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Range-variable intent definition and operation

Abstract

Described are examples for providing intent based network configuration with intent expectations including prioritized goals. A system for network configuration includes a network management function configured to receive an intent including requirements, goals, and constraints for a network and generate an intent expectation including a set of prioritized goals based on the intent. An infrastructure service management (ISM) system is configured to: receive the intent expectation from the network management function; select at least one of the prioritized goals as an active target; configure computing resources to satisfy at least the active target; and report the active target and a configuration status to the network management function. The ISM may monitor a status of the computing resources and select a higher priority goal that can be satisfied or select a lower priority goal in the case of resource or performance degradation.

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Background/Summary

BACKGROUND

(1) A radio access network (RAN) may provide multiple user devices with wireless access to a network. The user devices may wirelessly communicate with a base station, which forwards the communications towards a core network. A core network may include multiple nodes or functions. For example, a 5G core network may include one or more Access and Mobility Management Functions (AMFs), Session Management Functions (SMFs), and a User Plane Functions (UPFs). For instance, the AMF may be a control node that processes the signaling between the UEs and the core network. Generally, the AMF provides quality of service (QoS) flow and session management. All user Internet protocol (IP) packets are transferred through the UPF. The UPF provides UE IP address allocation as well as other functions. The UPF may be connected to IP Services. The IP Services may include the Internet, an intranet, an IP Multimedia Subsystem, a packet switched (PS) Streaming Service, and/or other IP services.

(2) A virtualized radio access network may utilize datacenters with generic computing resources for performing RAN processing for network functions. For example, instead of performing PHY and MAC layer processing locally on dedicated hardware, a virtualized radio access network may forward radio signals from the radio units to an edge datacenter for processing and similarly forward signals from the edge datacenter to the radio units for wireless transmission. As another example, core network functions may be implemented on generic cloud resources at various datacenters. Because the network datacenters utilize generic computing resources, a virtualized RAN may provide scalability and fault tolerance for network processing. Conventionally, whether using dedicated hardware or more generic computing resources, network configuration has been performed by pushing a network configuration down to lower level management functions until each network function is configured.

(3) In complex systems, such as cellular networks in general and in cloud-based virtualized deployments specifically, variations in system resources and network conditions may result in many interactions between management functions and infrastructure management leading to a suboptimal performance.

SUMMARY

(4) The following presents a simplified summary of one or more aspects in order to provide a basic understanding of such aspects. This summary is not an extensive overview of all contemplated aspects, and is intended to neither identify key or critical elements of all aspects nor delineate the scope of any or all aspects. Its sole purpose is to present some concepts of one or more aspects in a simplified form as a prelude to the more detailed description that is presented later.
(5) In an example, a system for network configuration includes a network management function configured to: receive an intent including requirements, goals, and constraints for a network; and generate an intent expectation including a set of prioritized goals based on the intent. The system includes an infrastructure service management (ISM) system configured to: receive the intent expectation from the network management function; select a highest prioritized goal of the set of prioritized goals that can be satisfied by the computing resources controlled by the ISM system as an active target based on a comparison between a status of the computing resources to parameters for each of the set of prioritized goals; and report the active target and a configuration status to the network management function.
(6) In another example, a computer-implemented method for network configuration includes receiving an intent expectation including a set of prioritized goals from a network management function. The method includes selecting a highest prioritized goal of the set of prioritized goals that can be satisfied by a set of computing resources as an active target based on a comparison between a status of the computing resources to parameters for each of the set of prioritized goals. The method includes configuring computing resources to satisfy at least the active target of the intent expectation. The method includes reporting the active target and a configuration status to the network management function.
(7) In another example, a non-transitory computer-readable medium includes computer executable instructions for network configuration. The non-transitory computer-readable medium includes instructions to receive an intent expectation including a set of prioritized goals from a network management function. The non-transitory computer-readable medium includes instructions to select a highest prioritized goal of the set of prioritized goals that can be satisfied by a set of computing resources as an active target based on a comparison between a status of the computing resources to parameters for each of the set of prioritized goals. The non-transitory computer-readable medium includes instructions to configure computing resources to satisfy at least the active target of the intent expectation. The non-transitory computer-readable medium includes instructions to report the active target and a configuration status to the network management function.
(8) To the accomplishment of the foregoing and related ends, the one or more aspects comprise the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative features of the one or more aspects. These features are indicative, however, of but a few of the various ways in which the principles of various aspects may be employed, and this description is intended to include all such aspects and their equivalents.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) FIG. **1** is a diagram of an example of an architecture for network management of a virtualized radio access network (RAN), in accordance with aspects described herein.
(2) FIG. **2** is a diagram of an example of network slice based management of a virtualized RAN, in accordance with aspects described herein.
(3) FIG. **3** is diagram of example intents, intent expectations, and resource configurations.
(4) FIG. **4** is a schematic diagram of an example of a device for intent based network configuration,

in accordance with aspects described herein.
(5) FIG. **5** is a flow diagram of an example of a method of configuring a network, in accordance with aspects described herein.
(6) FIG. **6** is a flow diagram of a first example of a method of maintaining an intent expectation, in accordance with aspects described herein.
(7) FIG. **7** is a flow diagram of a second example of a method of maintaining an intent expectation, in accordance with aspects described herein.
(8) FIG. **8** is a schematic diagram of an example of a device for performing functions described herein, in accordance with aspects described herein.

