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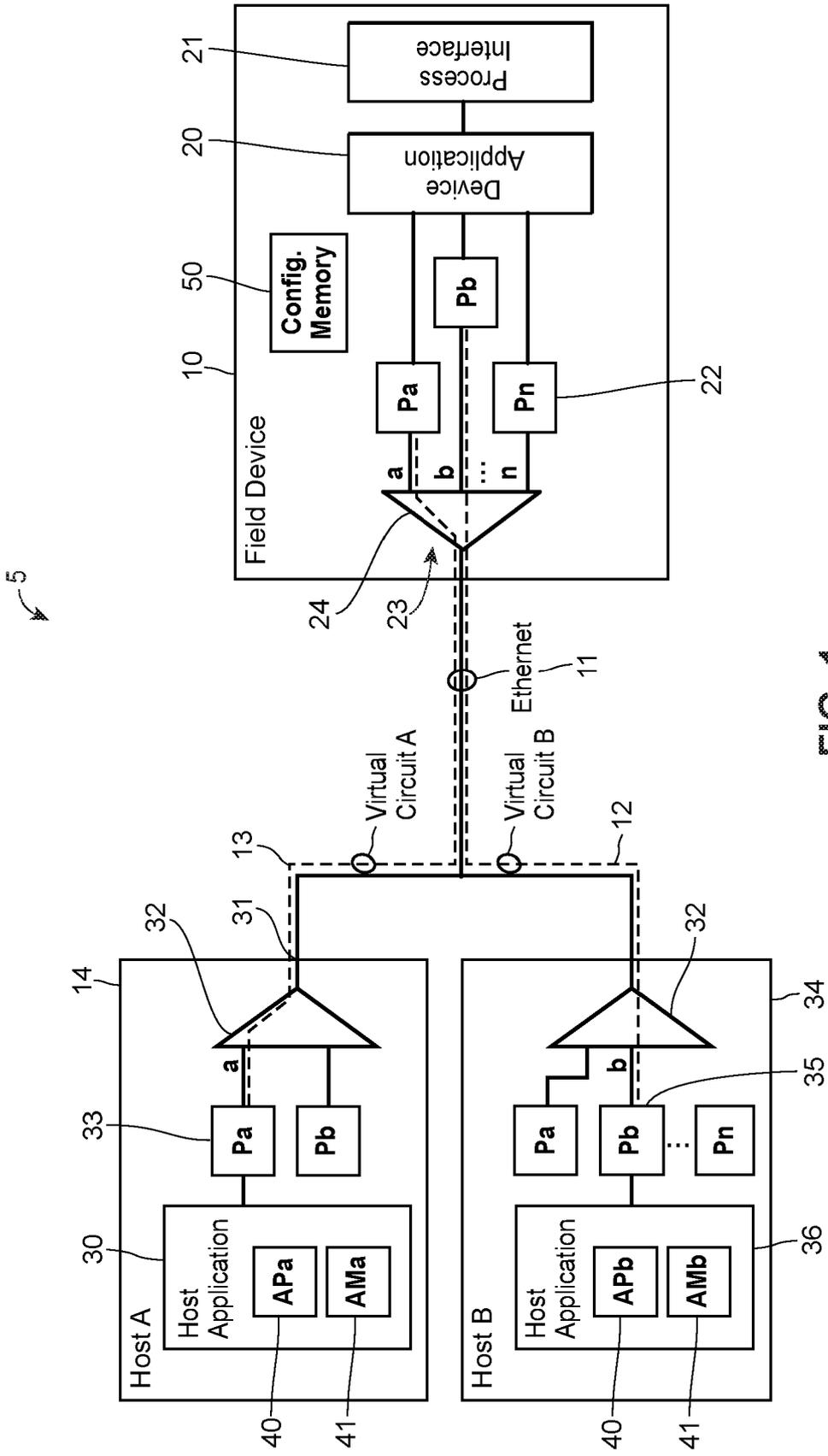


FIG. 1

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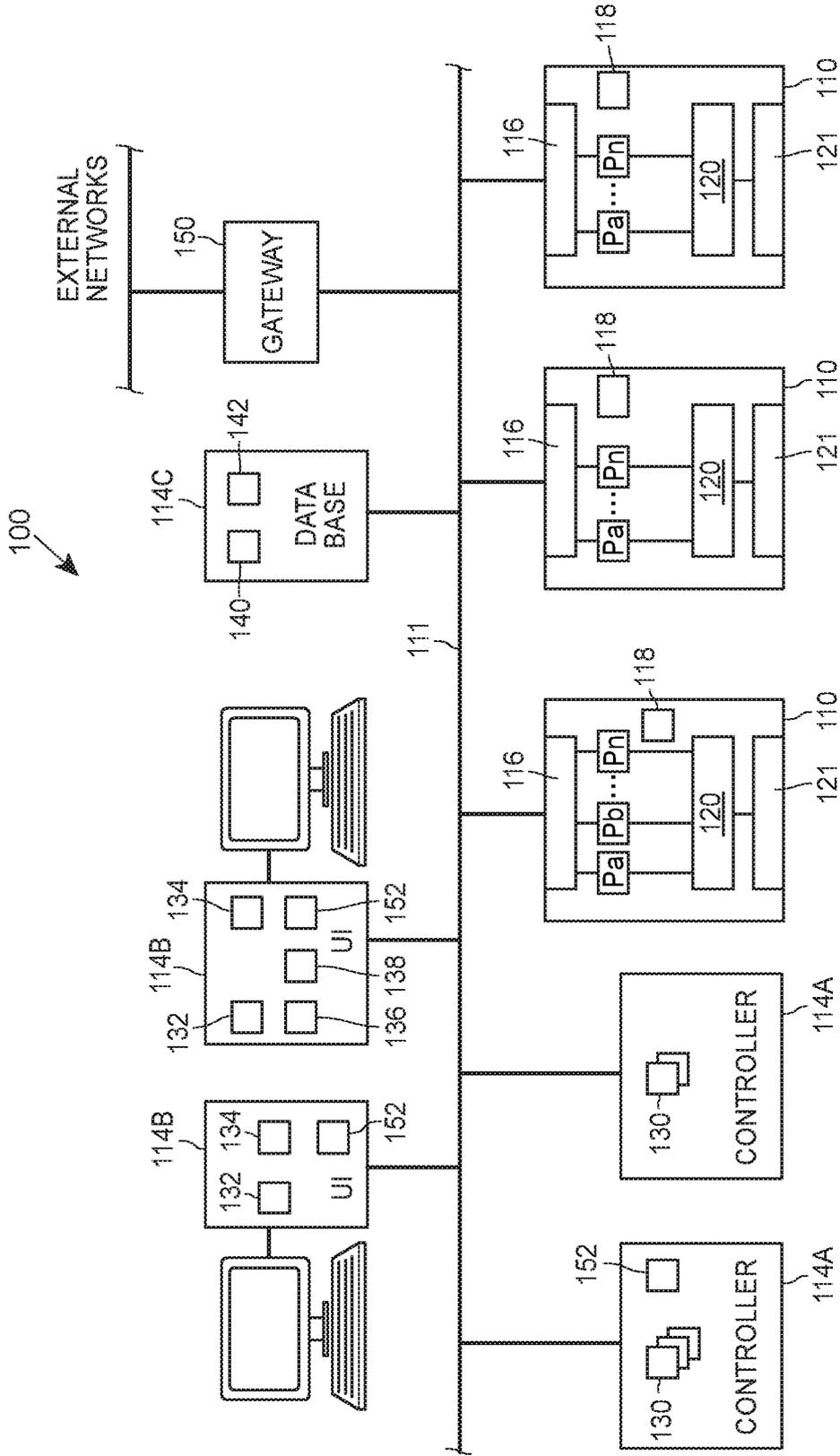


