PRIVATE NETWORK CONFIGURATION METHOD, APPARATUS AND DEVICE, COMPUTER READABLE STORAGE MEDIUM, AND COMPUTER PROGRAM PRODUCT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The application is based on and claims priority to Chinese Patent Application No. 202211175253.3, filed on September 26, 2022, the entire contents of which are incorporated herein by reference.

TECHNICAL FIELD

[0002] Embodiments of the present disclosure relates to a field of network communication technology, including but not limited to, a method, an apparatus, and a device for configuring a private network, a computer-readable storage medium and a computer program product.

BACKGROUND

[0003] In the related art, the deployment of private networks faces various challenges such as a weak infrastructure and a long implementation cycle. In addition, application requirements of different scenarios have different configuration of communication devices.

[0004] The existing method for configuring a private network generally relies on manual experience to configure a private network device based on hardware parameters and software parameters of the device, which may not be automatically implement configuration of a private network integrated apparatus for service requirements of private network users in different industries, resulting in a poor user experience of the private network device configuration.

SUMMARY

[0005] To solve the above technical problems, embodiments of the present disclosure provide a method, an apparatus, and a device for configuring a private network, a computer-readable storage medium and a computer program product, so as to solve problems of low accuracy and low efficiency of the private network scenario configuration existing in the related art.

[0006] The embodiments of the present disclosure provide a method for configuring a private network, including: defining a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; obtaining a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and obtaining private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

[0007] In some embodiments, the private network configuration model includes a configuration generative network and a configuration discriminative network, in which the private network configuration model takes generated configuration information satisfying a sample private network service requirement indicator and a resource consumption cost corresponding to the generated configuration information as constraint conditions in a training process, the generated configuration information is an output of the configuration generative network for the private network service requirement indicator, and the sample private network service requirement indicator corresponds to sample device configuration information; and the configuration discriminative network is determined based on a discriminant result between the generated configuration information and corresponding sample device configuration information.

[0008] In some embodiments, the method further includes: obtaining a configuration device performance indicator corresponding to the generated configuration information by converting the generated configuration information according to the unit device performance indicator, in which the generated configuration information corresponds to at least one procurable device, and the unit device performance indicator is configured to represent a private network service capacity that each procurable device is capable to provide; obtaining a satisfaction situation that the generated configuration information satisfies the sample private network service requirement indicator by comparing the private network service requirement indicator and the configuration device performance indicator; and determining the resource consumption cost corresponding to the generated configuration information.

[0009] In some embodiments, the method further includes: determining a non-additive performance attribute corresponding to the private network service requirement indicator, in which the non-additive performance attribute is configured to represent whether the private network service requirement indicator fails being satisfied by an additive configuration of a plurality of procurable devices; in response to determining that there is a corresponding non-additive performance attribute in the private network service requirement indicator, obtaining a configuration device performance indicator with the non-additive performance attribute corresponding to the generated configuration information according to the non-additive performance attribute and the configuration device performance indicator corresponding to the generated configuration information, and comparing a configuration device performance indicator with the non-additive performance attribute and the sample private network service requirement indicator with the non-additive performance attribute; and in response to determining that there is no corresponding non-additive performance attribute in the private network service requirement indicator, determining an additive performance attribute according to the non-additive performance attribute, obtaining a configuration device performance indicator with the additive performance attribute corresponding to the generated configuration information according to the additive performance attribute and the configuration device performance indicator corresponding to the generated configuration information, and comparing the configuration device performance indicator with the additive performance attribute and the sample private network service requirement indicator with the additive performance attribute.

[0010] In some embodiments, the method also includes: determining a resource consumption cost for each procurable device corresponding to the generated configuration information in a computing dimension of a preset unit device consumption cost, in which the computing dimension of the preset unit device consumption cost includes at least one of a unit device price, a unit device space occupation, or a unit device power consumption; and obtaining the resource consumption cost by performing weighted summation on the unit device consumption cost corresponding to each procurable device corresponding to the generated configuration information.

[0011] In some embodiments, the method also includes: determining a generated configuration information change corresponding to the sample private network service requirement indicator according to requirement change information corresponding to the sample private network service requirement indicator and the configuration generative network; determining a configuration discriminant result information change between the generated configuration information from the configuration generative network and the corresponding sample device configuration information according to the configuration discriminative network; and updating according to the requirement change information corresponding to the sample private network service requirement indicator, the generated configuration information change, the configuration discriminant result information change, and the resource consumption cost corresponding to the generated configuration information.

[0012] In some embodiments, the private network configuration model further includes a capacity expansion-based private network configuration model, in which the capacity expansion-based private network configuration model takes the generated configuration information satisfying the sample private network service requirement indicator and a resource consumption cost based on capacity expansion as constraint conditions in the training process; in which the resource consumption cost based on the capacity expansion is determined according to the resource consumption cost and a predicted resource consumption cost.

[0013] The embodiments of the present disclosure provide an apparatus for configuring a private network, including: a defining module, configured to define a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; a modeling module, configured to obtain a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and a configuring module, configured to obtain private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

[0014] The embodiments of the present disclosure provide a device for configuring a private network, including a processor, a memory, a communication interface, and a communication bus, in which the processor, the memory and the communication interface communicate with each other via the communication bus, and the memory is configured to store at least one executable instruction to cause the processor to perform any one of the operations of the method for configuring a private network.

[0015] The embodiments of the present disclosure provides a computer-readable storage medium for storing at least one executable instruction, in which the at least one executable instruction causes the device for configuring a private network to perform the method for configuring a private network in any of the foregoing method embodiments.

[0016] The embodiments of the present application provide a computer program product, including a computer program stored on a computer-readable storage medium, in which the computer program includes program instructions. When the program instructions are running on a computer, the computer is caused to perform the method for configuring a private network in any of the foregoing method embodiments.

[0017] The embodiments of the present disclosure at least have the following beneficial effects: defining a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; obtaining a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and obtaining private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model. In the embodiments of the present disclosure, the private network configuration model is obtained by training based on the improved generative adversarial network algorithm according to the defined private network service requirement indicator and the unit device performance indicator of the procurable device in combination with the historical device configuration information, so that the private network integrated apparatus may be quickly and accurately configured for the needs of private network users according to the private network configuration model, and the configuration efficiency and user experience of the private network integrated apparatus may be improved.

[0018] The above description is only an overview of the technical solution of the embodiments of the present disclosure. In order to more clearly understand the technical means of the embodiments of the present disclosure, the embodiments may be implemented in accordance with the content of the description, and in order to make the above and other purposes, characteristics and advantages of the embodiments of the present disclosure more apparent and readily understood, the specific embodiments of the present disclosure are listed below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The accompanying drawings are used only to illustrate the embodiments and are not considered to be a limitation of the present disclosure. In the accompanying drawings, the same reference symbols are used to represent the same parts.

[0020] FIG. 1 is a flowchart of a method for configuring a private network integrated apparatus according to an embodiment of the present disclosure.

[0021] FIG. 2 is a block diagram of a private network integrated apparatus according to embodiment of the present disclosure.

[0022] FIG. 3 is a schematic diagram of a private network configuration model according to an embodiment of the present disclosure.

[0023] FIG. 4 is another flowchart of a method for configuring a private network according to an embodiment of the present disclosure.

[0024] FIG. 5 is a block diagram of an apparatus for configuring a private network according to an embodiment of the present disclosure.

[0025] FIG. 6 is a block diagram of a device for configuring a private network according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0026] Reference will now be made in detail to exemplary embodiments with reference to the accompanying drawings. Although exemplary embodiments of the present disclosure are shown in the accompanying drawings, it should be understood that the present disclosure may be realized in various forms and should not be limited by the embodiments herein.

[0027] Before the description of the embodiments of the present disclosure, the related art and its problems are further described.

[0028] The deployment of private networks faces various challenges such as a weak infrastructure, a long implementation cycle, and the like. In addition, the application requirements of different scenarios have different configurations of the device. Based on service requirements of private network users in different industries, a rapid and automatic configuration of the private network integrated apparatus is conducive to gaining a competitive advantage.

[0029] At present, the existing private network devices or systems are for private network scenarios in a certain industry, such as a visualization system for monitoring and early warning coal and rock dynamic disasters based on the 5G communication, a dedicated mobile communication system suitable for working in a harsh environment of a mine area, a smart logistics park management system based on the 5G network, and the like. The above systems include a plurality of functional modules or functional systems. Since the requirements of different service scenarios are different, each system needs to configure different functional modules, which may not be quickly copied to different scenarios.

[0030] Existing methods for configuring a device are only for consumer electronic devices, such as a computer, a mobile phone, and automatically calculate indicators for reasonable configuration of the device using a neural network method based on hardware load information and/or software usage information as device-related information, such as information of a central processing unit (CPU), information of an internal hard disk, information of an input/output (IO), screen brightness, a latency, and the like. In the methods for configuring a device, an influence of a previous state is considered, the methods are not applicable to automatically calculate a device configuration based on service requirements of the private network.

[0031] In summary, the existing private network devices or systems are for private network scenarios of a certain industry, which may not be quickly copied to satisfy the service requirements of different scenarios. However, the existing methods for configuring a device are only for the consumer electronic devices, which use the neural network method to automatically calculate the indicators of reasonable configuration of the device based on the previous state, failing to directly apply to a case of automatically calculating a device configuration based on the requirements of private network services. Therefore, there is an urgent need for an automatic method for configuring a private network that satisfies the automatic configuration of the private network integrated apparatus based on the private network service requirements in different scenarios.

[0032] FIG. 1 is a flowchart of a method for configuring a private network integrated apparatus according to an embodiment of the present disclosure. The method for configuring a device is executed by a computer processing device. Here, the computer processing device may include a mobile phone, a laptop, and the like.

[0033] FIG. 2 is a block diagram of a private network integrated apparatus according to an embodiment of the present disclosure. As shown in FIG. 2, the private network integrated apparatus 200 is configured to provide services for private network users. The device includes a plurality of optional functional modules and a plurality of procurable devices corresponding to each of the plurality of optional functional modules. The optional functional module may be divided into a service module 210, an infrastructure module 220 and an integrated rack (including a module reserved) 230. The service module 210 may include at least one of an access module 211, a transmission module 212, a switching module 213, a computing application module 214, a management module 215 or a networking module 216. The infrastructure module 220 may include at least one of a refrigeration module 221, a fire fighting module 222, a monitoring module 223, a power supply module 224 and a connector module 225.

