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(54) **LIFECYCLE MANAGEMENT FOR INFORMATION TECHNOLOGY INFRASTRUCTURE**

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(60) Provisional application No. 62/776,433, filed on Dec. 6, 2018, provisional application No. 62/766,434, filed on Oct. 18, 2018.

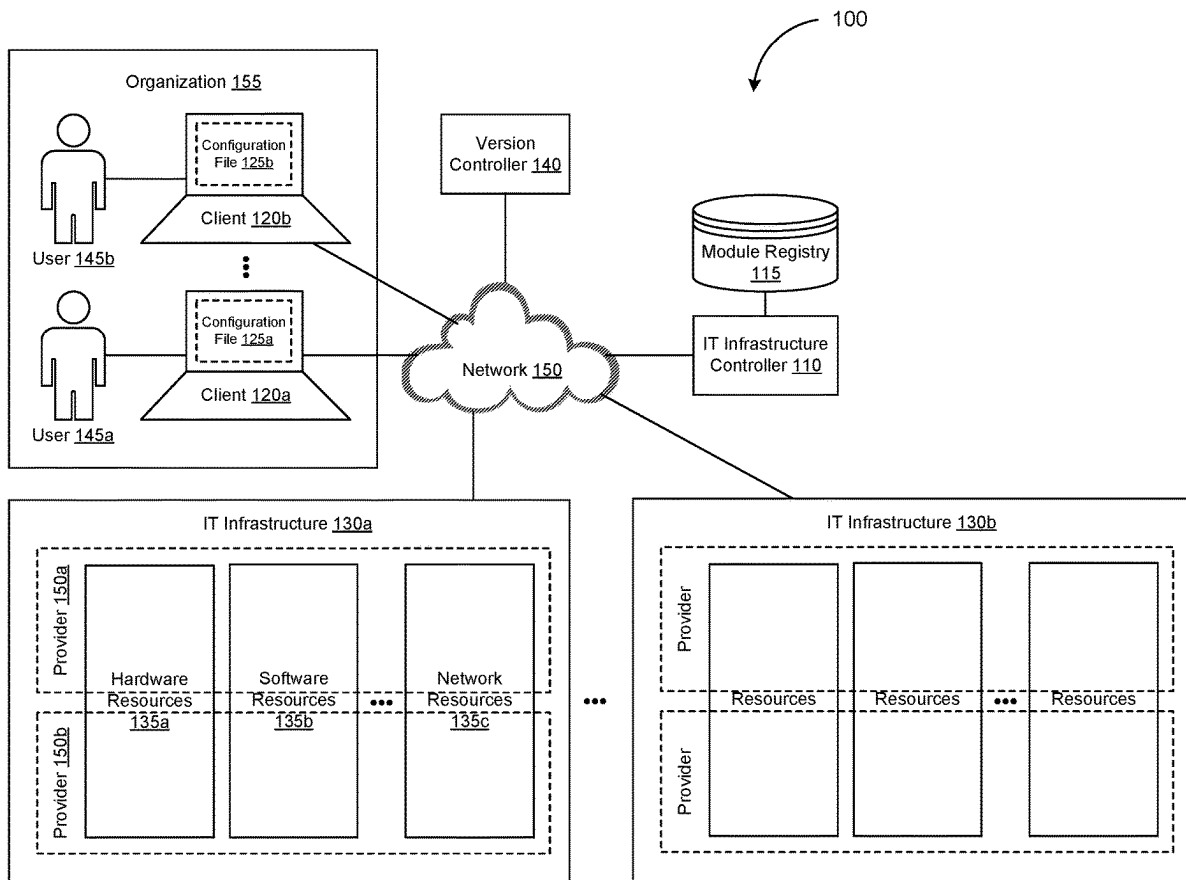
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CPC **G06F 9/44505** (2013.01); **G06F 9/4406** (2013.01)

(57) **ABSTRACT**

A method for managing an information technology infrastructure is provided. The method may include generating a workspace configured to maintain configurations for the information technology infrastructure. A configuration file specifying configurations to apply to the information technology infrastructure may be merged into the workspace. An execution plan may be generated based on the workspace. The execution plan may include operations to apply, to the information technology infrastructure, the configurations specified in the configuration file. The configurations may be applied, based on the execution plan, by at least provisioning, modifying, and/or de-provisioning one or more resources at the information technology infrastructure. Related systems and articles of manufacture, including computer program products, are also provided.



