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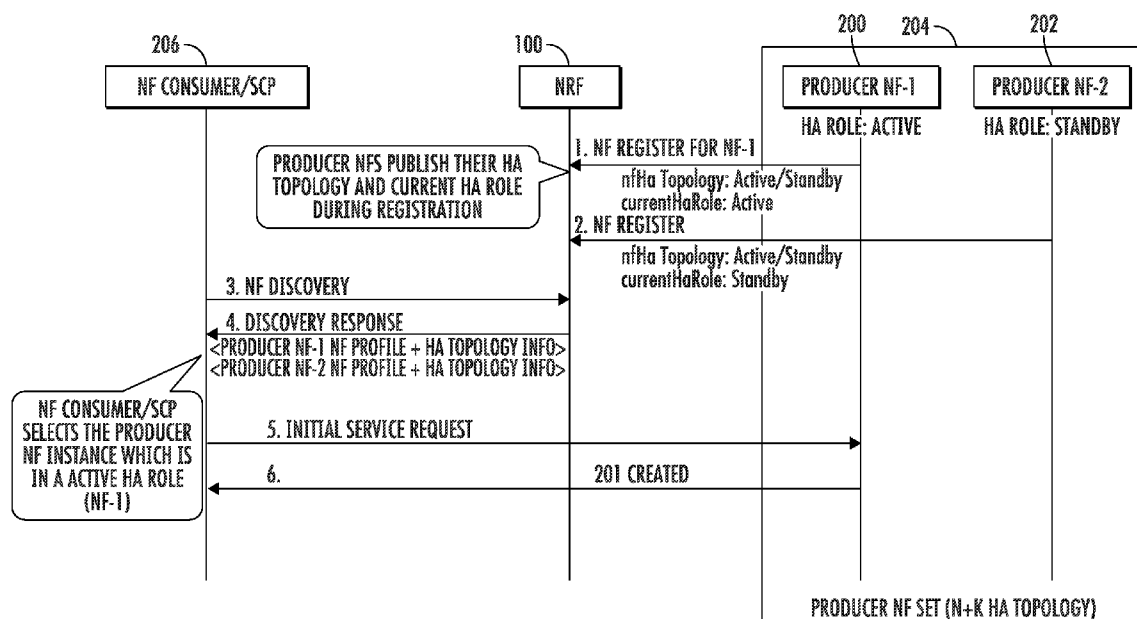


FIG. 4

(57) Abstract: A method for distributing network function (NF) high availability (HA) topology information in a core network includes, at an NF repository function (NRF) including at least one processor, receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF HA topology information for the producer NFs. The method further includes registering the producer NFs and storing the NF HA topology information for the producer NFs. The method further includes receiving, from a consumer NF or service communication proxy (SCP), an NFDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs. The method further includes responding to the NFDiscover request by generating an NFDiscover response, including, in the NFDiscover response, the NF HA topology information for the producer NFs, and transmitting the

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NFDDiscover response to the consumer NF or SCP.

METHODS, SYSTEMS, AND COMPUTER READABLE MEDIA FOR
DISTRIBUTING NETWORK FUNCTION (NF) HIGH AVAILABILITY (HA)
TOPOLOGY INFORMATION IN A CORE NETWORK

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PRIORITY CLAIM

This application claims the priority benefit of U.S. Patent Application Serial No. 17/334,268, filed May 28, 2021, the disclosure of which is incorporated herein by reference in its entirety.

10

TECHNICAL FIELD

The subject matter described herein relates to providing high availability support for NFs. More particularly, the subject matter described herein relates to methods, systems, and computer readable media for distributing NF HA topology information in a core network.

15

BACKGROUND

In 5G telecommunications networks, a network function that provides service is referred to as a producer NF or NF service producer. A network function that consumes services is referred to as a consumer NF or NF service consumer. A network function can be a producer NF, a consumer NF, or both, depending on whether the network function is consuming, producing, or consuming and producing services. The terms “producer NF” and “NF service producer” are used interchangeably herein. Similarly, the terms “consumer NF” and “NF service consumer” are used interchangeably herein.

25

A given producer NF may have many service endpoints, where a service endpoint is the point of contact for one or more NF instances hosted by the producer NF. The service endpoint is identified by a combination of Internet protocol (IP) address and port number or a fully qualified domain name that resolves to an IP address and port number on a network node that hosts a producer NF. An NF instance is an instance of a producer NF that provides a service. A given producer NF may include more than one NF instance. It should also be noted that multiple NF instances can share the same service endpoint.

30

Producer NFs register with a network function repository function (NRF). The NRF maintains service profiles of available NF instances identifying the services supported by each NF instance. The terms “service profiles” and “NF profiles” are used interchangeably herein. Consumer NFs
5 can subscribe to receive information about producer NF instances that have registered with the NRF.

In addition to consumer NFs, another type of network node that can subscribe to receive information about NF service instances is a service communication proxy (SCP). The SCP subscribes with the NRF and obtains
10 reachability and service profile information regarding producer NF service instances. Consumer NFs connect to the service communication proxy, and the service communication proxy load balances traffic among producer NF service instances that provide the required services or directly routes the traffic to the destination producer NF instances.

In addition to the SCP, another example of an intermediate proxy node that routes traffic between producer and consumer NFs is the security edge protection proxy (SEPP). The SEPP is the network node used to protect control plane traffic that is exchanged between different 5G public land mobile networks (PLMNs). As such, the SEPP performs message filtering, policing
15 and topology hiding for all application programming interface (API) messages that are transmitted between PLMNs.
20

One problem in 5G communications networks is that 3GPP standards do not provide a way for NFs to publish their HA topology information to other NFs in the 5G network. NFs in the 5G network support different HA
25 topologies, including active-active, active-standby, an N+K, where N is the number of active NF instances and K is the number of standby NF instances. Consumer NFs seeking to obtain service from a producer NF that operates in an HA topology need to know the HA topology for load balancing and for rerouting in the event that a producer NF providing service to a consumer NF
30 fails. However, 3GPP standards do not currently provide a way for producer NFs to publish their HA topology information to the core network. As a result, load balancing and rerouting may be sub-optimally performed in the 5G core network.

In light of these and other difficulties, there exists a need for methods, systems, and computer readable media for distributing NF HA topology information in the core network.

5

SUMMARY

A method for distributing network function (NF) high availability (HA) topology information in a core network includes, at an NF repository function (NRF) including at least one processor, receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF HA topology information for the producer NFs. The method further includes registering the producer NFs and storing the NF HA topology information for the producer NFs. The method further includes receiving, from a consumer NF or service communication proxy (SCP), an NFDDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs. The method further includes responding to the NFDDiscover request by generating an NFDDiscover response, including, in the NFDDiscover response, the NF HA topology information for the producer NFs, and transmitting the NFDDiscover response to the consumer NF or SCP.

According to another aspect of the subject matter described herein, receiving the NFRegister requests including the NF HA topology information includes receiving the NFRegister requests including information identifying an NF HA topology type supported by the producer NFs.

According to another aspect of the subject matter described herein, the information identifying the NF HA topology type includes information identifying one of: an active-active NF HA topology type, an active-standby NF HA topology type, and an N+K NF HA topology type, where N and K are integers respectively identifying a number of active NFs and a number of standby NFs in the NF set.

According to another aspect of the subject matter described herein, receiving the NFRegister requests including the NF HA topology information includes receiving the NFRegister requests, each including information identifying a current NF HA topology role of a producer NF in the NF set.

According to another aspect of the subject matter described herein, the information identifying the current NF HA topology role of the producer NF in the NF set includes information identifying the producer NF as an active NF or a standby NF.

5 According to another aspect of the subject matter described herein, responding to the NFDDiscover request with the NFDDiscover response including the NF HA topology information comprises including, in the NFDDiscover response, the information identifying the NF HA topology type and the information identifying the current NF HA topology role.

10 According to another aspect of the subject matter described herein, the method for distributing NF HA topology information includes, at the NRF, receiving, from at least one of the producer NFs, an NFUpdate request including updated NF HA topology information for the at least one producer NF and, in response to the receiving the NFUpdate request with the updated
15 NF HA topology information for the at least one producer NF, storing the updated NF HA topology information for the at least one producer NF and automatically communicating the updated NF HA topology information to consumer NFs subscribed to receive updates in NF profile information for the at least one producer NF.

20 According to another aspect of the subject matter described herein, the updated NF HA topology information indicates a change in role of a first producer NF in the NF set from an active HA role to a standby HA role and of a second producer NF in the NF set from a standby HA role to an active HA role and wherein the method further comprises, at the consumer NF or SCP,
25 transmitting a service request to the second producer NF.

 According to another aspect of the subject matter described herein, receiving the NFDDiscover request from a consumer NF or SCP includes receiving the NFDDiscover request from a consumer NF, and further comprising, at the consumer NF, using the NF HA topology information to
30 select a producer NF in the NF set to provide service to the consumer NF.

 According to another aspect of the subject matter described herein, receiving the NFDDiscover request from a consumer NF or SCP includes receiving the NFDDiscover request from an SCP, and further comprising, at the

SCP, using the NF HA topology information to select a producer NF in the NF set to provide service to the consumer NF.

According to another aspect of the subject matter described herein, a system for distributing network function (NF) high availability (HA) topology information in a core network is provided. The system includes a network function (NF) repository function (NRF) including at least one processor. The system further includes an NF profiles manager implemented by the at least one processor for receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF HA topology information for the producer NFs, registering the producer NFs and storing the NF HA topology information for the producer NFs, receiving, from a consumer NF or service communication proxy (SCP), an NFDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs, and responding to the NFDiscover request by generating an NFDiscover response, including, in the NFDiscover response, the NF HA topology information for the producer NFs, and transmitting the NFDiscover response to the consumer NF or SCP.

According to another aspect of the subject matter described herein, the NFRegister requests include information identifying an NF HA topology type supported by the producer NFs.

According to another aspect of the subject matter described herein, the information identifying the NF HA topology type includes information identifying one of: an active-active NF HA topology type, an active-standby NF HA topology type, and an N+K NF HA topology type, where N and K are integers respectively identifying a number of active NFs and a number of standby NFs in the NF set.

According to another aspect of the subject matter described herein, the NFRegister requests each include information identifying a current NF HA topology role of a producer NF in the NF set.

According to another aspect of the subject matter described herein, the information identifying the current NF HA topology role of the producer NF in the NF set includes information identifying the producer NF as an active NF or a standby NF.

According to another aspect of the subject matter described herein, the NFDDiscover response includes the information identifying the NF HA topology type and the information identifying the current NF HA topology role.

