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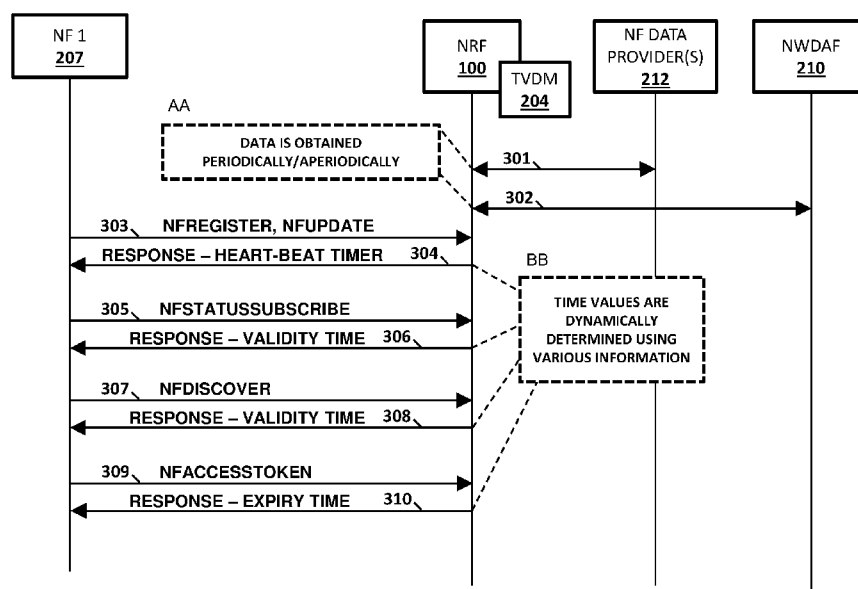


FIG. 3

(57) Abstract: Methods, systems, and computer readable media for determining time related parameter values for a communications network are disclosed. One method for determining time related parameter values for a communications network occurs at network function (NF) repository function (NRF) comprising at least one processor. The method comprises: receiving, from a first network function (NF), a service request message; determining, using network information and/or NF information, a time related parameter value associated with the service request message; and generating and sending, to the first NF, a service response message indicating the time related parameter value.



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METHODS, SYSTEMS, AND COMPUTER READABLE MEDIA FOR
DETERMINING TIME RELATED PARAMETER VALUES FOR A
COMMUNICATIONS NETWORK

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PRIORITY CLAIM

This application claims the priority benefit of U.S. Patent Application Serial No. 17/331,620, filed May 26, 2021, the disclosure of which is incorporated herein by reference in its entirety.

10

TECHNICAL FIELD

The subject matter described herein relates to improving communications in fifth generation (5G) and subsequent generation communications networks. More particularly, the subject matter described herein relates to methods, systems, and computer readable media for determining time related parameter values for 5G and subsequent generation communications networks.

20

BACKGROUND

In fifth generation (5G) communications networks, a network node that provides service is referred to as a producer network function (NF). A network node that consumes services is referred to as a consumer NF. A network function can be both a producer NF and a consumer NF depending on whether it is consuming or providing service.

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.

5 Producer NFs register with an NF repository function (NRF). The NRF maintains service profiles of available NF instances identifying the services supported by each NF instance. Consumer NFs 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 reachability and service profile information regarding producer NF service instances. 10 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 service or directly routes the traffic to the destination producer NF instance.

15 In addition to the SCP, other examples of intermediate proxy nodes or groups of network nodes that route traffic between producer and consumer NFs include the security edge protection proxy (SEPP), the service gateway, and nodes in the 5G service mesh. 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 various amounts of message filtering, policing, and topology hiding for application programming interface (API) messages. 20

 In 5G and various other communications networks, timing issues can affect connectivity and usability. For example, if an access token or a subscription expires too soon, then an NF may not receive an expected or desired response. Hence, there exists a need for improving a communications network by reducing or mitigating timing issues. 25

SUMMARY

30 Methods, systems, and computer readable media for determining time related parameter values for a communications network are disclosed. One method for determining time related parameter values for a communications network occurs at a network function (NF) repository function (NRF)

comprising at least one processor. The method comprises: receiving, from a first NF, a service request message; determining, using network information and/or NF information, a time related parameter value associated with the service request message; and generating and sending, to the first NF, a service response message indicating the time related parameter value.

One example system for determining time related parameter values for a communications network includes an NRF comprising at least one processor and a memory. The NRF is configured for: receiving, from a first NF, a service request message; determining, using network information and/or NF information, a time related parameter value associated with the service request message; and generating and sending, to the first NF, a service response message indicating the time related parameter value.

One example non-transitory computer readable medium comprising computer executable instructions embodied in the non-transitory computer readable medium that when executed by at least one processor of at least one computer cause the at least one computer to perform steps comprising: at an NRF comprising at least one processor: receiving, from a first NF, a service request message; determining, using network information and/or NF information, a time related parameter value associated with the service request message; and generating and sending, to the first NF, a service response message indicating the time related parameter value.

According to an aspect of the subject matter described herein, at least some network information or NF information (e.g., used in determining a time related parameter value) may be obtained periodically or aperiodically from one or more data sources.

According to an aspect of the subject matter described herein, one or more data sources may include a local data store, a remote data source, a network data analytics function (NWDAF), or an NF data provider.

According to an aspect of the subject matter described herein, at least some network information may be obtained using an Nnwdaf_EventsSubscription service or an Nnwdaf_AnalyticsInfo service.

According to an aspect of the subject matter described herein, determining a time related parameter value may include determining that an

NRF, a first NF, or a network entity may be experiencing a congestion status change, a change in workload amount, or an operational status change; and, in response to the determination, adjusting the time related parameter value from a default value or a prior value.

5 According to an aspect of the subject matter described herein, a default value or a prior value (e.g., of a time related parameter) may be predetermined by a network operator or may be generated using a predetermined policy or rule.

 According to an aspect of the subject matter described herein,
10 determining a time related parameter value may include determining that a service request message or a related message requires NRF to NRF forwarding; and, in response to the determination, increasing the time related parameter value from an initial or default value.

 According to an aspect of the subject matter described herein,
15 determining a time related parameter value may include determining that a service request message or a related message may be an inter public land mobile network (PLMN) message; and, in response to the determination, increasing the time related parameter value from an initial or default value.

 According to an aspect of the subject matter described herein, a service
20 request message may include an NF registration request message, an NF update request message, an NF status subscription request message, an NF discovery request message, or an NF access token request message.

 According to an aspect of the subject matter described herein, a time
25 related parameter value may indicate an NF heartbeat interval, an NF subscription validity time, an NF discovery validity time, an NF access token expiry time, or a hypertext transfer protocol (HTTP) header retry timer.

 The subject matter described herein may be implemented in hardware,
software, firmware, or any combination thereof. As such, the terms “function”
“node” or “module” as used herein refer to hardware, which may also include
30 software and/or firmware components, for implementing the feature being described. In one example implementation, the subject matter described herein may be implemented using a computer readable medium having stored thereon computer executable instructions that when executed by the

processor of a computer control the computer to perform steps. Example 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

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 example fifth generation (5G) network architecture;

Figure 2 is a diagram illustrating an example network node for determining time related parameter values for a communications network;

Figure 3 is a message flow diagram illustrating an example NRF dynamically determining time related parameter values using network information and/or NF information;

Figure 4 is a diagram illustrating example rule data indicating rule IDs and related time related parameter value determination rules ;

Figure 5 is a diagram illustrating example default value information for various time related parameters; and

Figure 6 is a flow chart illustrating an example process for determining time related parameter values for a communications network.

DETAILED DESCRIPTION

The subject matter described herein relates to methods, systems, and computer readable media for determining time related parameter values in a communications network. In a Third Generation Partnership Project (3GPP) defined 5G communications network, an network function (NF) repository function (NRF) can make decisions on various time related parameter values (e.g., timer values and validity time values) for various service operations.

However, current NRF implementations use statically configured or unanimously agreed-upon values for various time related parameters, e.g., an NF heartbeat interval (e.g., a 3GPP heart-beat timer), an NF subscription validity time, an NF discovery validity time, an NF access token expiry time, or an HTTP header retry timer (e.g., a value in a "Retry-After" HTTP header parameter field). Moreover, there is no mechanism in 3GPP Technical Specification (TS) 29.510 defining NRF functionality for determining time related parameters values by considering dynamic network and/or deployment conditions. Various issues, such as connectivity problems and/or timing issues, can arise when time related parameter values are not appropriate for relevant use-cases or scenarios (e.g., current network conditions or other factors affecting one or more NFs). For example, statically configured time related parameter values may not allow effective communications between NFs or other network elements, e.g., since some network use-cases or scenarios (e.g., communications that traverse different localities and PLMNs) can cause various delays.

