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(54) **SYSTEMS AND METHODS FOR EFFICIENT AND SCALABLE ROUTING FOR CONTAINERIZED SERVICES**

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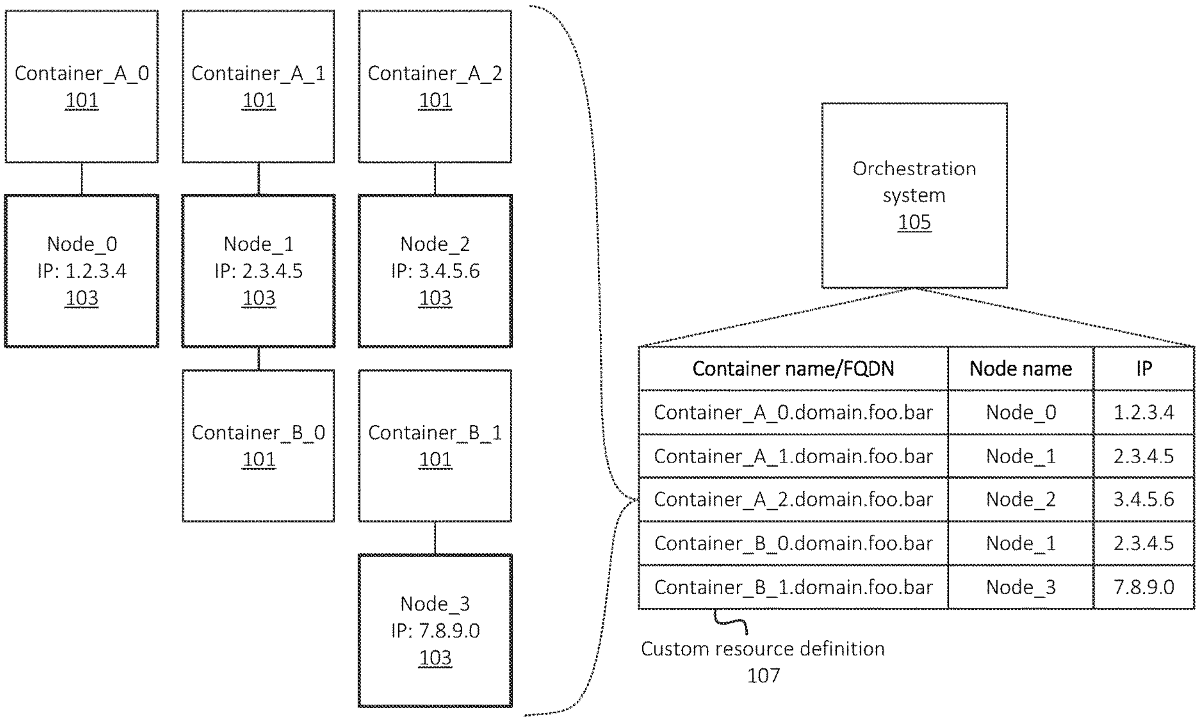
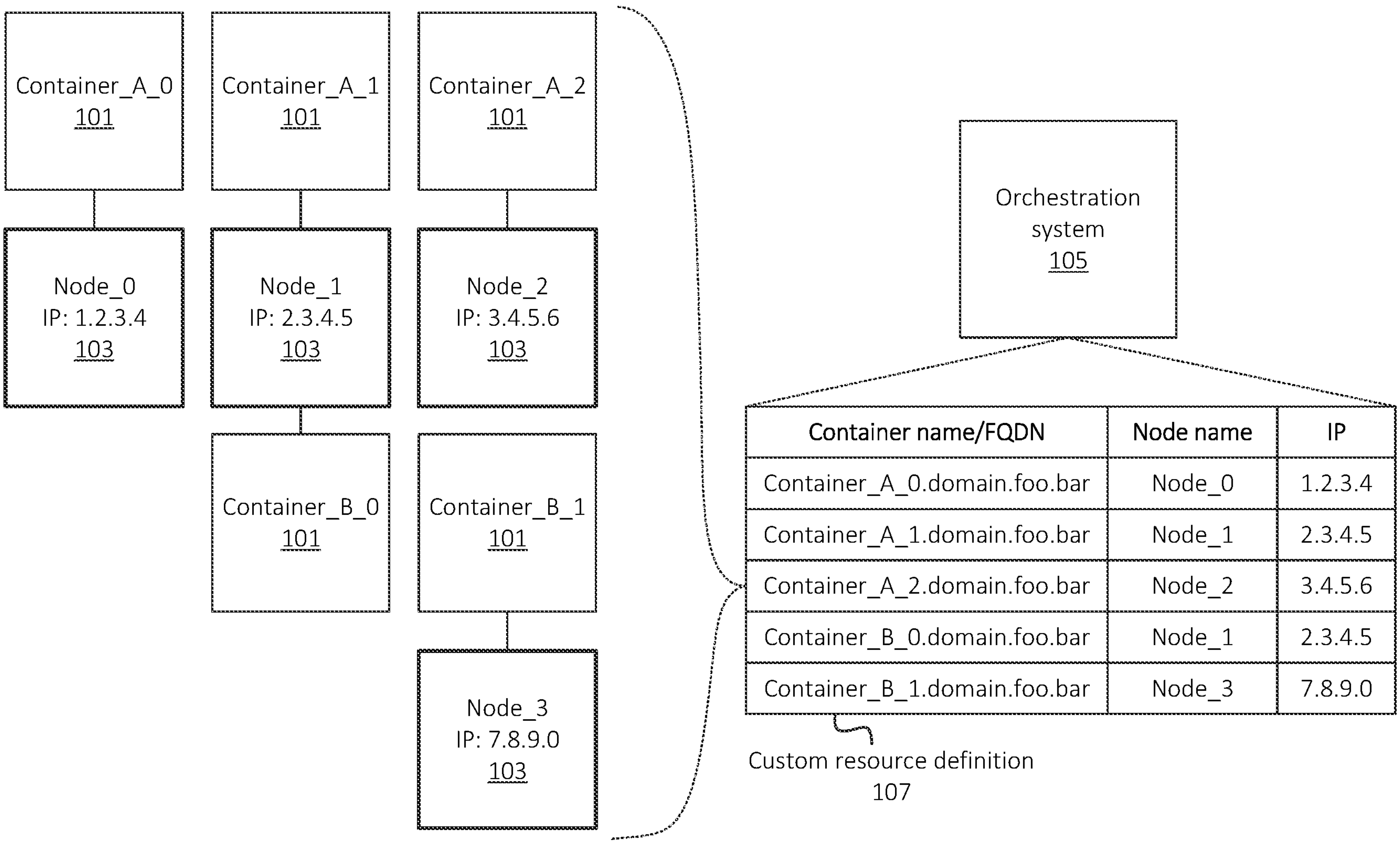
(57) **ABSTRACT**

A system described herein may identify that a first container and a second container of a virtualized environment are instantiated at a particular node that is associated with a particular address (e.g., an Internet Protocol ("IP") address). The system may identify a logical association between the first and second containers, such as a logical and/or hierarchical association specified by a custom resource definition. The system may generate a first Domain Name System ("DNS") record (e.g., an "A" record) associating the first container with the address of the particular node, and may a second DNS record (e.g., a "CNAME" record) associating the second container with the first container. The system may provide the first and second DNS records to a DNS server, which may provide the address of the particular node when receiving a DNS request specifying the second container.

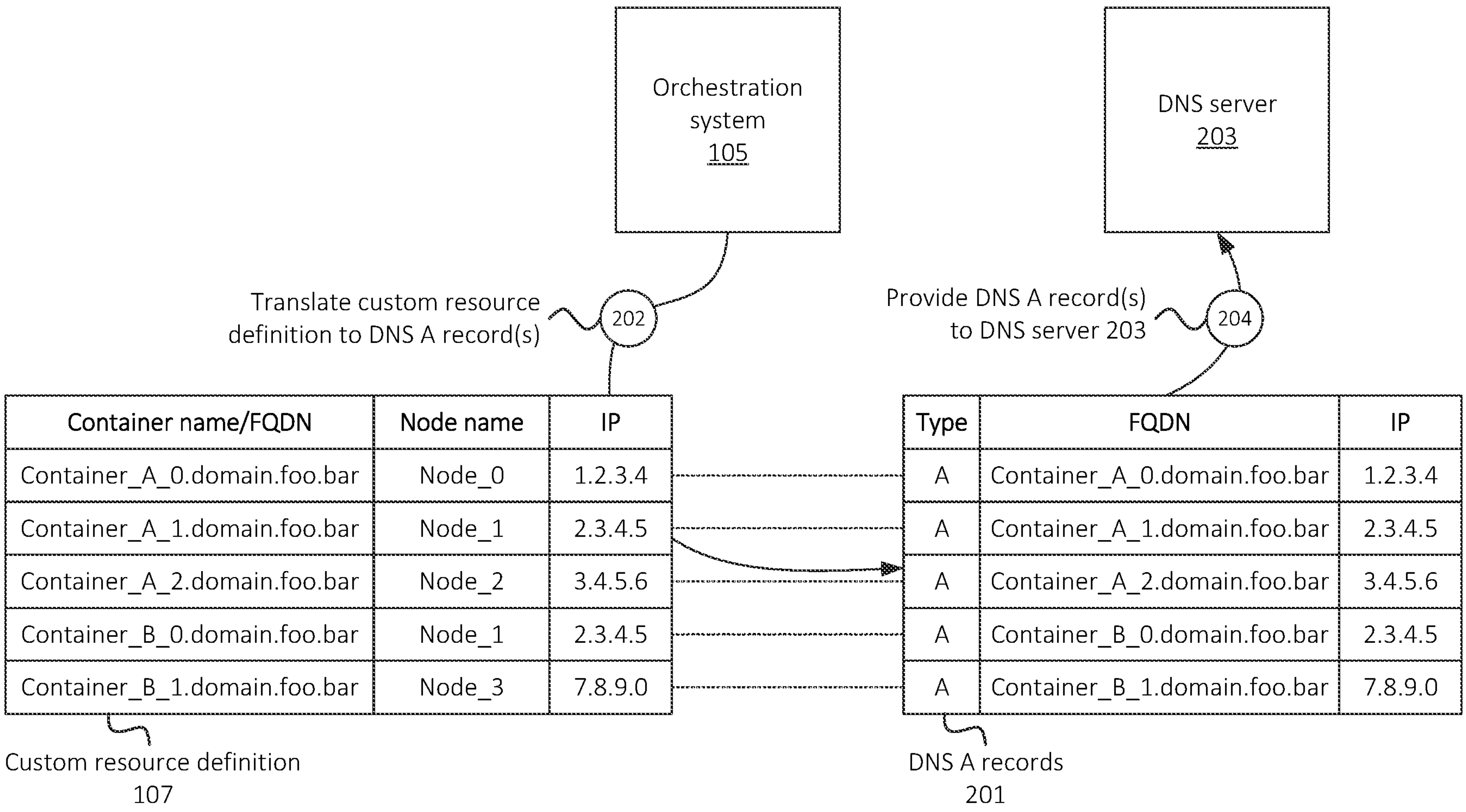


Container name/FQDN	Node name	IP
Container_A_0.domain.foo.bar	Node_0	1.2.3.4
Container_A_1.domain.foo.bar	Node_1	2.3.4.5
Container_A_2.domain.foo.bar	Node_2	3.4.5.6
Container_B_0.domain.foo.bar	Node_1	2.3.4.5
Container_B_1.domain.foo.bar	Node_3	7.8.9.0



Container name/FQDN	Node name	IP
Container_A_0.domain.foo.bar	Node_0	1.2.3.4
Container_A_1.domain.foo.bar	Node_1	2.3.4.5
Container_A_2.domain.foo.bar	Node_2	3.4.5.6
Container_B_0.domain.foo.bar	Node_1	2.3.4.5
Container_B_1.domain.foo.bar	Node_3	7.8.9.0