FIG. 2

MULTI-PROTOCOL FIELD DEVICE IN PROCESS CONTROL SYSTEMS

RELATED APPLICATION

[0001] This application is a regular filed case of and claims priority to U.S. Provisional Patent Application Serial No. 62/337,160, entitled "Multi-Protocol Field Device in Process Control Systems," which was filed on May 16, 2016, the entire disclosure of which is hereby expressly incorporated by reference herein.

TECHNICAL FIELD

[0002] This patent relates generally to communications within control and monitoring systems such as those in process plants, and more particularly, to a field device that is capable of communicating within a plant or with different plant automation systems using various different communication protocols.

BACKGROUND

[0003] Process or factory automation systems typically use one of several different industrial communication protocols when providing communications between controllers, input/output devices and field devices, such as Foundation™ Fieldbus protocol, the HART® protocol (such as the HART-IP protocol, the WirelessHART protocol), the Profibus protocol, the CAN protocol, the Modbus protocol, etc. Because the design and implementation of the automation system is tightly coupled with the communication protocol that is used, field devices used within the plant must communicate using the designated protocol to successfully integrate with the automation system. This architecture forces the field device manufacturer to make several versions of a field device available to customers to successfully participate in the automation marketplace, which leads to the need to have different drawings, user manuals, parts, inventory, etc., for essentially the same field device. Moreover, because field devices use only one protocol, the same field device is not easily transportable across or easily used within different plants or different plant automation systems.

SUMMARY

[0004] A field device includes components to communicate with a control and/or asset management system of a process control system, an automation system, a factory control system, etc., using any of several different communication protocols such as several different internet protocol (IP) protocols. This architecture allows for a single version of a field device to be provided in automation or plant control systems that use any of these communication protocols, thus saving on inventory and product development costs. Moreover, the multi-protocol field device or a system using the multi-protocol field device can manage the asset (read and write parameterized data from and to the asset) using one protocol while at the same time communicating real-time process/factory automation information using a second and different protocol. For example, a control system may use a protocol such as Ethernet/IP for real-time data while at the same time use another protocol such as HART-IP to manage the device assets. Moreover, the field device may be able to communicate to other devices using both of these protocols or other protocols for different purposes.

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[0005] In one case, a field device adapted to be connected to a communication network link includes a communication interface for connecting the field device to the communication network link, a device application unit that converts one or more process measurements to parameterized data or that converts parameterized data to one or more physical actions, a first communication unit associated with a first communication protocol that performs communications via the communication network link using the first protocol, and a second communication unit associated with a second communication protocol different from the first communication protocol that performs communications via the communication network link using the second protocol. Each of the communication units may be associated with or be configured as layers within an OSI communication model, such as parts of different data link layers, network layers, transport layers, session layers, presentation layers, or application layers, for example, of a communication system using a common physical layer within the OSI communication model.

[0006] The communication interface may be coupled to the first and second communication units and may include a multiplexer, such as a transport control protocol (TCP) multiplexer, to multiplex signals from the first and second communication units onto the communication network link and to provide communications in the first communication protocol arriving on the communication network link to the first communication unit and to provide communications in the second communication protocol arriving on the communication network link to the second communication unit.

[0007] The first communication protocol may be a first internet protocol (IP) and the second communication protocol may be a second internet protocol (IP) different than the first internet protocol (IP). If desired, the first internet protocol may be a generic communication internet protocol, such as an Ethernet/IP protocol or a Profinet protocol, and the second internet protocol may be a process control internet protocol, such as a HART-IP protocol or a Foundation Fieldbus protocol.

[0008] The field device may further include one or more sensors coupled to the device application for detecting a process condition to produce a process measurement and/or the field device may include one or more control mechanisms or apparatus coupled to the device application for performing one or more physical actions to control one or more process variables. The sensor may generate a process variable measurement that may be converted to parameterized data and the control apparatus may convert parameterized data (e.g., a digital control signal) to a current or voltage signal for performing the physical action and to control a process variable based on parameterized data from the device application. The control apparatus may be an actuator, such as a hydraulic or electrical actuator, or some other element that performs a physical movement of an element within the field device, another device or the plant.

[0009] In one example, the first communication unit may perform device management communications using the first communication protocol and the second communications unit may perform process control communications using the second communication protocol. The process control communications may include communications of real time process measurement or control signals for use in controlling a process, and these communication signals may be sent at a rate of 50 milliseconds or faster, at a rate of 10 milliseconds or faster or at other rates. The device management

communications may include one or more of alarm signals, device data request signals, or device configuration signals and these communication signals may be sent at a rate of 50 milliseconds or slower, 500 milliseconds or slower, or between 500 and 1000 milliseconds, for example. The process control and/or the device management communication signals may be sent in a non-periodic manner or in a periodic manner, if desired.

[0010] The field device or a host device connected to the field device may further include a memory that stores communication protocol configuration data for multiple different communication protocols and one or more of the first and second communication units may be configurable with the communication protocol configuration data stored in the memory to perform communications with respect to the stored and configured communication protocol. A user that interacts with a host device or another application executed on a host device may cause the host device to send messages to the field device to configure the communication protocol(s) used by the field device based on the communication protocol configuration data. In one case, the configuration data may be different communication or application layers that use different communication protocols, and the host device or an application within a host device may configure the field device using the communication protocol configuration data by instructing the field device to use a particular communication or application layer associated with a particular communication protocol for particular communications. As will be understood, the communication protocol configuration data may include data related to sending messages or otherwise communicating using the protocol, such as definitions of packet sizes and packet formats, commands, etc.

[0011] If desired, the first or second communication unit may perform voice communications using a voice and/or video over internet protocol and the field device may further include a sound and/or video detection and transmission unit coupled to the one of the first or second communication units and/or may include an audio and/or video communication port for connection to an external audio and/or video device. Either or both of the first or second communication protocols may be a wired or a wireless communication protocol.

[0012] In another case, a method of performing field device communications over a communication network link includes establishing a communication connection between the field device and the communication network link, converting, via a processor on the field device, one or more process measurements to parameterized data or parameterized data to a control signal(s) to cause a physical action at the field device, performing communications over the communication network link via a first communication unit in the field device using a first communication protocol, and performing communications over the communication network link via a second communication unit at the field device using a second communication protocol different from the first communication protocol.

