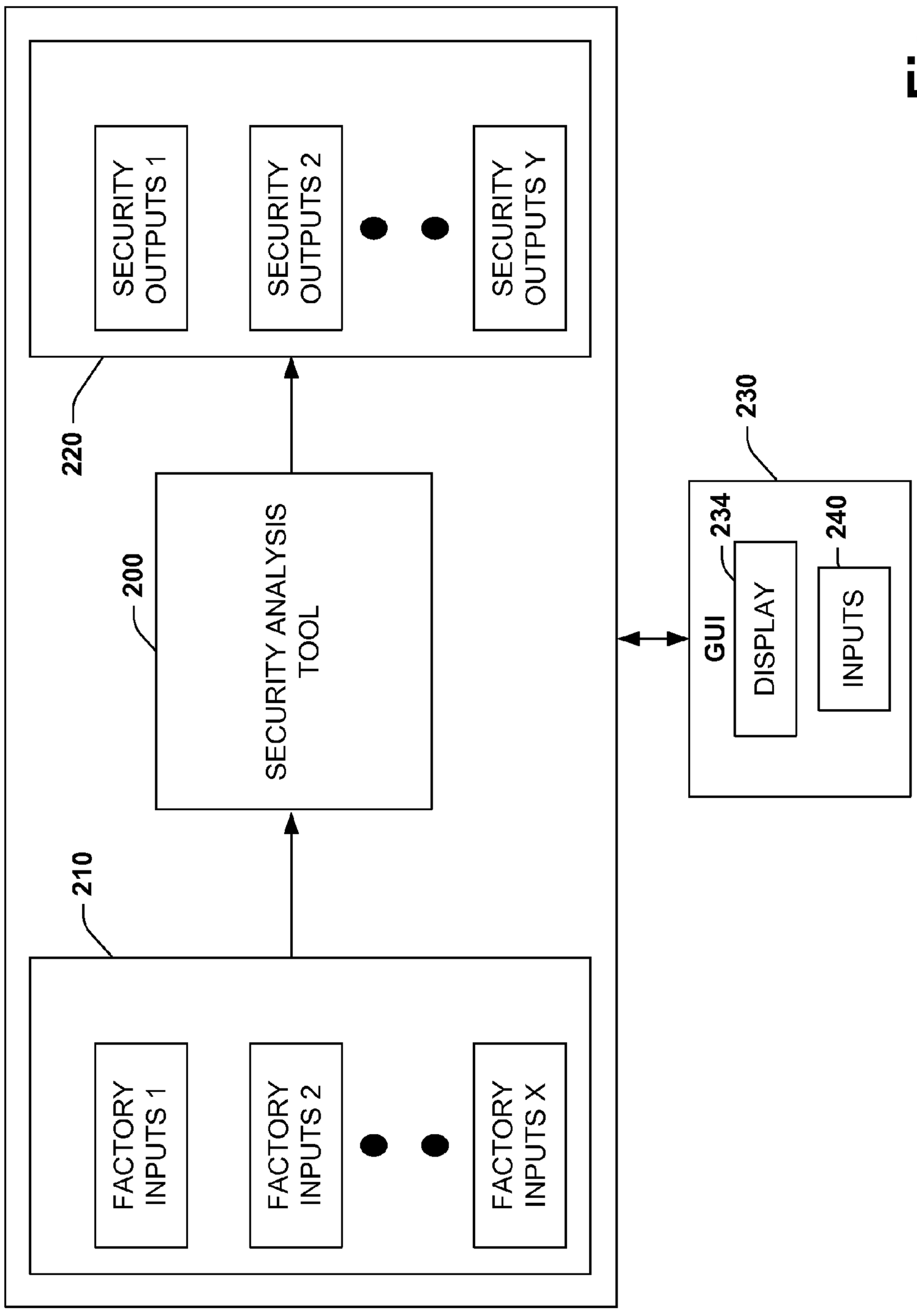


Fig. 1


100
130
AUTOMATION NETWORKS AND/OR PUBLIC NETWORKS
124
NETWORK DEVICES
120
AUTOMATION ASSETS
HOST AND/OR NETWORK BASED TOOLS
LEARNING TOOLS
170
VALIDATION TOOLS
160
SHARED INFORMATION
150
SECURITY OUTPUT DATA
140
SECURITY ANALYSIS TOOL
FACTORY INPUT DATA
144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SECURITY OUTPUTS 2
SECURITY OUTPUTS Y
220
200
SECURITY ANALYSIS TOOL
210
FACTORY INPUTS 1
FACTORY INPUTS 2
FACTORY INPUTS X
230
GUI
234
DISPLAY
240
INPUTS

Fig. 2

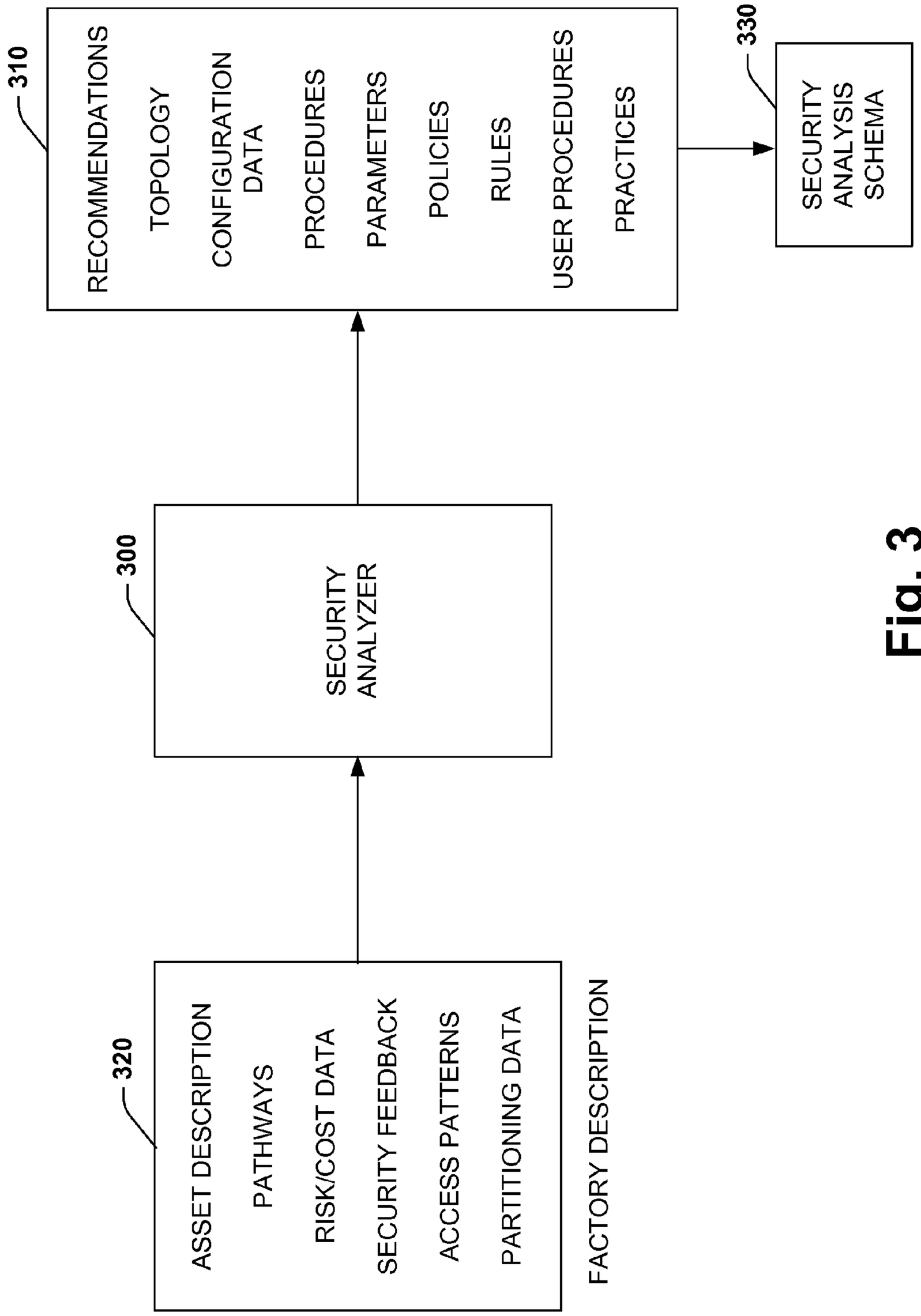
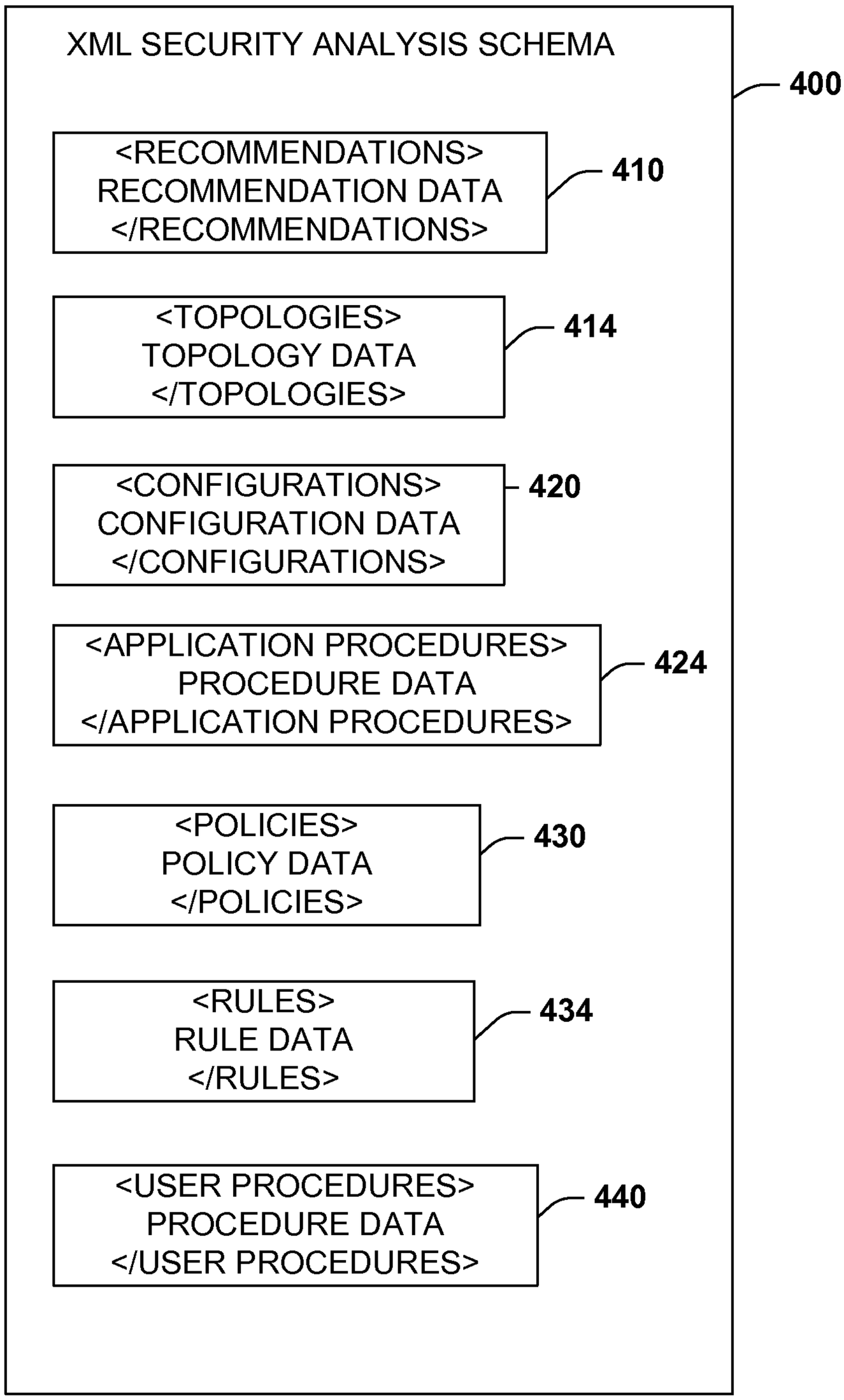

