

SIMULATION SYSTEM AND METHOD FOR INDUSTRIAL CONTROL DEVICE NETWORK, COMPUTER-READABLE STORAGE MEDIUM, AND COMPUTER DEVICE

TECHNICAL FIELD

The present disclosure relates to but is not limited to the fields of industrial automation, informatization and computer, and in particular, to a simulation system and method for an industrial control device network, a computer-readable storage medium, and a computer device.

BACKGROUND

The industrial control device plays an important role in industrial informatization. It is widely used in industry, power, energy, transportation, water conservancy, public utilities, and production enterprises. The industrial control device can control a wide range of objects, such as production processes, mechanical devices, vehicles, experimental facilities, instruments, living facilities, and household appliances. The industrial control device guarantees the normal operation of industrial facilities through automated monitoring, command, control, and adjustment of work processes, and is an important part of the country's critical infrastructure and information systems.

With the advent of Industry 4.0 and the convergence of industrialization and informatization, more and more industrial control devices have been connected to the Internet, resulting in increasing vulnerabilities of industrial control devices. Therefore, information security protection for industrial control device networks is required.

However, to avoid misoperation, research work on the information security protection operation of industrial control devices usually cannot be directly run in an actual industrial control device network in the production environment.

Therefore, it is necessary to propose a technical solution for simulating the actual industrial control device network.

SUMMARY

Embodiments of the present disclosure aim to resolve the above problems.

According to a first aspect of the present disclosure, a simulation system for an industrial control device network is provided, including:

a virtualization management module, configured to create a virtual environment for system simulation of the industrial control device network;

a simulation parameter configuration module, configured to configure a configuration parameter for the system simulation; and

an execution module, configured to create a simulated network resource in the virtual environment based on the configuration parameter, and perform simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network.

The simulation system for an industrial control device network according to the present disclosure further includes:

a real network resource information obtaining module, configured to obtain real network resource information in real time, where

the execution module is further configured to: update corresponding information of the simulated network resource based on the real network resource information,

where the real network resource information includes at least one of the following:

network resource asset information, network resource performance information, network resource-related event information, network resource-related security vulnerability information, network resource-related security threat information, network resource-related traffic information, and network topology information.

According to the simulation system for an industrial control device network of the present disclosure, the simulation parameter configuration module includes at least one of the following:

a networking parameter configuration module, configured to configure a first configuration parameter used to describe a topology of the industrial control device network; and

a network resource configuration module, configured to configure a second configuration parameter used to describe a network resource.

According to the simulation system for an industrial control device network of the present disclosure, the virtualization management module uses a software-defined infrastructure (SDI),

where the SDI includes an open-source OpenStack cloud computing management stack and an open-source software-defined storage Ceph, and the virtual environment includes a virtual computing resource, a virtual storage resource, and a virtual network resource.

According to the simulation system for an industrial control device network of the present disclosure, a network resource includes at least one of the following:

a programmable logic controller (PLC), a remote test unit (RTU), a distributed control system (DCS) controller, an industrial control device, a workstation, a historical data station, an industrial application software product, and a security protection product.

According to the simulation system for an industrial control device network of the present disclosure, the simulated network resource is created by using a virtual machine (VM) in the virtual environment.

According to a second aspect of the present disclosure, a simulation method for an industrial control device network is provided, including:

creating, by a virtualization management module, a virtual environment for system simulation of the industrial control device network;

configuring, by a simulation parameter configuration module, a configuration parameter for the system simulation; and

creating, by an execution module, a simulated network resource in the virtual environment based on the configuration parameter, and performing simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network.

The simulation method for an industrial control device network according to the present disclosure further includes:

obtaining, by a real network resource information obtaining module, real network resource information in real time; and

updating, by the execution module, corresponding information of the simulated network resource based on the real network resource information,

where the real network resource information includes at least one of the following: network resource asset information, network resource performance information, network resource-related event information, network resource-related security vulnerability information, network resource-related security threat information, network resource-related traffic information, and network topology information.