According to another aspect of the subject matter described herein, the NF profiles manager is configured to receive, from at least one of the producer NFs, an NFUpdate request including updated NF HA topology information for the at least one producer NF and, in response to the receiving the NFUpdate request with the updated NF HA topology information for the at least one producer NF, store the updated NF HA topology information for the at least one producer NF and automatically communicate the updated NF HA topology information to consumer NFs subscribed to receive updates in NF profile information for the at least one producer NF.

According to another aspect of the subject matter described herein, the updated NF HA topology information indicates a change in role of a first producer NF in the NF set from an active HA role to a standby HA role and of a second producer NF in the NF set from a standby HA role to an active HA role.

According to another aspect of the subject matter described herein, the NF profiles manager receives the NFDDiscover request from a consumer NF.

According to another aspect of the subject matter described herein, the NF profiles manager receives the NFDDiscover request from an SCP.

According to another aspect of the subject matter described herein, a non-transitory computer readable medium having stored thereon executable instructions that when executed by a processor of a computer control the computer to perform steps is provided. The steps are performed at a network function (NF) repository function (NRF). The steps include receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF high availability (HA) topology information for the producer NFs. The steps further include registering the producer NFs and storing the NF HA topology information for the producer NFs. The steps further include receiving, from a consumer NF or service communications proxy (SCP), an NFDDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs. The steps further include responding

to the NFDDiscover request by generating an NFDDiscover response, including, in the NFDDiscover response, the NF HA topology information for the producer NFs, and transmitting the NFDDiscover response to the consumer NF or SCP.

The subject matter described herein can be implemented in software in combination with hardware and/or firmware. For example, the subject matter described herein can be implemented in software executed by a processor. In one exemplary implementation, the subject matter described herein can be implemented using a non-transitory computer readable medium having stored thereon computer executable instructions that when executed by the processor of a computer control the computer to perform steps. Exemplary computer readable media suitable for implementing the subject matter described herein include non-transitory computer-readable media, such as disk memory devices, chip memory devices, programmable logic devices, and application specific integrated circuits. In addition, a computer readable medium that implements the subject matter described herein may be located on a single device or computing platform or may be distributed across multiple devices or computing platforms.

BRIEF DESCRIPTION OF THE DRAWINGS

Exemplary implementations of the subject matter described herein will now be explained with reference to the accompanying drawings, of which:

Figure 1 is a network diagram illustrating an exemplary 5G system network architecture;

Figure 2 is a message flow diagram illustrating exemplary messages exchanged between network functions in a network that does not provide support for the distribution of NF HA topology information where a consumer NF selects a producer NF that is currently in a standby HA role;

Figure 3 is a message flow diagram illustrating exemplary messages exchanged between network functions in a network that does not provide support for the distribution of NF HA topology information where a producer NF transitions to a standby HA role and a consumer NF attempts to obtain service from the producer NF after the HA state transition;

Figure 4 is a message flow diagram illustrating an exemplary network that supports distribution of NF HA topology information where a producer NF provides the HA topology type implemented by the NF set of which producer NF is a member and the current HA role of the producer NF to an NRF and
5 the NRF provides the HA topology information to a consumer NF in a discovery response so that the consumer NF can use the HA topology information in selecting a producer NF to provide service;

Figure 5 is a message flow diagram illustrating an exemplary network that supports distribution of HA topology information where a producer NF
10 provides the HA topology type implemented by the NF set of which producer NF is a member and the current HA role of the producer NF to an NRF, the NRF publishes the update in the HA topology information to a consumer NF, and the consumer NF uses the updated HA topology information to select an active producer NF to provide service;

15 Figure 6 is a block diagram illustrating an exemplary architecture for an NRF that facilitates distribution of NF HA topology information to consumer NFs and SCPs;

Figure 7 is a flow chart illustrating an exemplary process performed by an NRF for distributing NF HA topology information to NFs and SCPs;

20 Figure 8 is a block diagram illustrating an exemplary architecture for a consumer NF for obtaining and using NF HA topology information;

Figure 9 is a flow chart illustrating an exemplary process performed by a consumer NF for obtaining and using NF HA topology information;

Figure 10 is a block diagram illustrating an exemplary architecture for
25 a producer NF for distributing NF HA topology information; and

Figure 11 is a flow chart illustrating an exemplary process performed by a producer NF for distributing NF HA topology information.

DETAILED DESCRIPTION

30 Figure 1 is a block diagram illustrating an exemplary 5G system network architecture. The architecture in Figure 1 includes NRF **100** and SCP **101**, which may be located in the same home public land mobile network (HPLMN). As described above, NRF **100** may maintain profiles of available

producer NF service instances and their supported services and allow consumer NFs or SCPs to subscribe to and be notified of the registration of new/updated producer NF service instances. SCP **101** may also support service discovery and selection of producer NF instances. SCP **101** may perform load balancing of connections between consumer and producer NFs.

NRF **100** is a repository for NF or service profiles of producer NF instances. In order to communicate with a producer NF instance, a consumer NF or an SCP must obtain the NF or service profile of the producer NF instance from NRF **100**. The NF or service profile is a JavaScript object notation (JSON) data structure defined in 3GPP TS 29.510. The NF or service profile definition includes at least one of a fully qualified domain name (FQDN), an Internet protocol (IP) version 4 (IPv4) address or an IP version 6 (IPv6) address.

In Figure 1, any of the network functions can be consumer NFs, producer NFs, or both, depending on whether they are requesting, providing, or requesting and providing services. In the illustrated example, the NFs include a policy control function (PCF) **102** that performs policy related operations in a network, a unified data management (UDM) **104** that manages user data, and an application function (AF) **106** that provides application services.

The NFs illustrated in Figure 1 further include a session management function (SMF) **108** that manages sessions between access and mobility management function (AMF) **110** and PCF **102**. AMF **110** performs mobility management operations similar to those performed by a mobility management entity (MME) in 4G networks. An authentication server function (AUSF) **112** performs authentication services for user equipment (UEs), such as user equipment (UE) **114**, seeking access to the network.

A network slice selection function (NSSF) **116** provides network slicing services for devices seeking to access specific network capabilities and characteristics associated with a network slice. A network exposure function (NEF) **118** provides application programming interfaces (APIs) for application functions seeking to obtain information about Internet of things (IoT) devices

and other UEs attached to the network. NEF **118** performs similar functions to the service capability exposure function (SCEF) in 4G networks.

A radio access network (RAN) **120** connects user equipment (UE) **114** to the network via a wireless link. Radio access network **120** may be accessed
5 using a g-Node B (gNB) (not shown in Figure 1) or other wireless access point. A user plane function (UPF) **122** can support various proxy functionality for user plane services. One example of such proxy functionality is multipath transmission control protocol (MPTCP) proxy functionality. UPF **122** may also support performance measurement functionality, which may be used by UE
10 **114** to obtain network performance measurements. Also illustrated in Figure 1 is a data network (DN) **124** through which UEs access data network services, such as Internet services.

SEPP **126** filters incoming traffic from another PLMN and performs topology hiding for traffic exiting the home PLMN. SEPP **126** may
15 communicate with a SEPP in a foreign PLMN which manages security for the foreign PLMN. Thus, traffic between NFs in different PLMNs may traverse two SEPP functions, one for the home PLMN and the other for the foreign PLMN.

As stated above, one problem in 5G networks is the lack of a defined
20 mechanism for an NF to distribute its HA topology information. For example, different NFs in the 5G core (5GC) network may implement different HA topology types. Examples of such HA topology types are:

Active-Active – where multiple NFs in an NF set are operational
25 and provide service at the same time;

Active-Standby – where some NFs are operational and provide service and other NFs are operational but do not provide service unless one of the active NFs fails or otherwise becomes unavailable; and

30 N+K model – where N NFs are operational and provide service and K NFs are operational but do not provide service unless one of the N active NFs fails or otherwise becomes unavailable.

It is important for the NF consumer/SCP to know the NF producer's HA topology for (re-)routing and load balancing of 5G SBI traffic. 3GPP does not provide a way to publish HA related information in the network. 3GPP implies
5 active-active HA topology for an NF set, which is not true for all deployments. An NF set is a logical group of NFs that provide the same service, support the same network slices, and are identified by the same NF set ID. 3GPP assumes that all of the NFs in an NF set are active, which may not be true, for example, if an operator decides to deploy some NFs in a NF set as active and
10 other NFs in the NF set as standby.

The subject matter described herein provides a method for publishing an NF's HA topology information so that a consumer NF or SCP can use this information when selecting an NF to provide service. The NF HA topology information may define the NF HA type implemented by an NF set, as well as
15 the publishing NF's role in the NF HA type. In absence of this solution, 5G SBI routing is not possible for an HA topology, other than active-active topology. As a workaround, NFs implementing an N+K HA are required to be deployed in an active-active topology where the network operator will face the following challenges:

20 the NF consumer/SCP would have to incur additional routing attempts in the case of HA an state transition (to standby) after resource creation; and
the consumer NF/SCP would have problems in load balancing
25 traffic between NF instances with different HA roles.

More routing attempts would be required if a consumer NF or SCP sends an SBI request to a producer NF operating in a standby role, as an NF operating in a standby role would not be expecting to receive traffic, and such traffic
30 would have to be re-routed by the consumer NF or SCP to another NF operating in an active role. Load balancing would be difficult if the consumer NF or SCP does not know the HA roles of producer NFs, because NFs operating in standby roles should not receive live traffic.

Figure 2 is a message flow diagram illustrating exemplary messages exchanged when a consumer NF or SCP attempts to route traffic to a standby producer NF in an NF set that implements an N+K HA topology. In Figure 2, producer NF-1 **200** operates in an active HA role, and producer NF-2 **202** operates in a standby HA role. Producer NF-1 **200** and producer NF-2 **202** form an NF set **204**. NF set **204** implements an N+K HA topology.

Referring to the message flow in Figure 2, in step 1, producer NF-1 **200** sends an NFRegister request to NRF **100**. The NFRegister request contains the NF profile of producer NF-1 **200**. However, 3GPP does not define a way for producer NF-1 **200** to communicate to NRF **100** the HA topology type implemented by NF set **204** or the role of producer NF-1 **200** in the HA topology type.

In step 2 of the message flow diagram, producer NF-2 **202** operating in a standby HA role sends an NFRegister request message to NRF **100**. The NFRegister request message does not include an indication that producer NF-2 **202** is operating in a standby role. As a result, there is no way for consumer NFs to know the NF HA topology type implemented by NF set **204** or the roles of the producer NFs in the NF set.

