Title: APPARATUS AND METHOD FOR USING CONFIGURABLE RULES LINKING TRIGGERS WITH ACTIONS TO SUPPORT NOTIFICATIONS ASSOCIATED WITH INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM

Abstract: A method includes receiving (1602) information defining at least one condition and at least one action associated with a rule. Each condition is associated with an event in an industrial process control and automation system (100), and each action is associated with information related to the event. The method also includes, based on actual events in the industrial process control and automation system, generating (1610) one or more notifications (502) for one or more users of one or more mobile devices (150) using the rule. The method further includes transmitting (1612) the one or more notifications for delivery to the one or more mobile devices.

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APPARATUS AND METHOD FOR USING CONFIGURABLE RULES LINKING TRIGGERS WITH ACTIONS TO SUPPORT NOTIFICATIONS ASSOCIATED WITH INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS AND PRIORITY CLAIM

[0001] This application claims priority under 35 U.S.C. § 119(e) to the following U.S. provisional patent applications:

U.S. Provisional Patent Application No. 62/161,536 filed on May 14, 2015 and entitled "APPARATUS AND METHOD FOR TRANSLATING INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM EVENTS INTO MOBILE NOTIFICATIONS";

U.S. Provisional Patent Application No. 62/161,542 filed on May 14, 2015 and entitled "APPARATUS AND METHOD FOR USING CONFIGURABLE RULES LINKING TRIGGERS WITH ACTIONS TO SUPPORT NOTIFICATIONS ASSOCIATED WITH INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM";

U.S. Provisional Patent Application No. 62/161,548 filed on May 14, 2015 and entitled "APPARATUS AND METHOD FOR AUTOMATED EVENT NOTIFICATION READ RECEIPT TO SUPPORT NON-REPUDIATED AUDITING IN INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM";

U.S. Provisional Patent Application No. 62/161,558 filed on May 14, 2015 and entitled "APPARATUS AND METHOD FOR EVENT DETECTION TO SUPPORT MOBILE NOTIFICATIONS RELATED TO INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM";

U.S. Provisional Patent Application No. 62/161,622 filed on May 14, 2015 and entitled "APPARATUS AND METHOD FOR PROTECTING PROPRIETARY INFORMATION OVER PUBLIC NOTIFICATION INFRASTRUCTURE";

U.S. Provisional Patent Application No. 62/161,644 filed on May 14, 2015 and entitled "APPARATUS AND METHOD FOR PROVIDING EVENT CONTEXT WITH NOTIFICATIONS RELATED TO INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM"; and
U.S. Provisional Patent Application No. 62/161,657 filed on May 14, 2015 and entitled "APPARATUS AND METHOD FOR UNIVERSAL ANNOTATION IN INDUSTRIAL PROCESS CONTROL AND AUTOMATION SYSTEM".

[0002] All of these provisional patent applications are hereby incorporated by reference in their entirety.

TECHNICAL FIELD

[0003] This disclosure relates generally to industrial process control and automation systems. More specifically, this disclosure relates to an apparatus and method for using configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system.

BACKGROUND

[0004] Industrial process control and automation systems are often used to automate large and complex industrial processes. These types of systems routinely include sensors, actuators, and controllers. The controllers are often arranged hierarchically in a control and automation system. For example, lower-level controllers are often used to receive measurements from the sensors and perform process control operations to generate control signals for the actuators. Higher-level controllers are often used to perform higher-level functions, such as planning, scheduling, and optimization operations. Human operators routinely interact with controllers and other devices in a control and automation system, such as to review warnings, alarms, or other notifications and make adjustments to control or other operations.
SUMMARY

[0005] This disclosure provides an apparatus and method for using configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system.

[0006] In a first embodiment, a method includes receiving information defining at least one condition and at least one action associated with a rule. Each condition is associated with an event in an industrial process control and automation system, and each action is associated with information related to the event. The method also includes, based on actual events in the industrial process control and automation system, generating one or more notifications for one or more users of one or more mobile devices using the rule. The method further includes transmitting the one or more notifications for delivery to the one or more mobile devices.

[0007] In a second embodiment, an apparatus includes at least one interface configured to communicate with one or more mobile devices. The apparatus also includes at least one processing device configured to receive information defining at least one condition and at least one action associated with a rule. Each condition is associated with an event in an industrial process control and automation system, and each action is associated with information related to the event. The at least one processing device is also configured, based on actual events in the industrial process control and automation system, to generate one or more notifications for one or more users of one or more mobile devices using the rule and initiate transmission of the one or more notifications for delivery to the one or more mobile devices.

[0008] In a third embodiment, a non-transitory computer readable medium contains computer readable program code that, when executed, causes at least one processing device to receive information defining at least one condition and at least one action associated with a rule. Each condition is associated with an event in an industrial process control and automation system, and each action associated with information related to the event. The medium also contains computer readable program code that, when executed, causes the at least one processing device, based on actual events in the industrial process control and automation system, to generate one or more notifications for one or more users of one or more mobile devices using the rule and initiate transmission of the one or more notifications for delivery to the one
or more mobile devices.

[0009] Other technical features may be readily apparent to one skilled in the art from the following figures, descriptions, and claims.
For a more complete understanding of this disclosure and its features, reference is now made to the following description, taken in conjunction with the accompanying drawings, in which:

FIGURE 1 illustrates an example industrial process control and automation system according to this disclosure;

FIGURE 2 illustrates an example device for creating and managing configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure;

FIGURE 3 illustrates an example context model that uses configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure;

FIGURE 4 illustrates an example system model that uses configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure;

FIGURES 5 and 6 illustrate example notifications related to an industrial process control and automation system according to this disclosure;

FIGURES 7A through 15 illustrate example graphical user interfaces that use configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure; and

FIGURE 16 illustrates an example method for using configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure.
DETAILED DESCRIPTION

[0018] FIGURES 1 through 16, discussed below, and the various embodiments used to describe the principles of the present invention in this patent document are by way of illustration only and should not be construed in any way to limit the scope of the invention. Those skilled in the art will understand that the principles of the invention may be implemented in any type of suitably arranged device or system.

[0019] FIGURE 1 illustrates an example industrial process control and automation system 100 according to this disclosure. As shown in FIGURE 1, the system 100 includes various components that facilitate production or processing of at least one product or other material. For instance, the system 100 is used here to facilitate control over components in one or multiple plants 101a-101n. Each plant 101a-101n represents one or more processing facilities (or one or more portions thereof), such as one or more manufacturing facilities for producing at least one product or other material. In general, each plant 101a-101n may implement one or more processes and can individually or collectively be referred to as a process system. A process system generally represents any system or portion thereof configured to process one or more products or other materials in some manner.

[0020] In FIGURE 1, the system 100 is implemented using the Purdue model of process control. In the Purdue model, "Level 0" may include one or more sensors 102a and one or more actuators 102b. The sensors 102a and actuators 102b represent components in a process system that may perform any of a wide variety of functions. For example, the sensors 102a could measure a wide variety of characteristics in the process system, such as temperature, pressure, or flow rate. Also, the actuators 102b could alter a wide variety of characteristics in the process system. The sensors 102a and actuators 102b could represent any other or additional components in any suitable process system. Each of the sensors 102a includes any suitable structure for measuring one or more characteristics in a process system. Each of the actuators 102b includes any suitable structure for operating on or affecting one or more conditions in a process system.