The simulation method for an industrial control device network according to the present disclosure further includes at least one of the following steps:

configuring, by a networking parameter configuration module, a first configuration parameter used to describe a topology of the industrial control device network; and

configuring, by a network resource configuration module, a second configuration parameter used to describe a network resource.

The simulation method for an industrial control device network according to the present

disclosure further includes:

implementing the virtualization management module by using an SDI,

where the SDI includes an open-source OpenStack cloud computing management stack and an open-source software-defined storage Ceph, and the virtual environment includes a virtual computing resource, a virtual storage resource, and a virtual network resource.

According to the simulation method for an industrial control device network of the present disclosure, a network resource includes at least one of the following:

a PLC, an RTU, a DCS controller, an industrial control device, a workstation, a historical data station, an industrial application software product, and a security protection product.

The simulation method for an industrial control device network according to the present disclosure further includes:

creating the simulated network resource by using a VM in the virtual environment.

According to a third aspect of the present disclosure, a computer-readable storage medium is provided, where the storage medium stores a computer program, and when the computer program is executed by a processor, steps of the method described above are implemented.

According to a fourth aspect of the present disclosure, a computer device is provided, including a memory, a processor, and a computer program stored in the memory and capable of running on the processor, where when the computer program is executed by the processor, at least one of the following steps is implemented:

creating, by a virtualization management module, a virtual environment for system simulation of the industrial control device network;

configuring, by a simulation parameter configuration module, a configuration parameter for the system simulation;

creating, by an execution module, a simulated network resource in the virtual environment based on the configuration parameter, and performing simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network;

obtaining, by a real network resource information obtaining module, real network resource information in real time;

updating, by the execution module, corresponding information of the simulated network

resource based on the real network resource information;

configuring, by a networking parameter configuration module, a first configuration parameter used to describe a topology of the industrial control device network;

configuring, by a network resource configuration module, a second configuration parameter used to describe a network resource;

implementing the virtualization management module by using a software-defined infrastructure; and

creating the simulated network resource by using a VM in the virtual environment.

The present disclosure provides a simulation system and method for an industrial control device network, a computer-readable storage medium, and a computer device, which implement simulation of the industrial control device network.

By reading the following description of the example embodiments with reference to the accompanying drawings, those skilled in the art will be clear about other characteristics, features and advantages of the embodiments of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings incorporated into the specification and constituting a part of the specification illustrate the embodiments of the present disclosure, and are used together with the description to explain the principles of the embodiments of the present disclosure. In these drawings, similar reference signs are used to represent similar elements. The drawings in the following description are a part rather than all of the embodiments of the present disclosure. Persons of ordinary skill in the art can obtain other drawings based on these drawings without creative efforts.

FIG. 1 is a schematic block diagram of a simulation system for an industrial control device network according to a first aspect of the present disclosure.

FIG. 2 is a schematic diagram of a software-defined infrastructure (SDI) that can be used by the simulation system for an industrial control device network according to the first aspect of the present disclosure.

FIG. 3 is a schematic diagram of a virtual network that can be used by the simulation system for an industrial control device network according to the first aspect of the present disclosure.

FIG. 4 is a schematic flowchart of a simulation method for an industrial control device network according to a second aspect of the present disclosure.

DETAILED DESCRIPTION

In order to make the objectives, technical solutions and advantages of the embodiments of the present disclosure clearer, the following clearly and completely describes the technical solutions in the embodiments of the present disclosure with reference to accompanying drawings in the embodiments of the present disclosure. Apparently, the described embodiments are some rather than all of the embodiments. All other embodiments obtained by persons of ordinary skill in the art based on the embodiments of the present disclosure without creative efforts shall fall within the scope of the present embodiments. It should be noted that the embodiments in the application and features in the embodiments of the present disclosure may be combined with each other in a non-conflicting situation.

FIG. 1 is a schematic block diagram of a simulation system 100 for an industrial control device network according to a first aspect of the present disclosure.