DETAILED DESCRIPTION

(9) The detailed description set forth below in connection with the appended drawings is intended as a description of various configurations and is not intended to represent the only configurations in which the concepts described herein may be practiced. The detailed description includes specific details for the purpose of providing a thorough understanding of various concepts. However, it will be apparent to those skilled in the art that these concepts may be practiced without these specific details. In some instances, well-known components are shown in block diagram form in order to avoid obscuring such concepts.
(10) The concept of intent driven network management allows a client to specify a specific goal (or intent target) to be satisfied within a set of specific expectations (also referred to as contexts). The server, e.g., the intent-handler or the service provider, provides the client with updates regarding the status of the intent. If the server cannot achieve the goal specified as the intent, then the server may reject the intent. If a satisfied intent is degraded and no longer fully satisfied, the server notifies the client of the degradation. The client then may choose to update the intent and set a new goal.
(11) In complex systems, such as cellular networks in general and in cloud-based virtualized deployments specifically, the variations in system resources and network conditions may result in many interactions between the intent-client and intent-server leading to a suboptimal performance. A proposal to address this issue is to enable the intent-server to provide predictive behavior; the predictive behavior information enables the intent-client to create intents with a higher chance of successful satisfaction. However, the predictive capability is complicated and limited in its performance and there is a limit to the extent of its scope and hence applicability.
(12) In an aspect, this disclosure describes various examples related to network management for virtualized radio access networks (RANs) using intent based interfaces with prioritization of goals. An intent-client may provide an intent expectation including a set of prioritized goals. An intent expectation may also be referred to as an intent target or intent declaration. An intent-server may select one of the goals as an active target and configure computing resources to satisfy at least the active target. For example, in the case of a virtualized RAN, a network management function may receive an intent including requirements, goals, and constraints for a network. For example, the intent may be received from a user (e.g., network operator) or a higher level network management function. The network management function may generate an intent expectation including a set of prioritized goals based on the intent. The network management function may provide the intent expectation to an infrastructure services management (ISM) system such as a container infrastructure services management (CISM) system that controls cloud resources. The ISM system may receive the intent expectation from the network management function and select at least one of the prioritized goals as an active target. The ISM system may configure computing resources to satisfy at least the active target. The ISM system may report the active target and configuration status to the network management function.
(13) In some implementations, the ISM system may monitor performance of the configured computing resources. For example, the ISM system may include or communicate with an analysis system to determine whether the active target is being satisfied or whether a higher prioritized goal could be satisfied. The ISM system may select a lower prioritized goal when the active target is not

satisfied or select a higher prioritized goal when possible. The ISM system may report a new active target. Accordingly, the ISM system may adapt the active target without a need for the network management function to provide a new intent.

(14) In an aspect, the inclusion of prioritized goals within an intent expectation may improve performance of network management functions and the network itself. For example, by including prioritized goals within an intent expectation, the overhead of communications between higher level network management functions and lower level network management functions or infrastructure management services may be reduced. That is, the fewer rounds of communications of failed intents may be needed to arrive at an operable configuration. As another example, inclusion of prioritized goals within an intent expectation moves decisions closer to resources, which may provide for configuration that improve network performance. For instance, if an ISM system is given more flexibility for allocating resources using prioritized goals, the ISM may be able to optimize for desired characteristics such as performance metrics or cost, whereas a higher level network management function may not be able to control for such characteristics. Similarly, the use of prioritized goals may allow a reconciliation loop to operate closer to the resources. For example, the ISM system may detect degraded performance resulting in selection of a lower priority goal or detect ability to satisfy a higher priority goal without need to receive an updated intent from a higher level management function. Accordingly, the network may be able to adapt more quickly to network conditions at the ISM using the prioritized goals in comparison to a larger reconciliation loop involving updated intents from higher level management functions.

(15) Turning now to FIGS. **1-8**, examples are depicted with reference to one or more components and one or more methods that may perform the actions or operations described herein, where components and/or actions/operations in dashed line may be optional. Although the operations described below in FIGS. **5-7** are presented in a particular order and/or as being performed by an example component, the ordering of the actions and the components performing the actions may be varied, in some examples, depending on the implementation. Moreover, in some examples, one or more of the actions, functions, and/or described components may be performed by a specially-programmed processor, a processor executing specially-programmed software or computer-readable media, or by any other combination of a hardware component and/or a software component capable of performing the described actions or functions.

(16) FIG. **1** is a diagram of an example of an architecture for management of a virtualized RAN **100**. The virtualized RAN **100** may be implemented on a cloud network **105** to provide access for user equipment (UEs) **104**. The virtualized RAN **100** may include radio units **110**, one or more edge datacenters **120**, one or more datacenters **130**, a network management system **140**, an infrastructure service management (ISM) system **160**, and an analysis system **180**.

(17) The radio units **110** may include antennas configured to transmit and/or receive radio frequency (RF) signals. In some implementations, the radio units **110** may include RF processing circuitry. For example, the radio units **110** may be configured to convert the received RF signals to baseband samples and/or convert baseband samples to RF signals. The radio units **110** may be connected to the edge datacenter **120** via front-haul connections **116**. The front-haul connections **116** may be wired connections such as fiber optic cables.