310
RECOMMENDATIONS
TOPOLOGY
CONFIGURATION DATA
PROCEDURES
PARAMETERS
POLICIES
RULES
USER PROCEDURES
PRACTICES
330
SECURITY ANALYSIS SCHEMA
300
SECURITY ANALYZER
320
ASSET DESCRIPTION
PATHWAYS
RISK/COST DATA
SECURITY FEEDBACK
ACCESS PATTERNS
PARTITIONING DATA
FACTORY DESCRIPTION

Fig. 3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414
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430
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434
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440

Fig. 4

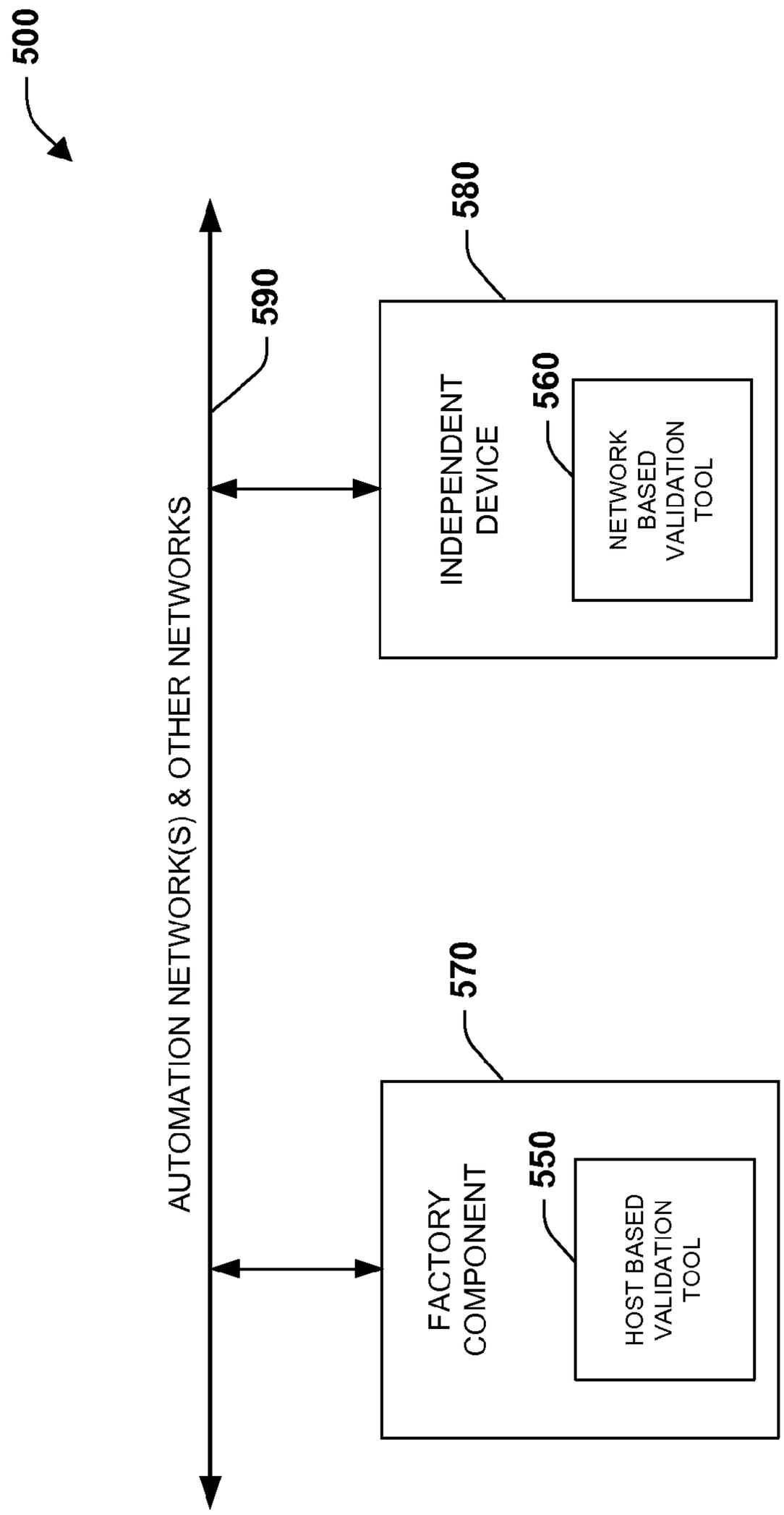
500
580
590
AUTOMATION NETWORK(S) & OTHER NETWORKS
INDEPENDENT DEVICE
560
NETWORK BASED VALIDATION TOOL
570
FACTORY COMPONENT
550
HOST BASED VALIDATION TOOL

Fig. 5

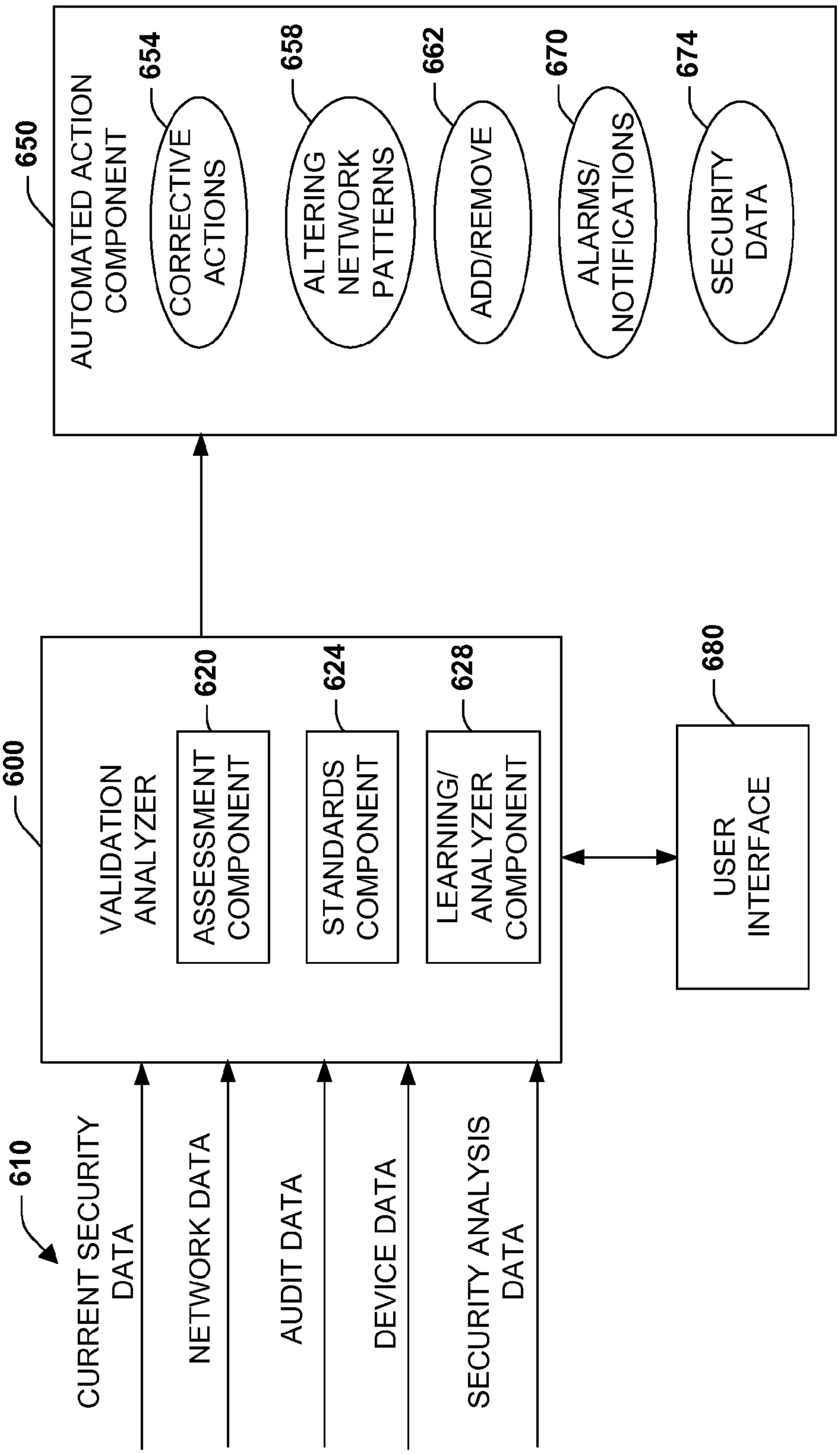
650
AUTOMATED ACTION COMPONENT
654
CORRECTIVE ACTIONS
658
ALTERING NETWORK PATTERNS
662
ADD/REMOVE
670
ALARMS/ NOTIFICATIONS
674
SECURITY DATA
600
VALIDATION ANALYZER
620
ASSESSMENT COMPONENT
624
STANDARDS COMPONENT
628
LEARNING/ ANALYZER COMPONENT
680
USER INTERFACE
610
CURRENT SECURITY DATA
NETWORK DATA
AUDIT DATA
DEVICE DATA
SECURITY ANALYSIS DATA