[0013] Performing communications via the first and second communication units may include multiplexing signals from the first and second communication units onto the communication network link, providing communications in the first communication protocol arriving on the communication network link to the first communication unit and providing communications in the second

communication protocol arriving on the communication network link to the second communication unit.

[0014] The method may further include generating a process measurement via a sensor on the field device or performing a physical action via an actuator on the field device. Additionally, the method may include performing device management communications using the first communication protocol and performing process control communications using the second communication protocol. The method may further include storing configuration data for multiple different communication protocols in a configuration memory of the field device or in an external device such as a host device, and enabling a host device (e.g., an application within a host device or a user at the host device) to configure one or both of the first and second communication units with the configuration data stored in the memory to perform communications. The method may also include performing voice and/or video communications using one of the first or second communication units.

[0015] Still further, a process control system may include a communication link associated with a communication network, one or more host devices communicatively coupled to the communication link, and one or more field devices. Each of the one or more field devices includes a communication interface for connecting the field device to the communication link, a device application unit that converts one or more process measurements to parameterized data or that converts parameterized data to one or more physical action control signals, a first communication unit associated with a first communication protocol that performs communications via the communication network link using the first protocol, and a second communication unit associated with a second communication protocol different from the first communication protocol that performs communications via the communication link using the second protocol.

[0016] Still further, a method of performing communications within a process control system includes communicatively coupling a field device to one or more other devices such as host devices or other field devices, via a communication link associated with a communication network, communicating first data between one of the one or more other devices and the field device using a first communication protocol, including using a first communication unit in the field device to perform communications using the first communication protocol, and communicating second data between one of the one or more other devices and the field device using a second communication protocol that is different than the first communication protocol, including using a second communication unit in the field device to perform communications using the second communication protocol.

[0017] Likewise, a field device adapted to be connected to a communication network link includes a communication interface for connecting the field device to the communication network link, a device application unit that converts one or more process measurements to parameterized data or that converts parameterized data to one or more physical actions, a configurable communication unit that may be configured to use a first communication protocol or a second communication protocol different than the first communication protocol to perform communications via the communication network, and a communication protocol configuration memory storing communication protocol configuration data

associated with one of the first or second communication protocols for use by the communication unit to communicate using the first or the second communication protocol.

[0018] An aspect provides a field device configured to be connected to a communication network link, comprising: a communication interface for connecting the field device to the communication network link; a device application unit that converts a process measurement to parameterized data or that converts parameterized data to a physical action; a first communication unit associated with a first communication protocol that performs communications via the communication network link using the first protocol; and a second communication unit associated with a second communication protocol different from the first communication protocol that performs communications via the communication network link using the second protocol.

[0019] The communication interface may be coupled to the first and second communication units and may include a multiplexer to multiplex signals from the first and second communication units onto the communication network link and to provide communications in the first communication protocol arriving on the communication network link to the first communication unit and to provide communications in the second communication protocol arriving on the communication network link to the second communication unit.

[0020] The multiplexer may be a transmission control protocol (TCP) multiplexer.

[0021] The first communication protocol may be a first internet protocol (IP) and the second communication protocol may be a second internet protocol (IP) different than the first internet protocol (IP).

[0022] The first internet protocol may be a generic communication internet protocol and the second internet protocol may be a process control internet protocol.

[0023] The first internet protocol may be an Ethernet/IP protocol or a Profinet protocol and the second internet protocol may be a HART-IP protocol or a Foundation Fieldbus protocol.

[0024] The field device may further include one of a sensor coupled to the device application unit for detecting a process condition to produce a process measurement or a control apparatus coupled to the device application unit for performing the physical action to control a process variable.

[0025] The field device may further include a control apparatus coupled to the device application unit for performing the physical action, to thereby control a process variable based on parameterized data from the device application.

[0026] The control apparatus may be an actuator.

[0027] The control apparatus may be an electric or a hydraulic actuator that performs physical movement of an element.

[0028] The field device may further include a sensor for detecting a process condition to produce a process measurement.

- [0029]** The first communication unit may perform device management communications using the first communication protocol and the second communication unit may perform process control communications using the second communication protocol.
- [0030]** The process control communications may include communications of real time process measurement or control signals for use in controlling a process.
- [0031]** The process control communications may be sent at a rate of 50 milliseconds or faster.
- [0032]** The process control communications may be sent at a rate of 10 milliseconds or faster.
- [0033]** The device management communications may include one or more of alarm signals, device data request signals, or device configuration signals.
- [0034]** The device management communications may be sent at a rate of 500 milliseconds or slower.
- [0035]** The device management communications may be sent in a non-periodic manner.
- [0036]** The field device may further include a memory that stores communication protocol configuration data for multiple different communication protocols and wherein one or more of the first and second communication units may be configurable with the communication protocol configuration data stored in the memory to perform communications with respect to the stored and configured communication protocol.
- [0037]** One of the first or second communication units may perform voice communications.
- [0038]** The field device may further include a sound detection and transmission unit coupled to the one of the first or second communication units.
- [0039]** The one of the first or second communication units may perform voice-over-internet communications.
- [0040]** The other one of the first or second communication units may perform process control signal communications.
- [0041]** The field device may further include an audio and/or video communication port for connection to an audio and/or video device.
- [0042]** One of the first or second communication protocols may be a wireless communication protocol.
- [0043]** Another aspect provides a method of performing field device communications over a communication network link, comprising: establishing a communication connection between a field device and the communication network link; converting, via a processor on the field device, a process measurement to parameterized data or parameterized data to a control signal to cause a physical action at the field device; performing communications over the communication network link via a first communication unit within the field device using a first communication protocol; and performing

communications over the communication network link via a second communication unit within the field device using a second communication protocol different than the first communication protocol.

[0044] Performing communications via the first and second communication units may include multiplexing signals from the first and second communication units onto the communication network link and providing communications in the first communication protocol arriving on the communication network link to the first communication unit and providing communications in the second communication protocol arriving on the communication network link to the second communication unit.

[0045] Multiplexing may include multiplexing signals using a transmission control protocol (TCP).

[0046] The first communication protocol may be a first internet protocol (IP) and the second communication protocol is a second internet protocol (IP) different than the first internet protocol (IP).

[0047] The first internet protocol may be a generic communication internet protocol and the second internet protocol may be a process control internet protocol.

[0048] The method may further include generating the process measurement via a sensor on the field device or performing the physical action via an actuator on the field device.

[0049] The method may further include performing device management communications using the first communication protocol and performing process control communications using the second communication protocol.

[0050] The method may further include storing communication protocol configuration data for multiple different communication protocols in a memory of the field device and enabling a host device to configure one or both of the first and second communication units of the field device with the communication protocol configuration data stored in the memory to perform communications.

[0051] The method may include performing voice communications using one of the first or second communication units.

[0052] Another aspect provides a process control system, comprising: a communication link associated with a communication network; one or more field devices, each of the one or more field devices including, a communication interface for connecting the field device to the communication link; a device application unit that converts a process measurement to parameterized data or that converts parameterized data to a physical action control signal; a first communication unit associated with a first communication protocol that performs communications via the communication link using the first protocol; and a second communication unit associated with a second communication protocol different than the first communication protocol that performs communications via the communication link using the second protocol; and one or more other devices communicatively coupled to the communication link.

