



US 20210029557A1

(19) **United States**

(12) **Patent Application Publication**

Zeng et al.

(10) **Pub. No.: US 2021/0029557 A1**

(43) **Pub. Date: Jan. 28, 2021**

(54) **RADIO FREQUENCY DATABASE
AUTOMATION FOR 5G OR OTHER NEXT
GENERATION NETWORK**

(52) **U.S. Cl.**
CPC *H04W 24/02* (2013.01); *H04W 16/18*
(2013.01); *H04W 16/32* (2013.01)

(71) Applicant: **AT&T Intellectual Property I, L.P.**,
Atlanta, GA (US)

(57) **ABSTRACT**

(72) Inventors: **Helen Zeng**, Mountain View, CA (US);
Mario Kosseifi, Roswell, GA (US)

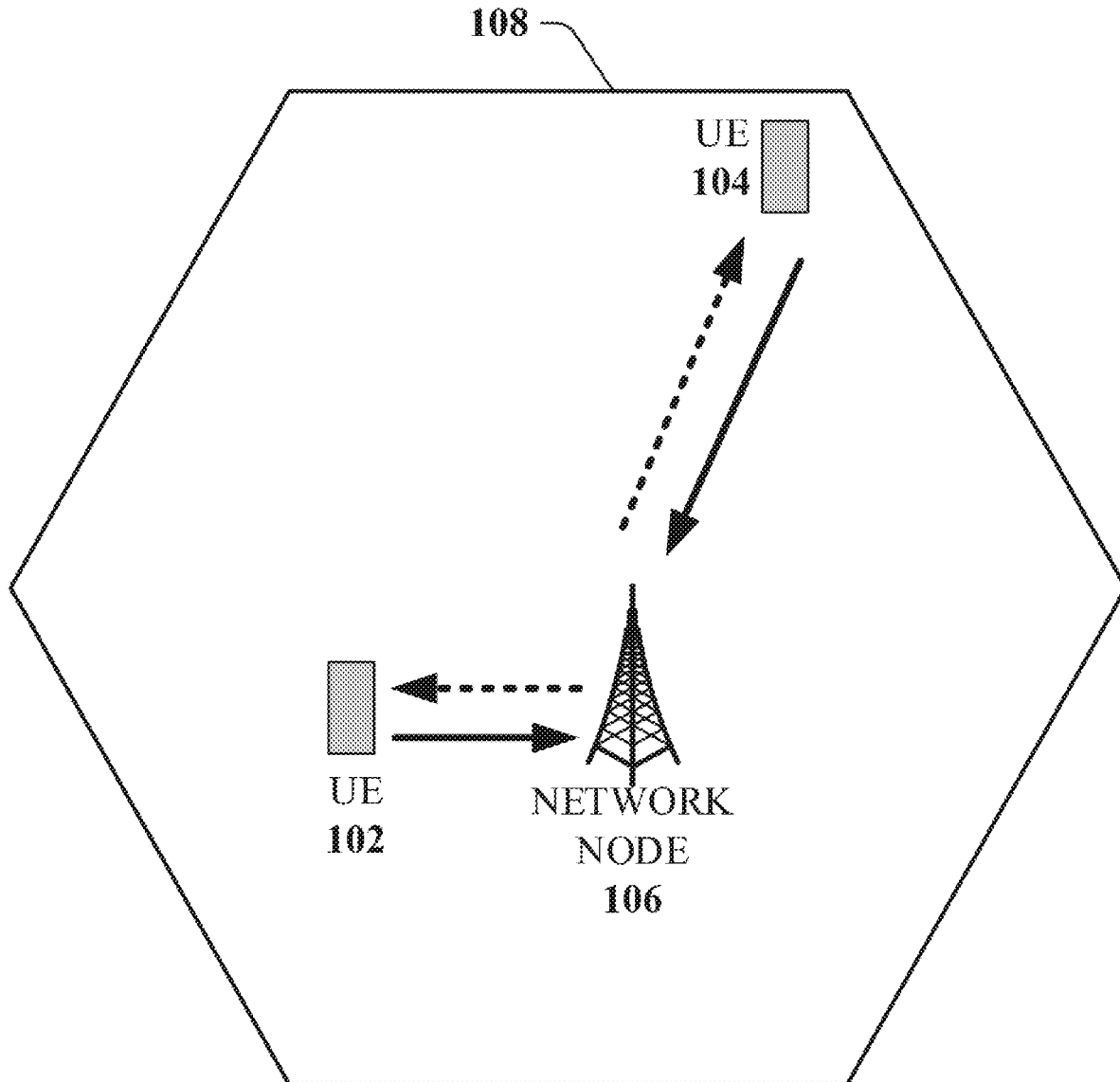
(21) Appl. No.: **16/523,058**

(22) Filed: **Jul. 26, 2019**

Publication Classification

(51) **Int. Cl.**
H04W 24/02 (2006.01)
H04W 16/32 (2006.01)
H04W 16/18 (2006.01)

By utilizing a database module, retrieving configuration management data related to network parameters can generate additional network efficiencies. The database module can be strategically placed to be utilized by various activities such as system network optimization, load balancing, network coverage, etc. The database module can also be utilized to automatically print out a radio frequency data sheet and utilized to perform network planning, generate updated sector information and import manually data that is currently procured manually.