In step 3 of the message flow diagram, consumer NF or SCP **206** sends an NFDDiscover request message to NRF **100**. The NFDDiscover request message may include discovery parameters for selecting a producer NF to provide service. In step 4 of the message flow diagram, NRF **100** responds to the NFDDiscover request message with an NFDDiscover response message including the NF profiles of producer NF-1 **200** and producer NF-2 **202**. However, the NFDDiscover response message does not include the NF HA type implemented by NF set **204** or the HA roles of producer NF-1 **200** and producer NF-2 **202**. As a result, consumer NF or SCP **206** may route a service based interface (SBI) service request, as indicated by step 5 of the message flow diagram, to a producer NF operating in the standby role. When producer NF-2 **202** receives the SBI service request message, because producer NF-2 **202** is operating in the standby role, producer NF-2 **202** will reject the SBI service request message. As a result, consumer NF or SCP **206** is required to re-route the service request by selecting another NF and sending the SBI

service request to another producer NF. Consumer NF or SCP **206** may be required to re-route the service request multiple times until the request is received by a producer NF operating in an active HA role. Such re-routing is time consuming and wastes network resources.

5 Figure 3 illustrates another problem that can occur when an NF HA state transition occurs. In Figure 3, it is assumed that producer NF-1 **200** and producer NF-2 **202** have registered with NRF **100** without specifying their NF HA topology types or the NF HA topology role implemented by the NF set of which producer NF-1 **200** or producer NF-2 **202** are members. In step 1 of the message flow diagram in Figure 3, consumer NF or SCP **206** sends an SBI service request to producer NF-1 **200**. Because producer NF-1 **200** is functioning in the active HA role, producer NF-1 **200** responds to the SBI service request in step 2 with a 201 Created message.

10 In step 3, an HA state transition occurs in NF set **204** where producer NF-1 **200** transitions to a standby HA role, and producer NF-2 **202** transitions to an active HA role. In step 4 of the message flow diagram, consumer NF or SCP **206** sends a subsequent service request to producer NF-1 **200**, which is currently operating in the standby HA role. Because producer NF-1 **200** is operating in the standby role, producer NF-1 **200** rejects the service request.

20 As a result, consumer NF or SCP **206** will be required to re-route the service request to another NF, which results in routing and network inefficiencies.

 In order to address the difficulties illustrated by the message flows in Figures 2 and 3, subject matter described herein includes the ability of a producer NF to communicate, to the NRF, the NF HA topology type implemented by the NF set of which the producer NF is a member and also the current HA role of the producer NF within the HA topology type. The NRF stores information that indicates the NF HA topology type and current NF HA role in the NF profiles database or in a separate database. When a consumer NF seeks to discover one or more producer NFs to provide a service, the NRF includes in the discovery response, information that indicates the NF HA topology type and NF HA topology role of the producer NFs. The NF service consumer can then use the NF HA topology type and information to select a producer NF to provide service.

25

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Figure 4 is a message flow diagram illustrating an exemplary network that supports distribution of NF HA topology information where a producer NF provides the HA topology type implemented by the NF set of which producer NF is a member and the current HA role of the producer NF to an NRF and the NRF provides the HA topology information to a consumer NF in a discovery response so that the consumer NF can use the HA topology information in selecting a producer NF to provide service. Referring to the message flow in Figure 4, in step 1, producer NF-1 **200** sends an NFRegister request message to NRF **100** to register producer NF-1 **200** to provide service. The NFRegister request message indicates the NF HA topology type, which in the illustrated example is active/standby and the HF HA role, which, for producer NF-2 **202**, is active. In step 3 of the message flow diagram, consumer NF or SCP **206** sends an NFDiscover request message to NRF **100**. The NFDiscover request message may include discovery parameters for selecting a producer NF to provide service to a consumer NF. In step 4 of the message flow diagram, NRF **100** responds to the NFDiscover request message with an NFDiscover response message including the NF profiles of producer NF-1 **200** and producer NF-2 **202**. The NFDiscover response message includes NF HA topology information that indicates the NF HA type implemented by NF set **204** and the HA roles of producer NF-1 **200** and producer NF-2 **202**. In the illustrated example, the NF HA topology information indicates that the NF HA topology type implemented by NF set **204** is active/standby, the NF HA role currently implemented by producer NF-1 **200** is active, and the NF HA role currently implemented by producer NF-2 **202** is standby.

Using the NF HA topology information, consumer NF or SCP **206** selects a producer NF that is currently in the active HA role to provide service. In the illustrated example, consumer NF or SCP **206** selects producer NF-1 **200** to provide service. In step 5 of the message flow diagram, producer NF or SCP **206** sends an SBI service request to producer NF-1 **200**, which is operating in the active HA role. Because producer NF-1 **200** is operating in the active HA role, producer NF-1 **200** accepts the SBI service request, and, in step 6, responds to the SBI service request with a 201 Created message.

Thus, Figure 4 illustrates the case where NF HA topology information is provided to NRF **100** in NFRegister messages, distributed to a consumer NF or SCP in an NFDiscover response message, and used by the consumer NF or SCP to select an active NF to process an initial SBI service request message. Because the consumer NF or SCP has the NF HA topology information, consumer NF or SCP **206** can avoid the routing inefficiency illustrated in Figure 2.

Figure 5 is a message flow diagram illustrating exemplary messages exchanged to distribute updated NF HA topology information in response to an HA state transition and the use of the update HA topology information to select a new active NF to provide service. Referring to Figure 5, in step 1, an NF HA state transition occurs. The NF HA state transition is producer NF-1 **200** switching its HA role from active to standby and producer NF-2 **202** switching its HA role from standby to active. In step 2 of the message flow diagram, producer NF-1 **200** sends an NFUpdate request to NRF **100** identifying the new HA role of producer NF-1 **200**.

In step 3 of the message flow diagram, NRF **100**, in response to receiving the NFUpdate request, publishes a notification message to all consumer NFs or SCPs that are subscribed to receive updates regarding changes in status of producer NF-1 **200**. In the illustrated example, producer NF-1 **200** sends the notification message to consumer NF or SCP **206**. The notification message includes the updated NF HA topology information for producer NF-1 **200**.

In step 4 of the message flow diagram, producer NF-2 **202** sends NFUpdate request to NRF **100** containing a new NF HA role for producer NF-2 **202**. In the illustrated example, the NF update message indicates that producer NF-2 **202** is switching to the active role. In step 5 of the message flow diagram, NRF **100** sends a notification message to consumer NF or SCP **206** with the updated NF HA topology information for producer NF-2 **202**.

In step 6 of the message flow diagram, consumer NF or SCP **206** formulates a subsequent SBI service request message, and, rather than sending the subsequent SBI service request message to producer NF-1 **200**, consumer NF or SCP **206** sends the subsequent SBI service request to

producer NF-2 **202** based on the current updated HF HA topology information. In the example illustrated in Figure 5, it is assumed that when producer NF-2 **202** switches to the active state, producer NF-2 **202** has obtained the necessary state information to process the subsequent SBI service request from consumer NF or SCP **206**. In step 7 of the message flow diagram producer NF-2 **202** sends a 200 OK message to consumer NF or SCP **206**.

Thus, Figure 5 illustrates the case where producer NFs automatically update their HA roles and communicate their new HA roles to NRF **100** and where NRF **100** automatically distributes indications of the change in status to consumer NFs and SCPs that are subscribed to receive updates regarding change in status of an NF. Using the updated NF HA topology information, the subject matter described herein avoids the scenario illustrated in Figure 3 where an NF HA state transition occurs and a subsequent SBI service request lands on a standby producer NF. Thus, the scenario illustrated in Figure 5 provides increased efficiency over the scenario illustrated in Figure 3 where the consumer NF or SCP is required to re-route the service request to another producer NF.

Figure 6 is a block diagram illustrating an exemplary architecture of NRF **100** capable of obtaining, storing, and distributing producer NF HA topology information. Referring to Figure 6, NRF **100** includes at least one processor **600** and a memory **602**. NRF **100** further includes an NF profiles database **604** that stores NF profiles of producer NFs that are registered with NRF **100**. NRF **100** further includes an NF profiles manager **606** that receives NFRegister request messages, stores NF profiles of producer NFs in database **604**, and distributes NF profile information from consumer NFs. NF profiles manager **606** may also receive NF HA topology information from producer NFs and store the HF HA topology information in NF profiles database **604** or in a separate database maintained by NRF **100**. NF profiles manager **606** may provide the NF HA topology information to consumer NFs or SCPs in response to NFDiscover requests and also in response to NFUpdate messages from producer NFs. NF profiles manager **606** may be implemented using computer executable instructions stored in memory **602** and executed by processor **600**.

Figure 7 is a flow chart illustrating an exemplary method for distributing NF HA information. The steps in Figure 7 are performed at an NRF, such as NRF **100**. Referring to Figure 7, in step **700**, the process includes receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF HA topology information for the producer NFs. For example, NRF **100** may receive NFRegister requests from producer NFs, where the NFRegister requests include information identifying an NF HA topology type implemented by the producer NFs and a current NF HA topology role implemented by each producer NF in the NF set. As described above, NF HA topology types may include active-active, active-standby, and N+K, where N and K are integers that respectively identify the number of active and standby NFs in an NF set. The NF HA topology role information provided in the NFRegister requests may identify each NF as active or standby.

In step **702**, the process includes registering the producer NFs and storing the NF HA topology information for the producer NFs. For example, NRF **100** may register the producer NFs by storing the NF profiles for the producer NFs in NF profiles database **604** and storing registration status or state indicators for the NFs indicating a status or state of REGISTERED. NRF **100** may store the NF HA topology information in NF profiles database **604** or in a separate database used to store NF HA topology information.

In step **704**, the process includes receiving, from a consumer NF or service communication proxy (SCP), an NFDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs. For example, NRF **100** may receive an NFDiscover request from a consumer NF that includes parameters identifying a type of service for which NF discovery is being requested.

In step **706**, the process includes responding to the NFDiscover request by generating an NFDiscover response, including, in the NFDiscover response, the NF HA topology information for the producer NFs, and transmitting the NFDiscover response to the consumer NF or SCP. For example, NRF **100** may generate an NFDiscover response message in response to a received NFDiscover request message. The NFDiscover response message may include NF profiles of producer NFs that match the

service identifying parameters in the NFDDiscover request. The NFDDiscover response may also include, for each NF for which NF HA topology information is available, the NF HA type implemented by the producer NF set and the current NF HA role of each producer NF. It should be noted that the NF HA topology information may be included as one or more attributes of the NF profile of each producer NF or may be communicated separately from the NF profiles of the producer NFs.

In step **708**, the process includes receiving updated NF HA topology information for a producer NF. For example, NRF **100** may receive an NFUpdate request message from a producer NF when the NF HA topology role of the producer NF changes. Examples of NF HA topology role changes include changes from active to standby or from standby to active.