(18) The edge datacenter **120** may include computing resources **122** and a switch **124**, which may be connected to RUs **110** via the front-haul connections **116**. The edge datacenter **120** may provide a virtualized base station for performing RAN processing for one or more cells. For example, the computing resources **122** may be hardware servers or virtual servers. The servers may be generic computing resources that can be configured to perform specific RAN protocol stacks including, for example, physical (PHY) layer, media access control (MAC) layer protocol stacks, radio link control (RLC) layer, and a radio resource control (RRC) layer. In some implementations, PHY layer processing may be more resource intensive than higher layer processing and may benefit from performance close to the RUs **110**. The computing resources **122** may be connected to the switch

124 and to each other via connections, which may be wired connections such as Ethernet.

(19) The datacenter **130** may include computing resources **132**. Unlike the edge datacenter **120**, the datacenter **130** may lack a direct connection to RUs **110**. Generally, the datacenter **130** may be more centrally located, be connected to multiple other datacenters, and/or have greater computing resources **132** than an edge datacenter **120**. In some implementations, higher layer network functions and/or core network functions may be performed at a datacenter **130**. For example, the datacenter **130** may instantiate network functions such one or more Access and Mobility Management Functions (AMFs) **134**, a Session Management Function (SMF) **136**, and a User Plane Function (UPF) **138**.

(20) The network management system **140** may provide a network operator with tools for configuring the virtualized RAN **100**. In an aspect, the network management system **140** provides intent based configuration of the virtualized RAN **100**. An intent specifies the expectations including requirements, goals, and constraints for a specific service or network management workflow. An intent is typically understandable by humans, and also can be interpreted by a machine without any ambiguity. In contrast to an imperative configuration that specifies how a network or component is to perform, an intent expresses what a network should achieve. For example, an intent may express the metrics that are be achieved and not how to achieve the metrics.

(21) In an aspect, the network management system **140** includes one or more network management functions **142**. Each network management function **142** may receive an intent and output an expectation or a configuration. For example, the network management function **142** may include an intent interface **144** configured to receive an intent including requirements, goals, and constraints for a network. The network management function **142** may include an expectation generator **146** configured to generate an intent expectation including a set of prioritized goals based on the intent. For instance, where an intent is represented by metrics, the set of prioritized goals may include a minimum operational metric, a satisfactory metric, and a desired metric. In some implementations, the set of prioritized goals may be subject to the same constraint indicated in the intent.

(22) In some implementations, the network management functions **142** are slice based network management functions arranged in a hierarchical order. For instance, the network management functions **142** may include a communication service management function (CSMF), network slice management function (NSMF), a network slice subnet management function (NSSMF), or a network function management function (NFMF). The slice based network management functions may manage on slice constituents such as a slice, a slice subnet, or a network function (NF). Each management function **142** may provide an intent expectation for a slice constituent to a lower level management function to the ISM system **160**, and/or to a NF. For example, the NFMF may provide an intent expectation that the ISM system **160** provide an NF such as the AMF **134**. The ISM system **160** may instantiate the AMF **134** on the network resources **132** at the datacenter **130**. The NFMF may communicate with the AMF **134**, for example, to configure a policy for the AMF **134** and/or monitor performance of the AMF **134**. The network management functions may similarly configure other network functions of the RAN. In some implementations, the network management system **140** may be implemented on cloud resources such as a datacenter **130**. In some implementations, the ISM system **160** may also be implemented on the cloud resources, and there may be a logical divide between the network management system **140** and the ISM system. In other implementations, the network management system **140** may be external to the cloud network **105** and may communicate with the ISM system **160** via a network connection.

(23) ISM system **160** may be a system configured to manage computing resources of the cloud network **105**. The cloud network **105** may support various services in addition to supporting the virtualized RAN **100**. For example, the ISM system **160** may configure the cloud network **105** to provide web hosting services, virtual wide area network (WAN) services, or storage services. In an aspect, the ISM system **160** includes an intent-based interface for allocating computing resources. The ISM system **160** may be an intent-server that satisfies intent expectations provided by the

network management system **140**. The ISM system **160** may include a variable intent component **170** configured to satisfy intent expectations that include a set of prioritized goals. Although illustrated as a component of the ISM system **160**, a network management function may also include a variable intent component **170**, for example, for satisfying an intent expectation from a higher level management function.

(24) In an aspect, the variable intent component **170** may include an expectation interface **162**, a target selector **164**, a configuration component **166**, and a reporting component **168**. The expectation interface **162** may be configured to receive an intent expectation from the network management function **142**. For example, the expectation interface **162** may provide one or more application programming interfaces (APIs) that define formats of intent expectations including prioritized goals. The target selector **164** may be configured to select at least one of the prioritized goals as an active target. For example, the target selector **164** may select a highest prioritized goal that can be satisfied by the computing resources of the cloud network **105** based on a status of the computing resources (e.g., as indicated by an analysis system **180**. The configuration component **166** may be configured to configure computing resources to satisfy at least the active target. For example, the configuration component **166** may instantiate a network function at a datacenter **130** or an edge datacenter **120**. As another example, the configuration component **166** may configure a policy at the network function. The reporting component **168** may be configured to report the active target and configuration status to the network management function **142**.