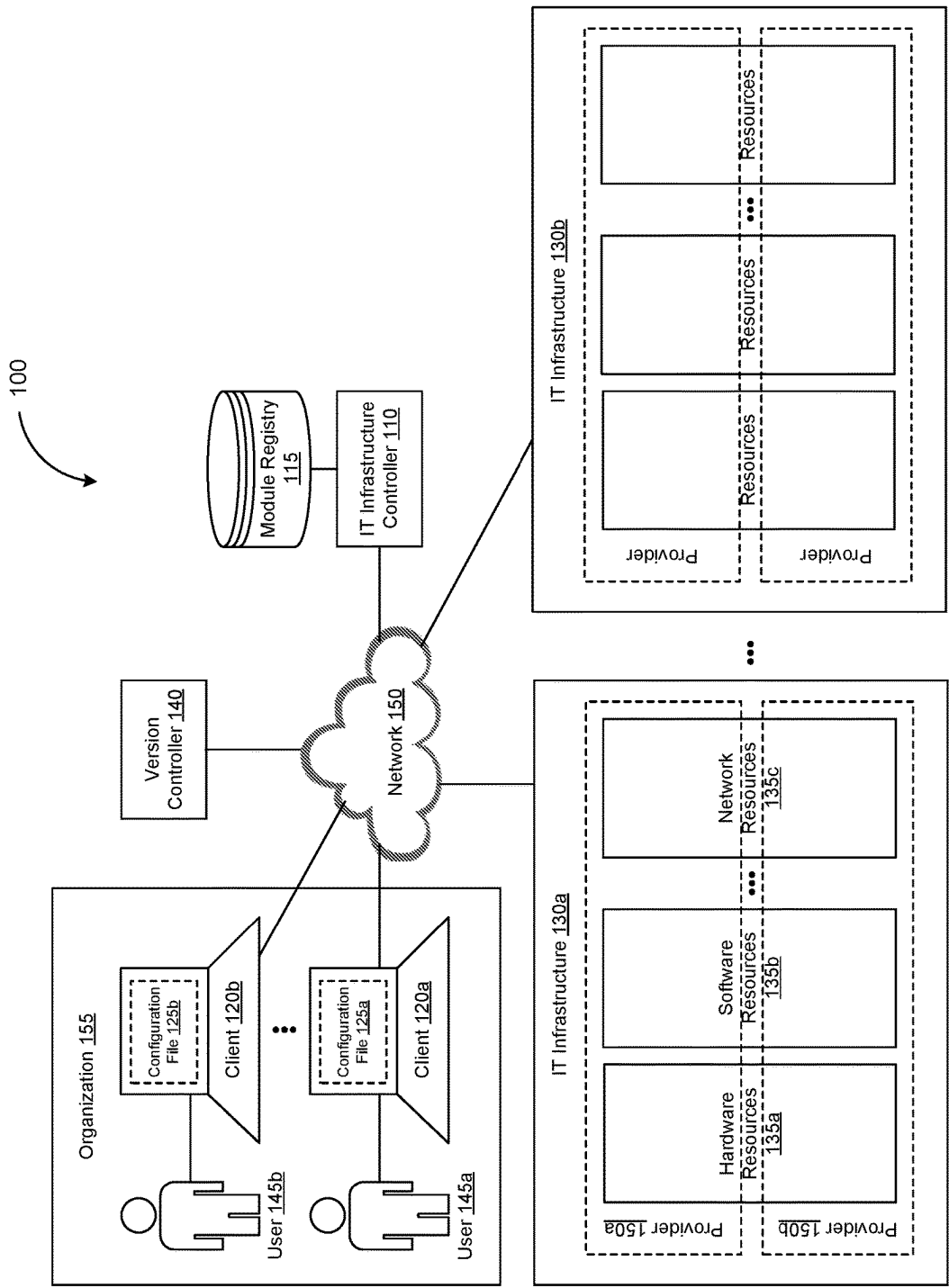


FIG. 1A

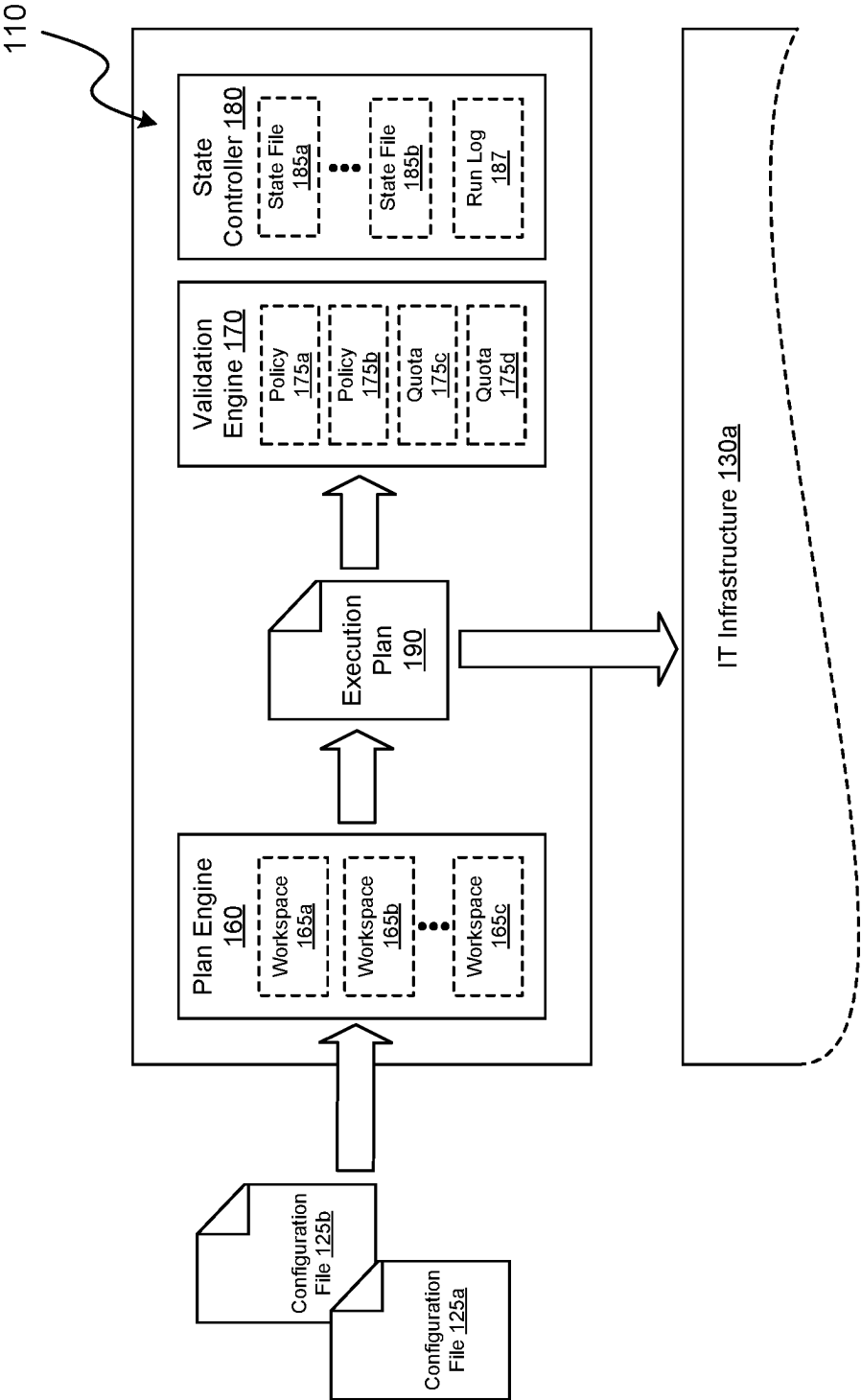


FIG. 1B

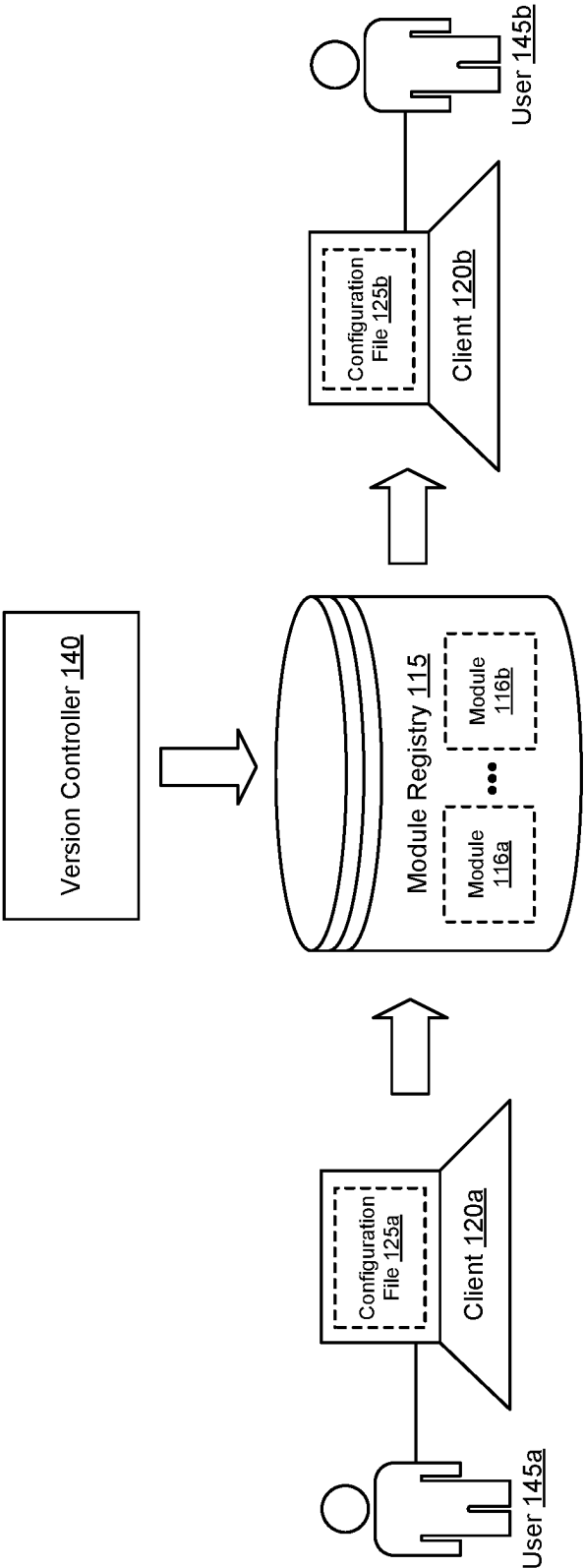


FIG. 1C

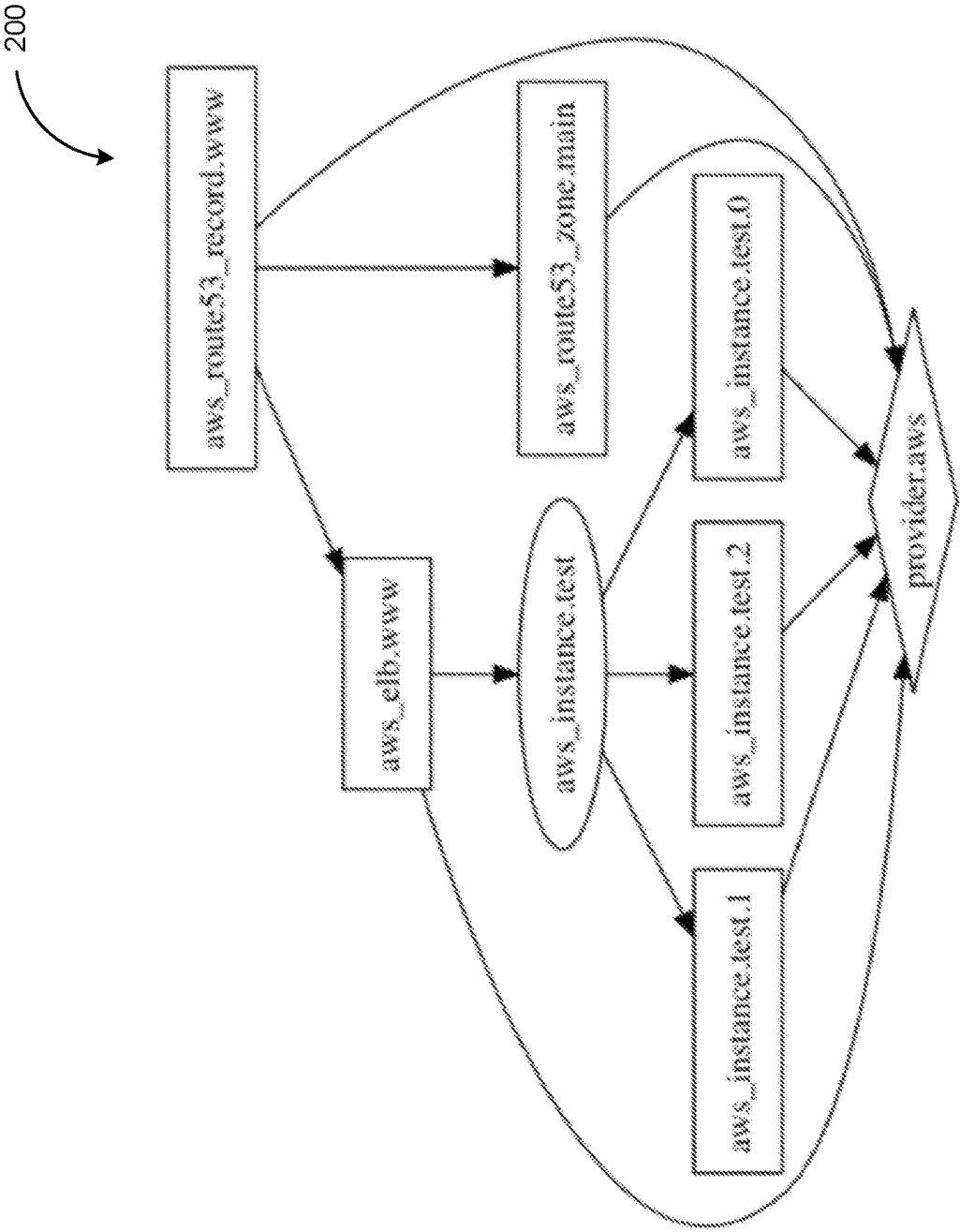


FIG. 2

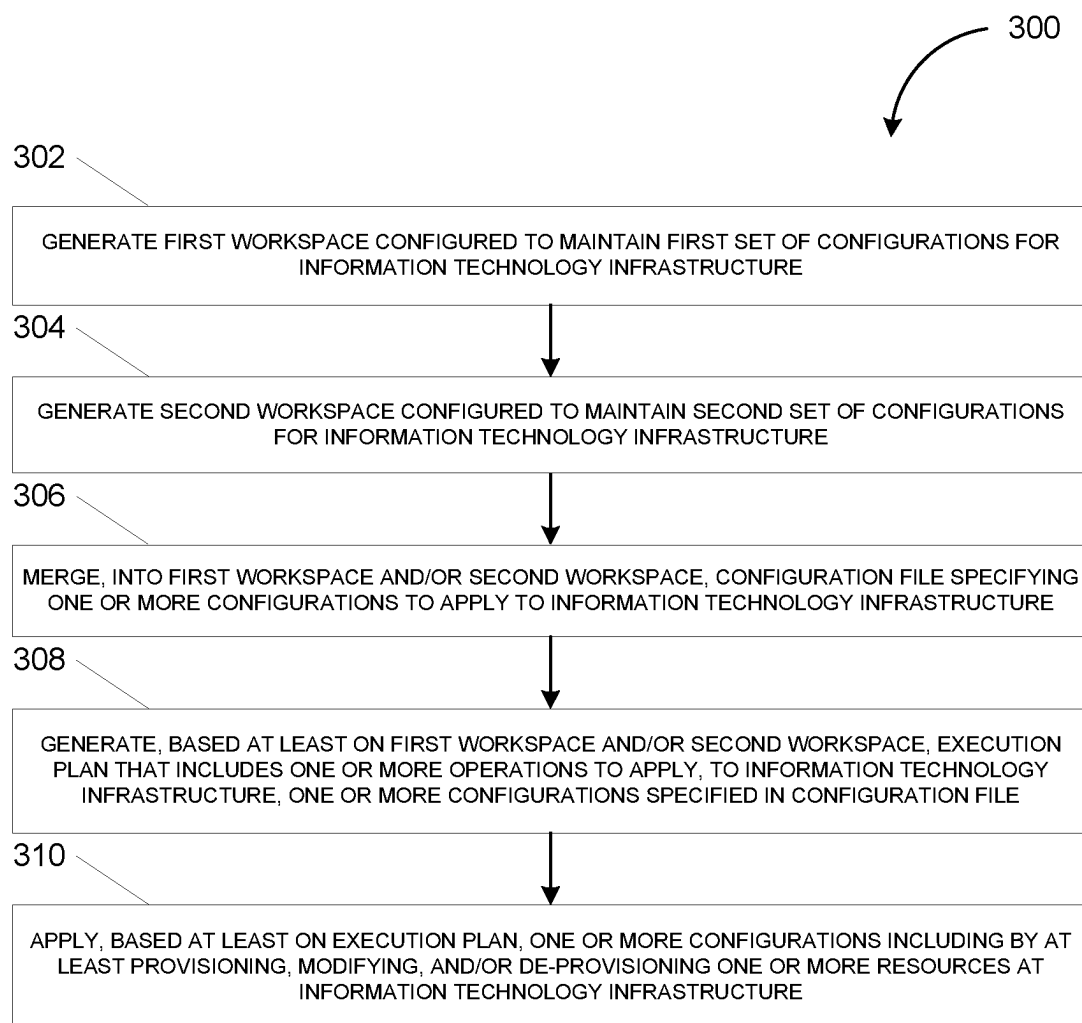


FIG. 3A

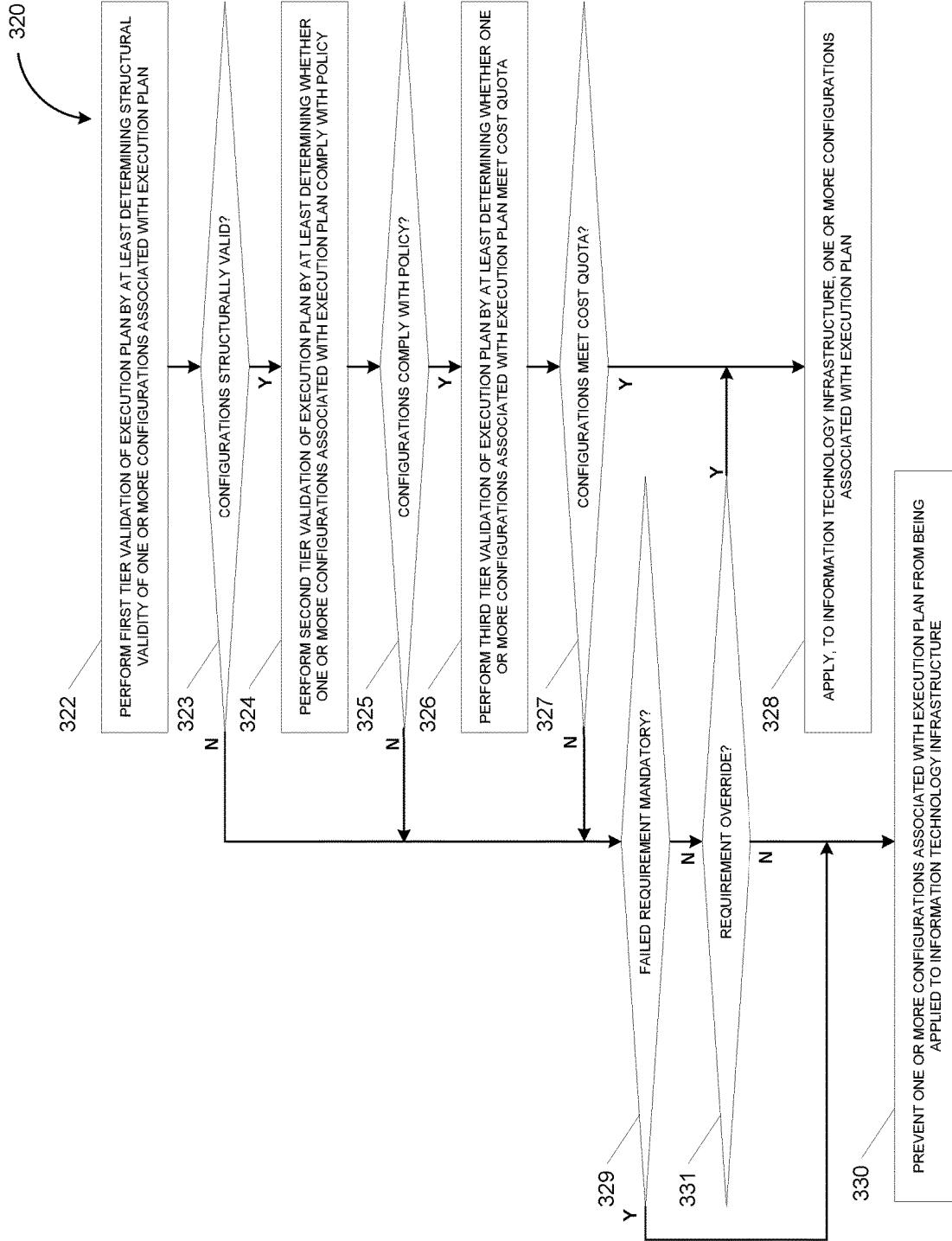


FIG. 3B

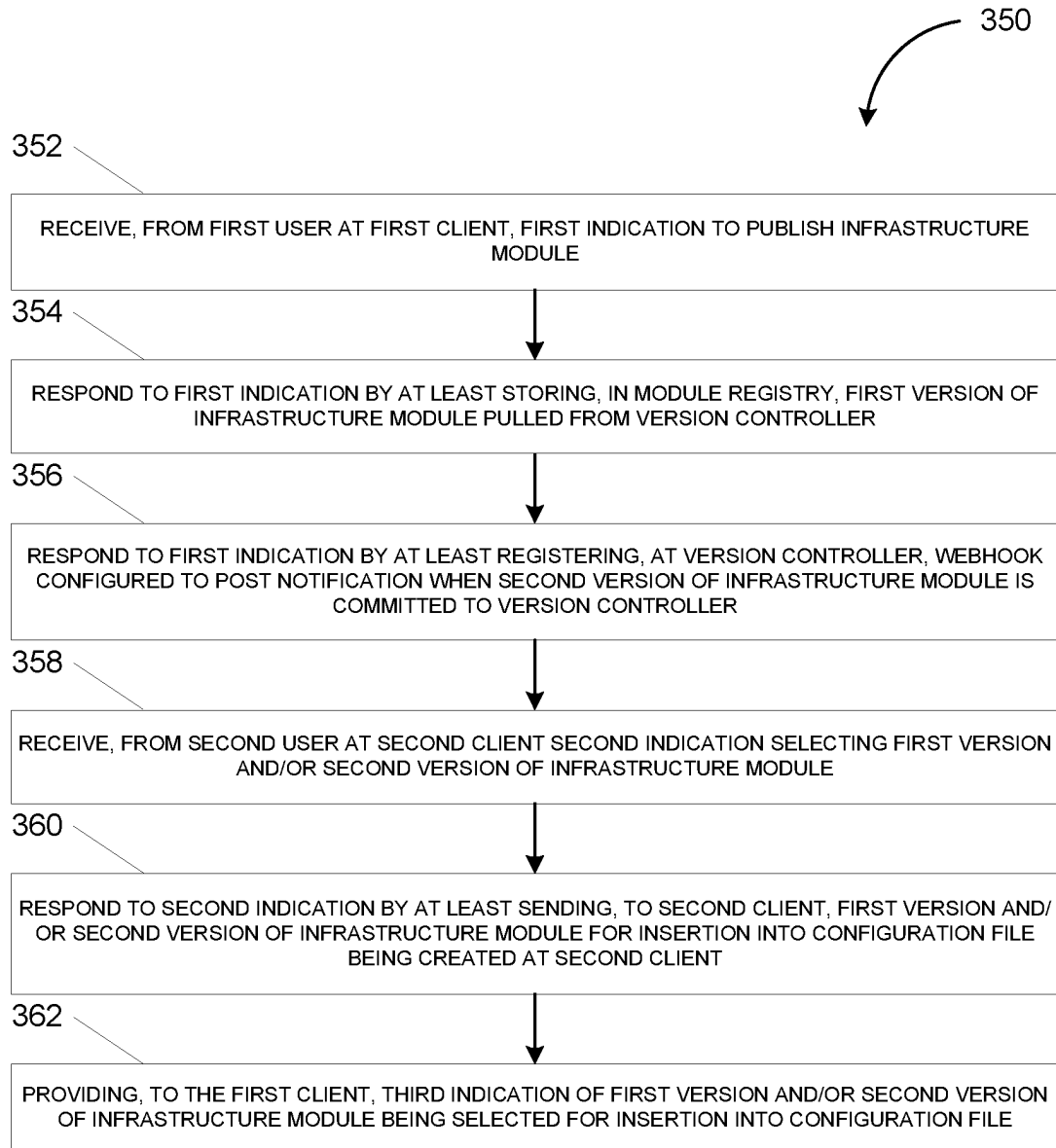


FIG. 3C

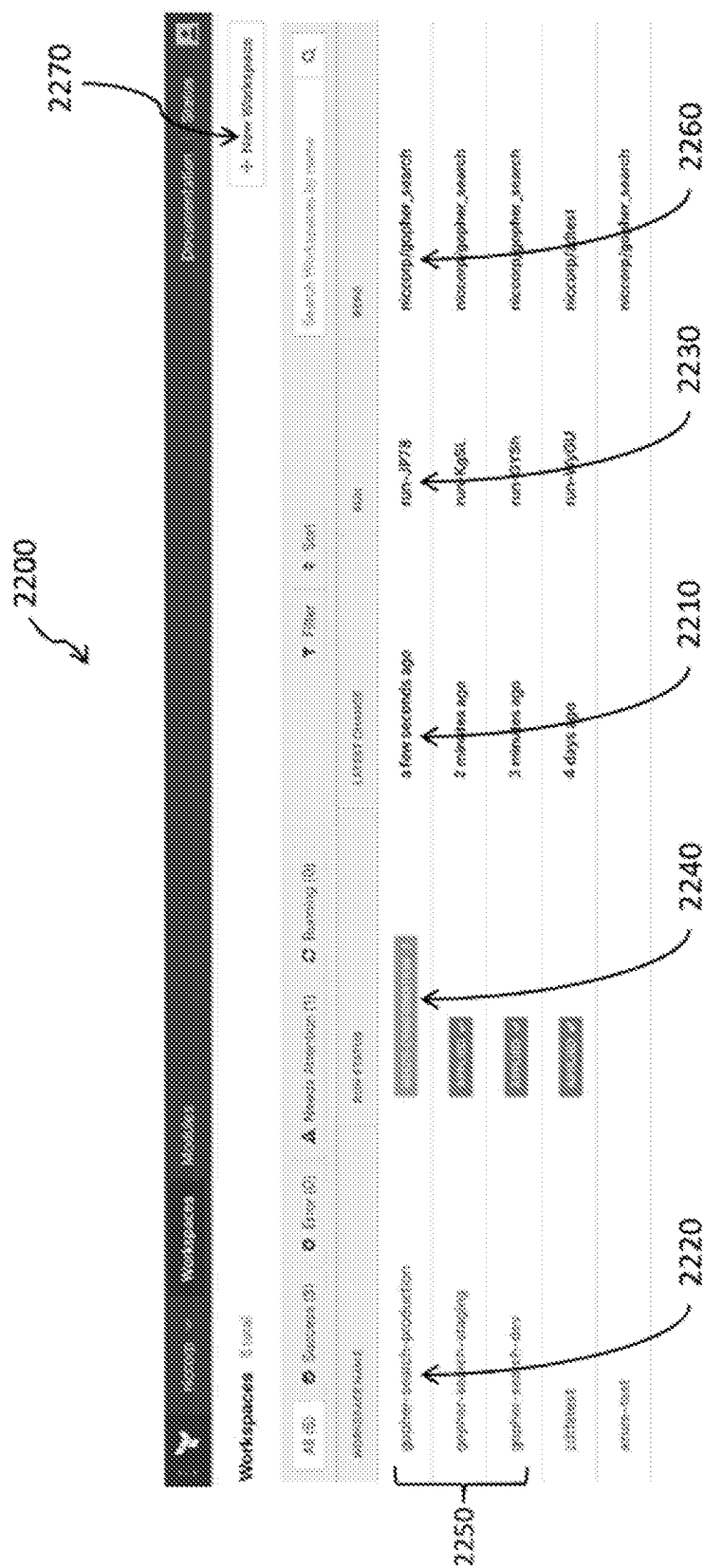


FIG. 4A

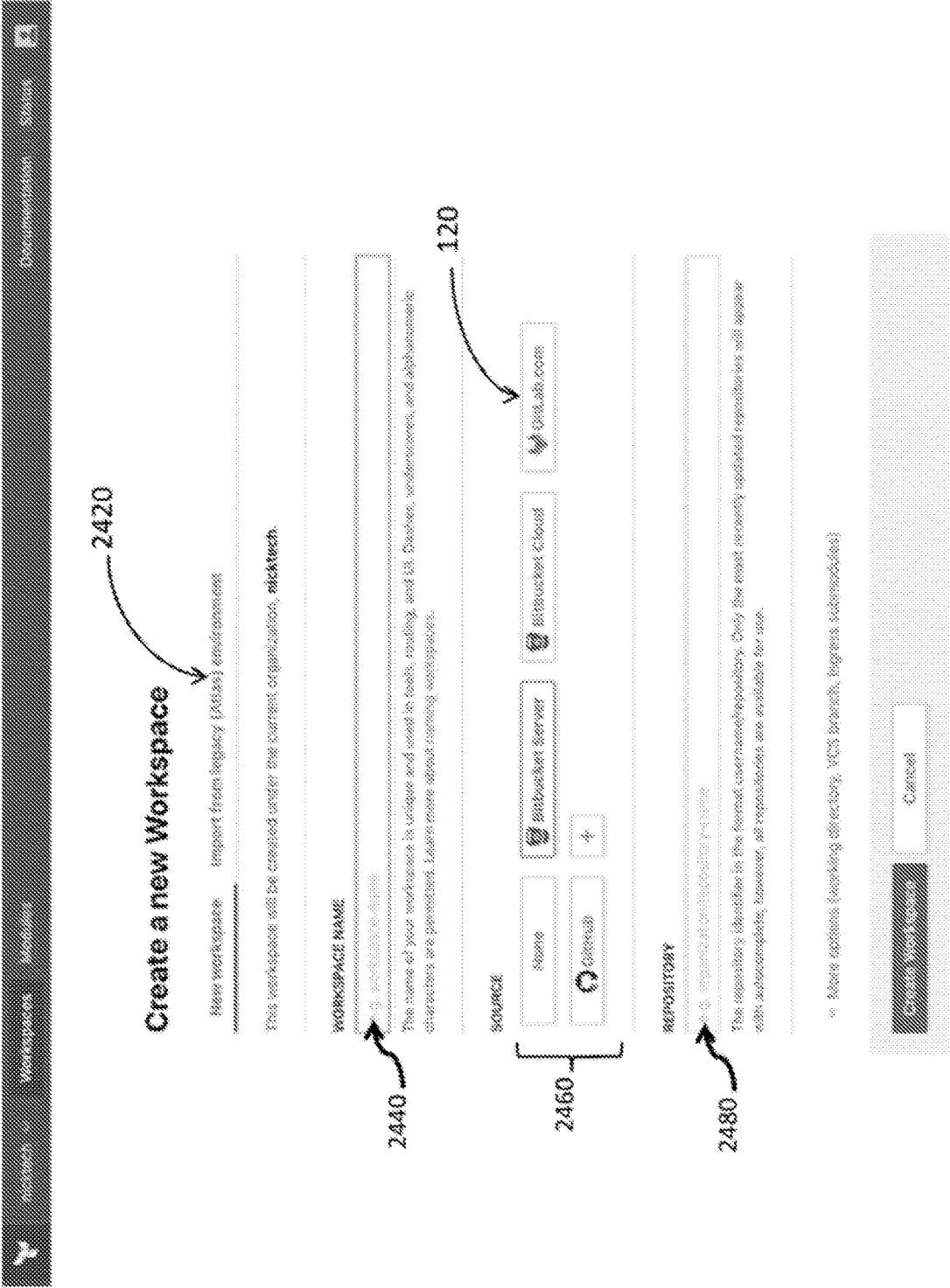


FIG. 4B



FIG. 4C

2620

TERRAFORM WORKING DIRECTORY

The directory that Terraform will execute within. This defaults to the root of your repository and is typically set to a subdirectory matching the environment when multiple environments exist within the same repository.

2640

VCS BRANCH

default branch

The branch from which to import new versions. This defaults to the value your version control provides as the default branch for this repository.

2660

☐ Include submodules on clone

Checking this box will perform a recursive clone of your repository's submodules, making them available in the resulting slug containing your Terraform configuration.

Create Workspace

Cancel

FIG. 4D

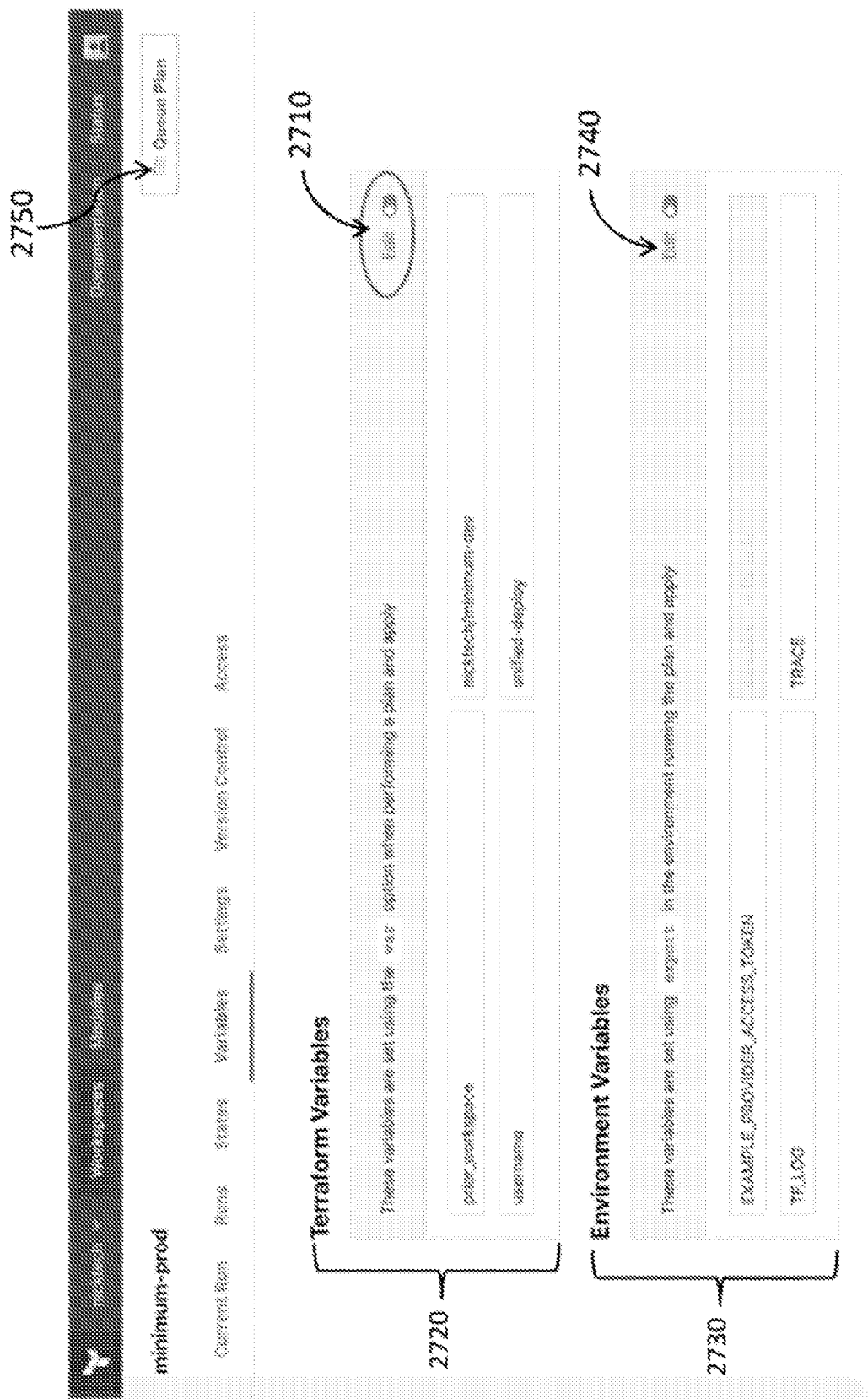


FIG. 4E

Terraform Variables

These variables are set using the `var` option when performing a plan and apply

Variable Name	Value	Variable Type	Variable Category
<code>prior_workspace</code>	<code>nicktech/minimum-dev</code>	String	Environment
<code>username</code>	This is a multi-line variable	String	Environment
<code>key</code>	<code>value</code>	String	Environment

Buttons: Save & Plan (2870), Save (2880), Cancel (2860), Add (2830)

Status: Editing (2810)

Note: These variables are set using the `var` option when performing a plan and apply (2820)