As shown by solid boxes in FIG. 1, the simulation system 100 for an industrial control device network according to the first aspect of the present disclosure includes:

a virtualization management module 101, configured to create a virtual environment for system simulation of the industrial control device network;

a simulation parameter configuration module 103, configured to configure a configuration parameter for the system simulation; and

an execution module 105, configured to create a simulated network resource in the virtual environment based on the configuration parameter, and perform simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network.

Optionally, as shown by the dashed box in FIG. 1, the simulation system 100 for an industrial control device network may further include:

a real network resource information obtaining module 107, configured to obtain real network resource information in real time, where

the execution module 105 is further configured to:

update corresponding information of the simulated network resource based on the real network resource information, where

the real network resource information includes at least one of the following:

network resource asset information, network resource performance information, network

resource-related event information, network resource-related security vulnerability information, network resource-related security threat information, network resource-related traffic information, and network topology information.

Optionally, the simulation parameter configuration module 103 may include at least one of the following:

a networking parameter configuration module, configured to configure a first configuration parameter used to describe a topology of the industrial control device network; and

a network resource configuration module, configured to configure a second configuration parameter used to describe a network resource.

Optionally, the virtualization management module 101 may use an SDI, where

the SDI includes an open-source OpenStack cloud computing management stack and an open-source software-defined storage Ceph, and the virtual environment includes a virtual computing resource, a virtual storage resource, and a virtual network resource.

FIG. 2 is a schematic diagram of an SDI that can be used by the simulation system for an industrial control device network according to the first aspect of the present disclosure.

As shown in FIG. 2, the open-source OpenStack cloud computing management stack and the open-source software-defined storage Ceph can be used, and the two can be combined to form a hyper-converged solution as an underlying platform of the entire SDI. Industrial-grade transformation may be further performed on Linux and KVM virtualization engines so that the engines can support industrial network requirements. New technologies such as DPDK hard acceleration are used to ensure the performance and real-time requirements of the entire infrastructure, so that the simulation system 100 for an industrial control device network according to the first aspect of the present disclosure better simulates the industrial network environment.

To enable those skilled in the art to more clearly understand how to implement the foregoing SDI, the following uses a specific embodiment for description.

1. Plan a virtual environment for system simulation of the industrial control device network.

For example, a plurality of X86 servers can be used to create a virtual environment for super-large-scale industrial network simulation.

1) Use a plurality of (for example, 4) hosts to achieve hyper-convergence of computing and storage: A computing node and a storage node can be set on a same physical node; high availability (HA) of images can be achieved through a storage resource pool, duplication and redundancy; and

HA can be implemented for virtual machines (VMs) with specific needs.

2) Use a plurality of (for example, 2) hosts to achieve hyper-convergence of network control: VLAN can be selected as a network mode, network node and control node services can be placed on a same physical node, network and control services can be provided at the same time, and heartbeat detection and HA can be implemented through HAproxy, Corsync, or the like.

In addition, the following methods may be used to increase link bandwidth, eliminate network bottlenecks caused by bandwidth in a switching network, achieve HA of network resources, and improve the efficiency data transmission of server network adapters:

- 1) Use server network adapter for binding;
- 2) Use switches for link aggregation (port aggregation);
- 3) Use the spanning tree protocol (STP).

2. Plan a virtual network for system simulation of the industrial control device network.

FIG. 3 is a schematic diagram of a virtual network that can be used by the simulation system for an industrial control device network according to the first aspect of the present disclosure.

As shown in FIG. 3, two types of virtual network nodes, computing (storage) nodes and (network) control nodes, can be planned. Since HA is implemented for computing (storage) nodes, downtime of any computing (storage) node only affects the VMs hosted on it, and does not affect other computing (storage) nodes. If the downtime is predictable, the VMs on that node can be migrated to other computing (storage) nodes, minimizing the impact on services.