[0021] At least one network 104 is coupled to the sensors 102a and actuators 102b. The network 104 facilitates interaction with the sensors 102a and actuators
102b. For example, the network 104 could transport measurement data from the sensors 102a and provide control signals to the actuators 102b. The network 104 could represent any suitable network or combination of networks. As particular examples, the network 104 could represent an Ethernet network, an electrical signal network (such as a HART or FOUNDATION FIELDBUS network), a pneumatic control signal network, or any other or additional type(s) of network(s).

[0022] In the Purdue model, "Level 1" may include one or more controllers 106, which are coupled to the network 104. Among other things, each controller 106 may use the measurements from one or more sensors 102a to control the operation of one or more actuators 102b. For example, a controller 106 could receive measurement data from one or more sensors 102a and use the measurement data to generate control signals for one or more actuators 102b. Each controller 106 includes any suitable structure for interacting with one or more sensors 102a and controlling one or more actuators 102b. Each controller 106 could, for example, represent a proportional-integral-derivative (PID) controller or a multivariable controller, such as a Robust Multivariable Predictive Control Technology (RMPCT) controller or other type of controller implementing model predictive control (MPC) or other advanced predictive control (APC). As a particular example, each controller 106 could represent a computing device running a real-time operating system.

[0023] Two networks 108 are coupled to the controllers 106. The networks 108 facilitate interaction with the controllers 106, such as by transporting data to and from the controllers 106. The networks 108 could represent any suitable networks or combination of networks. As a particular example, the networks 108 could represent a redundant pair of Ethernet networks, such as a FAULT TOLERANT ETHERNET (FTE) network from HONEYWELL INTERNATIONAL INC.

[0024] At least one switch/firewall 110 couples the networks 108 to two networks 112. The switch/firewall 110 may transport traffic from one network to another. The switch/firewall 110 may also block traffic on one network from reaching another network. The switch/firewall 110 includes any suitable structure for providing communication between networks, such as a HONEYWELL CONTROL FIREWALL (CF9) device. The networks 112 could represent any suitable networks, such as an FTE network.
In the Purdue model, "Level 2" may include one or more machine-level controllers 114 coupled to the networks 112. The machine-level controllers 114 perform various functions to support the operation and control of the controllers 106, sensors 102a, and actuators 102b, which could be associated with a particular piece of industrial equipment (such as a boiler or other machine). For example, the machine-level controllers 114 could log information collected or generated by the controllers 106, such as measurement data from the sensors 102a or control signals for the actuators 102b. The machine-level controllers 114 could also execute applications that control the operation of the controllers 106, thereby controlling the operation of the actuators 102b. In addition, the machine-level controllers 114 could provide secure access to the controllers 106. Each of the machine-level controllers 114 includes any suitable structure for providing access to, control of, or operations related to a machine or other individual piece of equipment. Each of the machine-level controllers 114 could, for example, represent a server computing device running a MICROSOFT WINDOWS operating system. Although not shown, different machine-level controllers 114 could be used to control different pieces of equipment in a process system (where each piece of equipment is associated with one or more controllers 106, sensors 102a, and actuators 102b).

One or more operator stations 116 are coupled to the networks 112. The operator stations 116 represent computing or communication devices providing user access to the machine-level controllers 114, which could then provide user access to the controllers 106 (and possibly the sensors 102a and actuators 102b). As particular examples, the operator stations 116 could allow users to review the operational history of the sensors 102a and actuators 102b using information collected by the controllers 106 and/or the machine-level controllers 114. The operator stations 116 could also allow the users to adjust the operation of the sensors 102a, actuators 102b, controllers 106, or machine-level controllers 114. In addition, the operator stations 116 could receive and display warnings, alerts, or other messages or displays generated by the controllers 106 or the machine-level controllers 114. Each of the operator stations 116 includes any suitable structure for supporting user access and control of one or more components in the system 100. Each of the operator stations 116 could, for example, represent a computing device running a MICROSOFT
At least one router/firewall couples the networks to two networks. The router/firewall includes any suitable structure for providing communication between networks, such as a secure router or combination router/firewall. The networks could represent any suitable networks, such as an FTE network.

In the Purdue model, "Level 3" may include one or more unit-level controllers coupled to the networks. Each unit-level controller is typically associated with a unit in a process system, which represents a collection of different machines operating together to implement at least part of a process. The unit-level controllers perform various functions to support the operation and control of components in the lower levels. For example, the unit-level controllers could log information collected or generated by the components in the lower levels, execute applications that control the components in the lower levels, and provide secure access to the components in the lower levels. Each of the unit-level controllers includes any suitable structure for providing access to, control of, or operations related to one or more machines or other pieces of equipment in a process unit. Each of the unit-level controllers could, for example, represent a server computing device running a MICROSOFT WINDOWS operating system. Although not shown, different unit-level controllers could be used to control different units in a process system (where each unit is associated with one or more machine-level controllers, controllers, sensors, and actuators).

Access to the unit-level controllers may be provided by one or more operator stations. Each of the operator stations includes any suitable structure for supporting user access and control of one or more components in the system. Each of the operator stations could, for example, represent a computing device running a MICROSOFT WINDOWS operating system.

At least one router/firewall couples the networks to two networks. The router/firewall includes any suitable structure for providing communication between networks, such as a secure router or combination router/firewall. The networks could represent any suitable networks, such as an FTE network.
In the Purdue model, "Level 4" may include one or more plant-level controllers 130 coupled to the networks 128. Each plant-level controller 130 is typically associated with one of the plants IOla-IOln, which may include one or more process units that implement the same, similar, or different processes. The plant-level controllers 130 perform various functions to support the operation and control of components in the lower levels. As particular examples, the plant-level controller 130 could execute one or more manufacturing execution system (MES) applications, scheduling applications, or other or additional plant or process control applications. Each of the plant-level controllers 130 includes any suitable structure for providing access to, control of, or operations related to one or more process units in a process plant. Each of the plant-level controllers 130 could, for example, represent a server computing device running a MICROSOFT WINDOWS operating system.

Access to the plant-level controllers 130 may be provided by one or more operator stations 132. Each of the operator stations 132 includes any suitable structure for supporting user access and control of one or more components in the system 100. Each of the operator stations 132 could, for example, represent a computing device running a MICROSOFT WINDOWS operating system.

At least one router/firewall 134 couples the networks 128 to one or more networks 136. The router/firewall 134 includes any suitable structure for providing communication between networks, such as a secure router or combination router/firewall. The network 136 could represent any suitable network, such as an enterprise-wide Ethernet or other network or all or a portion of a larger network (such as the Internet).