Fig. 6

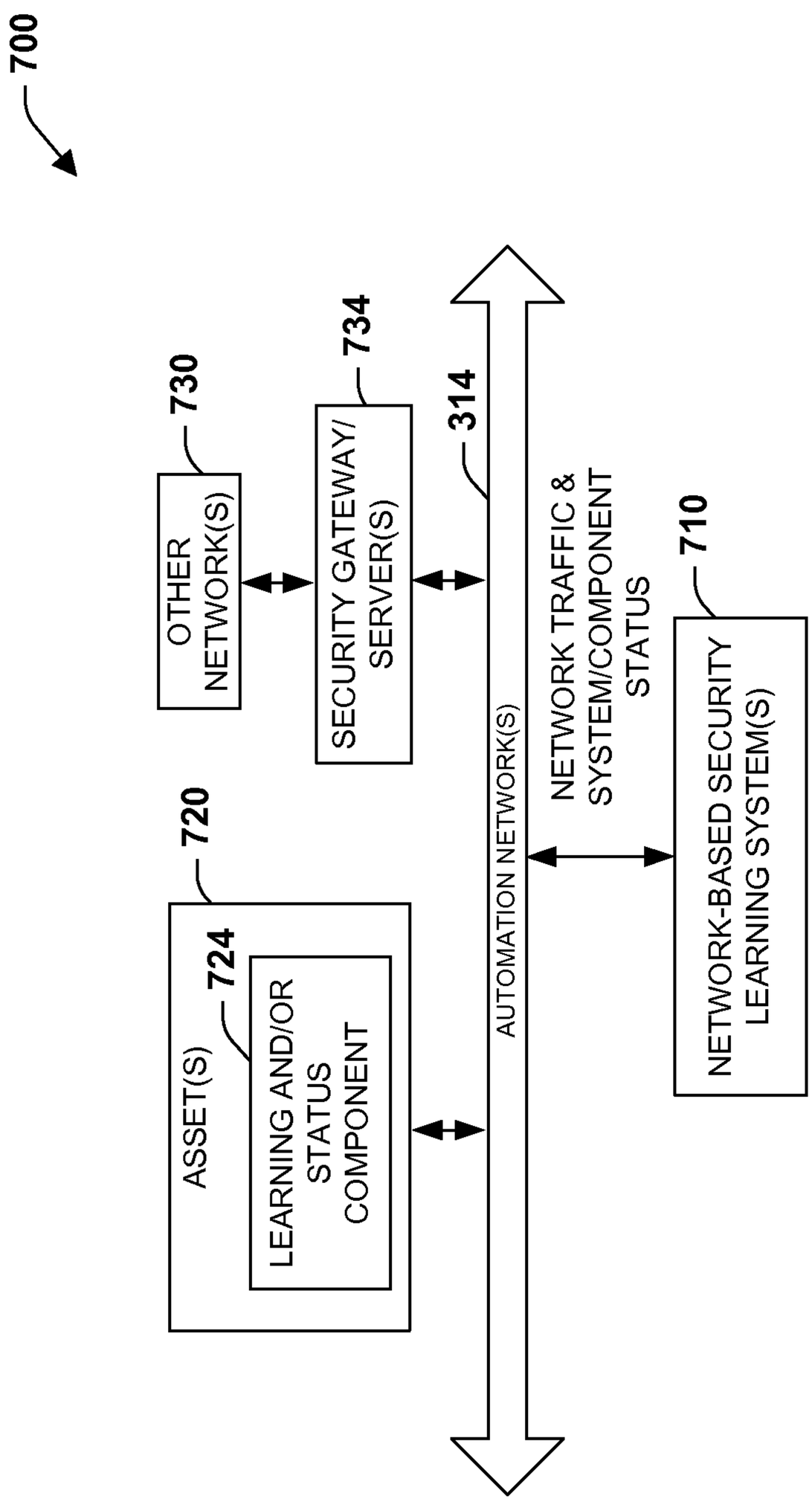
700
OTHER NETWORK(S)
730
SECURITY GATEWAY/ SERVER(S)
734
314
ASSET(S)
720
LEARNING AND/OR STATUS COMPONENT
724
AUTOMATION NETWORK(S)
NETWORK TRAFFIC & SYSTEM/COMPONENT STATUS
NETWORK-BASED SECURITY LEARNING SYSTEM(S)
710

Fig. 7

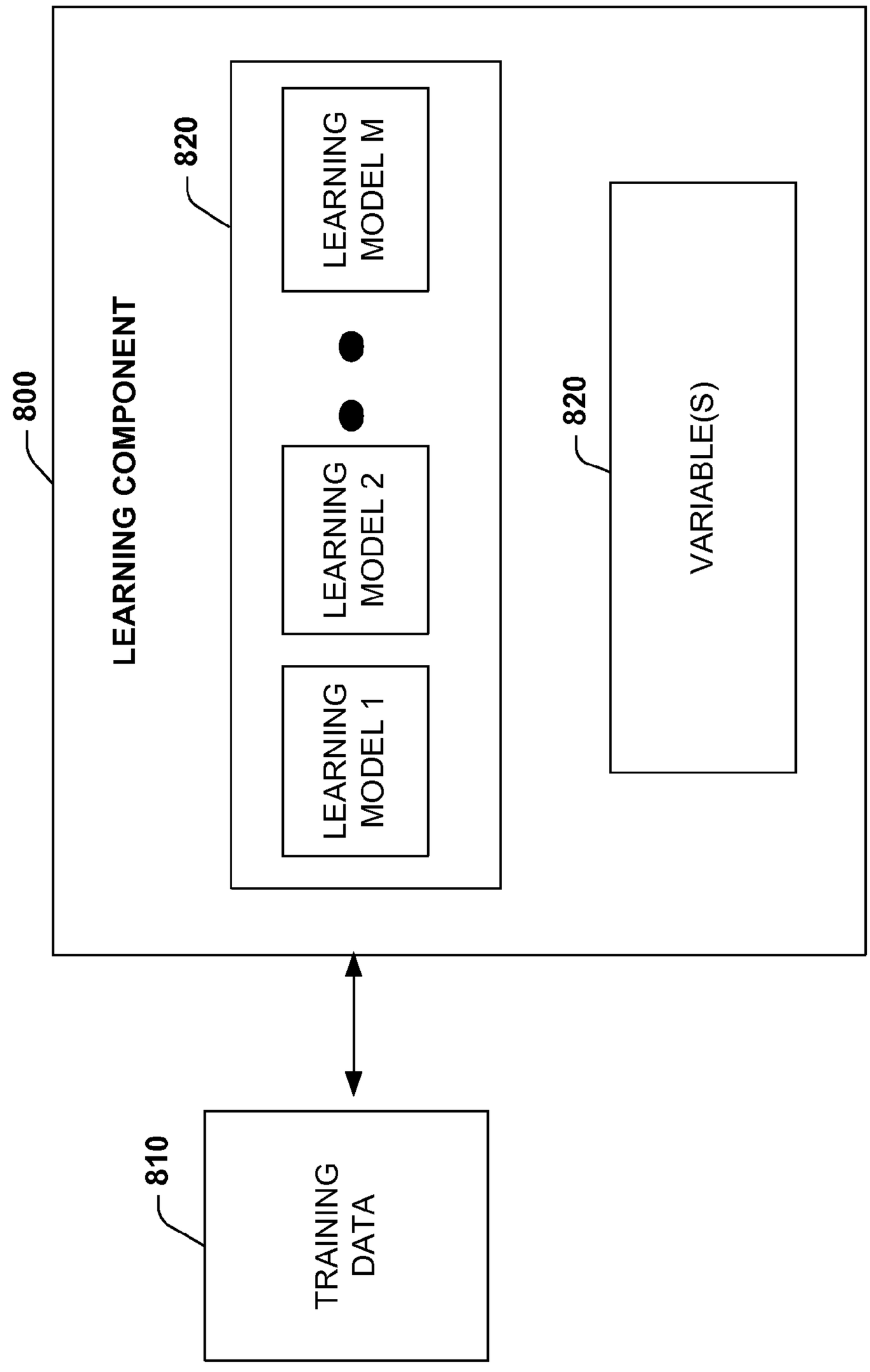
800
LEARNING COMPONENT
820
LEARNING MODEL M
LEARNING MODEL 2
LEARNING MODEL 1
820
VARIABLE(S)
810
TRAINING DATA

Fig. 8

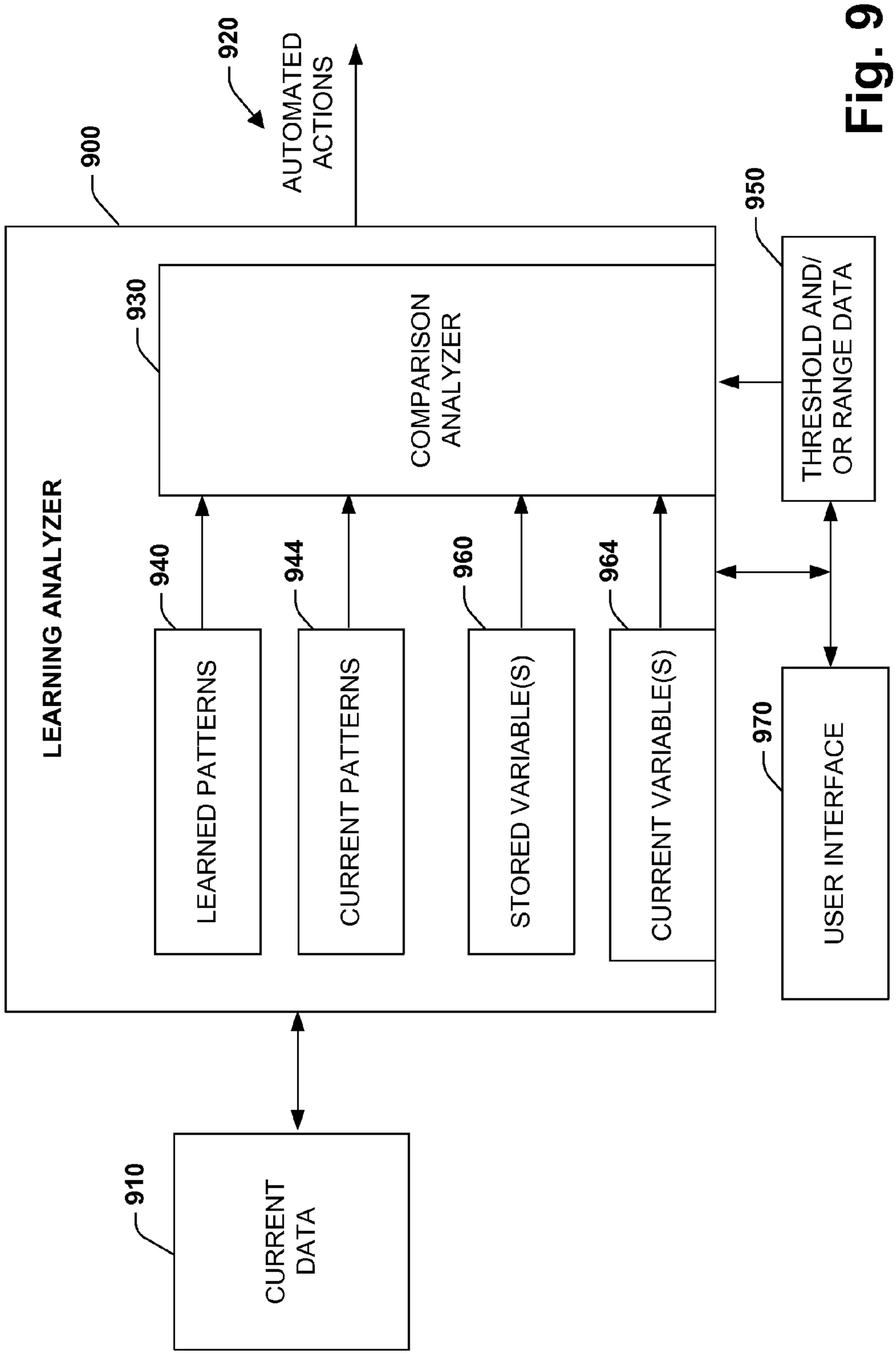
900
920
AUTOMATED ACTIONS
950
930
COMPARISON ANALYZER
THRESHOLD AND/ OR RANGE DATA
LEARNING ANALYZER
940
LEARNED PATTERNS
944
CURRENT PATTERNS
960
STORED VARIABLE(S)
964
CURRENT VARIABLE(S)
970
USER INTERFACE
910
CURRENT DATA