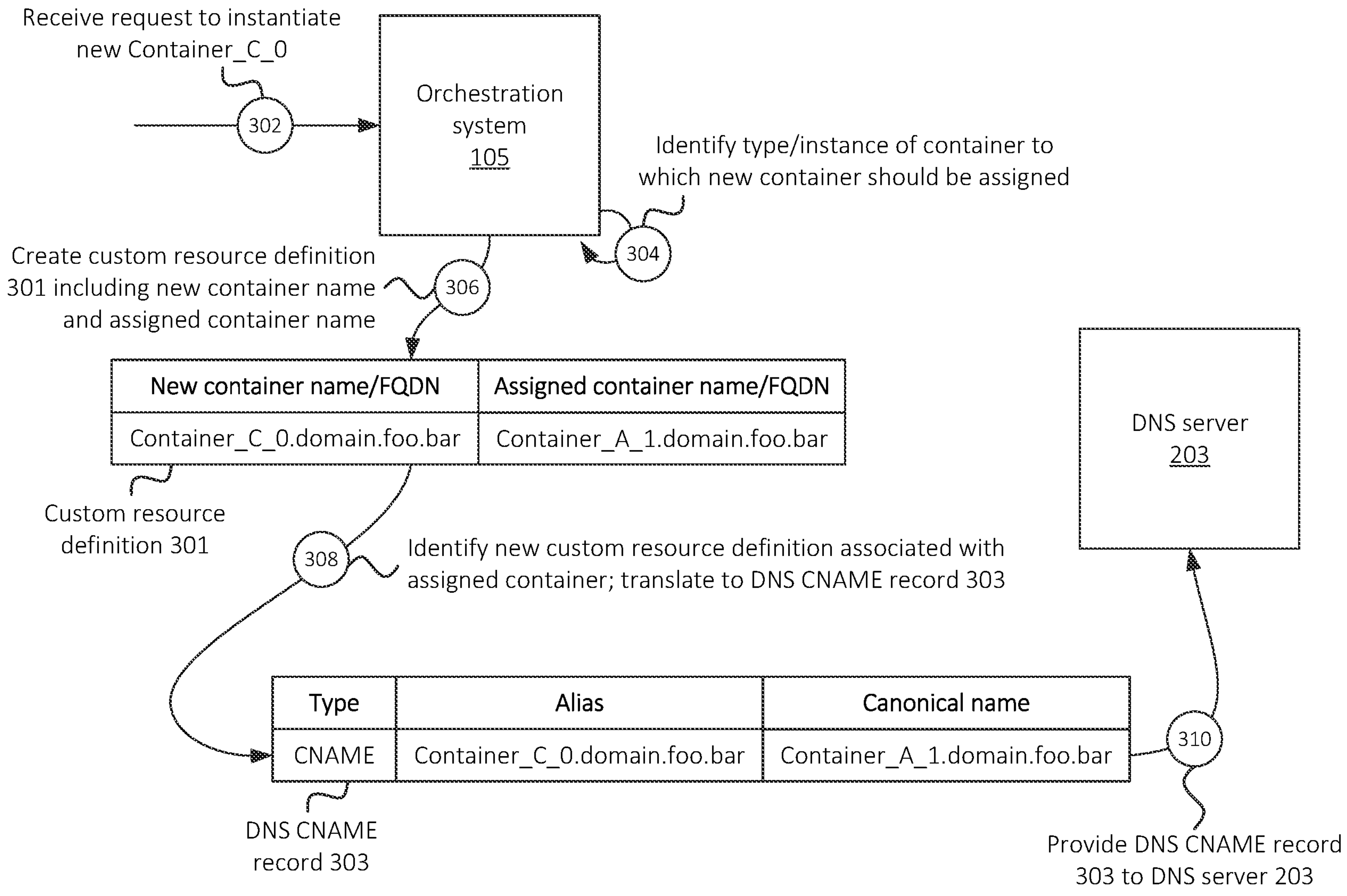
FIG. 1


Orchestration system 105
DNS server 203
Translate custom resource definition to DNS A record(s)
202
Provide DNS A record(s) to DNS server 203
204
Custom resource definition 107
DNS A records 201

Container name/FQDN	Node name	IP
Container_A_0.domain.foo.bar	Node_0	1.2.3.4
Container_A_1.domain.foo.bar	Node_1	2.3.4.5
Container_A_2.domain.foo.bar	Node_2	3.4.5.6
Container_B_0.domain.foo.bar	Node_1	2.3.4.5
Container_B_1.domain.foo.bar	Node_3	7.8.9.0

Type	FQDN	IP
A	Container_A_0.domain.foo.bar	1.2.3.4
A	Container_A_1.domain.foo.bar	2.3.4.5
A	Container_A_2.domain.foo.bar	3.4.5.6
A	Container_B_0.domain.foo.bar	2.3.4.5
A	Container_B_1.domain.foo.bar	7.8.9.0

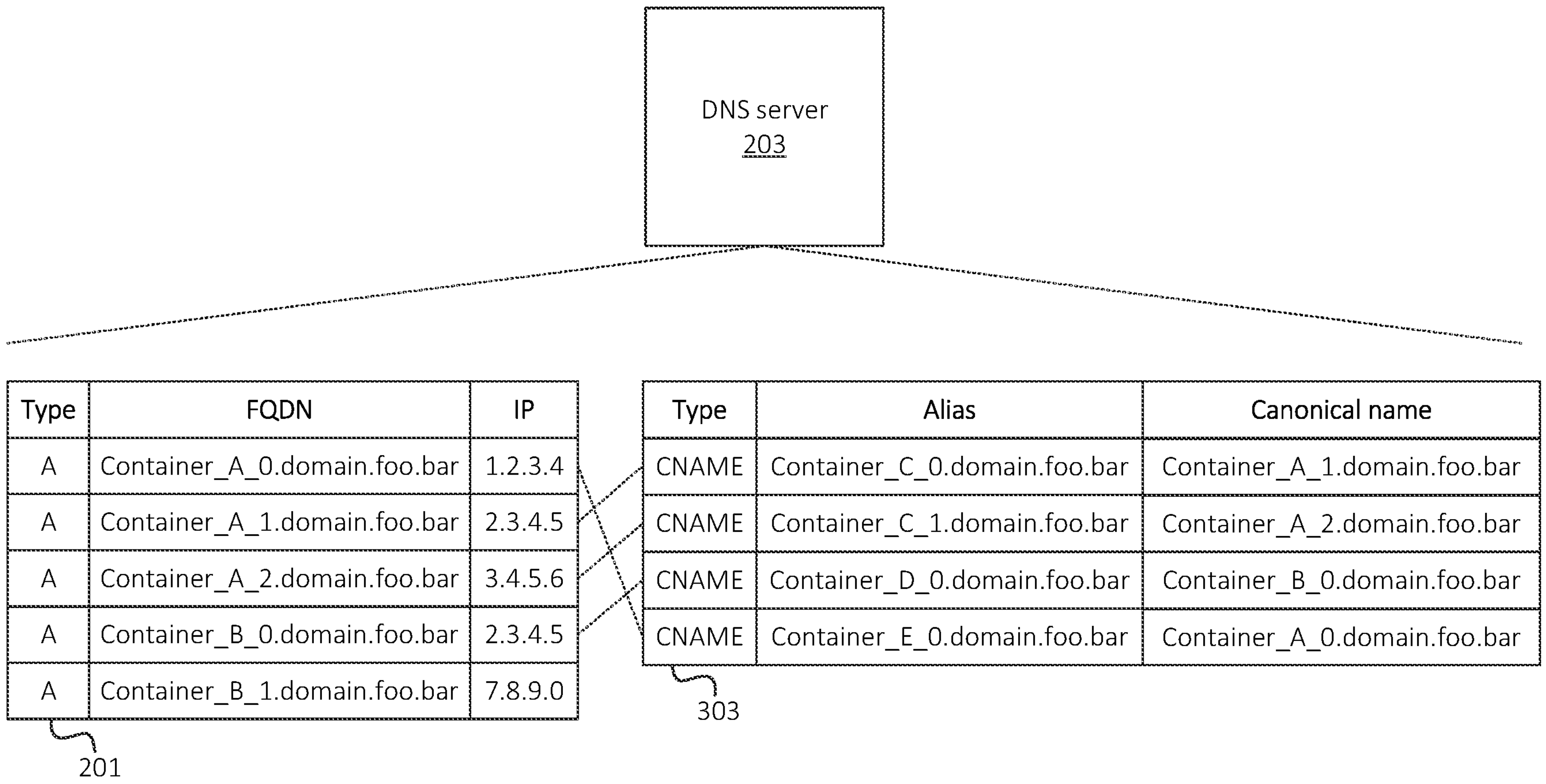
FIG. 2


Receive request to instantiate new Container_C_0
302
Orchestration system 105
Identify type/instance of container to which new container should be assigned
304
Create custom resource definition 301 including new container name and assigned container name
306
Custom resource definition 301
308
Identify new custom resource definition associated with assigned container; translate to DNS CNAME record 303
DNS CNAME record 303
310
Provide DNS CNAME record 303 to DNS server 203
DNS server 203

New container name/FQDN	Assigned container name/FQDN
Container_C_0.domain.foo.bar	Container_A_1.domain.foo.bar

Type	Alias	Canonical name
CNAME	Container_C_0.domain.foo.bar	Container_A_1.domain.foo.bar

FIG. 3



Type	FQDN	IP
A	Container_A_0.domain.foo.bar	1.2.3.4
A	Container_A_1.domain.foo.bar	2.3.4.5
A	Container_A_2.domain.foo.bar	3.4.5.6
A	Container_B_0.domain.foo.bar	2.3.4.5
A	Container_B_1.domain.foo.bar	7.8.9.0

Type	Alias	Canonical name
CNAME	Container_C_0.domain.foo.bar	Container_A_1.domain.foo.bar
CNAME	Container_C_1.domain.foo.bar	Container_A_2.domain.foo.bar
CNAME	Container_D_0.domain.foo.bar	Container_B_0.domain.foo.bar
CNAME	Container_E_0.domain.foo.bar	Container_A_0.domain.foo.bar

FIG. 4

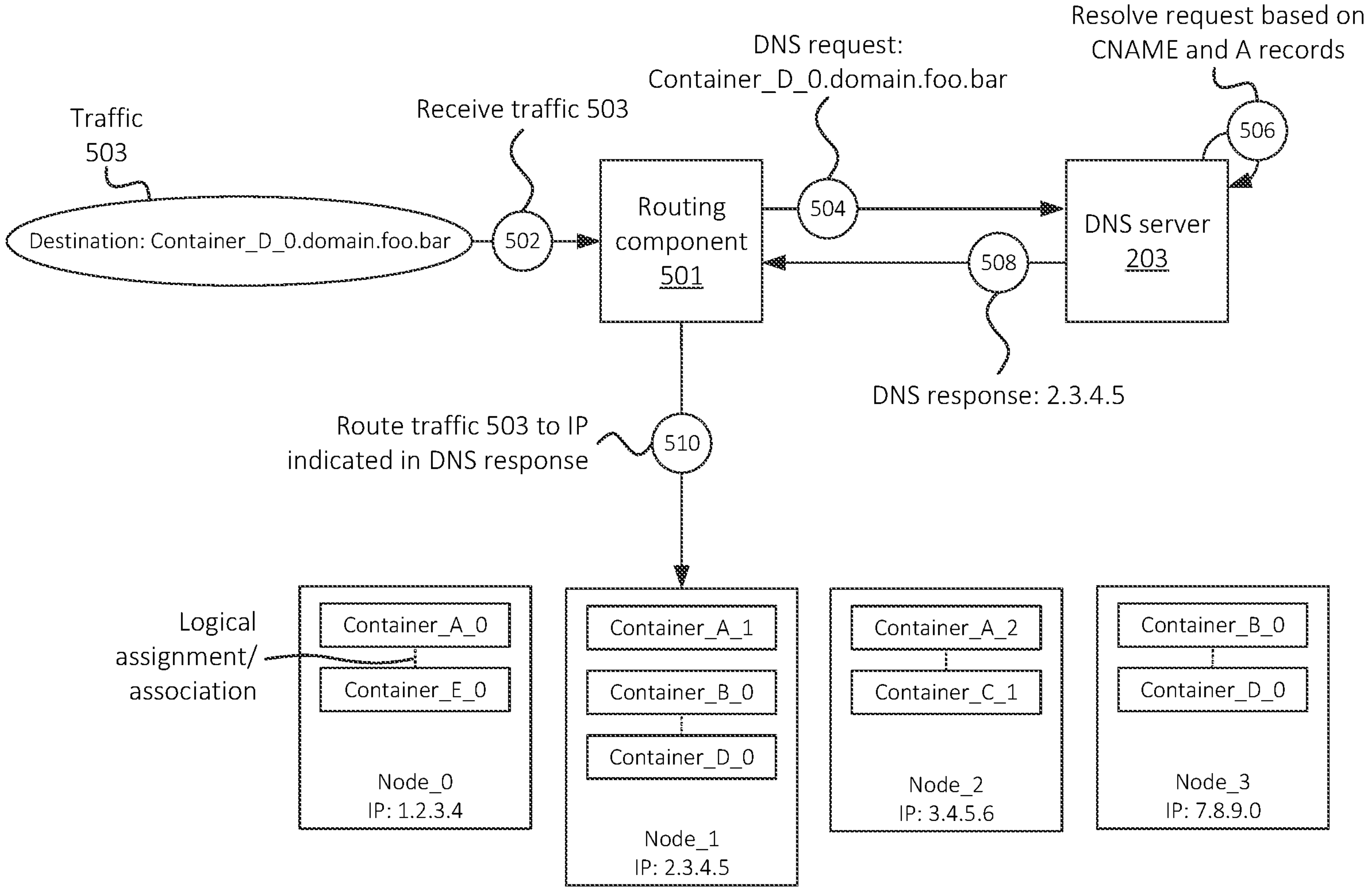
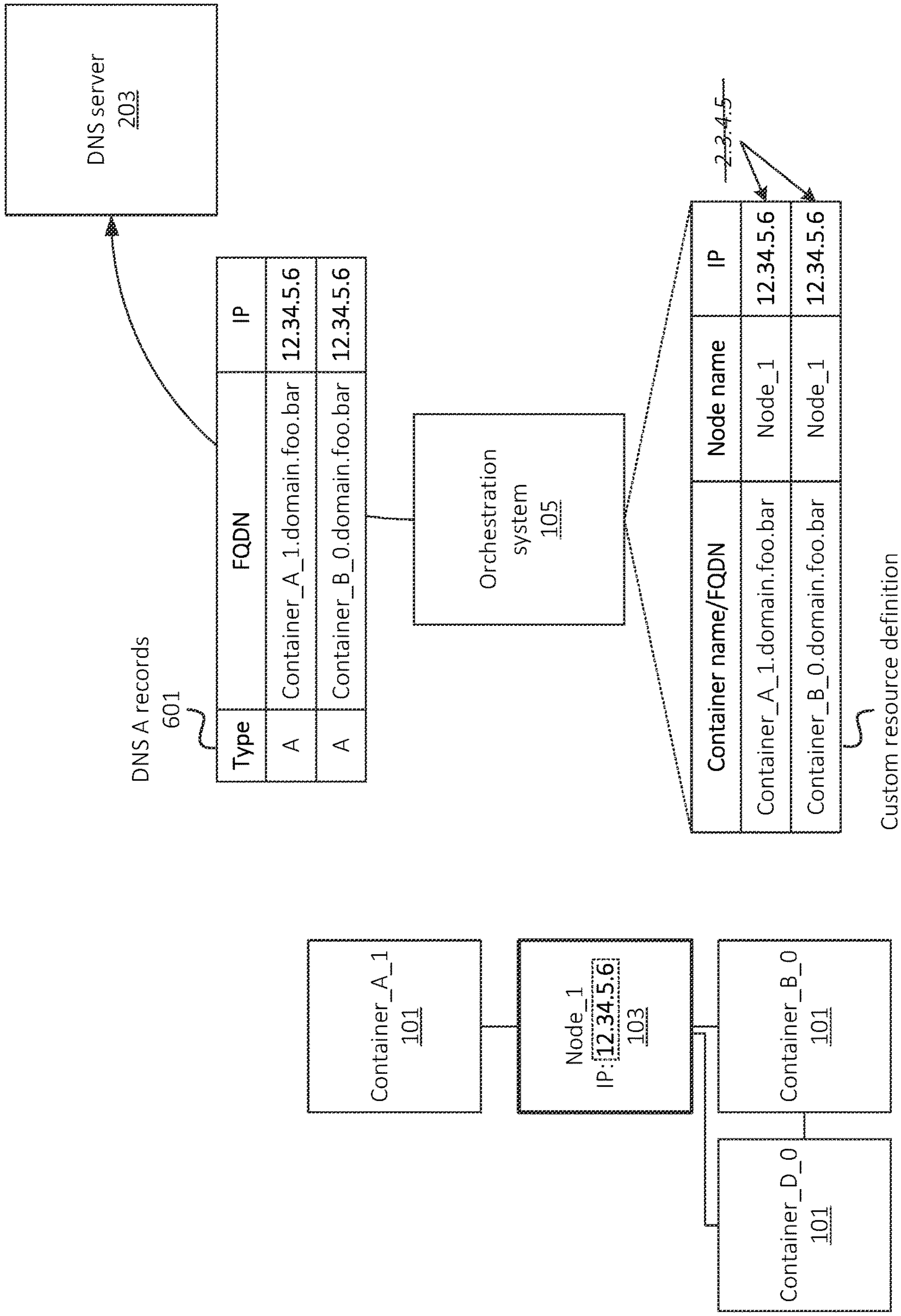

