पेटेंट कार्यालय
शासकीय जर्नल

OFFICIAL JOURNAL
OF
THE PATENT OFFICE

निर्गमन सं. 26/2022	शुक्रवार	दिनांक: 01/07/2022
ISSUE NO. 26/2022	**FRIDAY**	**DATE: 01/07/2022**

पेटेंट कार्यालय का एक प्रकाशन
PUBLICATION OF THE PATENT OFFICE

(12) PATENT APPLICATION PUBLICATION

(19) INDIA

(22) Date of filing of Application :24/06/2022

(21) Application No.202241036326 A

(43) Publication Date : 01/07/2022

(54) Title of the invention : METHOD AND SYSTEM FOR ANALYZING CLOUD ARCHITECTURE USING MACHINE LEARNING MODELS

(51) International classification	:H04L0029080000, G06N0020000000, G06F0009500000, G05B0019418000, H04L0029060000
(86) International Application No Filing Date	:PCT// :01/01/1900
(87) International Publication No	: NA
(61) Patent of Addition to Application Number Filing Date	:NA :NA
(62) Divisional to Application Number Filing Date	:NA :NA

(71)**Name of Applicant :**

1)DR. D. SURESH BABU (Head and BoS Chairperson)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. sureshd123@gmail.com Ph: 8179108983 Khammam ----------- -----------

2)DR. K. NAGESWAR RAO (Lecturer)

3)J.V.S ARUNDATHI (Lecturer)

4)K. USHA PAVANI (Lecturer)

5)BABULU (Lecturer)

6)J. GULABSINGH (Lecturer)

7)V. PULLARAO (Lecturer)

8)V. SWAPNA (Lecturer)

Name of Applicant : NA

Address of Applicant : NA

(72)**Name of Inventor :**

1)DR. D. SURESH BABU (Head and BoS Chairperson)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. sureshd123@gmail.com Ph: 8179108983 Khammam ----------- -----------

2)DR. K. NAGESWAR RAO (Lecturer)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. kasalanag@gmail.com Ph: 8686206907 Khammam ----------- -----------

3)J.V.S ARUNDATHI (Lecturer)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. jvs.arundathi@gmail.com Ph: 8639168744 Khammam ----------- -----------

4)K. USHA PAVANI (Lecturer)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. kusumausha03@gmail.com Ph: 9154317942 Khammam ----------- -----------

5)BABULU (Lecturer)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. babulu.ahirwar@gmail.com Ph: 9985238180 Ph: 8341022336 Khammam ----------- -----------

6)J. GULABSINGH (Lecturer)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. gulab1.mca015@gmail.com Ph: 7396986513 Khammam ----------- -----------

7)V. PULLARAO (Lecturer)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. pullaraovanam2@gmail.com Ph: 9398756062 Khammam ----------- -----------

8)V. SWAPNA (Lecturer)

Address of Applicant :DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001 Email. swapnagadupudi7799@gmail.com Ph: 9553677799 Khammam ----------- -----------

(57) Abstract :

METHOD AND SYSTEM FOR ANALYZING CLOUD ARCHITECTURE USING MACHINE LEARNING MODELS ABSTRACT The present invention provides an approach for analyzing cloud architecture using machine learning models. The system includes an interface component, a validation component and an execution component. The interface component transmits industrial data associated with an industrial device to the cloud platform that analyzes the industrial data. The interface component also receives, from the cloud platform, command data for the industrial device that is generated based on the industrial data. The validation component validates the command data received from the cloud platform based on execution data indicative of a set of conditions for the command data. The validation component also establishes a secure communication link with the industrial device in response to a determination that the command data is approved for execution on the industrial device. The execution component initiates execution of the command data via the industrial device.

No. of Pages : 19 No. of Claims : 5

FORM 2

THE PATENT ACT, 1970

(39 OF 1970)

&

THE PATENT RULES, 2003

COMPLETE SPECIFICATION

[SEE SECTION 10 AND RULE 13]

TITLE: METHOD AND SYSTEM FOR ANALYZING CLOUD ARCHITECTURE USING MACHINE LEARNING MODELS	
APPLICANTS:	
DR. D. SURESH BABU	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001
DR. K. NAGESWAR RAO	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001
J.V.S ARUNDATHI	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001
K. USHA PAVANI	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001
BABULU	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001

J. GULABSINGH	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001
V. PULLARAO	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001
V. SWAPNA	DEPARTMENT OF COMPUTER SCIENCE & APPLICATIONS SR & BGNR GOVT. ARTS & SCIENCE COLLEGE (A), KHAMMAM, KHAMMAM DISTRICT, TELANGANA, INDIA 507001

The following specification particularly describes the invention and the manner in which it is to be performed

METHOD AND SYSTEM FOR ANALYZING CLOUD ARCHITECTURE USING MACHINE LEARNING MODELS

FIELD OF THE INVENTION

[0001] The present invention generally relates to cloud architecture. More particularly, the invention relates to analyzing cloud architecture using Machine Learning (ML) models.