[0034] The power supply module 224 is configured to provide power to the private network integrated apparatus by obtaining the power supply input of the private network integrated apparatus through the power supply introduction or a power supply device in the machine room. When the private network integrated apparatus is configured with a plurality of racks, the power supply module may provide a plurality of outputs as needed to supply power to each rack. Based on a power supply condition of a private network machine room, the power supply module may support an introduction of a mains electricity, an uninterruptible power supply (UPS) access or a direct current access as needed. When the functional modules in the private network integrated apparatus require different power supply modes, the power supply module may satisfy a rectifying function of alternating an alternating current (AC) to a direct current (DC) and an inverter function of alternating the DC to the AC. When a reliability requirement of the private network services is high, the power supply module may be equipped with a battery as needed and when the access of the mains electricity of the machine room is powered off, a power output may be satisfied for a certain period of backup time.

[0035] The connector module 225 is configured to provide a standard connection for an interconnection among the functional module devices in the private network integrated apparatus and a standard connection for an external connection, including a power connector module and a signal connector module. The power connector module is configured in a rack dimension, whose input is a voltage and current output provided by the power supply module, and whose output is a power input required by each functional module device of a present rack. Miniature circuit breaker terminals or the power distribution unit (PDU) sockets are configured as needed based on power consumption of each module device in the present rack and power connection terminal. The signal connector module is configured in the rack dimension, providing connectors such as a standard optical fiber, a network cable, a 2-megabit (2M) line, and the like to realize a data communication connection among the functional module devices in the present rack, an inter-rack data communication connection among the functional module devices in the present rack, and an external data communication connection among the functional module devices in the present rack. The signal connector module configures an external bandwidth and a connector type as needed based on each functional module device in the present rack, and configures connectors, such as an optical fiber, a network cable, and a 2M line as needed.

[0036] The monitoring module 223 is configured to monitor a machine room environment and the infrastructure function module, at least including a dynamic environment monitoring, and a video monitoring. The dynamic environment monitoring includes smoke detection, water leak detection, temperature and humidity detection, detections of battery clips, a door magnet, a smart power supply, a smart UPS, a smart air conditioner, pressure detection for fire extinguisher cylinders, and the like.

[0037] The refrigeration module 221 is implemented by a configured air conditioning system and the hot and cold air channels in racks of the private network integrated apparatus, is configured to provide refrigeration for the private network integrated apparatus and its surrounding environment, and to realize temperature controllability. The refrigeration module is configured as needed based on cooling capacity requirements of all functional modules of the rack.

[0038] The fire fighting module 222 is implemented by configuration of the gas extinguisher, configured to provide gas extinguishing for the private network integrated apparatus and its surrounding environment. For a filling volume of a fire extinguisher cylinder and selection of a pipeline, a volume of a protection area needs to be considered. The fire fighting module is configured to extinguish the fire based on the abnormal smoke detection monitored by the monitoring module or fire fighting instructions issued by the management module.

[0039] The access module 211 is configured to provide a network access for users within the private network, and provides a wireless access or a wired access according to service requirements, including a 2G/4G/5G, a wireless local area network (WLAN), a network cable, an optical fiber access, at least including a building baseband unit (BBU), a WLAN access controller (AC), an access switch, an optical fiber access device.

[0040] The transmission module 212 is configured to realize external long-distance data transmission of the private network integrated apparatus, at least including a slicing packet network (SPN), a packet transport network (PTN), and a synchronous digital hierarchy (SDH) device.

[0041] The switching module 213 is configured to realize service control forwarding for private network users, at least including control and forwarding of a data service and a voice service, at least including a user plane function (UPF) and a private network core network device.

[0042] The computing application module 214 is configured to provide application deployment capacities of private network services, such as a mobile edge computing (MEC) Platform (MEP), at least including a server and a magnetic array device.

[0043] The networking module 216 is configured to realize internal data connection and external data connection and corresponding security isolation of each functional module device, at least including a switch, a router, and a firewall.

[0044] The management module 215 is configured to collect and count basic data of each functional module device, provides service data display (service data at least includes visual displays in dimensions of a functional module device, a service process, a user, an operating state, and a location dimension), and manages and controls all functional module devices and rack operation control (at least including: an abnormal alarm, an operation control of each functional module device, a rack operation control (e.g., opening and closing of a rack door)) of this device.

The operation control of each functional module device at least includes judging the operating states of each module based on statistical data of each functional module or monitoring data of the monitoring module, and optimizing control, such as shutting down an appropriate number of devices when the service is idle.

[0045] Continuing to refer to FIG. 1. As shown in FIG. 1, the method for configuring a private network includes the following steps 10, 20 and 30.

[0046] At step 10, a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus are defined.

[0047] In some embodiments, the private network service requirement indicator may be predefined as $\vec{x} = (x_1, x_2, \cdots, x_m)^T$, in which $\vec{x}$ represents a $m \times 1$ dimensional vector, x_i represents an i-th item in the private network service requirement indicator, and m represents a number of defined private network service requirement indicators. For numerical private network service requirement indicators such as a single user traffic, a number of users, and a concurrency rate, corresponding x_i in the private network service requirement indicator may be directly assigned a value based on the private network service requirement value. For textual private network service requirement indicators such as a terminal type, an access mode, and a service continuity requirement, textual private network service requirement values need to be mapped to different values, such as respectively mapping to 1, 2, 3, and the like, and mapped values are assigned to corresponding x_i.

[0048] The private network service requirement indicators may correspond to at least one of a plurality of indicators, such as a supported terminal type, an access mode, a coverage area, an access limit, a transmission type, a transmission distance, a service type, a data location, a user service application type, a data isolation, a protection level, a slicing requirement and type, a single user traffic, a number of users, a concurrency rate, a number of sessions, a service continuity requirement, a number of applications carried, a rate, a bandwidth, a latency, reliability, a security level, a jitter, a packet loss rate, a disaster recovery mode, a management and maintenance type, a management and maintenance capacity, a power mode, a power capacity, a backup time, a refrigeration mode, a refrigeration capacity, an air supply type, a monitoring mode, a monitoring capacity, a fire fighting type, a fire fighting capacity, a connector type, a device size, a device weight, a device power supply type, and the like. The data location at least includes that control plane data and user plane data do not leave a campus, the user plane data does not leave the campus, and the user plane data may leave the campus. The disaster recovery mode at least includes a POOL mode, a 1+1 backup, and an N+1 backup. The power mode at least includes a switching power supply, a UPS, a rectifier, an inverter, and a power distribution module. The refrigeration mode at least includes an air-cooling mode, a water-cooling mode, and a backplate heat pipe refrigeration mode. The air supply type at least includes: front air intake and rear air exhaust, bottom air intake and top air exhaust, left air intake and right air exhaust. The connector type at least includes an optical fiber port, a network cable port, a 2M port, a Miniature circuit breaker, and a PDU.

[0049] The procurable devices include all optional devices that constitute the private network integrated apparatus with various different private network capacities, and may provide a specific type and number of pieces of private network service performance after a purchase and configuration is completed. The unit device performance indicator represents device performance capacities that may be provided by all available procurable devices after normalization processing.

[0050] Device configuration information items of all procurable devices are predefined as $\vec{e} = (e_1, e_2, \cdots, e_t)^T$, in which $\vec{e}$ represents a $t \times 1$ dimensional vector, $t = \sum_{p=1}^{n} t_p$, in which n represents the number of all procurable device types of the private network integrated apparatus, t_p represents a number of device configuration information items of a p-th kind procurable device, and $e_{\sum_{k=0}^{p-1} t_k + q}$ represents a q-th device configuration information item of the p-th kind procurable device. For example, $e_{\sum_{k=0}^{p-1} t_k + q} = \text{"the number of power supply modules"}$ means that the q-th device configuration information item of the p-th kind procurable device is the “number of power supply modules”, or for example, $e_{\sum_{k=0}^{p-1} t_k + q} = \text{"the number of 2} - \text{port 100GE interface subcards"}$ means that the q-th device configuration information item of the p-th kind procurable device is the “the number of 2-port 100GE interface subcards”.

[0051] In some embodiments, based on the private network service requirement indicator and the device configuration information items of all procurable devices, the unit device performance indicator of the procurable devices corresponding to the private network integrated apparatus is defined as $C_{t\times m} = (c_{w,i})_{t\times m}$, $t = \sum_{p=1}^{n} t_p$, where n represents the number of all procurable device types of the private network integrated apparatus, t_p represents the number of device configuration information items of the p-th kind procurable device, m represents a number of defined private network service requirement indicators, and $c_{\sum_{k=0}^{p-1} t_k+q,i}$ represents an i-th unit device sub-performance indicator of the unit device performance indicator corresponding to an i-th sub-indicator x_i of the private network service requirement indicator corresponding to the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k+q}$ of the p-th kind procurable device. When the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k+q}$ of the p-th kind procurable device does not have corresponding unit device sub-performance of the i-th sub-indicator x_i of the private network service requirement indicator, $c_{\sum_{k=0}^{p-1} t_k+q,i} = 0$, and when the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k+q}$ of the p-th kind procurable device has corresponding unit device sub-performance of the i-th sub-indicator x_i of the private network service requirement indicator, $c_{\sum_{k=0}^{p-1} t_k+q,i}$ represents the unit device sub-performance indicator value corresponding to the i-th sub-indicator x_i of the private network service requirement indicator corresponding to the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k+q}$ of the p-th kind procurable device. For numerical unit device sub-performance indicators such as a latency, and the like, the corresponding $c_{\sum_{k=0}^{p-1} t_k+q,i}$ may be directly assigned a value based on the unit device sub-performance value. For textual unit device sub-performance indicators such as the supported terminal type and the access mode, the textual unit device sub-performance needs to be mapped to different values and the mapped values are assigned to the corresponding $c_{\sum_{k=0}^{p-1} t_k+q,i}$, for example, a textual unit device sub-performance indicator of supporting SPN is mapped to 1 and a textual unit device sub-performance indicator of supporting PTN is mapped to 2.