Traffic
503
Destination: Container_D_0.domain.foo.bar
Receive traffic 503
502
Routing
component
501
DNS request:
Container_D_0.domain.foo.bar
504
DNS server
203
Resolve request based on
CNAME and A records
506
508
DNS response: 2.3.4.5
Route traffic 503 to IP
indicated in DNS response
510
Logical
assignment/
association
Container_A_0
Container_E_0
Node_0
IP: 1.2.3.4
Container_A_1
Container_B_0
Container_D_0
Node_1
IP: 2.3.4.5
Container_A_2
Container_C_1
Node_2
IP: 3.4.5.6
Container_B_0
Container_D_0
Node_3
IP: 7.8.9.0

FIG. 5



Type	FQDN	IP
A	Container_A_1.domain.foo.bar	12.34.5.6
A	Container_B_0.domain.foo.bar	12.34.5.6

Container name/FQDN	Node name	IP
Container_A_1.domain.foo.bar	Node_1	12.34.5.6
Container_B_0.domain.foo.bar	Node_1	12.34.5.6

FIG. 6

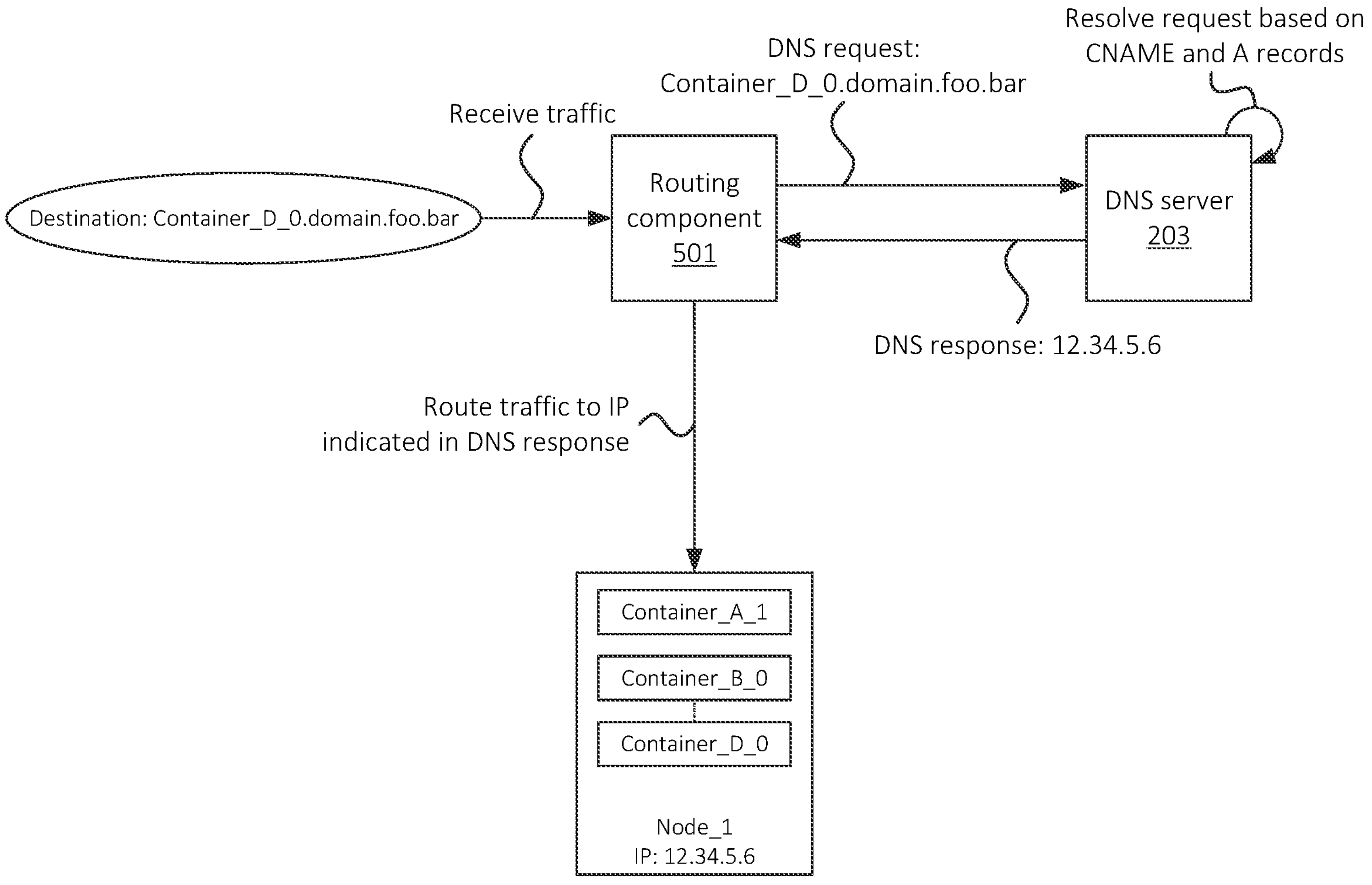

Resolve request based on
CNAME and A records
DNS request:
Container_D_0.domain.foo.bar
Receive traffic
Destination: Container_D_0.domain.foo.bar
Routing
component
501
DNS server
203
DNS response: 12.34.5.6
Route traffic to IP
indicated in DNS response
Container_A_1
Container_B_0
Container_D_0
Node_1
IP: 12.34.5.6

FIG. 7

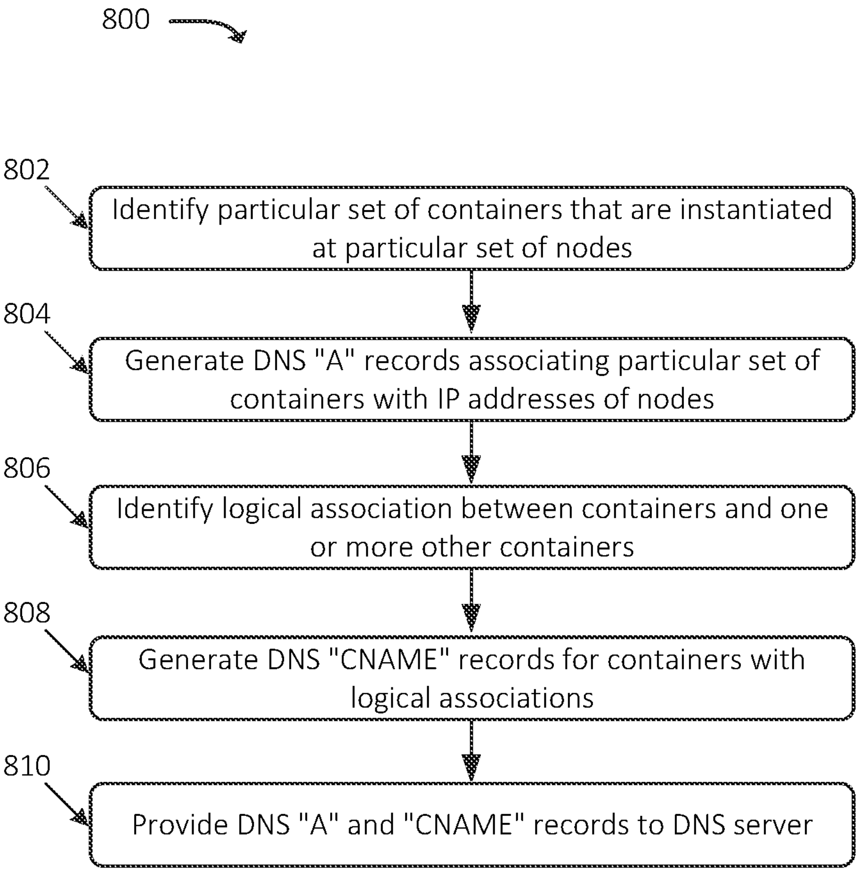

800
802
Identify particular set of containers that are instantiated at particular set of nodes
804
Generate DNS "A" records associating particular set of containers with IP addresses of nodes
806
Identify logical association between containers and one or more other containers
808
Generate DNS "CNAME" records for containers with logical associations
810
Provide DNS "A" and "CNAME" records to DNS server

FIG. 8

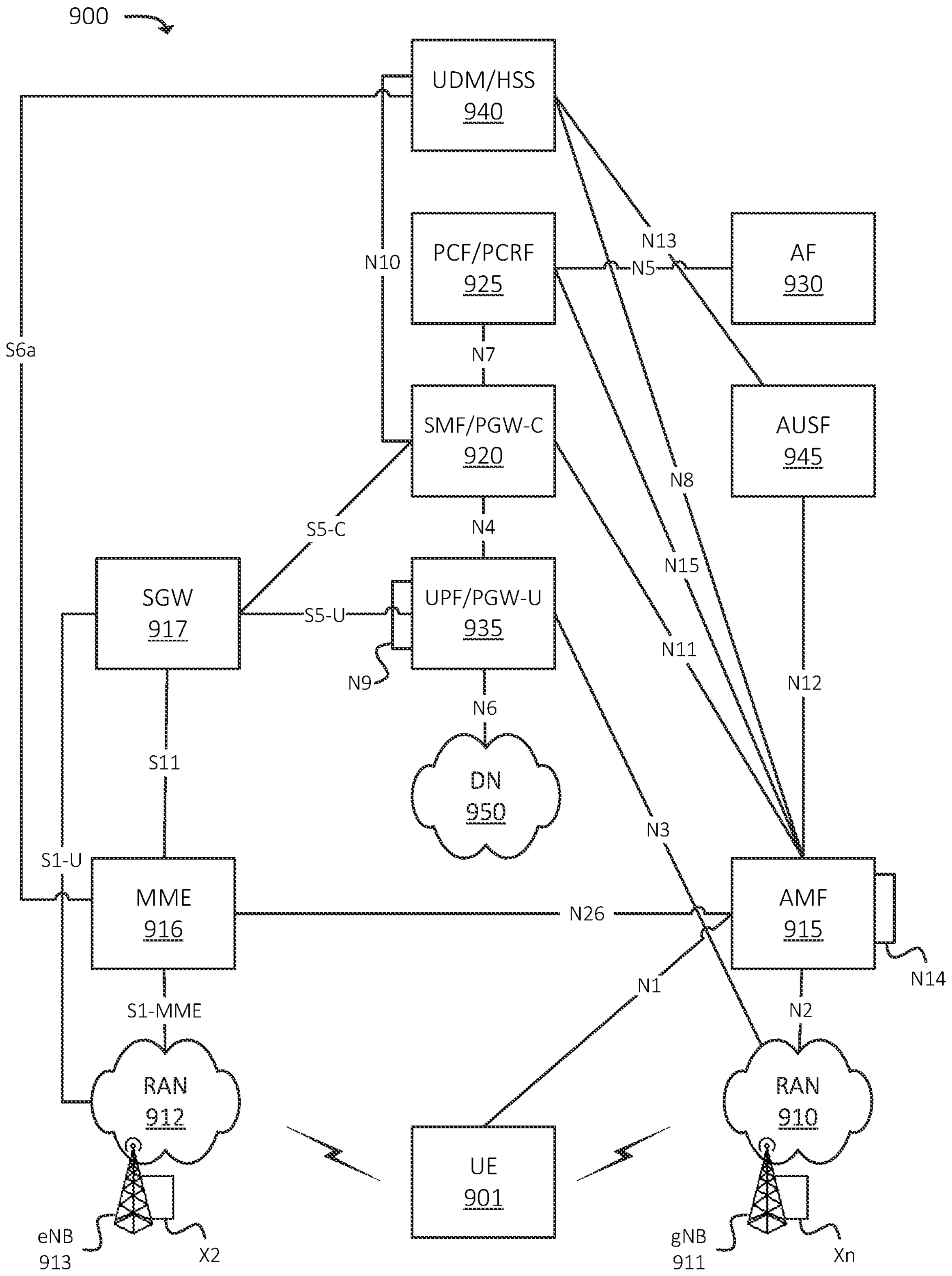

900
UDM/HSS
940
PCF/PCRF
925
AF
930
N13
N5
N10
N7
S6a
SMF/PGW-C
920
AUSF
945
N8
S5-C
N4
N15
SGW
917
S5-U
UPF/PGW-U
935
N11
N12
N9
N6
S11
DN
950
N3
S1-U
MME
916
N26
AMF
915
N14
N1
S1-MME
N2
RAN
912
RAN
910
UE
901
eNB
913
X2
gNB
911
Xn