BACKGROUND OF THE INVENTION

[0002] The "cloud" is an abstraction that relates to resource management over a network and, more specifically, to a data center architecture that provides a platform for delivering services via a network. For example, the cloud may refer to various services delivered over the Internet such as network-based storage services or compute services. Typical cloud architecture deployments include a layered hierarchy that includes a physical layer of network hardware, and one or more software layers that enable users to access the network hardware. For example, one common type of cloud architecture deployment includes a physical layer of network resources (e.g., servers, storage device arrays, network switches, etc.) accompanied by a multi-layered hierarchical software framework that includes a first layer that implements Infrastructure as a Service (IaaS), a second layer that implements Platform as a Service (PaaS), and a third layer that implements Software as a Service (SaaS). In general, although there may be exceptions, resources in the third layer are dependent on resources in the second layer, resources in the second layer are dependent on resources in the first layer, and resources in the first layer are dependent on resources in the physical layer.

[0003] In conventional cloud architectures, the resources in the physical layer may be allocated to services implemented in the first layer (i.e., IaaS services). For example, a resource manager for the first layer may be configured to allocate resources in the physical layer to different IaaS services running in the first layer. Examples of IaaS services include the Amazon® Elastic Compute Cloud (EC2) platform, which enables a client to reserve one or more nodes in the physical layer of the cloud to perform some computations or run an application, and the Amazon®

Simple Storage Service (S3) storage platform, which provides cloud-based storage in one or more data centers. Each instance of an IaaS service may also include a resource manager that requests resources to implement the service from the resource manager of the first layer and manage the allocated resources within the service.

[0004] In turn, the resources in the first layer (i.e., IaaS services) may be allocated to services implemented in the second layer (i.e., PaaS services). For example, a resource manager for the second layer may be configured to allocate resources in the first layer to different PaaS services running in the second layer. Examples of PaaS services include the Microsoft® Azure App Service platform, which enables a client to build applications that run on a Microsoft cloud infrastructure, and the Google® Heroku platform, which enables a client to build applications that run on Amazon® IaaS services. PaaS services typically provide containers that manage infrastructure resources such that applications running in the cloud are easily scalable without the developer having to manage those resources. Again, multiple PaaS services may be run simultaneously in the PaaS layer, each PaaS service including a separate and distinct resource manager that is dependent on the resource manager of the PaaS layer for requesting resources to run the PaaS service.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] FIG. 1 illustrates depicting an example high-level overview of a cloud-based architecture where machine learning models are implemented.

[0006] FIG. 2 illustrates an example architecture that uses cloud-based analytics to control industrial operation.

[0007] FIG. 3 illustrates an example cloud-based control system.

DETAILED DESCRIPTION OF THE INVENTION

[0008] The following presents a simplified summary in order to provide a basic understanding of some aspects described herein. This summary is not an extensive overview nor is intended to identify key/critical elements or to delineate the scope of the various aspects described herein. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description that is presented later.

[0009] In one or more embodiments, a system includes an interface component, a validation component and an execution component. The interface component transmits industrial data associated with an industrial device to a cloud service system that analyzes the industrial data. The interface component also receives, from the cloud service system, command data for the industrial device that is generated based on the industrial data. The validation component validates the command data received from the cloud service system based on execution data indicative of a set of conditions for the command data. The validation component also establishes a secure communication link with the industrial device in response to a determination that the command data is approved for execution on the industrial device. The execution component transmits the command data to the industrial device via the secure communication link. The execution component also initiates execution of the command data via the industrial device.

[0010] As used herein, the terms “to infer” and “inference” refer generally to the process of reasoning about or inferring states of the system, environment, and/or user from a set of observations as captured via events and/or data. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states, for example. The inference can be probabilistic—that is, the computation of a probability distribution over states of interest based on a consideration of data and events. Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether or not the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources.

[0011] Additionally, one or more embodiments provide a method for transmitting, by a cloud agent device comprising a processor, industrial data associated with an industrial device to a cloud platform system. The method also includes receiving, by the cloud agent device, command data for the industrial device, where the command data is received from the cloud platform system. Also, the method includes validating, by the cloud agent device, the command data received from the cloud platform system based on execution data indicative of a set of security criteria for the command data. Moreover, the method includes establishing, by the cloud agent device, a communication channel with the industrial device in response to a determination that the command data satisfies the set of security criteria for the command data, and initiating, by the cloud agent device, execution of the command data on the industrial device.