[0052] At step 20, a private network configuration model is obtained by modeling based on an improved generative adversarial network algorithm based on an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator.

[0053] In some embodiments, the obtained private network service requirement indicator and the device configuration information corresponding to the private network service requirement indicator may be the private network device data that is historically configured. An improvement of the generative adversarial network algorithm may include dividing the private network configuration model into two parts: a configuration generative network G and a configuration discriminative network D. Generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ is obtained by inputting the sample private network service requirement indicator $\overrightarrow{x_{in}}$ into the configuration generative network G. The configuration discriminative network D may determine whether a real sample device configuration information Y_{in} and the generated configuration information Y_{out}.

[0054] The configuration generative network and the configuration discriminative network are obtained by cooperative training in advance. In the training process, the configuration generative network receives a sample private network service requirement indicator input, and outputs corresponding generated configuration information. The generated configuration information is used to configure the private network integrated apparatus to satisfy the requirement of the sample private network service requirement indicator. Specifically, the generated configuration information is configuration numbers corresponding to the device configuration information item $\vec{e}$, including a number of devices, a number of board card configurations, a number of port configurations, and a number of power supply module configurations corresponding to all the procurable devices. The sample private network service requirement indicator may be obtained by feature extraction and other processing based on the private network service requirement data obtained by experience of experts. The configuration discriminative network receives the sample device configuration information and generated configuration information corresponding to the sample private network service requirement indicator, and outputs a result of whether the generated configuration information may be distinguished from the sample device configuration information. The sample device configuration information is the real device configuration information corresponding to the sample private network service requirement indicator. Parameters of the configuration generative network are constrained based on whether the generated configuration information may satisfy the sample private network service requirement indicator, and parameters of the configuration discriminative network and the configuration generative network are updated when the configuration discriminative network may distinguish the generated configuration information from the sample device configuration information. When the configuration discriminative network cannot distinguish the generated configuration information from the sample device configuration information, training of the configuration discriminative network and the configuration generative network are determined to be completed.

[0055] In some embodiments, the private network configuration model includes the configuration generative network and the configuration discriminative network. The private network configuration model takes generated configuration information satisfying a sample private network service requirement indicator and a resource consumption cost corresponding to the generated configuration information as constraint conditions in a training process. The generated configuration information is an output of the configuration generative network for the private network service requirement indicator, and the sample private network service requirement indicator corresponds to the sample device configuration information. The configuration discriminative network is determined based on a discriminant result between the generated configuration information and a corresponding sample device configuration information.

[0056] The generated configuration information satisfying the sample private network service requirement indicator refers to that private network service processing performance provided by the generated configuration information is greater than or equal to private network service processing performance represented by the sample private network service requirement indicator. The resource consumption cost is used to represent resources that need to be consumed in the procurement and the usage by the procurable devices corresponding to the generated configuration information. The resource consumption cost may be obtained by calculating the generated configuration information according to a preset unit device consumption cost. Specifically, the resource consumption cost may include a purchase cost of the procurable devices, a cost of space that needs to be occupied after configuration, and an energy consumption cost.

[0057] In some embodiments, the training process of the private network configuration model based on the improved generative adversarial network includes two parts. One part is training of the configuration discriminative network D, the configuration discriminative network D is trained by using the real sample device configuration information Y_{in} and the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ until the configuration discriminative network is capable (able) to distinguish the real sample device configuration information Y_{in} from the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$. The other part is training of the configuration generative network G, that is, the sample private network service requirement indicator $\overrightarrow{x_{in}}$ is inputted and the generated configuration information Y_{out} is obtained, until the configuration discriminative network fails to distinguish the real sample device configuration information Y_{in} from the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$. For target functions of the configuration generative network and the configuration discriminative network, the generated configuration information Y_{out} output by the configuration generative network should be closer to the real sample device configuration information Y_{in} corresponding to the input $\overrightarrow{x_{in}}$, which makes the configuration generated by the configuration generative network more accurate. On this basis, in order to improve the user's private network experience, when the configuration is generated, generating the configuration with less resource consumption cost may set as a goal. Correspondingly, at the same time that the target functions of the configuration generative network and the configuration discriminative network fail to distinguish the difference between the real sample device configuration information Y_{in} and the generated configuration information Y_{out}, the device configuration of the private network integrated apparatus may consume less resources.

[0058] In some embodiments, step 20 includes steps 201 to 204.

[0059] At step 201, a configuration device performance indicator corresponding to the generated configuration information is obtained by converting the generated configuration information based on the unit device performance indicator, in which the generated configuration information corresponds to at least one procurable device, and the unit device performance indicator is configured to represent private network service capacities that each procurable device is capable to provide.

[0060] In some embodiments, for the private network service requirement indicator $\vec{x} = (x_1, x_2, \cdots, x_m)^T$, the corresponding device configuration information and the generated configuration information obtained by inputting the device configuration information into the configuration generative network are both expressed as: $Y_{n\times t} = (y_{p,w})_{n\times t}, t = \sum_{p=1}^{n} t_p$, where n represents the number of all the procurable device types of the private network integrated apparatus, and t_p represents the number of device configuration information items of the p-th kind procurable device. When $z = \sum_{k=0}^{p-1} t_k + 1, \cdots, \sum_{k=0}^{p} t_k$, $y_{p,z} = y_{p,\sum_{k=0}^{p-1} t_k + q}$ represents the number of configurations in the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k + q}$ of the p-th procurable device. When $z = 1,2, \cdots, \sum_{k=0}^{p-1} t_k, \sum_{k=0}^{p} t_k + 1, \cdots, t$, $y_{p,z} = 0$.

[0061] For the sample private network service requirement indicator $\overrightarrow{x_{in}}$, the configuration device performance indicator of the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ obtained via the configuration generative network G is $Y_{out} C_{t\times m} = G(\overrightarrow{x_{in}}) C_{t\times m}$.

[0062] At step 202, a satisfaction situation that the generated configuration information satisfies the sample private network service requirement indicator is obtained by comparing the private network service requirement indicator and the configuration device performance indicator.

[0063] In some embodiments, the private network service requirement indicator may be directly compared with the configuration device performance indicator. When the configuration device performance indicator is greater than or equal to the sample private network service requirement indicator, the generated configuration information is determined to satisfy the sample private network service requirement indicator, otherwise, the generated configuration information is determined not to satisfy the sample private network service requirement indicator.

[0064] In the embodiments of the present disclosure, some private network service requirement indicators may be satisfied by adding a plurality of same or different devices. Therefore, when the configuration device performance indicator of a single procurable device in the generated configuration information fails satisfying the private network service requirement indicator, a non-additive performance attribute and an additive performance attribute of the private network service requirement indicator may be determined. The additive performance attribute is configured to represent that the private network service requirement indicator may be satisfied by an additive configuration of a plurality of procurable devices, and correspondingly, the non-additive performance attribute is configured to represent that the private network service requirement indicator fails being satisfied by the additive configuration of a plurality of procurable devices. Specifically, a configuration device performance indicator with the non-additive performance attribute and a configuration device performance indicator with the additive performance attribute corresponding to the generated configuration information may be obtained based on the non-additive performance attribute and the additive performance attribute. A configuration device performance indicator with the non-additive performance attribute is compared with a private network service requirement indicator with the non-additive performance attribute, and a configuration device performance indicator with the additive performance attribute is compared with a private network service requirement indicator with the additive performance attribute, and the satisfaction situation that the generated configuration information satisfies the private network service requirement indicator is obtained.

[0065] In some embodiments, step 202 also includes steps 2021 to 2023.

[0066] At step 2021, a non-additive performance attribute corresponding to the private network service requirement indicator is determined, in which the non-additive performance attribute is configured to represent whether the private network service requirement indicator fails being satisfied by an additive configuration of a plurality of procurable devices.

[0067] In some embodiments, corresponding to the private network service requirement indicator $\vec{x} = (x_1, x_2, \cdots, x_m)^T$, the non-additive performance attribute of the private network service requirement indicator is defined as $\vec{a} = (a_1, a_2, \cdots, a_m)^T$, where $\vec{a}$ represents a $m \times 1$ dimensional vector, configured to represent whether the private network service requirement indicator fails being satisfied by the additive configuration of a plurality of procurable devices.

[0068] In some embodiments, when $a_i = 0$, it identifies that the i-th sub-indicator x_i of the private network service requirement indicator has the non-additive performance attribute, that is, the corresponding sub-indicator x_i fails being satisfied by the additive configuration of a plurality of procurable devices. When $a_i = \pm 1$, it identifies that the i-th sub-indicator x_i of the private network service requirement indicator has the additive performance attribute, that is, the corresponding sub-indicator x_i is capable to be satisfied by the additive configuration of a plurality of procurable devices. $a_i = 1$ is used to identify that the i-th sub-indicator x_i of the private network service requirement indicator is less than a certain value, and $a_i = -1$ is used to correct the i-th sub-indicator x_i of the private network service requirement indicator to ensure that $a_i \times x_i = -x_i$ is less than a certain value.

[0069] It should be noted that when $a_i = 1$, the larger the i-th sub-indicator x_i of the private network service requirement indicator is, the better a performance capacity under the sub-indicator is, which may better satisfy the needs of users, that is, a size of the sub-indicator value is proportional to the performance capacity. When $a_i = 1$, the sub-indicator of the private network service requirement indicator may be a network speed, a storage capacity, and the number of users. Correspondingly, when $a_i = -1$, the smaller the indicator value of the i-th sub-indicator x_i of the private network service requirement indicator is, the better the performance capacity under the indicator is, which may better satisfy the needs of users, that is, the size of the sub-indicator value is inversely proportional to the performance capacity. When $a_i = -1$, the sub-indicator of the private network service requirement indicator may be a number of lost packets, a number of alarms, and the like.

[0070] Corresponding to the private network service requirement indicator $\vec{x} = (x_1, x_2, \cdots, x_m)^T$, a private network service requirement indicator with the non-additive performance attribute is $\overrightarrow{x_{in}} \cdot (\vec{1} - \text{abs}(\vec{a}))$, and a private network service requirement indicator with the additive performance attribute is $\overrightarrow{x_{in}} \cdot \vec{a}$, in which $\cdot$ represents a Hadamard product (also known as element-wise product, and U·W represents a multiplication of elements corresponding to the matrix U and elements corresponding to the matrix W) of matrices, $\vec{1}$ represents an all-1 vector of $m \times 1$ dimensions, that is, $\vec{1} = (1,1,\cdots,1)^T$, and $\text{abs}(*)$ represents taking absolute values of all elements of a matrix.