FIG. 4F

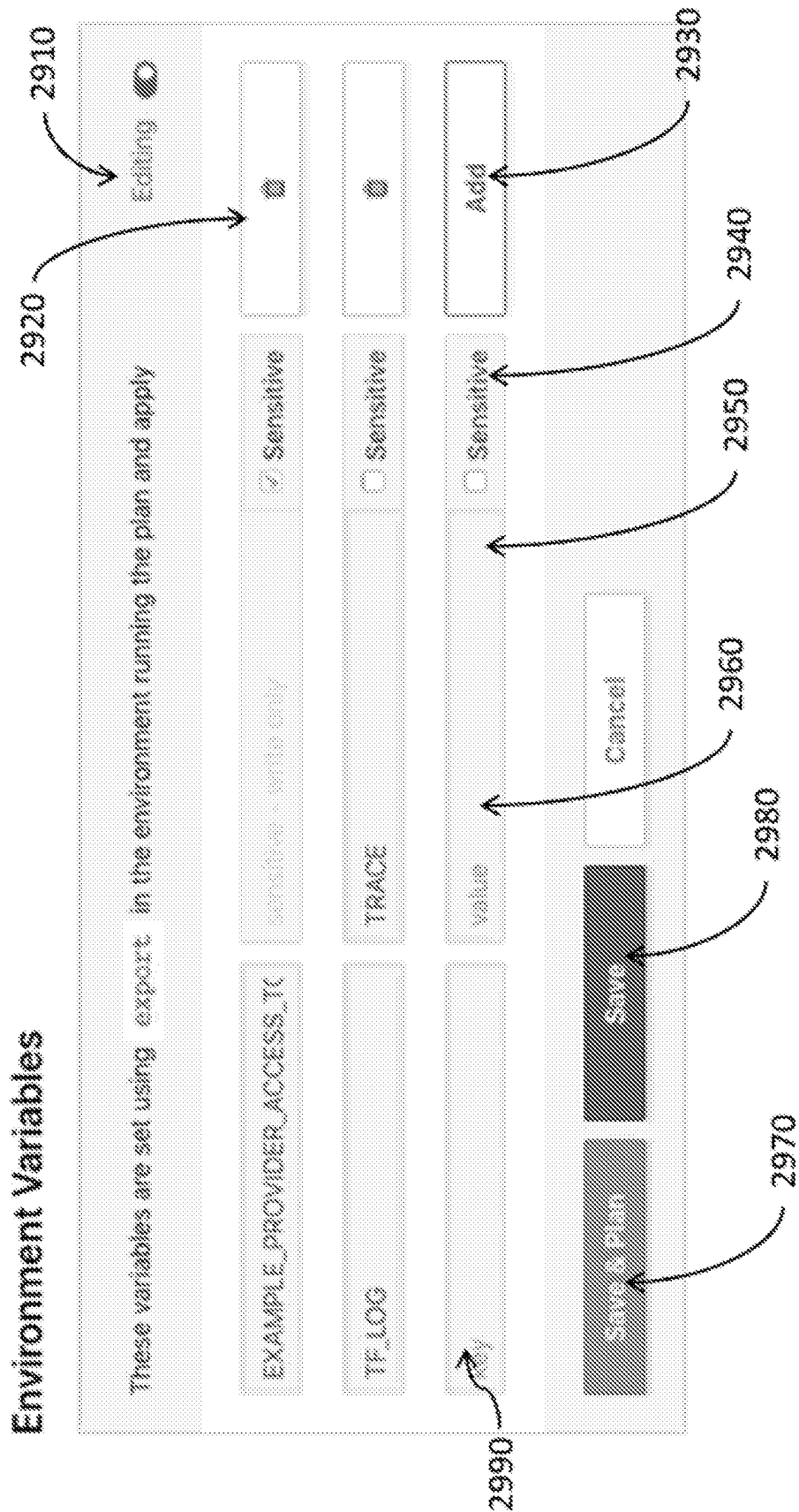


FIG. 4G

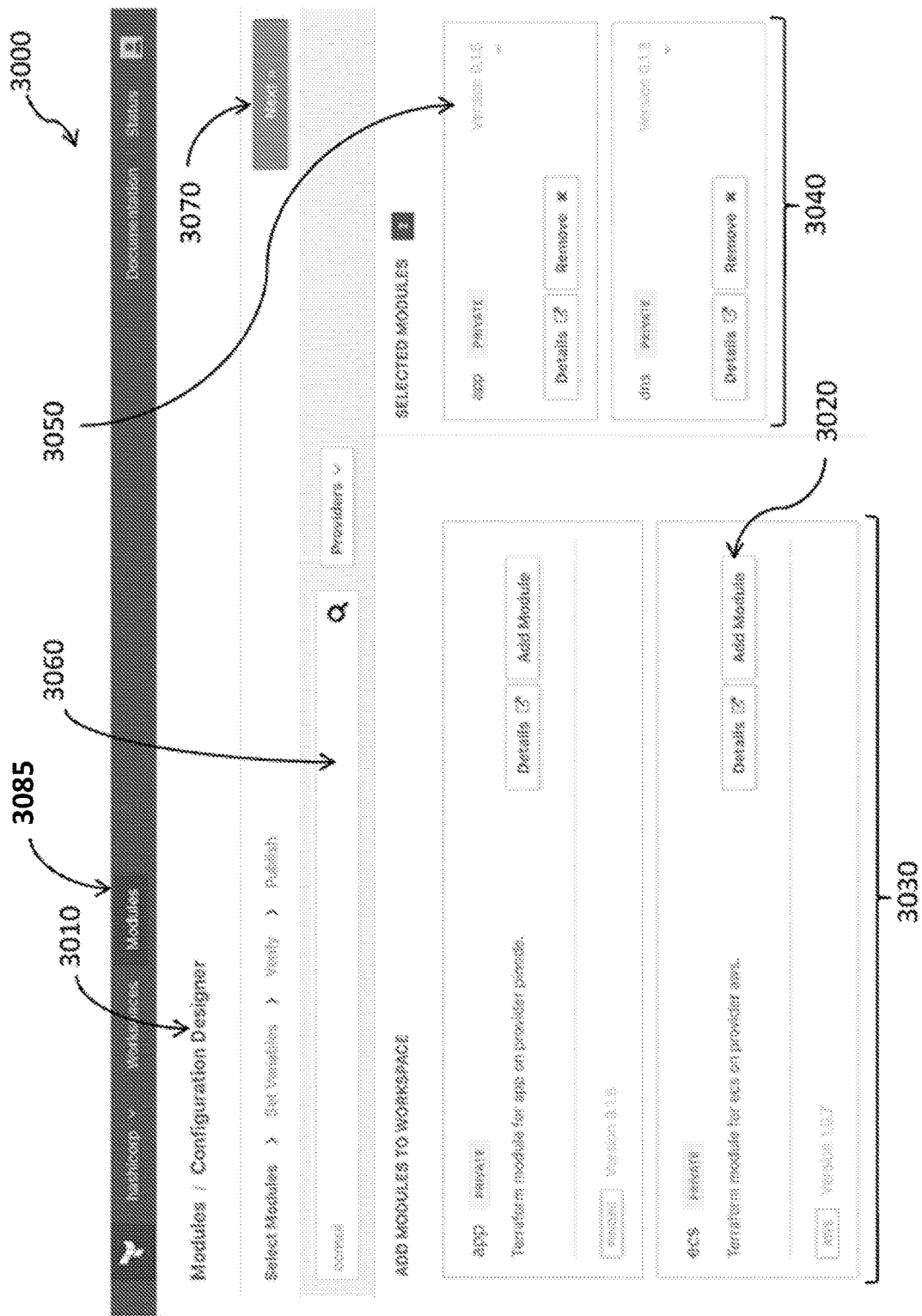


FIG. 4H

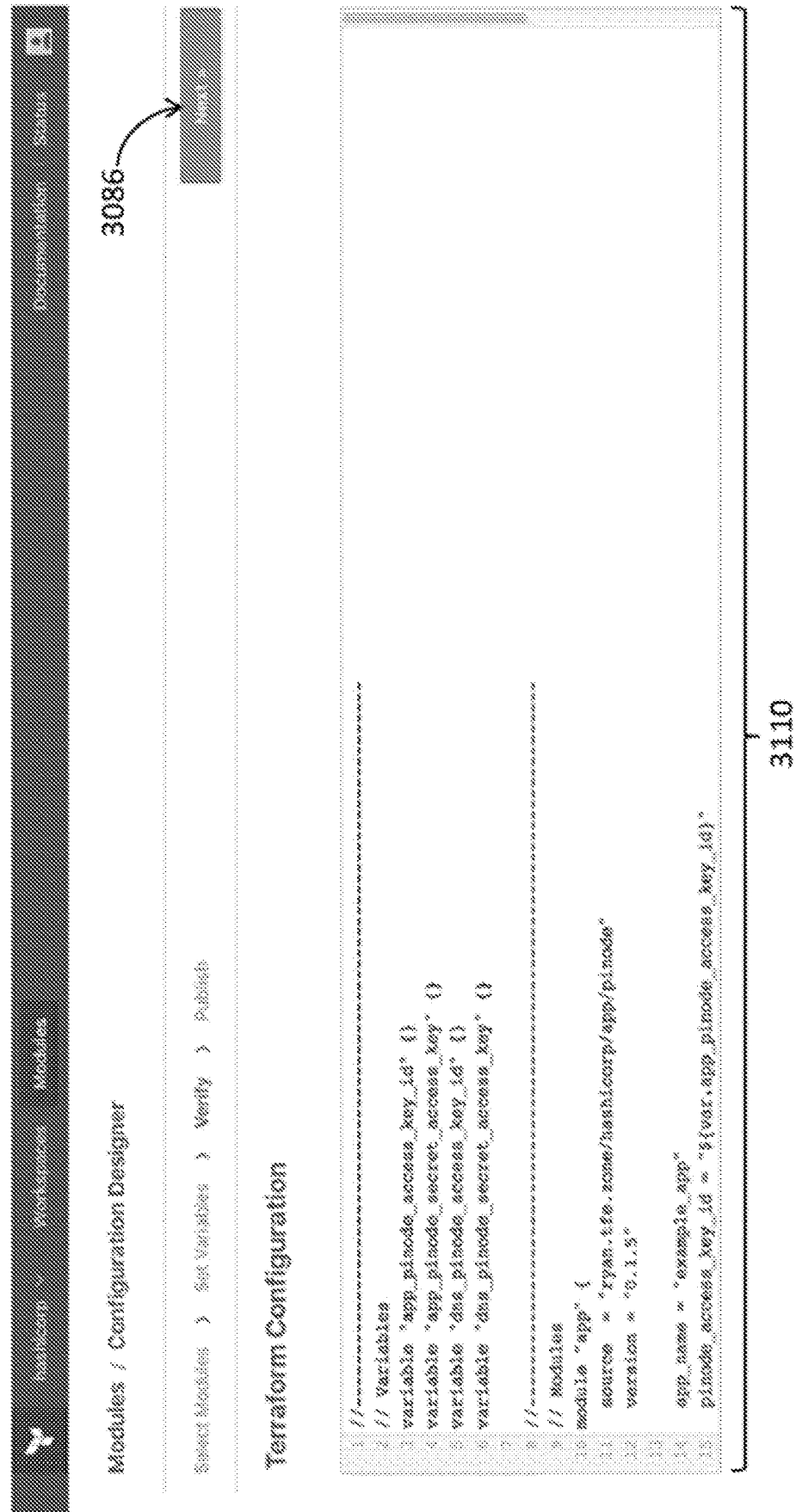


FIG. 4I

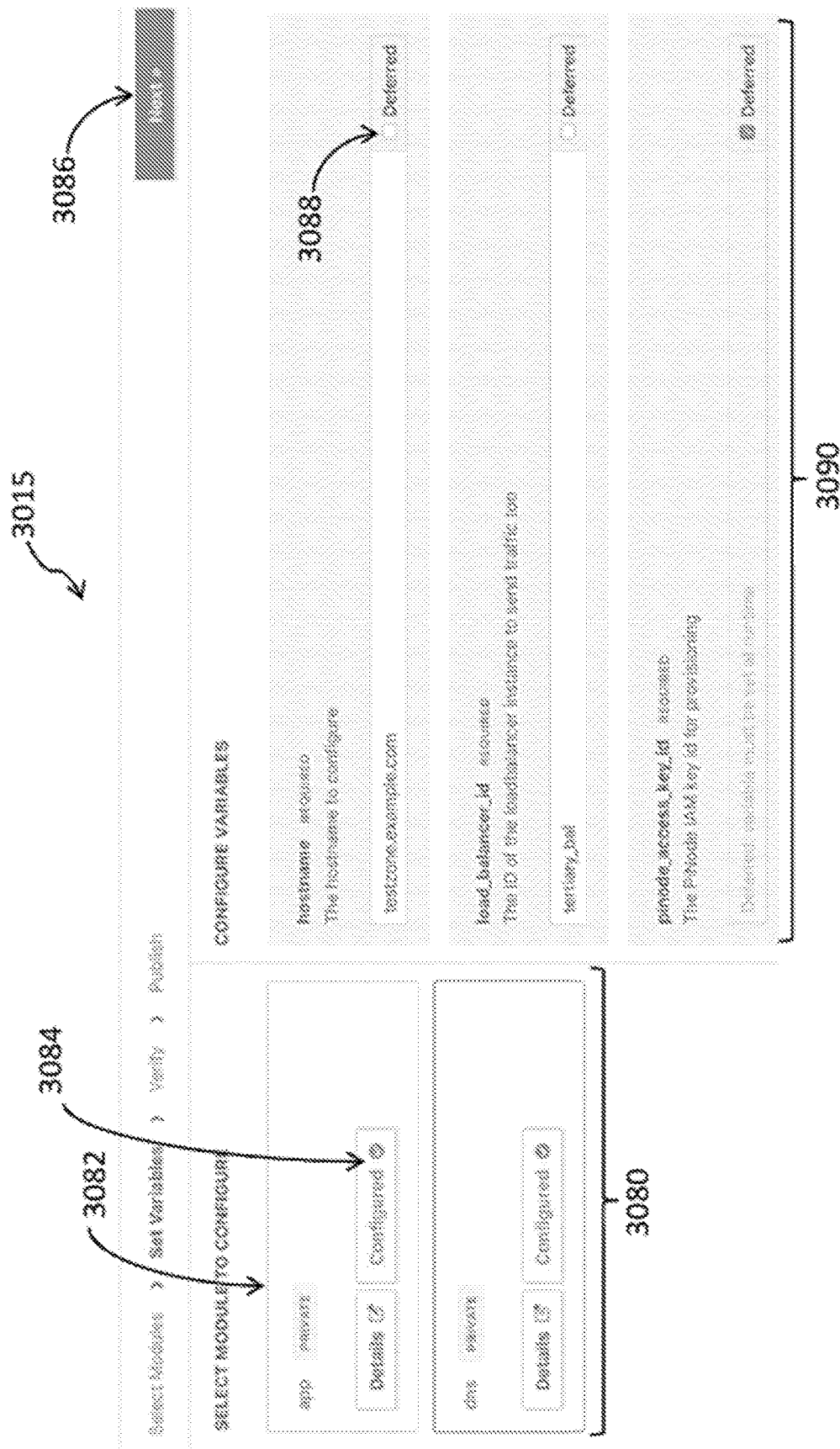


FIG. 4J

Settings

Auto apply

Automatically apply changes when a Terraform plan is successful. Plans that have no changes will not be applied. If this workspace is linked to version control, a push to the default branch of the linked repository will trigger a plan and apply.

Manual apply

Require an operator to confirm the result of the Terraform plan before applying. If this workspace is linked to version control, a push to the default branch of the linked repository will only trigger a plan and then wait for confirmation.

TERRAFORM VERSION

0.11.7

▼

The version of Terraform to use for this workspace. Upon creating this workspace, the latest version was selected and will be used until it is changed manually. It will not upgrade automatically.

Save settings

3340

FIG. 4K

SSH Key

Optionally choose a private SSH key for downloading Terraform modules from Git-based module sources. This key is not used for cloning the workspace VCS repository or for provisioner connections. (More info.)

Manage SSH keys for the nicorp organization.

SSH KEY

(No SSH key)

Update SSH key

3470

3410

Workspace Lock

This workspace is not currently locked. All operations can proceed normally. You can manually lock this workspace to prevent Terraform plans and applies.