In the Purdue model, "Level 5" may include one or more enterprise-level controllers 138 coupled to the network 136. Each enterprise-level controller 138 is typically able to perform planning operations for multiple plants IOla-IOln and to control various aspects of the plants 10la-10ln. The enterprise-level controllers 138 can also perform various functions to support the operation and control of components in the plants IOla-IOln. As particular examples, the enterprise-level controller 138 could execute one or more order processing applications, enterprise resource planning (ERP) applications, advanced planning and scheduling (APS) applications, or any other or additional enterprise control applications. Each of the enterprise-level
controllers 138 includes any suitable structure for providing access to, control of, or operations related to the control of one or more plants. Each of the enterprise-level controllers 138 could, for example, represent a server computing device running a MICROSOFT WINDOWS operating system. In this document, the term "enterprise" refers to an organization having one or more plants or other processing facilities to be managed. Note that if a single plant 101a is to be managed, the functionality of the enterprise-level controller 138 could be incorporated into the plant-level controller 130.

[0035] Various plant applications 139 could also be executed in the system 100. In this example, the plant applications 139 are shown as residing on Level 5 of the system 100, although plant applications 139 could reside on other or additional levels of the system 100. The plant applications 139 could represent any suitable applications that are executed by server computers or other computing devices.

[0036] Access to the enterprise-level controllers 138 and plant applications 139 may be provided by one or more enterprise desktops (also referred to as operator stations) 140. Each of the enterprise desktops 140 includes any suitable structure for supporting user access and control of one or more components in the system 100. Each of the enterprise desktops 140 could, for example, represent a computing device running a MICROSOFT WINDOWS operating system.

[0037] Various levels of the Purdue model can include other components, such as one or more databases. The database(s) associated with each level could store any suitable information associated with that level or one or more other levels of the system 100. For example, a historian 142 can be coupled to the network 136. The historian 142 could represent a component that stores various information about the system 100. The historian 142 could, for instance, store information used during production scheduling and optimization. The historian 142 represents any suitable structure for storing and facilitating retrieval of information. Although shown as a single centralized component coupled to the network 136, the historian 142 could be located elsewhere in the system 100, or multiple historians could be distributed in different locations in the system 100.

[0038] In particular embodiments, the various controllers and operator stations in FIGURE 1 may represent computing devices. For example, each of the controllers...
106, 114, 122, 130, 138 and each of the operator stations 116, 124, 132, 140 could include one or more processing devices and one or more memories for storing instructions and data used, generated, or collected by the processing device(s). Each of the controllers 106, 114, 122, 130, 138 and each of the operator stations 116, 124, 132, 140 could also include at least one network interface, such as one or more Ethernet interfaces or wireless transceivers, facilitating communication over one or more networks or communication paths.

[0039] The widespread use of mobile "smart" devices (such as APPLE IPHONEs and IPADs and ANDROID devices) allows users to remain connected and to interact with remote computing devices from virtually anywhere each user travels. Among other things, this could allow personnel associated with an industrial process control and automation system to receive warnings, alerts, or other notifications associated with events and other information and trigger actions associated with the control and automation system, regardless of whether the personnel are physically located at an industrial site. For example, events that are generated in a process control and automation system are often presented to operators currently on shift in one or more control rooms. There may also typically be a need or desire to inform users outside of control rooms, outside of an industrial plant, or while off network of events that are happening in the control and automation system. These events can come from a variety of applications, such as from a distributed control system (DCS) itself, advanced process control applications, operations applications, or business applications. Deliver]’ of notifications describing these events to a user's handheld mobile device enables the user to receive notifications virtually anywhere and at any time.

[0040] To support this functionality, the system 100 includes a notification server 144, which receives data from other component(s) of the system 100 and generates notifications for users. For example, the notification server 144 could receive information identifying different events that occur with the system 100. The events could be associated with any suitable activities or conditions in the system 100, such as the generation of warnings or alerts by other components in the system 100. The notification server 144 could receive this information in any suitable manner and from any suitable source(s), such as from a historian, controller, or plant application.
The notification server 144 uses this information to generate notifications (such as push notifications) and other messages to be sent to appropriate users. The notification server 144 could also provide additional information to appropriate users in response to user interactions with those notifications or other messages.

[0041] The notification server 144 communicates over a third-party network 146 with a third-party server 148. The third-party network 146 generally represents any suitable communication network(s) outside the system 100 (and therefore out of the control of the owners/operators of the system 100). The third-party network 146 could, for example, represent the Internet, a cellular communication network, or other network or combination of networks. The third-party server 148 represents a server used to provide notifications to end-user devices 150. For example, the third-party server 148 could push notifications to the end-user devices 150, allow retrieval of notifications by the end-user devices 150 at specified intervals or when requested, or provide notifications in any other suitable manner. The end-user devices 150 can then connect to the notification server 144 over the network 146 to receive details about notifications and events or to query for any notifications. As a particular example, the third-party server 148 could be used by companies like APPLE, SAMSUNG, or GOOGLE to provide push notifications or other notifications to mobile devices.

[0042] The end-user devices 150 denote any suitable user devices that can receive and present notifications to users. Examples of end-user devices 150 include smartphones, tablet computers, or other communication/computing devices. Specific examples could include APPLE IPHONES, APPLE IPADS, and ANDROID devices.

[0043] The use of notifications sent to mobile devices can help plant personnel to understand and resolve plant issues while they are away from their normal working environments. However, the plant personnel often need to receive details of important events and related information that can help determine an appropriate response on their mobile end-user devices 150.

[0044] In accordance with this disclosure, the notification server 144 or other device(s) in the system 100 support a technique whereby rules associated with notifications are created, managed, and used. In some embodiments, each rule can define or be associated with:

* a set of interested plant personnel who will receive a notification;
* an event or set of events of interest (referred to as "conditions"); and
* related information (referred to as "actions") that can assist a recipient to diagnose and assist in resolving the root cause of an issue.

Note that the events and related information can be retrieved from multiple different sources (such as different applications) instead of a single source.

[0045] The conditions (sources of events) and actions (related information) can be defined using a graphical user interface (examples of which are provided below) or in any other suitable manner. The events typically include process-related events, and the related information typically includes other events, process values displayed in one or different forms (such as numeric, trend, or stylized shape forms), video, or other recorded information. A given condition or action may expose selectable criteria that are specific to a source. Multiple rules can be defined by users, and one or multiple conditions and one or multiple actions can be defined for each rule. For a condition, a user could select criteria to filter events to those that are important or otherwise of interest. For an action, a user could select criteria to define which information is most relevant to the event(s) that match(es) the criteria identified in the corresponding condition(s) defined for this rule. A user can also select which sets of personnel (roles) could receive notifications for each of the rules. As new sources of information are developed, those sources can be added as conditions or actions as appropriate.

[0046] In this way, rules can be defined that control which personnel receive notifications, which events can trigger the notifications, and which additional information can be provided in or with the notifications. This can help to significantly ease the management of the notifications generated in the system 100.

[0047] Although FIGURE 1 illustrates one example of an industrial process control and automation system 100, various changes may be made to FIGURE 1. For example, a control and automation system could include any number of sensors, actuators, controllers, operator stations, networks, servers, end-user devices, and other components. Also, the makeup and arrangement of the system 100 in FIGURE 1 is for illustration only. Components could be added, omitted, combined, further subdivided, or placed in any other suitable configuration according to particular needs. Further, particular functions have been described as being performed by particular components
of the system 100. This is for illustration only. In general, control and automation systems are highly configurable and can be configured in any suitable manner according to particular needs. In addition, FIGURE 1 illustrates an example environment in which configurable rules can be used to control the generation of notifications. This functionality can be used in any other suitable system.