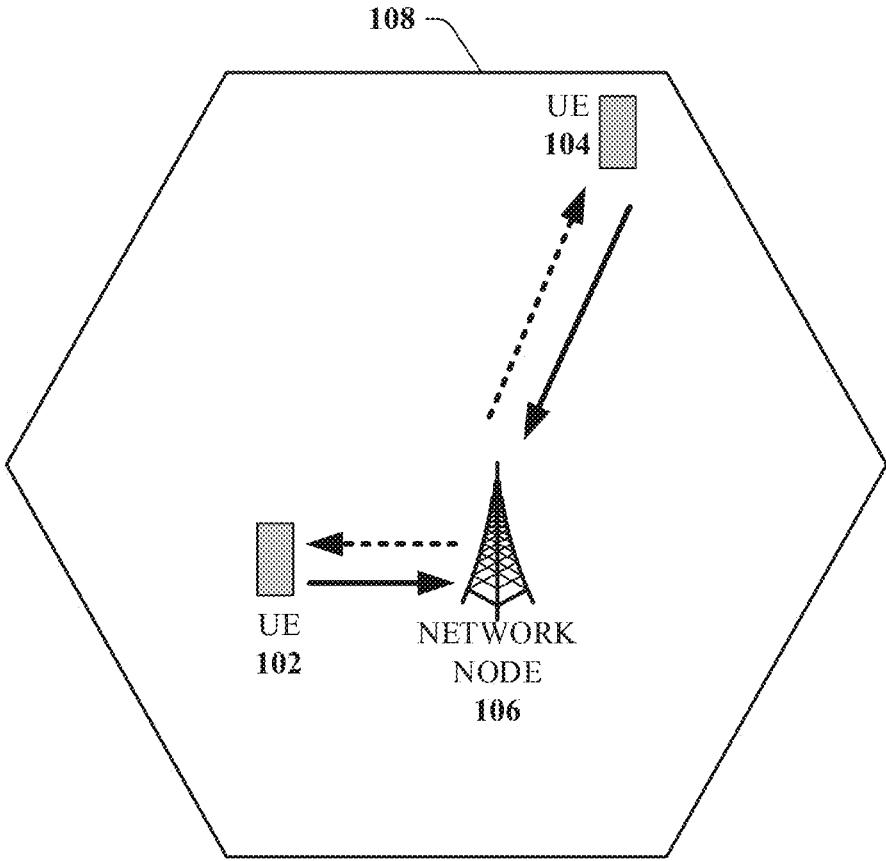


FIG. 1

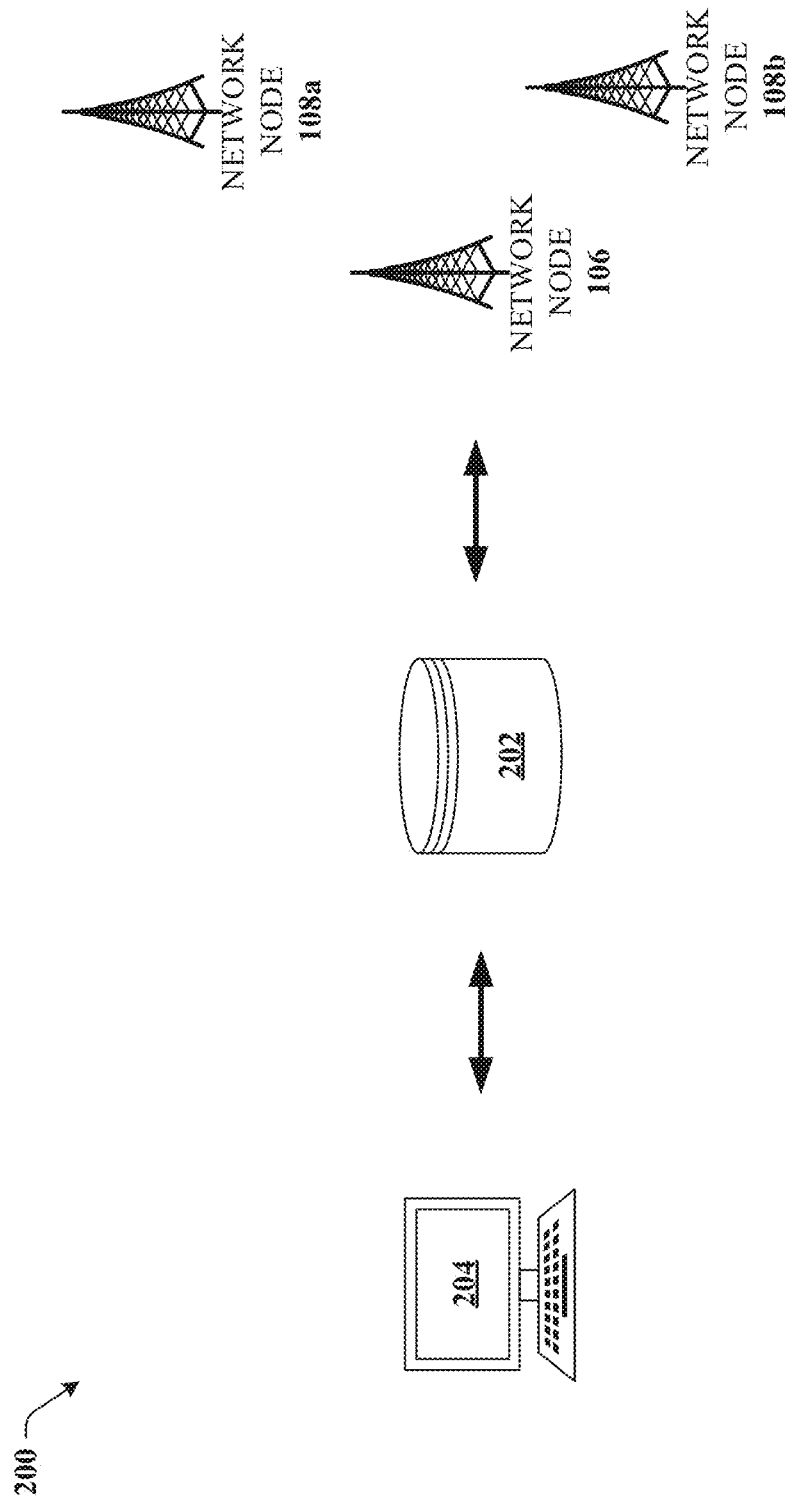


FIG. 2

300

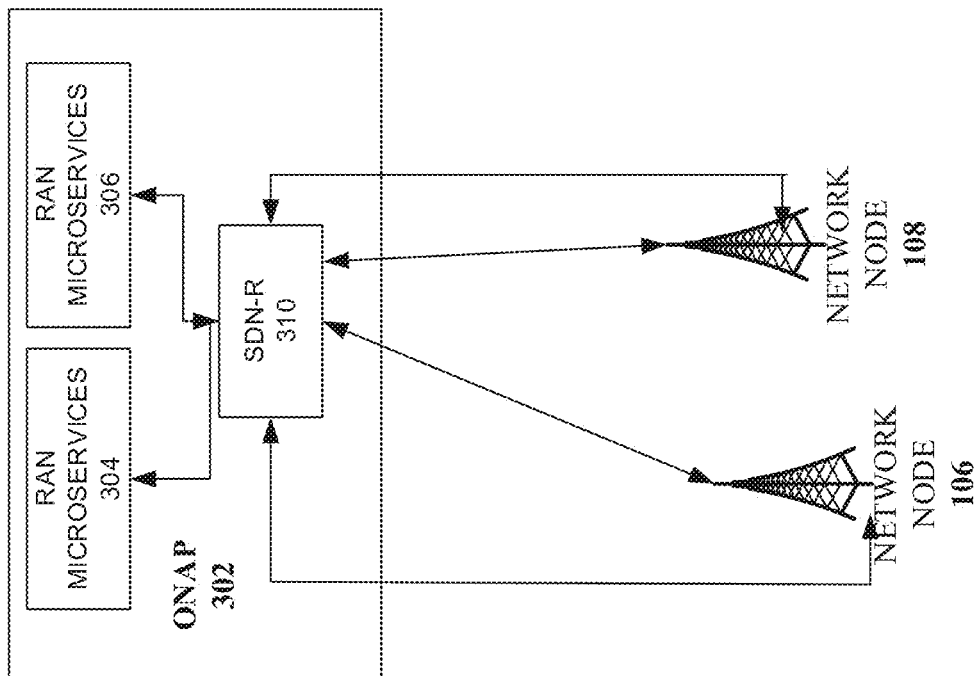


FIG. 3

400 →