Lock nicorp/azure-test

3430

FIG. 4L

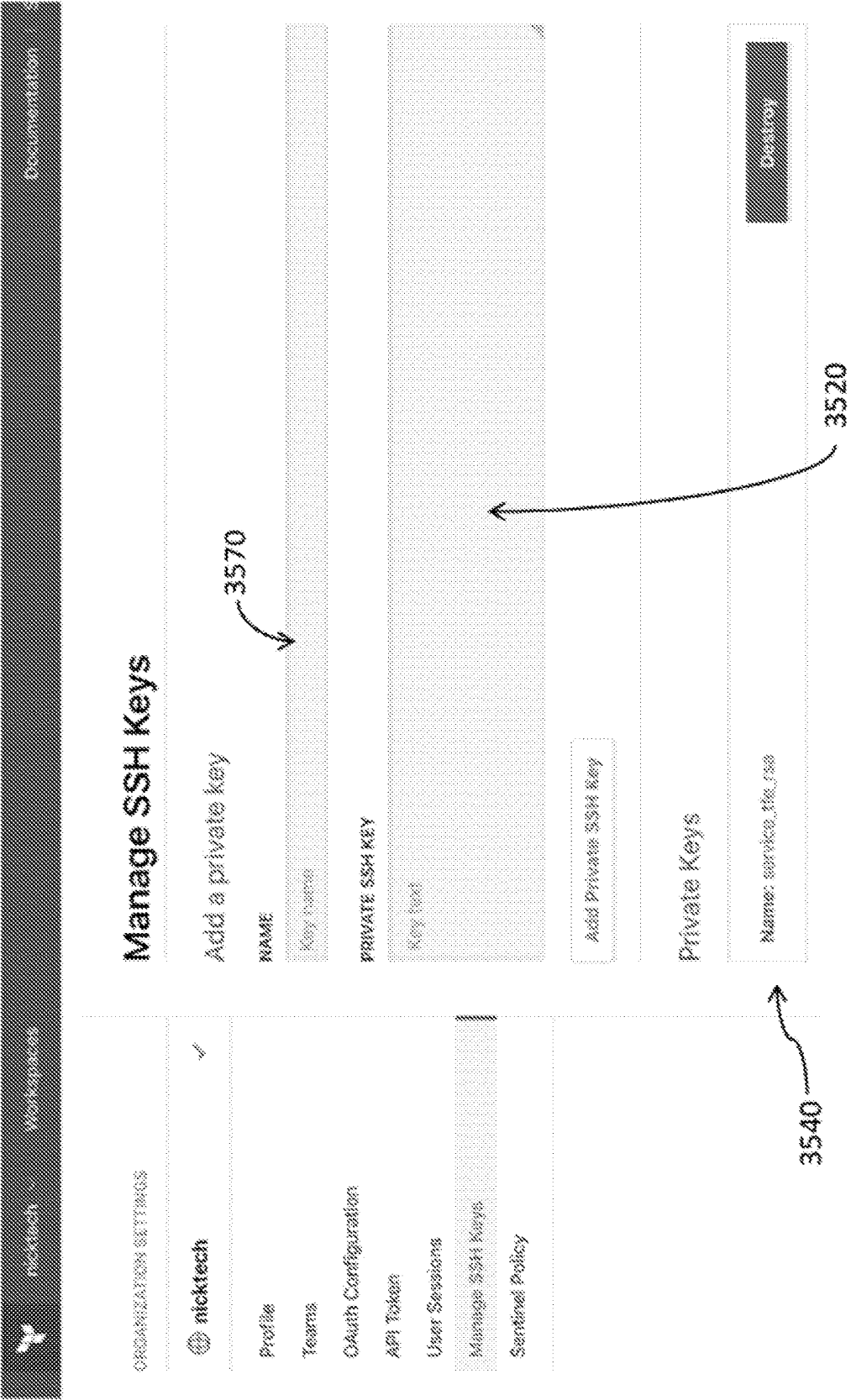


FIG. 4M

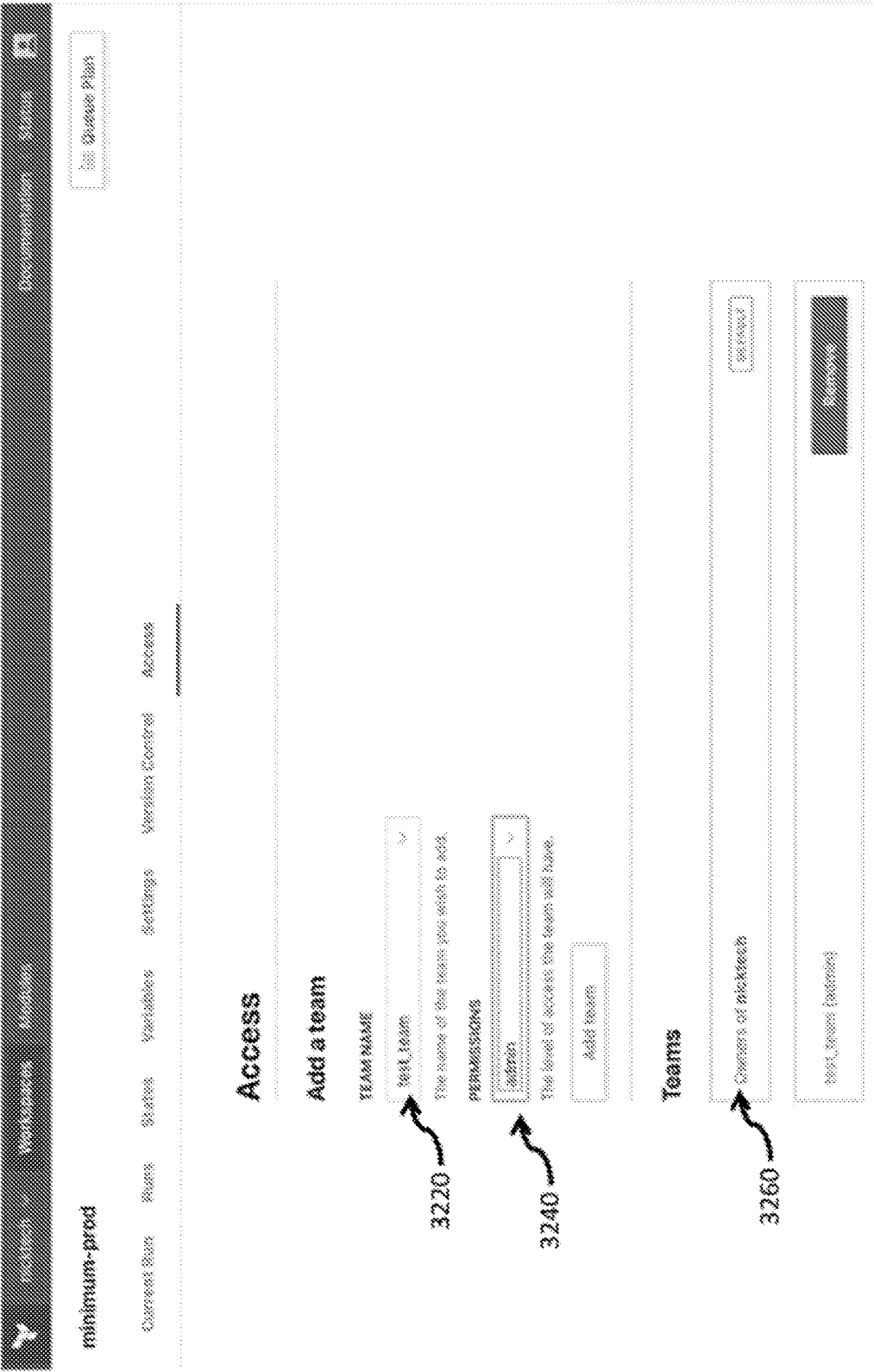


FIG. 4N

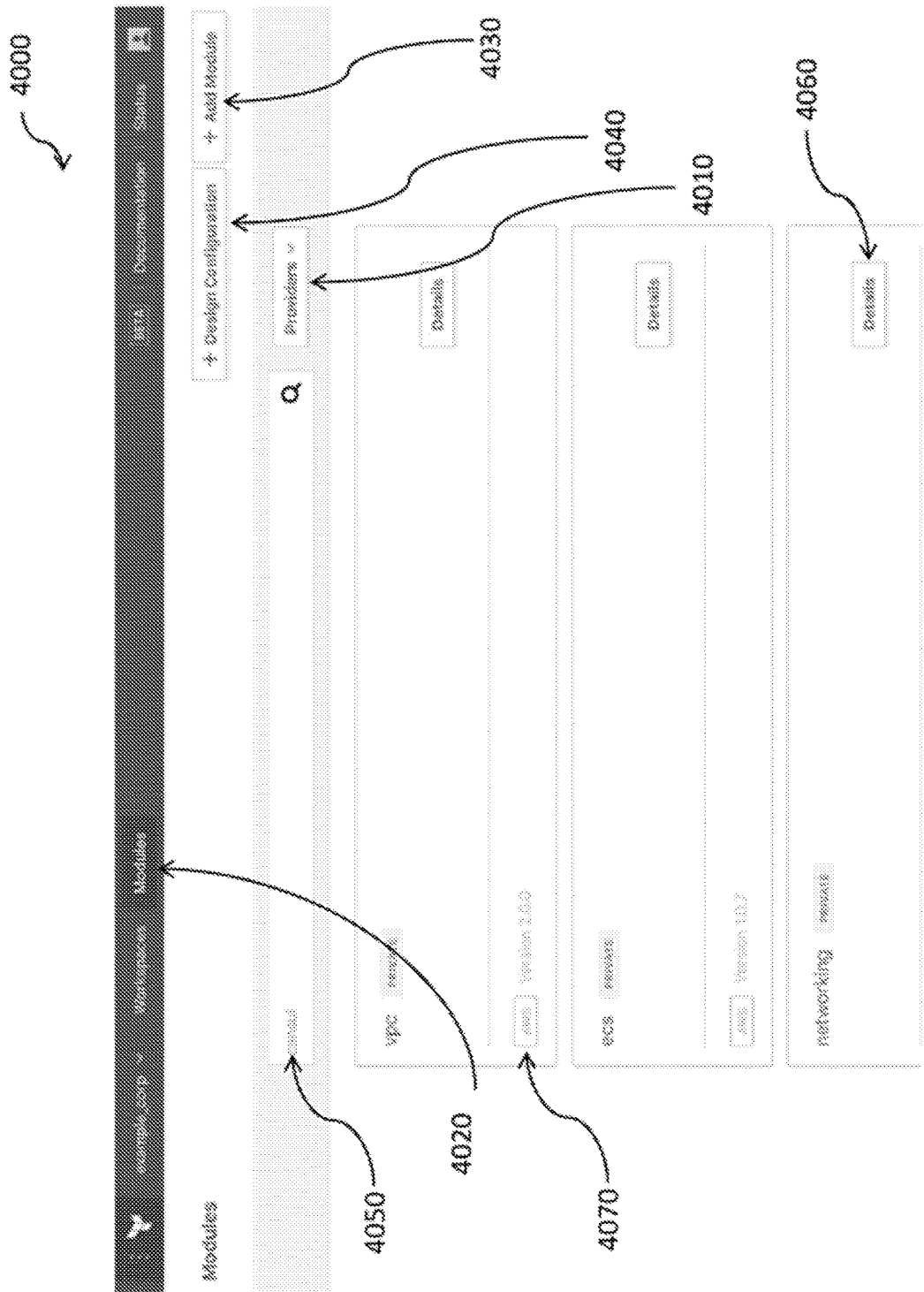


FIG. 5A



FIG. 5B

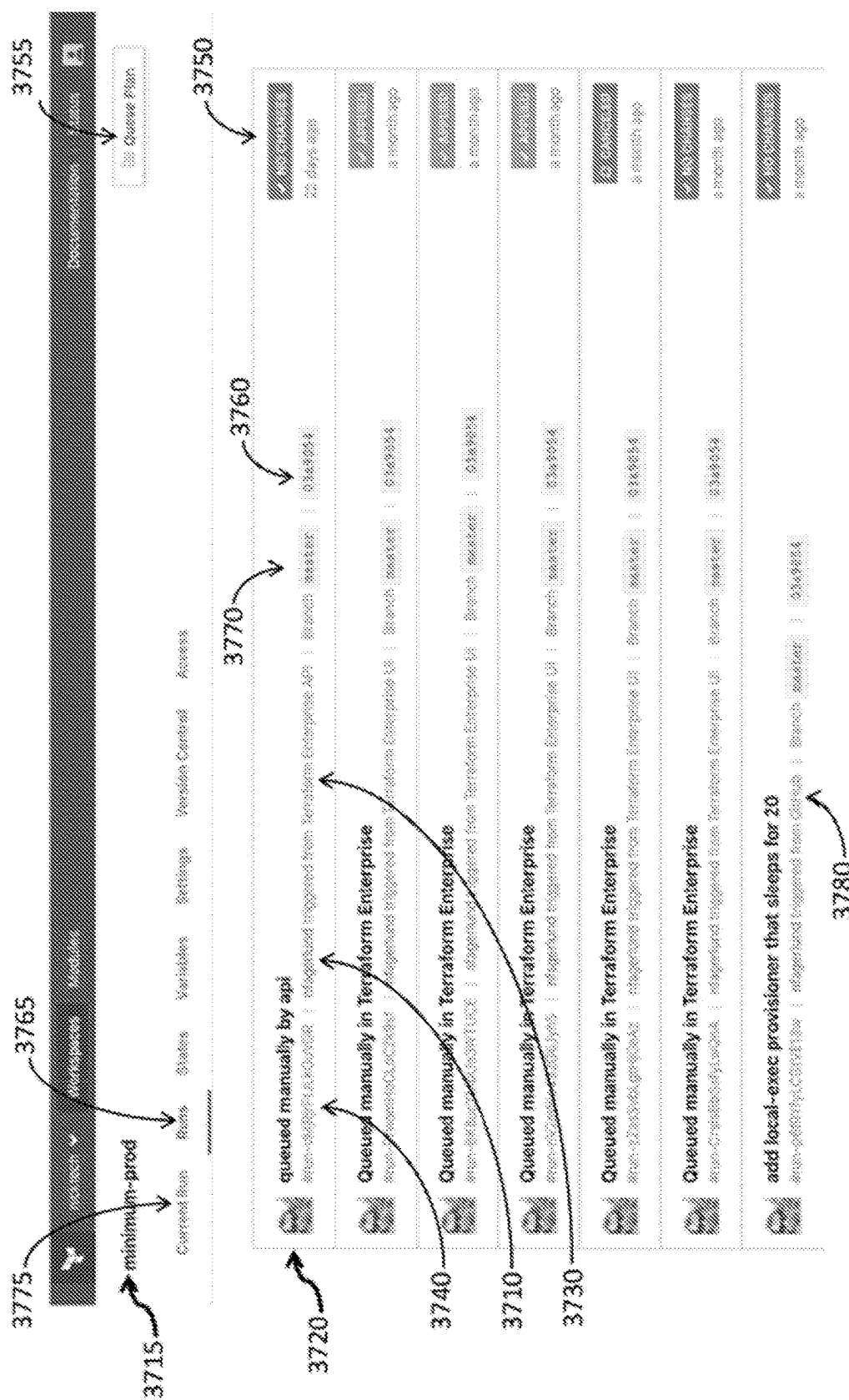
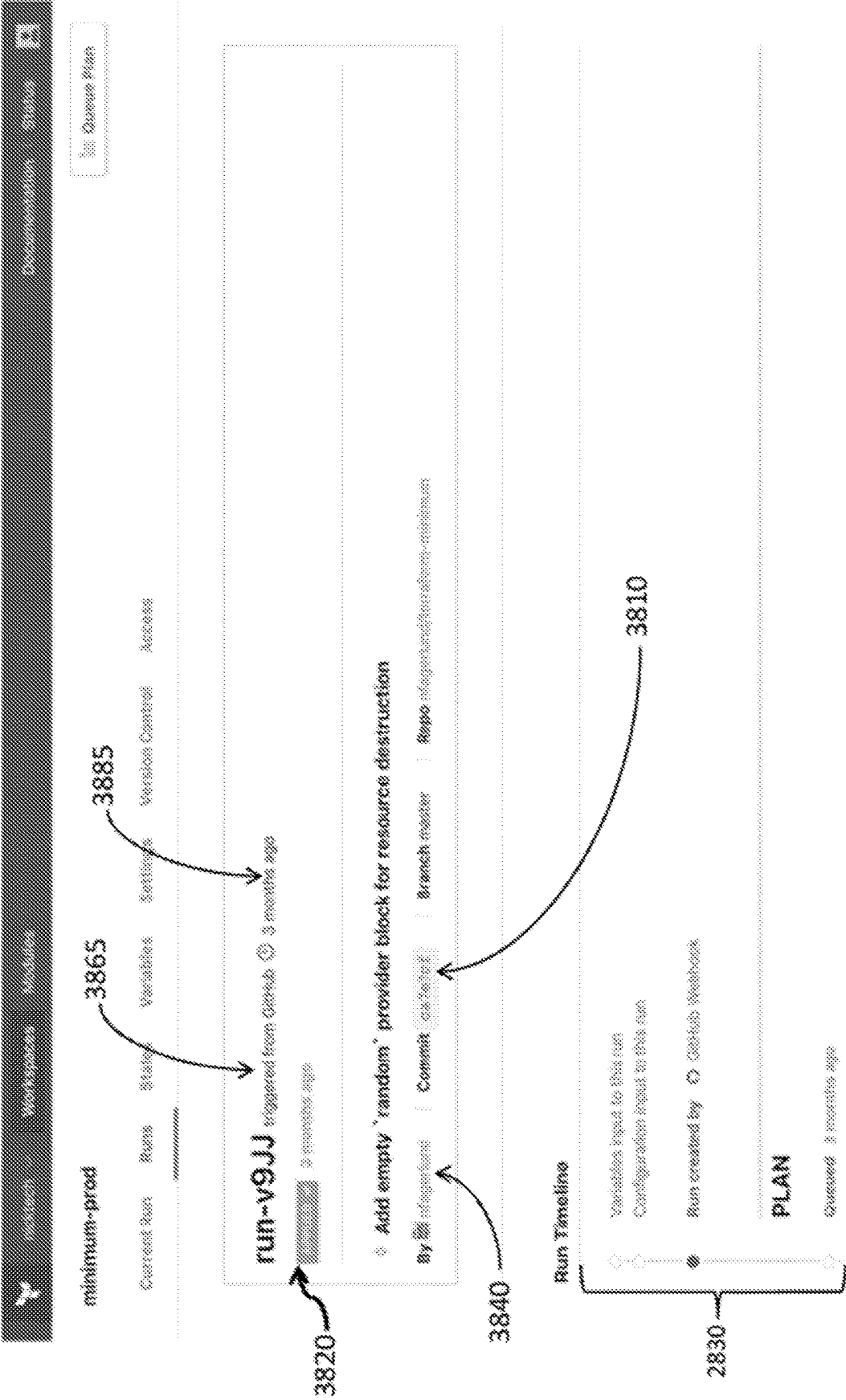


FIG. 6A



Executed and saved successfully
3 minutes ago

Hide Plan

View raw log

3930

```
terraform will perform the following actions:

- /> null_resource.random [new resource required]
  id: "991948930016540472" => "completed" (Planned new resource)
  triggers: &{
    "id" => "id"
  }
  triggers.version: "unified-deploy" => "version-deploy" (Planned new resource)
  2018/06/28 17:55:53 [DEBUG] plugin: waiting for all plugin processes to complete...

Plan 1 to add, 0 to change, 1 to destroy.
2018-06-28T17:55:53.798 [DEBUG] plugin: process exited path=/terraform/terraform/plugin/links_terraform-provider-null_v1.0.0_x4
2018-06-28T17:55:53.798 [DEBUG] plugin:terraform local-exec-provider [internal] 2018/06/28 17:55:53 [DEBUG] plugin: waiting for all plugin pro
2018-06-28T17:55:53.802 [DEBUG] plugin: process exited path=/terraform/terraform
```

State versions output with this plan

No state versions output

Leave a Comment

Custom & Apply

Discard Plan

FIG. 6C

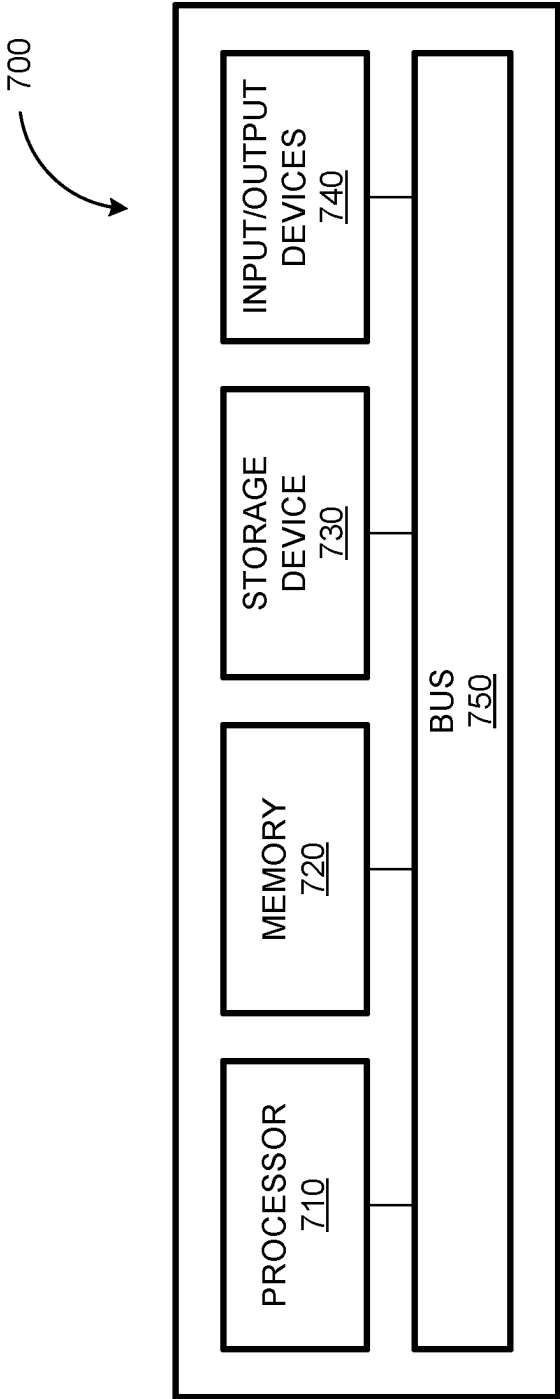


FIG. 7

LIFECYCLE MANAGEMENT FOR INFORMATION TECHNOLOGY INFRASTRUCTURE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Application No. 62/776,433, filed on Dec. 6, 2018 and entitled “LIFECYCLE MANAGEMENT FOR INFORMATION TECHNOLOGY INFRASTRUCTURE,” U.S. Provisional Application No. 62/776,434, filed on Dec. 6, 2018 and entitled “VALIDATION OF EXECUTION PLAN FOR CONFIGURING AN INFORMATION TECHNOLOGY INFRASTRUCTURE,” and U.S. Provisional Application No. 62/776,437, filed on Dec. 6, 2018 and entitled “GENERATING CONFIGURATION FILES FOR CONFIGURING AN INFORMATION TECHNOLOGY INFRASTRUCTURE,” the disclosures of which are incorporated herein by references in their entirety.

TECHNICAL FIELD

[0002] The present disclosure generally relates to information technology infrastructure and, more specifically, to lifecycle management for information technology infrastructure including the provisioning, modification, and/or de-provisioning of the underlying resources.

BACKGROUND

[0003] Information technology (IT) infrastructure may refer to the hardware resources, software resources, and/or network resources forming an enterprise’s information technology environment. For example, hardware resources may include servers, computers, data centers, switches, hubs, routers, and/or the like. Meanwhile, software resources may include enterprise resource planning (ERP) software applications, customer relationship management (CRM) software applications, productivity software applications, and/or the like. The network resources of the enterprise’s information technology infrastructure may include any resources providing network enablement, network connectivity, network security, and/or the like.

[0004] The information technology infrastructure of the enterprise may enable the delivery of information technology services and/or solutions to a variety of internal and external users including, for example, employees, partners, customers, and/or the like. For instance, the hardware resources of the enterprise’s information technology infrastructure may be used to host the software resources. At least some of the software resources within the enterprise’s information technology infrastructure may be available remotely, for example, as a software-as-a-service (SaaS), a web application, and/or the like. Remote access to these software resources may be enabled and/or regulated by the network resources within the enterprise’s information technology infrastructure.

SUMMARY

[0005] Methods, systems, and articles of manufacture, including computer program products, are provided for managing information technology (IT) infrastructure. In some implementations of the current subject matter, there is provided a system. The system can include at least one data processor. The system can further include at least one

memory storing instructions that result in operations when executed by the at least one data processor. The operations can include: generating a first workspace and a second workspace, the first workspace configured to maintain a first set of configurations for an information technology infrastructure, and the second workspace configured to maintain a second set of configurations for the information technology infrastructure; merging, into the first workspace and/or the second workspace, a configuration file specifying one or more configurations to apply to the information technology infrastructure; generating, based at least on the first workspace and/or the second workspace, an execution plan that includes one or more operations to apply, to the information technology infrastructure, the one or more configurations specified in the configuration file; and applying, based at least on the execution plan, the one or more configurations including by at least provisioning, modifying, and/or de-provisioning one or more resources at the information technology infrastructure.

[0006] In some variations, one or more features disclosed herein including the following features may optionally be included in any feasible combination. The first set of configurations may be associated with a first iteration of configurations for the information technology infrastructure and the second set of configurations may be associated with a second iteration of configurations for the information technology infrastructure. The first iteration of configurations may be applied to the information technology infrastructure in order for the information technology infrastructure to support a first environment and the second iteration of configurations may be applied to the information technology infrastructure in order for the information technology infrastructure to support a second environment. The first environment and the second environment may each include a different one of a development environment, a staging environment, and a production environment.

[0007] In some variations, the first set of configurations may be associated with a first portion of the information technology infrastructure and the second set of configurations may be associated with a second portion of the information technology infrastructure. The information technology infrastructure may include hardware resources, software resources, and network resources. The first portion of the information technology infrastructure and the second portion of the information technology infrastructure may each include a different one of the hardware resources, software resources, and network resources.

[0008] In some variations, the first workspace may be associated with a first team of users and the second workspace may be associated with a second team of users. The first workspace may be inaccessible to the second team of users and the second workspace may be inaccessible to the first team of users.

[0009] In some variations, the configuration file may be pulled from a version controller in response to receiving, from a webhook at the version controller, a notification of the configuration file being committed at the version controller.

[0010] In some variations, the configuration file may include a programming code-based representation of one or more resources at the information technology infrastructure.