[0048] FIGURE 2 illustrates an example device 200 for creating and managing configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure. The device 200 could, for example, represent the notification server 144 or the end-user device 150 in the system 100 of FIGURE 1. However, the notification server 144 or the end-user device 150 could be implemented using any other suitable device or system, and the device 200 could be used in any other suitable system.

[0049] As shown in FIGURE 2, the device 200 includes a bus system 202, which supports communication between at least one processing device 204, at least one storage device 206, at least one communications unit 208, and at least one input/output (I/O) unit 210. The processing device 204 executes instructions that may be loaded into a memory 212. The processing device 204 may include any suitable number(s) and type(s) of processors or other devices in any suitable arrangement. Example types of processing devices 204 include microprocessors, microcontrollers, digital signal processors, field programmable gate arrays, application specific integrated circuits, and discrete circuitry.

[0050] The memory 212 and a persistent storage 214 are examples of storage devices 206, which represent any structure(s) capable of storing and facilitating retrieval of information (such as data, program code, and/or other suitable information on a temporary or permanent basis). The memory 212 may represent a random access memory or any other suitable volatile or non-volatile storage device(s). The persistent storage 214 may contain one or more components or devices supporting longer-term storage of data, such as a read only memory, hard drive, Flash memory, or optical disc.

[0051] The communications unit 208 supports communications with other systems or devices. For example, the communications unit 208 could include a network interface that facilitates communications over at least one Ethernet, HART,
FOUNDATION FIELDBUS, or other network. The communications unit 208 could also include a wireless transceiver facilitating communications over at least one wireless network. The communications unit 208 may support communications through any suitable physical or wireless communication link(s).

[0052] The I/O unit 210 allows for input and output of data. For example, the I/O unit 210 may provide a connection for user input through a keyboard, mouse, keypad, touchscreen, or other suitable input device. The I/O unit 210 may also send output to a display, printer, or other suitable output device.

[0053] When implementing the notification server 144, the device 200 could execute instructions used to perform any of the functions associated with the notification server 144. For example, the device 200 could execute instructions that present one or more interfaces allowing users to create, define, and manage rules and associate those rules with user roles. The device 200 could also execute instructions that detect the occurrence of various events, such as by detecting warnings or alarms generated in the system 100, and that generate notifications based on the defined rules and associated roles. The device 200 could further execute instructions that transmit the notifications for delivery to end-user devices 150 and that provide information associated with the notifications to the end-user devices 150.

[0054] When implementing the end-user device 150, the device 200 could execute instructions used to perform any of the functions associated with the end-user device 150. For example, the device 200 could execute instructions that process notifications and present information about the notifications to a user. The device 200 could also execute instructions that present one or more interfaces allowing users to define rules associated with the notifications.

[0055] Although FIGURE 2 illustrates one example of a device 200 for creating and managing configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system, various changes may be made to FIGURE 2. For example, components could be added, omitted, combined, further subdivided, or placed in any other suitable configuration according to particular needs. Also, computing devices can come in a wide variety of configurations, and FIGURE 2 does not limit this disclosure to any particular configuration of computing device.
FIGURE 3 illustrates an example context model 300 that uses configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure. For ease of explanation, the context model 300 is described as being supported by the industrial process control and automation system 100 of FIGURE 1. However, the context model 300 could be supported by any other suitable system.

As shown in FIGURE 3, the context model 300 includes a mobile solution 302, which generally denotes at least part of the functionality of the notification server 144 and the application executed by the end-user devices 150. The mobile solution 302 interacts with three types of users 304-308 in this example, namely mobile users 304, product administrators 306, and system administrators 308. The mobile users 304 generally denote end users who use the end-user devices 150 to receive notifications and optionally act on those notifications. For example, the mobile users 304 could use the end-user devices 150 to review notifications regarding events in the industrial process control and automation system 100 and interact with other users to resolve undesirable or problematic situations in the system 100. Note, however, that the notifications could be used in any other suitable manner. The mobile users 304 could also have the ability to configure or control the notifications that are sent to those mobile users 304, such as by defining different rules used to generate the notifications.

The product administrators 306 represent users who configure the functionality of the mobile solution 302. For example, the product administrators 306 could define rules or other logic that control the generation of the notifications. As a particular example, the product administrators 306 could create rules that define the notifications sent in response to various events, the users who receive those notifications, and the contents of those notifications. In some embodiments, rules can be defined for different roles, and associations of users to those roles can be used to identify the mobile users 304 who receive notifications for those roles. As noted above, end users can also create their own rules for notifications, and the product administrators 306 could have the ability to review, modify, or delete the end user-created rules.

The system administrators 308 represent users who are responsible for
allowing the mobile application executed by the end-user devices 150 to be authorized in the environment. For example, the system administrators 308 could grant permissions for end-user devices 150 to access the mobile solution 302 and register the end-user devices 150 with the mobile solution 302.

[0060] The application executed by the end-user devices 150 could be provided via an electronic store or marketplace, such as a corporate store 310 or a third-party store 312. Each electronic store 310-312 generally represents a computing system hosting one or more applications or "apps" that can be downloaded to the end-user devices 150. As the names imply, the corporate store 310 denotes a computing system operated by a corporation or other entity associated with the industrial process control and automation system 100 or other system. The third-party store 312 denotes a computing system operated by a third party unrelated to the industrial process control and automation system 100 or other system, such as APPLE or GOOGLE. End users can use their end-user devices 150 to access one or more of the electronic stores 310-312 and download an app that supports the use of notifications related to industrial process control and automation.

[0061] Once configured and placed into operation, the mobile solution 302 receives information about events from various sources, such as one or more process control systems or applications 314. Each process control system or application 314 could represent any component within the industrial process control and automation system 100 that can generate events or data indicative of events. In some instances, a process control system or application 314 can be designed to specifically integrate with the mobile solution 302, and the process control system or application 314 can itself provide events with or without tags (event-related information) to the mobile solution 302. In other instances, a process control system or application 314 may be unable to provide this information to the mobile solution 302 itself, and a plug-in or other mechanism can be used with the process control system or application 314 to identify events and transmit information to the mobile solution 302.

[0062] However the events are detected, the mobile solution 302 receives information about the events and uses rules or other logic to generate notifications for mobile users 304. The mobile solution 302 also sends the notifications to the end-user devices 150 of the mobile users 304. In some embodiments, the notifications are sent
to the mobile users 304 directly via a third-party notification service 316, which could
denote a service provided by the third-party server 148. The third-party notification
service 316 could include an APPLE or ANDROID push notification service, although other push or non-push notification services could be used. The third-party
notification service 316 provides the notifications to the end-user devices 150 used by
the mobile users 304. Alternatively, the mobile solution 302 can generate obfuscated
messages (such as unique alphanumeric codes, brief summaries, or other obfuscations) for the generated notifications, and the obfuscated messages can be sent
to the third-party notification service 316 for delivery to the mobile users 304 as
obfuscated notifications. The obfuscated notifications can be used by the end-user
devices 150 to securely interact with the mobile solution 302 in order to obtain and
present non-obfuscated notifications to the mobile users 304.