FIG. 9

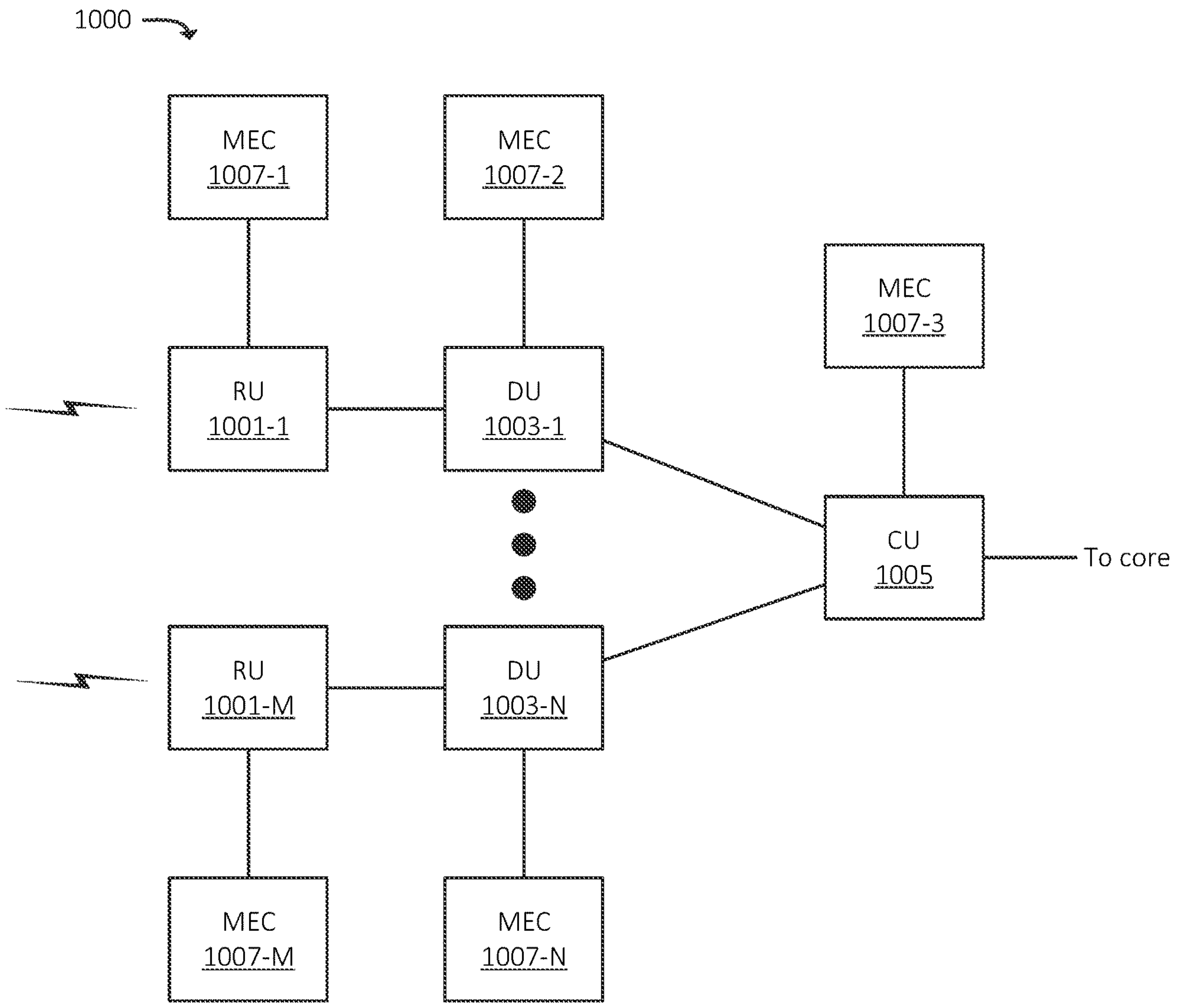

1000
MEC
1007-1
MEC
1007-2
MEC
1007-3
RU
1001-1
DU
1003-1
CU
1005
To core
RU
1001-M
DU
1003-N
MEC
1007-M
MEC
1007-N

FIG. 10

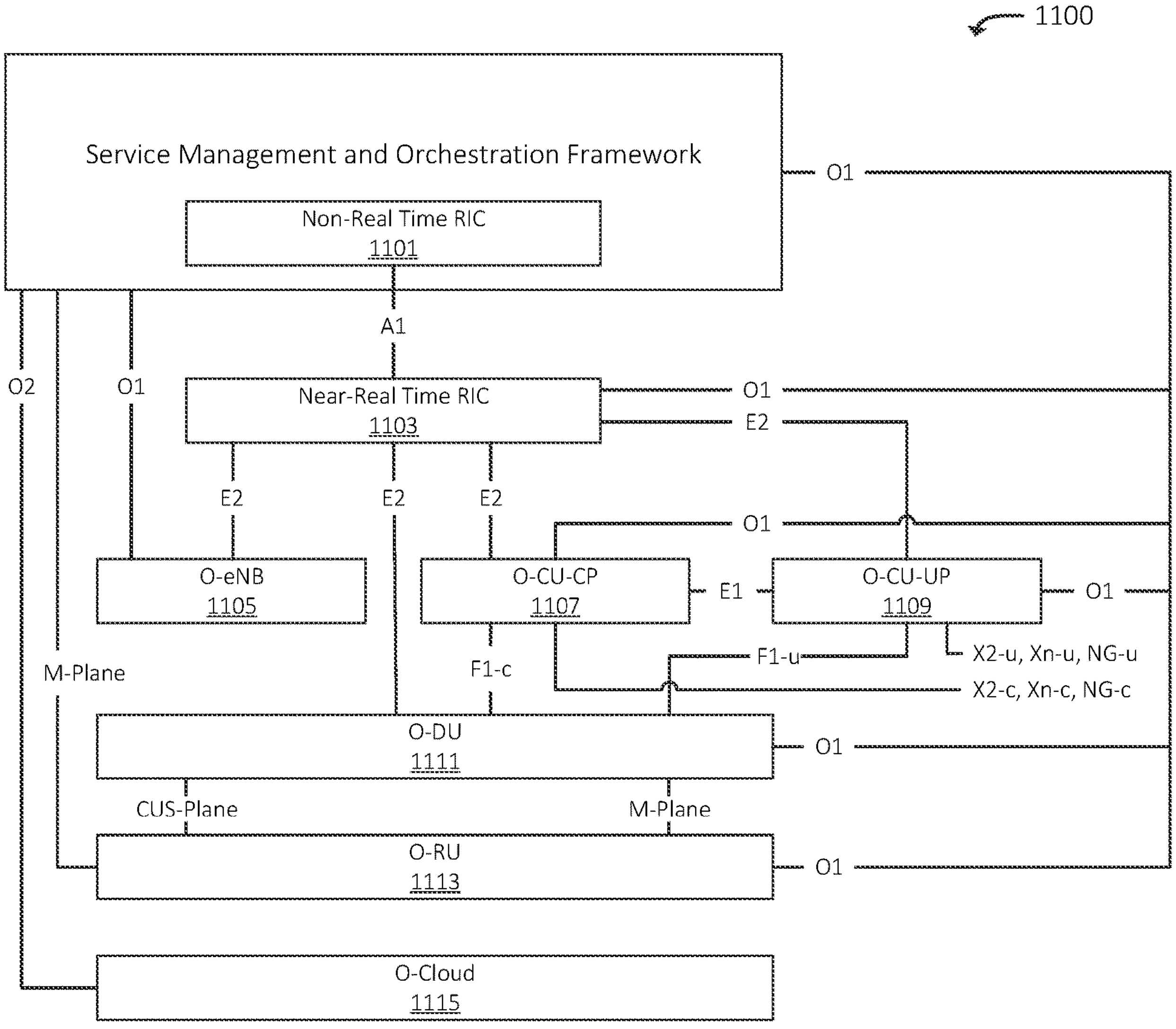

1100
Service Management and Orchestration Framework
Non-Real Time RIC
1101
A1
Near-Real Time RIC
1103
O1
O1
E2
O2
O1
E2
E2
E2
O1
O-eNB
1105
O-CU-CP
1107
E1
O-CU-UP
1109
O1
F1-u
X2-u, Xn-u, NG-u
X2-c, Xn-c, NG-c
M-Plane
F1-c
O-DU
1111
O1
CUS-Plane
M-Plane
O-RU
1113
O1
O-Cloud
1115

FIG. 11

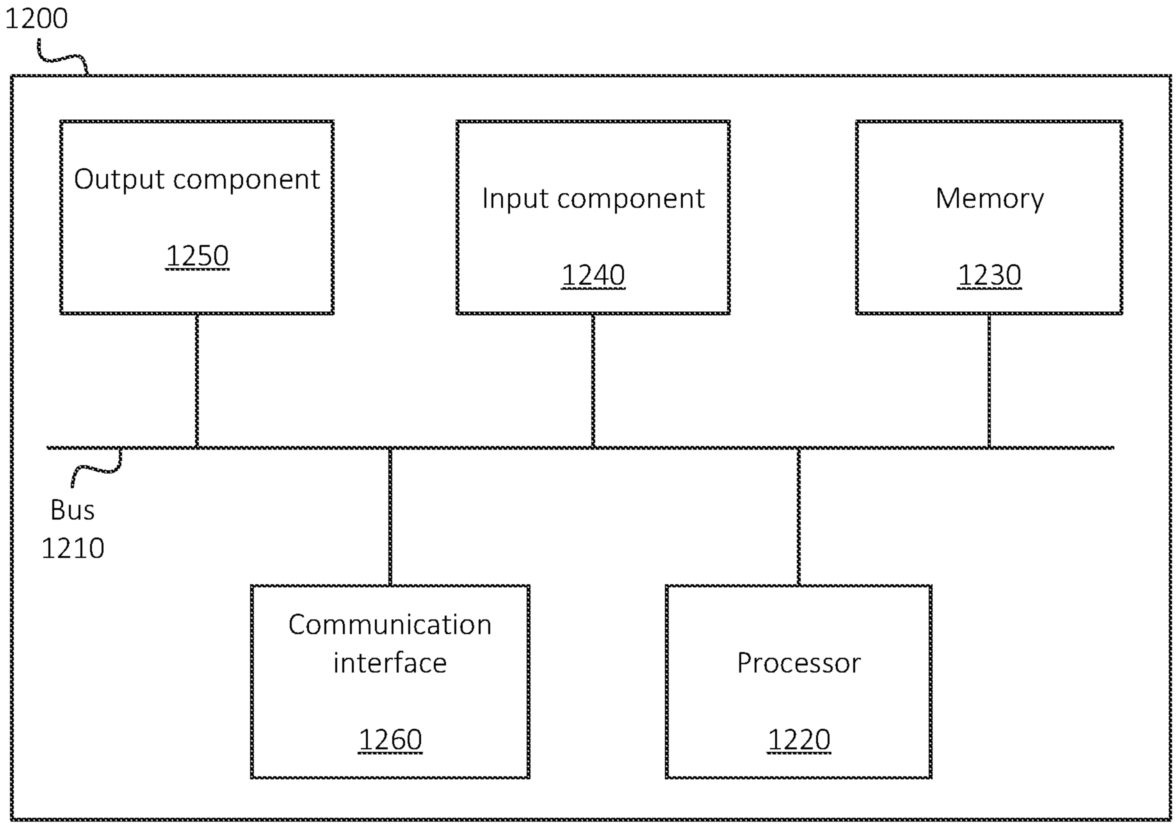

1200
Output component
1250
Input component
1240
Memory
1230
Bus
1210
Communication interface
1260
Processor
1220

FIG. 12

SYSTEMS AND METHODS FOR EFFICIENT AND SCALABLE ROUTING FOR CONTAINERIZED SERVICES

BACKGROUND

[0001] Wireless networks or other systems may make use of virtualized environments, which may include nodes that are implemented by virtual machines, cloud systems, bare metal devices, etc. Containerized processes, or containers, may be instantiated on the nodes. In the context of a software-defined network ("SDN"), the containers may implement one or more network functions of the SDN.