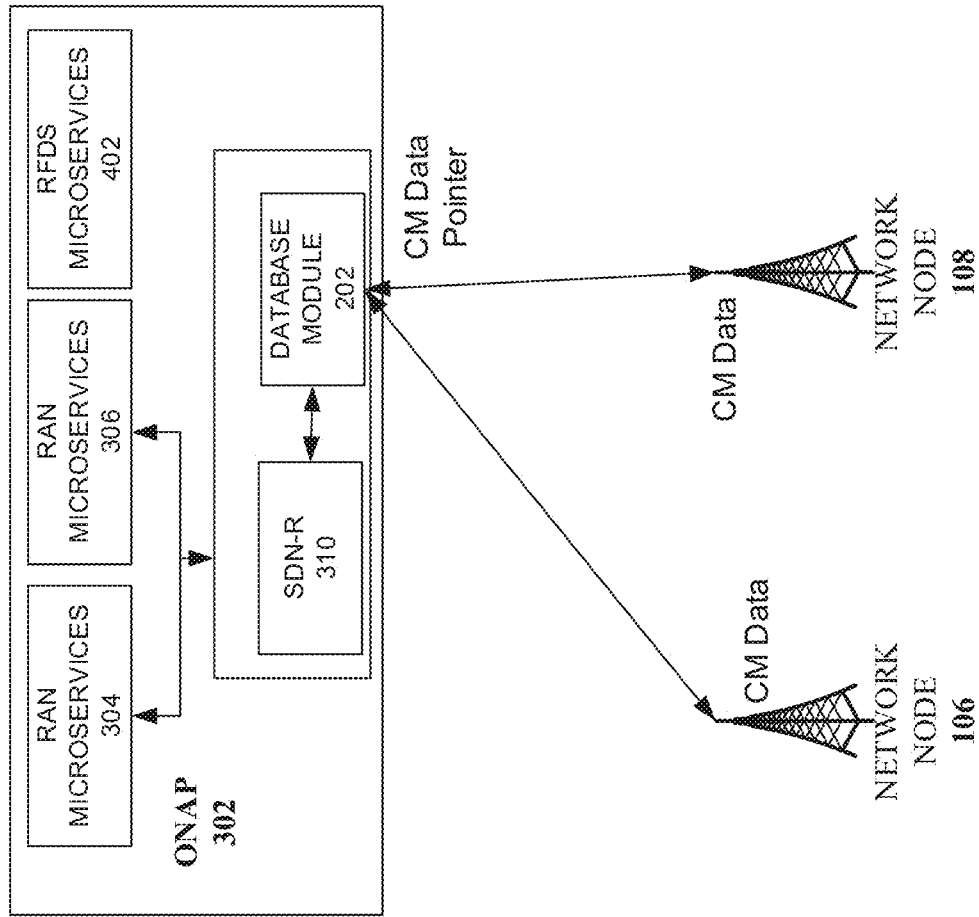


FIG. 4

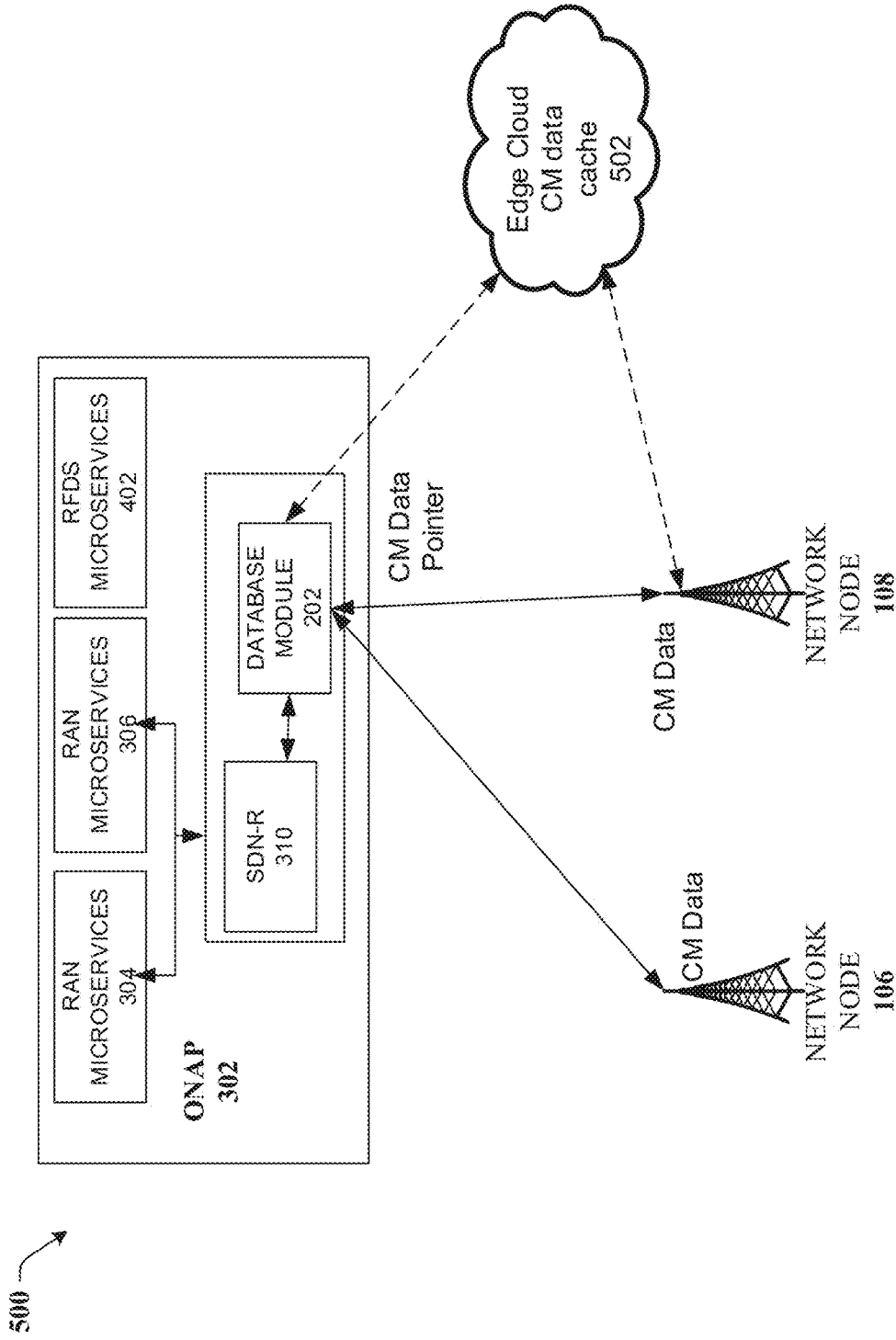


FIG. 5

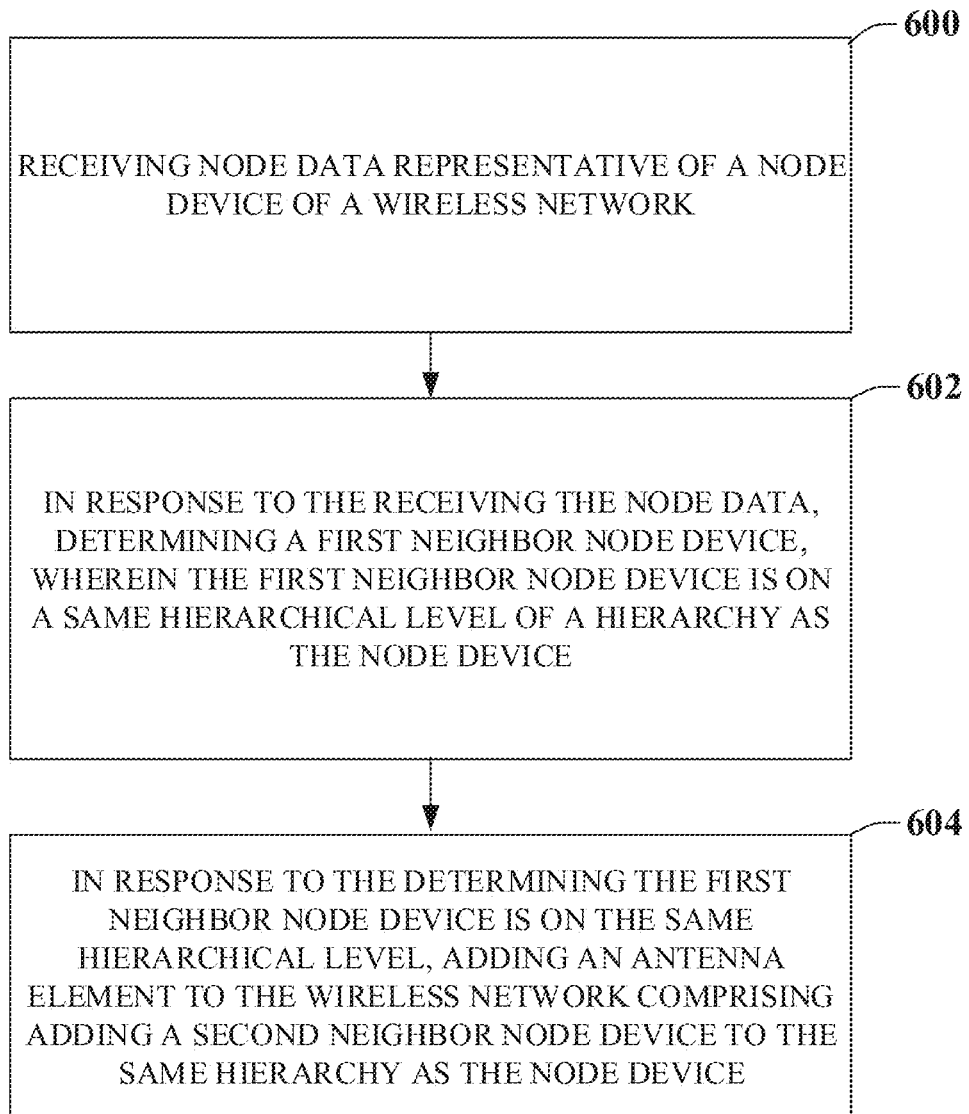
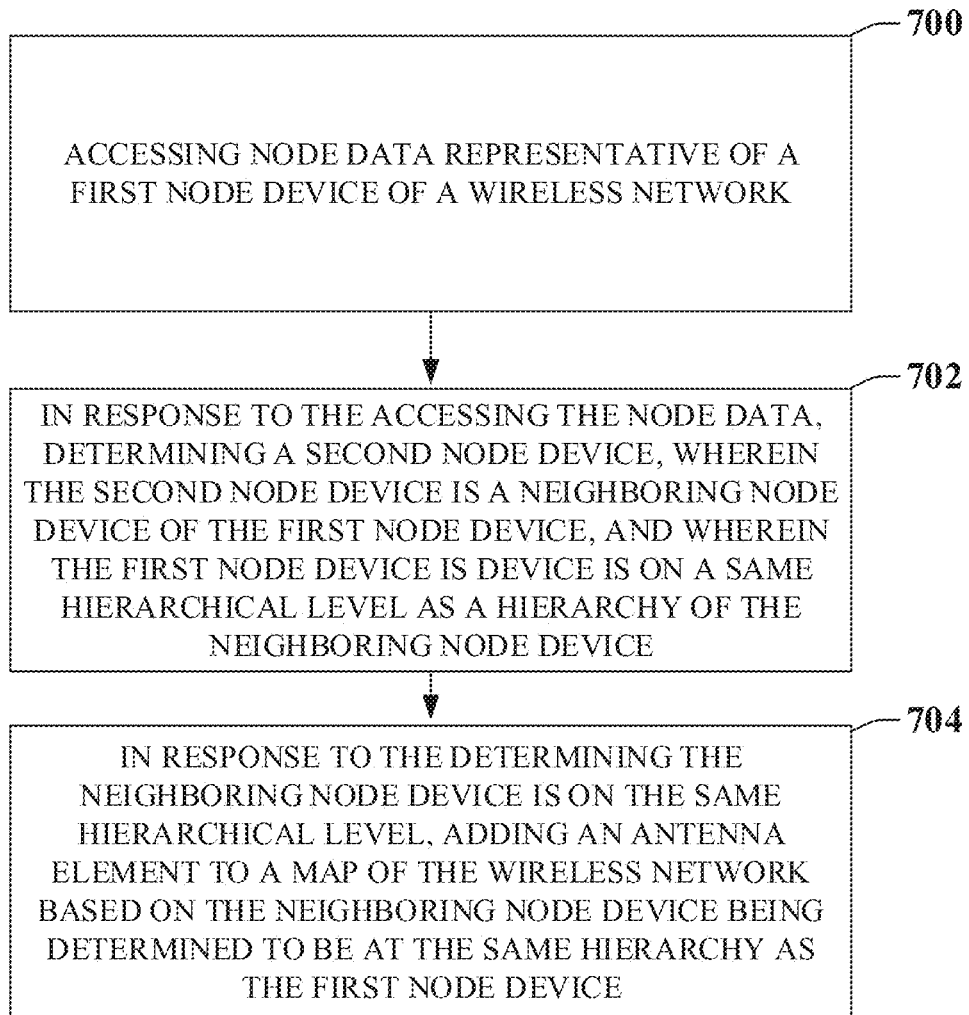