[0071] At step 2022, in response to determine that there is a corresponding non-additive performance attribute in the private network service requirement indicator, a configuration device performance indicator of a non-additive performance attribute corresponding to the generated configuration information is obtained based on the non-additive performance attribute and the configuration device performance indicator corresponding to the generated configuration information, and a configuration device performance indicator with the non-additive performance attribute is compared with a sample private network service requirement indicator with the non-additive performance attribute.

[0072] In some embodiments, the configuration device performance indicator corresponding to the generated configuration information is weighted based on the non-additive performance attribute, and the configuration device performance indicator of the non-additive performance attribute corresponding to the generated configuration information is obtained.

[0073] It is easy to understand that the unit device performance indicator of the private network integrated apparatus has the same non-additive performance attribute $\vec{a} = (a_1, a_2, \cdots, a_m)^T$ as the private network service requirement indicator, that is, for the sub-indicator of the private network service requirement indicator with the non-additive performance attribute, the unit device sub-performance indicators of the unit device performance indicator of the private network integrated apparatus corresponding to the sub-indicator of the private network service requirement indicator has the same non-additive performance attribute.

[0074] Therefore, the non-additive performance attribute of the unit device performance indicator of the private network integrated apparatus may be determined as follows. When $a_i = 0$, it identifies that the unit device sub-performance indicator $c_{\sum_{k=0}^{p-1} t_k + q, i}$ of the i-th sub-indicator x_i of the private network service requirement indicator corresponding to the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k + q}$ of the p-th kind procurable device has the non-additive performance attribute. When $a_i = \pm 1$, it identifies that the unit device sub-performance indicator $c_{\sum_{k=0}^{p-1} t_k + q, i}$ of the i-th sub-indicator x_i of the private network service requirement indicator corresponding to the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k + q}$ of the p-th kind procurable device has the additive performance attribute. $a_i = 1$ is used to identify the unit device sub-performance indicator $c_{\sum_{k=0}^{p-1} t_k + q, i}$ of the i-th sub-indicator x_i of the private network service requirement indicator corresponding to the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k + q}$ of the p-th kind procurable device is larger than or equal to a certain value, and $a_i = -1$ is used to correct the unit device sub-performance indicator $c_{\sum_{k=0}^{p-1} t_k + q, i}$ of the i-th sub-indicator x_i of the private network service requirement indicator corresponding to the q-th device configuration information item $e_{\sum_{k=0}^{p-1} t_k + q}$ of the p-th kind procurable device to ensure that $a_i \times c_{\sum_{k=0}^{p-1} t_k + q, i} = -c_{\sum_{k=0}^{p-1} t_k + q, i}$ is greater than or equal to a certain value.

[0075] For the sample private network service requirement indicator $\overrightarrow{x_{in}}$, the configuration device performance indicator of the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ obtained via the configuration generative network is $Y_{out} C_{t \times m} = G(\overrightarrow{x_{in}}) C_{t \times m}$. The configuration device performance indicator of the non-additive performance attribute corresponding to the generated configuration information is $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T/\left|(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T\right|\cdot(\vec{1}-abs(\vec{a}))$. $(p,:)$ represents a p-th row of the matrix, and $|*|$ represents a norm of a vector *.

[0076] The configuration device performance indicator with the non-additive performance attribute is compared with the sample private network service requirement indicator with the non-additive performance attribute. When a value of the configuration device performance indicator with the non-additive performance attribute is greater than or equal to a value of the private network service requirement indicator with the non-additive performance attribute, the generated configuration information is capable to satisfy the private network service requirement indicator with the non-additive performance attribute. Otherwise, the generated configuration information fails to satisfy the private network service requirement indicator with the non-additive performance attribute.

[0077] In some embodiments, a single device sub-performance with the non-additive performance attribute of the generated configuration information Y_{out} should be greater than or equal to a corresponding sub-indicator of the private network service requirement indicator. That is, the configuration device performance indicator $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T/\left|(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T\right|\cdot(\vec{1}-abs(\vec{a}))$ with the non-additive performance attribute of single generated configuration information of the p-th kind procurable device should be greater than or equal to the private network service requirement indicator $\overrightarrow{x_{in}}\cdot(\vec{1}-abs(\vec{a}))$ with the non-additive performance attribute, that is:

[0078] $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T/\left|(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T\right|\cdot(\vec{1}-abs(\vec{a}))\geq\overrightarrow{x_{in}}\cdot(\vec{1}-abs(\vec{a}))$, for $\forall p\in(1,2,\cdots,n)$. $\forall$ represents any, $\in$ represents belonging to, and $\geq$ represents that there is a greater than or equal relationship between values of elements corresponding to two vectors.

[0079] At step 2023, in response to determine that there is no corresponding non-additive performance attribute in the private network service requirement indicator, an additive performance attribute is determined based on the non-additive performance attribute, a configuration device performance indicator with the additive performance attribute corresponding to the generated configuration information is obtained based on the additive performance attribute and the configuration device performance indicator corresponding to the generated configuration information, and the configuration device performance indicator with the additive performance attribute is compared with the sample private network service requirement indicator with the additive performance attribute.

[0080] In some embodiments, when there is no corresponding non-additive performance attribute in the private network service requirement indicator, the additive performance attribute is considered. Based on the additive performance attribute similar to the above step 2022, the configuration device performance indicator with the additive performance attribute corresponding to the generated configuration information is obtained by weighting the configuration device performance indicator corresponding to the generated configuration information. The additive performance attribute is an opposite event of the non-additive performance attribute. The additive performance attribute represents that the device performance indicator may be satisfied by the additive configuration of a plurality of procurable devices.

[0081] For the sample private network service requirement indicator $\overrightarrow{x_{in}}$, the configuration device performance indicator of the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ obtained via the configuration generative network is $Y_{out}C_{t\times m} = G(\overrightarrow{x_{in}})C_{t\times m}$, in which the configuration device performance indicator with the additive performance attribute corresponding to the generated configuration information is $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T \cdot \vec{a}$.

[0082] The configuration device performance indicator with the additive performance attribute is compared with the sample private network service requirement indicator with the additive performance attribute. When a value of the configuration device performance indicator with the additive performance attribute is greater than or equal to a value of the private network service requirement indicator with the additive performance attribute, the generated configuration information is capable to satisfy the private network service requirement indicator with the additive performance attribute. Otherwise, it is determined that the generated configuration information does not satisfy the private network service requirement indicator with the additive performance attribute.

[0083] In some embodiments, a configuration device overall sub-performance with the additive performance attribute of the generated configuration information Y_{out} should be greater than or equal to the sub-indicator of a corresponding private network service requirement indicator. That is, the configuration device performance indicator $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T \cdot \vec{a}$ with the additive performance attribute of the generated configuration information of the p-th kind procurable device should be greater than or equal to the private network service requirement indicator $\overrightarrow{x_{ln}} \cdot \vec{a}$ with the additive performance attribute, that is:

$$(G(\overrightarrow{x_{ln}})C_{t\times m})(p,:)^T \cdot \vec{a} \geq \overrightarrow{x_{ln}} \cdot \vec{a}, \text{ for } \forall p \in (1,2,\cdots,n), \text{ for } \forall p \in (1,2,\cdots,n).$$

[0084] At step 203, the resource consumption cost corresponding to the generated configuration information is determined.

[0085] In some embodiments, the resource consumption cost is used to represent the resources that need to be consumed in the procurement and the usage by the at least one procurable device corresponding to the generated configuration information. The resource consumption cost may be obtained based on the generated configuration information and the preset unit device consumption cost. The resource consumption cost may be calculated from a plurality of dimensions such as a capital consumption, a device space consumption, and an energy consumption of the at least one procurable device. The device space consumption may be determined based on a size of the procurable device, a required space between devices, and the like, and the energy consumption may be determined based on power consumption, an amount of occupied storage, and an occupied bandwidth of the procurable devices. Specifically, the resource consumption cost is calculated based on a unit device price, a unit device space occupation, or a unit device power consumption of the procurable devices.

[0086] In some embodiments, with respect to the calculation of the resource consumption cost, the above step 203 further includes:

[0087] At step 2031, a resource consumption cost of the procurable devices corresponding to the generated configuration information in a computing dimension of a preset unit device consumption cost is determined, in which the computing dimension of the preset unit device consumption cost includes at least one of the unit device price, the unit device space occupation, or the unit device power consumption.

[0088] In an embodiment of the present disclosure, the resource consumption cost may include the purchase cost of the at least one procurable device, the cost of the space that needs to be occupied after configuration, and the energy consumption cost. Specifically, the unit device price is a cost of purchasing the procurable device of a smallest purchase unit. The unit device space occupation is configured to represent the space occupied by the rack when devices to be configured is installed and deployed, which may be determined based on sizes of the devices to be configured, a space between two racks, and space requirements. The unit device power consumption is configured to represent energy consumed by the devices to be configured during the operation, such as electric energy, water energy, and the like.

[0089] In some embodiments, the unit device consumption cost is defined as $\vec{m_l}$, which is a $t \times 1$ dimensional vector, l=1, 2, 3, $m_{\sum_{k=0}^{p-1} t_k+q,l}$ is the unit device price, the unit device space occupation, and the unit device power consumption corresponding to the device configuration information item $e_{\sum_{k=0}^{p-1} t_k+q}$, and $t = \sum_{p=1}^{n} t_p$, where n represents the number of all procurable device types of the private network integrated apparatus, and t_p represents the number of the device configuration information items of the p-th kind procurable device.

[0090] The resource consumption cost of the at least one procurable device corresponding to the generated configuration information in the computing dimension of the preset unit device consumption cost is $Y_{out}\vec{m_l}$=$G(\overrightarrow{x_{in}})\vec{m_l}$. When l=1, 2, 3, $Y_{out}\vec{m_l}$ are respectively a device price, a space occupation, and a device power consumption of the private network integrated apparatus under the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$.