[0011] In some variations, the merging of the configuration file into the first workspace and/or the second workspace may modify at least one configuration for the infor-

mation technology infrastructure. The at least one configuration may be modified by at least setting and/or modifying, based at least on the configuration file, one or more variables associated with the first workspace and/or the second workspace.

[0012] In another aspect, there may be provided a computer-implemented method for managing information technology (IT) infrastructure. The method may include: generating a first workspace and a second workspace, the first workspace configured to maintain a first set of configurations for an information technology infrastructure, and the second workspace configured to maintain a second set of configurations for the information technology infrastructure; merging, into the first workspace and/or the second workspace, a configuration file specifying one or more configurations to apply to the information technology infrastructure; generating, based at least on the first workspace and/or the second workspace, an execution plan that includes one or more operations to apply, to the information technology infrastructure, the one or more configurations specified in the configuration file; and applying, based at least on the execution plan, the one or more configurations including by at least provisioning, modifying, and/or de-provisioning one or more resources at the information technology infrastructure.

[0013] In some variations, one or more features disclosed herein including the following features may optionally be included in any feasible combination. The first set of configurations may be associated with a first iteration of configurations for the information technology infrastructure and the second set of configurations may be associated with a second iteration of configurations for the information technology infrastructure. The first iteration of configurations may be applied to the information technology infrastructure in order for the information technology infrastructure to support a first environment and the second iteration of configurations may be applied to the information technology infrastructure in order for the information technology infrastructure to support a second environment. The first environment and the second environment may each include a different one of a development environment, a staging environment, and a production environment.

[0014] In some variations, the first set of configurations may be associated with a first portion of the information technology infrastructure and the second set of configurations may be associated with a second portion of the information technology infrastructure. The information technology infrastructure may include hardware resources, software resources, and network resources. The first portion of the information technology infrastructure and the second portion of the information technology infrastructure may each include a different one of the hardware resources, software resources, and network resources.

[0015] In some variations, the first workspace may be associated with a first team of users and the second workspace may be associated with a second team of users. The first workspace may be inaccessible to the second team of users and the second workspace may be inaccessible to the first team of users.

[0016] In some variations, the method may further include pulling, from a version controller, the configuration file. The configuration file may be pulled in response to receiving,

from a webhook at the version controller, a notification of the configuration file being committed at the version controller.

[0017] In some variations, the configuration file may include a programming code-based representation of one or more resources at the information technology infrastructure.

[0018] In some variations, the merging of the configuration file into the first workspace and/or the second workspace may modify at least one configuration for the information technology infrastructure. The at least one configuration may be modified by at least setting and/or modifying, based at least on the configuration file, one or more variables associated with the first workspace and/or the second workspace.

[0019] In another aspect, there is provided a non-transitory computer readable medium storing instructions. The instructions may be executed by at least one data processor to result in operations. The operations may include: generating a first workspace and a second workspace, the first workspace configured to maintain a first set of configurations for an information technology infrastructure, and the second workspace configured to maintain a second set of configurations for the information technology infrastructure; merging, into the first workspace and/or the second workspace, a configuration file specifying one or more configurations to apply to the information technology infrastructure; generating, based at least on the first workspace and/or the second workspace, an execution plan that includes one or more operations to apply, to the information technology infrastructure, the one or more configurations specified in the configuration file; and applying, based at least on the execution plan, the one or more configurations including by at least provisioning, modifying, and/or de-provisioning one or more resources at the information technology infrastructure.

[0020] Implementations of the current subject matter can include, but are not limited to, methods consistent with the descriptions provided herein as well as articles that comprise a tangibly embodied machine-readable medium operable to cause one or more machines (e.g., computers, etc.) to result in operations implementing one or more of the described features. Similarly, computer systems are also described that may include one or more processors and one or more memories coupled to the one or more processors. A memory, which can include a non-transitory computer-readable or machine-readable storage medium, may include, encode, store, or the like one or more programs that cause one or more processors to perform one or more of the operations described herein. Computer implemented methods consistent with one or more implementations of the current subject matter can be implemented by one or more data processors residing in a single computing system or multiple computing systems. Such multiple computing systems can be connected and can exchange data and/or commands or other instructions or the like via one or more connections, including, for example, to a connection over a network (e.g. the Internet, a wireless wide area network, a local area network, a wide area network, a wired network, or the like), via a direct connection between one or more of the multiple computing systems, etc.

[0021] The details of one or more variations of the subject matter described herein are set forth in the accompanying drawings and the description below. Other features and advantages of the subject matter described herein will be apparent from the description and drawings, and from the

claims. While certain features of the currently disclosed subject matter are described for illustrative purposes in relation to the management of information technology infrastructure, it should be readily understood that such features are not intended to be limiting. The claims that follow this disclosure are intended to define the scope of the protected subject matter.

DESCRIPTION OF THE DRAWINGS

[0022] The accompanying drawings, which are incorporated in and constitute a part of this specification, show certain aspects of the subject matter disclosed herein and, together with the description, help explain some of the principles associated with the disclosed implementations. In the drawings,

[0023] FIG. 1A depicts a system diagram illustrating an information technology infrastructure management system, in accordance with some example embodiments;

[0024] FIG. 1B depicts a block diagram illustrating an information technology infrastructure controller, in accordance with some example embodiments;

[0025] FIG. 1C depicts a block diagram illustrating a module registry, in accordance with some example embodiments;

[0026] FIG. 2 depicts an example of a dependency graph, in accordance with some example embodiments;

[0027] FIG. 3A depicts a flowchart illustrating a process for managing an information technology infrastructure, in accordance with some example embodiments;

[0028] FIG. 3B depicts a flowchart illustrating a process for running an execution plan to an information technology infrastructure, in accordance with some example embodiments;

[0029] FIG. 3C depicts a flowchart illustrating a process for configuring an information technology infrastructure, in accordance with some example embodiments;

[0030] FIG. 4A depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0031] FIG. 4B depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0032] FIG. 4C depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0033] FIG. 4D depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0034] FIG. 4E depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0035] FIG. 4F depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0036] FIG. 4G depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0037] FIG. 4H depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0038] FIG. 4I depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0039] FIG. 4J depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0040] FIG. 4K depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0041] FIG. 4L depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0042] FIG. 4M depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0043] FIG. 4N depicts an example of a user interface for creating and configuring a workspace, in accordance with some example embodiments;

[0044] FIG. 5A depicts an example of a user interface for managing modules, in accordance with some example embodiments;

[0045] FIG. 5B depicts an example of a user interface for managing modules, in accordance with some example embodiments;

[0046] FIG. 6A depicts an example of a user interface for interacting with runs within a workspace, in accordance with some example embodiments;

[0047] FIG. 6B depicts an example of a user interface for interacting with runs within a workspace, in accordance with some example embodiments;

[0048] FIG. 6C depicts an example of a user interface for interacting with runs within a workspace, in accordance with some example embodiments; and

[0049] FIG. 7 depicts a block diagram illustrating a computing system consistent with implementations of the current subject matter.

[0050] When practical, like labels are used to refer to same or similar items in the drawings.

DETAILED DESCRIPTION

[0051] The development of a software application may often be divorced from the subsequent deployment, testing, and maintenance of the software application. For instance, a software application may be developed in one environment by a team of software engineers before being deployed to another environment where the software application is tested and/or maintained by a separate team of information technology (IT) professionals. The absence of communication and collaboration between the software developers and the information technology professionals may result in the development and delivery of a software application that is difficult to deploy, test, and/or maintain.

[0052] Deploying the software application may require configuring an enterprise's information technology infrastructure to host the software application including, for example, by provisioning, modifying, and/or de-provisioning one or more hardware resources, software resources, network resources, and/or the like. It should be appreciated that the enterprise's information technology infrastructure may include private resources owned and operated by the enterprise for exclusive use by the enterprise. Alternatively and/or additionally, the enterprise's information technology infrastructure may include public resources owned and operated by a third party provider including, for example, an infrastructure-as-a-service (IaaS) provider, a platform-as-a-service (PaaS) provider, a software-as-a-service (SaaS) provider, and/or the like. Accordingly, the configuration of the

enterprise's information technology infrastructure may include provisioning, modifying, and/or de-provisioning private resources and/or public resources to support the operations of the software application. Moreover, the enterprise's information technology infrastructure may require continuous monitoring and/or updates in order to ensure that the performance of the software application meets a threshold metric such as, for example, a service level objective (SLO) and/or the like.

[0053] In some example embodiments, an information technology (IT) infrastructure controller may be configured to provide lifecycle management for the information technology infrastructure of an enterprise. As noted, the information technology infrastructure of the enterprise may be configured to host a software application and/or ensure that the performance of the software application meets a threshold metric (e.g., a service level objective (SLO) and/or the like). For example, the enterprise's information technology infrastructure may be configured by at least provisioning, modifying, and/or de-provisioning one or more resources (e.g., hardware resources, software resources, network resources, and/or the like) within the information technology infrastructure in order to accommodate the deployment, testing, and/or maintenance of the software application. Accordingly, the information technology infrastructure controller may manage the provisioning, modification, and/or de-provisioning of the one or more resources engendered by the deployment, testing, and/or maintenance of the software application.

[0054] FIG. 1A depicts a system diagram illustrating an information technology (IT) infrastructure management system 100, in accordance with some example embodiments. Referring to FIG. 1A, the information technology infrastructure management system 100 may include an information technology infrastructure controller 110, a first client 120a, a second client 120b, and a version controller 140. Furthermore, the information technology infrastructure management system 100 may include one or more information technology infrastructures including, for example, a first information technology infrastructure 130a, a second information technology infrastructure 130b, and/or the like. As FIG. 1A shows, the information technology infrastructure controller 110, the first client 120a, the second client 120b, the first information technology infrastructure 130a, the second information technology infrastructure 130b, and/or the version controller 140 may be communicatively coupled via a network 150. The network 150 may be any wired and/or wireless network including, for example, a local area network (LAN), a wide area network (WAN), a public land mobile network (PLMN), the Internet, and/or the like.

[0055] Referring again to FIG. 1A, each of the first information technology infrastructure 130a and the second information technology infrastructure 130b may include a plurality of resources from one or more different providers including, for example, physical equipment, virtual machines, and/or the like. To further illustrate, FIG. 1A shows the first information technology infrastructure 130a as including, for example, hardware resources 135a, software resources 135b, network resources 135c, and/or the like. Moreover, FIG. 1A shows that the first information technology infrastructure 130a may include resources from multiple providers including, for example, a first provider 150a, a second provider 150b, and/or the like. For example, at least one of the first provider 150a and the second

provider 150b may be a private provider such that at least a portion of the hardware resources 135a, the software resources 135b, and/or the network resources 135c are private resources owned and operated by an enterprise for exclusive use by the enterprise. Alternatively and/or additionally, at least one of the first provider 150a and/or the second provider 150b may be a third party provider including, for example, an infrastructure-as-a-service (IaaS) provider, a platform-as-a-service (PaaS) provider, a software-as-a-service (SaaS) provider, and/or the like. As such, at least a portion of the hardware resources 135a, the software resources 135b, and/or the network resources 135c may be public resources shared amongst multiple enterprises.

[0056] In some example embodiments, the information technology infrastructure controller 110 may be configured to provide lifecycle management for one or more information technology infrastructures including, for example, the first information technology infrastructure 130a, the second information technology infrastructure 130b, and/or the like. For example, the information technology infrastructure controller 110 may provide lifecycle management for the first information technology infrastructure 130a by at least managing the provisioning, modifying, and/or de-provisioning of one or more of the hardware resources 135a, the software resources 135b, and the network resources 135c. The provisioning, modifying, and/or de-provisioning of one or more of the hardware resources 135a, the software resources 135b, and the network resources 135c may be engendered by the deployment, testing, and/or maintenance of a software application.

[0057] In some example embodiments, the information technology infrastructure controller 110 may provision, modify, and/or de-provision one or more resources in the first information technology infrastructure 130a and/or the second information technology infrastructure 130b as part of configuring the first information technology infrastructure 130a and/or the second information technology infrastructure 130b to host the software application and/or to ensure that the performance of the software application meets a threshold metric (e.g., a service level objective (SLO) and/or the like). However, it should be appreciated that the first information technology infrastructure 130a and/or the second information technology infrastructure 130b may be configured and/or reconfigured to achieve any information technology objective including, for example, support for multi-tier software applications, self-service clusters, software demonstrations, disposable environments (e.g., production environments, staging environments, and/or the like), software defined networking, resource schedulers, multi-cloud deployment, and/or the like.

[0058] In some example embodiments, at least a portion of the first information technology infrastructure 130a and/or the second information technology infrastructure 130b may be configured using infrastructure as code (IaC). That is, instead of and/or in addition to physical hardware configuration, the first information technology infrastructure 130a and/or the second information technology infrastructure 130b may be configured via software using, for example, one or more configuration files specifying the configurations to apply to the first information technology infrastructure 130a and/or the second information technology infrastructure 130b as well as one or more corresponding variables. For instance, in order to support the deployment, testing, and/or maintenance of a software application at the first

information technology infrastructure **130a**, the first information technology infrastructure **130a** may be configured based on a first configuration file **125a** and/or a second configuration file **125b** created respectively, for example, by a first user **145a** at the first client **120a** and a second user **145b** at the second client **120b**. As shown in FIG. 1A, the first user **145a** at the first client **120a** and the second user **145b** at the second client **120b** may be associated with a same organization, for example, an organization **155**. However, it should be appreciated that the first user **145a** at the first client **120a** and the second user **145b** at the second client **120b** may be associated with different organizations.

[0059] The first configuration file **125a** and the second configuration file **125b** may each include a programming code-based representation of the hardware resources **135a**, the software resources **135b**, and/or the network resources **135c** in the information technology infrastructure **130**. For example, the first configuration file **125a** and/or the second configuration file **125b** may be rendered in a configuration language (e.g., HashiCorp Configuration Language (HCL) provided by HashiCorp, San Francisco, CA) and/or a data interchange language (e.g., JavaScript Object Notation (JSON)) that is human readable and editable as well as machine readable. Moreover, the first configuration file **125a** and/or the second configuration file **125b** may specify one or more configurations to apply to the first information technology infrastructure **130a** including, for example, the provisioning, modification, and/or de-provisioning of the hardware resources **135a**, the software resources **135b**, and/or the network resources **135c**.

[0060] To further illustrate, Table 1 below depicts the syntax of a configuration language such as, for example, HashiCorp Configuration Language (HCL).

TABLE 1

An AMI
variable "ami" {
description = "the AMI to use"
}
/* A multi
line comment. */
resource "aws_instance" "web" {
ami = "\${var.ami}"
count = 2
source_dest_check = false
connection {
user = "root"
}
}

[0061] Table 2 below depicts the syntax of a data interchange language such as, for example, JavaScript Object Notation (JSON).

TABLE 2

{
"variable": {
"ami": {
"description": "the AMI to use"
}
},
"resource": {
"aws_instance": {
"web": {
"ami": "\${var.ami}",
"count": 2,
}
}
}
}

TABLE 2-continued

"source_dest_check": false,
"connection": {
"user": "root"
}
}
}

[0062] In some example embodiments, the information technology infrastructure controller **110** may be configured to generate, based at least on the first configuration file **125a** and/or the second configuration file **125b**, an execution plan for applying, to the information technology infrastructure **130**, the one or more configurations specified in the first configuration file **125a** and/or the second configuration file **125b**. For example, the first configuration file **125a** and/or the second configuration file **125b** may be sent to the version controller **140** before being transferred to the information technology infrastructure controller **110**. The version controller **140** may be configured to manage and/or reconcile different versions of the first configuration file **125a** and/or the second configuration file **125b**. It should be appreciated that the version controller **140** may be any version control system, revision control system, and/or source control system capable of tracking and managing changes made to a configuration file by one or more users. For instance, the version controller **140** may be Github, Github Enterprise, GitLab, GitLab EE and CE, Bitbucket Cloud, Bitbucket Server, and/or the like. Alternatively and/or additionally, the version controller **140** may be the private and/or proprietary version control system implemented for exclusive use by an enterprise.

[0063] FIG. 1B depicts a block diagram illustrating the information technology infrastructure controller **110**, in accordance with some example embodiments. Referring to FIGS. 1A-B, the information technology infrastructure controller **110** may include a plan engine **160**, a validation engine **170**, and a state controller **180**. As shown in FIG. 1B, in some example embodiments, the information technology infrastructure controller **110** may be configured to generate an execution plan **190** for applying, to the first information technology infrastructure **130a**, one or more configurations specified, for example, in the first configuration file **125a** and/or the second configuration file **125b**.

[0064] Referring again to FIG. 1B, the plan engine **160** may include one or more workspaces including, for example, a first workspace **165a**, a second workspace **165b**, and a third workspace **165c**. Each of the first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may be configured to maintain the configurations for at least a portion of the first information technology infrastructure **130a**. Alternatively, the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may be configured to maintain configurations for different information technology infrastructures, each of which associated with a different organization. For instance, the first workspace **165a** may maintain the configurations for at least a portion of the first information technology infrastructure **130a** associated with one organization while the second workspace **165b** may maintain the configurations for at least a portion of the second information technology infrastructure **130b** associated with a different organization. When the

first configuration file **125a** and/or the second configuration file **125b** are pushed and/or pulled from the version controller **140**, the plan engine **160** may merge the first configuration file **125a** and/or the second configuration file **125b** into the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**.

[0065] In some example embodiments, the first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may each maintain a different iteration of configurations for at least a portion of the first information technology infrastructure **130a**. For example, the first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may each maintain the configurations that are applied to the first information technology infrastructure **130a** in order to configure the first information technology infrastructure **130a** to support a production environment, a staging environment, and a development environment for a software application. Accordingly, the first workspace **165a** may maintain the configurations associated with a production environment, the second workspace **165b** may maintain the configurations associated with a staging environment, and the third workspace **165c** may maintain the configurations associated with a development environment.

[0066] Alternatively and/or additionally, each of the first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may be associated with the configurations for a specific portion of the first information technology infrastructure **130a**. For examples, the first workspace **165a** may maintain the configurations for the hardware resources **135a** of the first information technology infrastructure **130a**, the second workspace **165b** may maintain the configurations for the software resources **135b** of the first information technology infrastructure **130a**, and the third workspace **165c** may maintain the configurations for the network resources **135c** of the first information technology infrastructure **130a**.

[0067] In some example embodiments, the first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may each be associated with a different set of variables. Each set of variables may correspond to a different iteration of configurations for the first information technology infrastructure **130a** (e.g., production environment, staging environment, development environment, and/or the like). Alternatively and/or additionally, each set of variables may correspond to the configurations for a different portion of the first information technology infrastructure **130a** (e.g., the hardware resources **135a**, the software resources **135b**, the network resources **135c**, and/or the like). At least some of these variables may be set and/or modified by the merging of the first configuration file **125a** and/or the second configuration file **125b** into the first workspace **165a**, the second workspace **165b**, and the third workspace **165c**.

[0068] The first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may be associated with one or more organizations including, for example, the organization **155**. However, as noted, the first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may be associated with multiple organizations, each of which having a distinct information technology infrastructure. Moreover, the first workspace **165a**, the second workspace **165b**, and the third workspace **165c** may each be associated with a team of one or more users from the organization **155**. For example, the first workspace **165a** may be associated with a first team of users that includes the

first user **145a** at the first client **120a** while the second workspace **165b** may be associated with a second team of users that includes the second user **145b** at the second client **120b**. Each team of users may be accorded exclusive access to the corresponding workspace. Moreover, different users within a team of users may be afforded different access privileges with respect to a corresponding workspace. For example, the first user **145a** may be provided read access, write access, and/or administrative access to the first workspace **165a** while the second user **145b** may be provided read access, write access, and/or administrative access to the second workspace **165b**. However, the first user **145a** may be prevented from accessing the second workspace **165b** if the first user **145** is not a member of the second team of user having exclusive access to the second workspace **165b**. Likewise, the second user **145b** may be prevented from accessing the first workspace **165a** if the second user **145b** is not a member of the first team of users having exclusive access to the first workspace **165a**.

[0069] In some example embodiments, the first user **145a** may access the first workspace **165a** by at least merging the first configuration file **125a** into the first workspace **165a**. For example, the information technology infrastructure controller **110** may register, at the version controller **140**, a webhook. The webhook may be a hypertext transfer protocol (HTTP) callback configured to post, to the information technology infrastructure controller **110**, a notification when the first user **145a** commits the first configuration file **125a** at the version controller **140**. Meanwhile, the information technology infrastructure controller **110** may respond to the notification by at least pulling the first configuration file **125a** from the version controller **140** and merging of the first configuration file **125a** into the first workspace **165a**.

[0070] As noted, merging the first configuration file **125a** into the first workspace **165a** may set and/or modify at least some of the variables associated with the first workspace **165a**. Moreover, by merging the first configuration file **125a** into the first workspace **165a**, the first user **145a** may modify the configurations specified for at least a portion of the first information technology infrastructure **130a**. For instance, merging the first configuration file **125a** into the first workspace **165a** may modify the configurations specified for the hardware resources **135a** of the first information technology infrastructure **130a** in order to provide a production environment for a software application. According to some example embodiments, two or more of the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may be linked such that updating a variable in one workspace may trigger an update to the same variable at the linked workspaces.