[0053] Communication interface for the field device may be coupled to the first and second communication units and may include a multiplexer to multiplex signals from the first and second communication units onto the communication link and to provide communications in the first

communication protocol arriving on the communication link to the first communication unit and to provide communications in the second communication protocol arriving on the communication link to the second communication unit.

[0054] The first communication protocol may be a first internet protocol (IP) and the second communication protocol may be a second internet protocol (IP) different than the first internet protocol (IP).

[0055] One of the one or more field devices may include a sensor coupled to the device application unit for detecting a process condition to produce a process measurement.

[0056] One of the one or more field devices may include a control apparatus coupled to the device application unit for performing the physical action to control a process variable.

[0057] The one or more other devices may include one or more host devices communicatively coupled to the communication link, and may further include first and second applications stored in and executed in the one or more host devices, wherein the first communication unit may perform communications with the first application using the first communication protocol and the second communication unit performs communications with the second application using the second communication protocol.

[0058] One of the first and second applications may be a process control application that performs on-line control activities.

[0059] The second one of the first and second applications may be a device or plant management application that performs device or plant management activities.

[0060] The second one of the first and second applications may be voice application that communicates voice and/or video signals over the communication link.

[0061] The one or more host devices may include a first host device and a second host device, and wherein the first host device may include a first host device communication interface that communicates with the first communication unit of one of the field devices using the first communication protocol and the second host device includes a second host device communication interface that communicates with the second communication unit of the one of the field devices using the second communication protocol.

[0062] The first and second applications may communicate with the field device simultaneously over the communication link using the first and second communication protocols.

[0063] One of the one or more field devices may further include a memory that stores communication protocol configuration data for multiple different communication protocols, and wherein at least one of the first and second communication units may be configurable with the communication protocol configuration data stored in the memory to perform communications.

[0064] One of the first and second communication units may be configurable via the communication link to configure the communication protocol used by the one of the first and second communication units.

[0065] The one or more other devices may include one or more host devices communicatively coupled to the communication link and wherein one of the one or more host devices may be a process controller device that executes a process control routine for controlling the process.

[0066] The one or more other devices may include one or more host devices communicatively coupled to the communication link and wherein one of the one or more host devices may be a user workstation.

[0067] The one or more other devices may include one or more host devices communicatively coupled to the communication link and wherein one of the one or more host devices may be a historian database.

[0068] The one or more other devices may include one or more host devices communicatively coupled to the communication link and wherein one of the one or more host devices may be a big data appliance.

[0069] Another aspect provides a method of performing communications within a process control system, comprising: communicatively coupling a field device to one or more other devices via a communication link associated with a communication network; communicating first data between one or more other devices and the field device over the communication link using a first communication protocol, including using a first communication unit in the field device to perform communications using the first communication protocol; and communicating second data between the one or more other devices and the field device over the communication link using a second communication protocol that is different than the first communication protocol, including using a second communication unit in the field device to perform communications using the second communication protocol.

[0070] The method of performing communications within a process control system may further include converting a process measurement to parameterized data or converting parameterized data to a physical action control signal within the field device.

[0071] Communicating the first and second data may include multiplexing signals from the first and second communication units onto the communication link and providing communications in the first communication protocol arriving on the communication link to the first communication unit and providing communications in the second communication protocol arriving on the communication link to the second communication unit.

[0072] The first communication protocol may be a first internet protocol (IP) and the second communication protocol may be a second internet protocol (IP) different than the first internet protocol (IP).

[0073] The method of performing communications within a process control system may include generating a process measurement via a sensor on the field device or performing a physical action via an actuator on the field device.

[0074] The method of performing communications within a process control system may further include performing device management communications using the first data communicated via the first communication protocol and performing process control communications using the second data communicated via the second communication protocol.

[0075] The method of performing communications within a process control system may further include storing communication protocol configuration data for multiple different communication protocols in a configuration memory and enabling a host device to configure one or both of the first and second communication units with the communication protocol configuration data stored in the configuration memory to perform communications.

[0076] The method of performing communications within a process control system may further include simultaneously communicating the first data and the second data over the communication link.

[0077] Simultaneously communicating the first data and the second data over the communication link may include interleaving messages of the first data in the first communication protocol with messages of the second data in the second communication protocol on the communication link.

[0078] Simultaneously communicating the first data and the second data over the communication link may include using a first channel on the communication link to communicate the first data and using a second channel on the communication link to communicate the second data.

[0079] The method of performing communications within a process control system may include performing voice communications using one of the first or second communication units.

[0080] The method of performing communications within a process control system may include performing communications between the field device and a first application in one of the one or more other devices using the first communication protocol and performing communications between the field device and a second application in one of the one or more other devices using the second communication protocol.

[0081] The method of performing communications within a process control system may further include configuring the communication protocol used by one of the first and second communication units in the field device.

[0082] The method of performing communications within a process control system may further include executing a process control routine within one of the one or more other devices for controlling a process using the field device and using the first or second communication protocol to send control signals between the field device and the control routine.

[0083] The method of performing communications within a process control system may further include executing a user interface routine within one of the one or more other devices and using the

first or second communication protocol to send user interface signals between the field device and the user interface.

[0084] The method of performing communications within a process control system may further include executing a database storage routine within one of the one or more other devices and using the first or second communication protocol to send data storage signals between the field device and the database storage routine.

[0085] Another aspect provides a field device configured to be connected to a communication network link, comprising: a communication interface for connecting the field device to the communication network link; a device application unit that converts a process measurement to parameterized data or that converts parameterized data to a physical action; a configurable communication unit that is configured to use a first communication protocol or a second communication protocol different than the first communication protocol to perform communications via the communication network link; and a configuration memory storing communication protocol configuration data associated with one of the first or second communication protocols for use by the communication unit to communicate using the first or the second communication protocol.

BRIEF DESCRIPTION OF THE DRAWINGS

[0086] Fig. 1 depicts a communication network having a multi-protocol field device connected to multiple different host devices via a network link using several different communication protocols.

[0087] Fig. 2 depicts a process control network that may be used in a process plant, for example, to perform communications between multiple field devices and each other and one or more host devices using multiple communication protocols over a single communication network or network link.

DETAILED DESCRIPTION

[0088] With the advent of industrial Ethernet, many industrial communication protocols now share the same transport layers of the communication protocol stack to carry their application layer messages. By implementing multiple application layers or other open system interconnection (OSI) model layers in a single field device using industrial Ethernet, for example, the choice of which application protocol to use can be made in the field when the field device is connected to the automation system, allowing for the same field device to be used on or with many different systems. It is also possible to use such a field device to simultaneously communicate with multiple host systems using different industrial communication protocols, such as Foundation Fieldbus, HART, Profibus, etc.