In accordance with some aspects of the subject matter described herein, methods, systems, mechanisms, and/or techniques are disclosed for determining time related parameter values for communications networks using obtained network information and/or NF information. For example, an NRF in accordance with various aspects described herein may be configured for receiving, from a first NF, a service request message; determining, using network information and/or NF information, a time related parameter value associated with the service request message; and generating and sending, to the first NF, a service response message indicating the time related parameter value. In this example, the network information and/or NF information used in the determination may be periodically or aperiodically obtained from various data sources, such as a network data analytics function (NWDAF) or another NF data provider (e.g., an NF metrics server).

Advantageously, by utilizing one or more techniques, systems, and/or methods described herein, a NRF or other entity may determine time related parameter values based on various information, e.g., dynamic network conditions and/or NF health or performance metrics. Further, since some time

related parameters values (e.g., an NF heartbeat interval value and/or an HTTP header retry timer value) can directly affect the amount and/or frequency of some traffic sent by NFs, dynamic determination of time related parameter values can reduce traffic processing load at NFs and NRF or
5 improve resource utilization. For example, by increasing the allowed time between consecutive heartbeat message when network congestion is detected, an NF can spend less time sending such messages and an NRF can spend less time processing such message. In this example, the reduction in heartbeat message may also help to reduce the congestion in the network.
10 Similar effects may also be seen by increasing some other time related parameter values, e.g., an NF subscription validity time, an NF discovery validity time, an NF access token expiry time. Furthermore, by utilizing one or more aspects described herein, an example NRF may increase overall core network performance by determining time related parameter values (e.g.,
15 optimized and/or use case based timer values) using current or recent network information and/or NF information. Moreover, an example NRF in accordance with various aspects described herein may be fully backward compatible, may not impact NFs from various vendors, and may not require changes to existing 3GPP defined 5GC call flows.

20 Reference will now be made in detail to various embodiments of the subject matter described herein, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Figure 1 is a block diagram illustrating an example 5G system network
25 architecture, e.g., a home 5G core (5GC) network. The architecture in Figure 1 includes an NRF **100** and an SCP **101**, which may be located in the same home public land mobile network (PLMN). 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
30 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. In addition, using the methodologies described

herein, SCP **101** may perform preferred NF location based selection and routing.

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 or the producer NF instance from NRF **100**. The NF or service profile may 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 nodes (other than NRF **100**) can be either consumer NFs or producer NFs, depending on whether they are requesting or providing services. In the illustrated example, the nodes include a policy control function (PCF) **102** that performs policy related operations in a network, a unified data management (UDM) function **104** that manages user data, and an application function (AF) **106** that provides application services. The nodes 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 devices, 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 UE **114** to the network via a wireless link. RAN **120** may be accessed 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 **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.

Security edge protection proxy (SEPP) **126** filters incoming traffic from another PLMN and performs topology hiding for traffic exiting the home PLMN. SEPP **126** may communicate with an 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.

SEPP **126** may utilize an N32-c interface and an N32-f interface. An N32-c interface is a control plane interface between two SEPPs usable for performing an initial handshake (e.g., a TLS handshake) and negotiating various parameters for an N32-f interface connection and related message forwarding. An N32-f interface is a forwarding interface between two SEPPs usable for forwarding various communications (e.g., 5GC request messages) between a consumer NF and a producer NF after applying application level security protection.

One issue with the existing 5G architecture is that current NRF implementations use statically configured or unanimously agreed-upon values for various time related parameters. However, connectivity issues and/or timing issues can arise when time related parameter values are not appropriate for relevant use-cases or scenarios (e.g., current network conditions or other factors affecting one or more NFs)

It will be appreciated that Figure 1 is for illustrative purposes and that various nodes and/or modules, locations, and/or functionality described above in relation to Figure 1 may be changed, altered, added, or removed.

Figure 2 is a diagram illustrating an example network node **200** for determining time related parameter values for a communications network (e.g., a 5G communications network). Node **200** may represent any suitable entity or entities for performing various aspects of authorization, registration, and/or configuration functions, e.g., determining appropriate time related

parameter values using relevant network information and/or NF information. In some embodiments, node **200** may represent or include one or more 5GC NFs, e.g., NRF **100**. In some embodiments, node **200** may represent or include a consumer NF or a producer NF. In some embodiments, node **200** may represent or include an authorization server, a data repository, a network gateway, a network proxy, an edge security device, or other functionality.

In some embodiments, node **200** or a related module (e.g., a parameter configuration module) may be configured (e.g., via programming logic) for determining time related parameter values (e.g., 3GPP network parameters values) using network information and/or NF information (e.g., obtained periodically or aperiodically from NWDAF **210** and/or NF data provider(s) **212**. For example, node **200** or a related module may communicate with a NWDAF **210** and/or an NF data provider(s) **212** to periodically or periodically obtain current network information or NF information. In this example, node **200** or a related module may use this obtained information to determine one or more time related parameter values for various NF instances, NF1 **207**, NF2 **208**, or NF3 **209**. Example time related parameter values may include values indicating an NF heartbeat interval (e.g., a 3GPP heart-beat timer), an NF subscription validity time, an NF discovery validity time, an NF access token expiry time, or an HTTP header retry timer (e.g., a value in a "Retry-After" HTTP header parameter field).

NWDAF **210** may represent a network node or device configured for performing various network analytics functions. For example, NWDAF **210** may include at least some NWDAF functionality defined in 3GPP TS 29.520. In some embodiments, NWDAF **210** may provide an Nnwdaf_EventsSubscription service for enabling NF service consumers to subscribe to/unsubscribe from notifications for different analytics information. Example notification events may include slice load level information, network slice instance load level information, service experience, NF load, network performance, abnormal behavior, UE mobility, UE communication, user data congestion, or quality of service (QoS) sustainability. In some embodiments, NWDAF **210** may provide an Nnwdaf_AnalyticsInfo service for enabling NF service consumers to request and get specific analytics information from

NWDAF **210**. Example analytics information available from NWDAF **210** may include slice load level information, network slice instance load level information, service experience, NF load, network performance, abnormal behavior, UE mobility, UE communication, user data congestion, or quality of service (QoS) sustainability.

NF data provider(s) **212** may represent one or more network nodes or devices configured for generating and/or providing NF metrics or other related NF information. For example, NF data provider(s) **212** may provide various types of metrics and/or data usable for determining appropriate time related parameter values to node **200**, a module for determining time related parameter values, and/or a data store accessible to node **200** or module(s) for determining time related parameter values. Example NF metrics or related information may include a congestion or overload status, message queue information, connectivity issue information, or various performance metrics, such as an nf-name_message_processing_time for indicating the time taken (in milliseconds) by an NF's specific microservice to process a service operation.

In some embodiments, NF data provider(s) **212** may include an NF or related node providing performance metrics, state information, or other relevant data about itself to one or more entities, e.g., node **200** (e.g., NRF **100**) or a data store. In some embodiments, NF data provider(s) **212** may include a network management system, a network tap, or a data aggregator that receives, intercepts, or derives various NF information and uses that information to generate and/or provide NF metrics and/or other data to one or more entities.

Referring to Figure 2, node **200** may include one or more communications interface(s) **202** for communicating messages via a communications environment, e.g., a home 5GC network. For example, communications interface(s) **202** may include a first communication interface for communicating with a first set of SEPPs **126** in a home network, a second communications interface for communicating with a second set of SEPPs **126** in a home network, and a third communications interface for communicating with other entities in a home network.

Node **200** may include a time value determination module (TVDM) **204**. TVDM **204** may be any suitable entity (e.g., software executing on at least one processor) for performing one or more aspects associated with parameter configuration, e.g., determining time related parameter values. In some
5 embodiments, TVDM **204** may be configured for communicating with NWDAF **210** and/or NF data provider(s) **212** to periodically or periodically obtain relevant (e.g., current or recent) network information or NF information for determining appropriate time related parameter values for various scenarios and/or service operations. For example, TVDM **204** may subscribe to various
10 events and may receive notifications of such events from NWDAF **210** and/or NF data provider(s) **212**. In this example, such event notifications and/or data therein may be used by TVDM **204** when determining appropriate time related parameter values.