[0071] Alternatively and/or additionally, the second user **145b** may access the second workspace **165b** by at least merging the second configuration file **125b** into the second workspace **165b**. The information technology infrastructure controller **110** may pull, from the version controller **140**, the second configuration file **125b** in response to a notification from the webhook at the version controller **140**. Merging the second configuration file **125b** into the second workspace **165b** may modify the configurations specified for at least a portion of the first information technology infrastructure **130a** by at least setting and/or modifying at least some of the variables associated with the second workspace **165b**. For example, merging the second configuration file **125b** into the second workspace **165b** may modify the configurations

specified for to the software resources **135b** of the first information technology infrastructure **130a** in order to provide a staging environment for a software application.

[0072] The information technology infrastructure controller **110** may generate, based at least on the configurations associated with the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**, the execution plan **190**. The execution plan **190** may include one or more operations to provision, modify, and/or de-provision resources at the first information technology infrastructure **130a** in order to apply, to the first information technology infrastructure **130a**, the configurations associated with the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**.

[0073] In some example embodiments, the information technology infrastructure controller **110** may generate the execution plan **190** by at least consolidating the configurations associated with the first workspace **165a**, the second workspace **165b**, and the third workspace **165c**. That is, the execution plan **190** may be generated to achieve a combination of the different iterations of the configurations for the first information technology infrastructure **130a** and/or the configurations for different portions of the first information technology infrastructure **130a**. Alternatively and/or additionally, the information technology infrastructure controller **110** may generate the execution plan **190** based on some but not all of the configurations associated with the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**. For example, the execution plan **190** may be generated to achieve only some iterations of the configurations for the first information technology infrastructure **130a** and/or the configurations for only a portion of the first information technology infrastructure **130a**.

[0074] In some example embodiments, the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may be marked for automatic destruction. For example, the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may persist for a period of time (e.g., 24 hours), after which the information technology infrastructure controller **110** may be configured to automatically destroy the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**. The first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may be persisted for a limited period of time in order to configure the first information technology infrastructure **130a** to provide a temporary environment or disposable environment (e.g., a demo environment).

[0075] The information technology infrastructure controller **110** may generate the execution plan **190** including by creating a corresponding dependency graph (e.g., a directed acyclic graph (DAG) and/or the like) having a plurality of nodes, at least some of which being interconnected by interconnected by one or more directed edges. FIG. 2 depicts an example of a dependency graph **200**, in accordance with some example embodiments.

[0076] To apply the configurations associated with the execution plan **190** to the first information technology infrastructure **130a**, the information technology infrastructure controller **110** may traverse the corresponding dependency graph. For instance, the information technology infrastructure controller **110** may perform a depth-first traversal of the dependency graph in order to determine the resources that the execution plan **190** indicates as requiring provisioning, modification, and/or de-provisioning. The information

technology infrastructure controller **110** may further identify, based on the dependency graph, independent resources that may be provisioned, modified, and/or de-provisioned in parallel. It should be appreciated that the information technology infrastructure controller **110** may be configured to maximize parallelization when applying, to the first information technology infrastructure **130a**, the configurations associated with the execution plan **190**.

[0077] Table 3 below depicts examples of nodes that may be present in the dependency graph corresponding to the execution plan **190**

TABLE 3

Type of Node	Description
Resource Node	Representative of a single resource such as, for example, a hardware resource, a software resource, a network resource, and/or the like.
Provider Node	Representative of a provider of one or more resources including, for example, hardware resources, software resources, network resources, and/or the like. Each provider node may include the time required to fully configure a corresponding provider to provide the corresponding resources.
Resource Meta Node	Representative of a group of resources including, for example, one or more hardware resources, software resources, network resources, and/or the like.
Data Node	Representative of data needing to be fetched, retrieved, and/or generated for purposes of configuring other resources and/or providers.

[0078] The information technology infrastructure controller **110** may generate the dependency graph by at least adding, to the dependency graph, one or more resource nodes corresponding to individual resources including, for example, one or more hardware resources **135a**, software resources **135b**, network resources **135c**, and/or the like. The one or more resource nodes may be mapped to the corresponding provider nodes, for example, to identify the first provider **150a** and/or the second provider **150b** as being the provider of the resources associated with each of the resource nodes. Moreover, the information technology infrastructure controller **110** may generate the dependency graph by at least inserting one or more edges to interconnect, for example, the resource nodes and the provider nodes. An edge interconnecting a resource node to a provider node may identify the provider associated with the provider node as being a provider of the resource associated with the resource node. Meanwhile, an edge interconnecting two resource nodes may indicate a dependency between the resources associated with the two resource nodes.

[0079] To represent resources that require de-provisioning, the dependency graph may include one or more “orphan” resource nodes, which may be disconnected from the provider nodes and other resource nodes in the dependency graph. Alternatively and/or additionally, in order to represent the modification of an existing resource within the first information technology infrastructure **130a**, the information technology infrastructure controller **110** may generate the dependency graph by at least splitting the corresponding resource node into a first resource node and a second resource node. The first resource node may correspond to the existing resource, which may be de-provisioned when the configurations specified in the execution plan **190** are applied to the first information technology infrastructure **130a**. Meanwhile, the second resource node may correspond

to the modified resource, which may be provisioned when the configurations specified in the execution plan **190** are applied to the first information technology infrastructure **130a**.

[0080] Referring again to FIG. 1B, the validation engine **170** may be configured to validate the execution plan **190** before the information technology infrastructure controller **110** applies the corresponding configurations to the information technology infrastructure **130**. In some example embodiments, the validation engine **170** may be configured to perform a multitier validation of the execution plan **190** in order to determine whether the configurations associated with the execution plan **190** satisfy one or more requirements including, for example, valid configurations, proper permissions, cost compliance, and/or the like.

[0081] For instance, the validation engine **170** may perform a first tier of validation by at least determining the structural validity of the configurations associated with the execution plan **190** including, for example, the syntactic validity and/or semantic validity of the configurations associated with the execution plan **190**. If the configurations associated with the execution plan **190** successfully passes the first tier of validation, the validation engine **170** may perform a second tier of validation by at least determining whether the configurations comply with one or more policies including, for example, a first policy **175a**, a second policy **175b**, and/or the like. The first policy **175a** and/or the second policy **175b** may impose limitations on the resources allocated by the configurations associated with the execution plan **190**. Upon determining that the configurations associated with the execution plan **190** comply with the one or more policies, the validation engine **170** may perform a third tier of validation by at least determining whether the configurations associated with the execution plan **190** meet one or more cost quotas including, for example, a first quota **175c**, a second quota **175d**, and/or the like. The first quota **175c** and/or the second quota **175d** may impose target values and/or limits on the projected costs of the configurations associated with the execution plan **190**.

[0082] In some example embodiments, a programming code based representation of the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be used to provide the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** to the validation engine **170**. Furthermore, the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be input by the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b**. Alternatively and/or additionally, the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be retrieved from a repository such as, for example, the version controller **140** and/or the like.

[0083] In some example embodiments, the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be custom configured, for example, by the first user **145a** and/or the second user **145b** based at least on the first user **145a** and/or the second user **145b** having the necessary access privileges (e.g., administrative access and/or the like) for setting and/or modifying a policy at the validation engine **170**. Moreover, the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be custom configured to have limited applicability. For example, each of the first work-

space **165a**, the second workspace **165b**, and the third workspace **165c** may be associated with attributes including, for example, environment, application type, region, cloud, and/or the like. Whether a policy or a cost quota is applicable to each of the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may be determined based on the corresponding attributes. That is, the validation engine **170** may identify the policies and/or cost quotas that are applicable to a workspace by at least filtering a broader set of policies and/or cost quotas based on the attributes of the workspace.

[0084] Accordingly, the first policy **175a** and/or the first quota **175c** may be configured to apply only to configurations associated with a staging environment while the second policy **175b** and/or the second quota **175d** may be configured to apply only to configurations associated with a production environment. Alternatively and/or additionally, the first policy **175a** and/or the first quota **175c** may be configured to apply only to configurations associated with one portion of the first information technology infrastructure **130a** (e.g., the hardware resources **135a**) while the second policy **175b** and/or the second quota **175d** may be configured to apply only to configurations associated with a different portion of the first information technology infrastructure **130a** (e.g., the network resources **135c**). In some example embodiments, the execution plan **190** may be validated against requirements that are classified as advisory, mandatory, and/or semi-mandatory. For example, the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be classified as advisory, mandatory, and/or semi-mandatory. Applying a requirement that is classified as advisory may merely trigger a notification (e.g., an informative output displayed at the first client **120a** and/or the second client **120b**) indicative, for example, of the configurations associated with the execution plan **190** as failing to comply with the requirement. By contrast, applying a requirement that is classified as mandatory and/or semi-mandatory may prevent the configurations associated with the execution plan **190** from being applied at the first information technology infrastructure **130a** in the event the configurations fail to satisfy the requirement. Moreover, while advisory requirements and semi-mandatory requirements may be overridden, a mandatory requirement must be satisfied before the configurations associated with the execution plan **190** may be applied at the first information technology infrastructure **130a**.

[0085] In some example embodiments, the first policy **175a**, the validation engine **170** may invoke an externally configured service in order to verify whether the execution plan **190** satisfies one or more externally configured policies and/or quotas. For example, the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be configured externally by a web hook mechanism. The result of the external validation (e.g., a pass and/or fail status) may be returned to the validation engine **170** via an application programming interface (API). The one or more externally configured policies and/or quotas may also be classified as advisory, mandatory, and/or semi-mandatory. Accordingly, failure of an external policy and/or quota classified as mandatory and/or semi-mandatory may prevent the execution plan **190** from being applied at the first information technology infrastructure **130a**. Contrastingly, failure of an external policy and/or quota classified as advisory may trigger instead a notification (e.g., an infor-

mative output displayed at the first client **120a** and/or the second client **120b**) indicative, for example, of the configurations associated with the execution plan **190** as being non-compliant.

[0086] The information technology infrastructure controller **110** may apply, to the information technology infrastructure **130**, the configurations associated with the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** by at least performing the operations included in the execution plan **190**, for example, to provision, modify, and/or de-provision one or more resources at the first information technology infrastructure **130a**. According to some example embodiments, the information technology infrastructure controller **110** may be configured to implement the execution plan **190** based at least on the execution plan **190** having been successfully validated by the validation engine **170**. The validation engine **170** may be configured to provide an indication of the execution plan **190** as having been successfully or unsuccessfully validated by the validation engine **170**. Alternatively and/or additionally, the validation engine **170** may provide an indication of the execution plan **190** as having passed or failed each of the first policy **175a**, the second policy **175b**, the first quota **175c**, the second quota **175d**, and/or the like. As noted, one or more of the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be classified as advisory and/or semi-mandatory. These policies and/or quotas may be overridden and/or excluded from the validation of the execution plan **190**. Alternatively, one or more of the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d** may be classified as mandatory. Mandatory policies and/or quotas may not be overridden and/or excluded from the validation of the execution plan **190**. Instead, the configurations associated with the execution plan **190** may be required to satisfy all mandatory policies and/or quotas before the configurations may be applied at the first information technology infrastructure **130a**.

[0087] In some example embodiments, instead of and/or in addition to the information technology infrastructure controller **110** ingesting, from the version controller **140**, the first configuration file **125a** and/or the second configuration file **125b** before merging the first configuration file **125a** and/or the second configuration file **125b** into the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** to generate the execution plan **190**, the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b** may upload the execution plan **190** directly to the information technology infrastructure controller **110**, for example, via an application programming interface (API). Furthermore, the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b** may remotely execute the execution plan **190**, for example, to provision, modify, and/or de-provision resources in the first information technology infrastructure **130a**.

[0088] In some example embodiments, the state controller **180** may be configured to track the changes that are applied to the configurations of the first information technology infrastructure **130a**. For example, the state controller **180** may generate and store a state file prior to implementing an execution plan such as, for example, the execution plan **190**. The state file may capture a current state at the first information technology infrastructure **130a**, including one or

more existing configurations at the first information technology infrastructure **130a**, prior to the application of the configurations associated with the execution plan **190**. The information technology infrastructure controller **110** may determine, based on one or more state files generated and stored by the state controller **180**, a previous state of the first information technology infrastructure **130a** including, for example, one or more previous configurations at the first information technology infrastructure **130a**. Alternatively and/or additionally, the information technology infrastructure controller **110** may restore, based at on the one or more state files generated and stored by the state controller **180**, the first information technology infrastructure **130a** to a previous state.

[0089] For instance, as FIG. 1B shows, the state controller **180** may generate and store a plurality of state files including, for example, a first state file **185a**, a second state file **185b**, and/or the like. The first state file **185a** and the second state file **185b** may capture successive states of the first information technology infrastructure **130a**. For example, the first state file **185a** may capture the configurations at the first information technology infrastructure **130a** at a first time t_1 prior to the implementation of a first execution plan while the second state file **185b** may capture the configurations at the first information technology infrastructure **130a** at a second time t_2 prior to the implementation of a second execution plan. The information technology infrastructure controller **110** may generate, based at least on the first state file **185a** and the second state file **185b**, a delta file or a difference file showing the difference between the configurations at the first information technology infrastructure **130a** at the first time t_1 and the configurations at the first information technology infrastructure **130a** at the second time t_2 .

[0090] Moreover, the information technology infrastructure controller **110** may restore, based at least on the first state file **185a**, the first information technology infrastructure **130a** to a state at the first time t_1 . Alternatively and/or additionally, the information technology infrastructure controller **110** may restore, based at least on the second state file **185b**, the first information technology infrastructure **130a** to a state at the second time t_2 . It should be appreciated that by restoring the first information technology infrastructure **130a** to an earlier state, the information technology infrastructure controller **110** may reverse subsequent changes to the configurations of the first information technology infrastructure **130a**.

[0091] Table 4 below depicts an example of a state file. As Table 4 shows, the state controller **180** may generate, prior to implementing an execution plan, a state file to capture a current state of the first information technology infrastructure **130a**, including one or more existing configurations at the first information technology infrastructure **130a**

TABLE 4

```
aws_instance.example:
  id = i-32cf65a8
  ami = ami-2757f631
  availability_zone = us-east-1a
  instance_state = running
  instance_type = t2.micro
  private_ip = 172.31.30.244
  public_dns = ec2-52-90-212-55.compute-1.amazonaws.com
```

TABLE 4-continued

public_ip = 52.90.212.55
subnet_id = subnet-1497024d
vpc_security_group_ids.# = 1
vpc_security_group_ids.3348721628 = sg-67672003

[0092] Referring again to FIG. 1B, the state controller **180** may also maintain a run log **187** tracking, for example, various runs of one or more execution plans including, for example, the execution plan **190**. As used herein, “running” the execution plan **190** may include generating the execution plan **190**, validating the execution plan **190**, applying the configurations associated with the execution plan **190**, canceling the execution plan **190**, discarding the execution plan **190**, and/or the like. Accordingly, each run of an execution plan may be associated with a run status including, for example, planning, planned, error, confirmed, applying, applied, canceled, discarded, pending, policy checking, policy checked, policy override, and/or the like. The run log **187** may be configured to track the runs of one or more execution plan including, for example, by storing a corresponding run status for each of the runs.

[0093] In some example embodiments, the state controller **180** may maintain state files and run logs for each individual workspace. For example, the first state file **185a**, the second state file **185b**, and the run log **187** may be associated with the first workspace **165a** while the state controller **180** may maintain additional state files and run logs for the other workspaces including, for example, the second workspace **165b**, the third workspace **165c**, and/or the like. However, it should be appreciated that the first state file **185a**, the second state file **185b**, and the run log **187** may be associated with the first information technology infrastructure **130a** as a whole instead of any individual workspace associated with the first information technology infrastructure **130a**.

[0094] FIG. 1C depicts a block diagram illustrating a module registry **115**, in accordance with some example embodiments. Referring to FIGS. 1A-C, the module registry **115** may include a plurality of infrastructure modules including, for example, a first module **116a**, a second module **116b**, and/or the like. The first module **116a** and the second module **116b** may each include the configurations that may be applied to an information technology infrastructure (e.g., the first information technology infrastructure **130a**, the second information technology infrastructure **130b**, and/or the like) to achieve, at least partially, an information technology objective such as, for example, support for a software application, a multi-tier software application, self-service clusters, software demonstrations, disposable environments (e.g., production environments, staging environments, and/or the like), software defined networking, resource schedulers, multi-cloud deployment, and/or the like.

[0095] Referring again to FIG. 1C, the first user **145a** may create the first module **116a** and/or the second module **116b** while creating the first configuration file **125a** at the first client **120a**. The first user **145a** may publish the first module **116a** and/or the second module **116b** such that the second user **145b** may add, to the second configuration file **125b**, the first module **116a** and/or the second module **116b** while the second user **145b** is creating the second configuration file **125b** at the second client **120b**. Adding the first module **116a** and/or the second module **116b** to the second configuration file **125b** may incorporate, into the second configuration file **125b**, the configurations included in first module **116a**

and/or the second module **116b**. For example, the first module **116a** and/or the second module **116b** may include the provisioning, modification, and/or de-provisioning of one or more of the hardware resources **135a**, the software resources **135b**, and/or the network resources **135c** at the first information technology infrastructure **130a** to support the deployment, testing, and/or maintenance of a software application. Accordingly, adding to the first module **116a** and/or the second module **116b** to the second configuration file **125b** may incorporate, into the second configuration file **125b**, the provisioning, modification, and/or de-provisioning of the same resources, for example, at a different information technology infrastructure such as the second information technology infrastructure **130b**.

[0096] In some example embodiments, the first module **116a** and/or the second module **116b** may be published directly to the module registry **115** by adding, to the module registry **115**, a version of the first module **116a** and/or the second module **116b**. Alternatively and/or additionally, the first module **116a** and/or the second module **116b** may be published via the version controller **140**. Publishing the first module **116a** and/or the second module **116b** via the version controller **140** may include registering, at the version controller **140**, a webhook (e.g., a hypertext transfer protocol (HTTP) callback) configured to post, to the information technology infrastructure controller **110**, a notification whenever a different version of the first module **116a** and/or the second module **116b** is committed to the version controller **140**. Accordingly, instead of storing static versions of the first module **116a** and/or the second module **116b**, the information technology infrastructure controller **110** may update the module registry **115** whenever, for example, the first user **145a** creates another version of the first module **116a** and/or the second module **116b**. In doing so, the second user **145b** may have access to multiple versions of the first module **116a** and/or the second module **116b** including, for example, the most recent versions of the first module **116a** and/or the second module **116b**, when creating the second configuration file **125b**.

[0097] In some example embodiments, the module registry **115** may be associated with the organization **155** such that only users from the organization **155** (e.g., the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b**) may have access to the module registry **115**, for example, to publish modules, consume modules, and/or the like. For example, the first user **145a** may publish the first module **116a** and/or the second module **116b** to the module registry **115** and the second user **145b** may consume the first module **116a** and/or the second module **116b** from the module registry **115** based at least on the first user **145a** and the second user **145b** being associated with the organization **155**. A user who is not associated with the organization **155** may be prevented from accessing the module registry **115**. That is, a user who is not associated with the organization **155** may neither publish nor consume an infrastructure module from the module registry **115**.

[0098] Table 5 below depicts programming code for an example of a module named “consul.” This module may be sourced from a public registry, a private registry, and/or version control system. In some example embodiments, the module may be associated with a version constraint to ensure that a specific version of the module is fetched from the public registry, private registry, and/or version control system. The module may require additional configuration

such as, for example, the quantity of servers. These additional configurations may be optional in some instances and mandatory in others.

TABLE 5

<pre> module "consul" { source = "hashicorp/consul/aws" version = "~> 0.0.5" servers = 3 } resource "aws_instance" "client" { ami = "ami-408c7f28" instance_type = "t1.micro" availability_zone = "\${module.consul.server_availability_zone}" } </pre>
--

[0099] FIG. 3A depicts a flowchart illustrating a process 300 for managing the information technology infrastructure 130, in accordance with some example embodiments. Referring to FIGS. 1A-C, 2, and 3A, the process 300 may be performed by the information technology infrastructure controller 110 to manage an information technology infrastructure such as, for example, the first information technology infrastructure 130a. For example, the management of the first information technology infrastructure 130a may include the provisioning, modification, and/or de-provisioning of one or more of the hardware resources 135a, the software resources 135b, and/or the network resources 135c to achieve an information technology objective such as, for example, support for a software application, a multi-tier software application, self-service clusters, software demonstrations, disposable environments (e.g., production environments, staging environments, and/or the like), software defined networking, resource schedulers, multi-cloud deployment, and/or the like. Nevertheless, it should be appreciated that the information technology infrastructure controller 110 may also perform the process 300 to manage other information technology infrastructures including, for example, the second information technology infrastructure 130b and/or the like.

[0100] The information technology infrastructure controller 110 may generate a first workspace configured to maintain a first set of configurations for the first information technology infrastructure 130a (302). Furthermore, the information technology infrastructure controller 110 may generate a second workspace configured to maintain a second set of configurations for the first information technology infrastructure 130a (304). In some example embodiments, the information technology infrastructure controller 110, for example, the plan engine 160, may generate the first workspace 165a, the second workspace 165b, and/or the third workspace 165c. The first workspace 165a, the second workspace 165b, and the third workspace 165c may each maintain a different iteration of configurations for at least a portion of the first information technology infrastructure 130a. For example, the first workspace 165a, the second workspace 165b, and the third workspace 165c may each maintain the configurations that are applied to the first information technology infrastructure 130a in order to configure the first information technology infrastructure 130a to support a production environment, a staging environment, and a development environment for a software application.