FIG. 6

**FIG. 7**

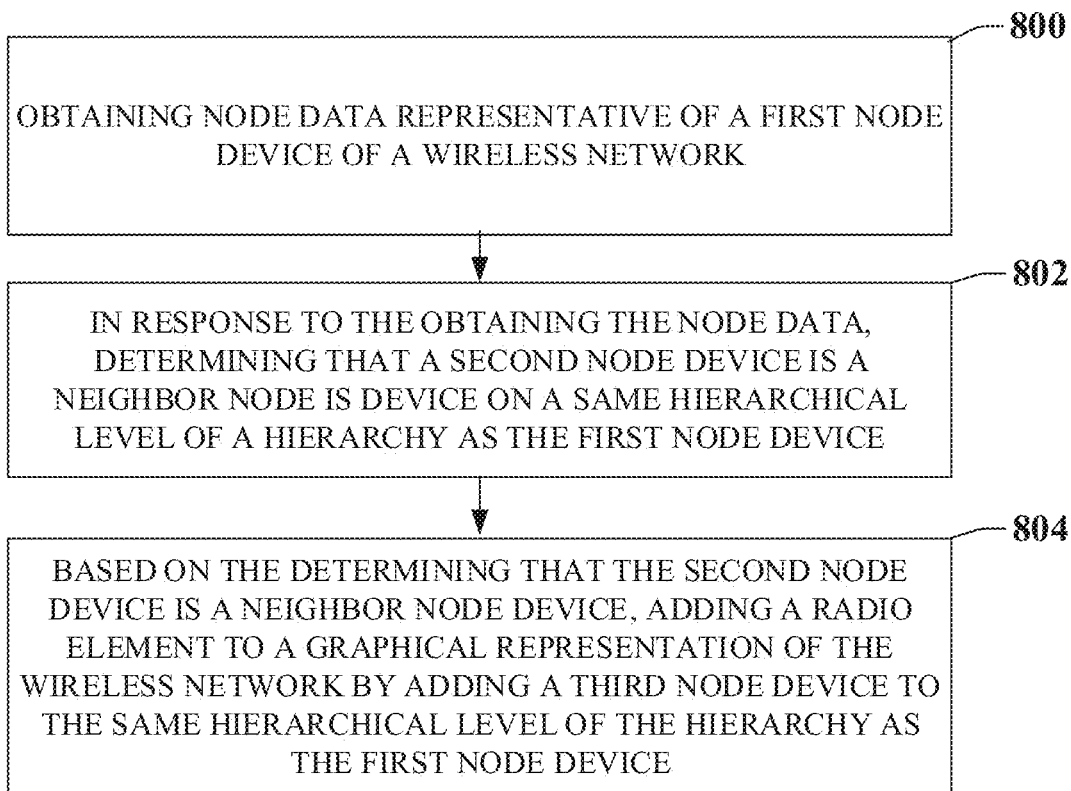


FIG. 8

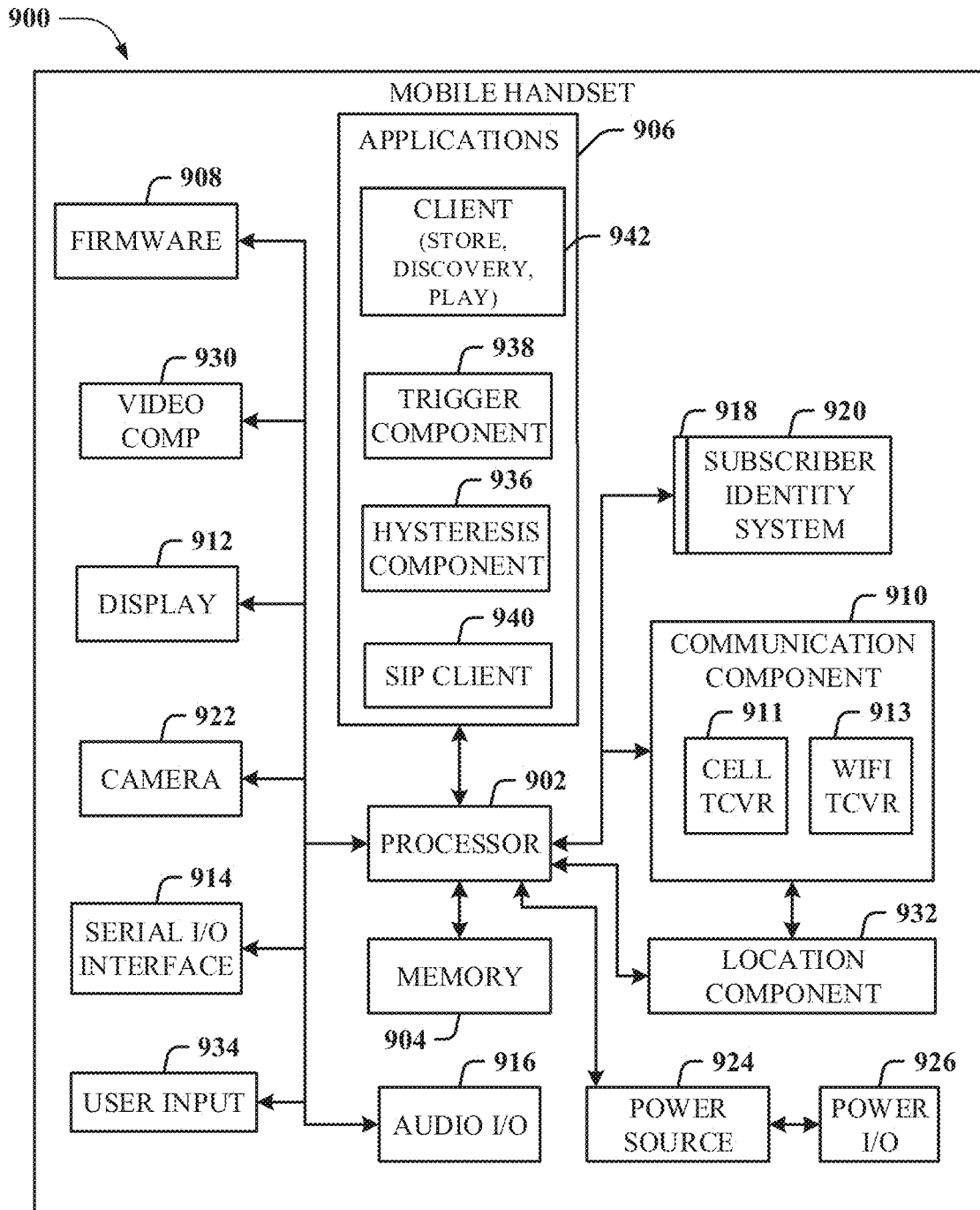


FIG. 9

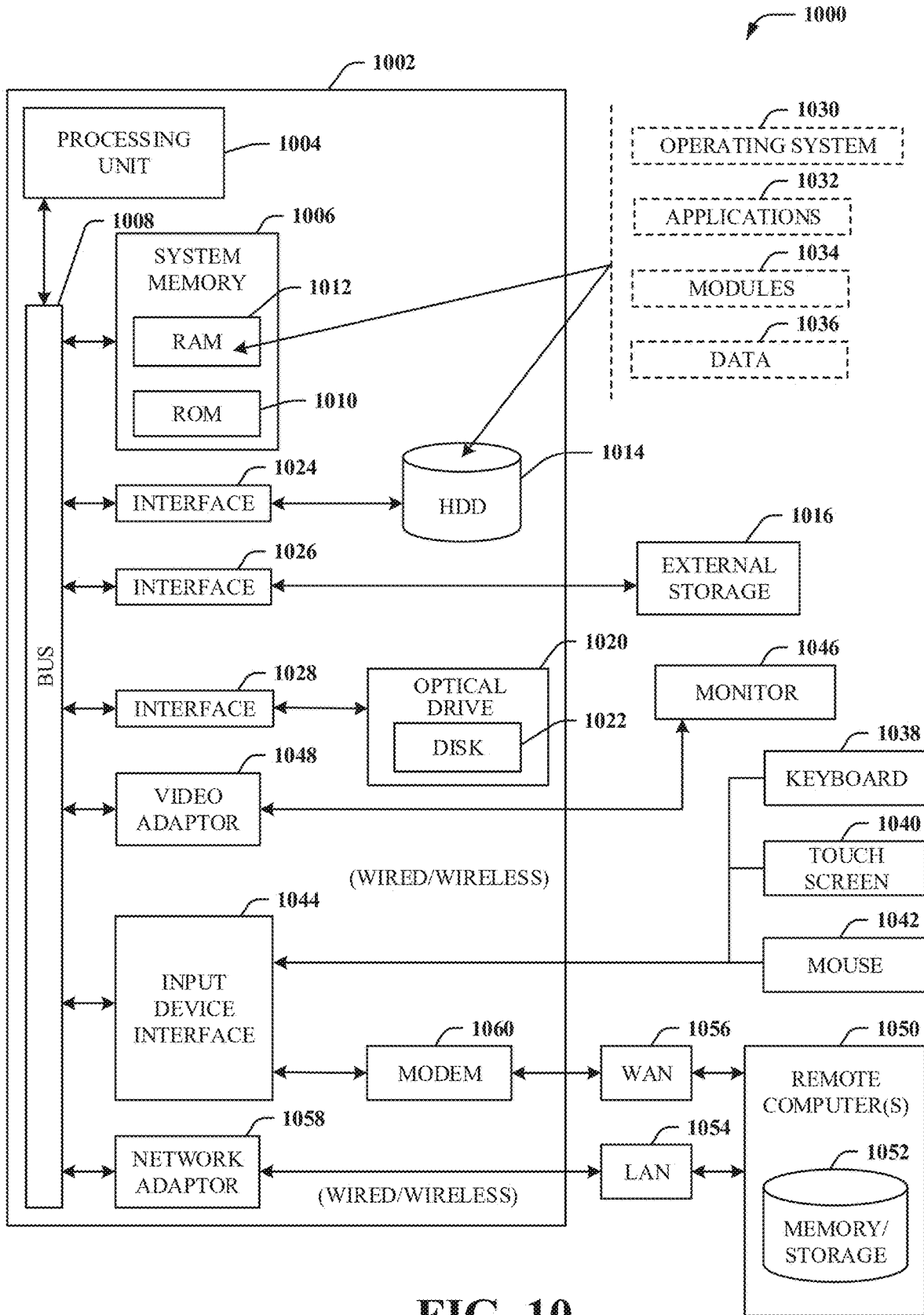


FIG. 10

RADIO FREQUENCY DATABASE AUTOMATION FOR 5G OR OTHER NEXT GENERATION NETWORK

TECHNICAL FIELD

[0001] This disclosure relates generally to facilitating radio frequency database automation. For example, this disclosure relates to facilitating radio frequency database automation for data retrieval and updates for a 5G, or other next generation network, air interface.

BACKGROUND

[0002] 5th generation (5G) wireless systems represent a next major phase of mobile telecommunications standards beyond the current telecommunications standards of 4th generation (4G). Rather than faster peak Internet connection speeds, 5G planning aims at higher capacity than current 4G, allowing a higher number of mobile broadband users per area unit, and allowing consumption of higher or unlimited data quantities. This would enable a large portion of the population to stream high-definition media many hours per day with their mobile devices, when out of reach of wireless fidelity hotspots. 5G research and development also aims at improved support of machine-to-machine communication, also known as the Internet of things, aiming at lower cost, lower battery consumption, and lower latency than 4G equipment.