(25) The analysis system **180** may be configured to monitor a status of the computing resources and/or network functions deployed on the computing resources. The analysis system **180** may collect metrics generated by the cloud network **105** (e.g., data rates, processor/memory utilization) and/or metrics generated by network functions (e.g., number of UEs, latency, throughput). In some implementations, the analysis system **180** may include a management data analytics function (MDAF) **180** for one or more levels of network management functions. The analysis system **180** may determine whether active targets are being satisfied. In some implementations, the analysis system **180** may determine whether alternative or potential targets could be satisfied based on network conditions. In some implementations, the analysis system **180** may be external to the ISM system **160**. In other implementations, the analysis system **180** may be included in the ISM system.

(26) FIG. **2** is a diagram **200** of an example of network slice based management of a virtualized RAN. The network management system **140** may include hierarchical management functions **142**. For example, the management functions **142** may include a CSMF **210**, a NSMF **220**, a NSSMF **230**, a NFMF **240**, and NFs **250**. Each management function **142** may be an intent based management function that receives an intent from a higher level and generates an intent expectation for a lower level and/or the ISM system **160**. For example, the CSMF **210** may receive an intent (e.g., for a service) from a network operator and generate an intent expectation **212** for the NSMF **220**. The NSMF may receive the intent expectation **212** as a new intent (e.g., for a network slice) and generate one or more intent expectations **222** for the NSSMF (e.g., intent expectations for various subnets). The NSSMF **230** may receive the intent expectation **222** as a new intent for a subnet and generate one or more intent expectations **232** for the NFMF **240** (e.g., intent defining required network functions). The NSSMF **230** may also generate an intent expectation **234** for the ISM system **160** to implement the subnet. For example, the intent expectation **234** from the NSSMF **230** may include prioritized goals for a geographic area for the subnet. The NFMF **240** may receive the intent expectation **232** and generate intent expectations **242** for NFs **250**. The NFMF **240** may also generate an intent expectation **244** for the ISM system **160**. For example, the intent expectation **244** may provide prioritized goals for NF performance metrics. In some implementations, any of the NSMF **220**, NSSMF **230**, or NFMF **240** may include the variable intent component **170** for satisfying a received intent expectation that includes prioritized goals. Any of the intent expectations **212**, **222**, or **232** may include prioritized goals.

(27) The ISM system **160** may include different APIs **262**, **264** for different network management

functions. For example, the ISM system **160** may receive the intent expectation **234** via the API **262** or receive the intent expectation **244** via the API **264**. In some implementations, each API **262**, **264** may be an example of the expectation interface **162** that defines relevant goals for the respective level of intent expectation. The ISM system **160** may include a separate API **266** for sending a configuration **254** to a NF **250**. The API **266** may be a non-intent based interface for sending an imperative configuration. In some implementations (e.g., where a network management function includes a variable intent component **170**), the API **262** and/or the API **264** may be a non-intent based interface that receives a configuration from the NSSMF **230** or NFMF **240**, respectively.

(28) In some implementations, MDAFs **182** may operate at various levels corresponding to the hierarchical network management functions **142** (e.g., MDAF-NS level **282**, MDAF-NSS level **284**, and MDAF-NF level **286**). An MDAF may provide analysis to the corresponding hierarchical network management functions **142**, which may change a configuration based on the analysis. In some implementations, (e.g., where a network management function includes a variable intent component **170**), the MDAF may provide analysis regarding whether a prioritized goal can be satisfied and/or select a prioritized goal based on the analysis. In some implementations, the MDAFs **182** may provide analysis to the ISM system **160** or the associated analysis system **180**. The ISM system **160** may modify a network configuration based on the analysis (e.g., by changing an active target). Accordingly, providing MDAF analysis to the ISM system **160** may shorten a feedback loop and allow faster responses to changing network conditions.

(29) FIG. **3** is diagram **300** of example intents **310**, intent expectations **330**, and resource configurations **350**. For instance, the intent **310** may correspond to the intent expectation **232** received at the NFMF **240**, the intent expectation **330** may correspond to the intent expectation **244** received at the ISM system **160**, and the resource configuration **350** may correspond to a configuration delivered to the datacenter **130** or edge datacenter **120**.

(30) The intent **310** may include a requirement **312**, a goal **314**, and a constraint **316**. For example, the intent **310** may be an intent for establishing a UPF **138** as indicated by the requirement **312**. The intent **310** may be generated by the NSSMF **230**. The intent **310** may have a goal of achieving a throughput greater than X, which may be selected by the NSSMF **230**, for example, based on a higher level intent expectation **222**. The intent **310** may have a constraint of a cost less than Y, which may also be selected by the NSSMF **230**.

(31) The NFMF **240** may receive the intent **310** and generate an intent expectation **330**. The intent expectation **330** may include a requirement **332**, a set of prioritized goals **340**, and a constraint **334**. For example, the NFMF **240** may determine that the UPF **138** should be implemented by the cloud network **105** and generate the intent expectation **330** for the ISM system **160**. The set of prioritized goals **340** may be based on the goal **314**. For example, the NFMF **240** may select performance goals based on a percentage of the goal **314**. For example, an enhanced goal **342** may specify a performance level greater than requested in the intent **310**, a standard goal **344** equal to the performance level requested in the intent **310**, and a minimum acceptable goal **346** less than requested in the intent **310**. The NFMF **240** may select the particular prioritized goals based on the particular metric and the specificity of the intent **310**. The constraint **334** may be the same as the constraint **316**. In some implementations, the constraint **334** may be a prioritized constraint associated with each prioritized goal **340**. For instance, a prioritized constraint may allow relaxation of the constraint for an enhanced goal.