[0101] Alternatively and/or additionally, each of the first workspace 165a, the second workspace 165b, and the third workspace 165c may be associated with the configurations

for a specific portion of the first information technology infrastructure 130a. For instance, the first workspace 165a may maintain the configurations for the hardware resources 135a of the first information technology infrastructure 130a, the second workspace 165b may maintain the configurations for the software resources 135b of the first information technology infrastructure 130a, and the third workspace 165c may maintain the configurations for the network resources 135c of the first information technology infrastructure 130a. As noted, different workspaces may also be generated to maintain configurations for different information technology infrastructures. For example, the first workspace 165a may be associated with configurations for at least a portion of the first information technology infrastructure 130a while the second workspace 165b may be associated with configurations for at least a portion of the second information technology infrastructure 130b.

[0102] The information technology infrastructure controller 110 may merge, into the first workspace and/or the second workspace, a configuration file specifying one or more configurations to apply to the first information technology infrastructure 130a (306). In some example embodiments, the information technology infrastructure controller 110 may register, at the version controller 140, a webhook (e.g., a hypertext transfer protocol (HTTP) callback) configured to post, to the information technology infrastructure controller 110, a notification the first configuration file 125a and/or the second configuration file 125b are committed at the version controller 140. The information technology infrastructure controller 110 may respond to the notification from the webhook at the version controller 140 by at least pulling the first configuration file 125a and/or the second configuration file 125b from the version controller 140. Furthermore, the information technology infrastructure controller 110 may merge the first configuration file 125a into the first workspace 165a and the second configuration file 125b into the second workspace 165b. As noted, merging the first configuration file 125a into the first workspace 165a may set and/or modify at least some of the variables associated with the first workspace 165a, for example, to modify the configurations specified for the hardware resources 135a of the first information technology infrastructure 130a. Meanwhile, merging the second configuration file 125b into the second workspace 165b may set and/or modify at least some of the variables associated with the second workspace 165b, for example, to modify the configurations specified for the software resources 135b of the first information technology infrastructure 130a.

[0103] The information technology infrastructure controller 110 may generate, based at least on the first workspace and/or the second workspace, an execution plan that includes one or more operations to apply, to the first information technology infrastructure 130a, the one or more configurations specified in the configuration file (308) in some example embodiments, the information technology infrastructure controller 110 may generate the execution plan 190 by at least consolidating the configurations associated with the first workspace 165a, the second workspace 165b, and the third workspace 165c. Alternatively and/or additionally, the information technology infrastructure controller 110 may generate the execution plan 190 based on some but not all of the configurations associated with the first workspace 165a, the second workspace 165b, and/or the third workspace 165c.

[0104] The information technology infrastructure controller 110 may apply, based at least on the execution plan, the one or more configurations including by at least provisioning, modifying, and/or de-provisioning one or more resources at the first information technology infrastructure 130a (310). In some example embodiments, to apply the configurations associated with the execution plan 190 to the first information technology infrastructure 130a, the information technology infrastructure controller 110 may generate and traverse a corresponding dependency graph. For example, the information technology infrastructure controller 110 may generate the dependency graph 200, which may include a plurality of resource nodes and provider nodes, at least some of which being interconnected by one or more directed edges. The information technology infrastructure controller 110 may traverse the dependency graph 200 to at least identify independent resources that may be provisioned, modified, and/or de-provisioned in parallel. As noted, the information technology infrastructure controller 110 may be configured to maximize parallelization when applying, to the first information technology infrastructure 130a, the configurations associated with the execution plan 190.

[0105] FIG. 3B depicts a flowchart illustrating a process 320 for running an execution plan, in accordance with some example embodiments. Referring to FIGS. 1A-C, 2, and 3B, the process 320 may be performed by the information technology infrastructure controller 110, for example, to perform a multitier validation of the execution plan 190 before the configurations associated with the execution plan 190 are applied to the first information technology infrastructure 130a. As noted, the execution plan 190 may include one or more operations, which may be applied to the first information technology infrastructure 130a in order to realize one or more configurations for achieving an information technology objective such as, for example, support for a software application, a multi-tier software application, self-service clusters, software demonstrations, disposable environments (e.g., production environments, staging environments, and/or the like), software defined networking, resource schedulers, multi-cloud deployment, and/or the like. The multitier validation of the execution plan 190 may include determining whether the configurations associated with the execution plan 190 satisfy one or more requirements including, for example, advisory, mandatory, and/or semi-mandatory requirements.

[0106] The information technology infrastructure controller 110 may perform a first tier validation of the execution plan 190 by at least determining a structural validity of one or more configurations associated with the execution plan 190 (322). In some example embodiments, the information technology infrastructure controller 110, for example, the validation engine 170, may determine whether the configurations associated with the execution plan 190 are free from syntactic errors (e.g., typographical errors, syntax errors, formatting errors, and/or the like) and/or semantic errors that would prevent the configurations from being processed. For example, the information technology infrastructure controller 110 may detect a syntactic error if the configurations associated with the execution plan 190 requests a negative quantity of resources and/or if the quantity of resources are defined using a string value instead of a numeric value. Alternatively and/or additionally, the information technology infrastructure controller 110 may detect a semantic error

if a mismatch in dependent resources is present in the configurations associated with the execution plan 190.

[0107] The information technology infrastructure controller 110 may determine that the configurations associated with the execution plan 190 are structurally valid (323-Y). Accordingly, the information technology infrastructure controller 110 may perform a second tier validation of the execution plan 190 by at least determining whether the one or more configurations associated with the execution plan 190 comply with at least one policy (424). For example, in some example embodiments, the information technology infrastructure controller 110, for example, the validation engine 170, may further validate the execution plan 190 by at least determining whether the first information technology infrastructure 130a would satisfy the requirements imposed by the first policy 175a and/or the second policy 175b if the configurations associated with the execution plan 190 are applied to the first information technology infrastructure 130a. The first policy 175a and/or the second policy 175b may each impose one or more limitations on the resources allocated for the first information technology infrastructure 130a. For instance, the first policy 175a may impose a maximum and/or a minimum on a quantity of a resource allocated for the first information technology infrastructure 130a. Meanwhile, the second policy 175b may specify that an X instance type may only be built during a Y period in a Z region of the first information technology infrastructure 130a.

[0108] The information technology infrastructure controller 110 may determine that the configurations associated with the execution plan 190 comply with the at least one policy (325-Y). As such, the information technology infrastructure controller 110 may perform a third tier validation of the execution plan 190 by at least determining whether the one or more configurations of the execution plan 190 meet at least one cost quota (326). In some example embodiments, the information technology infrastructure controller 110, for example, the validation engine 170, may further validate the execution plan 190 by at least determining whether the first information technology infrastructure 130a would satisfy the requirements imposed by the first quota 175c and/or the second quota 175d if the configurations associated with the execution plan 190 are applied to the first information technology infrastructure 130a. The first quota 175c and/or the second quota 175d may impose limitations of the projected costs of the configurations associated with the execution plan 190. Accordingly, the information technology infrastructure controller 110 may determine whether the first information technology infrastructure 130a would exceed these limitations on projected costs if the configurations associated with the execution plan 190 are applied to the first information technology infrastructure 130a.

[0109] The information technology infrastructure controller 110 may determine that the configurations associated with the execution plan 190 meet the at least one cost quota (327-Y). As such, the information technology infrastructure controller 110 may apply, to the first information technology infrastructure 130a, the one or more configurations associated with the execution plan 190 (328). For example, the information technology infrastructure controller 110 may implement the execution plan 190 based at least on the configurations associated with the execution plan 190 having successfully passed the multitier validation. Implementing the execution plan 190 may include applying, to the first

information technology infrastructure **130a**, the configurations associated with the execution plan **190**. For example, applying, to the first information technology infrastructure **130a**, the configurations associated with the execution plan **190** may include provisioning, modifying, and/or de-provisioning one or more of the hardware resources **135a**, software resources **135b**, and/or network resources **135c** associated with the information technology infrastructure **130**.

[0110] As noted, the information technology infrastructure controller **110** may perform a multitier validation of the execution plan **190**. The configurations associated with the execution plan **190** may be applied at the first information technology infrastructure **130a** if the configurations associated with the execution plan **190** successfully passes the multitier validation including, for example, by being structurally valid, complying with at least one policy, and meeting at least one cost quota. By contrast, the information technology infrastructure controller **110** may also determine that the execution plan **190** fails to pass at least a portion of the multitier validation. For example, the information technology infrastructure controller **110** may determine that the configurations associated with the execution plan **190** are not structurally valid (**323-N**). Alternatively, the information technology infrastructure controller **110** may determine that the configurations associated with the execution plan **190** do not comply with at least one policy (**325-N**). The information technology infrastructure controller **110** may also determine that the configurations associated with the execution plan **190** do not meet at least one cost quota (**327-N**).

[0111] In the event the information technology infrastructure controller **110** determines that the execution plan **190** fails to pass any portion of the multitier validation, the information technology infrastructure controller **110** may determine if the failed requirement is mandatory (**329**). In some example embodiments, as part of the multitier validation, the execution plan **190** may be validated against requirements classified as advisory, mandatory, and/or semi-mandatory. For example, the structural validity of the execution plan **190** may be classified as a mandatory requirement. By contrast, the policy compliance of the execution plan **190** may be classified as a semi-mandatory requirement whereas the cost quota compliance of the execution plan **190** may be classified as an advisory requirement. As noted, while advisory requirements and semi-mandatory requirements may be overridden, a mandatory requirement must be satisfied before the configurations associated with the execution plan **190** may be applied at the first information technology infrastructure **130a**.

[0112] Accordingly, if the information technology infrastructure controller **110** determines that the execution plan **190** failed a mandatory requirement (**329-Y**), the information technology infrastructure controller **110** may prevent the one or more configurations associated with the execution plan **190** from being applied to the first information technology infrastructure **130a** (**330**). In some example embodiments, the information technology infrastructure controller **110** may provide an indication of the execution plan **190** as having been successfully or unsuccessfully validated by the validation engine **170**. Alternatively and/or additionally, the information technology infrastructure controller **110** may provide an indication of the execution plan **190** as being structurally invalid and/or having passed or failed each of the first policy **175a**, the second policy **175b**, the first quota **175c**, and/or the second quota **175d**. These indications may

include any form of notification including, for example, an email, a slack message, a webhook, and/or the like.

[0113] Alternatively, if the information technology infrastructure controller **110** determines that the execution plan **190** failed a non-mandatory requirement (**329-N**), the information technology infrastructure controller **110** may determine whether the requirement is overridden (**331**). If the information technology infrastructure controller **110** determines that the execution plan **190** failed a non-mandatory requirement that is overridden (**331-Y**), the information technology infrastructure controller **110** may apply, to the first information technology infrastructure **130a**, the one or more configurations associated with the execution plan **190**. By contrast, if the information technology infrastructure controller **110** determines that the execution plan **190** failed a non-mandatory requirement that is not overridden (**331-N**), the information technology infrastructure controller **110** may prevent the one or more configurations associated with the execution plan **190** from being applied at the first information technology infrastructure **130a** (**330**).

[0114] FIG. 3C depicts a flowchart illustrating a process **350** for configuring the information technology infrastructure **130**, in accordance with some example embodiments. Referring to FIGS. 1A-C, 2, and 3C, the process **350** may be performed by the information technology infrastructure controller **110** to enable the generation of the first configuration file **125a** and/or the second configuration file **125b**. As noted, the first configuration file **125a** and/or the second configuration file **125b** may be merged into the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**. Meanwhile, the execution plan **190** may be generated based at least on the configurations associated with the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**.

[0115] The information technology infrastructure controller **110** may receive, from the first user **145a** at the first client **120a**, a first indication to publish an infrastructure module (**352**). For example, while creating the first configuration file **125a** at the first client **120a**, the first user **145a** may create the first module **116a** and/or the second module **116b**. The first module **116a** and the second module **116b** may each include the configurations that may be applied to the information technology infrastructure **130** to achieve, at least partially, an information technology objective such as, for example, support for a software application, a multi-tier software application, self-service clusters, software demonstrations, disposable environments (e.g., production environments, staging environments, and/or the like), software defined networking, resource schedulers, multi-cloud deployment, and/or the like. By publishing the first module **116a** and/or the second module **116b**, the first user **145a** may render the first module **116a** and/or the second module **116b** available for use by other users including, for example, the second user **145b** at the second client **120b**.

[0116] The information technology infrastructure controller **110** may respond to the first indication by at least storing, in the module registry **115**, a first version of the infrastructure module pulled from the version controller **140** (**354**). Furthermore, the information technology infrastructure controller **110** may respond to the first indication by at least registering, at the version controller **140**, a webhook configured to post, to the information technology infrastructure controller **110**, a notification when a second version of the infrastructure module is committed to the version controller

140 (356). In some example embodiments, the first module **116a** and/or the second module **116b** may be published may be published via the version controller **140**. Publishing the first module **116a** and/or the second module **116b** via the version controller **140** may include registering, at the version controller **140**, a webhook (e.g., a hypertext transfer protocol (HTTP) callback) configured to post, to the information technology infrastructure controller **110**, a notification whenever a different version of the first module **116a** and/or the second module **116b** is committed to the version controller **140**. As such, the information technology infrastructure controller **110** may be able to update the module registry **115** whenever, for example, the first user **145a** creates another version of the first module **116a** and/or the second module **116b**. The update to the module registry **115** may include, for example, incrementing the version number associated with the first module **116a** and/or the second module **116b**. Moreover, the second user **145b** may have access to multiple versions of the first module **116a** and/or the second module **116b** including, for example, the most recent versions of the first module **116a** and/or the second module **116b**.

[0117] It should be appreciated that the module registry **115** may be associated with the organization **155** such that only users from the organization **155** may have access to the module registry **115**, for example, to publish modules, consume modules, and/or the like. As such, the first user **145a** may be able to publish the first module **116a** and/or the second module **116b** only if the first user **145a** is associated with the organization **155**. Alternatively and/or additionally, access to the module registry **115** may be role and/or permission based such that the first user **145a** may publish the first module **116a** and/or the second module **116b** to the module registry **115** only if the first user **145a** is associated with the appropriate role and/or permissions.

[0118] The information technology infrastructure controller **110** may receive, from the second user **145b** at the second client **120b**, a second indication selecting the first version and/or the second version of the infrastructure module (358). The information technology infrastructure controller **110** may respond to the second indication by at least sending, to the second client **120b**, the first version and/or the second version of the infrastructure module for insertion into a configuration file being created at the second client **120b** (360). For example, while creating the second configuration file **125b** at the second client **120**, the second user **145b** may select to add, to the second configuration file **125b**, the first module **116a** and/or the second module **116b**. The second user **145b** may select to add the first module **116a** and/or the second module **116b** instead of and/or in addition to creating the corresponding configurations. The first module **116a** and/or the second module **116b** may be added to the second configuration file **125b** in order to achieve, at least partially, an information technology objective such as, for example, support for a software application, a multi-tier software application, self-service clusters, software demonstrations, disposable environments (e.g., production environments, staging environments, and/or the like), software defined networking, resource schedulers, multi-cloud deployment, and/or the like.

[0119] As noted, the module registry **115** may be associated with the organization **155** such that only users from the organization **155** may have access to the module registry **115**, for example, to publish modules, consume modules,

and/or the like. As such, the second user **145b** may access the module registry **115** to consume the first module **116a** and/or the second module **116b** only if the second user **145b** is associated with the organization **155**. Alternatively and/or additionally, access to the module registry **115** may be role and/or permission based such that the second user **145b** may access the module registry **115** to consume the first module **116a** and/or the second module **116b** only if the second user **145b** is associated with the appropriate role and/or permissions. The role and/or permissions associated with the second user **145b** may further determine whether the second user **145b** is able to consume certain modules from the module registry **115**. For example, the role and/or permissions associated with the second user **145b** may allow the second user **145b** to consume the first module **116a** but not the second module **116b**.

[0120] The information technology infrastructure controller **110** may provide, to the first client **120a**, a third indication of the first version and/or the second version of the infrastructure module being selected for insertion into the configuration file (362). In some example embodiments, the information technology infrastructure controller **110** may generate and/or update a user interface to display, at the first client **120a**, an indication that the first module **116a** and/or the second module **116b** have been selected for insertion into the second configuration file **125b**. For example, the indication may identify the second user **145b** at the second client **120b** as having selected the first module **116a** and/or the second module **116b**. Moreover, if the second configuration file **125b** is merged into the first workspace **165a**, the indication from the information technology infrastructure controller **110** may further identify the first workspace **165a** as having the first module **116a** and/or the second module **116b**.

[0121] FIGS. 4A-N depict examples of user interfaces for creating and configuring a workspace, in accordance with some example embodiments. Referring to FIGS. 1A-C and 4A-P, the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b** may interact with the user interfaces shown in FIGS. 4A-N to create and/or configure the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**.

[0122] Referring to FIG. 4A, a new workspace may be created by clicking on a tab **2270**. Alternatively and/or additionally, a workspace may also be imported by clicking on a second tab **2420** shown in FIG. 4B, which may be trigger the migration of legacy environments to a new organization while preserving their existing state and settings. A workspace may also be created using a configuration designer **3010** shown in FIGS. 4H-J.

[0123] Referring again to FIG. 4B, a workspace name may be entered in a field **2440**. The workspace name may be unique and selected by combining one or more distinguishing attributes including, for example, the resources being managed, the environment in which the resources run, the region into which the resources are provisioned, and/or the like. The user interface shown in FIG. 4B may include a selection of sources **2460**, which may include, for example, the version controller **140**. Meanwhile, as shown in FIGS. 4B-C, the user interface may further provide a selection of repositories **2520** at, for example, the version controller **140** from which the information technology infrastructure controller **110** may pull the first configuration file **125a** and/or the second configuration file **125b**.

[0124] Referring to FIG. 4D, the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b** may select a directory **2620** in which the information technology infrastructure controller **110** may run the execution plan **190**. The directory **2620** may be specified as a relative path from a root of the repository **2510** and set to a subdirectory matching a particular environment (e.g., production, staging, development, and/or the like) if multiple environments exist within the same repository **2510**. A version control branch **2640** of the repository for the workspace may also be selected, which may refer to a production branch, a staging branch, and/or a development branch. Furthermore, the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b** may indicate, by selecting a box **2660**, whether to recursively clone all of the submodules within the repository **2510** when fetching a configuration.

[0125] Referring to FIGS. 4E-G, a workspace may include different types of variables. For example, the workspace may include variables defining the parameters for a configuration and environment variables affecting a behavior of the information technology infrastructure controller **110**. Alternatively and/or additionally, the workspace may include shell environment variables used, for example, by the first provider **150a** and/or the second provider **150b**, for credentials and/or other data. If a required variable is missing, an execution plan in the workspace may fail and a corresponding run log may be updated accordingly. Variables in the workspace may be identified in any manner including, for example, by reviewing programming code and/or documentation.

[0126] Variables in a workspace may be edited either via the example of the user interface shown in FIGS. 4E-G and/or via an application programming interface (API). Variables may also be uploaded via, for example, the first configuration file **125a** and/or the second configuration file **125b**. For large quantities of complex variables, a command line interface (CLI) tool may be used to update the variables in the workspace using a local variables file.

[0127] FIGS. 4E-G further depict how the variables of the workspace may be edited using a first button **2710** and/or a second button **2740**. In particular, FIGS. 4F-G depict examples of the user interface when a first variable **2810** and a second variable **2910** are in an editing mode. New variables may also be added by completing the field **2890** and/or the field **2990** before clicking the button **2830** and/or the button **2930**. Variables may also be removed by clicking on the button **2820** and/or the button **2920**. Where the field **2860** and/or the field **2960** contain sensitive values (e.g., passwords, keys, and/or the like), these values may be securely stored by checking the box **2840** and/or the box **2940**.

[0128] It should be appreciated that marking a variable as sensitive may limit how the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b** may interact with the variable. For example, no user including, for example, the user who created and/or modified the variable, may view and/or modify the value of the variable, whether displayed in a user interface and/or retrieved via an application programming interface (API). Instead, modifying a sensitive variable may require deleting the existing variable and creating a new variable. The values of at least some variables may be encrypted prior to being stored, for example, as part of the workspace.

[0129] FIG. 4H depicts the configuration designer **3010** used to outline a configuration for a new workspace, which may include, selecting from the module registry **115**, the first module **116a**, the second module **116b**, and/or the like. The variables of the selected module may be listed as a fillable hypertext markup language (HTML) form, with a helper interface for finding interpolatable values. Once completed, the configuration designer **3010** may return the first configuration file **125a** and/or the second configuration file **125b**, which may subsequently merged into the workspace.

[0130] To select and/or add, for example, to the second configuration file **125b**, the first module **116a** and/or the second module **116b**, the second user **145b** at the second client **120b** may navigate to a list of modules using the button **3085**. The “Select Modules” page **3000** may display a filterable and/or searchable list **3030** of at least a portion of the modules available from the module registry **115**. Any quantity of modules from the filterable and/or searchable list **3030** may be added to by clicking the button **3020**. List **3040** may display a list of the selected modules.