[0003] The above-described background relating to a facilitating radio frequency database automation is merely intended to provide a contextual overview of some current issues, and is not intended to be exhaustive. Other contextual information may become further apparent upon review of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] Non-limiting and non-exhaustive embodiments of the subject disclosure are described with reference to the following figures, wherein like reference numerals refer to like parts throughout the various views unless otherwise specified.

[0005] FIG. 1 illustrates an example wireless communication system in which a network node device (e.g., network node) and user equipment (UE) can implement various aspects and embodiments of the subject disclosure.

[0006] FIG. 2 illustrates an example schematic system block diagram of a configuration management system according to one or more embodiments.

[0007] FIG. 3 illustrates an example schematic system block diagram of a radio software-defined network according to one or more embodiments.

[0008] FIG. 4 illustrates an example schematic system block diagram of a radio software-defined network comprising storing configuration management data at node devices according to one or more embodiments.

[0009] FIG. 5 illustrates an example schematic system block diagram of a radio software-defined network comprising caching configuration management data at an edge cloud according to one or more embodiments.

[0010] FIG. 6 illustrates an example flow diagram for a method for facilitating radio frequency database automation for a 5G network according to one or more embodiments.

[0011] FIG. 7 illustrates an example flow diagram for a system for facilitating radio frequency database automation for a 5G network according to one or more embodiments.

[0012] FIG. 8 illustrates an example flow diagram for a machine-readable medium for facilitating radio frequency database automation for a 5G network according to one or more embodiments.

[0013] FIG. 9 illustrates an example block diagram of an example mobile handset operable to engage in a system architecture that facilitates secure wireless communication according to one or more embodiments described herein.

[0014] FIG. 10 illustrates an example block diagram of an example computer operable to engage in a system architecture that facilitates secure wireless communication according to one or more embodiments described herein.

DETAILED DESCRIPTION

[0015] In the following description, numerous specific details are set forth to provide a thorough understanding of various embodiments. One skilled in the relevant art will recognize, however, that the techniques described herein can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring certain aspects.

[0016] Reference throughout this specification to “one embodiment,” or “an embodiment,” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrase “in one embodiment,” “in one aspect,” or “in an embodiment,” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments.

[0017] As utilized herein, terms “component,” “system,” “interface,” and the like are intended to refer to a computer-related entity, hardware, software (e.g., in execution), and/or firmware. For example, a component can be a processor, a process running on a processor, an object, an executable, a program, a storage device, and/or a computer. By way of illustration, an application running on a server and the server can be a component. One or more components can reside within a process, and a component can be localized on one computer and/or distributed between two or more computers.

[0018] Further, these components can execute from various machine-readable media having various data structures stored thereon. The components can communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network, e.g., the Internet, a local area network, a wide area network, etc. with other systems via the signal).

[0019] As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry; the electric or electronic circuitry can be operated by a software application or a firmware application executed by one or more processors; the one or more processors can be internal or external to the apparatus and can execute at least a part of the software or firmware application. As yet another example, a

component can be an apparatus that provides specific functionality through electronic components without mechanical parts; the electronic components can include one or more processors therein to execute software and/or firmware that confer(s), at least in part, the functionality of the electronic components. In an aspect, a component can emulate an electronic component via a virtual machine, e.g., within a cloud computing system.

[0020] The words “exemplary” and/or “demonstrative” are used herein to mean serving as an example, instance, or illustration. For the avoidance of doubt, the subject matter disclosed herein is not limited by such examples. In addition, any aspect or design described herein as “exemplary” and/or “demonstrative” is not necessarily to be construed as preferred or advantageous over other aspects or designs, nor is it meant to preclude equivalent exemplary structures and techniques known to those of ordinary skill in the art. Furthermore, to the extent that the terms “includes,” “has,” “contains,” and other similar words are used in either the detailed description or the claims, such terms are intended to be inclusive—in a manner similar to the term “comprising” as an open transition word—without precluding any additional or other elements.

[0021] As used herein, the term “infer” or “inference” refers generally to the process of reasoning about, or inferring states of, the system, environment, user, and/or intent from a set of observations as captured via events and/or data. Captured data and events can include user data, device data, environment data, data from sensors, sensor data, application data, implicit data, explicit data, etc. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states of interest based on a consideration of data and events, for example.

[0022] Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources. Various classification schemes and/or systems (e.g., support vector machines, neural networks, expert systems, Bayesian belief networks, fuzzy logic, and data fusion engines) can be employed in connection with performing automatic and/or inferred action in connection with the disclosed subject matter.

[0023] In addition, the disclosed subject matter can be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement the disclosed subject matter. The term “article of manufacture” as used herein is intended to encompass a computer program accessible from any computer-readable device, machine-readable device, computer-readable carrier, computer-readable media, or machine-readable media. For example, computer-readable media can include, but are not limited to, a magnetic storage device, e.g., hard disk; floppy disk; magnetic strip(s); an optical disk (e.g., compact disk (CD), a digital video disc (DVD), a Blu-ray Disc™ (BD)); a smart card; a flash memory device (e.g., card, stick, key drive); and/or a virtual device that emulates a storage device and/or any of the above computer-readable media.

[0024] As an overview, various embodiments are described herein to facilitate radio frequency database auto-

mation for a 5G air interface or other next generation networks. For simplicity of explanation, the methods (or algorithms) are depicted and described as a series of acts. It is to be understood and appreciated that the various embodiments are not limited by the acts illustrated and/or by the order of acts. For example, acts can occur in various orders and/or concurrently, and with other acts not presented or described herein. Furthermore, not all illustrated acts may be required to implement the methods. In addition, the methods could alternatively be represented as a series of interrelated states via a state diagram or events. Additionally, the methods described hereafter are capable of being stored on an article of manufacture (e.g., a machine-readable storage medium) to facilitate transporting and transferring such methodologies to computers. The term article of manufacture, as used herein, is intended to encompass a computer program accessible from any computer-readable device, carrier, or media, including a non-transitory machine-readable storage medium.

[0025] It should be noted that although various aspects and embodiments have been described herein in the context of 5G, Universal Mobile Telecommunications System (UMTS), and/or Long Term Evolution (LTE), or other next generation networks, the disclosed aspects are not limited to 5G, a UMTS implementation, and/or an LTE implementation as the techniques can also be applied in 3G, 4G or LTE systems. For example, aspects or features of the disclosed embodiments can be exploited in substantially any wireless communication technology. Such wireless communication technologies can include UMTS, Code Division Multiple Access (CDMA), Wi-Fi, Worldwide Interoperability for Microwave Access (WiMAX), General Packet Radio Service (GPRS), Enhanced GPRS, Third Generation Partnership Project (3GPP), LTE, Third Generation Partnership Project 2 (3GPP2) Ultra Mobile Broadband (UMB), High Speed Packet Access (HSPA), Evolved High Speed Packet Access (HSPA+), High-Speed Downlink Packet Access (HSDPA), High-Speed Uplink Packet Access (HSUPA), Zigbee, or another IEEE 802.XX technology. Additionally, substantially all aspects disclosed herein can be exploited in legacy telecommunication technologies.

[0026] Described herein are systems, methods, articles of manufacture, and other embodiments or implementations that can facilitate radio frequency database automation for a 5G network. Facilitating radio frequency database automation for a 5G network can be implemented in connection with any type of device with a connection to the communications network (e.g., a mobile handset, a computer, a handheld device, etc.) any Internet of things (IoT) device (e.g., toaster, coffee maker, blinds, music players, speakers, etc.), and/or any connected vehicles (cars, airplanes, space rockets, and/or other at least partially automated vehicles (e.g., drones)). In some embodiments the non-limiting term user equipment (UE) is used. It can refer to any type of wireless device that communicates with a radio network node in a cellular or mobile communication system. Examples of UE are target device, device to device (D2D) UE, machine type UE or UE capable of machine to machine (M2M) communication, PDA, Tablet, mobile terminals, smart phone, laptop embedded equipped (LEE), laptop mounted equipment (LME), USB dongles etc. Note that the terms element, elements and antenna ports can be interchangeably used but carry the same meaning in this disclosure. The embodiments are applicable to single carrier as

well as to multicarrier (MC) or carrier aggregation (CA) operation of the UE. The term carrier aggregation (CA) is also called (e.g. interchangeably called) “multi-carrier system”, “multi-cell operation”, “multi-carrier operation”, “multi-carrier” transmission and/or reception.

[0027] In some embodiments the non-limiting term radio network node or simply network node is used. It can refer to any type of network node that serves UE is connected to other network nodes or network elements or any radio node from where UE receives a signal. Examples of radio network nodes are Node B, base station (BS), multi-standard radio (MSR) node such as MSR BS, eNode B, network controller, radio network controller (RNC), base station controller (BSC), relay, donor node controlling relay, base transceiver station (BTS), access point (AP), transmission points, transmission nodes, RRU, RRH, nodes in distributed antenna system (DAS) etc.

[0028] Cloud radio access networks (RAN) can enable the implementation of concepts such as software-defined network (SDN) and network function virtualization (NFV) in 5G networks. This disclosure can facilitate a generic channel state information framework design for a 5G network. Certain embodiments of this disclosure can comprise an SDN controller that can control routing of traffic within the network and between the network and traffic destinations. The SDN controller can be merged with the 5G network architecture to enable service deliveries via open application programming interfaces (“APIs”) and move the network core towards an all internet protocol (“IP”), cloud based, and software driven telecommunications network. The SDN controller can work with, or take the place of policy and charging rules function (“PCRF”) network elements so that policies such as quality of service and traffic management and routing can be synchronized and managed end to end.