[0063] In whatever manner the notifications are provided to the end-user
devices 150, the end-user devices 150 can present the notifications to the mobile users
304. For example, an end-user device 150 can receive and present a listing of
notifications for a particular mobile user 304, where the listing identifies the
notification messages, their associated identifiers, and some (or possibly all) of the
fields of the notification messages. Annotations or other text-based communications
associated with those notifications can also be provided to or received from the end-
user device 150. Annotations could include communications such as comments from
users or read receipts, forwarding indicators, or other system-generated annotations.
In addition, context (such as detailed historical data for one or more process variables)
can be provided to the end-user device 150. Note, however, that notifications can be
used in any other suitable manner and that any other suitable data associated with the
notifications can be sent to or received from the end-user devices 150.

[0064] Although FIGURE 3 illustrates one example of a context model 300
that uses configurable rules linking triggers with actions to support notifications
associated with an industrial process control and automation system, various changes
may be made to FIGURE 3. For example, additional types of users could be
associated with the mobile solution 302, or functions of multiple user types could be
combined. Also, while specific entities such as APPLE and ANDROID are described
above, other stores or notification services could be used. In addition, various
components could be added, omitted, combined, further subdivided, or placed in any other suitable configuration according to particular needs.

[0065] FIGURE 4 illustrates an example system model 400 that uses configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure. For ease of explanation, the system model 400 is described as being supported by the industrial process control and automation system 100 of FIGURE 1. However, the system model 400 could be supported by any other suitable system. Also, in the following discussion, it is assumed that obfuscated notifications are sent to the end-user devices 150 via the third-party notification service 316 and that the end-user devices 150 request non-obfuscated notifications securely from the notification server 144. However, other mechanisms for providing notifications to the end-user devices 150 could be used, such as direct delivery of non-obfuscated notifications via the third-party notification service 316.

[0066] As shown in FIGURE 4, the system model 400 includes an event detection unit 402, a mobile notification unit 404, and a mobile services unit 406. These units 402-406 could, for example, denote different functional units of the mobile solution 302. Each of the units 402-406 could be implemented using any-suitable hardware or a combination of hardware and software/firmware instructions. For instance, each of the units 402-406 could be implemented using one or more software routines executed by the processing device(s) 204 of the notification server 144.

[0067] The event detection unit 402 receives information associated with events, such as from one or more process control systems or applications 314. The information associated with the events could include information such as a time of an event, a source of the event, a condition associated with the event, a category (such as minor, major, or critical) of the event, and a description of the event. The event detection unit 402 can obtain the information about the events in any suitable manner. For example, the event detection unit 402 could poll the process control systems or applications 314 at specified intervals, in response to triggering events, or at other times. The event detection unit 402 could also receive the information from plug-ins or other data collection components in or associated with the process control systems.
or applications 314 at specified intervals, in response to triggering events, or at other times. The events here could represent all events generated by the process control systems or applications 314 or only a subset of events generated by the process control systems or applications 314 (such as only certain types of events). The event detection unit 402 processes the information and outputs information identifying the events, such as in a standard format, to the mobile notification unit 404.

[0068] The mobile notification unit 404 receives the information identifying the events from the event detection unit 402 and generates obfuscated notifications for end-user devices 150. For example, the mobile notification unit 404 can generate non-obfuscated notifications containing suitable information about the events, generate unique identifiers for the non-obfuscated notifications, and generate obfuscated notifications that include the unique identifiers. The obfuscated notifications (referred to in FIGURE 4 as notification summaries) are sent to the third-party notification service 316 for delivery to mobile applications 408. The mobile applications 408 represent an application executed by one or more end-user devices 150. The mobile notification unit 404 also provides various information, such as lists of notifications and the notifications themselves, to the mobile services unit 406.

[0069] The mobile services unit 406 interacts with each mobile application 408 securely, such as by using Virtual Private Network (VPN) or other secure communication protocol. The mobile services unit 406 performs various functions related to notifications. For example, the mobile services unit 406 could receive unique identifiers or other obfuscations from the mobile applications 408, retrieve non-obfuscated notifications associated with those obfuscations, and provide the non-obfuscated notifications to the mobile applications 408. The mobile services unit 406 can also manage lists of notifications that particular users have received, manage read-receipts for notifications that are read or viewed on the users’ end-user devices 150, and allow rules to be configured by the end-user devices 150. The mobile services unit 406 can further provide user-generated or system-generated annotations to the end-user devices 150 and receive user annotations from end-user devices 150 for delivery to other end-user devices 150. In addition, the mobile services unit 406 can receive invocations of various commands from the end-user devices 150, such as commands for obtaining historical data, user comments, or other contextual
information about a specific notification.

[0070] Although FIGURE 4 illustrates one example of a system model 400 that uses configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system, various changes may be made to FIGURE 4. For example, various components could be added, omitted, combined, further subdivided, or placed in any other suitable configuration according to particular needs. Also, various components in FIGURE 4 (such as components 402-406) could be implemented using a common device, or at least some of those components could be implemented using different devices.

[0071] FIGURES 5 and 6 illustrate example notifications related to an industrial process control and automation system according to this disclosure. As shown in FIGURE 5, a graphical user interface 500 can be presented by the mobile application 408 on the display screen of an end-user device 150. The graphical user interface 500 here includes a listing of notifications 502. Each notification 502 includes various details about an event, such as a name and severity of the event, a time of the notification, and comments about the event. As shown in this example, the notifications 502 are grouped into different categories, although other categories or arrangements could be used. The graphical user interface 500 also includes various controls 504, such as controls for viewing all notifications, flagged notifications, or closed notifications and controls for changing the viewing arrangement.

[0072] Selection of a specific notification 502 in the graphical user interface 500 can cause the mobile application 408 to present a graphical user interface 600 as shown in FIGURE 6. The graphical user interface 600 includes information 602 identifying a particular event and a trend diagram 604 showing historical values of one or more process variables associated with the particular event. The graphical user interface 600 also includes specific process variable values 606 associated with the event and an identification of the rule(s) 608 that triggered the notification or that are related to the notification. Moreover, the graphical user interface 600 includes controls 610 that allow a user to close a notification, escalate the notification to one or more specific users, own the notification (meaning the user will be responsible for resolving the event), flag the notification (so it appears as a flagged notification in FIGURE 5), or share the notification with other users. In addition, the graphical user
interface 600 includes tabs 612 that can be used to select whether detailed information or historical information associated with the selected notification is being presented to the user. In FIGURE 6, the "Detail" tab has been selected. Selection of the "History" tab can present the user with, for example, other users’ comments, indications that certain users have taken ownership of or escalated the notification, or other actions or information related to the notification.

[0073] Although FIGURES 5 and 6 illustrate examples of notifications related to an industrial process control and automation system, various changes may be made to FIGURES 5 and 6. For example, the content and arrangement of each graphical interface are for illustration only. Also, while shown as being used with an APPLE IPHONE, the notifications could be used with any other suitable devices.