In addition, the network control node can use active/standby mode to achieve HA, and use cold standby mode, but a database keeps real-time synchronization. This private cloud architecture relies very little on the control node. Therefore, when the control node is down, the normal operation of the virtual machine is hardly affected, without restarting the openvswitch-agent of the computing node.

In the network architecture, a VM network is directly connected to a physical router or switch in trunk mode through a bridge, which has good performance and extremely high stability. A management network is a network through which various components of OpenStack communicate for image distribution, VM migration, and the like. A storage network is a network through which VMs access shared storage GlusterFS or Ceph (in the hyper-converged infrastructure, the storage network is generally not used independently).

In this kind of network control infrastructure that supports hyper-converged computing and

storage, a VLAN-based Neutron mode is used. VLAN packets are directly routed to an external network through an IP network, and therefore L3 virtual routers are not required. In addition, due to the stability and performance issues of L3-Agent, L3 is quite complex. Therefore, L3-Agent is eliminated.

In this kind of network control infrastructure, a VM is first connected to br-int, br-int is connected to br-em3, and then the external network can be reached through a trunk. This infrastructure solves two problems: ensuring the performance and stability of the network and implementing seamless communication with other machines on the intranet.

Because the virtualization management module 101 adopts the foregoing SDI, the simulation system 100 for an industrial control device network according to the first aspect of the present disclosure has the following advantages:

1. Flexible and unified resource management

The SDI platform has a unified resource scheduling function, that is, multi-center unified management and multi-resource pool intelligent scheduling. Multi-center unified management can realize multi-data center features such as unified management and authority and domain based OM of multiple data centers, and can also realize unified management integrating cloud and non-cloud, and linkage management of infrastructure and architecture. Multi-resource pool intelligent scheduling can set scheduling policies based on services and resources, and automatically execute operation procedures to select and deploy required resources.

Unified resource scheduling can achieve unified management, accurate quantification, sharing and utilization of software and hardware resources, to improve resource efficiency; and can also achieve integrated, unified and intensive management of multiple data centers, to reduce operating costs.

2. Automated rapid deployment

The SDI platform adopts solutions based on a policy- and intent-driven infrastructure to enhance the automated IT resource allocation. The SDI platform can automatically transform policies and intents into commands on the corresponding infrastructure without manual intervention. An administrator only needs to formulate corresponding automatic deployment policies and service templates according to service types, and the management platform applies for resources and deploys/offloads services according to the automation policies, to implement the rapid allocation and recycling of resources. In addition, the SDI management platform continuously monitors events and changes in the infrastructure of the industrial control device network. When an application or a virtual resource reaches a threshold set in the policies, the SDI management platform can

automatically respond in real time based on the specified policies and perform server expansion, change, or dynamic migration.

Optionally, the network resources may include at least one of the following:

a programmable logic controller (PLC), a remote test unit (RTU), a distributed control system (DCS) controller, an industrial control device, a workstation, a historical data station, an industrial application software product, and a security protection product.

Optionally, the simulated network resource is created by using a VM in the virtual environment.

FIG. 4 is a schematic flowchart of a simulation method for an industrial control device network according to a second aspect of the present disclosure.

As shown by solid boxes in FIG. 4, the simulation method for an industrial control device network according to the second aspect of the present disclosure includes the following steps.

Step S402: A virtualization management module creates a virtual environment for system simulation of the industrial control device network.

Step S404: A simulation parameter configuration module configures a configuration parameter for the system simulation.

Step S406: An execution module creates a simulated network resource in the virtual environment based on the configuration parameter, and performs simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network.

Optionally, as shown by dashed boxes in FIG. 4, the simulation method for an industrial control device network according to the second aspect of the present disclosure further includes the following steps.

Step S408: A real network resource information obtaining module obtains real network resource information in real time.

Step S410: The execution module updates corresponding information of the simulated network resource based on the real network resource information, where

the real network resource information includes at least one of the following:

network resource asset information, network resource performance information, network resource-related event information, network resource-related security vulnerability information,

network resource–related security threat information, network resource–related traffic information, and network topology information.