(32) The ISM system **160** may receive the intent expectation **330** and generate a resource configuration **350**. The resource configuration **350** may be based on available computing resources within the cloud network **105** and a status of the computing resources. For instance, the ISM system **160** may receive feedback from the datacenters **120**, **130** regarding available resources as well as the performance of the resources for other applications. For instance, the ISM system **160** may have information about network or resource outages. The ISM system **160** may select at least

one of the prioritized goals **340** as an active target. For example, the ISM system **160** may select a highest prioritized goal that can be satisfied by the computing resources of the cloud network **105** based on the status of the computing resources. The ISM system **160** may also consider the constraint **334** when selecting a prioritized goal **340**. For instance, if the cloud network **105** has sufficient resources to satisfy the goal **342** but doing so would violate the constraint **334** (e.g., cost too much), the ISM system **160** may select the goal **344**.

(33) The resource configuration **350** may be a configuration of computing resources within the cloud network **105**. For example, the resource configuration **350** may configure a first instance **352** of a UPF service at a first datacenter **130** and a second instance **354** of a UPF service at a second datacenter **130**. In this example, the resource configuration **350** may allocate sufficient resources such that each instance handles at least 50% of the active target, but the resource allocation may vary based on the status of the resources. Accordingly, the ISM system **160** may configure computing resources to satisfy the active target. The ISM system **160** may report the active target and the configured resources to the network management function (e.g., the NFMF **240**) via the API **264**.

(34) In an aspect, the ISM system **160** may continue to monitor the status of the network resources and/or the performance of the configured NFs **250**. For instance, the ISM system **160** may determine that a higher prioritized goal of the intent expectation **330** (e.g., goal **342**) can be satisfied by the computing resources. The ISM system **160** may configure the computing resources (e.g., generate a new resource configuration **350**) to satisfy the higher prioritized goal **342**. The ISM system **160** may then report the higher prioritized goal **342** as the active target, for example, via the API **264**. Conversely, if the ISM system **160** detects a degradation of the computing resources, the ISM system **160** may select a lower prioritized goal **346** of the intent expectation **330** as the active target. The ISM system **160** may configure the computing resources to satisfy the lower prioritized goal **346** of the intent expectation **330** and report the lower prioritized goal **346** of the intent expectation **330** as the active target. Accordingly, the ISM system **160** may adjust the configuration of network resources to satisfy a selected prioritized goal without needing to receive an updated intent expectation **330** from the network management function.

(35) FIG. **4** is a schematic diagram of an example of a device **400** (e.g., a computing device) for network configuration. The device **400** may be an example of a computing resource **132** such as a server at a datacenter **130** that hosts the network management system **140** and/or the ISM system **160**. The device **400** is connected to other servers within the datacenter via a switch **422** and may be connected to servers at other datacenters.

(36) In an example, device **400** can include one or more processors **402** and/or memory **404** configured to execute or store instructions or other parameters related to providing an operating system **406**, which can execute one or more applications or processes, such as, but not limited to, at least one of a network management function **142** or an ISM system **160** including a variable intent component **170**. For example, processor **402** and memory **404** may be separate components communicatively coupled by a bus (e.g., on a motherboard or other portion of a computing device, on an integrated circuit, such as a system on a chip (SoC), etc.), components integrated within one another (e.g., processor **402** can include the memory **404** as an on-board component), and/or the like. Memory **404** may store instructions, parameters, data structures, etc. for use/execution by processor **402** to perform functions described herein.

(37) In an example, the network management system **140** may optionally include one or more network management functions **142** (e.g., CSMF **210**, NSMF **220**, NSSMF **230**, NFMF **240**, or NFs **250**), each network management function **142** including an intent interface **144** and an expectation generator **146**. The network management system **140** and/or a network management function **142** may optionally include a variable intent component **170** for satisfying an intent expectation received from a higher level network management function that includes prioritized goals.