Fig. 9

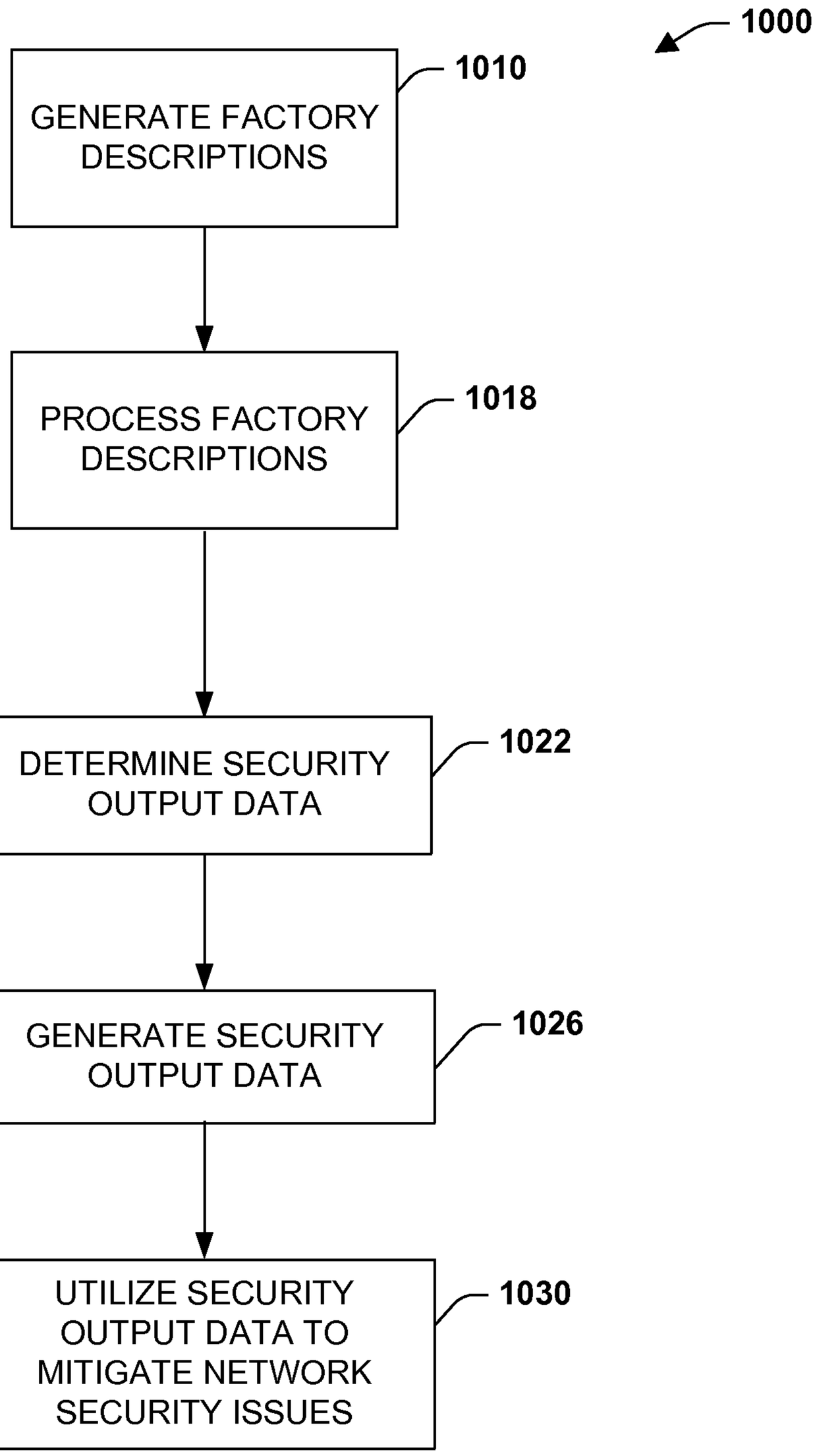
1000
GENERATE FACTORY DESCRIPTIONS
1010
PROCESS FACTORY DESCRIPTIONS
1018
DETERMINE SECURITY OUTPUT DATA
1022
GENERATE SECURITY OUTPUT DATA
1026
UTILIZE SECURITY OUTPUT DATA TO MITIGATE NETWORK SECURITY ISSUES
1030

Fig. 10

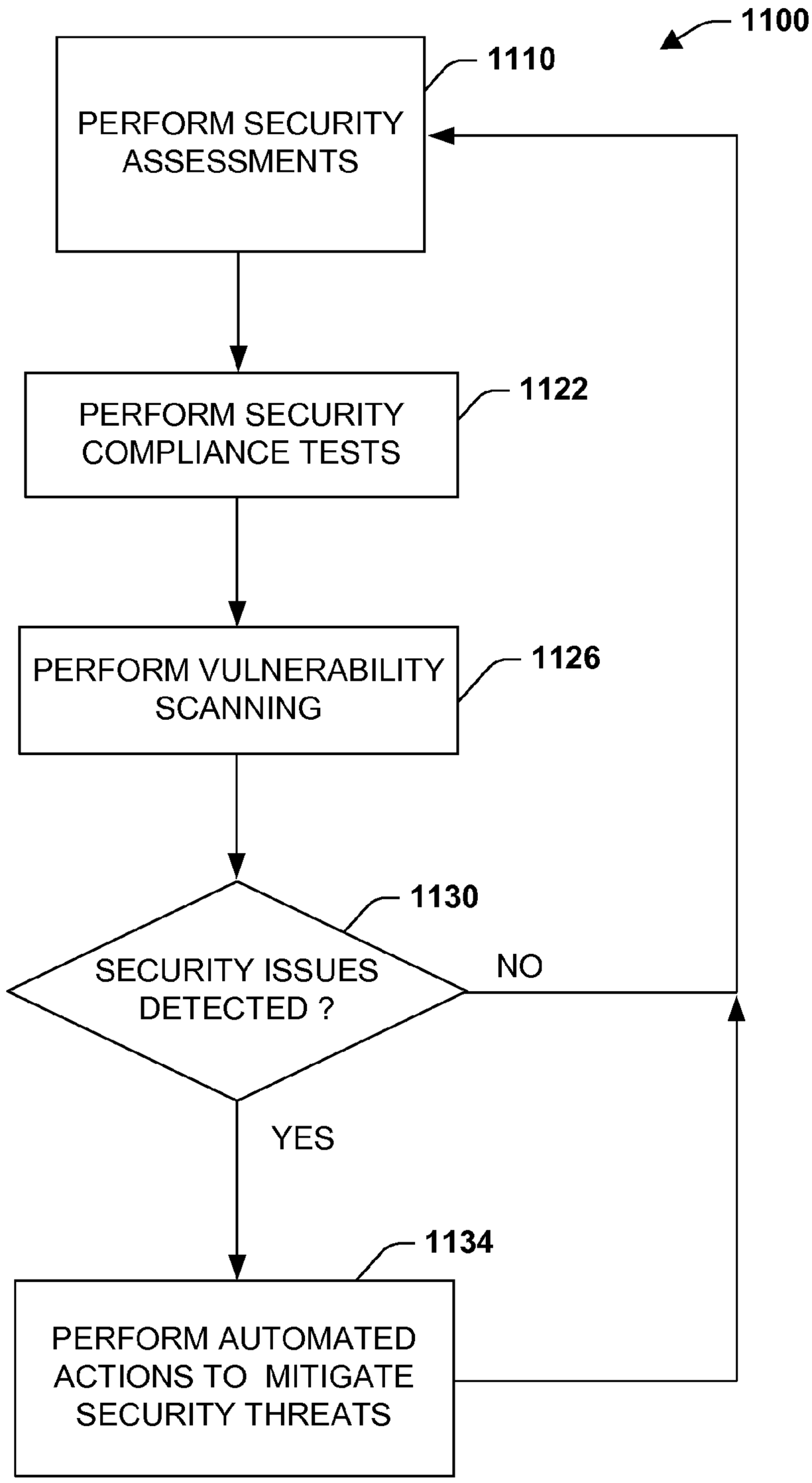
1100
1110
PERFORM SECURITY ASSESSMENTS
1122
PERFORM SECURITY COMPLIANCE TESTS
1126
PERFORM VULNERABILITY SCANNING
1130
SECURITY ISSUES DETECTED ?
NO
YES
1134
PERFORM AUTOMATED ACTIONS TO MITIGATE SECURITY THREATS

Fig. 11

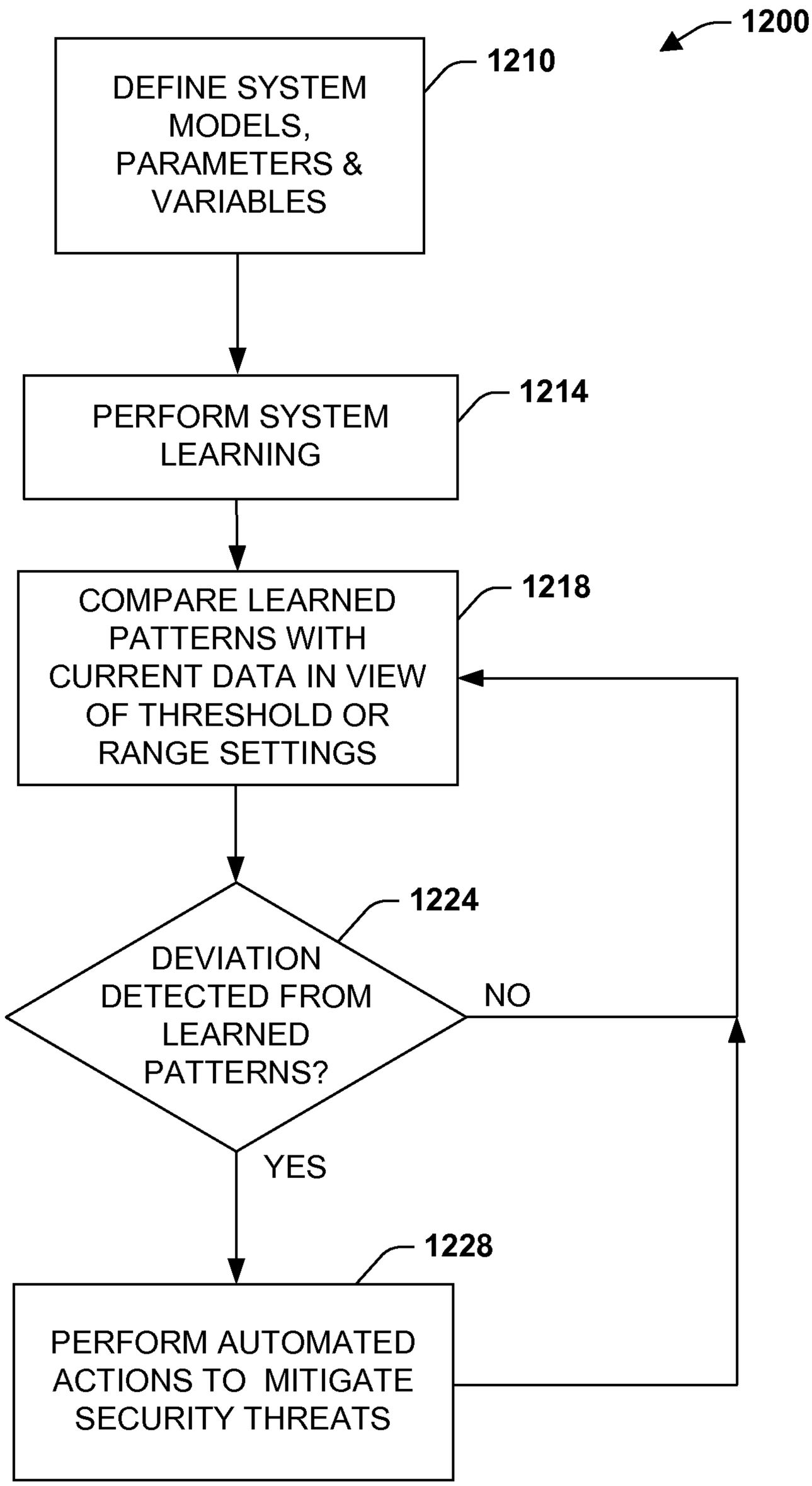
1200
DEFINE SYSTEM MODELS, PARAMETERS & VARIABLES
1210
PERFORM SYSTEM LEARNING
1214
COMPARE LEARNED PATTERNS WITH CURRENT DATA IN VIEW OF THRESHOLD OR RANGE SETTINGS
1218
DEVIATION DETECTED FROM LEARNED PATTERNS?
1224
NO
YES
PERFORM AUTOMATED ACTIONS TO MITIGATE SECURITY THREATS
1228

Fig. 12

SYSTEM AND METHODOLOGY PROVIDING AUTOMATION SECURITY ANALYSIS, VALIDATION, AND LEARNING IN AN INDUSTRIAL CONTROLLER ENVIRONMENT

REFERENCE TO RELATED APPLICATION(S)

[0001] This application is a continuation of, and claims priority to, U.S. patent application Ser. No. 10/661,696, filed on Sep. 12, 2003, and entitled "SYSTEM AND METHODOLOGY PROVIDING AUTOMATION SECURITY ANALYSIS, VALIDATION, AND LEARNING IN AN INDUSTRIAL CONTROLLER ENVIRONMENT," which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/420,006, filed Oct. 21, 2002, and entitled "SYSTEM AND METHODOLOGY PROVIDING AUTOMATION SECURITY IN AN INDUSTRIAL CONTROLLER ENVIRONMENT." The entireties of these related applications are incorporated herein by reference.