Optionally, as shown by dashed boxes in FIG. 4, the simulation method for an industrial control device network according to the second aspect of the present disclosure further includes at least one of the following steps.

Step S412: A networking parameter configuration module configures a first configuration parameter used to describe a topology of the industrial control device network.

Step S414: A network resource configuration module configures a second configuration parameter used to describe a network resource.

Optionally, as shown by dashed boxes in FIG. 4, the simulation method for an industrial control device network according to the second aspect of the present disclosure further includes the following step.

Step S416: Implement the virtualization management module by using an SDI.

The SDI includes an open-source OpenStack cloud computing management stack and an open-source software-defined storage Ceph, and the virtual environment includes a virtual computing resource, a virtual storage resource, and a virtual network resource.

In the simulation method for an industrial control device network according to the present disclosure, the network device includes at least one of the following:

a PLC, an RTU, a DCS controller, an industrial control device, a workstation, a historical data station, an industrial application software product, and a security protection product.

Optionally, as shown by dashed boxes in FIG. 4, the simulation method for an industrial control device network according to the second aspect of the present disclosure further includes the following step.

Step S418: Create the simulated network resource by using a VM in the virtual environment.

According to a third aspect of the present disclosure, a computer-readable storage medium is provided, where the storage medium stores a computer program, and when the computer program is executed by a processor, steps of the foregoing method are implemented.

According to a fourth aspect of the present disclosure, a computer device is provided, including a memory, a processor, and a computer program stored in the memory and capable of running on the processor, where when the computer program is executed by the processor, at least one of the following steps is implemented:

creating, by a virtualization management module, a virtual environment for system simulation of the industrial control device network;

configuring, by a simulation parameter configuration module, a configuration parameter for the system simulation;

creating, by an execution module, a simulated network resource in the virtual environment based on the configuration parameter, and performing simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network;

obtaining, by a real network resource information obtaining module, real network resource information in real time;

updating, by the execution module, corresponding information of the simulated network resource based on the real network resource information;

configuring, by a networking parameter configuration module, a first configuration parameter used to describe a topology of the industrial control device network;

configuring, by a network resource configuration module, a second configuration parameter used to describe a network resource;

implementing the virtualization management module by using an SDI; and

creating the simulated network resource by using a VM in the virtual environment.

The present disclosure provides a simulation system and method for an industrial control device network, a computer-readable storage medium, and a computer device, which implement simulation of the industrial control device network.

The content described above can be implemented individually or in various combinations, and these modifications are all within the protection scope of the embodiments of the present disclosure.

Finally, it should be noted that the foregoing embodiments are only used to explain the technical solutions of the present disclosure, and are not intended to limit the same. Although the present disclosure is described in detail with reference to the foregoing embodiments, those of ordinary skill in the art should understand that they can still modify the technical solutions described in the foregoing embodiments, or make equivalent substitutions on some technical features therein. These modifications or substitutions do not make the essence of the corresponding technical solutions deviate from the spirit and scope of the technical solutions of the embodiments of the present disclosure.

Industrial Applicability

The present disclosure provides a simulation system and method for an industrial control device network, a computer-readable storage medium, and a computer device, which implement simulation of the industrial control device network.

What is claimed is:

1. A simulation system for an industrial control device network, comprising:
 - a virtualization management module, configured to create a virtual environment for system simulation of the industrial control device network;
 - a simulation parameter configuration module, configured to configure a configuration parameter for the system simulation; and
 - an execution module, configured to create a simulated network resource in the virtual environment based on the configuration parameter, and perform simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network.
2. The simulation system for an industrial control device network according to claim 1, further comprising:
 - a real network resource information obtaining module, configured to obtain real network resource information in real time, wherein
 - the execution module is further configured to:
 - update corresponding information of the simulated network resource based on the real network resource information,
 - wherein the real network resource information comprises at least one of the following:
 - network resource asset information, network resource performance information, network resource-related event information, network resource-related security vulnerability information, network resource-related security threat information, network resource-related traffic information, and network topology information.
3. The simulation system for an industrial control device network according to claim 1, wherein the simulation parameter configuration module comprises at least one of the following:
 - a networking parameter configuration module, configured to configure a first configuration parameter used to describe a topology of the industrial control device network; and
 - a network resource configuration module, configured to configure a second configuration parameter used to describe a network resource.
4. The simulation system for an industrial control device network according to claim 1, wherein the virtualization management module uses a software-defined infrastructure (SDI),