[0074] FIGURES 7A through 15 illustrate example graphical user interfaces that use configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system according to this disclosure. As shown in FIGURES 7A through 8C, a graphical user interface 700 could be provided on the screen of a computing device (such as a desktop or laptop computer). The graphical user interface 700 could, for example, be used by an administrator to define various rules and to associate rules with various user roles. The interface 700 includes a selection area 702, where a user can choose to define rules for generating notifications or to associate rules with specific user roles. In FIGURE 7A, the user has selected the "Rules" option and can define rules. In FIGURE: 7B, the user has selected the "Roles" option and can associate defined rules with roles.

[0075] In the interface 700 shown in FIGURE 7A, the interface 700 includes a list 704 of existing rules (if any). Each rule in the list 704 is identified by name, and the types of condition(s) and action(s) associated with that rule are identified. The list 704 also identifies which role or roles (if any) have been associated with each rule. The interface 700 also includes buttons 706, which allow a user to define a new rule or copy or delete an existing rule.

[0076] In the interface 700 shown in FIGURE 7B, when the "Roles" option is selected in the selection area 702 of the interface 700, the "Roles" option expands to include a list 708 of roles that could be selected by a user. Upon selection of one of
the roles in the list 708, a list 710 of available rules is presented to the user. The rules in the list 710 could include all of the rules defined using the mechanism shown in FIGURE 7A. The user can use checkboxes in the list 710 to select which rules are associated with the selected role(s), and highlighting 712 or other indicator could be used to identify the rules in the list 710 that have or have not already been assigned to the selected role. Buttons 714 can be used to accept the user's selection of rules for the selected role(s) or to cancel and ignore the current selections.

[0077] FIGURES 8A through 8C illustrate the graphical user interface 700 when a user elects to create a new rule by selecting the appropriate button 706. As shown in FIGURE 8A, to create a new rule, the interface 700 presents a section 802 for defining the rule's name, a section 804 for defining one or more conditions associated with the rule, and a section 806 for defining one or more actions associated with the rule. Note that while shown here as allowing the user to name a rule, the name of the rule could also be automatically generated, such as in accordance with some naming scheme. The sections 804-806 expand when a user elects to add a condition or action and are shown in greater detail in FIGURE 8B.

[0078] For each condition, the section 804 allows a user to identify a location associated with an event, a source of the event, a category of the event, a condition that caused the event, and a priority of the event. Note, however, that the fields shown in the section 804 of FIGURE 8B are relevant to the selected type of data source (DYNAMO in this example), and different elements could appear here for other types of data sources. For each action, the section 806 allows a user to identify a source of information for a trend or process value to be provided as additional information in or with a notification. Again, the fields shown in the section 806 of FIGURE 8B are what are relevant based on prior user selections. Also note that selecting map locations, identifying videos, or other options could be used to configure various items. Buttons 808 allow the user to either save the new rule or cancel. If a trend is defined in the section 806 as an action, FIGURE 8C illustrates input boxes 810-812 that could be presented to the user and used to define the trend. The input box 810 allows the user to search for a source, and the input box 812 allows the user to define a trend for a selected source.

[0079] As shown in FIGURES 9 through 15, a graphical user interface 900
could be provided on the screen of a mobile device (such as a smartphone or tablet computer). The graphical user interface 900 could, for example, be used by a mobile user of an end-user device 150 to view and control rules associated with that user. As shown in FIGURE 9, the interface 900 allows a user of a mobile device to view a list 902 of the rules that have been created by that user. The rules in the list 902 can represent those rules relevant to the user's specific interests that the user has created. The user can modify or delete existing rules or create new rules. In some embodiments, global rules (such as those created using the graphical user interface 700) cannot be controlled by the user using the graphical user interface 900, as those global rules can be controlled by a product administrator 306. Each rule in the list 902 can be selected to view details of that rule, and a control 904 can be selected to create a new rule. Indicators 906 can be used to identify different types and statuses of rules. For instance, an indicator 906 in the shape of a person could denote an enabled local rule established by the user, an indicator 906 in the shape of a circle with a slash could denote a disabled local rule, and an indicator 906 in the shape of the globe could denote an enabled global rule (which the user may not be allowed to disable). Using standard iOS control mechanisms, sliding any local rule in the list 902 to the right could present options for enabling/disabling or deleting that rule.

When a new rule is being created, the interface 900 can provide various controls as shown in FIGURE 10 to a user. The controls include options 1002 for selecting different types of sources as a trigger. Once a particular type of trigger is selected, options 1004 can be provided that allow the user to complete the definition of that source. Note that the options 1004 can vary based on the type of trigger being defined and that multiple triggers could be selected and defined for the rule.

A "Source" option 1004 in FIGURE 10 allows the user to specify a parameter (such as a process variable) of an asset (such as a piece of hardware within the industrial process control and automation system). This asset parameter identifies the source of information that might be used to trigger a notification if and when the other conditions of the rule being defined are satisfied. Selection of the "Source" option 1004 could cause the graphical user interface 900 to present a list 1102 of sources as shown in FIGURE 11. One of the sources in the list 1102 could be selected for use in the new trigger, or a control 1104 could be selected to define a new source.
The new source could be defined in any suitable manner, such as in the manner shown in FIGURE 12 where the user can enter one or more search terms 1202 and view a list 1204 of matching sources. Any of the sources in the list 1204 could be selected for use in the new trigger, and pattern matching could be used to select multiple sources at one time based on wildcards provided as part of the search term(s) 1202. Note that a source can be a tag (such as a parameter) or a location (such as a particular unit of a plant). Using a location as the source allows a user to see notifications of events across an entire area of the plant.

[0082] Other options 1004 in FIGURE 10 include "Category-", "Condition," and "Priority," which are used to specify characteristics of the asset parameter to be met in order for a notification to be generated. Selection of each of these options 1004 could present the user with a list of categories, conditions, or priorities, at least one of which could be selected (such as by using checkboxes). In this case, the user has indicated that an urgent process variable (PV) low alarm from the identified source will lead to the generation of a notification. Note, however, that multiple categories, conditions, or priorities could also be defined.

[0083] Once one or more triggers are defined, the user can define one or more actions using various controls shown in FIGURE 13. The controls include options 1302 for selecting different types of actions. In this example, the options 1302 include an option for displaying a trend of one or more process variables and an option for displaying one or more specific process variable values. The user in this example has selected both actions.

[0084] Once a particular type of action is selected, options 1304 can be provided that allow the user to complete the definition of that action. Here, the options 1304 include options 1306 for defining a trend and options 1308 for identifying specific process variables. For each option 1306-1308, the user can specify at least one source for trend or process variable data, and the source(s) can be selected using the same mechanism described above for defining the conditions. For example, when the user attempts to add a source for an action, the user could provide one or more search terms 1402, view a list 1404 of parameters satisfying the search terms 1402, and select one or more items from the list 1404 for inclusion in the action as shown in FIGURE 14. A "same as trigger" option can also be provided to avoid requiring the
user to re-enter the same information that was provided earlier for the trigger source.