[0029] To meet the huge demand for data centric applications, 4G standards can be applied 5G, also called new radio (NR) access. 5G networks can comprise the following: data rates of several tens of megabits per second supported for tens of thousands of users; 1 gigabit per second can be offered simultaneously to tens of workers on the same office floor; several hundreds of thousands of simultaneous connections can be supported for massive sensor deployments; spectral efficiency can be enhanced compared to 4G; improved coverage; enhanced signaling efficiency; and reduced latency compared to LTE. In multicarrier system such as OFDM, each subcarrier can occupy bandwidth (e.g., subcarrier spacing). If the carriers use the same bandwidth spacing, then it can be considered a single numerology. However, if the carriers occupy different bandwidth and/or spacing, then it can be considered a multiple numerology.

[0030] Self-optimizing networks (SON) can automatically update parameters to increase performance. During updating of network algorithms, a system can check completion management parameters controlled by various service providers. The service provider identities can have specific data structures and/or storage space for such parameters. A graphic user interface (GUI) can be used to access these various databases such that when the SON algorithm needs to change a parameter, the GUI can lock into an information tree of the service identifiers to change the parameter.

[0031] The disclosed module can assist in retrieving configuration management data related to the parameters. The database module can be strategically placed to be utilized by various activities: SON features, scheduler (e.g., algorithm

at base station to schedule data, voice, and/or video calls), load balancing, coverage, energy saving, etc.). The activities can be hosted by a base station device and/or some other management system. Map visualizations can also utilize the database module to retrieve configuration management parameters and display/utilize a size of a cell, latitude, longitude, cellular capability, etc. The database module can be utilized to generate information needed and then automatically print out a radio frequency data sheet and/or import to an Atoll. The Atoll (a tool for doing radio network planning), which can be utilized to perform network planning, can utilize latitude, longitude, sector frequency, etc., to be updated when sector information is changed. By utilizing the database module, the Atoll information can import manually printed files.

[0032] Wireless network service providers can store their information within an information tree, which can increase access time. However, by using a hash table, where nodes are the same hierarchical level, the need to go through another node, to access data, can be eliminated. For example, after a node is accessed, a graphical representation can be used to access neighbor nodes: to add new antenna or radio elements to one node, a neighboring node with these capabilities can be added to the topology, and to delete an antenna or radio element, a neighbor node with these capabilities can be removed. Thus, whenever one node’s information is accessed, information of neighboring nodes can be shared.

[0033] Data structure attributes for a node, wherein a cell can be designed as a node, can comprise: identification data, location data, height data, azimuth data, type data (e.g., small cell, macro, in-building service (IBS)), generation data (e.g., 3G, LTE, 5G), market data, antenna model data, tilt data, band data, transmission power data, scheduler setting data, cell capability subscription data, blacklist data, whitelist data, and/or edge data). Data Structure attributes for an edge, which can represent the relationship between two cells can comprise: from node to node data, offset data, affiliation data (e.g., internal, external), and/or priority). These attributes can determine the relationships between the nodes used in the hash table.

[0034] Once a module is created, information for the module can be initialized by a setup, which can assign a variable for each parameter. Once the module is setup, when there is an update, another procedure call can specify which information shall be updated. For example, if a corresponding variable for a neighbor node needs to be updated, then the update procedure can facilitate this function. If there is a mismatch of neighbor information, then the database module can generate an error detection message. For example, if there is a mismatch in data from an engineer versus data pulled down from a service provider, then the database module can generate the error message.

[0035] To access service provider information via a radio software-defined network (SDNR), the database module can be placed within an open network platform (ONAP). By adding the database module to the ONAP, the system can facilitate additional radio frequency datasheet (RFDS) microservices at the ONAP also. There are two ways to store the data: Option 1: the data is still on the vendor side and a pointer/graph is provided to access the data more quickly, and Option 2: although the data is still on the vendor side,

a cache can be performed on edge cloud computing to store a temporary copy of the data instead of pulling the data from the vendor database again.

[0036] This disclosure comprises parts: 1) is storing of the data pointer with graphical representations in the SDN-R, 2) is automatically printing out the RFDS and Atoll data sheet, and; 3) is to propose caching in an edge cloud. With the graphical representation, the SON platform can immediately obtain a node's neighbor, then further retrieve neighbor cell's configuration data through a service provider database. Without the pointer, the SON platform needs to go through vendors' configuration information tree to get the neighbor relationship first, then further retrieve neighbor cell's configuration data. As the trend of mobile edge computing, the configuration data can be put in edge cloud. The foreseen advantage of using the data pointer is that some frequently accessed CM (configuration management) data can be placed in the edge cloud cache for quick access. The data pointer can retrieve the CM data from edge cloud cache, which is more efficient for real-time computing. Then the edge cloud can sync the data with service provider's database. Once the data pointer stored, the RFDS can be printed and Atoll database on demand, which changes the traditional way of human manual inputs using Excel.

[0037] The database module can be added in the SDN-R and store the network nodes (cells) in a hash table, and all nodes can be connected in a graphical data structure. When it is time to access each node, the neighbor information can be available via the graph. Once the neighbor information is known, then the service provider's database can be accessed to get the neighbor's CM data. There can also be a function update to update the CM data. The update can be triggered either by SON features or by regular update. With the graphical representation of the RF database, new radio elements can be added or removed by manipulating the graph neighbor list.

[0038] In one embodiment, described herein is a method comprising receiving, by a wireless network device comprising a processor, node data representative of a node device of a wireless network. In response to the receiving the node data, the method can comprise determining, by the wireless network device, a first neighbor node device, wherein the first neighbor node device is on a same hierarchical level of a hierarchy as the node device. Furthermore, in response to the determining the first neighbor node device is on the same hierarchical level, the method can comprise adding, by the wireless network device, an antenna element to the wireless network comprising adding a second neighbor node device to the same hierarchy as the node device.

[0039] According to another embodiment, a system can facilitate, accessing node data representative of a first node device of a wireless network. In response to the accessing the node data, the system can comprise determining a second node device, wherein the second node device is a neighboring node device of the first node device, and wherein the first node device is on a same hierarchical level as a hierarchy of the neighboring node device. Additionally, in response to the determining the neighboring node device is on the same hierarchical level, the system can comprise adding an antenna element to a map of the wireless network based on the neighboring node device being determined to be at the same hierarchy as the first node device.

[0040] According to yet another embodiment, described herein is a machine-readable storage medium that can per-

form the operations comprising obtaining node data representative of a first node device of a wireless network. In response to the obtaining the node data, the machine-readable storage medium can perform the operations comprising determining that a second node device is a neighbor node device on a same hierarchical level of a hierarchy as the first node device. Furthermore, based on the determining that the second node device is a neighbor node device, the machine-readable storage medium can perform the operations comprising adding a radio element to a graphical representation of the wireless network by adding a third node device to the same hierarchical level of the hierarchy as the first node device.

[0041] These and other embodiments or implementations are described in more detail below with reference to the drawings.

[0042] Referring now to FIG. 1, illustrated is an example wireless communication system 100 in accordance with various aspects and embodiments of the subject disclosure. In one or more embodiments, system 100 can comprise one or more user equipment UEs 102. The non-limiting term user equipment can refer to any type of device that can communicate with a network node in a cellular or mobile communication system. A UE can have one or more antenna panels having vertical and horizontal elements. Examples of a UE comprise a target device, device to device (D2D) UE, machine type UE or UE capable of machine to machine (M2M) communications, personal digital assistant (PDA), tablet, mobile terminals, smart phone, laptop mounted equipment (LME), universal serial bus (USB) dongles enabled for mobile communications, a computer having mobile capabilities, a mobile device such as cellular phone, a laptop having laptop embedded equipment (LEE, such as a mobile broadband adapter), a tablet computer having a mobile broadband adapter, a wearable device, a virtual reality (VR) device, a heads-up display (HUD) device, a smart car, a machine-type communication (MTC) device, and the like. User equipment UE 102 can also comprise IOT devices that communicate wirelessly.

[0043] In various embodiments, system 100 is or comprises a wireless communication network serviced by one or more wireless communication network providers. In example embodiments, a UE 102 can be communicatively coupled to the wireless communication network via a network node 104. The network node (e.g., network node device) can communicate with user equipment (UE), thus providing connectivity between the UE and the wider cellular network. The UE 102 can send transmission type recommendation data to the network node 104. The transmission type recommendation data can comprise a recommendation to transmit data via a closed loop MIMO mode and/or a rank-1 precoder mode.

[0044] A network node can have a cabinet and other protected enclosures, an antenna mast, and multiple antennas for performing various transmission operations (e.g., MIMO operations). Network nodes can serve several cells, also called sectors, depending on the configuration and type of antenna. In example embodiments, the UE 102 can send and/or receive communication data via a wireless link to the network node 104. The dashed arrow lines from the network node 104 to the UE 102 represent downlink (DL) communications and the solid arrow lines from the UE 102 to the network nodes 104 represent an uplink (UL) communication.