[0012] In order to simplify the process of determining command data (e.g., set point parameters, operating commands, open/close commands, operating parameter values, etc.) for an industrial device and/or to maximize efficiency and/or performance of an industrial system, one or more embodiments of the present disclosure provide an industrial control system that includes a cloud platform and facilitates secure execution of command data generated by the cloud platform. The command data can be executed by an industrial system and/or one or more industrial devices in communication with the cloud platform. The cloud-based industrial control system automatically identifies suitable command data for a given industrial system application by leveraging cloud-side analytics and an industrial system behavioral model generated based on industrial data collected and maintained on cloud storage (e.g., big data storage). The industrial system behavioral model creates a virtual determination of maximum efficiency and/or maximum performance associated with a set of industrial devices in an industrial system application based on industrial data collected for the industrial control system. To this end, the cloud-based industrial control system monitors industrial data (e.g., process variables, other operational data, etc.) and incrementally builds a high-fidelity model of the industrial system over time as new industrial data is collected into the cloud. The industrial control system can apply iterative analytics to the model until command data for the set of industrial devices are converged upon that satisfy a defined optimization criterion (e.g., maximum efficiency, maximum performance, etc.), and provide the calculated command data to a cloud agent associated with the set of industrial devices. The cloud agent can verify the command data before allowing the command data to be executed by the set of industrial devices. For example, the industrial system and/or the cloud agent located remotely from the cloud platform can maintain a security manifest for the industrial system. The security manifest can be an encrypted document that resides at the industrial system and/or the cloud agent located remotely from the cloud platform. The security manifest can also include a set of security validation requirements for the command data provided by the cloud platform. Once the command data is validated, the command data can be forwarded to a controller (e.g., a plant master control system) and/or the set of industrial devices on a plant floor of the industrial system. Thus, the industrial control system described herein mitigates the need to manually determine command data and/or manually execute command data using trial-and-error methods by leveraging big data analysis and machine modeling in the cloud platform to automatically generate and/or validate suitable command data for a given industrial control application.

[0013] To illustrate an example cloud architecture that can be used to provide cloud-based boiler control services, an example high-level overview of an industrial enterprise (e.g., one or more boiler systems) that leverages cloud-based services is now described in connection with FIG. 1. The industrial enterprise comprises one or more industrial systems 104 1-N, each having one or more industrial devices 108 1-N. The industrial devices 108 1-N can be associated with and/or can operate within the respective industrial systems 104 1-N. Industrial devices 108 1-N can include such devices as field devices such as sensors (e.g., analog sensors, digital sensors, etc.), meters and/or alarms; industrial controllers (e.g., programmable logic controllers or other types of programmable automation controllers); operator interfaces (e.g., human-machine interfaces, industrial monitors, graphic terminals, message displays, etc.); vision system devices (e.g., vision cameras); manufacturing tools; industrial machines; automated industrial devices; or other such industrial devices.

[0014] An example industrial system can include one or more industrial automation systems that facilitate monitoring and control of respective industrial processes. Controllers in the one or more industrial systems 104 1-N can exchange data with the industrial devices 108 1-N using native hardwired I/O or via a plant network such as EtherNet/IP, Data Highway Plus, ControlNet, Devicenet, or the like. A given controller typically receives any combination of digital or analog signals from the industrial devices 108 1-N indicating a current state of the devices and their associated processes (e.g., temperature, pressure, speed, fluid level, etc.), and executes a user-defined control program that performs automated decision-making for the controlled processes based on the received signals. The controller then outputs appropriate digital and/or analog control signaling to the industrial devices 108 1-N in accordance with the decisions made by the control program. These outputs can include device actuation signals, temperature or pressure control signals, operational commands, process commands, and the like. The control program can comprise any suitable type of code used to process input signals read into the controller and to control output signals generated by the controller, including but not limited to ladder logic, sequential function charts, function block diagrams, structured text, or other such platforms.

[0015] According to one or more embodiments, on-premise cloud agents 106 can collect data from industrial devices 108 1-N—or from other data sources, including but not limited to data historians, business-level systems, etc.—and send this data to cloud platform 102 for processing and storage. Cloud platform 102 can be any infrastructure that allows cloud services 112 (such as the cloud-based industrial control system described herein) to be accessed and utilized by cloud-capable devices. Cloud platform 102 can be a public cloud accessible via the Internet by devices having

Internet connectivity and appropriate authorizations to utilize the cloud services 112. In some scenarios, cloud platform 102 can be provided by a cloud provider as a platform-as-a-service (PaaS), and the cloud services 112 can reside and execute on the cloud platform 102 as a cloud-based service. In some such configurations, access to the cloud platform 102 and the cloud services 112 can be provided to customers as a subscription service by an owner of the cloud services 112. Alternatively, cloud platform 102 can be a private or semi-private cloud operated internally by the enterprise, or a shared or corporate cloud environment. An exemplary private cloud can comprise a set of servers hosting the cloud services 112 and residing on a corporate network protected by a firewall.

[0016] Cloud services 112 can include, but are not limited to, data storage, data analysis, control applications (e.g., applications that can generate and deliver control instructions to industrial devices 108 1-N based on analysis of real-time system data or other factors), command execution (e.g., secure fail safe command execution provided to industrial devices 108 1-N based on analysis of real-time system data or other factors), visualization applications such as the cloud-based operator interface system described herein, reporting applications, Enterprise Resource Planning (ERP) applications, notification services, or other such applications. Cloud-based data analytics can include embodiments of the industrial control system described herein. Cloud platform 102 may also include one or more object models to facilitate data ingestion and processing in the cloud. If cloud platform 102 is a web-based cloud, cloud agents 106 at the respective industrial systems 104 may interact with cloud services 112 directly or via the Internet. In an exemplary configuration, the industrial devices 108 1-N connect to the on-premise cloud agents 106 through a physical or wireless local area network or radio link. In another exemplary configuration, the industrial devices 108 1-N may access the cloud platform 102 directly using integrated cloud agents. Cloud agents and their associated data collection and processing services are discussed in more detail below.