[0091] At step 2032, the resource consumption cost is obtained by performing weighted summation on unit device consumption costs corresponding to all the procurable devices corresponding to the generated configuration information.

[0092] In some embodiments, each cost computing dimension may correspond to one preset dimension weight, and the resource consumption cost of the at least one procurable device corresponding to the generated configuration information is obtained by performing the weighted summation on the unit device consumption cost based on the corresponding dimension weight. A configuration weight may be determined based on the service requirements of the private network users, and is configured to represent a degree of emphasis of the private network users to the resource consumption of the private network integrated apparatus. In this way, the generated configuration information output by the private network configuration model not only satisfies the private network service requirement indicator, but also save the cost of the private network users for purchasing and normally use the private network integrated apparatus, thus improving the user experience.

[0093] The preset unit device consumption cost $\overrightarrow{m_l}$ corresponds to a weight ϕ_l, where ϕ_l is the weight values of the resource consumption cost of the price, the space occupation and the power consumption respectively, and l=1, 2 and 3. The resource consumption cost of the generated configuration information is $k = \sum_{l=1}^{3} \left| \phi_l Y_{out} \overrightarrow{m_l} \right| = \sum_{l=1}^{3} \left| \phi_l G(\overrightarrow{x_{in}}) \overrightarrow{m_l} \right|$.

[0094] At step 204, a generated configuration information change corresponding to the sample private network service requirement indicator is determined based on requirement change information corresponding to the sample private network service requirement indicator and the configuration generative network; a configuration discriminant result information change between the generated configuration information from the configuration generative network and the corresponding sample device configuration information based on the configuration discriminative network is determined; and it is updated based on the requirement change information corresponding to the sample private network service requirement indicator, the generated configuration information change, the configuration discriminant result information change, and the resource consumption cost corresponding to the generated configuration information.

[0095] In some embodiments, the requirement change information corresponding to the sample private network service requirement indicator may be different sample private network service requirement indicators. Different generated configuration information output by the configuration generative network is obtained by inputting different sample private network service requirement indicators into the configuration generative network.

[0096] In order to make the configuration discriminative network unable to distinguish the real sample device configuration information from the generated configuration information output by the configuration generative network, it is necessary to update the parameters of the configuration discriminative network and the configuration generative network based on the configuration discriminant result information change, so as to satisfy the target functions of the configuration generative network and the configuration discriminative network.

[0097] The target function of the configuration discriminative network is expressed as the following formula (1):

$$\max_{D} L(D, G) = E(\log D(Y_{in})) + E(\log(1 - D(G(\overrightarrow{x_{in}})))) \quad (1).$$

[0098] The target function of the configuration generative network is expressed as the following formula (2):

$$\min_{G} L(D, G) = E(\log D(Y_{in})) + E(\log(1 - D(G(\overrightarrow{x_{in}})))) \quad (2).$$

[0099] $E(\log D(Y_{in}))$ represents a mathematical expectation of $\log D(Y_{in})$, and $E(\log(1 - D(G(\overrightarrow{x_{in}}))))$ represents the mathematical expectation of $\log(1 - D(G(\overrightarrow{x_{in}})))$.

[00100] In order to make the configuration discriminative network unable to distinguish the real sample device configuration information from the generated configuration information output by the configuration generative network, and to reduce the resource consumption cost corresponding to the generated configuration information, it is necessary to update the parameters of the configuration discriminative network and the configuration generative network based on the configuration discriminant result information change and the resource consumption cost, and obtain the private network configuration model. The target functions of the private network configuration model include the following formula (3) and formula (4).

$$\min_{G} \max_{D} L(D, G) = E(\log D(Y_{in})) + E(\log(1 - D(G(\overrightarrow{x_{in}})))) \quad (3)$$

$$\min_{G} k = \sum_{l=1}^{3} \left| \phi_{l} G(\overrightarrow{x_{in}}) \overrightarrow{m_l} \right| \quad (4)$$

[00101] At step 30, private network device configuration information corresponding to a user to be configured is obtained by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

[00102] In some embodiments, the trained private network configuration model includes a trained configuration generative network and a trained configuration discriminative network. The private network device configuration information corresponding to the user to be configured is obtained by inputting the private network service requirement indicator of the user to be configured into the trained configuration generative network.

[00103] For the private network service requirement indicator $\overrightarrow{x_{conf}}$ of the user to be configured, the generated configuration information $Y_{conf} = G(\overrightarrow{x_{conf}})$ is obtained by the trained configuration generative network.

[00104]FIG. 3 is a schematic diagram of a private network configuration model according to an embodiment of the present disclosure. The structure of the private network configuration model is shown in FIG. 3.

[00105]The private network configuration model is based on an improved generative adversarial network algorithm, and includes two parts, namely, a configuration generation network and a configuration discriminative network. The generative generation network G obtains generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ by inputting a sample private network service requirement indicator $\overrightarrow{x_{in}}$. The configuration discriminative network D determines whether it is capable to distinguish real sample device configuration information from the generated configuration information Y_{out}.

[00106]A training process of the private network configuration model includes two parts. One part is the training of the configuration discriminative network D, including training the configuration discriminative network D by using real sample device configuration information Y_{in} and the generated configuration information Y_{out} until the configuration discriminative network may distinguish the real sample device configuration information Y_{in} from the generated configuration information Y_{out}. The other part is the training of the configuration generative network G, including: inputting the sample private network service requirement indicator $\overrightarrow{x_{in}}$, updating parameters of the configuration generative network, and obtaining the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$, until the configuration discriminative network fails to distinguish the real sample device configuration information Y_{in} from the generated configuration information Y_{out}.

[00107]A target function of the configuration generative network is expressed as the following formula (5):

$$\min_{G} L(D, G) = E(\log D(Y_{in})) + E(\log(1 - D(G(\overrightarrow{x_{in}})))) \quad (5).$$

[00108]A target function of the configuration discriminative network is expressed as the following formula (6):

$$\max_{D} L(D, G) = E(\log D(Y_{in})) + E(\log(1 - D(G(\overrightarrow{x_{in}})))) \quad (6).$$

[00109]Considering that a unit device performance indicator of a private network integrated apparatus has a same non-additive performance attribute as the private network service requirement indicator. However, the non-additive performance attribute makes that a device capability corresponding to the private network service requirement indicator cannot be realized by adding a plurality of devices when devices are configuring. For the sample private network service requirement indicator $\overrightarrow{x_{in}}$, a configuration device performance indicator of the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ obtained by the configuration generative network is $Y_{out}C_{t\times m} = G(\overrightarrow{x_{in}})C_{t\times m}$, and a single device sub-performance with the non-additive performance attribute of the generated configuration information Y_{out} should be greater than or equal to a corresponding sub-indicator of the private network service requirement indicator. That is, a configuration device performance indicator $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T / \left|(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T\right| \cdot (\vec{1} - abs(\vec{a})$ with the non-additive performance attribute of single generated configuration information of a p-th kind procurable device should be greater than or equal to a private network service requirement indicator $\overrightarrow{x_{in}} \cdot (\vec{1} - abs(\vec{a}))$ with the non-additive performance attribute, that is:

[00110] $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T / \left|(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T\right| \cdot (\vec{1} - abs(\vec{a})) \geq \overrightarrow{x_{in}} \cdot (\vec{1} - abs(\vec{a}))$, for $\forall p \in (1,2,\cdots,n)$. For the sample private network service requirement indicator $\overrightarrow{x_{in}}$, the configuration device performance indicator of the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ obtained by the configuration generative network is $Y_{out}C_{t\times m} = G(\overrightarrow{x_{in}})C_{t\times m}$, and a configuration device overall sub-performance with an additive performance attribute of the generated configuration information Y_{out} should be greater than or equal to the corresponding sub-indicator of the private network service requirement indicator. That is, a configuration device performance indicator $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:) \cdot \vec{a}$ with the additive performance attribute of the generated configuration information of the p-th kind procurable device should be greater than or equal to a private network service requirement indicator $\overrightarrow{x_{in}} \cdot \vec{a}$ with the additive performance attribute, that is:

[00111] $(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T \cdot \vec{a} \geq \overrightarrow{x_{in}} \cdot \vec{a}$, for $\forall p \in (1,2,\cdots,n)$. $(p,:)$ represents a p-th row of a matrix, $|*|$ represents a norm of a vector *, and $\cdot$ represents a Hadamard product (also known as element-wise product, and U·W represents a multiplication of elements corresponding to the matrix U and elements corresponding to the matrix W) of matrices, $\vec{1}$ represents an all-1 vector of $m \times 1$ dimensions, that is, $\vec{1} = (1,1,\cdots,1)^T$, $\forall$ represents any, $\in$ represents belonging to, and $\geq$

represents that there is a greater than or equal relationship between values of elements corresponding to two vectors, and $\mathrm{abs}(*)$ represents taking absolute values of all elements of a matrix.

[00112]Considering that different procurable devices may consume different resources to achieve same device performance, on the basis of ensuring that the generated configuration information may satisfy the private network service requirement indicator of a user, in order to optimize the user experience of private network configuration and provide users with a configuration solution with a lower resource consumption cost, generated configuration information that consumes a lowest resource cost to complete the configuration is selected from all the generated configuration information that satisfies the private network service requirement indicator output by the configuration generative network. A resource consumption cost may be calculated from a plurality of dimensions such as a capital consumption, a device space consumption, and an energy consumption of the procurable device. The device space consumption may be determined based on a size of the procurable device, a required space between devices, and the like, and the energy consumption may be determined based on power consumption, an amount of occupied storage, and an occupied bandwidth of the procurable device. Specifically, the resource consumption cost is calculated based on a unit device price, a unit device space occupation, or unit device power consumption of the procurable device. A resource consumption value of the private network integrated apparatus is $k = \sum_{l=1}^{3}\left| \phi_{l} Y_{out}\, \overrightarrow{m_l} \right| = \sum_{l=1}^{3}\left| \phi_{l} G(\overrightarrow{x_{in}})\, \overrightarrow{m_l} \right|$, where $Y_{out}\, \overrightarrow{m_l}$ are respectively the device price, the space occupation, and the device power consumption of the private network integrated apparatus under the configuration information $Y_{out} = G(\overrightarrow{x_{in}})$.