[0045] System **100** can further include one or more communication service provider networks **106** that facilitate providing wireless communication services to various UEs, including UE **102**, via the network node **104** and/or various additional network devices (not shown) included in the one or more communication service provider networks **106**. The one or more communication service provider networks **106** can include various types of disparate networks, including but not limited to: cellular networks, femto networks, picocell networks, microcell networks, internet protocol (IP) networks, Wi-Fi service networks, broadband service network, enterprise networks, cloud based networks, and the like. For example, in at least one implementation, system **100** can be or include a large scale wireless communication network that spans various geographic areas. According to this implementation, the one or more communication service provider networks **106** can be or include the wireless communication network and/or various additional devices and components of the wireless communication network (e.g., additional network devices and cell, additional UEs, network server devices, etc.). The network node **104** can be connected to the one or more communication service provider networks **106** via one or more backhaul links **110**. For example, the one or more backhaul links **110** can comprise wired link components, such as a T1/E1 phone line, a digital subscriber line (DSL) (e.g., either synchronous or asynchronous), an asymmetric DSL (ADSL), an optical fiber backbone, a coaxial cable, and the like. The one or more backhaul links **110** can also include wireless link components, such as but not limited to, line-of-sight (LOS) or non-LOS links which can include terrestrial air-interfaces or deep space links (e.g., satellite communication links for navigation).

[0046] Wireless communication system **100** can employ various cellular systems, technologies, and modulation modes to facilitate wireless radio communications between devices (e.g., the UE **102** and the network node **104**). While example embodiments might be described for 5G new radio (NR) systems, the embodiments can be applicable to any radio access technology (RAT) or multi-RAT system where the UE operates using multiple carriers e.g. LTE FDD/TDD, GSM/GERAN, CDMA2000 etc.

[0047] For example, system **100** can operate in accordance with global system for mobile communications (GSM), universal mobile telecommunications service (UMTS), long term evolution (LTE), LTE frequency division duplexing (LTE FDD, LTE time division duplexing (TDD), high speed packet access (HSPA), code division multiple access (CDMA), wideband CDMA (WCDMA), CDMA2000, time division multiple access (TDMA), frequency division multiple access (FDMA), multi-carrier code division multiple access (MC-CDMA), single-carrier code division multiple access (SC-CDMA), single-carrier FDMA (SC-FDMA), orthogonal frequency division multiplexing (OFDM), discrete Fourier transform spread OFDM (DFT-spread OFDM) single carrier FDMA (SC-FDMA), Filter bank based multi-carrier (FBMC), zero tail DFT-spread-OFDM (ZT DFT-s-OFDM), generalized frequency division multiplexing (GFDM), fixed mobile convergence (FMC), universal fixed mobile convergence (UFMC), unique word OFDM (UW-OFDM), unique word DFT-spread OFDM (UW DFT-Spread-OFDM), cyclic prefix OFDM CP-OFDM, resource-block-filtered OFDM, Wi Fi, WLAN, WiMax, and the like. However, various features and functionalities of system **100** are particularly described wherein the devices (e.g., the UEs

102 and the network device **104**) of system **100** are configured to communicate wireless signals using one or more multi carrier modulation schemes, wherein data symbols can be transmitted simultaneously over multiple frequency sub-carriers (e.g., OFDM, CP-OFDM, DFT-spread OFDM, UFMC, FMBC, etc.). The embodiments are applicable to single carrier as well as to multicarrier (MC) or carrier aggregation (CA) operation of the UE. The term carrier aggregation (CA) is also called (e.g. interchangeably called) “multi-carrier system”, “multi-cell operation”, “multi-carrier operation”, “multi-carrier” transmission and/or reception. Note that some embodiments are also applicable for Multi RAB (radio bearers) on some carriers (that is data plus speech is simultaneously scheduled).

[0048] In various embodiments, system **100** can be configured to provide and employ 5G wireless networking features and functionalities. 5G wireless communication networks are expected to fulfill the demand of exponentially increasing data traffic and to allow people and machines to enjoy gigabit data rates with virtually zero latency. Compared to 4G, 5G supports more diverse traffic scenarios. For example, in addition to the various types of data communication between conventional UEs (e.g., phones, smartphones, tablets, PCs, televisions, Internet enabled televisions, etc.) supported by 4G networks, 5G networks can be employed to support data communication between smart cars in association with driverless car environments, as well as machine type communications (MTCs). Considering the drastic different communication needs of these different traffic scenarios, the ability to dynamically configure waveform parameters based on traffic scenarios while retaining the benefits of multi carrier modulation schemes (e.g., OFDM and related schemes) can provide a significant contribution to the high speed/capacity and low latency demands of 5G networks. With waveforms that split the bandwidth into several sub-bands, different types of services can be accommodated in different sub-bands with the most suitable waveform and numerology, leading to an improved spectrum utilization for 5G networks.

[0049] To meet the demand for data centric applications, features of proposed 5G networks may comprise: increased peak bit rate (e.g., 20 Gbps), larger data volume per unit area (e.g., high system spectral efficiency—for example about 3.5 times that of spectral efficiency of long term evolution (LTE) systems), high capacity that allows more device connectivity both concurrently and instantaneously, lower battery/power consumption (which reduces energy and consumption costs), better connectivity regardless of the geographic region in which a user is located, a larger numbers of devices, lower infrastructural development costs, and higher reliability of the communications. Thus, 5G networks may allow for: data rates of several tens of megabits per second should be supported for tens of thousands of users, 1 gigabit per second to be offered simultaneously to tens of workers on the same office floor, for example; several hundreds of thousands of simultaneous connections to be supported for massive sensor deployments; improved coverage, enhanced signaling efficiency; reduced latency compared to LTE.

[0050] The upcoming 5G access network may utilize higher frequencies (e.g., >6 GHz) to aid in increasing capacity. Currently, much of the millimeter wave (mmWave) spectrum, the band of spectrum between 30 gigahertz (Ghz) and 300 Ghz is underutilized. The millimeter waves have shorter wavelengths that range from 10 millimeters to 1

millimeter, and these mmWave signals experience severe path loss, penetration loss, and fading. However, the shorter wavelength at mmWave frequencies also allows more antennas to be packed in the same physical dimension, which allows for large-scale spatial multiplexing and highly directional beamforming.

[0051] Performance can be improved if both the transmitter and the receiver are equipped with multiple antennas. Multi-antenna techniques can significantly increase the data rates and reliability of a wireless communication system. The use of multiple input multiple output (MIMO) techniques, which was introduced in the third-generation partnership project (3GPP) and has been in use (including with LTE), is a multi-antenna technique that can improve the spectral efficiency of transmissions, thereby significantly boosting the overall data carrying capacity of wireless systems. The use of multiple-input multiple-output (MIMO) techniques can improve mmWave communications, and has been widely recognized a potentially important component for access networks operating in higher frequencies. MIMO can be used for achieving diversity gain, spatial multiplexing gain and beamforming gain. For these reasons, MIMO systems are an important part of the 3rd and 4th generation wireless systems, and are planned for use in 5G systems.

[0052] Referring now to FIG. 2, illustrated is an example schematic system block diagram of a configuration management system 200 according to one or more embodiments.

[0053] Once a database module 202 is created, information for the database module 202 can be initialized by a setup function from a GUI 204, which can assign a variable for each parameter. For an eNB (e.g., network node 106) site level, this can comprise add/removing antenna elements and/or radio elements. Once the database module 202 is set up, when there is an update to be sent to the database module 202, another procedure call from the GUI 204 can specify which information shall be updated, which can be a regular update or triggered by a SON feature. For example, if a corresponding variable for a neighbor node (e.g., network node 108) needs to be updated, then the update procedure can facilitate this function. For an eNB site level, this can comprise adding/removing antenna elements and/or radio elements. If there is a mismatch of neighbor information, then the database module can generate an error detection message. For example, if there is a mismatch in data from an engineer versus data pulled down from a service provider, then the database module 202 can generate the error message. The system can also facilitate a print out: neighbors within XX number of hops, cells belonging to a market, macro cell's, macro cell neighbors, small cell neighbors, surrounding 5G cells within XX number of hops, external neighbors (belonging to a different site), etc.

[0054] Referring now to FIGS. 3 and 4, illustrated is an example schematic system block diagram of a radio software-defined network 300, 400 according to one or more embodiments.

[0055] Under normal operations, a radio software-defined network (SDNR) module 310, can be placed within an open network platform (ONAP) 302. However, by adding the database module 202 to the ONAP 302, the system can facilitate additional radio frequency data sheet (RFDS) microservices 402 at the ONAP 302 also. Thus, the GUI 204 can now be used to provide RAN microservices 304, 306 and RFDS microservices 402 to the network nodes 106, 108 via the SDN-R 310 and the database module 202. Specifi-

cally with regards to FIG. 4, the configuration management data can remain on the service provider side (e.g., network node 106, 108). However, a pointer/graph can be used by the database module 202 to provide access the data more quickly.

[0056] Referring now to FIG. 5 illustrates an example schematic system block diagram of a radio software-defined network 500 comprising caching configuration management data at an edge cloud according to one or more embodiments.

[0057] Conversely, as opposed to the pointer and/or graph depicted and discussed with regards to FIG. 4, FIG. 5 depicts that the system can facilitate the additional RFDS microservices 402 at the ONAP 302 by leveraging a cloud edge to cache data, although the data can still remain on the vendor side (e.g., network nodes 106, 108). Thus, a cache can be performed on edge cloud computing system 502 to store a temporary copy of the data, that is accessible by the database module 202, instead of pulling the data from the vendor database and/or network nodes 106, 108. Therefore, this can save processing time, allowing the system 500 to operate more efficiently.

[0058] Referring now to FIG. 6, illustrated is an example flow diagram for a method for facilitating radio frequency database automation for a 5G network according to one or more embodiments.