[0017] Ingestion of industrial device data in the cloud platform 102 through the use of cloud agents 106 can offer a number of advantages particular to industrial control systems. For one, cloud-based storage offered by the cloud platform 102 can be easily scaled to accommodate the large quantities of data generated daily by an industrial enterprise (e.g., one or more industrial systems). Moreover, multiple industrial devices and/or multiple industrial device systems can migrate respective industrial data and/or demand data to the cloud for aggregation, collation, collective analysis, visualization, and reporting. Cloud agents 106 can be configured to automatically detect and communicate with the cloud platform 102 upon installation associated with any industrial system, simplifying integration with existing cloud-based data storage, analysis, or reporting applications for an industrial system. In another example application, cloud-based diagnostic applications can monitor the health of respective industrial systems or their associated industrial devices across an entire plant, or across multiple industrial facilities that make up an enterprise. Cloud-based industrial control applications can be used to track industrial device efficiency and/or capacity throughout a period of operation. Moreover, cloud based control applications can perform remote decision-making for a controlled industrial system based on data collected in the cloud from the industrial system, and issue control commands to the system via the cloud agent. These industrial cloud-computing applications are only intended to be exemplary, and the systems and methods described herein are not limited to these particular applications. The cloud platform 102 can allow software vendors to provide software as a service, removing the burden of software maintenance, upgrading, and backup from their customers.

[0018] The cloud platform 102 in combination with command validation 110 of the respective on-premise cloud agents 106 1-N can also facilitate safe interaction between the cloud platform 102 and the industrial systems 104 1-N (e.g., respective on-premise cloud agents 106 1-N and/or industrial devices 108 1-N of the industrial systems 104 1-N). Therefore, the cloud platform 102 can allow software vendors to provide a 'cloud closed loop' service to their customers. In an aspect, the cloud platform 102 can send one or more commands (e.g., one or more digital commands and/or one or more analog commands) to the industrial systems 104 1-N. For example, cloud platform 102 can send one or more commands (e.g., one or more digital commands and/or one or more analog commands) to respective on-premise cloud agents 106 1-N and/or industrial devices 108 1-N. The cloud platform 102 in combination with the command validation 110 can provide a security mechanism (e.g., a fail safe secure mechanism, a handshake mechanism) to send the one or more commands to the industrial systems 104 1-N (e.g., respective on-premise cloud agents 106 1-N and/or industrial devices 108 1-N). Additionally or alternatively, the cloud platform 102 can receive one or more commands (e.g., one or more digital commands and/or one or more analog commands) from the industrial systems 104 1-N. For example, cloud platform 102 can also receive one or more commands (e.g., one or more digital commands and/or one or more analog commands) from respective on-premise cloud agents 106 1-N and/or industrial devices 108 1-N. Therefore, the safety mechanism provided by the cloud platform 102 and the command validation 110 can additionally or alternatively allow the cloud platform to receive the one or more commands from the industrial systems 104 1-N (e.g., respective on-premise cloud agents 106 1-N and/or industrial devices 108 1-N).

[0019] FIG. 2 illustrates an example architecture that uses cloud-based analytics to control industrial device operation for an example industrial system. The example architecture illustrated in FIG. 2 can also provide validation of commands generated by the cloud-based analytics for control of industrial device operation. In this example system, cloud agents 204 1-N (e.g., on-premise cloud agents) are deployed at the remote customer site and used to collect industrial data (e.g., industrial device data, operational data, configuration data, sensor data, etc.) associated with the industrial systems 202 1-N. A particular industrial system 202 1-N can correspond to a particular industrial system 104 1-N. For example, each of the industrial systems 202 1-N can include one or more industrial devices such as industrial devices 208 1-N. In one example, the industrial data can be time-series data (e.g., time-series sensor data, etc.).

[0020] The cloud agents 204 1-N can collect and/or determine the industrial data by monitoring the one or more industrial devices 208 1-N included in the industrial systems 202 1-N. For example, the cloud agents 204 1-N can collect the industrial data by monitoring analog tags associated with industrial device(s) included in the industrial systems 202 1-N. Analog tags can contain near real-time operational information for the industrial device(s) included in the industrial systems 202 1-N and/or can indicate alarm statuses. In an non-limiting example of a five industrial device system, this may entail collecting data from approximately 200 analog tags and 700 alarm tags, resulting in collection of approximately 30 Gb of data per month. The cloud agents 204 1-N can also collect and/or determine demand data associated with the industrial systems 202 1-N.