TECHNICAL FIELD

[0002] The present invention relates generally to industrial control systems, and more particularly to a system and methodology to facilitate electronic and network security in an industrial automation system.

BACKGROUND OF THE INVENTION

[0003] Industrial controllers are special-purpose computers utilized for controlling industrial processes, manufacturing equipment, and other factory automation, such as data collection or networked systems. In accordance with a control program, the industrial controller, having an associated processor (or processors), measures one or more process variables or inputs reflecting the status of a controlled system, and changes outputs effecting control of such system. The inputs and outputs may be binary, (e.g., on or off), as well as analog inputs and outputs assuming a continuous range of values.

[0004] Measured inputs received from such systems and the outputs transmitted by the systems generally pass through one or more input/output (I/O) modules. These I/O modules serve as an electrical interface to the controller and may be located proximate or remote from the controller including remote network interfaces to associated systems. Inputs and outputs may be recorded in an I/O table in processor memory, wherein input values may be asynchronously read from one or more input modules and output values written to the I/O table for subsequent communication to the control system by specialized communications circuitry (e.g., back plane interface, communications module). Output modules may interface directly with one or more control elements, by receiving an output from the I/O table to control a device such as a motor, valve, solenoid, amplifier, and the like.

[0005] At the core of the industrial control system, is a logic processor such as a Programmable Logic Controller (PLC) or PC-based controller. Programmable Logic Controllers for instance, are programmed by systems designers to operate manufacturing processes via user-designed logic programs or user programs. The user programs are stored in memory and generally executed by the PLC in a sequential manner although instruction jumping, looping and interrupt routines, for example, are also common. Associated with the user program are a plurality of memory elements or variables that provide dynamics to PLC operations and programs. These variables can be user-defined and can be defined as bits, bytes, words, integers, floating point numbers, timers, counters and/or other data types to name but a few examples.

[0006] Various remote applications or systems often attempt to update and/or acquire PLC information or related device information via a plurality of different, competing and often incompatible or insecure network technologies. A major concern with this type of access to PLC's and control systems in general, relates to the amount of security that is provided when sending or receiving data to and from the PLC and/or associated equipment. In most factories or industrial environments, complex and sometimes dangerous operations are performed in a given manufacturing setting. Thus, if a network-connected controller were inadvertently accessed, or even worse, intentional sabotage were to occur by a rogue machine or individual, potentially harmful results can occur.

[0007] One attempt at providing security in industrial control systems relates to simple password protection to limit access to the systems. This can take the form of a plant or controls Engineer or Administrator entering an alpha-numeric string that is typed by an operator each time access is attempted, wherein the controller grants access based on a successful typing of the password. These type passwords are highly prone to attack or discovery, however. Often times, users employ passwords that are relatively easy to determine (e.g., person's name or birthday). Sometimes, users exchange passwords with other users, whereby the password is overheard or simply, a user with improper authorization comes in contact with the password. Even if a somewhat higher level of security is provided, parties employing sophisticated hacking techniques can often penetrate sensitive control systems, whereby access should be limited to authorized users and/or systems in order to mitigate potentially harmful consequences.

SUMMARY OF THE INVENTION

[0008] The following presents a simplified summary of the invention in order to provide a basic understanding of some aspects of the invention. This summary is not an extensive overview of the invention. It is intended to neither identify key or critical elements of the invention nor delineate the scope of the invention. Its sole purpose is to present some concepts of the invention in a simplified form as a prelude to the more detailed description that is presented later.

[0009] The present invention relates to a system and methodology to facilitate network and/or automation device security in an industrial automation environment. Various systems and methodologies are provided to promote security across and/or within networks and in accordance with different automation device capabilities. In one aspect of the present invention, a Security Analysis Methodology (SAM) and tool provides an automated process, component, and tool that generates a set (or subset) of security guidelines, security data, and/or security components. An input to the tool can be in the form of an abstract description or model of a factory, wherein the factory description includes one or more assets to be protected and associated pathways to access the assets. Security data generated by the tool includes a set of recommended security components, related interconnection topology, connection configurations, application procedures, security policies, rules, user procedures, and/or user practices, for example.

[0010] SAM can be modeled on a risk-based/cost-based approach, if desired. A suitable level of protection can be

determined to facilitate integrity, privacy, and/or availability of assets based on risk and/or cost. In addition, descriptions of shop floor access, Intranet access, Internet access, and/or wireless access can also be processed by the tool. Since multiparty involvement can be accommodated (IT, Manufacturing, Engineering, etc.), the tool can be adapted for partitioned security specification entry and sign-off. The security data of the SAM tool can be generated in a structured security data format (e.g., XML, SQL) that facilitates further validation and compliance checking of the security data, if desired.

[0011] In another aspect of the present invention, a security Validation Methodology and associated tools can be provided. The validation tools perform initial and periodic live security assessment of a physical system. This enables security flaws or weaknesses to be identified. One aspect of the tools is to check a system prior to security modifications in order to assess current security levels. Another aspect is to check a system for conformance—either to recommendations of a security analysis, and/or against standards such as ISO, for example. The validation tools can be executed on end devices (host based), and/or executed as an independent device that is operatively coupled to a network (network based) at selected points. One function of host-validation tools is to perform vulnerability scanning and/or auditing on devices. This includes revision checks, improper configuration check, file system/registry/database permissions check, user privilege/password and/or account policy checks, for example.

[0012] One function of the network validation tools is to perform vulnerability scanning and auditing on the networks. This includes checking for susceptibility to common network-based attacks, searching for open TCP/UDP ports, and scanning for vulnerable network services. The tools can also attempt to gain key identity information about end devices that may enable hacker entry. Another function of the network validation tools is to perform vulnerability scanning and auditing on firewalls, routers, and/or other network/security devices. In addition, a complementary tool can be provided to assess CIP-based factory automation systems for security. This will typically be a network-based tool, since factory automation devices often are not as capable as general purpose computing devices. The tool can also be operable in an assessment mode to discover system flaws with little or no configuration, and the tool can operate in a validation mode to check system security against security analysis methodology determinations described above. Still yet other functions can include non-destructively mapping a topology of IT and automation devices, checking revisions and configurations, checking user attributes, and/or checking access control lists. The validation tools described herein can also be adapted to automatically correct security problems (e.g., automatically adjust security parameters/rules/policies, install new security components, remove suspicious components, and so forth).

[0013] According to another aspect of the present invention, a Security Learning system is provided that can include network-based aspects and/or host-based aspects and similar to some of the security aspects described above with respect to the Validation tools. A network-based security learning system (also referred to as learning component) is provided that monitors an automation network during a predetermined training period (e.g., monitor network activities for 1 week). During the training period, the learning component monitors and learns activities or patterns such as: the number of network requests to and from one or more assets; the type of requests (e.g., read/write, role/identity of person/system requesting access, time of requests); status or counter data (e.g., network access counters, error codes) which can be provided or queried from a learning or status component within the asset; and/or monitor and learn about substantially any data type or pattern that may be retrieved from the network and/or the asset.

[0014] After the training period, the learning component monitors the automation network and/or assets for detected deviations from data patterns learned during the training period. If desired, a user interface can be provided, wherein one or more pattern thresholds can be adjusted (also can provide options for the type of data patterns to monitor/learn). For example, if the number of network requests to the asset has been monitored and learned to be about 1000 requests per hour during the past month, then a threshold can be set via the user interface that triggers an alarm or causes an automated event to occur if a deviation is detected outside of the threshold (e.g., automatically disable all network requests from the other networks if the number of network requests to the asset exceeds 10% of the average daily network requests detected during the training period).

[0015] Various learning functions and/or processes can be provided to facilitate automated learning within the learning components. This can include mathematical processes, statistical processes, functions, and/or algorithms and include more elaborate systems such as a neural network, for example. In addition, artificial intelligence functions, components and/or processes can be provided. Such components can include automated classifiers for monitoring and learning data patterns, wherein such classifiers include inference models, Hidden Markov Models (HMM), Bayesian models, Support Vector Machines (SVM), vector-based models, decision trees, and the like.

[0016] The following description and the annexed drawings set forth in detail certain illustrative aspects of the invention. These aspects are indicative, however, of but a few of the various ways in which the principles of the invention may be employed and the present invention is intended to include all such aspects and their equivalents. Other advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1** is a schematic block diagram illustrating automation security tools in accordance with an aspect of the present invention.

[0018] FIG. **2** is a schematic block diagram illustrating a security analysis tool in accordance with an aspect of the present invention.

[0019] FIG. **3** is a diagram illustrating an example security analyzer in accordance with an aspect of the present invention.

[0020] FIG. **4** is a diagram illustrating an example security analysis schema in accordance with an aspect of the present invention.

[0021] FIG. **5** is a diagram illustrating a validation system, methodology, and security validation tools in accordance with an aspect of the present invention.

[0022] FIG. **6** is a schematic block diagram illustrating a validation analyzer in accordance with an aspect of the present invention.

[0023] FIG. **7** is a schematic block diagram illustrating a security learning system in accordance with an aspect of the present invention.

[0024] FIG. **8** is a diagram illustrating a learning component in accordance with an aspect of the present invention.

[0025] FIG. **9** is a schematic block diagram illustrating a learning analyzer in accordance with an aspect of the present invention.

[0026] FIG. **10** is a flow diagram illustrating security analysis processing in accordance with an aspect of the present invention.

[0027] FIG. **11** is a flow diagram illustrating security validation processing in accordance with an aspect of the present invention.

[0028] FIG. **12** is a flow diagram illustrating security learning and detection processing in accordance with an aspect of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0029] The present invention relates to a system and methodology facilitating automation security in a networked-based industrial controller environment. Various components, systems and methodologies are provided to facilitate varying levels of automation security in accordance with security analysis tools, security validation tools and/or security learning systems. The security analysis tool receives abstract factory models or descriptions for input and generates an output that can include security guidelines, components, topologies, procedures, rules, policies, and the like for deployment in an automation security network. The validation tools are operative in the automation security network, wherein the tools perform security checking and/or auditing functions, for example, to determine if security components are in place and/or in suitable working order. The security learning system monitors/learns network traffic patterns during a learning phase, fires alarms or events based upon detected deviations from the learned patterns, and/or causes other automated actions to occur.