(38) In an example, the ISM system **160** may include a variable intent component **170** that includes one or more of the expectation interface **162**, target selector **164**, configuration component **166**, or reporting component **168**. In some implementations, the ISM system **160** may optionally include one or more of the APIs **262**, **264**, or **266** for communication with one or more of the network management functions **142**. In some implementations, the expectation interface **162** may receive an intent expectation **330** via one of the APIs **262** or **264**, and the reporting component **168** may report an active target or configuration status via the one of the APIs **262** or **264**.
(39) FIG. **5** is a flow diagram of an example of a method **500** for network configuration based on an intent with prioritized goals. For example, the method **500** can be performed by a device **400** and/or one or more components thereof to instantiate one or more network functions **250** within a cloud network **105** to provide a network service. For instance, the method **500** may be performed by a device implementing any of an NSMF **220**, NSSMF **230**, NFMF **240**, ISM system **160**, or NF **250** that includes a variable intent component **170**.
(40) At block **510**, the method **500** may optionally include receiving an intent including requirements, goals, and constraints for a network. In an example, the intent interface **144** of a network management function **142**, e.g., in conjunction with processor **402**, memory **404**, and operating system **406**, can receive an intent **310** including requirements **312**, goals **314**, and constraints **316** for a network.
(41) At block **520**, the method **500** may optionally include generating an intent expectation including a set of prioritized goals based on the intent. In an example, the expectation generator **146** of the network management function **142**, e.g., in conjunction with processor **402**, memory **404**, and operating system **406**, can generate the intent expectation **330** including the set of prioritized goals **340** based on the intent **310**.
(42) At block **530**, the method **500** includes receiving an intent expectation including a set of prioritized goals from a network management function. In an example, the expectation interface **162** of the variable intent component **170**, e.g., in conjunction with processor **402**, memory **404**, and operating system **406**, can receive the intent expectation **330** including the set of prioritized goals **340** from a network management function **142**. In some implementations, at block **532** the block **530** may optionally include receiving the intent expectation via a separate API selected from a set of APIs (e.g., APIs **262** or **264**) for each of the NSSMF **230** or NFMF **240**.
(43) At block **540**, the method **500** includes selecting at least one of the prioritized goals as an active target. In an example, the target selector **164** of the variable intent component **170**, e.g., in conjunction with processor **402**, memory **404**, and operating system **406**, can select at least one of the prioritized goals **340** as an active target. In an aspect, the target selector **164** may select a highest prioritized goal of the prioritized goals that can be satisfied by a set of computing resources as the active target based on a comparison between a status of the computing resources to parameters for each of the prioritized goals. For example, in some implementations, at sub-block **542**, the block **540** may optionally include monitoring a status of the computing resources **122** (e.g., at datacenters **120**, **130**). For instance, the variable intent component **170** may include or communicate with the analysis system **180** or an MDAF **282**, **284**, **286** to monitor the status of the computing resources **122**. At sub-block **544**, the block **540** may optionally include comparing the status of the computing resources to parameters for each of the prioritized goals to select a highest prioritized goal that can be satisfied by the computing resources based on the status of the computing resources. In some implementations, at sub-block **546**, the block **540** may optionally include autonomously selecting the active target from the prioritized goals **340** without further input from the network management function **142** beyond the intent expectation **330**.
(44) At block **550**, the method **500** includes configuring computing resources to satisfy at least the active target. In an example, the configuration component **166** of the variable intent component **170**, e.g., in conjunction with processor **402**, memory **404**, and operating system **406**, can configure computing resources **122**, **132** (e.g., at datacenters **120**, **130**) to satisfy at least the active target. In

some implementations, at sub-block **552**, the configuration component **166** may issue an imperative (i.e., non-intent based) network configuration to the computing resources and/or the network function **250**. For instance, the NFMF **240** may issue a policy to one or more NFs **250** via the interface **242**. In some implementations, at sub-block **554**, the block **550** may include generating an intent expectation for a lower level network management function, infrastructure management service, or a network function. For instance, the NFMF **240** may issue the intent expectation **330** to the ISM system **160**.

(45) At block **560**, the method **500** reporting the active target and a configuration status to the network management function. In an example, the reporting component **168** of the variable intent component **170**, e.g., in conjunction with processor **402**, memory **404**, and operating system **406**, can report the active target and a configuration status to the network management function **142**. In some implementations, the reporting component **168** may report the active target and the configuration status via the respective API for the network management function (e.g., API **262**, **264**, or **266**).

(46) FIG. **6** is a flow diagram of an additional optional method **600** for maintaining an intent expectation including prioritized goals. For example, the method **600** can be performed after the method **500** by the device **400** and/or one or more components thereof (e.g., the variable intent component **170**) to modify an active target for the intent expectation **330**.

(47) At block **610**, the method **600** may include determining that a higher prioritized goal of the intent target expectation can be satisfied by the computing resources. For example, in some implementations, the variable intent component **170** may communicate with the analysis system **180** to determine that the higher prioritized goal (e.g., goal **342**) of the intent target expectation **330** can be satisfied by the computing resources **122**, **132**. At block **620**, the method **600** may include configuring the computing resources to satisfy the higher prioritized goal of the intent expectation. For example, the configuration component **166** may configure the computing resources **122**, **132** to satisfy the higher prioritized goal **342** of the intent expectation **330**. At block **630**, the method **600** may include reporting the higher prioritized goal of the intent expectation as the active target. For example, the reporting component **168** may report the higher prioritized goal **342** of the intent expectation **330** as the active target.

(48) FIG. **7** is a flow diagram of an additional optional method **700** for maintaining an intent expectation including prioritized goals. For example, the method **700** can be performed after the method **500** by the device **400** and/or one or more components thereof (e.g., the variable intent component **170**) to modify an active target for the intent expectation **330**.

(49) At block **710**, the method **700** may include detecting a degradation of the computing resources. For example, in some implementations, the variable intent component **170** may communicate with the analysis system **180** to detect a degradation of the computing resources **122**, **132**. At block **720**, the method **700** may include selecting a lower prioritized goal of the intent expectation as the active target. For example, the target selector **164** may select a lower prioritized goal (e.g., goal **346**) of the intent expectation **330** as the active target based on the status of the computing resources as determined by the analysis system **180**. At block **730**, the method **700** may include configuring the computing resources to satisfy the lower prioritized goal of the intent expectation. For example, the configuration component **166** may configure the computing resources **122**, **132** to satisfy the lower prioritized goal **346** of the intent expectation **330**. At block **740**, the method **700** may include reporting the lower prioritized goal of the intent expectation as the active target. For example, the reporting component **168** may report the lower prioritized goal **346** of the intent expectation **330** as the active target.