[0089] Fig. 1 illustrates an example communication system 5 having a multi-protocol field device 10 that communicates via a communication network link 11 with multiple other devices, which in this case are illustrated as other host devices 14 and 34 (Host A and Host B) within the system 5, using different process plant or other industrial communication protocols. It will be noted however, that the devices 14 and 34 could be other field devices or that other field devices 10 and even other host devices could be connected to the network 11 and communicate with the field device 10 illustrated in

Fig. 1 either at the same or at different times, using the multi-protocol communications described herein. In particular, as illustrated in Fig. 1, the field device 10 includes a device application 20 that operates to convert one or more process measurements to parameterized data or that converts parameterized data to one or more actuator actions through a process interface 21. While not shown specifically in Fig. 1, the field device 10 may be a transmitter and, as such, the process interface 21 may include hardware and/or firmware, such as one or more sensors, for determining a process condition to obtain one or more process measurements (e.g., an indication of a process variable value), such as a temperature sensor, a pressure sensor, a flow sensor, a level sensor, etc. The field device 10 may also or instead be a control device and the process interface 21 may include hardware and/or firmware that produces one or more control signals that take or cause some physical action to control one or more process variables in the plant based on parameterized data in the form of digital control signals, such as opening or closing a valve, moving an actuator or other element, etc. In this case, the field device 10 may produce a control signal as a current or voltage signal that drives an actuator (such as a hydraulic or electrical actuator) or other control device, or may be a valve or other device that includes an actuator. Of course, the field device 10 could include both types of hardware and/or firmware including sensors and actuators or other physical control operators.

[0090] Moreover, the field device 10 has a communication layer, circuit, or application that implements one or more industrial communication protocols 22, labeled as $P_a - P_n$. Still further, the field device 10 includes a network communication interface 23 such as an Ethernet interface or a Profinet interface. The interface 23 may use a communication multiplexer 24 such as a transmission control protocol (TCP) multiplexer to establish one or more virtual circuits 12 and 13 (illustrated in dotted line in Fig. 1) over the common channel or link 11. The channel or link 11 may be a hardwired or a wireless communication channel. Moreover, the virtual circuits 12 and 13 may be used for different ones of the protocols $P_a - P_n$. The first host device 14 (Host A) includes a host application 30 and an Ethernet interface 31 with a multiplexer 32 similar to that of the field device 10. In this case, the host application 30 is connected to a communication circuit or layer 33 that uses the industrial protocol P_a and that selects the virtual circuit 13 to be used for transporting information using the industrial communication protocol P_a , as the host device 14 may be designed to communicate using the protocol P_a . Likewise, the second host device 34 includes a similar configuration that selects the virtual circuit 12 for use in communicating using the industrial communication protocol P_b as implemented by a communication circuit or layer 35. Also, the second host device 34 includes one or more host applications 36 which are connected to the communication circuit or layer 35 that uses the industrial protocol P_b and that selects the virtual circuit 12. As noted above, the field device 10 could also or instead communicate with other field devices (not shown in Fig. 1) or to other host devices connected to the communication link 11 using the virtual circuits 12 and 13 or other virtual circuits, and/or using the same or different ones of the communication protocols $P_a - P_n$.

[0091] As will be understood, the field device 10 in Fig. 1 can be configured to communicate to the first host device 14 and/or to the second host device 34 (or to other devices, such as other host devices or other field devices) depending on the requirements of the application. For example, the first host device 14 may be used in the automation system of one plant using one type of

communication protocol, while the second host device 34 may be used in the automation system of a second plant that uses a different communication protocol. In another case, the first and second host devices 14 and 34 may be parts of different automation systems used in the same plant or factory or may be different parts of the same automation system used in the same or multiple plants. This architecture allows the same field device 10 to be used in either or both plant or automation systems (serially or simultaneously) without modifying the firmware of the field device 10 and without needing to change the communication protocol of the different automation systems. This system 5 also enables field device 10 to more easily be moved into different plant environments or in different automation systems that use different communication protocols.

[0092] As will be understood, automation systems, such as process plant automation systems, are typically made up of several sub-systems and, as such, the host devices 14 and 34 may execute different applications associated with those different sub-systems. On the other hand, a single one of the host devices 14 and 34 may execute applications associated with the different sub-systems. In any event, one such sub-system may be or include a process/factory automation application 40 that uses real-time process information from field measurement devices to calculate positions of field actuator devices to control the plant process (e.g., a real-time control subsystem). A sub-system may include a second application 41 used to manage the configuration of or the maintenance of the field devices within the plant by reading and writing parameterized data contained in or generated by the field device and sending data request signals to the field devices to obtain this data. These types of applications are typically referred to as asset management applications. As illustrated in Fig. 1, the second host device 34 includes similar applications 40, 41 associated with control and maintenance systems of a different system (e.g., a different plant or automation system in the same plant).

[0093] The use of TCP/IP protocols over industrial Ethernet allows multiple simultaneous connections or virtual circuits to be established between the field device 10 of Fig. 1 and the automation systems (such as those associated with host device 14 and host device 34 and/or other field devices) using different communication protocols or formats, allowing for multiple application layers to be used at the same time. This architecture allows the field device 10 to use one virtual circuit to communicate with one host 14 with one application 40 containing the process/factory automation application using a protocol such as an Ethernet/IP protocol or a Profinet protocol, to name but a few, and a second virtual circuit to simultaneously communicate with a second host 32 containing an asset management system 41 using a different protocol such as a HART-IP protocol or a Foundation Fieldbus protocol. As noted above, the applications 40 and 41 for the same automation system could be stored and executed in the same host device 14 or 34 and the communications using the various different protocols over the network link or channel 11 may be implemented between the same two devices (a host 14 or 34 and the field device 10) for each protocol. However, applications within multiple different host devices (or other field devices) could use the same protocol to communicate with the field device 10 and each host device 14 and 34 (or other field device) could include multiple applications that use different protocols to communicate with the field device 10. In this case, the interfaces of the host devices 14, 34 (and other field devices) will support each of the multiple communication protocols associated with the applications stored and executed therein.

[0094] In one case, the field device 10 in an industrial process control network or the factory automation network uses Ethernet to simultaneously communicate with the automation system using two different communication protocols. One Ethernet based protocol may be used, for example, to communicate the real-time/run-time process/factory automation information to the automation system, while a second Ethernet based protocol in the same field device 10 may be used to communicate the asset management information to the device management system of automation system.