BRIEF DESCRIPTION OF THE DRAWINGS

[0002] FIG. **1** illustrates an example data structure, associated with a virtualized environment, indicating a set of containers that are instantiated at a set of nodes, in accordance with some embodiments;

[0003] FIG. **2** illustrates an example translation of a data structure, associated with the virtualized environment, to one or more Domain Name System ("DNS") "A" records, in accordance with some embodiments;

[0004] FIG. **3** illustrates an example translation of a data structure, associated with the virtualized environment, to one or more DNS "CNAME" records, in accordance with some embodiments;

[0005] FIG. **4** illustrates an example state of a DNS server after generation of DNS "A" and "CNAME" records based on data structures associated with the virtualized environment, in accordance with some embodiments;

[0006] FIG. **5** illustrates example routing of traffic to a particular container that is mounted to another container, based on the generated DNS records, in accordance with some embodiments;

[0007] FIGS. **6** and **7** illustrate an example modification to one or more DNS "A" records based on the moving of a set of containers from one node to another, in accordance with some embodiments;

[0008] FIG. **8** illustrates an example process for translating records associated with the virtualized environment to one or more DNS records based on which traffic may be routed to containers of the virtualized environment, in accordance with some embodiments;

[0009] FIG. **9** illustrates an example environment in which one or more embodiments, described herein, may be implemented;

[0010] FIG. **10** illustrates an example arrangement of a radio access network ("RAN"), in accordance with some embodiments;

[0011] FIG. **11** illustrates an example arrangement of an Open RAN ("O-RAN") environment in which one or more embodiments, described herein, may be implemented; and

[0012] FIG. **12** illustrates example components of one or more devices, in accordance with one or more embodiments described herein.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0013] The following detailed description refers to the accompanying drawings. The same reference numbers in different drawings may identify the same or similar elements.

[0014] Embodiments described herein provide for efficient scaling and routing of a virtualized environment. For example, a virtualized environment may include nodes that include, and/or that are implemented by, virtual machines, cloud systems, bare metal hardware, or the like, as well as containers, images, etc. that are instantiated on the nodes. The nodes and containers may both be associated with addresses, names, identifiers, locators, etc. (e.g., Internet Protocol ("IP") addresses, Fully Qualified Domain Names ("FQDNs"), logical names, Uniform Resource Locators ("URLs"), etc.). Embodiments described herein may utilize DNS techniques in order to quickly and efficiently route traffic to and/or from containers and/or nodes of the virtualized environment, which may result in faster performance, reduced maintenance overhead, as well as reduced resources compared to, for example, a lookup table that stores information mapping logical names or FQDNs to IP addresses. Further, leveraging existing DNS techniques provides for improved scalability, risk of faulty code, and reduced development efforts compared to implementing a lookup table that stores information mapping logical names or FQDNs to IP addresses. As discussed below, for example, some embodiments may translate, port, etc. configuration parameters of the virtualized environment (e.g., custom resource definitions of a virtualized environment implemented using the open source Kubernetes application programming interface ("API") or some other configuration parameters of a suitable type of virtualized environment) to one or more DNS records (e.g., A records and/or CNAME records) to provide for the use of DNS techniques to provide efficient routing in a virtualized environment.

[0015] As shown in FIG. **1**, for example, a set of containers **101** may be instantiated, installed, etc. on respective nodes **103**. As noted above, each container **101** may be an instance, image, copy, etc. of a given type, class, category, etc. of container. In the following description, the following naming convention is used to indicate instances and/or types of containers **101**. "Container_i_j" refers to the j-th instance of a container of type i. For example, Container_A_1 and Container_A_2, in FIG. **1**, are two separate instances of the same type of container (e.g., container type "A"). As noted above, nodes **103** may represent hardware resources, such as virtual machines, bare metal devices, etc. on which respective containers **101** are instantiated, installed, etc. For example, nodes **103** may include and/or may be implemented by server devices, datacenters, cloud systems, etc.

[0016] In some embodiments, containers **101** may implement controllers, network functions, etc. associated with a SDN. For example, containers **101** may implement, include, etc. Virtualized Network Functions ("VNFs") of a wireless network, such as User Plane Functions ("UPFs"), Session Management Functions ("SMFs"), Access and Mobility Management Functions ("AMFs"), Unified Data Management functions ("UDMs"), etc. In some embodiments, containers **101** may implement, include, etc. network controllers that control other containers **101**. For example, a particular type of container **101** may include an SDN controller that manages, provides configuration instructions to, etc. other containers **101**.

[0017] One example type of SDN controller may be implemented using the open source OpenDaylight ("ODL") API. In some embodiments, some VNFs, as implemented by one or more containers **101**, may be implemented using the Internet Engineering Task Force ("IETF") Network Configuration ("NETCONF") protocol. In practice, other types of protocols, APIs, etc. may be implemented by containers **101**. Further, in practice, containers **101** may be used for other purposes in addition to, or in lieu of, implementing an SDN.

[0018] As noted above, containers **101** and nodes **103** may be part of a virtualized environment, which may be managed by Orchestration system **105**. Orchestration system **105** may, for example, serve as an interface via which containers **101** and nodes **103** may be configured, installed, modified, etc. In some embodiments, Orchestration system **105** may be an orchestration system provided via the open source Kubernetes API or some other suitable type of virtualized environment orchestration and/or management platform.

[0019] Orchestration system **105** may maintain custom resource definition **107** and/or some other suitable type of data structure, indicating the configuration of the virtualized environment. For example, as shown, custom resource definition **107** may include an addressable name and/or FQDN associated with each container **101**, as well as one or more indications of respective nodes **103** on which each container **101** is installed. In some embodiments, custom resource definitions **107** may include other suitable information, configuration parameters, etc. associated with each container **101**. For the sake of explanation, such other information is not described herein.

[0020] As shown, custom resource definition **107** may indicate that Container_A_0 (e.g., associated with the FQDN Container_A_0.domain.foo.bar) is associated with (e.g., installed on) Node_0, which has the IP address of 1.2.3.4. In some embodiments, Orchestration system **105** may also maintain a respective set of custom resource definitions or other suitable information indicating the respective locator information (e.g., IP addresses) for each node **103**. In some embodiments, custom resource definition **107** may be generated by Orchestration system **105** based on instructions, commands, configuration parameters, etc. provided via one or more APIs, portals, and/or other suitable communication pathways associated with Orchestration system **105**. Additionally, or alternatively, custom resource definition **107** may itself be provided via such communication pathways. In some embodiments, for example, Orchestration system **105** may receive an instruction to instantiate a particular instance of a given type of container **101**, and may select a particular node **103** on which to instantiate such container **101** (e.g., based on respective measures of load and/or performance associated with nodes **103** and/or based on one or more other factors). Additionally, or alternatively, Orchestration system **105** may receive an instruction to instantiate a particular container **101** on a particular node **103**. In some embodiments, as discussed below, Orchestration system **105** may receive an instruction to mount a given container **101** to another container **101** (or type of container **101**) that is already instantiated on a given node **103**. For example, the already instantiated container **101** may include a controller, such as an ODL instance or some other type of SDN controller, and the container **101** to mount may include a NETCONF instance or other type of VNF instance. "Mounting" one container **101** to another container **101** may refer to a logical and/or hierarchical association between such containers **101**. In some embodiments, mounting may also indicate that such containers **101** are instantiated on the same node **103**. For example, assume that a first container **101** is mounted to a second container **101**. In some embodiments, the mounting of the first container **101** to the second container may indicate that the first and second containers are instantiated on the same node **103**. The mounting may further indicate a hierarchical association between the first and second nodes **103**, such as an association in which the second container **101** may receive communications, configuration parameters, etc. associated with the first container **101** (which is mounted to the second container **101**), and may forward such communications to the first container **101**, may implement or initiate configuration parameter modifications of the first container **101** based on the communications, and/or may perform other operations with respect to the communications associated with the first container **101**.

[0021] In accordance with some embodiments, as shown in FIG. **2**, Orchestration system **105** may translate (at **202**) some or all of custom resource definition **107** into a set of DNS records (e.g., DNS "A" records **201**). In some embodiments, for each container **101** indicated in custom resource definition **107**, Orchestration system **105** may generate a respective DNS "A" record **201**. The "A" record may associate each respective container **101** with the address, locator, etc. (e.g., IP address) of the respective node **103** on which container **101** is installed. As noted above, the IP address of the respective nodes **103** on which each container **101** is installed is included in custom resource definition **107** of each respective container **101**.

[0022] As shown, for example, the DNS "A" record for Container_A_0 (e.g., having the FQDN "Container_A_0.domain.foo.bar") may include the IP address 1.2.3.4, which is the IP address of Node_0 on which Container_A_0 is instantiated. Additionally, the DNS "A" record for Container_A_1 may include the IP address 2.3.4.5, which the IP address of Node_1 on which Container_A_1 is instantiated. Similarly, the DNS "A" record for Container_B_0 may also include the IP address 2.3.4.5, as Container_B_0 is also instantiated on Node_1. Orchestration system **105** may further provide (at **204**) DNS "A" records **201** to DNS server **203**, which may be associated with one or more networks and/or routing topologies of the virtualized environment (e.g., may be associated with one or more routers, switches, etc. that provide routing for containers **101** and/or nodes **103**).

[0023] In some embodiments, some or all of the operations described as being performed by Orchestration system **105** may be performed by some other device or system. For example, some other device or system may receive custom resource definition **107** from Orchestration system **105** and/or from some other source, and may translate (at **202**) custom resource definition **107** into DNS "A" records **201** and/or provide (at **204**) DNS "A" records **201** to DNS server **203**.

[0024] As shown in FIG. **3**, Orchestration system **105** may receive (at **302**) a request, command, instruction, etc. to instantiate a new container **101**, of type "C" (e.g., "Container_C_0"). Assume, for example, that the request (at **302**) specifies that Container_C_0 should be mounted to, or otherwise associated with, a container **101** of type "A." For example, the type "C" container may be a VNF (e.g., may implement or may otherwise be associated with the NETCONF protocol), and the type "A" container may be a controller (e.g., an ODL instance or other type of SDN controller). Additionally, or alternatively, the request (at **302**) may otherwise specify that Container_C_0 should be instantiated on the same node **103** as a container **101** of type

"A." In some embodiments, Orchestration system **105** may identify (at **304**) that Container_C_0 should be instantiated on the same node **103** as a container **101** of type "A" based on one or more rules, policies, etc. For example, in some situations, the request (at **302**) may specify that Container_C_0 should be instantiated on the same node **103** as a container **101** of type "A." In other situations, the request may not include such an indication, in which case Orchestration system **105** may determine that Container_C_0 should be instantiated on the same node **103** as a container **101** of type "A" based on previously received policy information.

[0025] Assume that Orchestration system **105** identifies (at **304**) that Container_C_0 should be instantiated on the same node **103** as Container_A_1. Orchestration system **105** may create (at **306**) custom resource definition **301**, which may include a name, FQDN, and/or other identifier of the new container **101** (i.e., Container_C_0) as well as a name, FQDN, etc. of the container **101** (i.e., Container_A_1, in this example) to which the new container **101** should be mounted, and/or should otherwise be instantiated on the same node **103** as. As similarly noted above, custom resource definition **301** may include other suitable information associated with Container_C_0, which is not discussed here for the sake of brevity. In some embodiments, instead of generating (at **306**) custom resource definition **301**, Orchestration system **105** may receive custom resource definition **301** from some other source, based on which Orchestration system **105** may mount Container_C_0 to Container_A_1. For example, Orchestration system **105** may cause Container_C_0 to be mounted to the same node **103** as Container_A_1, which may include identifying the particular node **103** based on a custom resource definition (or other suitable data structure) associated with Container_A_1.

[0026] As further shown, Orchestration system **105** may identify (at **308**) that custom resource definition **301** has been received and/or created (at **306**), and may translate at least a portion of custom resource definition **301** into DNS "CNAME" record **303**. In some embodiments, Orchestration system **105** may identify that DNS "CNAME" record **303** should be generated by one or more tags, flags, etc. in custom resource definition **301**. For example, Orchestration system **105** may identify that a "kind" field of custom resource definition **301** includes or matches a particular label, category, tag, etc. The "kind" field may indicate, for example, that Container_C_0 is of a particular type (e.g., type "C," a NETCONF type, a particular type of VNF, etc.). As another example, a "status" or "deviceStatus" field of custom resource definition **301** may indicate a value such as "MOUNTED," indicating that Container_C_0 is mounted to or is otherwise associated with another type of container **101** (i.e., Container_A_1, in this example). Additionally, or alternatively, Orchestration system **105** may identify that custom resource definition **301** matches one or more other policies or criteria, based on which Orchestration system **105** may identify that DNS "CNAME" record **303** should be generated based on custom resource definition **301**.

[0027] DNS "CNAME" records may, for example, associate an alias with a canonical name. The alias, for example, may include a name, FQDN, etc. that may be used to refer to a given resource, while the canonical name may be a "true" or canonical name, FQDN, of the resource. In some situations, the same canonical name may be mapped to multiple aliases. In accordance with some embodiments, in this example, DNS "CNAME" record **303** may indicate that the FQDN of the newly mounted container **101** (i.e., Container_C_0.domain.foo.bar) is an alias of the container **101** (i.e., Container_A_1.domain.foo.bar) to which Container_C_0 is mounted. For example, as noted above, Orchestration system **105** may identify (e.g., based on custom resource definition **301**) that Container_C_0 is mounted to, and/or is otherwise associated with, Container_A_1. Orchestration system **105** may further provide (at **310**) the generated DNS "CNAME" record **303** to DNS server **203**.