In step **710**, the process includes publishing the updated NF HA topology information for the producer NF to NFs subscribed to receive NFUpdates regarding the producer NF. For example, NRF **100**, in response to receiving an NFUpdate request message regarding a producer NF may update the profile for the producer NF in the NF profiles database. In addition, NRF **100** may also update the NF HA role for the producer NF if the NF HA role for the producer NF changed. NRF **100** may then communicate notification of changes in the NF profile and the NF HA topology information to consumer NFs and SCPs that are subscribed to receive the updates.

Figure 8 is a block diagram illustrating an exemplary architecture for consumer NF or SCP **206** that obtains and uses NF HA topology information to route SBI service requests. Referring to Figure 8, consumer NF or SCP **206** includes at least one processor **800** and a memory **802**. Consumer NF or SCP **206** further includes and NF discovery/SBI request generator **804** that generates and sends NFDDiscover requests to NRF **100**, receives NFDDiscover responses from NRF **100**, where the NFDDiscover responses include NF HA topology information, and generates and sends SBI requests to producer NFs selected using the NF HA topology information. NF discovery/SBI request generator **804** may be implemented using computer executable instructions stored in memory **802** and executed by processor **800**.

Figure 9 is a flow chart illustrating an exemplary process implemented by a consumer NF or SCP for obtaining and using NF HA topology information to select a producer NF to provide service. The steps illustrated in Figure 9 may be implemented by consumer NF or SCP **206** illustrated in Figure 8.

5 Referring to Figure 9, in step **900**, the process includes generating an NFDDiscover request and sending the NFDDiscover request to an NRF. For example, consumer NF or SCP **206** may generate an NFDDiscover request including discovery parameters for a service needed by a consumer NF and send the NFDDiscover request to NRF **100**.

10 In step **902**, the process includes, in response to the NFDDiscover request, receiving an NFDDiscover response. The NFDDiscover response includes NF profiles matching the discovery parameters from the request as well as NF HA topology information of producer NFs. The NF HA topology information may be included in the NF profiles or may be included in data
15 structures separate from the NF profiles.

In step **904**, the process includes selecting a producer NF to provide a service using the NF HA topology information. For example, consumer NF for SCP **206** may use the NF HA topology information to select an active NF to provide service for the consumer NF. In step **906**, the process includes
20 sending a new SBI request to the producer NF. For example, consumer NF or SCP **206** may send an SBI request to the producer NF that was selected using the NF HA topology information.

In step **908**, the process includes receiving an NFUpdate request message with updated NF HA topology information for the producer NF. For
25 example, consumer NF for SCP **206** may receive an NFUpdate request message containing updated NF HA topology information for a producer NF currently providing service for the consumer NF. The updated NF HA topology information may indicate that the role of the producer NF has changed.

In step **910**, the process includes selecting a new producer NF to
30 provide the service based on the updated NF HA topology information. For example, consumer NF or SCP **206** may select a new active producer NF to provide service when the role of the producer NF currently providing service changes to standby. In step **912**, consumer NF or SCP **206** generates and

sends a new SBI request to the new producer NF. For example, consumer NF or SCP **206** may generate and send an SBI request to a producer NF that is currently active.

Figure 10 is a block diagram illustrating an exemplary producer NF **200** or **202** capable of distributing NF HA topology information to other NFs. Referring to Figure 10, producer NF **200** or **202** includes at least one processor **1000** and a memory **1002**. Producer NF **200** or **202** further includes an NF HA topology manager **1004** that maintains, in memory **1002**, indications of the NF HA topology type and NF HA topology role implemented by producer NF **200** or **202**. NF HA topology manager **1004** may also determine when the NF HA topology role of producer NF **200** or **202** needs to change, e.g., based on input from a network operator that the NF HA topology of producer NF **200** or **202** needs to change. Producer NF **200** or **202** also distributes its NF HA topology information to other NFs by sending NFRegister and NFUpdate messages to NRF **100**. NF HA topology manager **1004** may be implemented using computer executable instructions stored in memory **1002** and executed by processor **1000**.

Figure 11 illustrates an exemplary process implemented by a producer NF in distributing its NF HA topology information to other NFs. Referring to Figure 11, in step **1100**, the process includes storing indications of HA topology type and HA topology role in memory. For example, producer NF **200** or **202** may store, in memory **1002**, an indication of the current HA topology type and HA topology role implemented by producer NF **200** or **202**.

In step **1102**, the process includes communicating the NF HA topology information to the NRF. For example, producer NF **200** or **202** may generate and send an NFRegister request including the NF HA topology information to NRF **100**.

In step **1104**, the process includes detecting a need for a change in NF HA role. For example, producer NF **200** or **202** may determine that its NF HA topology role needs to change in response to receiving notification of the need for a change from a network operator.

In step **1106**, producer NF **200** or **202** changes its NF HA role. For example, producer NF **200** or **202** may change from active to standby or from

standby to active. In step **1108**, producer NF **200** or **202** communicates an indication of the updated NF HA role to the NRF. For example, producer NF **200** or **202** may generate and send an NFUpdate request message with the updated NF HA role to NRF **100**.

5 Benefits of the subject matter described herein include synergy between the NRF and SCP in indirect communication models. Another benefit is that the subject matter enables NFs to expose their supported HA topology in the 5GC, which results in better (re-)routing and load balancing handling at the NF consumer/SCP. The subject matter described herein also provides
10 better routing resiliency for producers supporting an active-standby or an N+K HA topology. The subject matter described herein also provides better routing resiliency for networks with hybrid NF deployments (virtual machine (VM), hardware, cloud-native) with different HA topologies.

 The disclosure of each of the following references is hereby
15 incorporated herein by reference in its entirety.

References

1. 3rd Generation Partnership Project; Technical Specification Group
Services and System Aspects; System architecture for the 5G System
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2. 3rd Generation Partnership Project; Technical Specification Group Core
Network and Terminals; 5G System; Network Function Repository
Services; Stage 3 (Release 17) 3GPP TS 29.510 V17.1.0 (2021-03).

25 It will be understood that various details of the subject matter described herein may be changed without departing from the scope of the subject matter described herein. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation, as the subject matter described herein is defined by the claims as set forth hereinafter.

30

CLAIMS

What is claimed is:

1. A method for distributing network function (NF) high availability (HA) topology information in a core network, the method comprising:
 - 5 at a network function (NF) repository function (NRF) including at least one processor:
 - receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF HA topology information for the producer NFs;
 - 10 registering the producer NFs and storing the NF HA topology information for the producer NFs;
 - receiving, from a consumer NF or service communication proxy (SCP), an NFDDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs; and
 - 15 responding to the NFDDiscover request by generating an NFDDiscover response, including, in the NFDDiscover response, the NF HA topology information for the producer NFs, and transmitting the NFDDiscover response to the consumer NF or SCP.
- 20 2. The method of claim 1 wherein receiving the NFRegister requests including the NF HA topology information includes receiving the NFRegister requests including information identifying an NF HA topology type supported by the producer NFs.
3. The method of claim 2 wherein the information identifying the NF HA topology type includes information identifying one of: an active-active NF HA topology type, an active-standby NF HA topology type, and an N+K NF HA topology type, where N and K are integers respectively identifying a number of active NFs and a number of standby NFs in the NF set.
- 25 4. The method of claims 2 or 3 wherein receiving the NFRegister requests including the NF HA topology information includes receiving the NFRegister requests, each including information identifying a current NF HA topology role of a producer NF in the NF set.
- 30

5. The method of claim 4 wherein the information identifying the current NF HA topology role of the producer NF in the NF set includes information identifying the producer NF as an active NF or a standby NF.
- 5 6. The method of claims 4 or 5 wherein responding to the NFDDiscover request with the NFDDiscover response including the NF HA topology information comprises including, in the NFDDiscover response, the information identifying the NF HA topology type and the information identifying the current NF HA topology role.
- 10 7. The method of any of the preceding claims comprising, at the NRF, receiving, from at least one of the producer NFs, an NFUpdate request including updated NF HA topology information for the at least one producer NF and, in response to the receiving the NFUpdate request with the updated NF HA topology information for the at least one
15 producer NF, storing the updated NF HA topology information for the at least one producer NF and automatically communicating the updated NF HA topology information to consumer NFs subscribed to receive updates in NF profile information for the at least one producer NF.
- 20 8. The method of claim 7 wherein the updated NF HA topology information indicates a change in role of a first producer NF in the NF set from an active HA role to a standby HA role and of a second producer NF in the NF set from a standby HA role to an active HA role and wherein the method further comprises, at the consumer NF or SCP, transmitting a service request to the second producer NF.
- 25 9. The method of any of the preceding claims wherein receiving the NFDDiscover request from a consumer NF or SCP includes receiving the NFDDiscover request from a consumer NF, and further comprising, at the consumer NF, using the NF HA topology information to select a producer NF in the NF set to provide service to the consumer NF.
- 30 10. The method of any of the preceding claims wherein receiving the NFDDiscover request from a consumer NF or SCP includes receiving the NFDDiscover request from an SCP, and further comprising, at the

SCP, using the NF HA topology information to select a producer NF in the NF set to provide service to the consumer NF.

11. A system for distributing network function (NF) high availability (HA) topology information in a core network, the system comprising:
 - 5 a network function (NF) repository function (NRF) including at least one processor; and
 - an NF profiles manager implemented by the at least one processor for receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF HA topology information for the producer NFs, registering the producer NFs and storing the NF HA topology information for the producer NFs, receiving, from a consumer NF or service communication proxy (SCP), an NFDDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs, and responding to the NFDDiscover request by generating an NFDDiscover response, including, in the NFDDiscover response, the NF HA topology information for the producer NFs, and transmitting the NFDDiscover response to the consumer NF or SCP.
12. The system of claim 11 wherein the NFRegister requests include information identifying an NF HA topology type supported by the producer NFs.
13. The system of claim 12 wherein the information identifying the NF HA topology type includes information identifying one of: an active-active NF HA topology type, an active-standby NF HA topology type, and an N+K NF HA topology type, where N and K are integers respectively identifying a number of active NFs and a number of standby NFs in the NF set.
14. The system of claims 12 or 13 wherein the NFRegister requests each include information identifying a current NF HA topology role of a producer NF in the NF set.
15. The system of claim 14 wherein the information identifying the current NF HA topology role of the producer NF in the NF set includes

- information identifying the producer NF as an active NF or a standby NF.
16. The system of claims 14 or 15 wherein the NFDiscover response includes the information identifying the NF HA topology type and the information identifying the current NF HA topology role.
17. The system of any of claims 11 to 16 wherein the NF profiles manager is configured to receive, from at least one of the producer NFs, an NFUpdate request including updated NF HA topology information for the at least one producer NF and, in response to the receiving the NFUpdate request with the updated NF HA topology information for the at least one producer NF, store the updated NF HA topology information for the at least one producer NF and automatically communicate the updated NF HA topology information to consumer NFs subscribed to receive updates in NF profile information for the at least one producer NF.
18. The system of claim 17 wherein the updated NF HA topology information indicates a change in role of a first producer NF in the NF set from an active HA role to a standby HA role and of a second producer NF in the NF set from a standby HA role to an active HA role.
19. The system of any of claims 11 to 18 wherein the NF profiles manager receives the NFDiscover request from a consumer NF.
20. The system of any of claims 11 to 19 wherein the NF profiles manager receives the NFDiscover request from an SCP.
21. A non-transitory computer readable medium having stored thereon executable instructions that when executed by a processor of a computer control the computer to perform steps comprising:
at a network function (NF) repository function (NRF):
receiving, from a plurality of producer NFs in an NF set, NFRegister requests including NF high availability (HA) topology information for the producer NFs;
registering the producer NFs and storing the NF HA topology information for the producer NFs;

receiving, from a consumer NF or service communication proxy (SCP), an NFDDiscover request containing at least one service discovery parameter that corresponds to a service provided by the producer NFs; and

- 5 responding to the NFDDiscover request by generating an NFDDiscover response, including, in the NFDDiscover response, the NF HA topology information for the producer NFs, and transmitting the NFDDiscover response to the consumer NF or SCP.