(50) FIG. **8** illustrates an example of a device **800** including additional optional component details as those shown in FIG. **4**. In one aspect, device **800** may include processor **802**, which may be similar to processor **402** for carrying out processing functions associated with one or more of components and functions described herein. Processor **802** can include a single or multiple set of

processors or multi-core processors. Moreover, processor **802** can be implemented as an integrated processing system and/or a distributed processing system.

(51) Device **800** may further include memory **804**, which may be similar to memory **404** such as for storing local versions of operating systems (or components thereof) and/or applications being executed by processor **802**, such as the network management system **140**, the ISM system **160**, etc. Memory **804** can include a type of memory usable by a computer, such as random access memory (RAM), read only memory (ROM), tapes, magnetic discs, optical discs, volatile memory, non-volatile memory, and any combination thereof.

(52) Further, device **800** may include a communications component **806** that provides for establishing and maintaining communications with one or more other devices, parties, entities, etc. utilizing hardware, software, and services as described herein. Communications component **806** may carry communications between components on device **800**, as well as between device **800** and external devices, such as devices located across a communications network and/or devices serially or locally connected to device **800**. For example, communications component **806** may include one or more buses, and may further include transmit chain components and receive chain components associated with a wireless or wired transmitter and receiver, respectively, operable for interfacing with external devices.

(53) Additionally, device **800** may include a data store **808**, which can be any suitable combination of hardware and/or software, that provides for mass storage of information, databases, and programs employed in connection with aspects described herein. For example, data store **808** may be or may include a data repository for operating systems (or components thereof), applications, related parameters, etc.) not currently being executed by processor **802**. In addition, data store **808** may be a data repository for network management system **140**, ISM system **160**, etc.

(54) Device **800** may optionally include a user interface component **810** operable to receive inputs from a user of device **800** and further operable to generate outputs for presentation to the user. User interface component **810** may include one or more input devices, including but not limited to a keyboard, a number pad, a mouse, a touch-sensitive display, a navigation key, a function key, a microphone, a voice recognition component, a gesture recognition component, a depth sensor, a gaze tracking sensor, a switch/button, any other mechanism capable of receiving an input from a user, or any combination thereof. Further, user interface component **810** may include one or more output devices, including but not limited to a display, a speaker, a haptic feedback mechanism, a printer, any other mechanism capable of presenting an output to a user, or any combination thereof.

(55) Device **800** may additionally include a network management system **140** for providing an intent expectation including prioritized goals, an ISM system **160** for configuring network resources based on the intent expectation, etc., as described herein.

(56) By way of example, an element, or any portion of an element, or any combination of elements may be implemented with a “processing system” that includes one or more processors. Examples of processors include microprocessors, microcontrollers, digital signal processors (DSPs), field programmable gate arrays (FPGAs), programmable logic devices (PLDs), state machines, gated logic, discrete hardware circuits, and other suitable hardware configured to perform the various functionality described throughout this disclosure. One or more processors in the processing system may execute software. Software shall be construed broadly to mean instructions, instruction sets, code, code segments, program code, programs, subprograms, software modules, applications, software applications, software packages, routines, subroutines, objects, executables, threads of execution, procedures, functions, etc., whether referred to as software, firmware, middleware, microcode, hardware description language, or otherwise.

(57) Accordingly, in one or more aspects, one or more of the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or encoded as one or more instructions or code on a computer-readable medium. Computer-readable media includes computer storage media. Non-

transitory computer-readable media excludes transitory signals. Storage media may be any available media that can be accessed by a computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium that can be used to carry or store desired program code in the form of instructions or data structures and that can be accessed by a computer. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), and floppy disk where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above should also be included within the scope of computer-readable media.

(58) The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. Various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but are to be accorded the full scope consistent with the claim language. Reference to an element in the singular is not intended to mean “one and only one” unless specifically so stated, but rather “one or more.” Unless specifically stated otherwise, the term “some” refers to one or more. All structural and functional equivalents to the elements of the various aspects described herein that are known or later come to be known to those of ordinary skill in the art are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed as a means plus function unless the element is expressly recited using the phrase “means for”.

Claims

1. A system for network configuration, comprising: a network management function configured to: receive an intent including requirements, goals, and constraints for a network; and generate an intent expectation including a set of prioritized goals based on the intent, each goal of the set of prioritized goals including a respective value for a same parameter as the other goals of the set of prioritized goals, wherein the network management function includes one or more of a network slice management function (NSMF), network slice subnet management function (NSSMF), or network function management function (NFMF); and an infrastructure service management (ISM) system, wherein the ISM system includes a separate application programming interface (API) for each of the NSSMF, the NFMF, and a network function (NF), wherein the ISM system is configured to: receive the intent expectation from the NSSMF via a first API or the NFMF via a second API, the received intent expectation including the set of prioritized goals based on the intent; select a highest prioritized goal of the set of prioritized goals that can be satisfied by a set of computing resources controlled by the ISM system as an active target based on a comparison between a status of the set of computing resources to the respective value of the parameter for each goal of the set of prioritized goals; configure the set of computing resources to satisfy at least the active target by sending an imperative configuration via a third interface to the network function; and report the active target and a configuration status to the network management function to the NSSMF via a first API or the NFMF via the second API.