[0028] FIG. **4** illustrates an example state of DNS server **203** based on multiple iterations of the procedure shown in FIG. **3**, with respect to multiple containers **101** being mounted to existing containers **101**. As shown, DNS server **203** may maintain the set of DNS "A" records **201** previously discussed above. DNS server **203** may also include multiple respective DNS "CNAME" records **303**, which may be generated based on respective custom resource definitions or other information associating respective containers **101** with each other (e.g., containers **101** that are mounted to other containers **101**). As shown, for example, Container_C_1 may be mounted to Container_A_2 , and the associated DNS "CNAME" record **303** may indicate that an FQDN, name, etc. of Container_C_1 (i.e., Container_C_1.domain.foo.bar) is an alias of the FQDN, name, etc. of Container_A_2 , to which Container_C_1 is mounted. Similarly, DNS "CNAME" records **303** may indicate that Container_D_0.domain.foo.bar is an alias of Container_B_0.domain.foo.bar, and that Container_E_0.domain.foo.bar is an alias of Container_A_0.domain.foo.bar.

[0029] DNS server **203** may use DNS "A" records **201** and DNS "CNAME" records **303** to route traffic (e.g., traffic with a name, FQDN, etc. of a respective container **101**, such as a container **101** that is mounted to another container **101**) to their appropriate destinations. For example, as shown in FIG. **5**, a given routing component **501** (e.g., a router, switch, etc.) that is communicatively coupled to nodes **103** may receive (at **502**) traffic **503**. In this example, traffic **503** may indicate the FQDN of Container_D_0 (e.g., Container_D_0.domain.foo.bar) as the destination of the traffic. As one example traffic **503** may be or may include user plane traffic sent by or directed to a User Equipment ("UE") connected to a wireless network, and Container_D_0 may be an instance of a UPF of a core of the wireless network.

[0030] Routing component **501** may output (at **504**) a DNS request to DNS server **203**, in order to determine where (e.g., to which IP address) to route traffic **503**. DNS server **203** may resolve (at **506**) the request based on DNS "A" records **201** and DNS "CNAME" records **303**. For example, DNS server **203** may determine that Container_D_0.domain.foo.bar is associated with a particular DNS "CNAME" record **303** (e.g., as shown in FIG. **4**) that indicates that Container_D_0.domain.foo.bar is an alias of Container_B_0.domain.foo.bar. DNS server **203** may further determine, based on DNS "A" records **201**, that Container_B_0.domain.foo.bar is associated with the IP address 2.3.4.5. Accordingly, DNS server **203** may provide (at **508**) a DNS response, indicating that Container_D_0.domain.foo.bar resolves to the IP address 2.3.4.5. Routing component **501** may accordingly route (at **510**) traffic **503** to the IP address indicated in the DNS response.

[0031] Accordingly, the corresponding node **103** that hosts Container_D_0 (i.e., Node_1, in this example), may receive traffic **503**. In some embodiments, a node controller of Node_1 may appropriately route, provide, etc. traffic **503** to Container_D_0 and/or to Container_B_0. For example, based on custom resource definition 301 associated with Container_D_0, the node controller of Node_1 may determine that Container_D_0 is mounted to, and/or is otherwise subordinate to or controlled by, Container_B_0. In such situations, the node controller may provide traffic **503** to Container_B_0, which may perform further processing (e.g., filtering, Quality of Service ("QoS") treatment, etc.) prior to providing traffic **503** to Container_D_0. Additionally, or alternatively, the node controller may provide traffic **503** directly to Container_D_0, and/or may provide a copy of some or all of traffic **503** to both Container_B_0 and Container_D_0.

[0032] The use of DNS techniques, as discussed above, may further provide for more efficient and robust modifications to the topology and/or addressing of nodes **103**. For example, as shown in FIG. **6**, Node_1 may be moved to a different IP address (e.g., 12.34.5.6, as opposed to the previous IP address of 2.3.4.5). For example, Node_1 may be failed over to a new set of physical resources if a set of resources, that previously implemented Node_1, has become unreachable, unstable, slow (e.g., if performance has degraded below a threshold measure of performance), etc. Additionally, or alternatively, Node_1 may be moved to a new set of physical resources for some other reason.

[0033] Based on the movement of Node_1 to the new set of physical resources (and, resultingly, to a new IP address), Orchestration system **105** may update custom resource definitions **107** associated with Container_A_1 and Container_B_0, as such custom resource definitions **107** may have specified the previous IP address 2.3.4.5. In some embodiments, custom resource definition **301**, associated with Container_D_0, may not be updated. For example, as noted above with respect to FIG. **3**, custom resource definition **301** may include a reference to Container_B_0. However, in some embodiments, custom resource definition **301** may not include an IP address associated with Container_B_0 and/or of Node_1.

[0034] Orchestration system **105** may generate updated DNS "A" records **601** based on the updates to custom resource definitions **107** associated with Container_A_1 and Container_B_0. For example, updated DNS "A" records **601** may include the new IP address 12.34.5.6 for the names and/or FQDNs of Container_A_1 and Container_B_0. Orchestration system **105** may provide updated DNS "A" records **601** to DNS server **203**, which may overwrite previous DNS "A" records **201** that were previously associated with Container_A_1 and Container_B_0 (e.g., mapping the FQDNs of these containers **101** to the IP address 2.3.4.5).

[0035] In such a situation, a DNS "CNAME" record **303** associated with Container_D_0 may not need to be updated. Thus, in examples where a relatively large quantity of containers **101** are mounted to other containers **101**, records associated with the mounted containers **101** need not be altered in situations where hardware resources implementing such containers **101** are moved. Forgoing altering such records may result in reduced expenditure of processing resources, time, and/or other resources that would be used to modify such records.

[0036] Thus, as shown in FIG. **7**, after Node_1 has been moved to the new set of hardware resources with the IP address 12.34.5.6, traffic indicating Container_D_0) may continue to be appropriately routed to Node_1. For example, based on the updated DNS "A" records **601**, as well as the previous (e.g., unmodified) DNS "CNAME" records **303**, DNS server **203** may resolve the FQDN Container_D_0.domain.foo.bar to the new IP address 12.34.5.6, and routing component **501** may accordingly route the traffic to the new IP address.

[0037] FIG. **8** illustrates an example process **800** for translating records associated with the virtualized environment to one or more DNS records based on which traffic may be routed to containers of the virtualized environment. In some embodiments, some or all of process **800** may be performed by Orchestration system **105**. In some embodiments, one or more other devices may perform some or all of process **800** in concert with, and/or in lieu of, Orchestration system **105**.

[0038] As shown, process **800** may include identifying (at **802**) a particular set of containers that are instantiated at a particular set of nodes. For example, as discussed above, Orchestration system **105** may identify custom resource definition **107** and/or some other suitable data structure associated with a virtualized environment, indicating that a set of containers **101** are instantiated at a particular set of nodes **103**. In some embodiments, Orchestration system **105** may identify containers **101** of a particular type, category, label, etc. that are instantiated at a particular set of nodes **103**. For example, Orchestration system **105** may identify containers **101** that are designated as SDN controllers, ODL instances, etc. As another example, the virtualized environment may include a hierarchical arrangement of containers **101**, and Orchestration system **105** may identify particular containers **101** that are at a highest level of the hierarchy, and/or at a higher level of the hierarchy than other containers **101**. For example, Orchestration system **105** may identify containers **101** that are associated with "child" or "subordinate" containers **101**, or for which child" or "subordinate" containers **101** may be assigned at a later time.

[0039] Process **800** may further include generating (at **804**) a set of DNS "A" records, associating the identified (at **802**) set of containers **101** with respective addresses (e.g., IP addresses) of nodes **103** on which such containers **101** are instantiated. For example, as discussed above, Orchestration system **105** may perform a translation of portions of one or more custom resource definitions **107**, which indicate IP addresses and identifiers (e.g., names, FQDNs, etc.) of nodes **103** on which containers **101** are instantiated, to one or more DNS "A" records **201**, which associate the identifiers (e.g., names, FQDNs, etc.) of such containers **101** to the IP addresses of respective nodes **103**.

[0040] Process **800** may additionally include identifying (at **806**) a logical association between the containers **101** (identified at **802**) and one or more other containers **101**. For example, Orchestration system **105** may identify custom resource definitions **301** and/or other suitable information indicating that one or more containers **101** have been mounted to and/or otherwise associated with containers **101** that were identified (at **802**) as being instantiated at nodes **103**. For example, the container(s) **101** identified (at **806**) may include instances of one or more VNFs, while the container(s) **101** previously identified (at **802**) may include instances of one or more SDN controllers that control such VNFs. In some embodiments, such association may indicate that particular VNFs (or other suitable types of containers

101) are instantiated on the same node **103** as the SDN controllers with which the VNFs are logically associated. For example, in situations where a failover, migration, etc. is performed, all containers **101** with logical associations (e.g., an SDN controller, as well as all VNFs with which the SDN controller is logically associated) would be moved from one node **103** (e.g., associated with a first IP address) to another node **103** (e.g., associated with a second IP address).

[0041] Process **800** may also include generating (at **808**) DNS "CNAME" records for the particular containers **101** that are logically associated with other containers **101**. For example, for containers **101** that are "child" or "subordinate" containers **101** with respect to other containers **101** (e.g., where a container **101** implementing a particular VNF may be a "child" or "subordinate" of a container **101** implementing an SDN controller), Orchestration system **105** may identify one or more custom resource definitions **301** or other suitable data structures indicating such association, and may extract relevant information for the DNS "CNAME" records. For example, Orchestration system **105** may identify the name, FQDN, etc. of the "child" or "subordinate" container **101** from custom resource definition **301** associated with the "child" or "subordinate" container **101**. Orchestration system **105** may also identify the name, FQDN, etc. of the container **101** with which the "child" or "subordinate" container **101** is mounted or otherwise associated. Orchestration system **105** may generate DNS "CNAME" record **303**, indicating that the name, FQDN, etc. of the "child" or "subordinate" container **101** is an alias of the name, FQDN, etc. of the container **101** to which the "child" or "subordinate" container **101** is mounted.

[0042] Process **800** may further include providing (at **810**) the DNS "A" and "CNAME" records to DNS server **203**. For example, Orchestration system **105** may provide DNS "A" records **201** and DNS "CNAME" records **303** to DNS server **203**, which may use such information when routing traffic to the "child" or "subordinate" container **101**. For example, particular traffic may include the name, FQDN, etc. of the "child" or "subordinate" container **101**, and DNS server **203** may resolve such name, FQDN, etc. to an IP address of the node **103** on which the "child" or "subordinate" container **101** is instantiated.

[0043] FIG. **9** illustrates an example environment **900**, in which one or more embodiments may be implemented. In some embodiments, environment **900** may correspond to a Fifth Generation ("5 G") network, and/or may include elements of a 5 G network. In some embodiments, environment **900** may correspond to a 5 G Non-Standalone ("NSA") architecture, in which a 5 G radio access technology ("RAT") may be used in conjunction with one or more other RATs (e.g., a Long-Term Evolution ("LTE") RAT), and/or in which elements of a 5 G core network may be implemented by, may be communicatively coupled with, and/or may include elements of another type of core network (e.g., an evolved packet core ("EPC")). In some embodiments, portions of environment **900** may represent or may include a 5 G core ("5GC"). As shown, environment **900** may include UE **901**, RAN **910** (which may include one or more Next Generation Node Bs ("gNBs") **911**), RAN **912** (which may include one or more evolved Node Bs ("eNBs") **913**), and various network functions such as AMF **915**, Mobility Management Entity ("MME") **916**, Serving Gateway ("SGW") **917**, SMF/Packet Data Network ("PDN") Gateway ("PGW")-Control plane function ("PGW-C") **920**, Policy Control Function ("PCF")/Policy Charging and Rules Function ("PCRF") **925**, Application Function ("AF") **930**, UPF/PGW-User plane function ("PGW-U") **935**, UDM/Home Subscriber Server ("HSS") **940**, and Authentication Server Function ("AUSF") **945**. Environment **900** may also include one or more networks, such as Data Network ("DN") **950**. Environment **900** may include one or more additional devices or systems communicatively coupled to one or more networks (e.g., DN **950**).

[0044] The example shown in FIG. **9** illustrates one instance of each network component or function (e.g., one instance of SMF/PGW-C **920**, PCF/PCRF **925**, UPF/PGW-U **935**, UDM/HSS **940**, and/or AUSF **945**). In practice, environment **900** may include multiple instances of such components or functions. For example, in some embodiments, environment **900** may include multiple "slices" of a core network, where each slice includes a discrete and/or logical set of network functions (e.g., one slice may include a first instance of SMF/PGW-C **920**, PCF/PCRF **925**, UPF/PGW-U **935**, UDM/HSS **940**, and/or AUSF **945**, while another slice may include a second instance of SMF/PGW-C **920**, PCF/PCRF **925**, UPF/PGW-U **935**, UDM/HSS **940**, and/or AUSF **945**). The different slices may provide differentiated levels of service, such as service in accordance with different Quality of Service ("QoS") parameters.