[0030] It is noted that as used in this application, terms such as "component," "tool," "analyzer, " and the like are intended to refer to a computer-related entity, either hardware, a combination of hardware and software, software, or software in execution as applied to an automation system for industrial control. For example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, a program and a computer. By way of illustration, both an application running on a server and the server can be components. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers, industrial controllers, and/or modules communicating therewith.

[0031] Referring initially to FIG. **1**, a system **100** illustrates various automation security tools in accordance with an aspect of the present invention. One or more automation assets **120** communicate and cooperate with various network devices **124** across a network **130**. The automation assets **120** include substantially any type of control, communications module, computer, I/O device, Human Machine Interface (HMI)) that communicate via the network **130** which includes control, automation, and/or public networks. In one example, the automation assets **120** include Programmable Logic Controllers (PLC) that can also communicate to and control various other assets such as Input/Output modules including Analog, Digital, Programmed/Intelligent I/O modules, other programmable controllers, communications modules, and the like. The network **130** includes public networks such as the Internet, Intranets, and automation networks such as Control and Information Protocol (CIP) networks including DeviceNet and ControlNet. Other networks **130** include Ethernet, DH/DH+, Remote I/O, Fieldbus, Modbus, Profibus, wireless networks, serial protocols, and so forth. In addition to the automation assets **120**, the network devices **124** include various possibilities (hardware and/or software components). These include components such as switches with virtual local area network (VLAN) capability, LANs, WANs, proxies, gateways, routers, firewalls, virtual private network (VPN) devices, intrusion detection systems, servers, clients, computers, configuration tools, monitoring tools, and/or other devices.

[0032] According to one aspect of the present invention, various security tools can be provided with the system **100**. Although three tools are illustrated, it is to be appreciated that more or less than three tools can be employed with the present invention and in a plurality of similar or different combinations. In one aspect, a security analysis tool **140** is provided that receives factory input data **144** describing or modeling various aspects of the automation assets **120**, network devices **124**, network **130**, and/or system **100**. The security analysis tool **140** processes the factory input data **144** and generates security output data **150** which is then deployed to machines and/or users in order to facilitate suitable network security measures and practices in the system **100**. As will be described in more detail below, such measures can include security recommendations, configuration guidelines or adjustments, procedures, rules, policies, and security parameters, for example, that are utilized to mitigate unwanted intrusions or attacks from the network **130** that may affect the automation assets **120** and/or network devices **124**.

[0033] In another aspect of the present invention, one or more validation tools **160** can be provided (can be host and/or networked based) that perform automated security auditing and checking functions on the network **130**, the automation assets **120**, and/or network devices **124** to determine if suitable security standards have been implemented. The validation tools also perform periodic or monitored assessments within the system **100** to determine if potential network threats or attacks are at hand. As will be described in more detail below, this can include automated and/or healing operations to mitigate network security threats. In another aspect of the present invention, one or more learning tools **170** can be provided (can also be host and/or networked based) that learn system activities or patterns during a training or configuration period, then perform automated actions in response to detected deviations from the learned activities or patterns. Such automated actions can include altering network activity (e.g., preventing further network attempts to automation assets or network devices) and firing an alarm such as an e-mail or pager to notify an entity (user and/or machine) of a potential or detected problem.

[0034] It is noted that the security tools **140**, **150** and/or **160** can share or exchange information between tools. For example, the security analysis tool **140** can receive input from the validation tool **160** (e.g., three new network devices detected in topology), wherein the security analysis tool generates new or adjusted security output data **150** in response thereto. It is further noted that one or more of the automation

assets **120** may directly access the network **130** and/or may employ the network devices **124** to achieve network access.

[0035] Turning to FIG. **2**, a security analysis tool **200** is illustrated in accordance with an aspect of the present invention. The security analysis tool **200** operates on a computer or workstation and receives one or more factory inputs **210** that can be generated from a plurality of sources. Such sources can include user input, model input (e.g., asset models, network models), schemas, formulas, equations, maps, and codes, for example. The factory inputs **210** are then processed by the security analysis tool **200** to generate one or more security outputs **220** which can also be provided in various forms such as manuals, documents, schemas, executables, codes, e-mails, and/or other electronic data that is described in more detail below. As illustrated, a Graphical User Interface **230** (GUI) or interface application can be provided to interact with the security analysis tool **200**, factory inputs **210**, and/or security outputs **220**. This can include substantially any type of application that sends, retrieves, processes, and/or manipulates factory input data **210**, receives, displays, formats, and/or communicates security output data **220**, and/or facilitates operation of the security analysis tool **200**. For example, such interfaces **230** can also be associated with an engine, editor tool or web browser although other type applications can be utilized. The GUI **230** includes a display **234** having one or more display objects (not shown) including such aspects as configurable icons, buttons, sliders, input boxes, selection options, menus, tabs and so forth having multiple configurable dimensions, shapes, colors, text, data and sounds to facilitate operations with the security analysis tool **200**. In addition, the GUI **230** can also include a plurality of other inputs **240** or controls for adjusting and configuring one or more aspects of the present invention. This can include receiving user commands from a mouse, keyboard, speech input, web site, remote web service and/or other device such as a camera or video input to affect or modify operations of the GUI **230**.

[0036] Referring now to FIG. **3**, an example security analyzer **300** is illustrated in accordance with an aspect of the present invention. The security analyzer **300** can be an automated process, application, component, and/or tool that generates a set of security guidelines or security data **310** and executes a Security Analysis Method (SAM) in accordance with the present invention. An input to the security analyzer **300** is an abstract description of a factory depicted as factory data **320**. The factory data **320** can describe or model one or more automation assets to be protected and associated network pathways to access the assets. Other factory data **320** can include risk data, cost data, security feedback from other security tools, network access patterns, and partitioning data, for example. Security data **310** generated by the security analyzer **300** includes a set of recommended security components, related interconnection topology, connection configurations, application procedures, security policies, rules, user procedures, and/or user practices, for example, that is employed to guide users and adapt systems with various security measures.

[0037] The Security Analysis Method noted above, and security analyzer **300** can also be modeled on a risk-based/cost-based approach, if desired. A suitable level of protection can be determined to facilitate integrity, privacy, and/or availability of assets based on risk and/or cost. Thus, security parameters, policies, and procedures, for example, can be increased if lower security risks and associated costs are desired, whereas security measures can be decreased if higher risks and/or costs associated with network attacks or intrusions are deemed acceptable. In addition, descriptions of shop floor access, Intranet access, Internet access, wireless access and/or other network access patterns can also be described as factory data **320** and processed by the security analyzer **300**. Since multiple party involvement can be accommodated (e.g., IT, Manufacturing, Engineering, etc.), the security analyzer **300** can be adapted for partitioned security specification entry and sign-off. The security data **310** can be generated in a structured security data format (e.g., XML, SQL) that facilitates further validation and compliance checking of the security data, if desired. As illustrated, a security analysis schema **330** which is described in more detail below, can be derived from the security data **310** and can be provided to other entities such as users or machines for further security processing/implementations.

[0038] FIG. **4** illustrates an exemplary schema that may be employed for security deployments, communications, and configurations in accordance with the present invention. Although the schema represents one possible manner in which to transfer data to and from an entity such as a user, interface, file, an automation component and associated network devices, it is to be appreciated that other possible data transfer mechanisms may be employed. For example, data can be transmitted in the form of binary or other type data packets that convey information in accordance with the present invention.

[0039] Referring to FIG. **4**, an example security analysis schema **400** is illustrated in accordance with an aspect of the present invention. The security analysis schema **400** includes one or more XML elements **410** through **440** (defined by starting and ending tags with (</> symbols), arranged in substantially any order) that relate to one or more security items or data and provide information to facilitate security guidelines and configurations. Although not shown, the XML elements and associated tags can also include attribute information if desired, wherein an attribute is a name-value pair associated with an element start tag (e.g., <topology="PLC connected to gateway device having firewall protection">). The security analysis schema **400** can then be deployed to various systems and/or components to control/adapt network access based upon the security contents specified therein.

[0040] Proceeding to **410**, a recommendations element can be provided having associated recommendations data. This can include suggestions as to how to adapt automation components and network devices for suitable security measures (e.g., in view of risk and cost criteria). In one example, a suggestion can be in the form of a statement "All real time control devices and networks should only be connected to public networks via front-end server having virus detection, intrusion detection, and virtual private network capabilities." In another example, "Remote factory network devices must be identified, authorized, and authenticated before achieving access to control network, otherwise, local factory network devices should communicate with low-end encryption technologies." As can be appreciated, a plurality of such recommendations can be provided. At **414**, a topologies element can be provided. This can include information on how to interconnect various devices and networks to achieve desired security goals (e.g., PLC connects to router, router connects to factory server and protected gateway . . .). In another aspect, the topology data **414** can be in the form of symbols or

codes that are employed to construct topology or network maps/displays via a visual or other type application.

[0041] At **420**, configuration data can be provided. This type of data can include settings or parameters for adapting network components with suitable security measures (e.g., communications module word three should be set to value 03AA Hex for extended security checking, set dip switch two on gateway to cause authentication and authorization procedures with outside network devices, install virus detection software on network server . . .). In another aspect, the configuration data can be sent or deployed to devices via the schema **400** and loaded to cause automatic configurations. At **424**, an applications procedure element can be provided having associated procedure data. Such data can include the types of security applications to load, any security adjustments or settings relating to the applications, application status information to verify, and procedures for correctly operating respective security applications to mitigate potential attacks or threats.

[0042] At **430**, policy data can be provided. The policy can be general and/or specific, applied system wide and/or to a device or subset of devices. For example location-based policies can be initiated (e.g., all network requests from listed URL's are to be denied, network requests from Pittsburgh server limited to 100 per day). Time-based policies can also be defined (e.g., no outside network requests allowed between 10:00 AM and 2:00 PM). Process-based policies can be defined such as for example, "Limit outside network requests to below 50 during real time batch operations." Other policies include load-based policies, whereby network requests that are responded to are regulated in accordance with an amount of desired network traffic (e.g., regulated according to requests/hour). Other policies may be related to the type of requests (e.g., all requests to write data to the PLC are to be denied, outside devices cannot update analog module configuration data, communications module to provide status data only). In general, substantially any policy that defines, regulates, and/or limits network activities in view of security considerations can be employed with the present invention.

[0043] At **434**, one or more security rules can be provided that have similar effects as the policies described above. For example, rules can be provided in an If/Then construct (can include else, else if, Boolean expressions and the like), wherein if a defined condition or conditions occur, then one or more listed actions result (can included nested constructs) (e.g., If more than 3 network access attempts are negotiated unsuccessfully, then deny further communications with node or address). At **440**, user procedure data can be provided. This can include actual procedure data and/or links to databases or websites to acquire the data. Such data can instruct users on suitable security procedures, security precautions, training, configurations, examples, wizards, manuals, trouble shooting, emergency contacts, contact information, maintenance, and the like which are designed to mitigate system security problems.