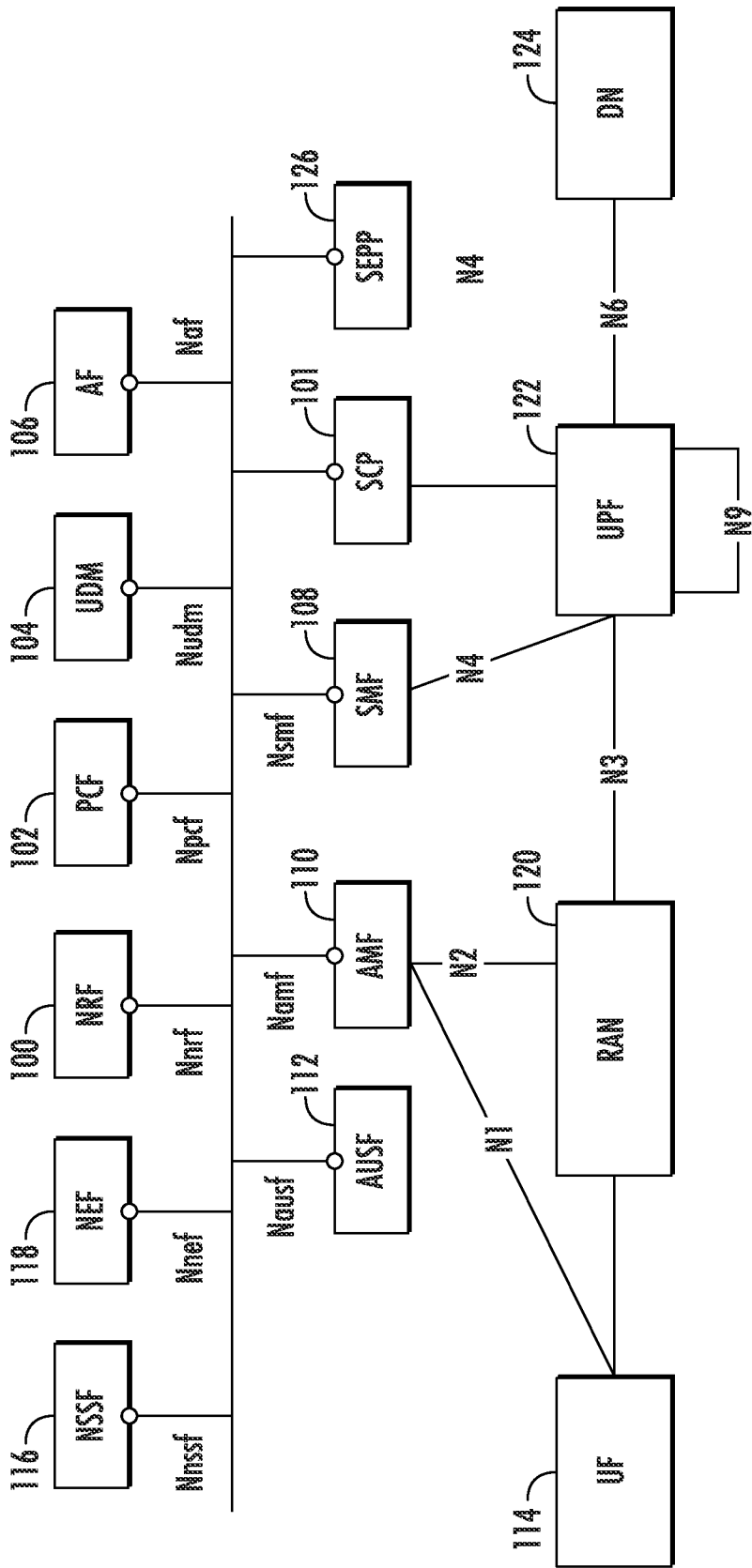


FIG. 1

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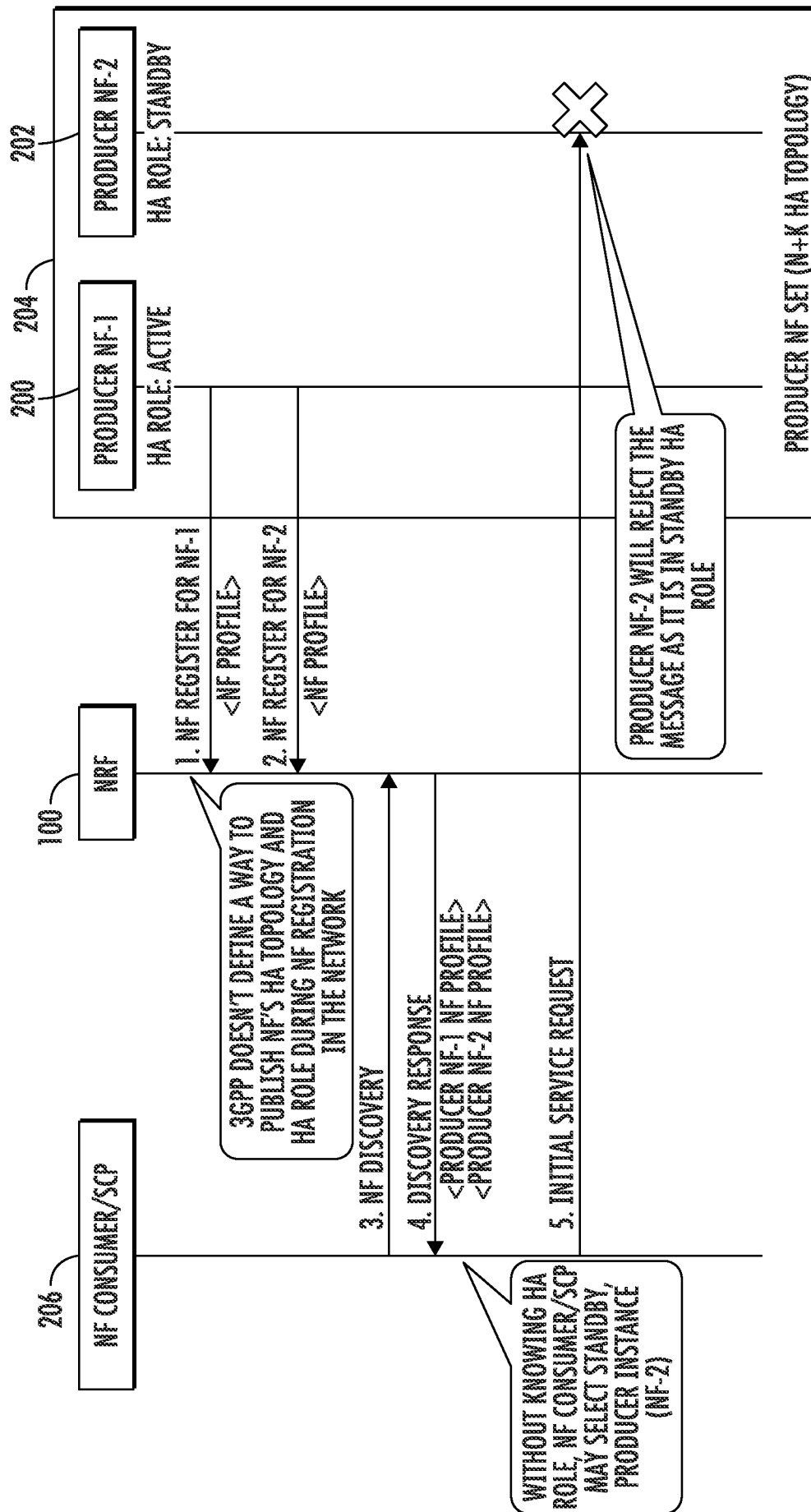