[00113]Considering the resource consumption cost of the private network integrated apparatus and the private network service requirement indicator as the constraint conditions of the private network configuration model, for the private network configuration model, the target functions of the private network configuration model may include the following formulas (7) to (10).

$$\min_{G} \max_{D} L(D, G) = E(\log D(Y_{in})) + E(\log(1 - D(G(\overrightarrow{x_{in}})))) \quad (7)$$

$$\min_{G} k = \sum_{l=1}^{3}\left| \phi_{l} G(\overrightarrow{x_{in}})\, \overrightarrow{m_l} \right| \quad (8)$$

$$(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^{T} / \left|(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^{T}\right| \cdot (\vec{1} - \mathrm{abs}(\vec{a})) \geq \overrightarrow{x_{in}} \cdot (\vec{1} - \mathrm{abs}(\vec{a})) , \quad \text{for} \quad \forall p \in (1,2,\cdots,n) \quad (9)$$

$(G(\overrightarrow{x_{in}})C_{t\times m})(p,:)^T \cdot \vec{a} \geq \overrightarrow{x_{in}} \cdot \vec{a}$, for $\forall p \in (1,2,\cdots,n)$ (10)

[00114] In some embodiments, considering a development and change of a private network user service, service requirements for the private network integrated apparatus may change. For example, a private network service requirement of a private network user may grow on the original basis, the private network integrated apparatus configured in the above step needs to be expanded. Correspondingly, the private network service will shrink with decrease of private network users and private network requirements, so the private network integrated apparatus may be integrated correspondingly, so as to reduce unnecessary cost of the user on configuring the private network integrated apparatus.

[00115] Therefore, in the embodiments of the present disclosure, in order to make finally obtained private network device configuration information not only satisfy the current user requirement and achieve the lowest resource consumption, but also achieve the lowest resource consumption in the future when the user requirement changes, based on the private network configuration model, a private network configuration model based on capacity expansion is proposed. The private network configuration model based on capacity expansion takes the generated configuration information satisfying the sample private network service requirement indicator and a resource consumption cost based on capacity expansion as constraint conditions in the training process, and a sum of a current resource consumption cost and a predicted resource consumption cost is determined as the resource consumption cost based on capacity expansion.

[00116] In some embodiments, in a later stage of operation of the private network integrated apparatus, that is, at an end of a planning period, the private network service requirement indicator becomes $\overrightarrow{x^f} = \left(x_1^f, x_2^f, \cdots, x_m^f\right)^T = \vec{x} \cdot (\vec{1} + \vec{v})$, where $\vec{x} = (x_1, x_2, \cdots, x_m)^T$ is a current private network service requirement indicator, $\vec{v} = (v_1, v_2, \cdots, v_m)^T$ is a growth rate of the current private network service requirement indicator at the end of the planning period, $x_i^f = x_i(1 + v_i)$, v_i is a growth rate of the i-th sub-indicator x_i of the private network service requirement indicator at the end of the planning period, v_i may be a positive value representing a positive growth, and v_i may be a negative value representing a negative growth.

[00117]By adding the predicted resource consumption cost to the resource consumption cost, the resource consumption cost based on capacity expansion is obtained. The expanded resource consumption cost is expressed as the following formula (11):

$$\min_G k_p = \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}})\,\overrightarrow{m_l}\right| + \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}^{f}})\,\overrightarrow{m_l}\right|$$

$$= \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}})\,\overrightarrow{m_l}\right| + \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}}\cdot(\vec{1}+\vec{v}))\,\overrightarrow{m_l}\right| \quad (11).$$

[00118]The resource consumption cost based on capacity expansion makes the private network configuration model based on capacity expansion is capable to automatically select devices with a lower configuration resource consumption cost, and is capable to obtain more capacity expansion space at the same time, so as to adapt to changes in the service requirements in the later stage of the planning.

[00119]Similarly, considering the resource consumption cost and the private network service requirement indicator of the private network integrated apparatus based on the capacity expansion as the constraint conditions of the private network configuration model, for the private network configuration model based on the capacity expansion, the target functions of the private network configuration model based on the capacity expansion are expressed as the following formulas (12) to (15).

$$\min_G \max_D L(D,G) = E(\log D(Y_{in})) + E(\log(1 - D(G(\overrightarrow{x_{ln}})))) \quad (12)$$

$$\min_G k_p = \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}})\,\overrightarrow{m_l}\right| + \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}^{f}})\,\overrightarrow{m_l}\right|$$

$$= \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}})\,\overrightarrow{m_l}\right| + \sum_{l=1}^{3}\left|\phi_l G(\overrightarrow{x_{ln}}\cdot(\vec{1}+\vec{v}))\,\overrightarrow{m_l}\right| \quad (13)$$

$$(G(\overrightarrow{x_{ln}})C_{t\times m})(p,:)^T / \left|(G(\overrightarrow{x_{ln}})C_{t\times m})(p,:)^T\right| \cdot (\vec{1} - \mathrm{abs}(\vec{a})) \geq \overrightarrow{x_{ln}} \cdot (\vec{1} - \mathrm{abs}(\vec{a})), \quad \text{for } \forall p \in (1,2,\cdots,n) \quad (14)$$

$$(G(\overrightarrow{x_{ln}})C_{t\times m})(p,:)^T \cdot \vec{a} \geq \overrightarrow{x_{ln}} \cdot \vec{a}, \text{ for } \forall p \in (1,2,\cdots,n) \quad (15)$$

[00120]FIG. 4 is another flowchart of a method for configuring a private network according to an embodiment of the present disclosure. As shown in FIG. 4, a configuration process of a private network integrated apparatus may include steps P10 to P30.

[00121] At step P10, a private network service requirement indicator and a non-additive performance attribute of the private network service requirement indicator are defined. The step is the same as the above embodiments and will not be repeated.

[00122] At step P11, device configuration information items of all procurable devices of the private network integrated apparatus and the unit device performance indicator are defined. The step is the same as the above embodiments and will not be repeated.

[00123] At step P20, sample private network service requirement indicators and corresponding real device configuration information in different private network scenarios are obtained.

[00124] At step P21, a dimension reduction process is performed on obtained real device configuration information corresponding to the sample private network service requirement indicator in each private network scenario and an obtained unit device performance indicator of the private network integrated apparatus.

[00125] Considering that there are hundreds of kinds of procurable devices, and the device configuration information items of the procurable devices are not exactly the same, for the obtained private network service requirement indicator $\vec{x} = (x_1, x_2, \cdots, x_m)^T$, corresponding device configuration information and the generated configuration information $Y_{n\times t} = (y_{p,w})_{n\times t}$ obtained by a configuration generative network may be a matrix with as many as thousands of columns, and the unit device performance indicator $C_{t\times m} = (c_{w,i})_{t\times m}$ of the private network integrated apparatus may be a matrix with as many as thousands of rows. Therefore, it is necessary to perform the dimension reduction process on $Y_{n\times t}$ and $C_{t\times m}$. After the dimension reduction, corresponding device configuration information and generated configuration information obtained by the configuration generative network is $Y^d_{n\times \max(t_p)} = (y^d_{p,q})_{n\times \max(t_p)}$. When $q \le t_p$, $y^d_{p,q} = y_{p,\sum_{k=0}^{p-1} t_k+q}$; and when $q > t_p$, $y^d_{p,q}$ =0. t_p represents a number of device configuration information items of a p-th kind procurable device, that is, each row (each row corresponds to one kind of procurable device) only retains configuration numbers of all device configuration information items of a corresponding procurable device, and zero filling for other elements. After the dimension reduction, the unit device performance indicator of the private network integrated apparatus is $C^d_{\max(t_p)\times m} = (c^d_{q,i})_{\max(t_p)\times m}$. When $q \le t_p$, $c^d_{q,i} = c_{\sum_{k=0}^{p-1} t_k+q,i}$; and when $q > t_p$,

$c_{q,i}^{d} = 0$. t_p represents the number of device configuration information items of the p-th kind procurable device, that is, each column (each column corresponds to one kind of procurable device) only retains all unit device performance indicator values of a corresponding procurable device, and zero filling for other elements.

[00126] At step P22, the sample private network service requirement indicator $\overrightarrow{x_{in}}$ in different private network scenarios is input into the configuration generative network G, the generated configuration information $Y_{out} = G(\overrightarrow{x_{in}})$ and the generated configuration information $Y_{out}^{d} = G(\overrightarrow{x_{in}})^{d}$ after the dimension reduction are obtained, and a number of training times of the private network configuration model is initialized to 1.

[00127] A network structure of the configuration generative network G mainly includes 5 fully connected layers. In order to maintain better convergence, a LeakyRelu layer and a BatchNormalization layer are added, and a Tanh activation function is used in the last fully connected layer. An input z of the Tanh activation function is the output of a previous layer (Dense_5). An expression of the Tanh activation function is expressed as the following formula (16):

$$\tanh(z) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}} \quad (16).$$

[00128] Table 1 is a structure parameter table of the determining configuration generative network G, which is as follows:

Module	Layer name	Name	Parameter value	Output size
Configuration generative network	Input layer	Input_1	-	(None， 42)
	Fully connected layer 1	Dense_1	128	(None， 128)
		LeakyReLU_1	0.2	(None， 128)
		BatchNormalization_1	0.8	(None， 128)
	Fully connected layer 2	Dense_2	256	(None， 256)
		LeakyReLU_2	0.2	(None， 256)
		BatchNormalization_2	0.8	(None， 256)

Module	Layer name	Name	Parameter value	Output size
	Fully connected layer 3	Dense_3	1024	(None，1024)
		LeakyReLU_3	0.2	(None，1024)
		BatchNormalization_3	0.8	(None，1024)
	Fully connected layer 4	Dense_4	2048	(None，2048)
		LeakyReLU_4	0.2	(None，2048)
		BatchNormalization_4	0.8	(None，2048)
	Fully connected layer 5	Dense_5	4000	(None，4000)
		Tanh_1	-	(None，4000)
		Reshape_1	-	(None，100，40)

Table 1 structure parameters of the determining configuration generative network G

[00129]At step P23, whether the configuration discriminative network D is capable to distinguish the generated configuration information $Y_{out}^{d} = G(\overrightarrow{x_{in}})^{d}$ after the dimension reduction and the real sample device configuration information Y_{in}^{d} after the dimension reduction output by the configuration generative network G is determined by inputting them into the configuration discriminative network D.