[0021] The cloud agents 204 1-N can process the industrial data for transmission to a cloud platform 216. The cloud agents 204 1-N can push the industrial data to the cloud platform 216 via cloud storage endpoint 210 for storage on cloud-based data storage 212. In an aspect, the cloud agents 204 can convert the industrial data into a communication format (e.g., a HTTPS format, a SSL format, etc.). In another aspect, a firewall 205 can be implemented between the cloud agents 204 1-N and the cloud platform 216. Analytic engine 214 can analyze the industrial data in view of one or more operational rules to calculate efficiency curves for each industrial device in the industrial systems 202 1-N. The analytic engine 214 can also determine command data for each industrial device in the industrial systems 202 1-N. The command data can control at least a portion of one or more processes associated with an industrial device in the industrial systems 202 1-N. In a non-limiting example, the command data can include one or more set point parameters, one or more operating commands, one or more open/close commands, one or more operating parameter values and/or other command data for an industrial device in industrial systems 202 1-N.

[0022] The command data can be securely transmitted to the cloud agents 204 1-N. Furthermore, the cloud agents 204 1-N can validate the command data before further transmitting (e.g., forwarding) the command data to the industrial systems 206 1-N. The cloud agents 204 1-N can each include command validation engine 218 to facilitate validation of the command data. The command validation engine 218 can be a fail safe mechanism to facilitate a secure closed-loop between the cloud agents 204 1-N and the cloud platform 216

[0023] FIG. 3 is a block diagram of an example cloud-based industrial control system 302 according to one or more embodiments of this disclosure. Aspects of the systems, apparatuses, or processes explained in this disclosure can constitute machine-executable components embodied within machine(s), e.g., embodied in one or more computer-readable mediums (or media) associated with one or more machines. Such components, when executed by one or more machines, e.g., computer(s), computing device(s), automation device(s), virtual machine(s), etc., can cause the machine(s) to perform the operations described. In an aspect, the cloud-based industrial control system 302 can be associated with a cloud platform (e.g., the cloud platform 102 and/or the cloud platform 216).

[0024] Cloud-based industrial control system 302 can include a system interface component 304, a client interface component 306, a correlation analytics component 308, a modeling component 310 and/or a command execution component 312. The cloud-based industrial control system 302 can also include one or more processors 314 and memory 316. In various embodiments, one or more of the system interface component 304, the client interface component 306, the correlation analytics component 308, the modeling component 310, the command execution component 312, the one or more processors 314, and memory 316 can be electrically and/or communicatively coupled to one another to perform one or more of the functions of the cloud-based industrial control system 302. In some embodiments, components 304, 306, 308, 310 and 312 can comprise software instructions stored on memory 316 and executed by processor(s) 314. Cloud-based industrial control system 302 may also interact with other hardware and/or software components not depicted in FIG. 3. For example, processor(s) 314 may interact with one or more external user interface devices, such as a keyboard, a mouse, a display monitor, a touchscreen, or other such interface devices.

[0025] System interface component 304 can be configured to receive industrial data from one or more industrial assets comprising an industrial automation system (e.g., an industrial control system). For example, the system interface component 304 can collect industrial data associated with the industrial systems 202 1-N and/or the cloud agents 204 1-N. The system interface component 304 can also store the industrial data on a cloud platform (e.g., the cloud platform 102, the cloud platform 216, etc.). The industrial data can be received directly from one or more cloud-capable industrial devices having integrated cloud interface capabilities (e.g., industrial devices 208 1-N, etc.) or via a cloud agent device (e.g., on-premise cloud agents 106, cloud agents 204 1-N, etc.) that collects data from one or more industrial assets and ingests the collected data to the cloud platform for storage and processing by the cloud-based industrial control system 302. In an aspect, the system interface component 304 can generate one or more data sets based on the industrial data. In another aspect, the system interface component 304 can receive at least a portion of the industrial data as a data packet from a cloud agent device associated with one or more industrial systems.

[0026] Client interface component 306 can be configured to exchange data with a client device to facilitate user interaction with the cloud-based industrial control system 302. The client device can be communicatively connected to a cloud platform (e.g., the cloud platform 102, the cloud platform 216, etc.) associated with the cloud-based industrial control system 302. Furthermore, the client device can include, but is not limited to, a desktop computer, a laptop computer, a tablet computer, a smartphone, or another type of user device. Data exchanged with the client device via client interface component 306 can include, but is not limited to, a command from the client device to initiate industrial device analysis for a given industrial system, information associated with which industrial devices and/or industrial systems to operate, a dashboard, user interface screens served to the client device by the cloud-based industrial control system 302, or other such information.