[0044] FIG. **5** illustrates a validation system **500**, methodology, and validation tools **550**, **560** in accordance with an aspect of the present invention. The validation tools **550** and **560** perform initial and periodic live security assessment of a physical system. This enables security flaws or weaknesses to be identified. One aspect of the tools is to check the system **500** prior to proposed or attempted security modifications in order to assess current security levels. Another aspect is to check the system **500** for conformance—to the recommendations of a security analysis tool described above, and/or against standards such as ISO, for example.

[0045] The validation tools **550** and **560** can be executed on end devices **570** (host based), and/or executed as an independent device **580** that is attached to a network **590** (network based) at selected points. One function of the host-validation tool **550** is to perform vulnerability scanning and/or auditing on devices. This includes revision checks, improper configuration check, file system/registry/database permissions check, user privilege/password and/or account policy checks, for example.

[0046] One function of the network validation tool **560** is to perform vulnerability scanning and auditing on the networks **590**. This includes checking for susceptibility to common network-based attacks, searching for open TCP/UDP ports, and scanning for vulnerable network services. The tools **550** and **560** can also attempt to gain key identity information about end devices that may enable hacker entry.

[0047] Another function of the network validation tool **560** is to perform vulnerability scanning and auditing on firewalls, routers, and/or other security devices. In addition, a complementary tool can be provided to assess CIP-based factory automation systems for security (includes substantially any factory protocol). This will typically be a network-based tool, since factory automation devices often are not as capable as general purpose computing devices. The network validation tool **560** can also be operable in an assessment mode to discover system flaws with little or no configuration, and the tool can operate in a validation mode to check system security against security analysis methodology determinations described above. Still yet other functions can include non-destructively mapping a topology of IT and automation devices, checking revisions and configurations, checking user attributes, and/or checking access control lists. The validation tools described herein can also be adapted to automatically correct security problems (e.g., automatically adjust security parameters, install new security components, remove suspicious components, and so forth). It is to be appreciated that one or more of the functions described herein for the host validation tool **550** may be shared/interchanged with the network validation tool **560**, and visa versa.

[0048] Referring now to FIG. **6**, a validation analyzer **600** is illustrated in accordance with an aspect of the present invention. The validation analyzer **600** can be a hardware device, computer, processor, application, and/or combination thereof that process one or more security data inputs **610** such as can be received or communicated from a network (not shown). The security data inputs **610** include current security data, network data, audit data, device data, security analysis data, and/or other data that can be derived from scanning or querying a network and associated devices via the validation analyzer **600** for information regarding current network security conditions. Various components can be provided with the validation analyzer **600** to facilitate security monitoring and processing. In one aspect, an assessment component **620** can be provided. The assessment component **620** performs initial and/or periodic security determinations on network systems to identify security deficiencies or problems therein. For example, the assessment component **620** may compare a stored security configuration with a network configuration received from the security data inputs **610**, flag such conditions, and/or institute further actions if differences are detected.

[0049] In another aspect, a standards component **624** can be provided to perform security compliance checking. This can include automated checking prior to proposed or attempted network security modifications in order to assess current security levels. Compliance checking can also include determining conformance to other automated security analysis recommendations, conformance to applicable device/network security standards, and/or in accordance with predetermined or factory-specific standards, for example. Such checking can be in accordance with stored standards or procedures within the validation analyzer **600**, or can include remote checking to such resources as network databases, web sites, web services (e.g., databases linked to Internet Protocol Security Standard, IEEE database). It is noted that the assessment component **620** and/or standards component **624** can initiate vulnerability scanning and/or auditing on devices/networks/systems. This can include revision checks, improper configuration checks, file system/registry/database permissions checks, user privilege/password and/or account policy checks, checking for susceptibility to network-based attacks, searching for open network ports, scanning for vulnerable network services, learning identity information about end devices/users that may enable attack entry, performing vulnerability scanning and auditing on firewalls, routers, and/or other security devices or components, non-destructively mapping a topology of network devices, checking revisions and configurations, checking user attributes, and/or checking network/device access control lists. As can be appreciated, such checking can include comparisons to local/remote databases or sites as noted above.

[0050] In yet another aspect of the present invention, a learning/analyzer component **628** can optionally be provided within the validation analyzer **600**. This component can be adapted to learn network, device, and/or system patterns, scan current network data, and process the current network data in accordance with the learned patterns to possibly initiate other automated actions. The learning/analyzer component **628** will be described in more detail below with respect to FIGS. **7-9**.

[0051] If a security issue or problem is detected by the assessment component **620**, standards component **624**, and/or learning/analyzer component **628**, a flag or event can be fired that triggers an automated action component **650**, wherein one or more automated security actions can be initiated. The automated security actions can include automatically correcting security problems at **654** such as automatically adjusting security parameters, altering network traffic patterns at **658** (e.g., increasing/decreasing communications with a node), installing new security components and/or removing/disabling suspicious components at **662**, firing alarms, and/or automatically notifying entities about detected problems and/or concerns at **670**, and/or generating security data at **674** such as generating an error or log file, generating a schema, generating data to re-configure or re-route network connections, updating a database or remote site, for example. As illustrated, the validation analyzer **600** can be configured and interacted with via a user interface **680** having similar input and output functionality as described above with respect to the user interface depicted in FIG. **2**.

[0052] FIG. **7** illustrates a security learning system **700** in accordance with an aspect of the present invention. The security learning system **700** that can include network-based aspects and/or host-based aspects and similar to some of the security aspects described above with respect to FIG. **5**. A network-based security learning system **710** (also referred to as learning component **710**) is provided that monitors an automation network **714** during a predetermined training period (e.g., monitor network activities for 1 month).

[0053] During the training period, the learning component **710** monitors and learns activities or patterns such as:

[0054] The number of network requests to and from one or more assets **720**;

[0055] the type of requests (e.g., read/write, role/identity of person/system requesting access, time of requests);

[0056] status or counter data (e.g., network access counters, error codes) which can be provided or queried from a learning or status component **724** within the asset **720**;

and/or

[0057] monitor and learn about substantially any data type or pattern that may be retrieved from the network **714** and/or the asset **720**.

[0058] Network activities can also include network requests that are received from outside networks **730** that may be routed through a security gateway or server **734** before reaching the automation network **714**.

[0059] After the training period, the learning component **710** monitors the automation network **714** and/or assets **720** for detected deviations from data patterns learned during the training period. If desired, a user interface (not shown) can be provided, wherein one or more pattern thresholds can be adjusted (also can provide options for the type of data patterns to monitor/learn). For example, if the number of network requests to the asset **720** has been monitored and learned to be about 1000 requests per hour during the past month, then a threshold can be set via the user interface that triggers an alarm or causes an automated event to occur if a deviation is detected outside of the threshold (e.g., automatically disable all network requests from the other networks **730** if the number of network requests to the asset **720** exceeds a set or determined percentage of the average daily network requests detected during the training period).

[0060] In one aspect, the learning component **710** and associated detection parameters or thresholds can be provided as a network-based tool or tools that can reside at various portions of the automation network **714**. In another aspect, the learning component can be provided as a host-based component as illustrated at **724**—depending on the resources available for the asset **720**.

[0061] Various learning functions and/or processes can be provided to facilitate automated learning within the learning components **710** and **724**. This can include mathematical processes, statistical processes, functions, and/or algorithms and include more elaborate systems such as a neural network, for example. In addition, artificial intelligence functions, components and/or processes can be provided. Such components can include automated classifiers for monitoring and learning data patterns, wherein such classifiers include inference models, Hidden Markov Models (HMM), Bayesian models, Support Vector Machines (SVM), vector-based models, decision trees, and the like.

[0062] FIG. **8** illustrates a learning component **800** in accordance with an aspect of the present invention. The learning component **800** can be configured with various data types, circuits, algorithms, applications, and so forth that are adapted to learn from data or events generated from a training data set **810**. The training data set **810** is derived by monitoring network or device activities over a predetermined time-

frame. Such activities include network events, network data, network device activities, automations asset activities, and monitoring status information, for example. The activities can also include network access patterns, network attempts, network sources, data transfer and exchange activities, network/device load considerations, time considerations, and location considerations, for example (e.g., what time does heaviest network traffic occur, where do most network requests originate, what regions do most hacking attempts originate).

[0063] In order to process the training data **810**, the learning component **800** includes one or more learning models **820** and/or learning variables **830**. As noted above, the learning models **820** can include such aspects as neural network functions, inference models, mathematical models, statistical models, probabilistic models, classifiers, and so forth that learn network patterns or occurrences from the training data **810**. It is also noted that the learning models can be adapted similarly (e.g., all models configured as Hidden Markov Models) or adapted in various combinations (e.g., 40 models configured as a neural network, 3 models adapted in a Bayesian configuration, 1 model configured as a vector-based classifier). The learning variables **830** can be focused on selected events or circumstances. For example, a network load variable may record the average number of outside network requests per hour. In another example, a PLC variable may record the average number of network retries that an associated PLC experiences in a given timeframe, whereas another PLC variable records the maximum number of network retries that the PLC experienced during the same timeframe. In another aspect, the learning variables **820** may be employed as counters to record amounts for various events (e.g., record the number of PLC network transfers to I/O device over the last hour). As can be appreciated, a plurality of such variables can be defined and updated to log various network events during a selected training period. After training, the learning component **810** stores learned patterns or events that are then employed by a learning analyzer component described below to monitor and detect network security problems or identify potential security issues.

[0064] FIG. **9** illustrates a learning analyzer **900** in accordance with an aspect of the present invention. The learning analyzer **900** monitors current network and/or device data **910**, determines whether the current data is within tolerance of historical data patterns that were previously learned/recorded, and initiates one or more automated actions **920** if current data **910** including trends derived therefrom are determined outside of the tolerance. These determinations can be achieved via a comparison analyzer **930** that compares learned data patterns with current data patterns **944** in accordance with threshold and/or range data illustrated at **950**. For example, a learned pattern **940** could be that between 11:00 and 12:00, network load between four network devices is about ten million data packet transfers. Thus, if a threshold **950** were set for one million transfers, and if current data patterns **944** exceeded more than one million transfers above the learned data patterns **940** (ten million transfers during the selected period), then the comparison analyzer **930** would detect this overload (e.g., via subtraction of current and learned data, then comparing to threshold data) and initiate the automated actions **920**.

[0065] Similar to the validation components described above, the automated actions **920** can include automatically correcting security problems such as automatically adjusting security parameters, altering network traffic patterns, installing new security components, removing/disabling suspicious components, firing alarms, and/or automatically notifying entities about detected problems and/or concerns among other actions, for example.

[0066] In another aspect, the threshold data **950** can include range data thus providing upper and lower thresholds for given patterns. For example, a range can be specified to detect events that occur within or outside the selected range. In the example above, a range may have been specified as plus and minus one million transfers (do not have to be equidistant ranges), thus if current data patterns were detected to be above eleven million or below nine million transfers, then an automated action **920** would be initiated by the comparison analyzer **930** if current data patterns were outside the selected range of 10 million, +/−1 million transfers. As can be appreciated, a plurality of thresholds and/or ranges **950** can be specified. In addition, the threshold and range data **950** can be specified in various formats (e.g., in accordance with standard deviation), and can include dynamically adjustable thresholds or ranges (e.g., set threshold high in the morning and lower in the afternoon, change threshold according to real time processing requirements).

[0067] As illustrated, the comparison analyzer **930** can also monitor, analyze, and detect deviations of stored variables **960** and current variables **964** in view of the threshold and range data **950**. A user interface **970**, having similar display/input functionality as previously described, can be provided to specify/adjust the threshold and/or range data **950**. The user interface **970** can also interact with and control the learning analyzer **900** (e.g., set threshold or ranges, add, remove, adjust learning models, view analyzer status, configure automated actions, monitor variables, adjust variables, generate security reports and the like).