In some embodiments, TVDM **204** may be configured for using
15 obtained network information and/or NF information when determining one or more time related parameter values. For example, TVDM **204** may be configured for receiving, from NF3 **209**, a service request message (e.g., an NFUpdate message); determining, using network information and/or NF information, a time related parameter value associated with the service
20 request message; and generating and sending, to NF3 **209**, a service response message (e.g., an "200 OK" response message) indicating the time related parameter value. In this example, using network information and/or NF information (e.g., stored in data storage **206**) obtained via NWDAF **210** and/or NF data provider(s) **212**, NRF **100** may determine that NRF **100** and/or
25 another NF (or a related transmission path) is experiencing congestion or operational issues, and, to alleviate congestion and/or mitigate one or more negative affects associated with the detected issue(s), NRF **100** may determine to temporarily increase (e.g., relative to a prior used value) an NF heartbeat interval (e.g., a 3GPP heart-beat timer) associated with NF3 **209**,
30 thereby reducing the number and frequency of heartbeat messages need to be sent by NF3 **209** to be deemed operational (or "alive"), e.g., by NRF **100**. Continuing with this example, after detected issues are resolved or are no longer relevant (e.g., as determined by NRF **100** using more recent network

information and/or NF information, NRF **100** may determine to decrease the NF heartbeat interval associated with NF3 **209** (e.g., back to a default or pre-issue value) when NF3 **209** sends another service request message (e.g., an NFUpdate message).

5 In some embodiments, TVDM **204** may be configured for accessing or utilizing one or more data stores (e.g., in data storage **206**) containing rules for determining time related parameters based on various scenarios (e.g., use-cases, network conditions, NRF and/or NF congestion, communications path related delays like inter-PLMN communications and/or geo-redundant
10 sites, etc.) and/or default values for various time related parameters. For example, TVDM **204** may identify and/or use relevant rules based on various information including, for example, network information and/or NF information obtained from or via one or more data sources, e.g., NWDAF **210** and/or NF data provider(s) **212**. In this example, a relevant rule may indicate an
15 acceptable value, an acceptable range of values or may provide a formula, an algorithm, or other way for determining one or more acceptable time parameter values.

 In some embodiments, TVDM **204** may be configured for accessing or utilizing one or more data stores (e.g., in data storage **206**) containing time
20 value information, e.g., default, historical, and/or acceptable values (or ranges of values) for various time related parameters. In such embodiments, TVDM **204** may use stored time value information along with relevant rules to determine appropriate time related parameter values. For example, TVDM
25 **204** may determine, using recently obtained network information and/or NF information, that a network element or NF is experiencing congestion, and may select a relevant rule for this scenario. In this example, the relevant rule may indicate that a default value or a prior used value associated with a particular time related parameter value (e.g., located in a time value
30 information data store) is to be increased by 100%, e.g., an HTTP header retry timer is increased to 60 seconds from 30 seconds.

 Node **200** and/or TVDM **204** may access (e.g., read from and/or write information to) data storage **206**. Data storage **206** may be any suitable entity (e.g., a computer readable medium or memory) for storing various data. In

some embodiments, data storage **206** may include network information, NF metrics, time value determination rules, default values, and/or related information used in dynamically determining or deriving time related parameter values. In some embodiments, data storage **206** may include logic
5 for obtaining or requesting relevant network information and/or NF information (e.g., NF performance metrics) from one or more data sources. In some embodiments, data storage **206** may include logic or rules for detecting or determining one or more scenarios (e.g., network use cases) for adjusting a time related parameter value. In some embodiments, data storage **206** may
10 include logic or rules for determining a time related parameter value based on detected or determined scenarios.

It will be appreciated that Figure 2 and its related description are for illustrative purposes and that node **200** may include additional and/or different modules, components, or functionality.

15 Figure 3 is a message flow diagram illustrating an example NRF **100** comprising functionality (e.g., TVDM **204**) for dynamically determining time related parameter values using network information and/or NF information. In some embodiments, NRF **100** or TVDM **204** therein may utilize recent or current network information (e.g., analytics information from NWDAF **210**)
20 and/or NF information (e.g., NF related metrics from NF data provider(s) **212**) to determine appropriate time related parameter values, e.g., by adjusting a default or prior value. For example, NRF **100** or TVDM **204** therein can dynamically determine time related parameter values (e.g., an NF heartbeat interval value) depending on a routing scenario associated with a requesting
25 entity or current network conditions learned from data obtained from one or more data sources.

Referring to Figure 3, in step **301**, NF metrics or other NF related information may be sent from NF data provider(s) **212** to NRF **100** or a related entity (e.g., data storage **206**). For example, NF data provider(s) **212** may
30 provide message processing time metrics associated with multiple NFs, e.g., NF1 **207**, NF2 **208** and NF3 **209**.

In step **302**, network information (e.g., analytics information) may be sent from NWDAF **210** to NRF **100** or a related entity (e.g., data storage **206**).

In some examples, NRF **100** or TVDM **204** may subscribe to various events via an Nnwdaf_EventsSubscription service provided by NWDAF **210** and may receive notifications (along with network information) when subscribed events occur. In some examples, NRF **100** or TVDM **204** may request analytics
5 information at periodic or aperiodic intervals using an Nnwdaf_AnalyticsInfo service provided by NWDAF **210**

In step **303**, an NF registration related request message (e.g., an NFRegister or NFUpdate message) may be sent to NRF **100** from NF1 **207**. For example, assuming NF1 **207** is a visitor PLMN (different from NRF **100**),
10 an NFRegister message may originate from NF1 **207** and may traverse SEPPs **126** before reaching NRF **100**. In this example, NRF **100** or TVDM **204** may analyze characteristics of the NFRegister message (e.g., its originating PLMN) along with learned network information and/or NF information to dynamically determine one or more time related parameters, such as an NF
15 heartbeat interval (e.g., a 3GPP heart-beat timer value), associated with the NF registration related request message.

In some embodiments, an NF heartbeat interval may represent a parameter or setting indicating an amount of time (e.g., in seconds) expected between two consecutive heart-beat messages, e.g., from an NF instance
20 (e.g., NF1 **207**) to NRF **100**. In some embodiments, an NF heartbeat interval may be determined and provided during an NF registration or an NF update procedure using a "heart-beat timer" parameter. For example, a proposed value for an NF heart-beat timer parameter may be provided in an NFRegister request message by NF1 **207** to NRF **100**. In this example, if the proposed
25 heart-beat timer value is acceptable (e.g., as determined by NRF **100** and/or TVDM **204** therein), NRF **100** may confirm the value in an NFRegister response message. If the proposed heart-beat timer value is unacceptable (e.g., as determined by NRF **100** and/or TVDM **204** therein), NRF **100** and/or TVDM **204** therein may determine a different time related parameter value
30 (e.g., by adjusting a default value in response to network and/or NF conditions) and provide the different time related parameter value in an NFRegister response message to NF1 **207**.

In step **304**, an NF registration related response message indicating one or more time related parameters may be sent from NRF **100** to NF1 **207**. For example, a response to an NFRegister message associated with NF1 **207** may indicate a 3GPP heart-beat timer value that is based on learned information or factors associated with NF1 **207**. In this example, the 3GPP heart-beat timer value associated with NF1 **207** may be different from a 3GPP heart-beat timer value associated with a different NF (e.g., NF2 **208**) or a standard or default value.

In step **305**, an NF subscription request message (e.g., an NFStatusSubscribe message) may be sent to NRF **100** from NF1 **207**. For example, NRF **100** or TVDM **204** may analyze characteristics of a received NFStatusSubscribe message along with learned network information and/or NF information and determine that the NF being subscribed to is overloaded or congested and may dynamically determine one or more time related parameters, such as an NF subscription validity time value, associated with the NF subscription request message.