wherein the SDI comprises an open-source OpenStack cloud computing management stack and an open-source software-defined storage Ceph, and the virtual environment comprises a virtual computing resource, a virtual storage resource, and a virtual network resource.

5. The simulation system for an industrial control device network according to claim 1, wherein a network resource comprises at least one of the following:

a programmable logic controller (PLC), a remote test unit (RTU), a distributed control system (DCS) controller, an industrial control device, a workstation, a historical data station, an industrial application software product, and a security protection product.

6. The simulation system for an industrial control device network according to claim 5, wherein the simulated network resource is created by using a virtual machine (VM) in the virtual environment.

7. A simulation method for an industrial control device network, comprising:

creating, by a virtualization management module, a virtual environment for system simulation of the industrial control device network;

configuring, by a simulation parameter configuration module, a configuration parameter for the system simulation; and

creating, by an execution module, a simulated network resource in the virtual environment based on the configuration parameter, and performing simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network.

8. The simulation method for an industrial control device network according to claim 7, further comprising:

obtaining, by a real network resource information obtaining module, real network resource information in real time; and

updating, by the execution module, corresponding information of the simulated network resource based on the real network resource information,

wherein the real network resource information comprises at least one of the following:

network resource asset information, network resource performance information, network resource-related event information, network resource-related security vulnerability information, network resource-related security threat information, network resource-related traffic information, and network topology information.

9. The simulation method for an industrial control device network according to claim 7, further comprising at least one of the following steps:

configuring, by a networking parameter configuration module, a first configuration parameter used to describe a topology of the industrial control device network; and

configuring, by a network resource configuration module, a second configuration parameter used to describe a network resource.

10. The simulation method for an industrial control device network according to claim 7, further comprising:

implementing the virtualization management module by using an SDI,

wherein the SDI comprises an open-source OpenStack cloud computing management stack and an open-source software-defined storage Ceph, and the virtual environment comprises a virtual computing resource, a virtual storage resource, and a virtual network resource.

11. The simulation method for an industrial control device network according to claim 7, wherein a network resource comprises at least one of the following:

a PLC, an RTU, a DCS controller, an industrial control device, a workstation, a historical data station, an industrial application software product, and a security protection product.

12. The simulation method for an industrial control device network according to claim 11, further comprising:

creating the simulated network resource by using a VM in the virtual environment.

13. A computer-readable storage medium, wherein the storage medium stores a computer program, and when the computer program is executed by a processor, steps of the method according to any one of claims 7 to 12 are implemented.

14. A computer device, comprising a memory, a processor, and a computer program stored in the memory and capable of running on the processor, wherein when the computer program is executed by the processor, at least one of the following steps is implemented:

creating, by a virtualization management module, a virtual environment for system simulation of the industrial control device network;

configuring, by a simulation parameter configuration module, a configuration parameter for the system simulation;

creating, by an execution module, a simulated network resource in the virtual environment

based on the configuration parameter, and performing simulation based on the simulated network resource or based on the simulated network resource and a real network resource of the industrial control device network;

obtaining, by a real network resource information obtaining module, real network resource information in real time;

updating, by the execution module, corresponding information of the simulated network resource based on the real network resource information;

configuring, by a networking parameter configuration module, a first configuration parameter used to describe a topology of the industrial control device network;

configuring, by a network resource configuration module, a second configuration parameter used to describe a network resource;

implementing the virtualization management module by using a software-defined infrastructure;
and

creating the simulated network resource by using a VM in the virtual environment.