[0095] In still another case, the field device 10 is capable of selecting from several industrial communication protocols for communication of asset management or process/factory automation information and/or of simultaneously communicating over Ethernet with one or more process or factory automation systems using different industrial communication protocols. The field device 10 includes a first communication unit P_a , for example, that performs device management communications using the first communication protocol and a second communications unit P_b , for example, that performs process control communications using the second communication protocol. If desired, the various communication units P_a - P_n may be associated with and/or executed as part of different application layers executed in the field device. For example, each of the communication units P_a - P_n may be associated with or be configured as layer within an OSI communication model, such as parts of different application layers or different transport layers, for example, of a communication system using a common physical layer within the OSI communication model. Of course, the communication units P_a - P_n may be implemented as parts of different data link layers, network layers, transport layers, session layers, presentation layers, or application layers, for example, of a communication system using a common physical layer within the OSI communication model. In other cases, the communication units P_a - P_n may be implemented as parts of different network layers, transport layers, session layers, presentation layers, or application layers, for example, of a communication system using a common physical layer and data link layer within the OSI communication model. Still further, the communication units P_a - P_n may be implemented as parts of different transport layers, session layers, presentation layers, or application layers, for example, of a communication system using a common physical layer, data link layer, and network layer within the OSI communication model. In yet another case, the communication units P_a - P_n may be implemented as parts of different session layers, presentation layers, or application layers, for example, of a communication system using a common physical layer, data link layer, network layer, and transport layer within the OSI communication model. In still another case, the communication units P_a - P_n may be implemented as parts of different presentation layers, or application layers, for example, of a communication system using a common physical layer, data link layer, network layer, transport layer, and session layer within the OSI communication model. On the other hand, the communication units P_a - P_n may be implemented as parts of different application layers of a communication system using a common physical layer, data link layer, network layer, transport layer, session layer, and presentation layer within the OSI communication model.

[0096] In more particular examples, the process control communications may include communications of real time process measurement or control signals for use in controlling a process and may be sent over the network 11 at a rate of 50 milliseconds or faster (slow control) or at a rate of

10 milliseconds or faster (fast control). Of course other rates could be used as well or instead. Additionally, the device management communications may include one or more of alarm signals, device data request signals, device configuration signals, historical or trend data stored in the device, or other typical asset management signals. If desired, the device management communications may be sent at a rate of 50 milliseconds or slower, 500 milliseconds or slower, between 500 and 1000 milliseconds, or any other rate, which may be the same as or different than the rate used for the process control communication signals. Communications using the different protocols may be asynchronous with respect to each other. Likewise, the process control communications and/or the device management communications may be sent in a periodic or a non-periodic manner. Of course, the use of process control communications and device management communications for the separate protocol communications is but one example, and other types of communications could be applied to the different protocols. Likewise, if desired, the two separate or different protocols could be used to send the same types of signals, such as process control signals or device management signals. For example, a first field device 10 could be connected to the network communication link 11 and communicate control signals using a first protocol and a second field device 10 could be connected to the link 11 and communicate control signals using the second protocol. The field devices (if they implement two or protocol communications) could receive and decode the communications of the other field devices 10 (which could be multi-protocol field devices or traditional single protocol field devices) and of one or more host devices 14 and/or 34. Likewise, each of the host devices 14, 34 may implement a control application for a particular control sub-system, and may receive and decode both types of protocol signals to perform control in the same control sub-system. If desired, different control applications may be executed in different ones of the host devices 14 and 34 or in the same host device 14 or 34 (which may be controllers) and these different control applications may use the different protocols to perform control.

[0097] As another example, the field device 10 may use this multi-protocol capability to perform other types of communications within a plant in addition to process control communications or device management communications, such as voice and/or video over Ethernet communications. In this case, one of the communication units P_a - P_n of the field device 10 may perform voice and/or video communications using a voice over IP or other communication protocol designed for that purpose. For example, many asset management tasks require communications between an instrumentation technician in the field near the asset and the personnel in the control room. Walkie-talkies are often used for this purpose. TCP/IP makes it possible to transport audio/video and process/factory automation data streams on the Ethernet network simultaneously. If an exterior physical port is made available at the field device 10 for connection of an audio/video communication device, the need for external communication devices like walkie-talkies and cell phones could be eliminated. This connection could be made available directly on the field device 10 or at a junction box near the field device 10 and the field device 10 may use the techniques described herein to perform voice or video over IP communications over one or more virtual circuits using one of the supported industrial protocols. In another case, the field device 10 itself may include a sound and/or video detection and/or display or transmission unit coupled to the one of the first or second communication units P_a - P_n

in the field device 10, or may include an audio and/or video communication port for connection to an external audio and/or video capture and/or display device.

[0098] Still further, the system 5 described herein, or the various devices therein, may incorporate a Bluetooth or other near field communication protocol headset connection. For example, a wireless connection, such as Bluetooth, could be used to connect a headset and/or a camera to the Ethernet network 11 for providing communications between the personnel in control room and those in the field over the process plant network 11. A wireless connection such as Bluetooth could also be used to connect a handheld field maintenance tool to the field device 10 so that calibration/configuration parameters could be set without opening the field device with a traditional wired connection.

[0099] In another case, the communication techniques described herein may incorporate or be used to perform thin-client mobile worker device communications. For example, using the multi-channel communication capabilities of TCP/IP, information between a thin-client terminal device and the control room automation system (e.g., user interface data) could be transported over the same Ethernet communication network 11 as the process/factory automation data. This architecture may allow some tasks taking two people today to be performed by a single person in the field.

[00100] Of course, as noted above, the first communication protocol may be a first internet protocol (IP), such as Ethernet/IP or Profinet, and the second communication protocol may be a second internet protocol (IP), such as HART-IP or Foundation Fieldbus, different than the first internet protocol (IP). In one example, the first internet protocol may be a generic communication internet protocol (such as Ethernet or Profinet) used in many different types of computer networks, and the second internet protocol may be a process control internet protocol, used in or designed for process control communications, such as HART or Fieldbus communications. As also noted above, the field device 10 may use or support more than two communication protocols, such as three, four, five, etc.

[00101] In another case, the field device 10 may further include a memory 50, such as a configuration memory, that stores communication protocol configuration data for one or multiple different communication protocols, such that one or more of the first and second communication units P_a - P_n is configurable with the communication protocol configuration data stored in the memory 50 to perform communications with respect to the stored and configured communication protocol. In this case, the field device 10 may be configured by a host device, such as a configuration application 41 running in a host device 14, 34, to communicate using one or more of the stored protocols. In particular, one or more of the communication units P_a - P_n may be configured to communicate using the same or different protocols at the factory, and the configuration application 41 may connect to the field device 10 via one of the preconfigured communication units P_a - P_n and access data in the configuration memory 50 of the field device 10 to determine the particular protocols to which the field device 10 or to which one or more of the communication units P_a - P_n of the field device 10 can be configured. The configuration application 41 may then configure one or all of the communication units P_a - P_n using the communication protocol configuration data stored in the configuration memory 50 to communicate over the network link 11. The configuration application 41 may additionally specify or configure the types of data (within the field device 10) to communicate using each of the

communication units P_a - P_n or the virtual circuits (e.g., 12 and 13) or other applications to which each of the communication units P_a - P_n should connect when communicating. Of course, if desired, one or more of the communication units P_a - P_n can be fixed or static in the protocol it uses, while one or more of the other communication units P_a - P_n may be configurable. Likewise, if desired, the configuration memory 50 may store communication protocol configuration data for any number of protocols and can support more protocols than there are communication units P_a - P_n , if desired. Likewise, the protocol configuration data may be updated as new protocols are designed or as protocols are updated. Still further, the communication protocol configuration memory 50 may be stored or located in the host device 14 and/or 34 or some other device and may be used by the configuration application 41 to configure the field device 10. Thus, the field device 10 does not need to have the configuration memory 50 disposed therein. Moreover, in one example, the configuration data 50 may be communication layers or application layers that use different communication protocols, and the host device or an application within a host device may configure the field device 10 using the configuration data by instructing the field device 10 to use a particular communication or application layer associated with a particular communication protocol.