[00130]A network structure of the configuration discriminative network D mainly includes 5 fully connected layers, and parameters of each layer may be referred to Table 2, which is a structural parameter table of the configuration discriminative network D. In order to maintain better convergence, a LeakyRelu layer is added, and a sigmoid activation function is used in the last fully connected layer. An input z of the activation function is an output of the previous layer (Dense_10). An expression of the sigmoid activation function is expressed as the following formula (17).

$$\text{sigmoid}(z) = \frac{1}{1+e^{-z}} \quad (17)$$

Module	Layer name	Name	Parameter value	Output size
Configuration discriminative network	Input layer	Input_2	-	(None，100，40)
		Flatten_1	-	(None，4000)
	Fully connected layer 1	Dense_6	2048	(None，2048)
		LeakyReLU_6	0.2	(None，2048)
	Fully connected layer 2	Dense_7	1024	(None，1024)
		LeakyReLU_7	0.2	(None，1024)
	Fully connected layer 3	Dense_8	512	(None，512)
		LeakyReLU_8	0.2	(None，512)
	Fully connected layer 4	Dense_9	256	(None，256)
		LeakyReLU_9	0.2	(None，256)
	Fully connected layer 5	Dense_10	1	(None，1)
		Sigmoid_1	-	(None，1)

Table 2 structure parameters of the configuration discriminative network D

[00131]In a training process of the configuration discriminative network D, it is necessary to keep the parameters of the configuration generative network G unchanged, an objective is that when the configuration discriminative network D is capable to accurately identify the real sample device configuration information Y_{in}^{d}, an output label is 1 and when the configuration discriminative network D is capable to accurately identify the generated configuration information $Y_{out}^{d} = G(\overrightarrow{x_{in}})^{d}$, the output label is 0. Therefore, a target function of the configuration discriminative network is expressed as the following formula (18):

$$\max_{D} L(D, G) = E(\log D(Y_{in}^{d})) + E(\log(1 - D(G(\overrightarrow{x_{in}})^{d}))) \quad (18).$$

[00132]When the configuration discriminative network D is capable to distinguish the generated configuration information $Y_{out}^d = G(\overrightarrow{x_{in}})^d$ after the dimension reduction from the real sample device configuration information Y_{in}^d after the dimension reduction output by the configuration generative network G, step P25 is implemented; otherwise, step P24 is implemented.

[00133]At the step P24, parameters of the configuration discriminative network D are updated, and the step P23 is implemented.

[00134]At the step P25, whether a single device sub-performance $(G(\overrightarrow{x_{in}})^d C_{max(t_p)\times m}^d)(p,:)^T / \left|(G(\overrightarrow{x_{in}})^d C_{max(t_p)\times m}^d)(p,:)^T\right| \cdot (\vec{1} - abs(\vec{a}))$ with the non-additive performance attribute of the generated configuration information $Y_{out}^d = G(\overrightarrow{x_{in}})^d$ after the dimension reduction output by the configuration generative network G is greater than or equal to a sub-indicator $\overrightarrow{x_{in}} \cdot (\vec{1} - abs(\vec{a}))$ in a corresponding private network service requirement indicator, and whether a configuration device overall sub-performance $(G(\overrightarrow{x_{in}})^d C_{max(t_p)\times m}^d)(p,:)^T \cdot \vec{a}$ with the additive performance attribute of the generated configuration information $Y_{out}^d = G(\overrightarrow{x_{in}})^d$ after the dimension reduction is greater than or equal to a sub-indicator $\overrightarrow{x_{in}} \cdot \vec{a}$ in the corresponding private network service requirement indicator, that is, to determine

$(G(\overrightarrow{x_{in}})^d C_{max(t_p)\times m}^d)(p,:)^T / \left|(G(\overrightarrow{x_{in}})^d C_{max(t_p)\times m}^d)(p,:)^T\right| \cdot (\vec{1} - abs(\vec{a})) \geq \overrightarrow{x_{in}} \cdot (\vec{1} - abs(\vec{a}))$, for $\forall p \in (1,2,\cdots,n)$; and $(G(\overrightarrow{x_{in}})^d C_{max(t_p)\times m}^d)(p,:)^T \cdot \vec{a} \geq \overrightarrow{x_{in}} \cdot \vec{a}$, for $\forall p \in (1,2,\cdots,n)$.

[00135]When a single device sub-performance with the additive performance attribute of the generated configuration information after the dimension reduction output by the configuration generative network G is less than a corresponding sub-indicator of the private network service requirement indicator, or the configuration device overall sub-performance with the additive performance attribute of the generated configuration information after the dimension reduction output by the configuration generative network G is less than a corresponding sub-indicator of the private network service requirement indicator, step P26 is implemented; otherwise, step P27 is implemented.

[00136]At the step P26, parameters of the configuration generative network G are updated, and the step P25 is implemented.

[00137] At the step P27, whether the configuration discriminative network D fails to distinguish the generated configuration information $Y_{out}^{d} = G(\overrightarrow{x_{in}})^{d}$ after the dimension reduction from the real sample device configuration information Y_{in}^{d} after the dimension reduction output by the configuration generative network G is determined by inputting them into the configuration discriminative network D.

[00138] In a training process of the configuration generative network G, the parameters of configuration discriminative network D need to remain unchanged, the objective is to make the configuration discriminative network D fail to distinguish the generated configuration information $Y_{out}^{d} = G(\overrightarrow{x_{in}})^{d}$ after the dimension reduction output by the configuration generative network G from the real sample device configuration information Y_{in}^{d} after the dimension reduction when they are input into the configuration discriminative network D. Moreover, the generated configuration information that consumes a lowest resource cost to complete the configuration is selected from the generated configuration information output by the configuration generative network. Therefore, target functions of the configuration generative network are expressed as the following formula (19) and formula (20).

$$\min_{G} L(D, G) = E(\log D(Y_{in}^{d})) + E(\log(1 - D(G(\overrightarrow{x_{in}})^{d}))) \quad (19)$$

$$\min_{G} k = \sum_{l=1}^{3} \left| \phi_{l} G(\overrightarrow{x_{in}}) \overrightarrow{m_{l}} \right| \quad (20)$$

[00139] When the configuration discriminative network D may distinguish the generated configuration information $Y_{out}^{d} = G(\overrightarrow{x_{in}})^{d}$ after the dimension reduction output by the configuration generative network G from the real sample device configuration information Y_{in}^{d} after the dimension reduction, the step P26 is implemented; otherwise, step P28 is implemented.

[00140] At the step P28, the number of training times of the private network configuration model are increased by 1.

[00141] At step P29, whether the number of training times of the private network configuration model reaches N is determined. When the number of training times of the private network configuration model does not reach N, the step P24 is implemented, that is, the parameters of the configuration discriminative network D are updated; otherwise, when the number of training times of the private network configuration model reaches N, the step P210 is implemented.

[00142]The number of training times N of the private network configuration model may be set to 2000, and may be adjusted based on the training result.

[00143]At step P210, the configuration generative network G and the configuration discriminative network D at the step P27 at this time are selected as the private network configuration model.

[00144]At step P30, a type selection and configuration of the private network integrated apparatus based on requirements are obtained by inputting the private network service requirement indicator of the user to be configured into the configuration generative network G obtained at step P27.

[00145]In the embodiments of the present disclosure, a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus are defined; a private network configuration model is obtain by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and private network device configuration information corresponding to a user to be configured is obtained by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model. In this way, in the embodiments of the present disclosure, the private network configuration model is obtained by training based on the improved generative adversarial network algorithm according to the defined private network service requirement indicator and the unit device performance indicator of the procurable device in combination with the historical device configuration information, so that the private network integrated apparatus may be quickly and accurately configured for the needs of private network users according to the private network configuration model, and the configuration efficiency and user experience of the private network integrated apparatus may be improved.

[00146]FIG. 5 is a block diagram of an apparatus for configuring a private network according to an embodiment of the present disclosure. As shown in FIG. 5, the apparatus 400 includes a defining module 401, a modeling module 402, and a configuring module 403.

[00147]The defining module 401 is configured to define a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus. The modeling module 402 is configured to obtain a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator. The configuring module 403 is configured to obtain private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

[00148]The specific operation process of the apparatus for configuring a private network in the embodiments of the present disclosure is the same as the operation process of the above method embodiments, and will not be repeated.

[00149]The apparatus for configuring a private network in the embodiments of the present disclosure defines a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; obtains a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and obtains private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model. In this way, in the embodiments of the present disclosure, the private network configuration model is obtained by training based on the improved generative adversarial network algorithm according to the defined private network service requirement indicator and the unit device performance indicator of the procurable device in combination with the historical device configuration information, so that the private network integrated apparatus may be quickly and accurately configured for the needs of private network users according to the private network configuration model, and the configuration efficiency and user experience of the private network integrated apparatus may be improved.

[00150]FIG. 6 is a block diagram of a device for configuring a private network according to an embodiment of the present disclosure. The embodiments of the present disclosure do not limit the specific implementation of the device for configuring a private network.

[00151]As shown in FIG. 6, the device for configuring a private network includes a processor 502, a communication interface 504, a memory 506, and a communication bus 508.

[00152]The processor 502, the communication interface 504, and the memory 506 communicate with each other via the communication bus 508. The communication interface 504 is configured to communicate with other devices such as clients or a network element of other servers. The processor 502 is configured to execute a program 510, which may specifically perform the related steps of the method for configuring a private network in the above embodiments.

[00153]In some embodiments, the program 510 may include program codes including computer executable instructions.

[00154]The processor 502 may be a central processing unit (CPU), an application specific integrated circuit (ASIC), or one or more integrated circuits configured to implement the embodiments of the present disclosure. One or more processors included in the device for configuring a private network may be the same type of processors, such as one or more CPUs; or may be different types of processors, such as one or more CPUs and one or more ASICs.

[00155]The memory 506 is configured to store the program 510. The memory 506 may include a high-speed random access memory (RAM), or it may also include a non-volatile memory, such as at least one disk memory.