FIG. 2

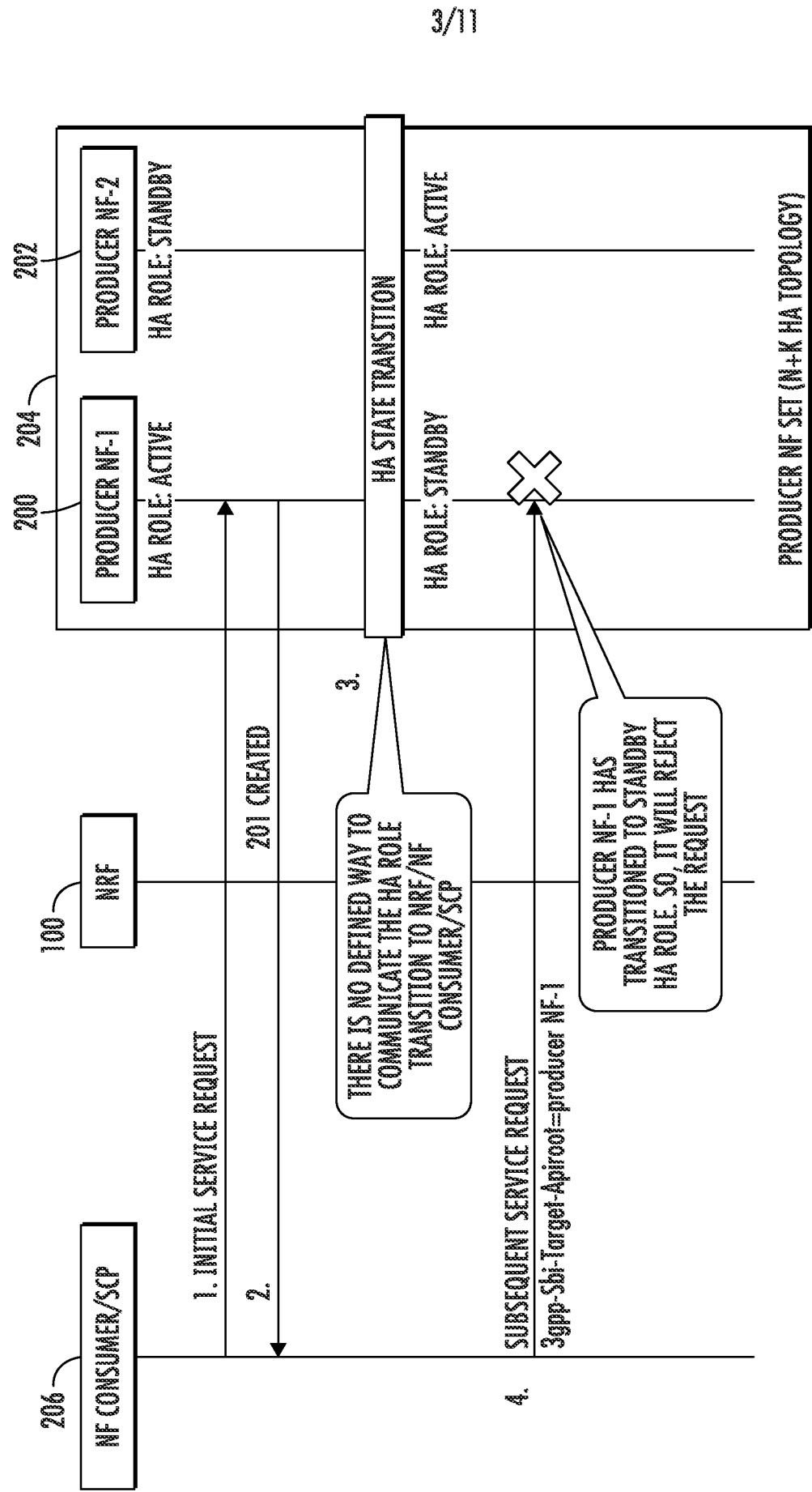


FIG. 3

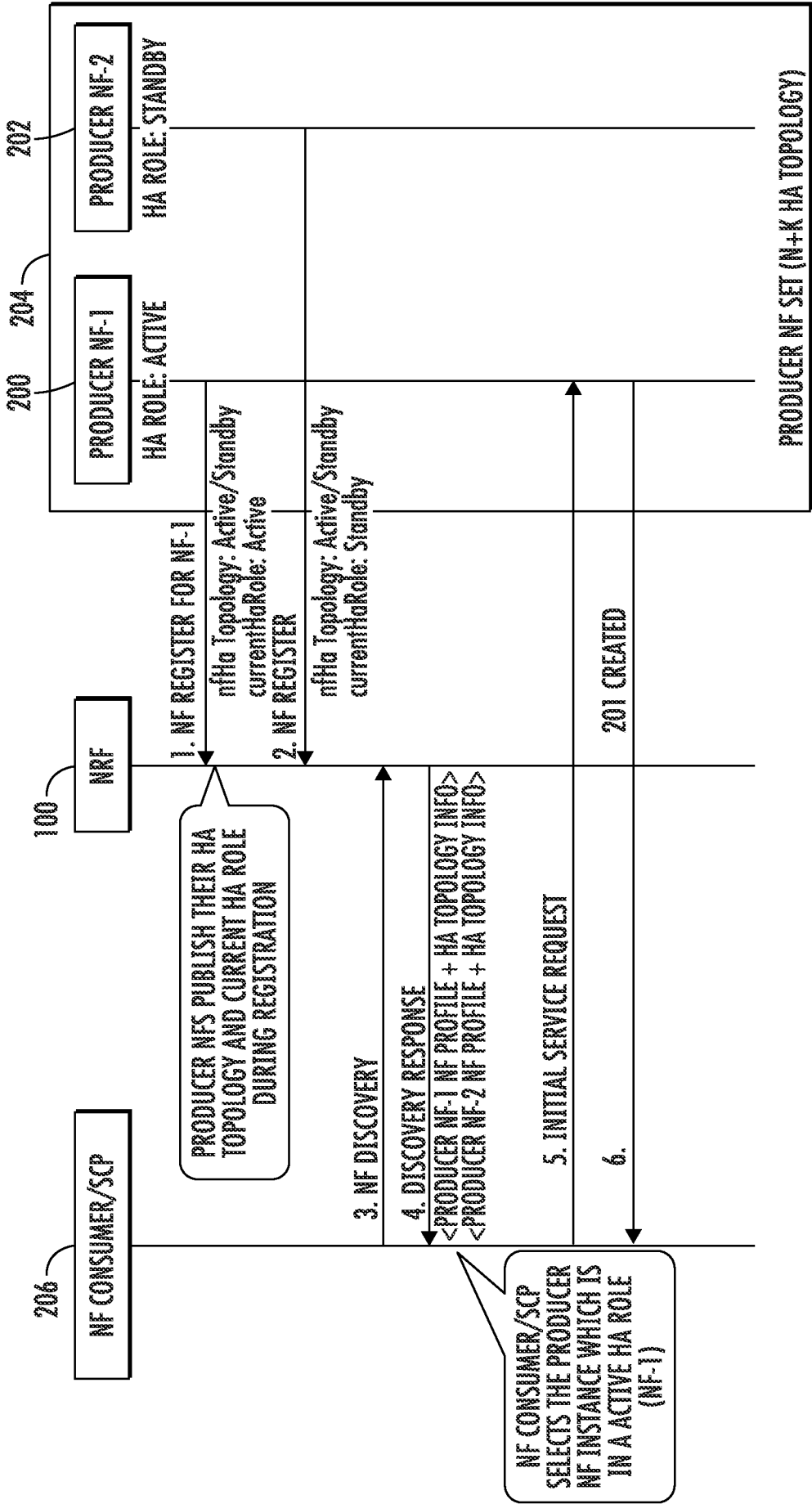


FIG. 4

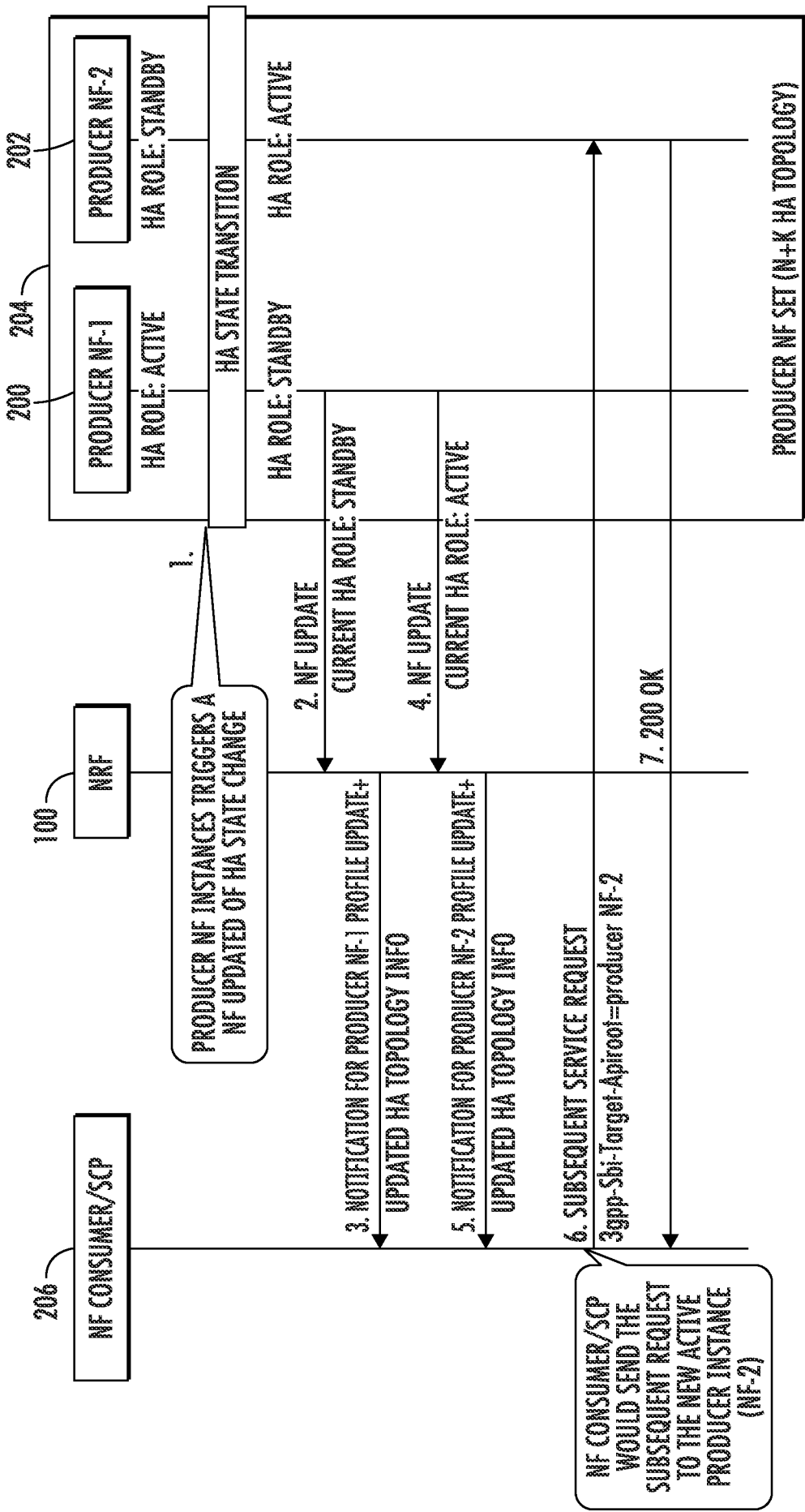


FIG. 5

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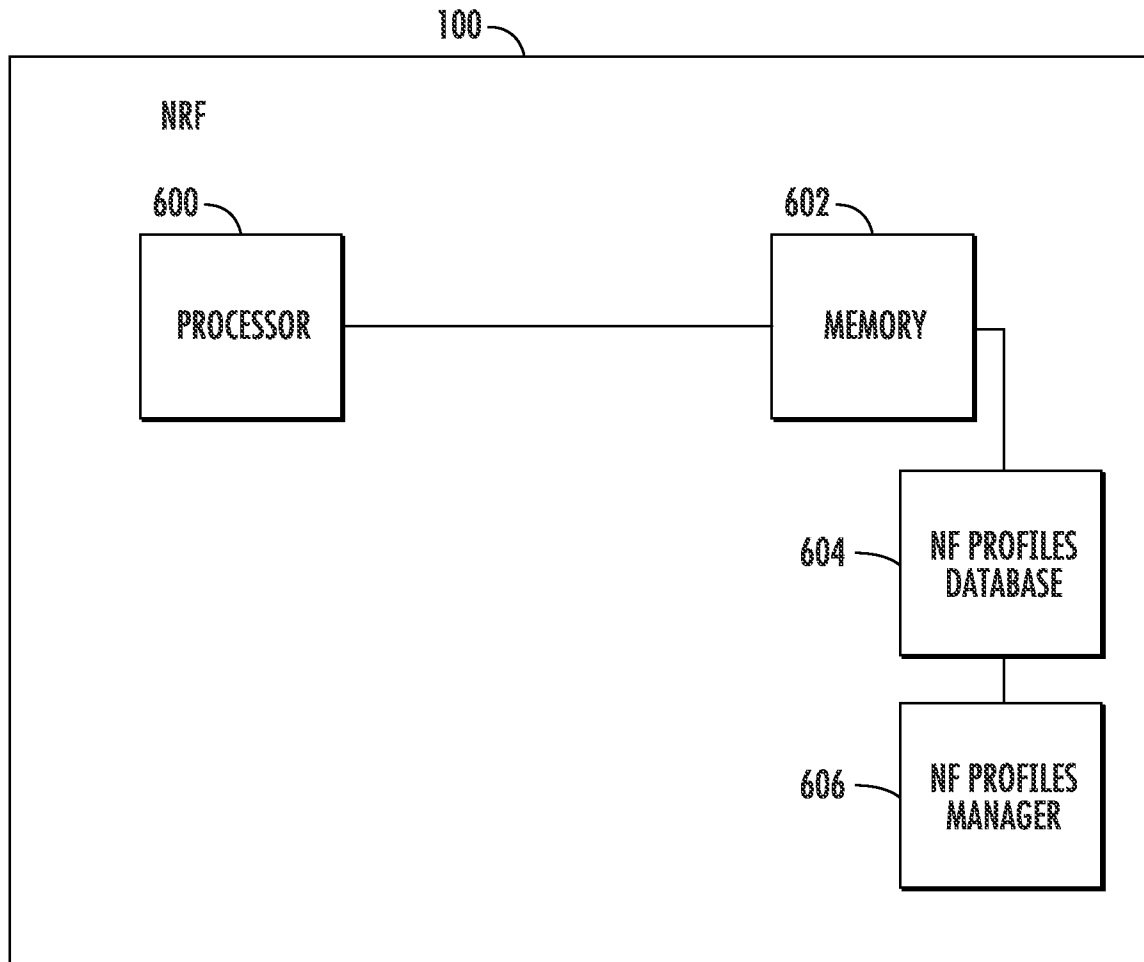