[00102] Still further, while the field device 10 is illustrated and described herein as including a plurality of communication units P_a - P_n , any or all of which can be configurable to use one of any number of different protocols, the field device 10 could include only one communication unit P_1 which could be configurable to use different communication protocols at different times. In this case, the field device 10 can be manufactured to be able to be used in many different types of networks or systems that use many different protocols, but the field device 10 can only communicate using a single protocol at any particular time.

[00103] Fig. 2 illustrates a process plant system 100 in which a plurality of multi-protocol field devices 110 are connected through a network link 111 to multiple host devices 114, which may be, for example, process controllers, user interfaces or workstations, databases, such as big data appliances, data historians, configuration databases, etc. As illustrated in Fig. 2, each of the field devices 110 includes one or more communication units P_a - P_n , which may be configurable, a network interface 116, a configuration memory 118, a device application 120, and sensor and/or control hardware and/or firmware 121. Here, one or more of the host devices 114A may be process controller devices which run or execute one or more control routines or control applications 130, one or more of the host devices 114B may be servers or user workstations that execute device or control system management applications 132, configuration applications 134, data analytics applications 136, data storage applications 138 or other display applications. Still further, one or more of the host devices 114C may be data storage devices that run or execute data storage applications 140 and data analytic applications 142, such as data historians, big data appliances, etc. The communication network link or network 111 may be coupled, via gateway devices 150 to other networks that may use the same or different communication protocols than the network 111. These other networks may be associated with other plants, other process control systems, business systems, cloud based systems, etc.

[00104] As will be noted, the system 100 of Fig. 2 illustrates one example of a process control system having a communication link 111 associated with communication network, one or more host devices 114 communicatively coupled to the communication link 111 and one or more field devices 110 communicatively coupled to the communication link 111. Each of the field devices 110 includes a communication interface 116 for connecting the field device 110 to the communication link 111, a device application unit 120 that converts one or more process measurements to parameterized data and/or that converts parameterized data to one or more physical action control signals, and one or more communication units P, including a first communication unit P_a associated with a first communication protocol that performs communications via the communication network link 111 using the first communication protocol and a second communication unit P_b, for example, associated with a second communication protocol different from the first communication protocol that performs communications via the communication network link 111 using the second communication protocol

[00105] As noted above, the communication interface 116 for the field device 110 is coupled to the first and second communication units P_a-P_n and includes a multiplexer 116 to multiplex signals from the first and second communication units P_a-P_n onto the communication link 111 and to provide communications in the first communication protocol on the communication link 111 to the first communication unit P_a and to provide communications in the second communication protocol on the communication link 111 to the second communication unit P_b, for example.

[00106] One of the one or more field devices 110 includes a sensor 121 coupled to the device application 120 for detecting a process condition to produce a process measurement and another one of the one or more field devices 110 includes a control apparatus 121 coupled to the device application 120 for performing the physical action to control a process variable.

[00107] The process control system 100 of Fig. 2 further includes first and second applications stored in and executed in one or more of the one or more host devices 114, wherein the first communication unit P_a of one of the field devices 110 performs communications with the first application using the first communication protocol and the second communication unit P_b, for example, performs communications with the second application using the second communication protocol. If desired, one of the first and second applications is a process control application 130 that performs on-line control activities, and a second one of the first and second applications is a device or plant management application 132, 134, etc. that performs device or plant management activities. Still further, one of the applications may be a voice over internet or video over internet application 152 that communicates voice and/or video signals over the communication link between a field device 110 and a user workstation 114B, for example.

[00108] The host devices 114 may also support multi-protocol communications. As an example, a first one of the host devices 114 includes a first host device communication interface 160 that communicates with the first communication unit P_a of one of the field devices 110 using the first communication protocol and a second one of the host devices 114 includes a second host device communication interface 160 that communicates with the second communication unit P_b, for example, of the one of the field devices 110 using the second communication protocol. The first and second

applications may communicate with the field device 110 or with different ones of the field devices 110 simultaneously over the communication link 111 using the first and second communication protocols.

[00109] The one or more field devices 110 may further include a memory 118 that stores configuration data for multiple different communication protocols (e.g., application layers, transport layers, etc.), and at least one of the communication units P_a - P_n may be configurable with the configuration data stored in the memory 118 to perform communications. If desired, the one or more of the communication units P_a - P_n is/are configurable via the communication link 111 to configure the communication protocol used by the communication units P_a - P_n . If desired, the communication protocol configuration memory 118 may instead or in addition be stored in one or more of the host devices 114, such as in the workstation or user interface device 114B associated with a configuration application.

[00110] Moreover, a method of performing communications within the process control system 100 may include communicatively coupling a field device 110 to one or more other devices, such as host devices 114 or other field devices 110, via the communication link 111 associated with a communication network, communicating first data between one of the one or more other devices 110, 114 and the field device 110 using a first communication protocol, including using a first communication unit P_a in the field device 110 to perform communications using the first communication protocol and communicating second data between one of the one or more other devices 110, 114 and the field device 110 using a second communication protocol that is different than the first communication protocol, including using a second communication unit P_b , for example, in the field device 110 to perform communications using the second communication protocol.

[00111] The method may further include converting a process measurement to parameterized data or converting parameterized data to a physical action control signal within the field device 110, and communicating the first and second data may include multiplexing signals from the first and second communication units P_a - P_n onto the communication link 111 and providing communications in the first communication protocol on the communication link 111 to the first communication unit P_a and providing communications in the second communication protocol on the communication link 111 to the second communication unit P_b . The first communication protocol may be a first internet protocol (IP) and the second communication protocol may be a second internet protocol (IP) different than the first internet protocol (IP). Generating a process measurement may include using a sensor on the field device 110 and performing the physical action may include using an actuator on the field device 110.

[00112] The communication method may include performing device management communications using the first data communicated via the first communication protocol and performing process control communications using the second data communicated via the second communication protocol. Still further, the method may include storing communication protocol configuration data for multiple different communication protocols in a configuration memory and enabling a user to configure one or both of the first and second communication units P_a - P_n with the configuration data stored in the

memory 118 to perform communications. The memory 118 may be in a field device 110 or in a host device 114 or an another device communicatively connected to the network 111.

[00113] The method may include simultaneously communicating the first data and the second data over the communication link 111 and simultaneously communicating the first data and the second data over the communication link 111 may include interleaving messages of the first data in the first communication protocol with messages of the second data in the second communication protocol on the communication link 111 or using different channels on the network link 111. The method may include using packet based messaging protocols on the communication link 111. In another case, simultaneously communicating the first data and the second data over the communication link 111 may include using a first channel on the communication link 111 to communicate the first data and using a second channel on the communication link 111 to communicate the second data. The method may include performing voice communications using one of the first or second communication units P_a - P_n . The method may also include performing communications between the field device 110 and a first application in one of the one or more host devices 114 using the first communication protocol and performing communications between the field device 110 and a second application in one of the one or more host devices 114 using the second communication protocol.