[00156]The program 510 may be configured to cause the processor 502 to perform the following operations: defining a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; obtaining a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and obtaining private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

[00157]The specific operation process of the device for configuring a private network in the embodiments of the present disclosure is the same as the operation process of the above method embodiments, and will not be repeated.

[00158]The device for configuring a private network provided in the embodiments of the present disclosure defines a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; obtains a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and obtains private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model. In this way, in the embodiments of the present disclosure, the private network configuration model is obtained by training based on the improved generative adversarial network algorithm according to the defined private network service requirement indicator and the unit device performance indicator of the procurable device in combination with the historical device configuration information, so that the private network integrated apparatus may be quickly and accurately configured for the needs of private network users according to the private network configuration model, and the configuration efficiency and user experience of the private network integrated apparatus may be improved.

[00159]The embodiments of the present disclosure provide a computer-readable storage medium for storing at least one executable instruction. When the at least one executable instruction is running on the device for configuring a private network, the device for configuring a private network is caused to implement the method for configuring a private network of any one of the above method embodiments.

[00160]The executable instruction is specifically configured to enable the device for configuring a private network to perform the following operations: defining a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; obtaining a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and obtaining private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

[00161]The specific operation process of the executable instruction stored in the computer storage medium in the embodiments of the present disclosure is the same as the operation process of the above method embodiments, and will not be repeated.

[00162]The executable instruction stored in the computer storage medium in the embodiments of the present disclosure is configured to cause the device for configuring a private network to perform the following operations: defining a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus; obtaining a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and obtaining private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model. In this way, in the embodiments of the present disclosure, the private network configuration model is obtained by training based on the improved generative adversarial network algorithm according to the defined private network service requirement indicator and the unit device performance indicator of the procurable device in combination with the historical device configuration information, so that the private network integrated apparatus may be quickly and accurately configured for the needs of private network users according to the private network configuration model, and the configuration efficiency and user experience of the private network integrated apparatus may be improved.

[00163]The embodiments of the present disclosure provide an apparatus for configuring a private network for implementing the above method for configuring a private network.

[00164]The embodiments of the present disclosure provide a computer program. When the computer program is called by a processor, the device for configuring a private network is caused to implement the method for configuring a private network of any one of the above method embodiments.

[00165]The embodiments of the present disclosure provide a computer program product including a computer program stored on a computer-readable storage medium, in which the computer program includes program instructions. When the program instructions are running on a computer, the computer is caused to implement the method for configuring a private network of any one of the above method embodiments.

[00166]Algorithms or displays provided herein are not inherently associated with any particular computer, any virtual system, or other device. Various general systems may also be used in conjunction with the teachings herein. From the above descriptions, a structure required to construct such a system is obvious. In addition, the embodiments of the present disclosure are not specific to any particular programming language. It should be understood that content of the disclosure described herein may be implemented in a variety of programming languages, and the above descriptions for specific languages are intended to disclose the preferred implementation of the disclosure.

[00167]A lot of details are given in the description provided herein. However, it should be understood that the embodiments of the present disclosure may be practiced without these specific details. In some examples, well-known methods, structures and techniques are not shown in detail so as not to obscure the understanding of the disclosure.

[00168]Similarly, it should be understood that, in the above description of exemplary embodiments of the present disclosure, various features in the embodiments of the present disclosure are sometimes grouped together into a single embodiment, drawing, or description thereof, in order to streamline the disclosure and to assist in understanding one or more of various aspects of the disclosure. However, the disclosed method should not be interpreted as reflecting the intention that the claims in the disclosure that need to be protected have more features than features described in each claim.

[00169]It may be understood by those skilled in the art that modules in the apparatus in the embodiment may be adaptively altered and be set in one or more apparatuses different from that in the present embodiment. Modules or units or components in the embodiment may be combined into a single module or unit or component, and they may also be divided into more submodules or subunits or subcomponents. Except that at least some of such features and/or processes or units are mutually exclusive, all features disclosed in the disclosure (including accompanying claims, abstract and accompanying drawings) and all processes or units of any method or device disclosed herein may be combined in any combination. Unless explicitly stated otherwise, each feature disclosed in the disclosure (including accompanying claims, abstract, and accompanying drawings) may be replaced by an alternative feature providing the same, equivalent, or similar objective.

[00170]It should be noted that the above embodiments are just explanatory rather than to limit the present disclosure, and that those skilled in the art may design alternative embodiments without departing from the scope of the attached claims. In the claims, any reference numerals located in parentheses should not be constructed as a limitation of the claims. The word “comprise/include” does not exclude the existence of an element or a step not listed in the claims. The word “a/an” or “one” before a component does not exclude the existence of a plurality of such components. The disclosure may be implemented by means of hardware including a number of different components and by means of a properly programmed computer. In the claims that lists units of several apparatuses, several of these apparatuses may be embodied by a same hardware item. The use of the words first, second, and third does not indicate any sequence. These words may be interpreted as names. The steps in the above embodiments shall not be construed as a limitation of the execution sequence unless otherwise specified.

CLAIMS

1. A method for configuring a private network, comprising:

defining a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus;

obtaining a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and

obtaining private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

2. The method of claim 1, wherein the private network configuration model comprises a configuration generative network and a configuration discriminative network, wherein the private network configuration model takes generated configuration information satisfying a sample private network service requirement indicator and a resource consumption cost corresponding to the generated configuration information as constraint conditions in a training process, the generated configuration information is an output of the configuration generative network for the private network service requirement indicator, and the sample private network service requirement indicator corresponds to sample device configuration information; and the configuration discriminative network is determined based on a discriminant result between the generated configuration information and corresponding sample device configuration information.

3. The method of claim 2, wherein obtaining the private network configuration model by modeling based on the improved generative adversarial network algorithm according to the obtained private network service requirement indicator and the device configuration information corresponding to the private network service requirement indicator comprises:

obtaining a configuration device performance indicator corresponding to the generated configuration information by converting the generated configuration information according to the unit device performance indicator, wherein the generated configuration information corresponds to at least one procurable device, and the unit device performance indicator is configured to represent a private network service capacity that each procurable device is capable to provide;

obtaining a satisfaction situation that the generated configuration information satisfies the sample private network service requirement indicator by comparing the private network service requirement indicator and the configuration device performance indicator; and

determining the resource consumption cost corresponding to the generated configuration information.

4. The method of claim 3, wherein obtaining the satisfaction situation that the generated configuration information satisfies the sample private network service requirement indicator by comparing the private network service requirement indicator and the configuration device performance indicator comprises:

determining a non-additive performance attribute corresponding to the private network service requirement indicator, wherein the non-additive performance attribute is configured to represent whether the private network service requirement indicator fails being satisfied by an additive configuration of a plurality of procurable devices;

in response to determining that there is a corresponding non-additive performance attribute in the private network service requirement indicator, obtaining a configuration device performance indicator with the non-additive performance attribute corresponding to the generated configuration information according to the non-additive performance attribute and the configuration device performance indicator corresponding to the generated configuration information, and comparing the configuration device performance indicator with the non-additive performance attribute and the sample private network service requirement indicator with the non-additive performance attribute; and

in response to determining that there is no corresponding non-additive performance attribute in the private network service requirement indicator, determining an additive performance attribute according to the non-additive performance attribute, obtaining a configuration device performance indicator with the additive performance attribute corresponding to the generated configuration information based on the additive performance attribute and the configuration device performance indicator corresponding to the generated configuration information, and comparing the configuration device performance indicator with the additive performance attribute and the sample private network service requirement indicator with the additive performance attribute.

5. The method of claim 3, wherein obtaining the private network configuration model by modeling based on the improved generative adversarial network algorithm according to the obtained private network service requirement indicator and the device configuration information corresponding to the private network service requirement indicator comprises:

determining a resource consumption cost for each procurable device corresponding to the generated configuration information in a computing dimension of a preset unit device consumption cost, wherein the computing dimension of the preset unit device consumption cost comprises at least one of a unit device price, a unit device space occupation, or a unit device power consumption; and

obtaining the resource consumption cost by performing weighted summation on the unit device consumption cost corresponding to each procurable device corresponding to the generated configuration information.

6. The method of claim 5, wherein after obtaining the resource consumption cost by performing weighted summation on the unit device consumption costs corresponding to all the procurable devices corresponding to the generated configuration information, the method comprises:

determining a generated configuration information change corresponding to the sample private network service requirement indicator according to requirement change information corresponding to the sample private network service requirement indicator and the configuration generative network;

determining a configuration discriminant result information change between the generated configuration information from the configuration generative network and the corresponding sample device configuration information according to the configuration discriminative network; and

updating according to the requirement change information corresponding to the sample private network service requirement indicator, the generated configuration information change, the configuration discriminant result information change, and the resource consumption cost corresponding to the generated configuration information.

7. The method of claim 5, wherein the private network configuration model further comprises a capacity expansion-based private network configuration model, wherein the capacity expansion-based private network configuration model takes the generated configuration information satisfying the sample private network service requirement indicator and a resource consumption cost based on capacity expansion as constraint conditions in the training process; wherein the resource consumption cost based on the capacity expansion is determined according to the resource consumption cost and a predicted resource consumption cost.

8. An apparatus for configuring a private network, comprising:

a defining module, configured to define a private network service requirement indicator and a unit device performance indicator of a procurable device corresponding to a private network integrated apparatus;

a modeling module, configured to obtain a private network configuration model by modeling based on an improved generative adversarial network algorithm according to an obtained private network service requirement indicator and device configuration information corresponding to the private network service requirement indicator; and

a configuring module, configured to obtain private network device configuration information corresponding to a user to be configured by inputting a private network service requirement indicator of the user to be configured into a trained private network configuration model.

9. A device for configuring a private network, comprising a processor, a memory, a communication interface, and a communication bus, wherein the processor, the memory and the communication interface communicate with each other via the communication bus, and the memory is configured to store at least one executable instruction to cause the processor to perform the operation of the method for configuring a private network of any one of claims 1 to 7.

10. A computer-readable storage medium for storing at least one executable instruction, wherein when the at least one executable instruction is running on a device for configuring a private network, the device for configuring a private network is caused to perform the operation of the method for configuring a private network of any one of claims 1 to 7.