FIG. 6

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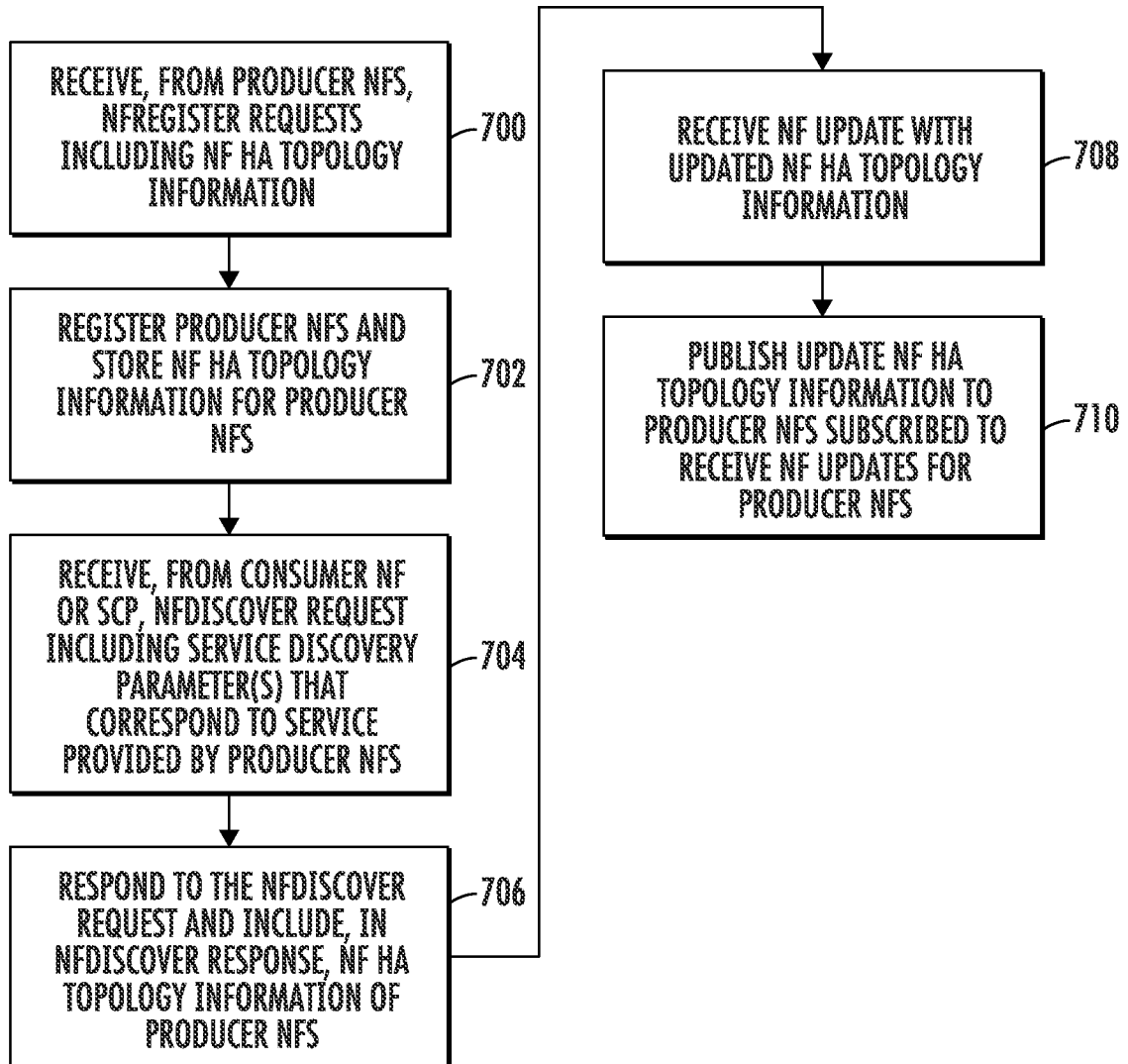


FIG. 7

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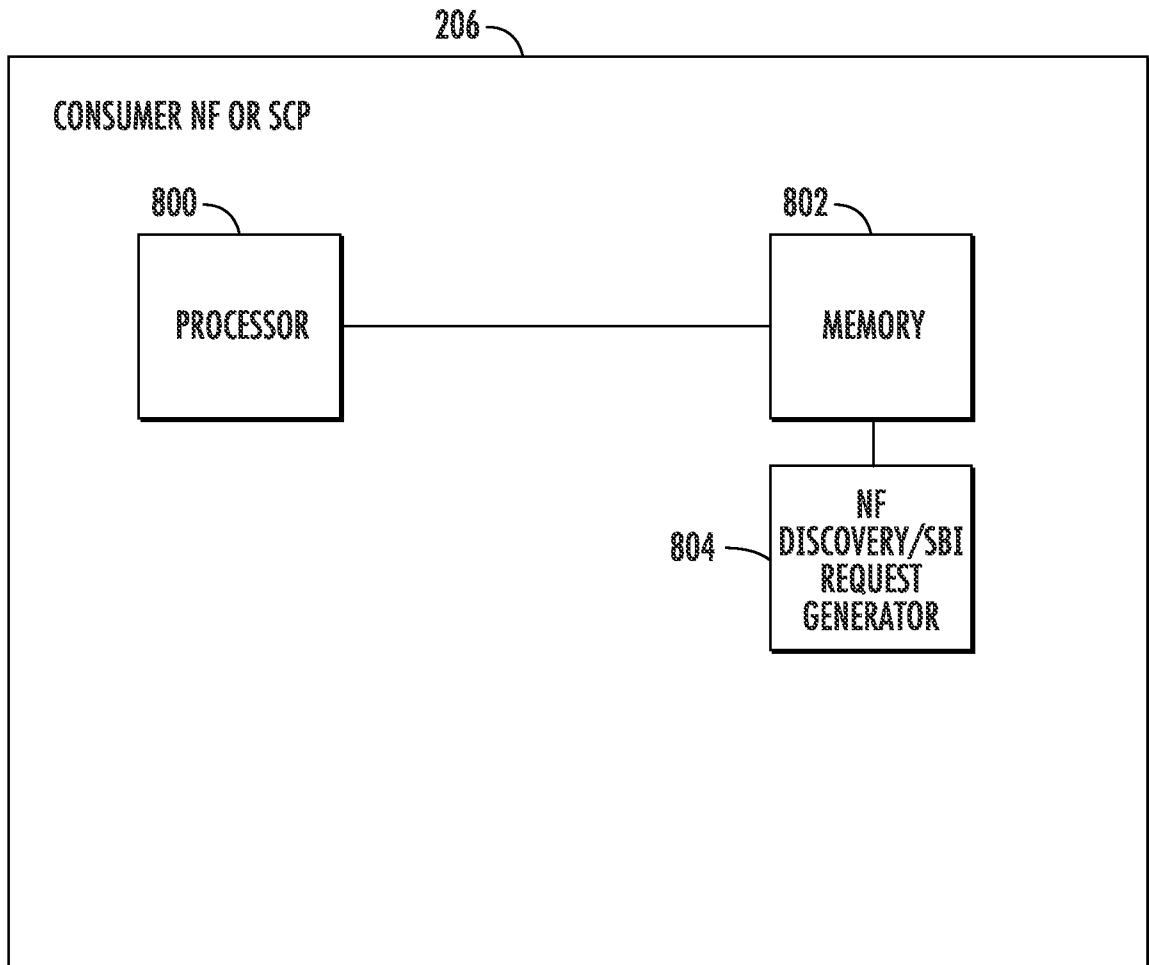