[0068] FIGS. **10-12** illustrate security methodologies in accordance with an aspect the present invention. While, for purposes of simplicity of explanation, the methodologies are shown and described as a series of acts, it is to be understood and appreciated that the present invention is not limited by the order of acts, as some acts may, in accordance with the present invention, occur in different orders and/or concurrently with other acts from that shown and described herein. For example, those skilled in the art will understand and appreciate that a methodology could alternatively be represented as a series of interrelated states or events, such as in a state diagram. Moreover, not all illustrated acts may be required to implement a methodology in accordance with the present invention.

[0069] FIG. **10** illustrates a security analysis process **1000** in accordance with an aspect of the present invention. Proceeding to **1010**, factory descriptions of automation assets, network devices, network topologies, and/or other factory data are generated. Such data can include an abstract description of a factory, models, equations, maps, and network pathways to access the automation assets. The descriptions can also include risk data, cost data, security data from other security tools, and partitioning or user data, for example. At **1018**, the factory descriptions are processed such as via an object, application, security engine, ASIC, computer, web service, and so forth.

[0070] At **1022**, security output data is determined in accordance with the factory descriptions and processing described above. The security output data can include a set or subset of recommended security components, codes, parameters, set-

tings, related interconnection topology, connection configurations, application procedures, security policies, rules, user procedures, and/or user practices, for example, as noted above. At **1026**, security output data is generated that can be automatically deployed to one or more entities such as users or devices in order to implement various security measures within an automation environment (e.g., data file or schema generated to automatically configure devices, provide user training and precautions, provide security configurations and topologies). At **1030**, when the security output data has been disseminated, entities employ the security data to mitigate network security issues such as unwanted network access and/or network attack.

[0071] FIG. **11** illustrates a security validation process **1100** in accordance with an aspect of the present invention and includes host-based and/or network based processing as noted above. Proceeding to **1110**, security assessments are performed. This can include initial and/or periodic live security assessment of a physical system to identify security flaws or weaknesses. At **1122**, security compliance tests are performed. This can include automated checking prior to proposed or attempted network security modifications in order to assess current security levels. Compliance checking can also include determining conformance to other automated security analysis recommendations, conformance to applicable device/network security standards, and/or in accordance with predetermined or factory-specific guidelines, for example.

[0072] At **1126**, vulnerability scanning and/or auditing on devices/networks is performed. This includes revision checks, improper configuration checks, file system/registry/database permissions checks, user privilege/password and/or account policy checks, checking for susceptibility to common network-based attacks, searching for open network ports, scanning for vulnerable network services, learning identity information about end devices/users that may enable hacker entry, performing vulnerability scanning and auditing on firewalls, routers, and/or other security devices, non-destructively mapping a topology of IT and automation devices, checking revisions and configurations, checking user attributes, and/or checking access control lists. At **1124**, a determination is made as to whether security issues have been detected such as in accordance with the assessments, compliance testing, and scanning/auditing described above. If no security issues are detected at **1124**, the process proceeds back to **1110**. If security issues are detected at **1130**, the process proceeds to **1134**. At **1134**, one or more automated security actions are performed to mitigate security threats. This can include automatically correcting security problems such as automatically adjusting security parameters, altering network traffic patterns, installing new security components, removing suspicious components, firing alarms, and/or automatically notifying entities about detected problems and/or suspicions. After automated processing at **1134**, the process proceeds back to **1110** for further security processing, analysis, scanning, and detection.

[0073] FIG. **12** illustrates a security learning and detection process **1200** in accordance with an aspect of the present invention and can also include network-based aspects and/or host-based aspects as noted above. At **1210**, one or more learning components such as learning models, learning systems, parameters, and/or variables are defined that describe various network and/or system properties. Such components can be adapted to determine statistical or pattern information regarding network and system activities. This information can include the number, quantity or average of network requests to and from one or more assets or network devices, the type of requests (e.g., read/write, role/identity of person/system requesting access, time of requests, location of requests), status or counter data (e.g., network access counters, error codes), and/or substantially any data type or pattern that may be retrieved from a network, automation asset, or network device. At **1214**, system learning is performed. This includes monitoring an automation network during a predetermined training period, wherein the learning components described above acquire information about network, system, user, and/or device activities during the training period. For example, a counter variable may learn the average number of network requests that are sent to an automation asset in a given time period (can also be other statistical measures than average). In another example, an intelligent component such as a Bayesian inference model, probability determination, or neural network learns patterns such as "During heaviest network loads, the PLC responds to 25% fewer requests, and during real time processing operations, 35% fewer requests for a maximum of 23 requests per minute processed during such periods, +/−1 standard deviation."

[0074] After the training period at **1214**, learned patterns are compared to current data patterns in view of predetermined threshold or range settings at **1218**. For example, if the mean number of factory network packets transmitted is learned to be about 20,000 bytes per/second, +/−5000 bytes, and a range is set up so that if network traffic goes above 26,000 bytes per second or below 10,000 bytes per second, then system security performance is considered acceptable as long as network traffic remains in the selected range. It is noted that thresholds/ranges can be set according to user desires, automated determinations, and/or according to the amount of risk and/or costs that are deemed acceptable (e.g., for lesser amount of security risk, set thresholds closer to learned patterns).

[0075] At **1224**, a determination is made as to whether or not deviations were detected from learned data patterns at **1218**. If no deviations are detected, the process proceeds back to **1218** for further comparison processing. If deviations are detected at **1224**, then one or more automated actions may be performed. Similar to the process described above, this can include automatically correcting security problems such as automatically adjusting security parameters, altering network traffic patterns, installing new security components, removing suspicious components, firing alarms, and/or automatically notifying entities about detected problems and/or suspicions (e.g., sending an e-mail, alerting a pager, calling a number, generating a file, sounding an alarm, interrupting a web session, opening an instant messaging service, and so forth). After automated processing at **1228**, the process proceeds back to **1224** for further security processing, comparison, and detection.

[0076] What has been described above are preferred aspects of the present invention. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the present invention, but one of ordinary skill in the art will recognize that many further combinations and permutations of the present invention are possible. Accordingly, the present invention is intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims.

What is claimed is:

1. A system for providing security on an industrial network, comprising:

a memory that stores computer-executable components; and

a processor, operatively coupled to the memory, that executes the computer-executable components, the computer-executable components comprising:

a learning component configured to determine a first pattern of data communication between an industrial controller and an industrial asset device based on monitoring of data exchanged between the industrial controller and the industrial asset device via an automation network during a training period; and

an analyzer component configured to determine a second pattern of data communication based on monitoring of the data exchanged between the industrial controller and the industrial asset device subsequent to the training period, and to generate a security output in response to a determination that the second pattern of data communication deviates from the first pattern of data communication in excess of a defined deviation threshold,

wherein the security output is configured to alter a network traffic pattern between the industrial controller and the industrial asset device.

2. The system of claim **1**, further comprising an interface component configured to receive input that modifies the defined deviation threshold.

3. The system of claim **1**, wherein the security output is configured to disable network requests to access the industrial controller from another network that is different than the automation network.

4. The system of claim **1**, wherein the data comprises at least one of input data received by the industrial controller from the industrial asset device and stored in an I/O memory space of the industrial controller or output data written to the I/O memory space by the industrial controller and sent to the industrial asset device.

5. The system of claim **1**, wherein

the learning component is further configured to determine a first average number of network retries performed by the industrial controller during the training period, and

the analyzer component is further configured to generate another security output in response to determining that a second average number of network retries performed by the industrial controller subsequent to the training period exceeds the first average number of network retries in excess of a tolerance.

6. The system of claim **1**, wherein the first pattern of data communication comprises an average number of data packet transfers between the industrial controller and the industrial asset device during a daily range of time.

7. The system of claim **1**, wherein the security output is further configured to adjust a security parameter on at least one of the industrial controller, the industrial asset device, or a network device on the automation network.

8. The system of claim **1**, wherein the analyzer component is further configured to set the security output based on model data that models the industrial controller, the industrial asset device, and one or more network pathways to at least one of the industrial controller or the industrial asset device.

9. The system of claim **8**, wherein the analyzer is further configured to generate, based on analysis of the model, a recommendation output specifying a recommendation for implementing a security countermeasure for an industrial system comprising the industrial controller and the industrial asset device.

10. The system of claim **9**, wherein the recommendation output specifies at least one of a recommended network architecture, a recommendation to connect an identified device of the industrial system to a router, or a recommended security component to be installed on an identified device of the industrial system.

11. A method for implementing industrial network security, comprising:

monitoring, by a system comprising a processor, first data exchange activity between an industrial controller and an industrial asset via a plant network during a training period;

determining, by the system based on the monitoring of the first data exchange activity, a first pattern of data communication between an industrial controller and an industrial asset device;

monitoring, by the system, second data exchange activity between the industrial controller and the industrial asset via the plant network subsequent to the training period;

determining, by the system based on the monitoring of the second data exchange activity, a second pattern of data communication between the industrial controller and the industrial asset device; and

in response to determining that the second pattern of data communication deviates from the first pattern of data communication in excess of a defined tolerance, generating a security output configured to alter a network traffic pattern between the industrial controller and the industrial asset device.

12. The method of claim **11**, wherein the generating the security output comprises configuring the security output to disable network requests for access to the industrial controller originating from another network that is different than the plant network.

13. The method of claim **11**, wherein the monitoring the first data exchange activity comprises monitoring at least one of input data received by the industrial controller from the industrial asset device and stored in an I/O memory space of the industrial controller or output data written to the I/O memory space by the industrial controller and sent to the industrial asset device.

14. The method of claim **11**, further comprising:

determining, based on monitoring of a data register stored on the industrial controller, a first average number of network retries performed by the industrial controller during the training period; and

generating another security output in response to determining that a second average number of network retries performed by the industrial controller subsequent to the training period exceeds the first average number of network retries in excess of the defined tolerance.

15. The method of claim **11**, wherein the determining the first pattern of data communication comprises determining an average number of data packet transfers between the industrial controller and the industrial asset device during a daily range of time.

16. The method of claim **11**, wherein the generating the security output comprises configuring the security output to

adjust a security parameter of at least one of the industrial controller, the industrial asset device, or a network device on the plant network.

17. The method of claim **11**, wherein the generating the security output comprises configuring the security output based on model information that models the industrial controller, the industrial asset device, and one or more network pathways to at least one of the industrial controller or the industrial asset device.

18. A non-transitory computer-readable medium having stored thereon instructions that, in response to execution, cause a security analysis system comprising a processor to perform operations, the operations comprising:

determining a first pattern of data communication between an industrial controller and an industrial asset based on monitoring of first data exchanged between the industrial controller and the industrial asset device via an industrial network during a training period;

determining a second pattern of data communication based on monitoring of second data exchanged between the industrial controller and the industrial asset device after the training period; and

generating a security output in response to a determination that the second pattern of data communication deviates from the first pattern of data communication in excess of a defined tolerance, wherein the security output is configured to alter a network traffic pattern between the industrial controller and the industrial asset device.

19. The non-transitory computer-readable medium of claim **18**, wherein the generating comprises configuring the security output to disable network requests for access to the industrial controller originating from another network that is different than the automation network.

20. The -transitory computer-readable medium of claim **18**, wherein the generating comprises configuring the security output to adjust a security parameter on at least one of the industrial controller, the industrial asset device, or a network device on the industrial network.

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