[0085] Once the trigger(s) and action(s) have been defined, a summary 1502 of the new rule as shown in FIGURE 15 can be presented to the user. The summary 1502 here identifies the name 1504 of the rule, one or more triggers 1506 defined for the rule, and one or more actions 1508 defined for the rule. If accepted, the rule can be sent to the notification server 144 or other destination for use in generating future notifications. In some embodiments, the name of the rule could also be automatically generated, such as in accordance with some naming scheme.

[0086] A similar summary could be presented when the user selects one of the existing rules in the list 902 in FIGURE 9. In that case, additional controls for enabling/disabling, deleting, and sharing the selected existing rule could be provided, such as at the bottom of the summary. The user could also be given the option of editing the existing rule, in which case a sequence similar to that described above could be used to modify an existing rule.

[0087] Note that a user could leave one or more fields of a rule blank or unconfigured, in which case that field could be viewed as including all options. For example, if all fields of a rule are left blank, a user could receive notifications based on all sources and all priorities.

[0088] The graphical user interfaces described above provide mechanisms that can be used to intuitively create and manage rules associated with notifications for mobile devices. The interfaces allow users on different types of devices (such as desktop/laptop computers and mobile devices) to create, modify, and delete rules.

[0089] Although FIGURES 7A through 15 illustrate examples of graphical user interfaces that use configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system, various changes may be made to FIGURES 7A through 15. For example, the content and arrangement of each graphical user interface are for illustration only. Also, while shown as supporting various input mechanisms (such as text boxes, checkboxes, trees, pop-up menus, lists, and buttons), any other suitable mechanisms could be used to obtain information from users.

[0090] FIGURE 16 illustrates an example method 1600 for using configurable rules linking triggers with actions to support notifications associated with an industrial
process control and automation system according to this disclosure. As shown in FIGURE: 16, information defining various rules is received at step 1602. This could include, for example, the mobile services unit 406 receiving information from one or more users using the graphical user interfaces 700, 900. The received information can include, among other things, one or more triggers for each rule and one or more actions for each rule.

[0091] Information associated with an event is received at step 1604. This could include, for example, the mobile notification unit 404 receiving data from the event detection unit 402, where the data identifies an event that has occurred. The event information is used to identify any of the rules having triggers satisfied by the event information at step 1606. This could include, for example, the mobile notification unit 404 or the mobile services unit 406 determining if (i) the event information was from a specified source, (ii) the event information defines an event of a specified category, (iii) the event deals with a specified condition, and (iv) the event has a specified priority. If the conditions of the trigger(s) associated with a rule are satisfied, the rule can be identified as a satisfied rule that is to be used to generate a notification.

[0092] One or more actions for any satisfied rules are identified at step 1608, and one or more notifications are generated based on the identified action(s) at step 1610. This could include, for example, the mobile notification unit 404 or the mobile services unit 406 identifying one or more actions in each rule whose trigger or triggers have been satisfied. As a particular example, this could include the mobile notification unit 404 or the mobile services unit 406 identifying one or more sources for trend diagrams or process variable values to be included in a notification and retrieving the necessary information.

[0093] The one or more notifications are transmitted to one or more mobile devices at step 1612. This could include, for example, the mobile notification unit 404 generating a unique identifier or other obfuscation for the notification and interacting with the third-party notification service 316 to transmit the obfuscation as part of an obfuscated notification to one or more end-user devices 150. This could also include the mobile services unit 406 establishing a VPN or other secure connection with the end-user devices 150 and providing a non-obfuscated notification to the end-user.
devices 150. Note, however, that the use of obfuscation and obfuscated notifications is not required, and the mobile notification unit 404 or the mobile services unit 406 could provide a non-obfuscated notification to the end-user devices 150 via the third-party notification service 316 or in some other manner. The mobile device(s) to receive the notification could be identified in any suitable manner, such as by identifying one or more user roles associated with each satisfied rule and identifying one or more mobile devices of one or more users associated with the identified role(s).

[0094] Although FIGURE 16 illustrates one example of a method 1600 for using configurable rules linking triggers with actions to support notifications associated with an industrial process control and automation system, various changes may be made to FIGURE 16. For example, while shown as a series of steps, various steps in FIGURE 16 could overlap, occur in parallel, occur in a different order, or occur any number of times. Also, the method could include any number of rules, roles, events, notifications, and mobile devices.

[0095] In some embodiments, various functions described in this patent document are implemented or supported by a computer program that is formed from computer readable program code and that is embodied in a computer readable medium. The phrase "computer readable program code" includes any type of computer code, including source code, object code, and executable code. The phrase "computer readable medium" includes any type of medium capable of being accessed by a computer, such as read only memory (ROM), random access memory (RAM), a hard disk drive, a compact disc (CD), a digital video disc (DVD), or any other type of memory. A "non-transitory" computer readable medium excludes wired, wireless, optical, or other communication links that transport transitory electrical or other signals. A non-transitory computer readable medium includes media where data can be permanently stored and media where data can be stored and later overwritten, such as a rewritable optical disc or an erasable memory device.

[0096] It may be advantageous to set forth definitions of certain words and phrases used throughout this patent document. The terms "application" and "program" refer to one or more computer programs, software components, sets of instructions, procedures, functions, objects, classes, instances, related data, or a
portion thereof adapted for implementation in a suitable computer code (including
source code, object code, or executable code). The term "communicate," as well as
derivatives thereof, encompasses both direct and indirect communication. The terms
"include" and "comprise," as well as derivatives thereof, mean inclusion without
limitation. The term "or" is inclusive, meaning and/or. The phrase "associated with,"
as well as derivatives thereof, may mean to include, be included within, interconnect
with, contain, be contained within, connect to or with, couple to or with, be
communicable with, cooperate with, interleave, juxtapose, be proximate to, be bound
to or with, have, have a property of, have a relationship to or with, or the like. The
phrase "at least one of," when used with a list of items, means that different
combinations of one or more of the listed items may be used, and only one item in the
list may be needed. For example, "at least one of: A, B, and C" includes any of the

[0097] The description in this patent document should not be read as implying
that any particular element, step, or function is an essential or critical element that
must be included in the claim scope. Also, none of the claims is intended to invoke 35
U.S.C. § 112(f) with respect to any of the appended claims or claim elements unless
the exact words "means for" or "step for" are explicitly used in the particular claim,
followed by a participle phrase identifying a function. Use of terms such as (but not
limited to) "mechanism," "module," "device," "unit," "component," "element,"
"member," "apparatus," "machine," "system," "processor," "processing device," or
"controller" within a claim is understood and intended to refer to structures known to
those skilled in the relevant art, as further modified or enhanced by the features of the
claims themselves, and is not intended to invoke 35 U.S.C. § 112(f).

[0098] While this disclosure has described certain embodiments and generally
associated methods, alterations and permutations of these embodiments and methods
will be apparent to those skilled in the art. Accordingly, the above description of
element embodiments does not define or constrain this disclosure. Other changes,
substitutions, and alterations are also possible without departing from the spirit and
scope of this disclosure, as defined by the following claims.
WHAT IS CLAIMED IS:

1. A method comprising:
   receiving (1602) information defining at least one condition and at least one action associated with a rule, each condition associated with an event in an industrial process control and automation system (100), each action associated with information related to the event;
   based on actual events in the industrial process control and automation system, generating (1610) one or more notifications (502) for one or more users of one or more mobile devices (150) using the rule; and
   transmitting (1612) the one or more notifications for delivery to the one or more mobile devices.