[0131] By default, selecting a module may add the most recent version of the module, for example, to the second configuration file **125b**. A different version of the module may be selected by clicking on the module’s version number **3050** in the list **3040**. The “Set Variables” page **3015** shown in FIG. 4J may be accessed by clicking the button **3070**. The “Set Variables” page **3015** may display a variables list **3090** for the module **3082** selected from the list **3080**. The variables list **3090** of the module **3082** may be viewed by clicking the button **3084**. Each variable may be labeled as required or optional. Once a value is set for all of a module’s required variables, the button **3084** may change to a “configured” button. When all modules are configured, FIG. 4I shows that the finished configuration may be viewed by clicking the button **3086**.

[0132] As shown in FIG. 4J, one user may delegate the setting and/or modifying of a variable in a module to another users by selecting a “deferred” checkbox, which ties the value of the variable to a new top-level variable having no default value. Anyone creating a workspace using the module may have an opportunity to provide a value for the delegated variable. Once complete, the first configuration file **125a** and/or the second configuration file **125b** may be viewed by clicking the button **3086**. The corresponding code may be copied into a text editor, saved as a `main.tf` file in a new directory, and committed to the version controller **140** to enable subsequent merging into a corresponding workspace. Additional changes to the first configuration file **125a** and/or the second configuration file **125b** may be made without selecting and adding existing modules from the module registry **115**.

[0133] Referring to FIG. 4K, only team **420** with administrative access for a workspace may make changes to settings of the workspace. The information technology infrastructure controller **110** may be configured to automatically apply the execution plan **190** by selecting the auto apply option. When the auto apply option is selected, the information technology infrastructure controller **110** may automatically apply, to the information technology infrastructure **130**, the configurations associated with the execution plan **190**, for example, when the execution plan **190** is successfully validated. By contrast, if the manual apply option is selected, the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b** may be required

to provide a confirmation before the configurations associated with the execution plan **190** are applied to the information technology infrastructure **130**.

[0134] Referring to FIG. 4L, if a key is required for the repository linked to the workspace, then a unique identifier associated with the key may be selected in the field **3470**. Clicking the button **3410** may update the key, which may be modified by the first user **145a** and/or the second user **145b** if the first user **145a** and/or the second user **145b** have administrative access. The information technology infrastructure controller **110** may use the key for cloning modules used during one or more runs of the execution plan **190**. As used here, the key may refer to, for example, a secure shell (SSH) key.

[0135] A workspace may be locked and/or unlocked by the first user **145a** and/or the second user **145b** if the first user **145a** and/or the second user **145b** has write access or administrative access. Locking a workspace may prevent users with write access from manually queuing runs, prevent automatic runs due to the first configuration file **125a** and/or the second configuration file **125b** being committed to the version controller **140**, prevent creation of runs via an application programming interface (API), prevent creation of runs using a command line interface (CLI) tool, and/or the like. To enable runs, the workspace may be unlocked via the toggle button **3430**.

[0136] In some example embodiments, having administrative access may enable the first user **145a** and/or the second user **145b** to delete a workspace. Before deleting the workspace, the first user **145a** and/or the second user **145b** may set the environment variable “CONFIRM_DESTROY” to “1” for the workspace and queue a destroy plan. Queueing a destroy plan may destroy the resources in the information technology infrastructure **130** managed by the workspace. It should be appreciated that resources must be destroyed before deleting a corresponding workspace. Otherwise, if the resources are not destroyed before deleting the workspace, these resources may become unmanaged and may require destruction by the first provider **150a** and/or the second provider **150b**.

[0137] In some example embodiments, the information technology infrastructure controller **110** may store one or more keys (e.g., secure shell (SSH) keys) such that the keys may be used in that clones modules from a server that requires credentials such as, for example, the version controller **140**. The information technology infrastructure controller **110** may manage the keys used to clone modules at the organization level and may allow multiple keys to be associated with, for example, the organization **155**. Keys may be added or deleted via organizational settings. Once a key is uploaded, the text of the key may be hidden from the first user **145a** at the first client **120a** and/or the second user **145b** at the second client **120b**.

[0138] The first user **145a** and/or the second user **145b** may set up an organizational key using, for example, the user interface shown in FIG. 4M. For example, as shown in FIG. 4M, to add a key (e.g., a secure shell (SSH) key) to the information technology infrastructure controller **110**, the first user **145a** and/or the second user **145b** may obtain a key pair that the information technology infrastructure controller **110** may use to download one or more modules (e.g., the first

module **116a**, the second module **116b**, and/or the like) during the running, for example, of the execution plan **190**. A key pair may be created using the following command:

```
[0139] ssh-keygen -t rsa -f “/Users/<NAME>/ssh/service_tfe”-C “service_terraform_enterprise”
```

[0140] The command above may create a service_tfe file with a private key as well as a service_tfe.pub file with the public key. The public key may be distributed, for example, to the version controller **140**. Meanwhile, as shown in FIG. 4M, a unique identifier for the private key **1040** may be entered in the field **3570** and the text of the private key **1040** may be entered in the field **3520** before the private key **1040** may be added by clicking the “Add Private SSH Key” button. Upon adding the private key **1040**, the key may appear in the list of keys **3740**, which may list the private key **1040** using the unique identifier **1062** of the private key **1040**. While the information technology infrastructure controller **110** may retain the text of the private key **1040**, the text of the private key **1040** may remain hidden from the first user **145a** and/or the second user **145b**.

[0141] Furthermore, FIGS. 4N-M shows that to delete a key (e.g., a secure shell (SSH) key), the first user **145a** and/or the second user **145b** may replace the key in the field **3470** in the workspace settings of the workspaces that use the key with another key. The first user **145a** and/or the second user **145b** may further click the “Destroy” button next to the keys’ unique identifier in the list of keys **3740**.

[0142] As noted, the first user **145a** and/or the second user **145b** may have access (e.g., read access, write access, administrative access, and/or the like) to a workspace by being associated with a team having access to the workspace. As shown in FIG. 4M, a team may be accorded access to the workspace by being added to the workspace and by setting the access privileges associated with the team. Each workspace may be associated with at least one team (e.g., the team **3260**) that has full access to the workspace including, for example, read access, write access, administrative access, and/or the like. Removing a team from a workspace may remove the team’s access to the workspace.

[0143] Referring now to FIG. 5A, all users in the organization **155** (e.g., the first user **145a**, the second user **145b**, and/or the like) may view the module registry **115**, which may be associated exclusively with the organization **196**. Alternatively, one or more of the modules in the module registry **115** may only be visible to some users or groups of users within the organization **155** but remain hidden from others users or groups of users within the organization **155**. In some example embodiments, a workspace associated with the organization **155** may only be permitted to use modules associated with the organization **155**. For a module to be available to users from more than one organization, the same module may be added to the module registry of each organization.

[0144] As shown in FIG. 5A, a list of available modules for an organization may be accessed by clicking the button **4020** in the main navigation bar. The modules page **4000** may list the available modules for an organization. The drop-down **4010** may be used to filter the list to show modules for one or more selected providers. The field **4050** may be used to enter a search for modules by keyword. The details associated with a module may be viewed by clicking the button **4060**. The dropdown **4070** may be used to switch between different versions of the same module. Selecting the tabs **4110** may provide detailed documentation for each

version of a module. Any module from an organization's module registry may be added to a configuration file such as, for example, the first configuration file **125a**, the second configuration file **125b**, and/or the like. Table 6 below depicts the syntax for referencing modules in source attributes.

TABLE 6

<TFE HOSTNAME>/<TFE ORGANIZATION>/ <MODULE NAME>/<PROVIDER>
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[0145] As noted, the module registry **115** may allow a corresponding organization to publish configuration modules for consumption by users across an organization **155**. The privilege to publish, for example, the first module **116a** and/or the second module **116b** to the module registry **115** may be limited to certain users and/or certain teams within the organization **155**. Once the first module **116a** and/or the second module **116b** is published to the module registry **115**, the version controller **140** may be configured to manage the release of new versions of the first module **116a** and/or the second module **116b**.

[0146] The first module **116a** and/or the second module **116b** may be published to the module registry **115** of the organization **155** by at least providing the name of a corresponding repository to the information technology infrastructure controller **110**. The module registry **115** may use the name of the repository to determine a name and a provider for each of the first module **116** and/or the second module **116b**. The module registry **115** may further use the repository's tags to identify one or more available versions of the first module **116** and/or the second module **116b**. Furthermore, the module registry may format documentation for each version of the first module **116a** and/or the second module **116b** based on the corresponding README and/or configurations in the repository. A new version of the first module **116** and/or the second module **116b** may be released by pushing a new tag to its repository. The module registry **115** may be update automatically, for example, to include new versions of the first module **116a** and/or the second module **116b**.

[0147] Consumers of a module do not need access to its source repository; the module registry **115** may handle downloads and may further use application programming interface (API) tokens associated with the information technology infrastructure controller **110** to control access to the module registry **115** and/or any infrastructure modules at the module registry **115**. Modules can be shared by multiple organizations by sharing the underlying VCS repository. Each organization **155** is granted access to the module's repository and then added to each organization's module registry. When tags are pushed to publish new module versions of the modules, all organizations' registries will update appropriately.

[0148] In some example embodiments, a module repository may reside at the version controller **140** while the information technology infrastructure controller **110** may have access (e.g., administrative access) to that repository. Since the module registry **115** may rely on a webhook to import new versions of the first module **116a** and/or the second module **116b** from the version controller **140**, the information technology infrastructure controller **110** may be required to have sufficient access privileges to create the

webhook. The first module **116a** and/or the second module **116b** may be required to conform to a standard structure to enable the module registry **115** to perform inspection, generate documentation, track resource usage, and/or the like.

[0149] As shown in FIG. 5A, the first module **116a** and/or the second module **116b** may be published clicking the button **4030** on the modules page **4000**, selecting the version controller **140** the list of VCS providers **4230**, entering the name of the repository, and clicking on the button **4210**. A new version of the first module **116a** and/or the second module **116b** may be added by pushing a new version tag to a corresponding repository at the version controller **140**. Pushing the new version tag (e.g., v1.0.4 and 0.9.2) may cause the module registry **115** to automatically import the new version of the first module **116a** and/or the second module **116b**. The module registry **115** may be configured to import new versions of the first module **116a** and/or the second module **116b** automatically, for example, when new versions of the first module **116a** and/or the second module **116b** are detected at the VCS providers **4230**. Alternatively and/or additionally, the module registry **115** may interact with the VCS provider **4230** periodically to determine whether new versions of the first module **116a** and/or the second module **116b** have been added to the VCS provider **4230**.

[0150] Referring to FIG. 5B, the first module **116a**, the second module **116b**, and/or any version thereof may be navigating to the module's details page. Each module's details page may include the button **4120**, which may be used to delete a version of the module and/or the module in its entirety. For example, a single version of a module may be deleted by selecting the version of the module to be deleted and then clicking on the button **4120**.

[0151] FIGS. 6A-C depict examples of user interfaces for interacting with runs within a workspace. Referring to FIG. 6A, all runs of the execution plan **190** may be performed within at least one workspace such as, for example, the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**. The first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may provide the state **526**, the variables **3750**, and the variables **3760** required for the run. The first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** may further specify the sources **810** and **820** of the configuration. Each workspace may include a button **3755** to start a run, a link **3765** to the full list of runs, and a link **3775** to the most recent active run or the last completed run. It should be appreciated that the most recent active run may not be the most recently initiated run because pending runs may remain inactive until the completion of a current run. Runs may be processed one at a time in order and only one active run may be permitted for each workspace. Whenever a new run is initiated, the run may be added to an end of a run queue. When a run in progress, the new run may be held in abeyance until the current run is complete.

[0152] The runs page may display the run name **3720**, the identity of the user who initiated the run **3710**, and the source of the run start **3730** (e.g., version controller **140**, the information technology infrastructure controller **110**, and/or the like). The run page may also display the name of the branch **3770**, the code commit for the run **3760**, and the status of the run **3750**. As noted, a run may be started via the information technology infrastructure controller **110** or the version controller **140**. Alternatively, a run may also be

created via a command line interface (CLI) and initiated via a user interface. When a run is initiated, the information technology infrastructure controller **110** may lock the run, for example, to the first configuration file **125a**. Any subsequent changes, for example, from the second configuration file **125b**, may apply to future runs but not the runs that are already in progress (e.g., pending, planning, or awaiting to be applied to the information technology infrastructure **130**).

[0153] The information technology infrastructure controller **110** may be configured to initiate a run for the execution plan **190** automatically. Whenever a new commit is detected at the version controller **140**, the information technology infrastructure controller **110** may respond by queuing a corresponding plan. The first user **145a** and/or the second user **145b** may also queue a plan, for example, after editing one or more variables associated with the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c**. Each run of a plan may pass through several stages of action including, for example, pending, planning, policy checking, applying, complete, and/or the like. The information technology infrastructure controller **110** may be configured to provide an indication of the status of each run. For example, in the list of workspaces, each workspace may be shown with the status of a current run and/or the most recently completed run.

[0154] FIG. 6B depicts an individual run page configured to display the progress and outcomes of each stage of a run. The run page may show a current status of the run **3820**, the code commit associated with the run **3810**, the manner in which the run was initiated **3865**, when the run was initiated **3885**, the user **3840** initiating the run, a timeline of events related to the run, the output **3930** from the plan, and/or the like.

[0155] Where a user has sufficient access privileges (e.g., write access) to a workspace, the run page may provide controls for interacting with a run while the run is in progress. For example, the run may be cancelled while the run is in progress or the execution plan **190** may be discarded before the execution plan **190** is applied during the run. One or more of the first policy **175a**, the second policy **175b**, first quota **175c**, and/or the second quota **175d** may also be overridden and thus excluded from the validation of the execution plan **190**. A user with sufficient access privileges (e.g., write access or administrative access) to the workspace may temporarily suspend the queuing of runs by at least locking the workspace. New runs may remain in a pending state until the workspace is unlocked.

[0156] Current and historical state data for a workspace may be viewed from a “states” tab. Each state in the list may be associated with a run and/or a commit to the version controller **140**. Each state in the list may be further associated with a link to a raw state file and a delta file storing one or more differences between a current state and a previous state. A given workspace may access state data for workspaces within the same organization (e.g., the first workspace **165a**, the second workspace **165b**, and/or the third workspace **165c** associated with the organization **155**). In some example embodiments, outputs from other workspaces may be accessed remotely, for example, by being added as a data source in the first configuration file **125a** and/or the second configuration file.

[0157] In some example embodiments, the information technology infrastructure controller **110** may generate a token (e.g., an application programming interface (API)

token) that is unique to each run. The token may be exported to the shell environment. Moreover, the token may be used to read and/or write state data for the workspace associated with the run as well as to read state data from any other workspace in the same organization **155**. However, a token may become invalid after a corresponding run is complete.

[0158] FIG. 7 depicts a block diagram illustrating a computing system **700** consistent with implementations of the current subject matter. Referring to FIGS. 1A-C and 7, the computing system **700** can be used to implement the information technology infrastructure controller **110** and/or any components therein.

[0159] As shown in FIG. 7, the computing system **700** can include a processor **710**, a memory **720**, a storage device **730**, and input/output device **740**. The processor **710**, the memory **720**, the storage device **730**, and the input/output device **740** can be interconnected via a system bus **750**. The processor **710** is capable of processing instructions for execution within the computing system **700**. Such executed instructions can implement one or more components of, for example, the information technology infrastructure controller **110**. In some implementations of the current subject matter, the processor **710** can be a single-threaded processor. Alternately, the processor **710** can be a multi-threaded processor. The processor **710** is capable of processing instructions stored in the memory **720** and/or on the storage device **730** to display graphical information for a user interface provided via the input/output device **740**.

[0160] The memory **720** is a computer readable medium such as volatile or non-volatile that stores information within the computing system **700**. The memory **720** can store data structures representing configuration object databases, for example. The storage device **730** is capable of providing persistent storage for the computing system **700**. The storage device **730** can be a floppy disk device, a hard disk device, an optical disk device, a tape device, a solid state device, and/or any other suitable persistent storage means. The input/output device **740** provides input/output operations for the computing system **700**. In some implementations of the current subject matter, the input/output device **740** includes a keyboard and/or pointing device. In various implementations, the input/output device **740** includes a display unit for displaying graphical user interfaces.

[0161] According to some implementations of the current subject matter, the input/output device **740** can provide input/output operations for a network device. For example, the input/output device **740** can include Ethernet ports or other networking ports to communicate with one or more wired and/or wireless networks (e.g., a local area network (LAN), a wide area network (WAN), the Internet).

[0162] In some implementations of the current subject matter, the computing system **700** can be used to execute various interactive computer software applications that can be used for organization, analysis and/or storage of data in various (e.g., tabular) format (e.g., Microsoft Excel®, and/or any other type of software). Alternatively, the computing system **700** can be used to execute any type of software applications. These applications can be used to perform various functionalities, e.g., planning functionalities (e.g., generating, managing, editing of spreadsheet documents, word processing documents, and/or any other objects, etc.), computing functionalities, communications functionalities, etc. The applications can include various add-in function-

alities or can be standalone computing products and/or functionalities. Upon activation within the applications, the functionalities can be used to generate the user interface provided via the input/output device 740. The user interface can be generated and presented to a user by the computing system 700 (e.g., on a computer screen monitor, etc.).

[0163] One or more aspects or features of the subject matter described herein can be realized in digital electronic circuitry, integrated circuitry, specially designed ASICs, field programmable gate arrays (FPGAs) computer hardware, firmware, software, and/or combinations thereof. These various aspects or features can include implementation in one or more computer programs that are executable and/or interpretable on a programmable system including at least one programmable processor, which can be special or general purpose, coupled to receive data and instructions from, and to transmit data and instructions to, a storage system, at least one input device, and at least one output device. The programmable system or computing system can include users and servers. A user and server are generally remote from each other and typically interact through a communication network. The relationship of user and server arises by virtue of computer programs running on the respective computers and having a user-server relationship to each other.

[0164] These computer programs, which can also be referred to as programs, software, software applications, applications, components, or code, include machine instructions for a programmable processor, and can be implemented in a high-level procedural and/or object-oriented programming language, and/or in assembly/machine language. As used herein, the term “machine-readable medium” refers to any computer program product, apparatus and/or device, such as for example magnetic discs, optical disks, memory, and Programmable Logic Devices (PLDs), used to provide machine instructions and/or data to a programmable processor, including a machine-readable medium that receives machine instructions as a machine-readable signal. The term “machine-readable signal” refers to any signal used to provide machine instructions and/or data to a programmable processor. The machine-readable medium can store such machine instructions non-transitorily, such as for example as would a non-transient solid-state memory or a magnetic hard drive or any equivalent storage medium. The machine-readable medium can alternatively or additionally store such machine instructions in a transient manner, such as for example, as would a processor cache or other random access memory associated with one or more physical processor cores.

[0165] To provide for interaction with a user, one or more aspects or features of the subject matter described herein can be implemented on a computer having a display device, such as for example a cathode ray tube (CRT) or a liquid crystal display (LCD) or a light emitting diode (LED) monitor for displaying information to the user and a keyboard and a pointing device, such as for example a mouse or a trackball, by which the user can provide input to the computer. Other kinds of devices can be used to provide for interaction with a user as well. For example, feedback provided to the user can be any form of sensory feedback, such as for example visual feedback, auditory feedback, or tactile feedback; and

input from the user can be received in any form, including acoustic, speech, or tactile input. Other possible input devices include touch screens or other touch-sensitive devices such as single or multi-point resistive or capacitive track pads, voice recognition hardware and software, optical scanners, optical pointers, digital image capture devices and associated interpretation software, and the like.

[0166] The subject matter described herein can be embodied in systems, apparatus, methods, and/or articles depending on the desired configuration. The implementations set forth in the foregoing description do not represent all implementations consistent with the subject matter described herein. Instead, they are merely some examples consistent with aspects related to the described subject matter. Although a few variations have been described in detail above, other modifications or additions are possible. In particular, further features and/or variations can be provided in addition to those set forth herein. For example, the implementations described above can be directed to various combinations and subcombinations of the disclosed features and/or combinations and subcombinations of several further features disclosed above. In addition, the logic flows depicted in the accompanying figures and/or described herein do not necessarily require the particular order shown, or sequential order, to achieve desirable results. For example, the logic flows can include different and/or additional operations than shown without departing from the scope of the present disclosure. One or more operations of the logic flows can be repeated and/or omitted without departing from the scope of the present disclosure. Other implementations can be within the scope of the following claims.

What is claimed is:

1. A system, comprising:

at least one data processor; and

at least one memory storing instructions which, when executed by the at least one data processor, result in operations comprising:

generating a first workspace and a second workspace, the first workspace configured to maintain a first set of configurations for an information technology infrastructure, and the second workspace configured to maintain a second set of configurations for the information technology infrastructure;

merging, into the first workspace and/or the second workspace, a configuration file specifying one or more configurations to apply to the information technology infrastructure;

generating, based at least on the first workspace and/or the second workspace, an execution plan that includes one or more operations to apply, to the information technology infrastructure, the one or more configurations specified in the configuration file; and

applying, based at least on the execution plan, the one or more configurations including by at least provisioning, modifying, and/or de-provisioning one or more resources at the information technology infrastructure.

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