[0045] The quantity of devices and/or networks, illustrated in FIG. **9**, is provided for explanatory purposes only. In practice, environment **900** may include additional devices and/or networks, fewer devices and/or networks, different devices and/or networks, or differently arranged devices and/or networks than illustrated in FIG. **9**. For example, while not shown, environment **900** may include devices that facilitate or enable communication between various components shown in environment **900**, such as one or more routing components **501** (e.g., routers, modems, gateways, switches, hubs, etc.). Further, environment **900** may include and/or may be communicatively coupled to one or more DNS servers **203** that provide resolution of FQDNs, URLs, etc. (e.g., as described above). Further, some or all of environment **900** may be implemented as a containerized environment, in which one or more elements of environment **900** may be implemented by one or more containers **101**, which may include VNF instances and/or controllers that control such VNF instances.

[0046] Alternatively, or additionally, one or more of the devices of environment **900** may perform one or more network functions described as being performed by another one or more of the devices of environment **900**. Devices of environment **900** may interconnect with each other and/or other devices via wired connections, wireless connections, or a combination of wired and wireless connections. In some implementations, one or more devices of environment **900** may be physically integrated in, and/or may be physically attached to, one or more other devices of environment **900**.

[0047] UE **901** may include a computation and communication device, such as a wireless mobile communication device that is capable of communicating with RAN **910**, RAN **912**, and/or DN **950**. UE **901** may be, or may include, a radiotelephone, a personal communications system ("PCS") terminal (e.g., a device that combines a cellular radiotelephone with data processing and data communications capabilities), a personal digital assistant ("PDA") (e.g., a device that may include a radiotelephone, a pager, Internet/intranet access, etc.), a smart phone, a laptop computer, a tablet computer, a camera, a personal gaming system, an Internet of Things ("IoT") device (e.g., a sensor, a smart home appliance, a wearable device, a Machine-to-Machine ("M2M") device, or the like), or another type of mobile computation and communication device. UE **901** may send traffic to and/or receive traffic (e.g., user plane traffic) from DN **950** via RAN **910**, RAN **912**, and/or UPF/PGW-U **935**.

[0048] RAN **910** may be, or may include, a 5 G RAN that includes one or more base stations (e.g., one or more gNBs **911**), via which UE **901** may communicate with one or more other elements of environment **900**. UE **901** may communicate with RAN **910** via an air interface (e.g., as provided by gNB **911**). For instance, RAN **910** may receive traffic (e.g., voice call traffic, data traffic, messaging traffic, signaling traffic, etc.) from UE **901** via the air interface, and may communicate the traffic to UPF/PGW-U **935**, and/or one or more other devices or networks. Similarly, RAN **910** may receive traffic intended for UE **901** (e.g., from UPF/PGW-U **935**, AMF **915**, and/or one or more other devices or networks) and may communicate the traffic to UE **901** via the air interface.

[0049] RAN **912** may be, or may include, a LTE RAN that includes one or more base stations (e.g., one or more eNBs **913**), via which UE **901** may communicate with one or more other elements of environment **900**. UE **901** may communicate with RAN **912** via an air interface (e.g., as provided by eNB **913**). For instance, RAN **912** may receive traffic (e.g., voice call traffic, data traffic, messaging traffic, signaling traffic, etc.) from UE **901** via the air interface, and may communicate the traffic to UPF/PGW-U **935**, and/or one or more other devices or networks. Similarly, RAN **912** may receive traffic intended for UE **901** (e.g., from UPF/PGW-U **935**, SGW **917**, and/or one or more other devices or networks) and may communicate the traffic to UE **901** via the air interface.

[0050] AMF **915** may include one or more devices, systems, VNFs, Cloud-Native Network Functions ("CNFs"), etc., that perform operations to register UE **901** with the 5 G network, to establish bearer channels associated with a session with UE **901**, to hand off UE **901** from the 5 G network to another network, to hand off UE **901** from the other network to the 5 G network, manage mobility of UE **901** between RANs **910** and/or gNBs **911**, and/or to perform other operations. In some embodiments, the 5 G network may include multiple AMFs **915**, which communicate with each other via the N**14** interface (denoted in FIG. **9** by the line marked "N**14**" originating and terminating at AMF **915**).

[0051] MME **916** may include one or more devices, systems, VNFs, CNFs, etc., that perform operations to register UE **901** with the EPC, to establish bearer channels associated with a session with UE **901**, to hand off UE **901** from the EPC to another network, to hand off UE **901** from another network to the EPC, manage mobility of UE **901** between RANs **912** and/or eNBs **913**, and/or to perform other operations.

[0052] SGW **917** may include one or more devices, systems, VNFs, CNFs, etc., that aggregate traffic received from one or more eNBs **913** and send the aggregated traffic to an external network or device via UPF/PGW-U **935**. Additionally, SGW **917** may aggregate traffic received from one or more UPF/PGW-Us **935** and may send the aggregated traffic to one or more eNBs **913**. SGW **917** may operate as an anchor for the user plane during inter-eNB handovers and as an anchor for mobility between different telecommunication networks or RANs (e.g., RANs **910** and **912**).

[0053] SMF/PGW-C **920** may include one or more devices, systems, VNFs, CNFs, etc., that gather, process, store, and/or provide information in a manner described herein. SMF/PGW-C **920** may, for example, facilitate the establishment of communication sessions on behalf of UE **901**. In some embodiments, the establishment of communications sessions may be performed in accordance with one or more policies provided by PCF/PCRF **925**.

[0054] PCF/PCRF **925** may include one or more devices, systems, VNFs, CNFs, etc., that aggregate information to and from the 5 G network and/or other sources. PCF/PCRF **925** may receive information regarding policies and/or subscriptions from one or more sources, such as subscriber databases and/or from one or more users (such as, for example, an administrator associated with PCF/PCRF **925**).

[0055] AF **930** may include one or more devices, systems, VNFs, CNFs, etc., that receive, store, and/or provide information that may be used in determining parameters (e.g., quality of service parameters, charging parameters, or the like) for certain applications.

[0056] UPF/PGW-U **935** may include one or more devices, systems, VNFs, CNFs, etc., that receive, store, and/or provide data (e.g., user plane data). For example, UPF/PGW-U **935** may receive user plane data (e.g., voice call traffic, data traffic, etc.), destined for UE **901**, from DN **950**, and may forward the user plane data toward UE **901** (e.g., via RAN **910**, SMF/PGW-C **920**, and/or one or more other devices). In some embodiments, multiple UPFs **935** may be deployed (e.g., in different geographical locations), and the delivery of content to UE **901** may be coordinated via the N9 interface (e.g., as denoted in FIG. **9** by the line marked "N9" originating and terminating at UPF/PGW-U **935**). Similarly, UPF/PGW-U **935** may receive traffic from UE **901** (e.g., via RAN **910**, SMF/PGW-C **920**, and/or one or more other devices), and may forward the traffic toward DN **950**. In some embodiments, UPF/PGW-U **935** may communicate (e.g., via the N4 interface) with SMF/PGW-C **920**, regarding user plane data processed by UPF/PGW-U **935**.

[0057] UDM/HSS **940** and AUSF **945** may include one or more devices, systems, VNFs, CNFs, etc., that manage, update, and/or store, in one or more memory devices associated with AUSF **945** and/or UDM/HSS **940**, profile information associated with a subscriber. AUSF **945** and/or UDM/HSS **940** may perform authentication, authorization, and/or accounting operations associated with the subscriber and/or a communication session with UE **901**.

[0058] DN **950** may include one or more wired and/or wireless networks. For example, DN **950** may include an Internet Protocol ("IP")-based PDN, a wide area network ("WAN") such as the Internet, a private enterprise network, and/or one or more other networks. UE **901** may communicate, through DN **950**, with data servers, other UEs **901**, and/or to other servers or applications that are coupled to DN **950**. DN **950** may be connected to one or more other networks, such as a public switched telephone network ("PSTN"), a public land mobile network ("PLMN"), and/or another network. DN **950** may be connected to one or more devices, such as content providers, applications, web servers, and/or other devices, with which UE **901** may communicate.

[0059] FIG. **10** illustrates an example Distributed Unit ("DU") network **1000**, which may be included in and/or implemented by one or more RANs (e.g., RAN **910**, RAN **912**, or some other RAN). In some embodiments, a particular RAN may include one DU network **1000**. In some embodiments, a particular RAN may include multiple DU networks **1000**. In some embodiments, DU network **1000** may correspond to a particular gNB **911** of a 5 G RAN (e.g., RAN **910**). In some embodiments, DU network **1000** may correspond to multiple gNBs **911**. In some embodiments, DU network **1000** may correspond to one or more other types of base stations of one or more other types of RANs. As shown, DU network **1000** may include Central Unit ("CU") **1005**, one or more Distributed Units ("DUs") **1003-1** through **1003**-N (referred to individually as "DU **1003**," or collectively as "DUs **1003**"), and one or more Radio Units ("RUs") **1001-1** through **1001**-M (referred to individually as "RU **1001**," or collectively as "RUs **1001**").

[0060] CU **1005** may communicate with a core of a wireless network (e.g., may communicate with one or more of the devices or systems described above with respect to FIG. **9**, such as AMF **915** and/or UPF/PGW-U **935**). In the uplink direction (e.g., for traffic from UEs **901** to a core network), CU **1005** may aggregate traffic from DUs **1003**, and forward the aggregated traffic to the core network. In some embodiments, CU **1005** may receive traffic according to a given protocol (e.g., Radio Link Control ("RLC")) from DUs **1003**, and may perform higher-layer processing (e.g., may aggregate/process RLC packets and generate Packet Data Convergence Protocol ("PDCP") packets based on the RLC packets) on the traffic received from DUs **1003**.

[0061] In accordance with some embodiments, CU **1005** may receive downlink traffic (e.g., traffic from the core network) for a particular UE **901**, and may determine which DU(s) **1003** should receive the downlink traffic. DU **1003** may include one or more devices that transmit traffic between a core network (e.g., via CU **1005**) and UE **901** (e.g., via a respective RU **1001**). DU **1003** may, for example, receive traffic from RU **1001** at a first layer (e.g., physical ("PHY") layer traffic, or lower PHY layer traffic), and may process/aggregate the traffic to a second layer (e.g., upper PHY and/or RLC). DU **1003** may receive traffic from CU **1005** at the second layer, may process the traffic to the first layer, and provide the processed traffic to a respective RU **1001** for transmission to UE **901**.

[0062] RU **1001** may include hardware circuitry (e.g., one or more RF transceivers, antennas, radios, and/or other suitable hardware) to communicate wirelessly (e.g., via an RF interface) with one or more UEs **901**, one or more other DUs **1003** (e.g., via RUs **1001** associated with DUs **1003**), and/or any other suitable type of device. In the uplink direction, RU **1001** may receive traffic from UE **901** and/or another DU **1003** via the RF interface and may provide the traffic to DU **1003**. In the downlink direction, RU **1001** may receive traffic from DU **1003**, and may provide the traffic to UE **901** and/or another DU **1003**.

[0063] RUs **1001** may, in some embodiments, be communicatively coupled to one or more Multi-Access/Mobile Edge Computing ("MEC") devices, referred to sometimes herein simply as "MECs" **1007**. For example, RU **1001-1** may be communicatively coupled to MEC **1007-1**, RU **1001**-M may be communicatively coupled to MEC **1007**-M, DU **1003-1** may be communicatively coupled to MEC **1007-2**, DU **1003**-N may be communicatively coupled to MEC **1007**-N, CU **1005** may be communicatively coupled to MEC **1007-3**, and so on. MECs **1007** may include hardware resources (e.g., configurable or provisionable hardware resources) that may be configured to provide services and/or otherwise process traffic to and/or from UE **901**, via a respective RU **1001**.

[0064] For example, RU **1001-1** may route some traffic, from UE **901**, to MEC **1007-1** instead of to a core network (e.g., via DU **1003** and CU **1005**). MEC **1007-1** may process the traffic, perform one or more computations based on the received traffic, and may provide traffic to UE **901** via RU **1001-1**. In this manner, ultra-low latency services may be provided to UE **901**, as traffic does not need to traverse DU **1003**, CU **1005**, and an intervening backhaul network between DU network **1000** and the core network. In some embodiments, MEC **1007** may include, and/or may implement, some or all of the functionality described above with respect to Orchestration system **105**, DNS server **203**, routing component **501**, UPF **935**, and/or one or more other devices, systems, VNFs, CNFs, etc.

[0065] FIG. **11** illustrates an example O-RAN environment **1100**, which may correspond to RAN **910**, RAN **912**, and/or DU network **1000**. For example, RAN **910**, RAN **912**, and/or DU network **1000** may include one or more instances of O-RAN environment **1100**, and/or one or more instances of O-RAN environment **1100** may implement RAN **910**, RAN **912**, DU network **1000**, and/or some portion thereof. As shown, O-RAN environment **1100** may include Non-Real Time Radio Intelligent Controller ("RIC") **1101**, Near-Real Time RIC **1103**, O-eNB **1105**, O-CU-Control Plane ("O-CU-CP") **1107**, O-CU-User Plane ("O-CU-UP") **1109**, O-DU **1111**, O-RU **1113**, and O-Cloud **1115**. In some embodiments, O-RAN environment **1100** may include additional, fewer, different, and/or differently arranged components. In some embodiments, O-RAN environment **1100** may be, or may be implemented by, a virtualized environment (e.g., some or all of the elements of O-RAN environment **1100** may be implemented by one or more containers **101** instantiated at one or more nodes **103**).