In some embodiments, an NF subscription validity time may represent a parameter or setting indicating an amount of time (e.g., in hours) that a related subscription is active, e.g., after which the subscription may be deemed inactive and/or deleted at NRF **100**. In some embodiments, an NF subscription validity time may be determined and provided during an NF subscription procedure using a "validity time" parameter. For example, a proposed value for a subscription validity time parameter may be provided in an NFStatusSubscribe request (e.g., subscription creation request) message by NF1 **207** to NRF **100**. In this example, if the proposed subscription validity value is acceptable (e.g., as determined by NRF **100** and/or TVDM **204** therein), NRF **100** may confirm the value in an NFStatusSubscribe response message. If the proposed subscription validity value is unacceptable (e.g., as determined by NRF **100** and/or TVDM **204** therein), NRF **100** and/or TVDM **204** therein may determine a different time related parameter value (e.g., by adjusting a default value in response to network and/or NF conditions) and provide the different time related parameter value in an NFStatusSubscribe response message to NF1 **207**.

In step **306**, an NF subscription response message indicating one or more time related parameters may be sent from NRF **100** to NF1 **207**. For example, a response to an NFStatusSubscribe message associated with NF1 **207** may indicate an NF subscription validity time value that is based on
5 learned information or factors associated with NF1 **207**. In this example, the NF subscription validity time value associated with NF1 **207** may be different from an NF subscription validity time value associated with a different NF (e.g., NF2 **208**) or a standard or default value.

In step **307**, an NF discovery request message (e.g., an NFDDiscover
10 message) may be sent to NRF **100** from NF1 **207**. For example, NRF **100** or TVDM **204** may analyze characteristics of a received NFDDiscover message along with learned network information and/or NF information and determine that the NF being discovered is overloaded or congested and may dynamically determine one or more time related parameters, such as an NF discover
15 validity time value, associated with the NF discovery request message.

In some embodiments, an NF discovery validity time may represent a parameter or setting indicating an amount of time (e.g., in hours) that search results from a discovery or search is valid, e.g., after which the search results may be deemed invalid and/or deleted from a cache at an NF service
20 consumer, e.g., NF1 **207**. In some embodiments, an NF discovery validity time may be determined and provided during an NF discovery procedure using a “validity time” parameter. For example, a proposed value for a discovery validity time parameter may be provided in an NFDDiscover request message by NF1 **207** to NRF **100**. In this example, if the proposed discovery validity
25 value is acceptable (e.g., as determined by NRF **100** and/or TVDM **204** therein), NRF **100** may confirm the value in an NFDDiscover response message. If the proposed discovery validity value is unacceptable (e.g., as determined by NRF **100** and/or TVDM **204** therein), NRF **100** and/or TVDM **204** therein may determine a different time related parameter value (e.g., by
30 adjusting a default value in response to network and/or NF conditions) and provide the different time related parameter value in an NFDDiscover response message to NF1 **207**.

In step **308**, an NF discovery response message indicating one or more time related parameters may be sent from NRF **100** to NF1 **207**. For example, a response to an NFDDiscover message associated with NF1 **207** may indicate an NF discovery validity time value that is based on learned information or factors associated with NF1 **207**. In this example, the NF discovery validity time value associated with NF1 **207** may be different from an NF discovery validity time value associated with a different NF (e.g., NF2 **208**) or a standard or default value.

In step **309**, an NF access token request message (e.g., an NFAccessToken request message) may be sent to NRF **100** from NF1 **207**. For example, NRF **100** or TVDM **204** may analyze characteristics of a received NFAccessToken request message along with learned network information and/or NF information and determine that the NF associated with the access token request is overloaded or congested and may dynamically determine one or more time related parameters, such as an NF access token expiry time value, associated with the NF access token request message.

In some embodiments, an NF access token expiry time may represent a parameter or setting indicating an amount of time (e.g., in hours) that an NF access token is valid, e.g., after which the access token may be deemed invalid. In some embodiments, an NF access token expiry time may be determined and provided during an NF access token request procedure using a “expiration time” parameter. For example, an NFAccessToken request message may be sent from NF1 **207** to NRF **100**. In this example, NRF **100** and/or TVDM **204** therein may determine an expiration time related parameter value (e.g., by adjusting a default value in response to network and/or NF conditions) and provide the time related parameter value in an NFAccessToken response message to NF1 **207**.

In step **310**, an NF subscription response message indicating one or more time related parameters may be sent from NRF **100** to NF1 **207**. For example, a response to an NFAccessToken request message associated with NF1 **207** may indicate an NF access token expiry time value that is based on learned information or factors associated with NF1 **207**. In this example, the access token expiry time value associated with NF1 **207** may be different from

an access token expiry time value associated with a different NF (e.g., NF2 **208**) or a standard or default value.

It will be appreciated that Figure 3 is for illustrative purposes and that different and/or additional messages and/or actions may be used. It will also
5 be appreciated that various messages and/or actions described herein may occur in a different order or sequence.

Figure 4 is a diagram illustrating example rule data **400** indicating rule IDs and related time related parameter value determination rules for determining time related parameter values for one or more time related
10 parameters (e.g., based on network conditions, NF performance metrics, and/or other factors). For example, rule data **400** may indicate mappings (e.g., associations) between a rule ID and a related time related parameter value determination rule. In some embodiments, a rule mapping or association may be statically configured by an operator or may be dynamically generated by
15 NRF **100**, e.g., using historical data and user-provided preferences. For example, NRF **100** may receive a set of rules for different scenarios from a network operator and expected performance information for NRF **100**. In this example, if a rule for a given scenario is not having an expected result (e.g., NRF is still experiencing congestion), NRF **100** may dynamically adjust the
20 rule (e.g., increase time related parameter value by 15%) in an attempt to achieve the expected result.

In some embodiments, node **200**, NRF **100**, or TVDM **204** may be configured for selecting time related parameter value determination rules and/or logic based on characteristics or scenarios associated with a received
25 message or a related entity, e.g., an NF service consumer or an NF service producer. For example, NRF **100** may analyze a received message to determine whether the message has originated or been forwarded from a different PLMN (e.g., by a visitor NRF **100** or NF1 **207**). In addition to or in lieu of where a received messages originates, NRF **100** may determine using
30 various data (e.g., periodically fetched network information and/or NF information) whether itself or another network entity (e.g., the requesting entity) is experience a congestion event or other issue that may effect processing or communications. In this example, using various information

available to NRF **100**, NRF **100** may select a relevant time related parameter value determination rule, wherein the time related parameter value determination rule may indicate a formula or logic for determining an appropriate value for a particular time related parameter. For example, if node
5 **200**, NRF **100**, or TVDM **204** determines that NRF **100** is experiencing congestion, a time related parameter value determination rule 'ID4' may be selected that double or triples a predetermined default value for a particular short term parameter (e.g., NF heartbeat interval or HTTP header retry timer). In another example, if node **200**, NRF **100**, or TVDM **204** determines that a
10 requesting entity is located in a different network, a time related parameter value determination rule 'ID1' may be selected that increasing a predetermined or proposed default value by 25% or increasing a predetermined default value such that the new time related parameter value is greater than a derived or estimated one-way delay or other metric.

15 Referring to Figure 4, a table representing rule data **400** comprises columns and/or fields for rule IDs and corresponding time related parameter value determination rules. A rule ID field may store information for representing an identifier that identifies a time related parameter value determination rules. In some embodiments, each rule ID may be globally
20 unique inside a PLMN, e.g., a unique number or alphanumeric value. In some embodiments, rule IDs may be hierarchical or provide insights into related rules. In some embodiments, rule IDs may be non-hierarchical or opaque regarding insights into related rules.

A time related parameter value determination rule field may represent
25 one or more rules or logic for determining a time related parameter value for one or more time related parameters. In some embodiments, a rule may be based on a network or NF scenario and/or discernible characteristics associated with a received message, a requesting entity, or a related service. Example scenario-based rules may include one or more time related
30 parameter value determination rules for an NRF to NRF forwarding scenario, a geo-redundant scenario, an NF congestion rule, and an NRF congestion scenario.

In some embodiments, node **200**, NRF **100**, or TVDM **204** may be configured for determining that a received message or related entity is associated with an NRF to NRF forwarding scenario and, using one or more related rules, may adjust one or more time related parameters according to various information, e.g., obtained via NWDAF **210** and/or NF data provider(s) **212**. For example, node **200**, NRF **100**, or TVDM **204** may determine that a received message is associated with an NRF to NRF forwarding scenario when NRF **100** lacks information for a relevant producer NF associated with a received message and, as such, may involve various messages traversing PLMN boundaries and localities. In this example, after detecting an NRF to NRF forwarding scenario, node **200**, NRF **100**, or TVDM **204** may determine an appropriate value for one or more time related parameters (e.g., an NF subscription validity time, an NF discovery validity time, or an NF access token expiry time), e.g., for reducing traffic crossing PLMN boundaries and different localities and/or for allowing additional time for expected or possible packet delays.