2. The system of claim 1, wherein the ISM system is configured to: determine that a higher prioritized goal of the intent expectation can be satisfied by the set of computing resources; configure the set of computing resources to satisfy the higher prioritized goal of the intent expectation; and report the higher prioritized goal of the intent expectation as the active target.

3. The system of claim 1, wherein the ISM system is configured to: detect a degradation of the set of computing resources; select a lower prioritized goal of the intent expectation as the active target; configure the set of computing resources to satisfy the lower prioritized goal of the intent expectation; and report the lower prioritized goal of the intent expectation as the active target.

4. The system of claim 1, wherein the intent expectation is for a constituent of a network slice of a radio access network.
5. The system of claim 1, wherein the ISM system is configured to autonomously select the active target from the set of prioritized goals without further input from the network management function beyond the intent expectation.
6. A method of network configuration, comprising: receiving, at an infrastructure service management (ISM) system via an application programming interface (API), an intent expectation including a set of prioritized goals from a network management function, each goal of the set of prioritized goals including a respective value for a same parameter as the other goals of the set of prioritized goals, wherein the intent expectation is received from a network management function that includes one or more of a network slice management function (NSMF), a network slice subnet management function (NSSMF), or a network function management function (NFMF), wherein the ISM system includes a separate API for each of the NSSMF, the NFMF, and a network function (NF), and wherein the intent expectation is received from the NSSMF via a first API or the NFMF via a second API, the received intent expectation including the set of prioritized goals based on an intent at the network management function; selecting, at the ISM system, a highest prioritized goal of the set of prioritized goals that can be satisfied by a set of computing resources as an active target based on a comparison between a status of the set of computing resources to the respective value of the parameter for each goal of the set of prioritized goals; configuring the set of computing resources to satisfy at least the active target of the intent expectation by sending an imperative configuration via a third interface to the network function; and reporting the active target and a configuration status from the ISM system to the network management function to the NSSMF via a first API or the NFMF via the second API.
7. The method of claim 6, further comprising: determining that a higher prioritized goal of the intent expectation can be satisfied by the set of computing resources; configuring the set of computing resources to satisfy the higher prioritized goal of the intent expectation; and reporting the higher prioritized goal of the intent expectation as the active target.
8. The method of claim 6, further comprising: detecting a degradation of the set of computing resources; selecting a lower prioritized goal of the intent expectation as the active target; configuring the set of computing resources to satisfy the lower prioritized goal of the intent expectation; and reporting the lower prioritized goal of the intent expectation as the active target.
9. The method of claim 6, wherein the intent expectation is for a constituent of a network slice of a radio access network.
10. The method of claim 6, wherein selecting the highest prioritized goal of the set of prioritized goals as the active target comprises autonomously selecting the active target from the set of prioritized goals without further input from the network management function beyond the intent expectation.
11. The method of claim 6, further comprising, at a network management function: receiving an intent including requirements, goals, and constraints for a network; and generating the intent expectation including the set of prioritized goals based on the intent.
12. The method of claim 6, wherein configuring the set of computing resources to satisfy at least one of the set of prioritized goals of the intent expectation comprises generating an intent expectation for a lower level network management function, infrastructure management service, or a network function.
13. A non-transitory computer-readable medium storing computer executable instructions, that when executed by a processor, cause the processor to: receive, at an infrastructure service management (ISM) system via an application programming interface (API), an intent expectation including a set of prioritized goals from a network management function, each goal of the set of prioritized goals including a respective value for a same parameter as the other goals of the set of prioritized goals, wherein the intent expectation is received from a network management function

that includes one or more of a network slice management function (NSMF), a network slice subnet management function (NSSMF), or a network function management function (NFMF), wherein the ISM system includes a separate API for each of the NSSMF, the NFMF, and a network function (NF), and wherein the intent expectation is received from the NSSMF via a first API or the NFMF via a second API, the received intent expectation including the set of prioritized goals based on an intent at the network management function; select, at the ISM system, a highest prioritized goal of the set of prioritized goals that can be satisfied by a set of computing resources as an active target based on a comparison between a status of the set of computing resources to the respective value of the parameter for each goal of the set of prioritized goals; configure the set of computing resources to satisfy at least one of the set of prioritized goals of the intent expectation by sending an imperative configuration via a third interface to the network function; and report the active target and a configuration status from the ISM system to the network management function to the NSSMF via a first API or the NFMF via the second API.

14. The non-transitory computer-readable medium of claim 13, further comprising instructions to determine that a higher prioritized goal of the intent expectation can be satisfied by the set of computing resources; configure the set of computing resources to satisfy the higher prioritized goal of the intent expectation; and report the higher prioritized goal of the intent expectation as the active target.

15. The non-transitory computer-readable medium of claim 13, further comprising instructions to: detect a degradation of the set of computing resources; select a lower prioritized goal of the intent expectation as the active target; configure the set of computing resources to satisfy the lower prioritized goal of the intent expectation; and report the lower prioritized goal of the intent expectation as the active target.