[00114] The method may also include configuring the communication protocol used by one of the first and second communication units P_a - P_n in the field device 110. Still further, the method may include executing a process control routine 130 within one of the one or more host devices 114A for controlling a process using the field device 110 and using the first or second communication protocol to send control signals between the field device 110 and the control routine 130. The method may also include executing a user interface routine 132 within one of the one or more host devices 114B and using the first or second communication protocol to send user interface signals between the field device 110 and the user interface routine 132. The method may also include executing a database storage routine 140, 142 within one of the one or more host devices 114C and using the first or second communication protocol to send data storage signals between the field device 110 and the database storage routine 140, 142.

[00115] Any or all of the systems, methods, and techniques disclosed herein may be utilized in any process plant or process control system that is configured to control or monitor a process in real-time. Moreover, as used herein, a “devices,” “field devices,” or “equipment,” generally refers to a physical element or component which may or may not be directly utilized during control of the process or portion thereof, but nonetheless may be ordered with other equipment pieces and/or process elements with respect to the control or flow of the process.

[00116] When implemented in software, any of the applications, routines, blocks, services, and engines described herein may be stored in any tangible, non-transitory computer readable memory such as on a magnetic disk, a laser disk, solid state memory device, molecular memory storage device, or other storage medium, in a RAM or ROM of a computer or processor, etc. Although the example systems disclosed herein are disclosed as including, among other components, software and/or firmware executed on hardware, such as computer processors, it should be noted that such

systems are merely illustrative and should not be considered as limiting. For example, it is contemplated that any or all of these hardware, software, and firmware components could be embodied exclusively in hardware, exclusively in software, or in any combination of hardware and software. Accordingly, while the example systems described herein are described as being implemented in software executed on a processor of one or more computer devices, persons of ordinary skill in the art will readily appreciate that the examples provided are not the only way to implement such systems.

[00117] Thus, while the present invention has been described with reference to specific examples, which are intended to be illustrative only and not to be limiting of the invention, it will be apparent to those of ordinary skill in the art that changes, additions or deletions may be made to the disclosed embodiments without departing from the spirit and scope of the invention.

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CLAIMS

1. A field device configured to be connected to a communication network link, comprising:

a communication interface for connecting the field device to the communication network link;

a device application unit that converts a process measurement to parameterized data or that converts parameterized data to a physical action;

a first communication unit associated with a first communication protocol that performs communications via the communication network link using the first protocol; and

a second communication unit associated with a second communication protocol different from the first communication protocol that performs communications via the communication network link using the second protocol.

2. The field device of claim 1, wherein the communication interface is coupled to the first and second communication units and includes a multiplexer to multiplex signals from the first and second communication units onto the communication network link and to provide communications in the first communication protocol arriving on the communication network link to the first communication unit and to provide communications in the second communication protocol arriving on the communication network link to the second communication unit.

3. The field device of claim 2, wherein the multiplexer is a transmission control protocol (TCP) multiplexer.

4. The field device of claim 1, wherein the first communication protocol is a first internet protocol (IP) and the second communication protocol is a second internet protocol (IP) different than the first internet protocol (IP).

5. The field device of claim 4, wherein the first internet protocol is a generic communication internet protocol and the second internet protocol is a process control internet protocol.

6. The field device of claim 5, wherein the first internet protocol is an Ethernet/IP protocol or a Profinet protocol and the second internet protocol is a HART-IP protocol or a Foundation Fieldbus protocol.

7. The field device of claim 1, further including one of a sensor coupled to the device application unit for detecting a process condition to produce a process measurement or a control apparatus coupled to the device application unit for performing the physical action to control a process variable.

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8. The field device of claim 1, further including a control apparatus coupled to the device application unit for performing the physical action, to thereby control a process variable based on parameterized data from the device application.

9. The field device of claim 8, wherein the control apparatus is an actuator.

10. The field device of claim 8, wherein the control apparatus is an electric or a hydraulic actuator that performs physical movement of an element.

11. The field device of claim 1, further including a sensor for detecting a process condition to produce a process measurement.

12. The field device of claim 1, wherein the first communication unit performs device management communications using the first communication protocol and the second communication unit performs process control communications using the second communication protocol.

13. The field device of claim 12, wherein the process control communications include communications of real time process measurement or control signals for use in controlling a process.

14. The field device of claim 13, wherein the process control communications are sent at a rate of 50 milliseconds or faster.

15. The field device of claim 13, wherein the process control communications are sent at a rate of 10 milliseconds or faster.

16. The field device of claim 12, wherein the device management communications include one or more of alarm signals, device data request signals, or device configuration signals.

17. The field device of claim 12, wherein the device management communications are sent at a rate of 500 milliseconds or slower.

18. The field device of claim 12, wherein the device management communications are sent in a non-periodic manner.

19. The field device of claim 1, further including a memory that stores communication protocol configuration data for multiple different communication protocols and wherein one or more of the first and second communication units is configurable with the communication protocol configuration data stored in the memory to perform communications with respect to the stored and configured communication protocol.

20. The field device of claim 1, wherein one of the first or second communication units performs voice communications.

21. The field device of claim 20, further including a sound detection and transmission unit coupled to the one of the first or second communication units.

22. A method of performing field device communications over a communication network link, comprising:

establishing a communication connection between a field device and the communication network link;

converting, via a processor on the field device, a process measurement to parameterized data or parameterized data to a control signal to cause a physical action at the field device;

performing communications over the communication network link via a first communication unit within the field device using a first communication protocol; and

performing communications over the communication network link via a second communication unit within the field device using a second communication protocol different than the first communication protocol.

23. A process control system, comprising:

a communication link associated with a communication network;

one or more field devices, each of the one or more field devices including,

a communication interface for connecting the field device to the communication link;

a device application unit that converts a process measurement to parameterized data or that converts parameterized data to a physical action control signal;

a first communication unit associated with a first communication protocol that performs communications via the communication link using the first protocol; and

a second communication unit associated with a second communication protocol different than the first communication protocol that performs communications via the communication link using the second protocol; and

one or more other devices communicatively coupled to the communication link.

24. A method of performing communications within a process control system, comprising:

communicatively coupling a field device to one or more other devices via a communication link associated with a communication network;

communicating first data between one or more other devices and the field device over the communication link using a first communication protocol, including using a first communication unit in the field device to perform communications using the first communication protocol; and

communicating second data between the one or more other devices and the field device over the communication link using a second communication protocol that is different than the first communication protocol, including using a second communication unit in the field device to perform communications using the second communication protocol.

25. A field device configured to be connected to a communication network link, comprising:

a communication interface for connecting the field device to the communication network link;

a device application unit that converts a process measurement to parameterized data or that converts parameterized data to a physical action;

a configurable communication unit that is configured to use a first communication protocol or a second communication protocol different than the first communication protocol to perform communications via the communication network link; and

a configuration memory storing communication protocol configuration data associated with one of the first or second communication protocols for use by the communication unit to communicate using the first or the second communication protocol.

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