In some embodiments, node **200**, NRF **100**, or TVDM **204** may be configured for determining that a received message or related entity is associated with a geo-redundant scenario and, using one or more related rules, may adjust one or more time related parameters according to various information, e.g., obtained via NWDAF **210** and/or NF data provider(s) **212**. For example, node **200**, NRF **100**, or TVDM **204** may determine that a received message is associated with a geo-redundant scenario when the received message or a related message traverses one or more geo-redundant sites and, as such, may involve various messages being handled from NFs of a mate or peer NRF **100**. In this example, after detecting a geo-redundant scenario, node **200**, NRF **100**, or TVDM **204** may determine an appropriate value for one or more time related parameters (e.g., an NF heartbeat interval, an NF subscription validity time, an NF discovery validity time, or an NF access token expiry time), e.g., for reducing traffic crossing geo-redundant sites and/or for allowing additional time for expected or possible packet delays.

In some embodiments, node **200**, NRF **100**, or TVDM **204** may be configured for determining that NRF **100** is experiencing an operational issue (e.g., overloaded, handling peak traffic, under maintenance, etc.) based on obtained network information and/or NF information and, using one or more related rules, may adjust one or more time related parameters according to such issue. For example, node **200**, NRF **100**, or TVDM **204** may determine that an NRF **100** is experiencing congestion or is under maintenance based on various information (e.g., via a subscribed event notification from NWDAF **210**). In this example, after detecting that NRF **100** is congested or under maintenance, node **200**, NRF **100**, or TVDM **204** may determine an appropriate value for one or more time related parameters (e.g., an NF heartbeat interval, an HTTP header retry timer, an NF subscription validity time, an NF discovery validity time, or an NF access token expiry time), e.g., for reducing traffic handled by NRF **100** and/or for allowing additional time for expected or probable packet delays.

In some embodiments, node **200**, NRF **100**, or TVDM **204** may be configured for determining that an NF (e.g., a requested or appropriate producer NF for handling a particular service request) is experiencing an operational issue (e.g., overloaded, handling peak traffic, under maintenance, etc.) based on obtained network information and/or NF information and, using one or more related rules, may adjust one or more time related parameters according to such issue. For example, node **200**, NRF **100**, or TVDM **204** may determine that a producer NF is experiencing congestion or is under maintenance based on various information (e.g., an nf-name_message_processing_time metric or related data from NF data provider(s) **212**). In this example, after detecting that the producer NF is congested or under maintenance, node **200**, NRF **100**, or TVDM **204** may determine an appropriate value for one or more time related parameters (e.g., an NF heartbeat interval, an HTTP header retry timer, an NF subscription validity time, an NF discovery validity time, or an NF access token expiry time), e.g., for reducing less important traffic and/or for allowing additional time for expected or possible packet delays. In some embodiments, by increasing values associated with time related parameters (e.g., an NF heartbeat

interval), an overloaded NF may reduce its heartbeat related traffic towards NRF **100** and instead use its resources for processing requests during overload conditions.

In some embodiments, node **200**, NRF **100**, or TVDM **204** may use one or more determined time related parameter values for subsequent requests or operations. For example, after an NRF **100** is determined to be congested, an NF heartbeat interval (e.g., a heart-beat timer value) used by NFs may be increased from 30 seconds to 90 seconds and the NFs can be informed of the new value in response to subsequent 3GPP operations, e.g., NF registrations and NF updates. In this example, after an NRF **100** is determined to be no longer be congested, the NF heartbeat interval used by NFs may be decreased back to 30 seconds and the NFs may be informed of the new value in response to subsequent 3GPP operations.

It will also be appreciated that rule data **400** is for illustrative purposes and that different and/or additional data than the data depicted in Figure 4 may be usable for determining time related parameter values. For example, rule data **400** may include various scenarios not depicted, including combination scenarios, such as NRF and NF congestion. In this example, rule data **400** may include priority values for indicating which rule(s) are to be selected or used. In another example, rule data **400** may include one or more rules for different time related parameters for the same scenario. Further, rule data **400** may be stored (e.g., in data storage **206** using various data structures and/or computer readable media.

Figure 5 is a diagram illustrating example default value information **500** for various time related parameters in a communications network. For example, default value information **500** may indicate values associated with various time related parameters. In some embodiments, e.g., where NRF **100** does not determine time related parameters based on recent network and/or NF information, NRF **100** may utilize default value information **500** for selecting time related parameters regardless of situation or scenario. before adjustment based on network information, NF metrics or other information. In this example, default values may be predetermined, e.g., by a network operator or a time related parameter value determination rule (e.g., in rule data

400). Continuing with this example, time related parameter values may be determined by adjusting (e.g., increasing or decreasing) default values in response to or based on at least part of current network information and/or NF information, e.g., information indicating network congestion, NRF maintenance, inter-PLMN communications, high NF load, etc.

In some embodiments, node 200, NRF 100, or TVDM 204 may be configured for identifying characteristics of a received message (e.g., determining that a received message is an inter-PLMN message or that a received message is forwarded from a visitor PLMN) and using those characteristics along with current (or recent) network conditions and/or NF metrics to dynamically determining values for time related parameters. and may determine, using default value information 500, a default or initial time related parameter value for a particular time related parameter and may use a relevant rule (e.g., from rule data 400) to determine an appropriate time related parameter value for a requesting NF or related service, e.g., by increasing or decreasing the initial time related parameter value. For example, node 200 or TVDM 204 may determine that NRF or a related network portion is experiencing congestion and may determine that increasing an initial or default value for an NF heart-beat timer or interval value from 30 seconds to 60 seconds would improve congestion and/or related issues significantly. In this example, adjustment from 30 seconds to 60 seconds may be based on a formula or a percentage amount. In another example, time adjustments may be based on historical data, e.g., prior congestion events and/or related connectivity or heartbeat issues during those events.

Referring to Figure 5, a table representing default value information 500 comprises columns and/or fields for time related parameters and corresponding default values. In some embodiments, default values may be predetermined, e.g., by a network operator or a time related parameter value determination rule (e.g., in rule data 400). A time related parameter field may store information for representing a time related parameter (e.g., 3GPP network parameters) indicating or representing or indicating a time amount or a period of time. Example time related parameters depicted in Figure 5 include an NF heartbeat interval (e.g., a 3GPP “heart-beat timer”), an NF subscription

validity time, an NF discovery validity time, an NF access token expiry time, or an HTTP header retry timer (e.g., a value in a "Retry-After" HTTP header parameter field).

5 A default value field may indicate a default value (e.g., an initial value) associated with a particular time related parameter. In some embodiments, default values may be in seconds, minutes, hours, or days and/or may be based on a percentage or a formula that utilizes a proposed time from an NF and/or other data (e.g., a default value for heartbeat interval parameter may 10% less than a proposed time but not to exceed 70 seconds).

10 As depicted in Figure 5, a default value for an NF heartbeat interval parameter may be 30 seconds; a default value for an NF subscription validity time parameter may be 6 hours; a default value for an NF discovery validity time parameter may be 1 hours; a default value for an NF access token expiry time parameter may be 1 hour; and a default value for an HTTP header retry 15 timer parameter may be 30 seconds.

For example, an HTTP header retry timer may represent a parameter or setting indicating an amount of time (e.g., in seconds) that an NF waits to retry a service operation at NRF **100**. In some embodiments, an HTTP header retry timer may be determined when NRF **100** is to send an HTTP 503 error 20 message indicating a service is unavailable and may be provided to an NF service consumer (e.g., NF1 **207**) in an "Retry-After" HTTP header field. For example, when NRF **100** undergoes an overload situation, NRF **100** may reject some HTTP requests by sending an HTTP 503 message including an HTTP header field "Retry-After" for indicating an estimated time (in number of 25 seconds) for the recovery of the service. In this example, NRF **100** and/or TVDM **204** therein may determine the HTTP retry timer value (e.g., by adjusting a default value in response to network and/or NF conditions).

It will also be appreciated that default value information **500** are for illustrative purposes and that different and/or additional data than the data 30 depicted in Figure 5 may be usable for indicating default values for various time related parameters. Further, default value information **500** may be stored (e.g., in data storage **206**) using various data structures and/or computer readable media.