[0027] Correlation analytics component 308 can be configured to determine and/or generate command data for an industrial system (e.g., an industrial system from industrial systems 104 1-N or industrial systems 202 1-N) and/or an industrial device (e.g., an industrial device from industrial devices 108 1-N) based on analysis of the industrial data. In some embodiments, correlation analytics component 308 can perform an iterative analysis of an industrial system behavioral model that links efficiency and capacity associated with industrial devices to yield suitable set point parameters for the industrial devices. Additionally or alternatively, the correlation analytics component 308 can be configured to determine which of the industrial devices to operate based on analysis of the industrial data. In an aspect, the correlation analytics component 308 can simulate an operating scenario for the industrial devices represented by initial conditions based on the industrial system behavioral model. The initial conditions can be random initial conditions. The initial conditions can include load data, industrial device identification data, industrial device capacity data, industrial device efficiency data, power consumption data, cost data and/or other data. In one example, the correlation analytics component 308 can apply a set of operational rules for the operating scenario. Operation rules can include rules such as, but not limited to, use at least two industrial devices for the operating scenario, worst single industrial device for the operating scenario should be able to fulfill critical demand, etc. In another aspect, the correlation analytics component 308 can determine whether the operating scenario for the industrial devices is associated with a maximum efficiency. In one example, the correlation analytics component 308 can modify the initial conditions in response to a determination that the operating scenario for the industrial devices is not associated with the maximum efficiency. In another example, the correlation analytics component 308 can generate the at least one set point parameter in response to a determination that the operating scenario for the industrial devices is associated with the maximum efficiency.

[0028] Modeling component 310 can be configured to generate the industrial system behavioral model based on the industrial data (e.g., process variable data, operational data, configuration data, sensor data, or other information collected from the industrial devices). For example, the modeling component 310 can generate an industrial system behavioral model for storage on the cloud platform based on analysis of the industrial data. The industrial system behavioral model can define at least one correlation between efficiency and capacity associated with the industrial devices. Modeling component 310 can incrementally refine the industrial system behavioral model as new industrial data is collected to produce a progressively higher fidelity model over time.

[0029] What has been described above includes examples of the subject innovation. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing the disclosed subject matter, but one of ordinary skill in the art may recognize that many further combinations and permutations of the subject innovation are possible. Accordingly, the disclosed subject matter is intended to embrace all such alterations, modifications, and variations that fall within the spirit and scope of the appended claims.

[0030] In particular and in regard to the various functions performed by the above described components, devices, circuits, systems and the like, the terms (including a reference to a "means") used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (e.g., a functional equivalent), even though not structurally equivalent to the disclosed structure, which performs the function in the herein illustrated exemplary aspects of the disclosed subject matter. In this regard, it will also be recognized that the disclosed subject matter includes a system as well as a computer-readable medium having computer-executable instructions for performing the acts and/or events of the various methods of the disclosed subject matter.

[0031] In addition, while a particular feature of the disclosed subject matter may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the terms "includes," and "including" and variants thereof are used in either the detailed description or the claims, these terms are intended to be inclusive in a manner similar to the term "comprising."

[0032] In this application, the word "exemplary" is used to mean serving as an example, instance, or illustration. Any aspect or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects or designs. Rather, use of the word exemplary is intended to present concepts in a concrete fashion.

[0033] Various aspects or features described herein may be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device, carrier, or media. For example, computer readable media can include but are not limited to magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips . . .), optical disks [e.g., compact disk (CD), digital versatile disk (DVD) . . .], smart cards, and flash memory devices (e.g., card, stick, key drive . . .).

I/WE CLAIM:

1. A method for analyzing cloud architecture using Machine Learning (ML) models comprising:
   receiving, at a cognitive engine service in communication with a plurality of cognitive agents deployed in the cloud, metrics data associated with one or more tasks, wherein the metrics data is collected by the plurality of cognitive agents;
   training one or more models based on the metrics data to predict scores for tasks executed with a particular number of resource units;
   receiving a request that specifies a first task for processing a dataset;
   determining an optimal number of resource units to allocate to the first task based on predicted scores output by a first model; and
   allocating the optimal number of resource units to a resource agent in the cloud to manage the execution of the first task.

2. The method for analyzing cloud architecture using Machine Learning (ML) models as claimed in Claim 1, wherein each model in the one or more models implements a machine learning algorithm.

3. The method for analyzing cloud architecture using Machine Learning (ML) models as claimed in Claim 1, wherein the security validation requirements are encrypted.

4. The method for analyzing cloud architecture using Machine Learning (ML) models as claimed in Claim 1, wherein the secure communication link is a first secure communication link, and wherein the validation component is configured to transmit the alert message to the cloud service system via a second secure communication link between the system and the cloud service system.

5. The method for analyzing cloud architecture using Machine Learning (ML) models as claimed in Claim 1, wherein the execution component is further configured to determine a processing role for the execution of the command data based on context data retained by an industrial system associated with the industrial device that is located remotely from the cloud service system.

METHOD AND SYSTEM FOR ANALYZING CLOUD ARCHITECTURE USING MACHINE LEARNING MODELS

ABSTRACT

The present invention provides an approach for analyzing cloud architecture using machine learning models. The system includes an interface component, a validation component and an execution component. The interface component transmits industrial data associated with an industrial device to the cloud platform that analyzes the industrial data. The interface component also receives, from the cloud platform, command data for the industrial device that is generated based on the industrial data. The validation component validates the command data received from the cloud platform based on execution data indicative of a set of conditions for the command data. The validation component also establishes a secure communication link with the industrial device in response to a determination that the command data is approved for execution on the industrial device. The execution component initiates execution of the command data via the industrial device.