FIG. 8

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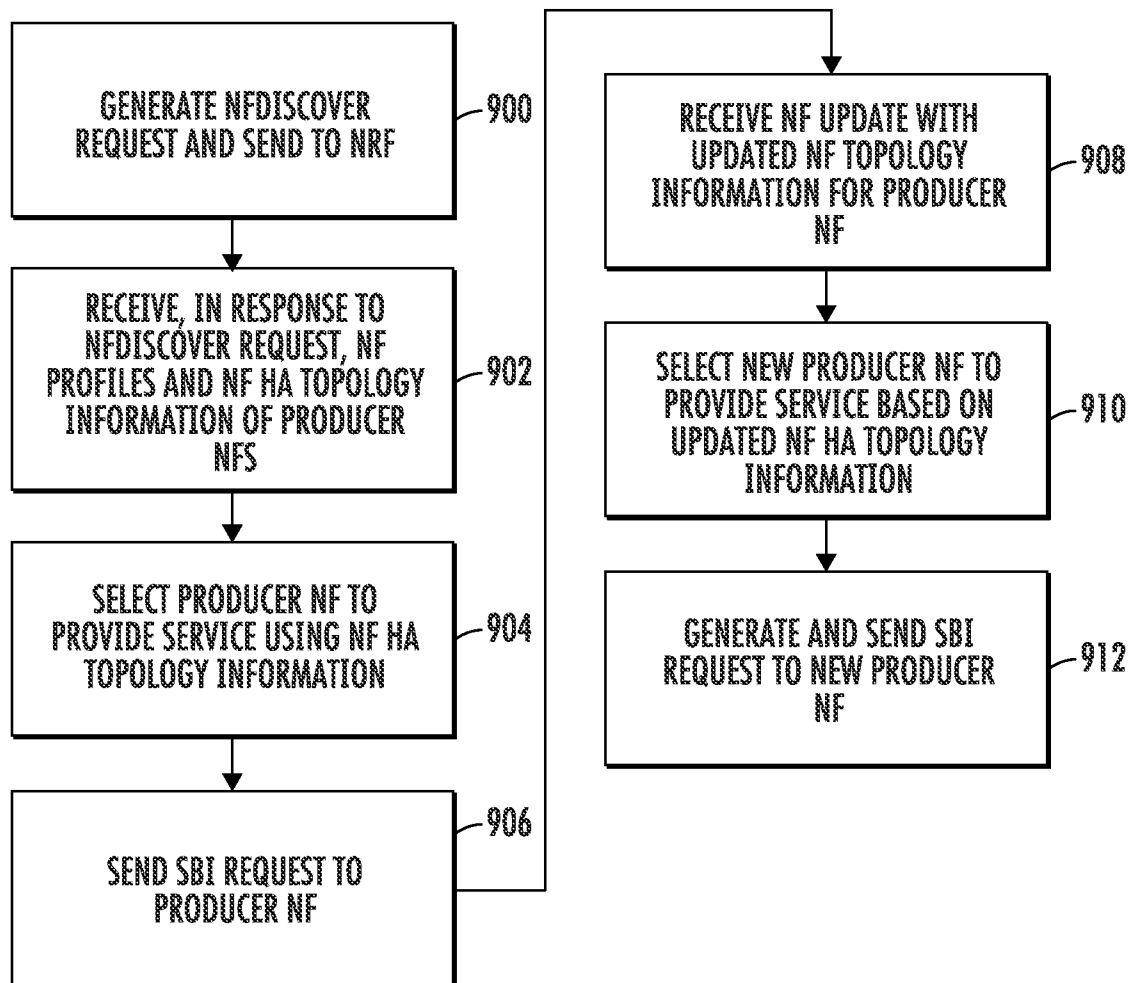


FIG. 9

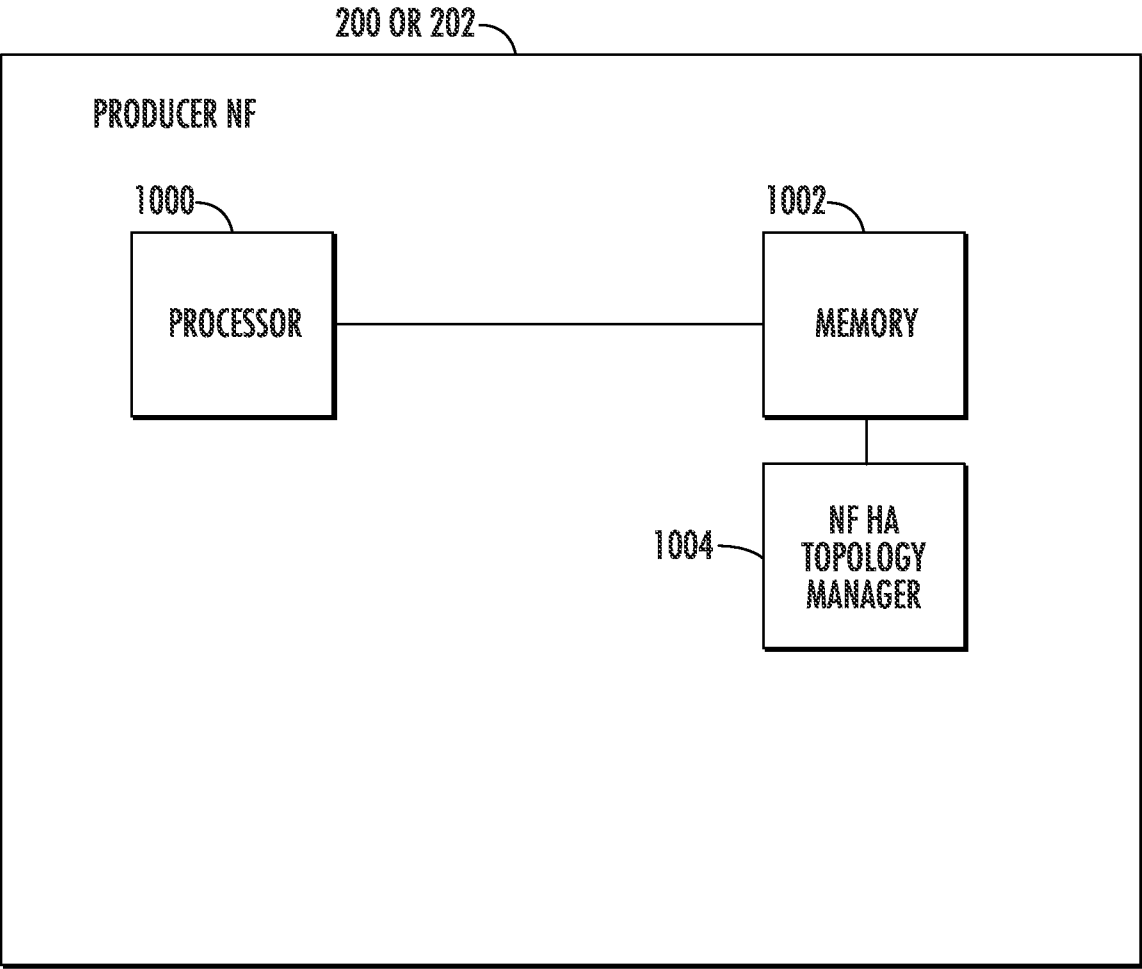


FIG. 10

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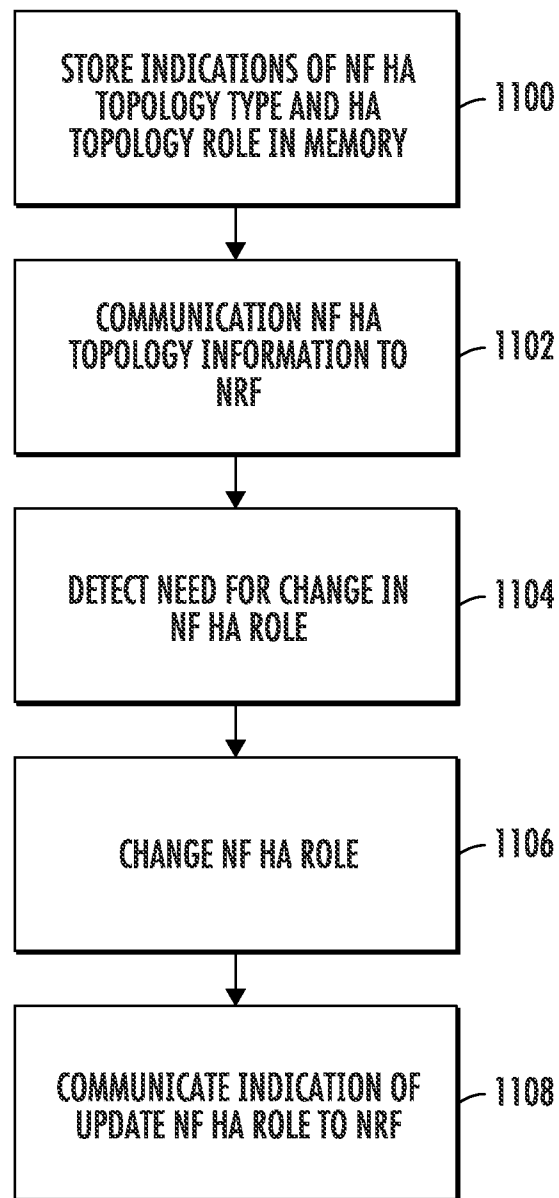


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2022/030874

A. CLASSIFICATION OF SUBJECT MATTER INV. H04L67/51 H04L67/562 H04L67/568 H04W4/50 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H04L H04W		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2021/111985 A1 (MAHALANK SHASHIKIRAN BHALACHANDRA [IN] ET AL) 15 April 2021 (2021-04-15) paragraphs [0002] - [0004] paragraph [0008] paragraphs [0043], [0044]; figure 1 -----	1-4, 6-14, 16-21 5, 15
A	paragraphs [0002] - [0004] paragraph [0008] paragraphs [0043], [0044]; figure 1 -----	1-4, 6-14, 16-21 5, 15
X	US 2020/396132 A1 (WANG CHENG [CN] ET AL) 17 December 2020 (2020-12-17) paragraphs [0052] - [0058]; figure 1 -----	1-4, 6-14, 16-21 5, 15
A	paragraphs [0052] - [0058]; figure 1 ----- -/--	1-4, 6-14, 16-21 5, 15
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 24 August 2022		Date of mailing of the international search report 01/09/2022
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Konrad, Markus

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2022/030874

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Study on enablers for network automation for the 5G System (5GS); Phase 2 (Release 17)", 3GPP STANDARD; TECHNICAL REPORT; 3GPP TR 23.700-91, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. SA WG2, no. V17.0.0 17 December 2020 (2020-12-17), pages 1-382, XP051999941, Retrieved from the Internet: URL:https://ftp.3gpp.org/Specs/latest/Rel- 17/23_series/23700-91-h00.zip 23700-91-h00.docx [retrieved on 2020-12-17] Section 6.12.1.2; pages 93-95; figures 6.12.1.2-1, 6.12.1.2-2 -----	1-21

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2022/030874

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US 2020396132 A1	17-12-2020	EP 3542515 A1	25-09-2019
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