Figure 6 is a diagram illustrating an example process **600** for determining time related parameter values a communications network. In some embodiments, example process **600** described herein, or portions thereof, may be performed at or performed by a network node, e.g., NRF **100**,
5 node **200**, TVDM **204**, and/or another module, NF, or node.

Referring to process **600**, in step **602**, a service request message may be received from a first NF. In some embodiments, a service request message may include an NF registration request message, an NF update request message, an NF status subscription request message, an NF discovery
10 request message, or an NF access token request message.

In step **604**, it may be determined, using network information and/or NF information, a time related parameter value associated with the service request message. In some embodiments, a time related parameter value may indicate an NF heartbeat interval (e.g., a 3GPP heart-beat timer), an NF
15 subscription validity time, an NF discovery validity time, an NF access token expiry time, or an HTTP header retry timer (e.g., a value in a "Retry-After" HTTP header parameter field).

In some embodiments, at least some network information or NF information may be obtained periodically or aperiodically (e.g., dynamically)
20 from one or more data sources, e.g., local data store (e.g., relative to NRF **100**), a remote data source (e.g., relative to NRF **100**), NWDAF **210**, or NF data provider(s) **212**.

In some embodiments, at least some network information may be obtained using an Nnwdaf_EventsSubscription service or an
25 Nnwdaf_AnalyticsInfo service. For example, every 60 seconds or so, NRF **100** or another entity may send one or more Nnwdaf_AnalyticsInfo service request messages to NWDAF **210** for obtaining load level information for one or more network slice instances associated with a 5G communications network. In another example, NRF **100** or another entity may send an
30 Nnwdaf_EventsSubscription service request message to subscribe to and receive an network slice specific congestion events notification from NWDAF **210**.

In some embodiments, determining a time related parameter value may include determining that an NRF, a first NF, or a network entity may be experiencing a congestion status change, a change in workload amount, or an operational status change; and in response adjusting the time related parameter value from a default value or a prior value. For example, a default value or a prior value may be predetermined by a network operator or generated using a predetermined policy or rule.

In some embodiments, determining a time related parameter value may include determining that a service request message or a related message requires NRF to NRF forwarding; and in response increasing the time related parameter value from an initial or default value.

In some embodiments, determining a time related parameter value may include determining that a service request message or a related message may be an inter public land mobile network (PLMN) message; and in response increasing the time related parameter value from an initial or default value.

In step **606**, a service response message indicating the time related parameter value may be generated and sent to the first NF. In some embodiments, a service response message may include an NF registration response message, an NF update response message, an NF status subscription response message, an NF discovery response message, or an NF access token response message.

It will be appreciated that process **600** is for illustrative purposes and that different and/or additional actions may be used. It will also be appreciated that various actions described herein may occur in a different order or sequence.

It will be appreciated that while some aspects of the subject matter described herein has been discussed with reference to 5G networks various other networks may utilize some aspects of the subject matter described herein. For example, any network that can benefit from dynamically determined time related parameter values, e.g., time related parameter values based on network conditions, NF related metrics, and/or other information.

It should be noted that node **200**, TVDM **204**, and/or functionality described herein may constitute a special purpose computing device. Further,

node **200**, TVDM **204**, and/or functionality described herein can improve the technological field of network communications. For example, by determining time related parameter values using current network information and/or NF information, communications between NFs or other entities can be improved and timing issues can be reduced. In this example, by utilizing one or more techniques and/or methods described herein, NRF **100** or TVDM **204** therein can determine time related parameter values based on network conditions, NF related metrics, and/or other factors. Further, such techniques and/or methods described herein, may be applicable to multiple services or related interfaces including, for example, nudm-sdm, nudm-uecm, npcfc-uepolicy, nsmf-pdusession, nssf-nsselection, nnrf-disc, and/or nnrf-nfm.

The disclosure of each of the following references is incorporated herein by reference in its entirety to the extent not inconsistent herewith and to the extent that it supplements, explains, provides a background for, or teaches methods, techniques, and/or systems employed herein.

References:

1. 3GPP TS 29.510; 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; 5G System; Network Function Repository Services; Stage 3 (Release 17), V17.1.0 (2021-03).
2. 3GPP TS 33.501; 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Security Architecture and Procedures for the 5G System; (Release 17), V17.1.0 (2021-03).
3. 3GPP TS 29.520; 3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; 5G System; Network Data Analytics Services; Stage 3 (Release 17), V17.2.0 (2021-03)

It will be understood that various details of the presently disclosed subject matter may be changed without departing from the scope of the presently disclosed subject matter. Furthermore, the foregoing description is for the purpose of illustration only, and not for the purpose of limitation.

CLAIMS

What is claimed is:

1. A method for determining time related parameter values for a communications network, the method comprising:
5 at a network function (NF) repository function (NRF) comprising at least one processor:
receiving, from a first network function (NF), a service request message;
determining, using network information and/or NF information, a
10 time related parameter value associated with the service request message; and
generating and sending, to the first NF, a service response message indicating the time related parameter value.
2. The method of claim 1 wherein at least some of the network information
15 or the NF information is obtained periodically or aperiodically from one or more data sources.
3. The method of claim 2 wherein the one or more data sources includes a local data store, a remote data source, a network data analytics function (NWDAF), or an NF data provider.
- 20 4. The method of any of claims 1, 2 or 3 wherein at least some the network information is obtained using an Nnwdaf_EventsSubscription service or an Nnwdaf_AnalyticsInfo service.
5. The method of any of the preceding claims wherein determining the time related parameter value includes determining that the NRF, the
25 first NF, or a network entity is experiencing a congestion status change, a change in workload amount, or an operational status change; and, in response, adjusting the time related parameter value from a default value or a prior value.
6. The method of claim 5 wherein the default value or the prior value is
30 predetermined by a network operator or generated using a predetermined policy or rule.
7. The method of any of the preceding claims wherein determining the time related parameter value includes determining that the service

- request message or a related message requires NRF to NRF forwarding; and, in response, adjusting the time related parameter value from an initial or default value.
- 5 8. The method of any of the preceding claims wherein determining the time related parameter value includes determining that the service request message or a related message is an inter public land mobile network (PLMN) message; and, in response, adjusting the time related parameter value from an initial or default value.
- 10 9. The method of any of the preceding claims wherein the service request message includes an NF registration request message, an NF update request message, an NF status subscription request message, an NF discovery request message, or an NF access token request message.
- 15 10. The method of any of the preceding claims wherein the time related parameter value indicates an NF heartbeat interval, an NF subscription validity time, an NF discovery validity time, an NF access token expiry time, or a hypertext transfer protocol (HTTP) header retry timer.
11. A system for determining time related parameter values for a communications network, the system comprising:
a network function (NF) repository function (NRF) comprising:
20 at least one processor; and
 a memory,
 wherein the NRF is configured for:
 receiving, from a first network function (NF), a service request message;
25 determining, using network information and/or NF information, a time related parameter value associated with the service request message; and
 generating and sending, to the first NF, an service response message indicating the time related parameter value.
- 30 12. The system of claim 11 wherein the NRF is configured for periodically or aperiodically obtaining at least some of the network information or the NF information from one or more data sources.

13. The system of claim 12 wherein the one or more data sources includes a local data store, a remote data source, a network data analytics function (NWDAF), or an NF data provider.
14. The system of claims 11, 12 or 13 wherein the NRF is configured for obtaining at least some of the network information using an NnwdafeventsSubscription service or an NnwdafeventsAnalyticsInfo service.
15. The system of any of claims 11 to 14 wherein determining the time related parameter value includes determining that the NRF, the first NF, or a network entity is experiencing a congestion status change, a change in workload amount, or an operational status change; and, in response, adjusting the time related parameter value from a default value or a prior value.
16. The system of any of claims 11 to 15 wherein determining the time related parameter value includes determining that the service request message or a related message requires NRF to NRF forwarding; and, in response, adjusting the time related parameter value from a default value or a prior value.
17. The system of any of claims 11 to 16 wherein determining the time related parameter value includes determining that the service request message or a related message is an inter public land mobile network (PLMN) message; and, in response, adjusting the time related parameter value from a default value or a prior value.
18. The system of any of claims 11 to 17 wherein the service request message includes an NF registration request message, an NF update request message, an NF status subscription request message, an NF discovery request message, or an NF access token request message.
19. The system of any of claims 11 to 18 wherein the time related parameter value indicates an NF heartbeat interval, an NF subscription validity time, an NF discovery validity time, an NF access token expiry time, or a hypertext transfer protocol (HTTP) header retry timer.
20. At least one non-transitory computer readable medium having stored thereon executable instructions that when executed by at least one

processor of a computer cause the computer to perform steps comprising:

at a network function (NF) repository function (NRF) comprising at least one processor:

5 receiving, from a first network function (NF), a service request message;

 determining, using network information and/or NF information, a time related parameter value associated with the service request message; and

10 generating and sending, to the first NF, a service response message indicating the time related parameter value.