[0066] In some embodiments, some or all of the elements of O-RAN environment **1100** may be implemented by one or more configurable or provisionable resources, such as virtual machines, cloud computing systems, physical servers, and/or other types of configurable or provisionable resources.

[0067] In some embodiments, some or all of O-RAN environment **1100** may be implemented by, and/or communicatively coupled to, one or more MECs **1007**. In some embodiments, one or more elements of O-RAN environment **1100** may be mounted to one or more other elements of O-RAN environment **1100**. For example, O-eNB **1105** may be mounted to Non-Real Time RIC **1101** and/or Near-Real Time RIC **1103**, O-DU **1111** may be mounted to Near-real Time RIC **1103**, and so on.

[0068] Non-Real Time RIC **1101** and Near-Real Time RIC **1103** may receive performance information (and/or other types of information) from one or more sources, and may configure other elements of O-RAN environment **1100** based on such performance or other information. For example, Near-Real Time RIC **1103** may receive performance information, via one or more E**2** interfaces, from

O-eNB **1105**, O-CU-CP **1107**, and/or O-CU-UP **1109**, and may modify parameters associated with O-eNB **1105**, O-CU-CP **1107**, and/or O-CU-UP **1109** based on such performance information. Similarly, Non-Real Time RIC **1101** may receive performance information associated with O-eNB **1105**, O-CU-CP **1107**, O-CU-UP **1109**, and/or one or more other elements of O-RAN environment **1100** and may utilize machine learning and/or other higher level computing or processing to determine modifications to the configuration of O-eNB **1105**, O-CU-CP **1107**, O-CU-UP **1109**, and/or other elements of O-RAN environment **1100**. In some embodiments, Non-Real Time RIC **1101** may generate machine learning models based on performance information associated with O-RAN environment **1100** or other sources, and may provide such models to Near-Real Time RIC **1103** for implementation.

[0069] O-eNB **1105** may perform functions similar to those described above with respect to eNB **913**. For example, O-eNB **1105** may facilitate wireless communications between UE 1uu and a core network. O-CU-CP **1107** may perform control plane signaling to coordinate the aggregation and/or distribution of traffic via one or more DUs **1003**, which may include and/or be implemented by one or more O-DUs **1111**, and O-CU-UP **1109** may perform the aggregation and/or distribution of traffic via such DUs **1003** (e.g., O-DUs **1111**). O-DU **1111** may be communicatively coupled to one or more RUs **1001**, which may include and/or may be implemented by one or more O-RUs **1113**. In some embodiments, O-Cloud **1115** may include or be implemented by one or more MECs **1007**, which may provide services, and may be communicatively coupled, to O-CU-CP **1107**, O-CU-UP **1109**, O-DU **1111**, and/or O-RU 1113 (e.g., via an O1 and/or O2 interface).

[0070] FIG. **12** illustrates example components of device **1200**. One or more of the devices described above may include one or more devices **1200**. Device **1200** may include bus **1210**, processor **1220**, memory **1230**, input component **1240**, output component **1250**, and communication interface **1260**. In another implementation, device **1200** may include additional, fewer, different, or differently arranged components.

[0071] Bus **1210** may include one or more communication paths that permit communication among the components of device **1200**. Processor **1220** may include a processor, microprocessor, or processing logic that may interpret and execute instructions. In some embodiments, processor **1220** may be or may include one or more hardware processors. Memory **1230** may include any type of dynamic storage device that may store information and instructions for execution by processor **1220**, and/or any type of non-volatile storage device that may store information for use by processor **1220**.

[0072] Input component **1240** may include a mechanism that permits an operator to input information to device **1200** and/or other receives or detects input from a source external to **1240**, such as a touchpad, a touchscreen, a keyboard, a keypad, a button, a switch, a microphone or other audio input component, etc. In some embodiments, input component **1240** may include, or may be communicatively coupled to, one or more sensors, such as a motion sensor (e.g., which may be or may include a gyroscope, accelerometer, or the like), a location sensor (e.g., a Global Positioning System ("GPS")-based location sensor or some other suitable type of location sensor or location determination component), a thermometer, a barometer, and/or some other type of sensor. Output component **1250** may include a mechanism that outputs information to the operator, such as a display, a speaker, one or more light emitting diodes ("LEDs"), etc.

[0073] Communication interface **1260** may include any transceiver-like mechanism that enables device **1200** to communicate with other devices and/or systems. For example, communication interface **1260** may include an Ethernet interface, an optical interface, a coaxial interface, or the like. Communication interface **1260** may include a wireless communication device, such as an infrared ("IR") receiver, a Bluetooth® radio, or the like. The wireless communication device may be coupled to an external device, such as a remote control, a wireless keyboard, a mobile telephone, etc. In some embodiments, device **1200** may include more than one communication interface **1260**. For instance, device **1200** may include an optical interface and an Ethernet interface.

[0074] Device **1200** may perform certain operations relating to one or more processes described above. Device **1200** may perform these operations in response to processor **1220** executing software instructions stored in a computer-readable medium, such as memory **1230**. A computer-readable medium may be defined as a non-transitory memory device. A memory device may include space within a single physical memory device or spread across multiple physical memory devices. The software instructions may be read into memory **1230** from another computer-readable medium or from another device. The software instructions stored in memory **1230** may cause processor **1220** to perform processes described herein. Alternatively, hardwired circuitry may be used in place of or in combination with software instructions to implement processes described herein. Thus, implementations described herein are not limited to any specific combination of hardware circuitry and software.

[0075] The foregoing description of implementations provides illustration and description, but is not intended to be exhaustive or to limit the possible implementations to the precise form disclosed. Modifications and variations are possible in light of the above disclosure or may be acquired from practice of the implementations.

[0076] For example, while series of blocks and/or signals have been described above (e.g., with regard to FIGS. **1-8**), the order of the blocks and/or signals may be modified in other implementations. Further, non-dependent blocks and/or signals may be performed in parallel. Additionally, while the figures have been described in the context of particular devices performing particular acts, in practice, one or more other devices may perform some or all of these acts in lieu of, or in addition to, the above-mentioned devices.

[0077] The actual software code or specialized control hardware used to implement an embodiment is not limiting of the embodiment. Thus, the operation and behavior of the embodiment has been described without reference to the specific software code, it being understood that software and control hardware may be designed based on the description herein.

[0078] In the preceding specification, various example embodiments have been described with reference to the accompanying drawings. It will, however, be evident that various modifications and changes may be made thereto, and additional embodiments may be implemented, without departing from the broader scope of the invention as set forth in the claims that follow. The specification and drawings are accordingly to be regarded in an illustrative rather than restrictive sense.

[0079] Even though particular combinations of features are recited in the claims and/or disclosed in the specification, these combinations are not intended to limit the disclosure of the possible implementations. In fact, many of these features may be combined in ways not specifically recited in the claims and/or disclosed in the specification. Although each dependent claim listed below may directly depend on only one other claim, the disclosure of the possible implementations includes each dependent claim in combination with every other claim in the claim set.

[0080] Further, while certain connections or devices are shown, in practice, additional, fewer, or different, connections or devices may be used. Furthermore, while various devices and networks are shown separately, in practice, the functionality of multiple devices may be performed by a single device, or the functionality of one device may be performed by multiple devices. Further, multiple ones of the illustrated networks may be included in a single network, or a particular network may include multiple networks. Further, while some devices are shown as communicating with a network, some such devices may be incorporated, in whole or in part, as a part of the network.

[0081] To the extent the aforementioned implementations collect, store, or employ personal information of individuals, groups or other entities, it should be understood that such information shall be used in accordance with all applicable laws concerning protection of personal information. Additionally, the collection, storage, and use of such information can be subject to consent of the individual to such activity, for example, through well known "opt-in" or "opt-out" processes as can be appropriate for the situation and type of information. Storage and use of personal information can be in an appropriately secure manner reflective of the type of information, for example, through various access control, encryption and anonymization techniques for particularly sensitive information.

[0082] No element, act, or instruction used in the present application should be construed as critical or essential unless explicitly described as such. An instance of the use of the term "and," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Similarly, an instance of the use of the term "or," as used herein, does not necessarily preclude the interpretation that the phrase "and/or" was intended in that instance. Also, as used herein, the article "a" is intended to include one or more items, and may be used interchangeably with the phrase "one or more." Where only one item is intended, the terms "one," "single," "only," or similar language is used. Further, the phrase "based on" is intended to mean "based, at least in part, on" unless explicitly stated otherwise.

1. A device, comprising:

one or more processors configured to:

identify a custom resource definition of a virtualized environment, wherein the custom resource definition includes configuration parameters associated with the virtualized environment

identify, based on the configuration parameters included in the custom resource definition, that a first container and a second container of a virtualized environment are instantiated at a particular node that is associated with a particular address;

identify, further based on the configuration parameters included in the custom resource definition, a logical association between the first and second containers;

generate a first Domain Name System ("DNS") record associating the first container with the address of the particular node;

generate, based on identifying the logical association between the first and second containers as indicated by the configuration parameters included in the custom resource definition, a second DNS record associating the second container with the first container, wherein the second DNS record includes an identifier of the first container and an identifier of the second container; and

provide the first and second DNS records to a DNS server, wherein the DNS server uses the first and second DNS records to provide the address of the particular node when receiving a DNS request that includes the identifier of the second container.

2. The device of claim **1**, wherein the first DNS record includes a DNS "A"

3. The device of claim **1**, wherein the second DNS record includes a DNS "CNAME" record.

4. The device of claim **3**, wherein the second DNS record indicates that the identifier of the second container is an alias of the identifier of the first container.

5. The device of claim **1**, wherein identifying the logical association between the first and second containers includes identifying, in a particular record of the custom resource definition associated with the virtualized environment, an indication that the second container is associated with the first container in a hierarchical manner.

6. The device of claim **5**, wherein the indication that the second container is associated with the first container in the hierarchical manner includes an indication that the second container is mounted to the first container.

7. The device of claim **1**, wherein the first container implements a software-defined network ("SDN") controller, and wherein the second container implements a Virtualized Network Function ("VNF") that is controlled by the SDN controller.

8. A non-transitory computer-readable medium, storing a plurality of processor-executable instructions to:

identify a custom resource definition of a virtualized environment, wherein the custom resource definition includes configuration parameters associated with the virtualized environment;

identify, based on the configuration parameters included in the custom resource definition, that a first container and a second container of a virtualized environment are instantiated at a particular node that is associated with a particular address;

identify, further based on the configuration parameters included in the custom resource definition, a logical association between the first and second containers;

generate a first Domain Name System ("DNS") record associating the first container with the address of the particular node;

generate, based on identifying the logical association between the first and second containers as indicated by the configuration parameters included in the custom resource definition, a second DNS record associating the second container with the first container, wherein the second DNS record includes an identifier of the first container and an identifier of the second container; and

provide the first and second DNS records to a DNS server, wherein the DNS server uses the first and second DNS records to provide the address of the particular node when receiving a DNS request that includes the identifier of the second container.

9. The non-transitory computer-readable medium of claim **8**, wherein the first DNS record includes a DNS "A" record.

10. The non-transitory computer-readable medium of claim **8**, wherein the second DNS record includes a DNS "CNAME" record.

11. The non-transitory computer-readable medium of claim **10**, wherein the second DNS record indicates that the identifier of the second container is an alias of the identifier of the first container.

12. The non-transitory computer-readable medium of claim **8**, wherein identifying the logical association between the first and second containers includes identifying, in a particular record of the custom resource definition associated with the virtualized environment, an indication that the second container is associated with the first container in a hierarchical manner.

13. The non-transitory computer-readable medium of claim **12**, wherein the indication that the second container is associated with the first container in the hierarchical manner includes an indication that the second container is mounted to the first container.

14. The non-transitory computer-readable medium of claim **8**, wherein the first container implements a software-defined network ("SDN") controller, and wherein the second container implements a Virtualized Network Function ("VNF") that is controlled by the SDN controller.

15. A method, comprising:

identifying a custom resource definition of a virtualized environment, wherein the custom resource definition includes configuration parameters associated with the virtualized environment

identifying, based on the configuration parameters included in the custom resource definition, that a first container and a second container of a virtualized environment are instantiated at a particular node that is associated with a particular address;

identifying, further based on the configuration parameters included in the custom resource definition, a logical association between the first and second containers;

generating a first Domain Name System ("DNS") record associating the first container with the address of the particular node;

generating, based on identifying the logical association between the first and second containers, a second DNS record associating the second container with the first container, wherein the second DNS record includes an identifier of the first container and an identifier of the second container; and

providing the first and second DNS records to a DNS server, wherein the DNS server uses the first and second DNS records to provide the address of the particular node when receiving a DNS request that includes the identifier of the second container.

16. The method of claim **15**, wherein the first DNS record includes a DNS "A" record, and wherein the second DNS record includes a DNS "CNAME" record.

17. The method of claim **16**, wherein the second DNS record indicates that the identifier of the second container is an alias of the identifier of the first container.

18. The method of claim **15**, wherein identifying the logical association between the first and second containers includes identifying, in a particular record of the custom resource definition associated with the virtualized environment, an indication that the second container is associated with the first container in a hierarchical manner.

19. The method of claim **18**, wherein the indication that the second container is associated with the first container in the hierarchical manner includes an indication that the second container is mounted to the first container.

20. The method of claim **15**, wherein the first container implements a software-defined network ("SDN") controller, and wherein the second container implements a Virtualized Network Function ("VNF") that is controlled by the SDN controller.

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