2. The method of Claim 1, wherein the information defining the at least one condition comprises, for each condition:
   a source of events in the industrial process control and automation system;
   a category of events;
   a condition identified by events; and
   a priority of events.

3. The method of Claim 1, wherein the information defining the at least one condition varies based on a type of a source of the events in the industrial process control and automation system.

4. The method of Claim 1, wherein the information defining the at least one action comprises, for each action:
   a type of information to be included in the one or more notifications; and
   a source of the information to be included in the one or more notifications, the source within the industrial process control and automation system.

5. The method of Claim 1, further comprising:
   associating the rule with one or more user roles; and
   identifying the one or more users to receive the one or more notifications.
based on the one or more user roles.

6. An apparatus comprising:
   at least one interface (208) configured to communicate with one or more mobile devices (150); and
   at least one processing device (204) configured to:
       receive information defining at least one condition and at least one action associated with a rule, each condition associated with an event in an industrial process control and automation system (100), each action associated with information related to the event;
       based on actual events in the industrial process control and automation system, generate one or more notifications (502) for one or more users of one or more mobile devices (150) using the rule; and
       initiate transmission of the one or more notifications for delivery to the one or more mobile devices.

7. The apparatus of Claim 6, wherein the at least one processing device is further configured to:
   obtain information identifying the actual events;
   determine whether the at least one condition of the rule is satisfied based on the information identifying the actual events; and
   based on the determination, generate the one or more notifications to contain the information related to the event defined by the at least one action.

8. The apparatus of Claim 7, wherein the at least one processing device is configured to obtain the information identifying the actual events from multiple devices or systems (314, 142) in the industrial process control and automation system.

9. The apparatus of Claim 6, wherein the at least one processing device is configured to:
   receive information defining at least one condition and at least one action for each of multiple rules;
apply the multiple rules to the actual events in the industrial process control and automation system to generate multiple notifications for multiple users of multiple mobile devices; and
transmit the multiple notifications for delivery to the multiple mobile devices.

10. A non-transitory computer readable medium containing computer readable program code that, when executed, causes at least one processing device to:
receive (1602) information defining at least one condition and at least one action associated with a rule, each condition associated with an event in an industrial process control and automation system (100), each action associated with information related to the event;
based on actual events in the industrial process control and automation system, generate (1610) one or more notifications (502) for one or more users of one or more mobile devices (150) using the rule; and
initiate transmission (1612) of the one or more notifications for delivery to the one or more mobile devices.

11. The non-transitory computer readable medium of Claim 10, wherein:
the information defining the at least one condition comprises, for each condition:
a source of events in the industrial process control and automation system;
a category' of events;
a condition identified by events; and
a priority of events; and
the information defining the at least one action comprises, for each action:
a type of information to be included in the one or more notifications; and
a source of the information to be included in the one or more notifications, the source within the industrial process control and automation system.

12. The non-transitory computer readable medium of Claim 10, further
containing computer readable program code that, when executed, causes the at least one processing device to:

associate the rule with one or more user roles; and

identify the one or more users to receive the one or more notifications based on the one or more user roles.

13. The non-transitory computer readable medium of Claim 10, further containing computer readable program code that, when executed, causes the at least one processing device to:

obtain information identifying the actual events from multiple devices or systems (314, 142) in the industrial process control and automation system;

determine whether the at least one condition of the rule is satisfied based on the information identifying the actual events; and

based on the determination, generate the one or more notifications to contain the information related to the event defined by the at least one action;

14. The non-transitory computer readable medium of Claim 10, further containing computer readable program code that, when executed, causes the at least one processing device to:

receive information defining at least one condition and at least one action for each of multiple rules;

apply the multiple rules to the actual events in the industrial process control and automation system to generate multiple notifications for multiple users of multiple mobile devices; and

transmit the multiple notifications for delivery to the multiple mobile devices.
FIG. 2
### All Critical Flow Rate Alarms

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>32FC243 PVLOW 19.90 M³/HR</td>
<td>11:32AM</td>
</tr>
<tr>
<td>PASS 1 FLOW TO HEATER</td>
<td></td>
</tr>
<tr>
<td>You commented: &quot;Will investigate this...&quot; 5 mins ago</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>32FC242 PVLOW 19.90 M³/HR</td>
<td>11:01AM</td>
</tr>
<tr>
<td>PASS 1 FLOW TO HEATER</td>
<td></td>
</tr>
<tr>
<td>John Doe escalated to Andy Blue. 1 hr ago</td>
<td></td>
</tr>
</tbody>
</table>

### All Critical or High System Alarms

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Alarm</td>
<td>12:00AM</td>
</tr>
<tr>
<td>007_DEA_Server COMMS</td>
<td></td>
</tr>
<tr>
<td>Server: Link to 007_DEA_Server</td>
<td></td>
</tr>
<tr>
<td>You took ownership. 15 mins ago</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Alarm</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Alarm</td>
<td>11:30AM</td>
</tr>
<tr>
<td>006_DEA_Server COMMS</td>
<td></td>
</tr>
<tr>
<td>Server: Link to 006_DEA_Server</td>
<td></td>
</tr>
</tbody>
</table>

**FIG. 5**
6/15

Event

DETAIL

ALARM

11:12AM

32FC243 PVLOW 19.90 M3/HR

Description

PASS 1 FLOW TO HEATER

LOW FLOW RATE TO HEATER

TREND

Pump034 FlowRate PV
B1 = A1
145 m³/s

Pump033 FlowRate PV
B1 = A1
136 m³/s

Values

Valve3105 Switch State
B1 = A1
Closed

Valve3105 Switch State
B1 = A1
Closed

Other Rules

All Critical Heater Alarms

Close Escalate Own Flag Share

FIG. 6
### Rule Management

**Condition**
- Dynamo

**Rule Name**
- All critical alarms All assets
- Flow rate issues All assets
- Heater PV LO Unit 1
- Heater PV HI Unit 1

**Roles**
- Engineer
- Manager Engineer
- Manager Engineer Administrator

**Actions**
- Trend Value
A. CLASSIFICATION OF SUBJECT MATTER
G06Q 50/10(2012.01)1, G05B 23/02(2006.01)1

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06Q 50/10; G21C 1700; G05B 11/01; G05B 15/02; H04W 8/00; G06Q 50/00; G05B 23/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: condition, action, rule, notification, industrial process, rule

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Relevant to claim No.</th>
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<td>US 2015-0077263 AI (NUOVO PIGNONE SRL) 19 March 2015 See abstract, paragraphs [0025], [0040] - [0042], [0109], claims 1, 4 and figures 1-2, 4-5.</td>
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<td>US 2007-0297557 AI (MOTIOCHI KUWATANI) 27 December 2007 See abstract, paragraphs [0061H0064], [0103H0105], claims 2, 4-5, 7, 10 and figures 1-3B.</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search 28 July 2016 (28.07.2016)

Date of mailing of the international search report 28 July 2016 (28.07.2016)

Name and mailing address of the ISA/KR
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