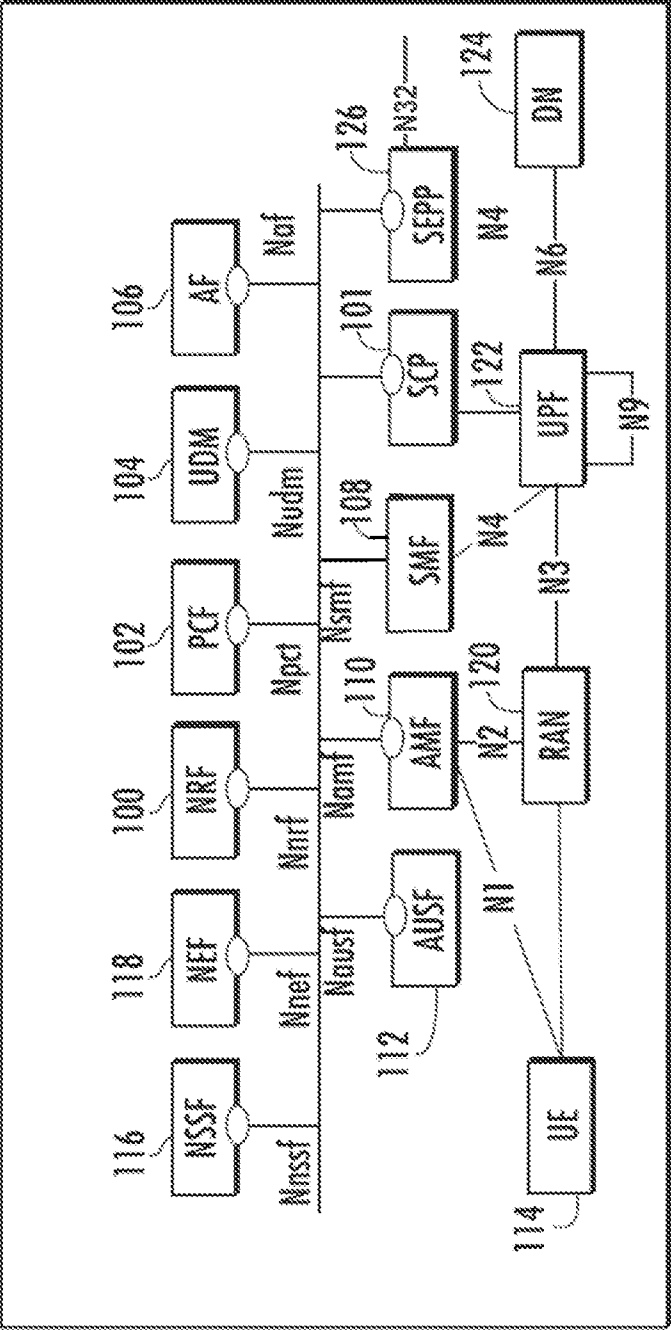


FIG. 1

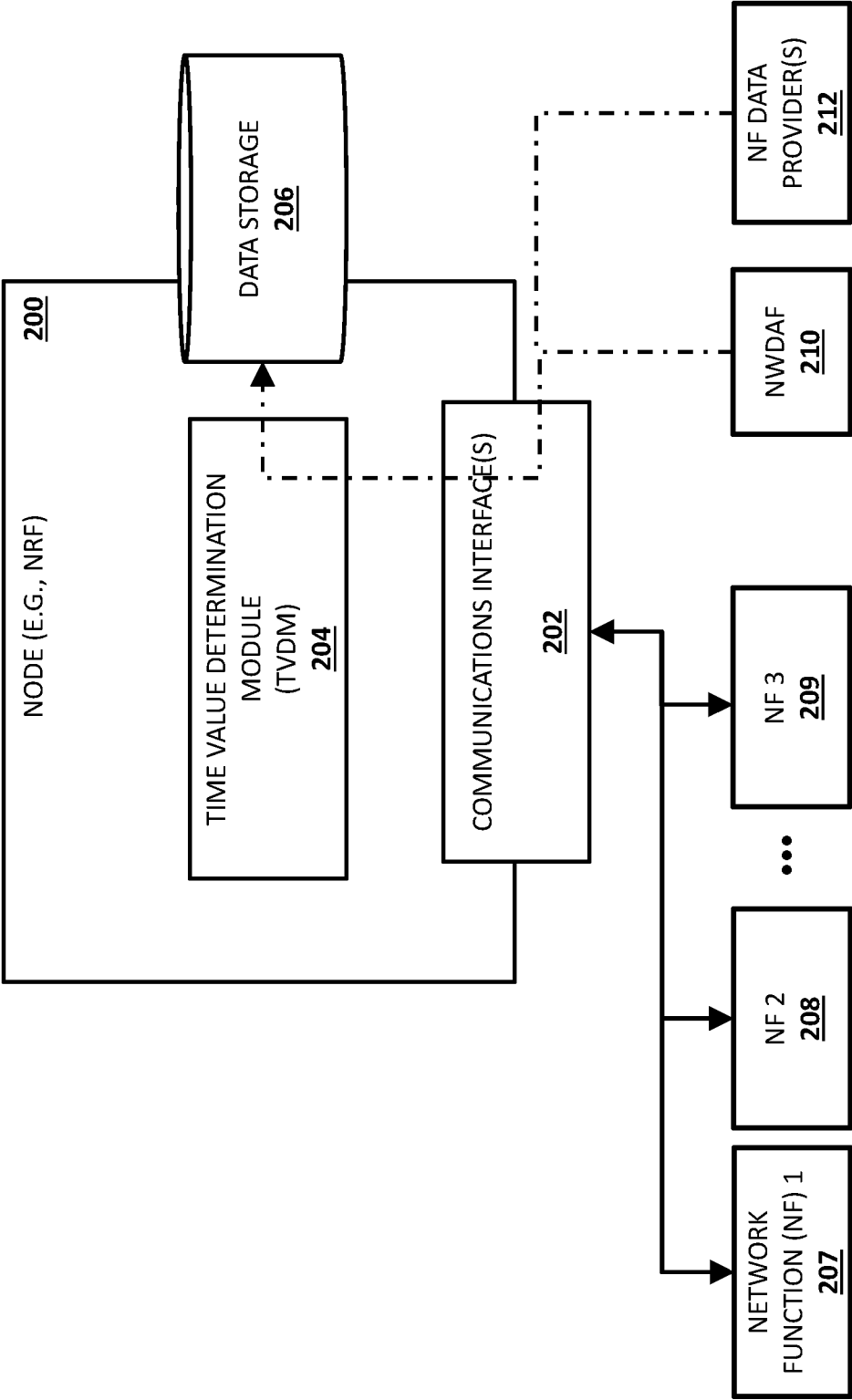


FIG. 2

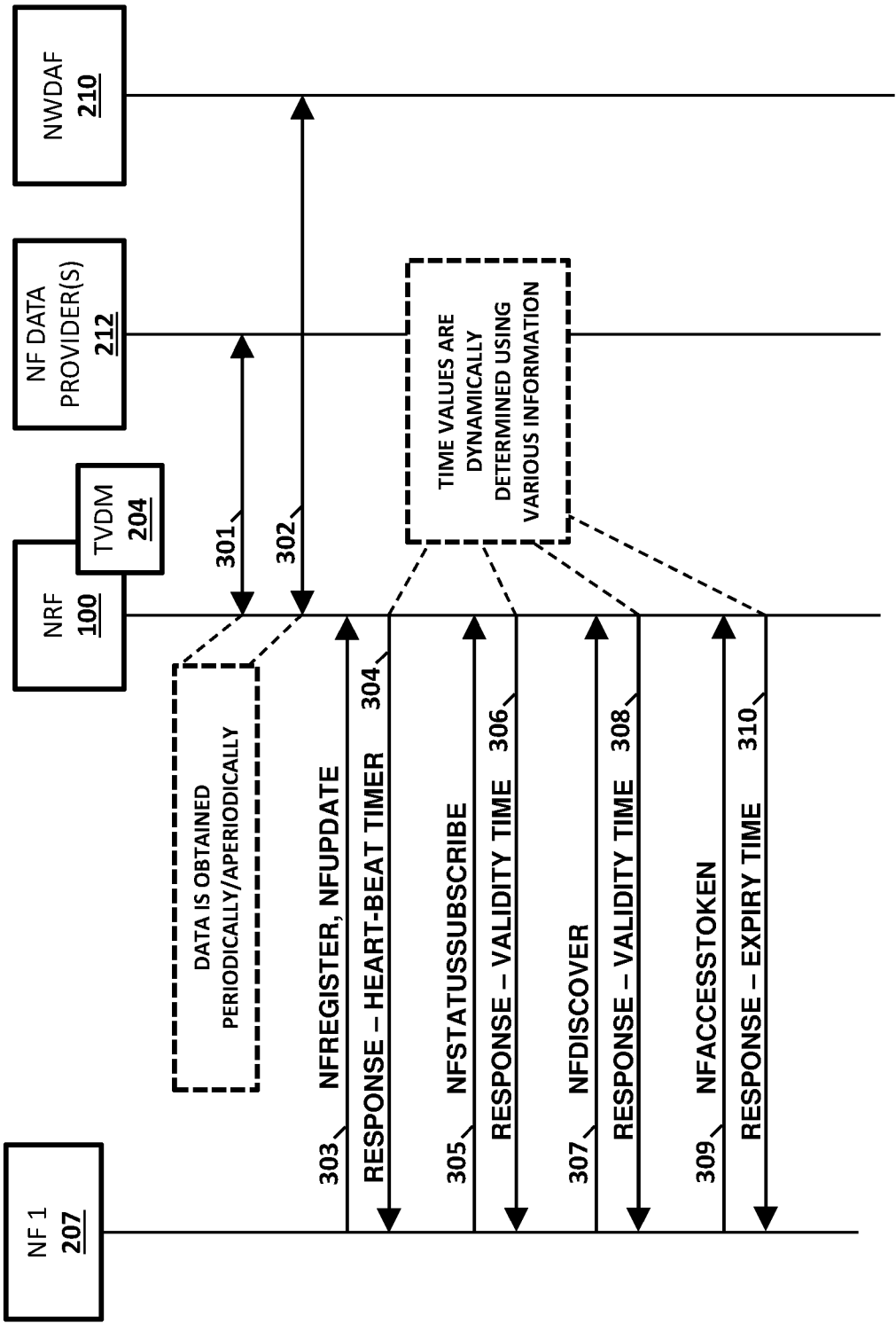


FIG. 3

400

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RULE ID	TIME VALUE DETERMINATION RULE
ID1	NRF-NRF FORWARDING SCENARIO RULE
ID2	GEO-REDUNDANT SCENARIO RULE
ID3	NF CONGESTION SCENARIO RULE
ID4	NRF CONGESTION SCENARIO RULE

FIG. 4

500

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TIME RELATED PARAMETERS	EXAMPLE DEFAULT VALUES (E.G., PRIOR TO DYNAMIC CONFIGURATION)
NF HEARTBEAT INTERVAL	30 SECONDS
NF SUBSCRIPTION VALIDITY TIME	6 HOURS
NF DISCOVERY VALIDITY TIME	1 HOUR
NF ACCESS TOKEN EXPIRY TIME	1 HOUR
HTTP HEADER RETRY TIMER	30 SECONDS

FIG. 5

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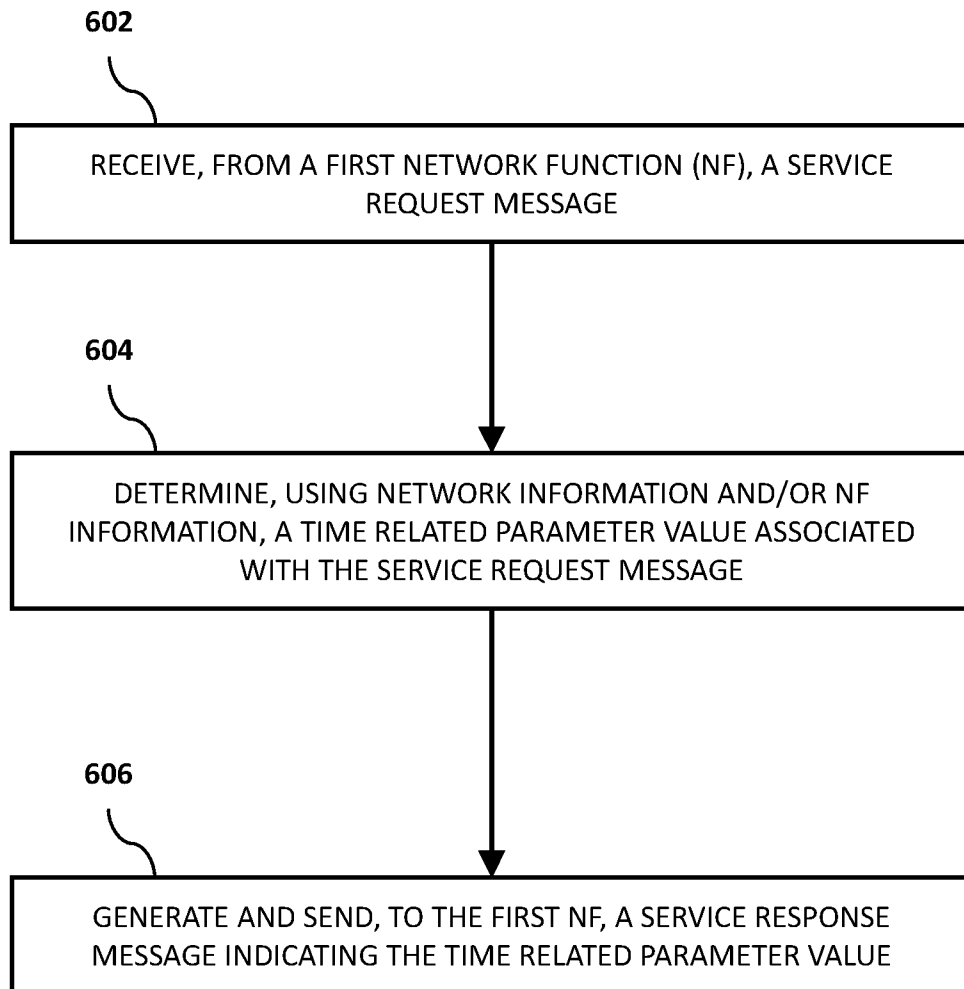
600

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2022/030887

A. CLASSIFICATION OF SUBJECT MATTER INV. H04L41/40 H04L43/0876 H04L67/51 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		
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, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	ANONYMOUS: "3rd Generation Partnership Project; Technical Specification Group Core Network and Terminals; 5G System; Network Function Repository Services; Stage 3 (Release 