COMPLETE SPECIFICATION

Sheet No. 1

Total No. of Sheets. 3

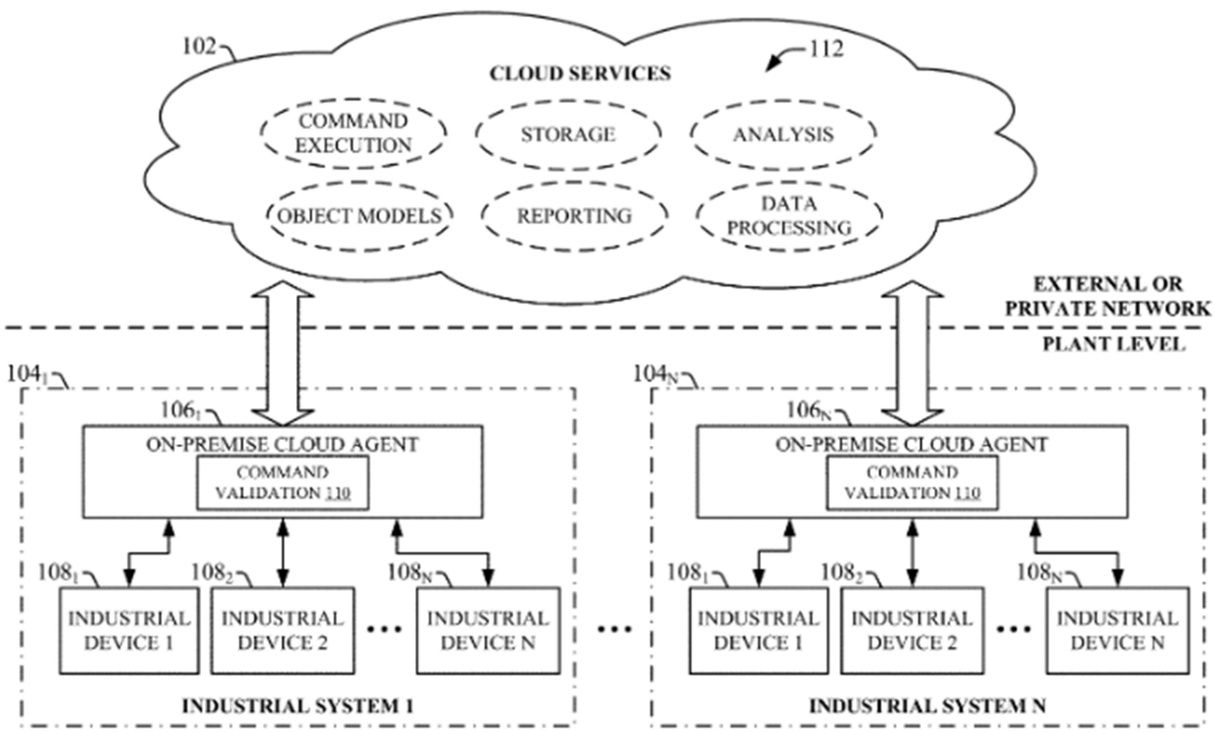


FIG. 1

COMPLETE SPECIFICATION

Sheet No. 2

Total No. of Sheets. 3

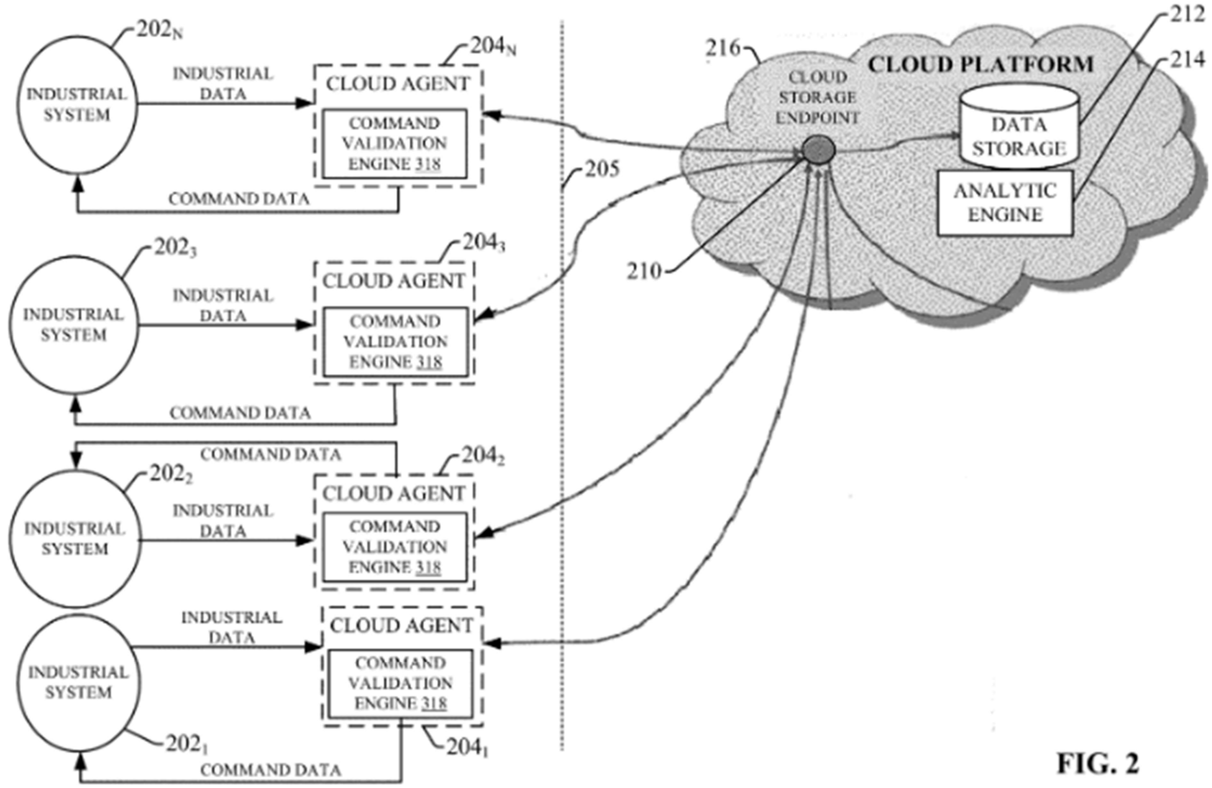
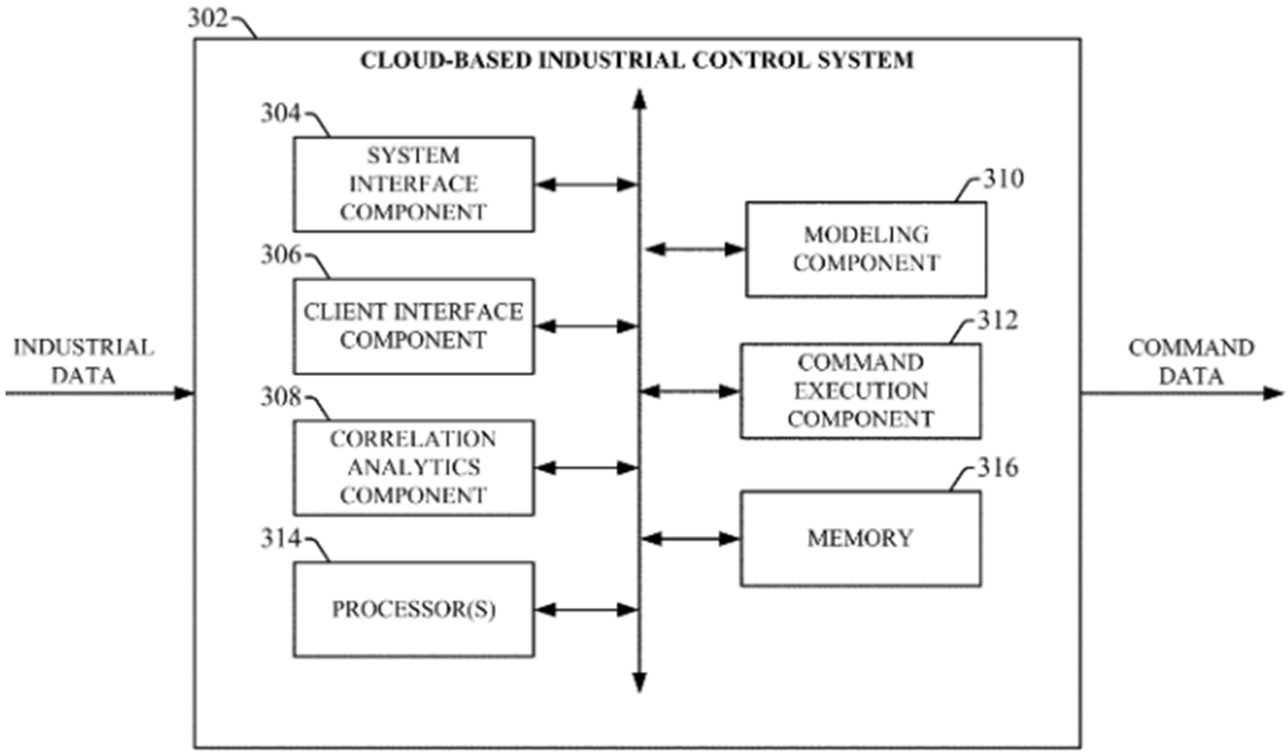


FIG. 2


302
CLOUD-BASED INDUSTRIAL CONTROL SYSTEM
304
SYSTEM INTERFACE COMPONENT
306
CLIENT INTERFACE COMPONENT
308
CORRELATION ANALYTICS COMPONENT
314
PROCESSOR(S)
310
MODELING COMPONENT
312
COMMAND EXECUTION COMPONENT
316
MEMORY
INDUSTRIAL DATA
COMMAND DATA