16)", 3GPP TS 29.510 V16.3.0, vol. 0, 1 March 2020 (2020-03-01), XP055877722, abstract; figures 5.2.2.2.2-1 page 15, paragraph 1 page 52; tables 6.1.6.2.2-1 page 79; tables 6.1.6.2.45-1 page 18, paragraph 1 page 22, last paragraph ----- -/--	1-20
☒ 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 2 September 2022		Date of mailing of the international search report 09/09/2022
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 Fantacone, Vincenzo

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2022/030887

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2020/249242 A1 (HUAWEI TECH CO LTD [CN]; MARY SHEEBA BACKIA [SE]) 17 December 2020 (2020-12-17) abstract; figure 3 page 24, line 2 – page 25, line 23 page 7, lines 17-35 page 17, lines 8-16 page 20, lines 8-32 -----	1-20
A	WO 2021/047551 A1 (ERICSSON TELEFON AB L M [SE]; LI PENG [CN]) 18 March 2021 (2021-03-18) abstract; figures 1-7 paragraph -----	1-20
A	WO 2020/221956 A1 (NOKIA TECHNOLOGIES OY [FI]) 5 November 2020 (2020-11-05) abstract; figures 5, 6A, 6B page 15, line 13 – page 17, line 30 -----	1-20
A	US 10 819 636 B1 (GOEL YESH [IN]) 27 October 2020 (2020-10-27) abstract; figure 1 columns 5-6 -----	1-20

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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