[0059] At element 600, a method can comprise receiving (e.g., via the database module 202) node data representative of a node device (e.g., network node 106) of a wireless network. In response to the receiving the node data, at element 602, the method can comprise determining (e.g., via the database module 202) a first neighbor node device (e.g., network node 108a), wherein the first neighbor node device is on a same hierarchical level of a hierarchy as the node device. Furthermore, in response to the determining the first neighbor node device (e.g., network node 108a) is on the same hierarchical level, the method can comprise adding (e.g., via the database module 202) an antenna element to the wireless network comprising adding a second neighbor node device (e.g., network node 108b) to the same hierarchy as the node device at element 604.

[0060] Referring now to FIG. 7, illustrated is an example flow diagram for a system for facilitating radio frequency database automation for a 5G network according to one or more embodiments.

[0061] At element 700, a system can facilitate, accessing (e.g., via the database module 202) node data representative of a first node device (e.g., network node 106) of a wireless network. In response to the accessing the node data, at element 702 the system can comprise determining (e.g., via the database module 202) a second node device (e.g., network node 108a), wherein the second node device is a neighboring node device of the first node device, and wherein the first node device is device is on a same hierarchical level as a hierarchy of the neighboring node device. Additionally, at element 704, in response to the determining the neighboring node device is on the same hierarchical level, the system can comprise adding (e.g., via the database module 202) an antenna element to a map of the wireless network based on the neighboring node device being determined to be at the same hierarchy as the first node device.

[0062] Referring now to FIG. 8, illustrated is an example flow diagram for a machine-readable medium for facilitating

radio frequency database automation for a 5G network according to one or more embodiments.

[0063] At element **800** the machine-readable storage medium can perform the operations comprising obtaining node data (e.g., via the database module **202**) representative of a first node device (e.g., network node **106**) of a wireless network. In response to the obtaining the node data, at element **802**, the machine-readable storage medium can perform the operations comprising determining (e.g., via the database module **202**) that a second node device (e.g., network node **108a**) is a neighbor node is device on a same hierarchical level of a hierarchy as the first node device (e.g., network node **106**). Furthermore, at element **804**, based on the determining that the second node device (e.g., network node **108a**) is a neighbor node device, the machine-readable storage medium can perform the operations comprising adding (e.g., via the database module **202**) a radio element to a graphical representation of the wireless network by adding a third node device (e.g., network node **108b**) to the same hierarchical level of the hierarchy as the first node device (e.g., network node **106**).

[0064] Referring now to FIG. 9, illustrated is an example block diagram of an example mobile handset **900** operable to engage in a system architecture that facilitates wireless communications according to one or more embodiments described herein. Although a mobile handset is illustrated herein, it will be understood that other devices can be a mobile device, and that the mobile handset is merely illustrated to provide context for the embodiments of the various embodiments described herein. The following discussion is intended to provide a brief, general description of an example of a suitable environment in which the various embodiments can be implemented. While the description includes a general context of computer-executable instructions embodied on a machine-readable storage medium, those skilled in the art will recognize that the innovation also can be implemented in combination with other program modules and/or as a combination of hardware and software.

[0065] Generally, applications (e.g., program modules) can include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the methods described herein can be practiced with other system configurations, including single-processor or multiprocessor systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

[0066] A computing device can typically include a variety of machine-readable media. Machine-readable media can be any available media that can be accessed by the computer and includes both volatile and non-volatile media, removable and non-removable media. By way of example and not limitation, computer-readable media can comprise computer storage media and communication media. Computer storage media can include volatile and/or non-volatile media, removable and/or non-removable media implemented in any method or technology for storage of information, such as computer-readable instructions, data structures, program modules, or other data. Computer storage media can include, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD ROM, digital video disk (DVD) or other optical disk storage, magnetic cassettes,

magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to store the desired information and which can be accessed by the computer.

[0067] Communication media typically embodies computer-readable instructions, data structures, program modules, or other data in a modulated data signal such as a carrier wave or other transport mechanism, and includes any information delivery media. The term “modulated data signal” means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media. Combinations of the any of the above should also be included within the scope of computer-readable media.

[0068] The handset includes a processor **902** for controlling and processing all onboard operations and functions. A memory **904** interfaces to the processor **902** for storage of data and one or more applications **906** (e.g., a video player software, user feedback component software, etc.). Other applications can include voice recognition of predetermined voice commands that facilitate initiation of the user feedback signals. The applications **906** can be stored in the memory **904** and/or in a firmware **908**, and executed by the processor **902** from either or both the memory **904** or/and the firmware **908**. The firmware **908** can also store startup code for execution in initializing the handset **900**. A communications component **910** interfaces to the processor **902** to facilitate wired/wireless communication with external systems, e.g., cellular networks, VoIP networks, and so on. Here, the communications component **910** can also include a suitable cellular transceiver **911** (e.g., a GSM transceiver) and/or an unlicensed transceiver **913** (e.g., Wi-Fi, WiMax) for corresponding signal communications. The handset **900** can be a device such as a cellular telephone, a PDA with mobile communications capabilities, and messaging-centric devices. The communications component **910** also facilitates communications reception from terrestrial radio networks (e.g., broadcast), digital satellite radio networks, and Internet-based radio services networks.

[0069] The handset **900** includes a display **912** for displaying text, images, video, telephony functions (e.g., a Caller ID function), setup functions, and for user input. For example, the display **912** can also be referred to as a “screen” that can accommodate the presentation of multimedia content (e.g., music metadata, messages, wallpaper, graphics, etc.). The display **912** can also display videos and can facilitate the generation, editing and sharing of video quotes. A serial I/O interface **914** is provided in communication with the processor **902** to facilitate wired and/or wireless serial communications (e.g., USB, and/or IEEE 1394) through a hardwire connection, and other serial input devices (e.g., a keyboard, keypad, and mouse). This can support updating and troubleshooting the handset **900**, for example. Audio capabilities are provided with an audio I/O component **916**, which can include a speaker for the output of audio signals related to, for example, indication that the user pressed the proper key or key combination to initiate the user feedback signal. The audio I/O component **916** also facilitates the input of audio signals through a microphone to record data and/or telephony voice data, and for inputting voice signals for telephone conversations.

[0070] The handset 900 can include a slot interface 918 for accommodating a SIC (Subscriber Identity Component) in the form factor of a card Subscriber Identity Module (SIM) or universal SIM 920, and interfacing the SIM card 920 with the processor 902. However, it is to be appreciated that the SIM card 920 can be manufactured into the handset 900, and updated by downloading data and software.

[0071] The handset 900 can process IP data traffic through the communications component 910 to accommodate IP traffic from an IP network such as, for example, the Internet, a corporate intranet, a home network, a person area network, etc., through an ISP or broadband cable provider. Thus, VoIP traffic can be utilized by the handset 900 and IP-based multimedia content can be received in either an encoded or decoded format.

[0072] A video processing component 922 (e.g., a camera) can be provided for decoding encoded multimedia content. The video processing component 922 can aid in facilitating the generation, editing, and sharing of video quotes. The handset 900 also includes a power source 924 in the form of batteries and/or an AC power subsystem, which power source 924 can interface to an external power system or charging equipment (not shown) by a power I/O component 926.

[0073] The handset 900 can also include a video component 930 for processing video content received and, for recording and transmitting video content. For example, the video component 930 can facilitate the generation, editing and sharing of video quotes. A location tracking component 932 facilitates geographically locating the handset 900. As described hereinabove, this can occur when the user initiates the feedback signal automatically or manually. A user input component 934 facilitates the user initiating the quality feedback signal. The user input component 934 can also facilitate the generation, editing and sharing of video quotes. The user input component 934 can include such conventional input device technologies such as a keypad, keyboard, mouse, stylus pen, and/or touchscreen, for example.

[0074] Referring again to the applications 906, a hysteresis component 936 facilitates the analysis and processing of hysteresis data, which is utilized to determine when to associate with the access point. A software trigger component 938 can be provided that facilitates triggering of the hysteresis component 936 when the Wi-Fi transceiver 913 detects the beacon of the access point. A SIP client 940 enables the handset 900 to support SIP protocols and register the subscriber with the SIP registrar server. The applications 906 can also include a client 942 that provides at least the capability of discovery, play and store of multimedia content, for example, music.

[0075] The handset 900, as indicated above related to the communications component 910, includes an indoor network radio transceiver 913 (e.g., Wi-Fi transceiver). This function supports the indoor radio link, such as IEEE 802.11, for the dual-mode GSM handset 900. The handset 900 can accommodate at least satellite radio services through a handset that can combine wireless voice and digital radio chipsets into a single handheld device.

[0076] Referring now to FIG. 10, illustrated is an example block diagram of an example computer 1000 operable to engage in a system architecture that facilitates wireless communications according to one or more embodiments described herein. The computer 1000 can provide networking and communication capabilities between a wired or

wireless communication network and a server (e.g., Microsoft server) and/or communication device. In order to provide additional context for various aspects thereof, FIG. 10 and the following discussion are intended to provide a brief, general description of a suitable computing environment in which the various aspects of the innovation can be implemented to facilitate the establishment of a transaction between an entity and a third party. While the description above is in the general context of computer-executable instructions that can run on one or more computers, those skilled in the art will recognize that the innovation also can be implemented in combination with other program modules and/or as a combination of hardware and software.

[0077] Generally, program modules include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the methods can be practiced with other computer system configurations, including single-processor or multiprocessor computer systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

[0078] The illustrated aspects of the innovation can also be practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

[0079] Computing devices typically include a variety of media, which can include computer-readable storage media or communications media, which two terms are used herein differently from one another as follows.

[0080] Computer-readable storage media can be any available storage media that can be accessed by the computer and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable instructions, program modules, structured data, or unstructured data. Computer-readable storage media can include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or other tangible and/or non-transitory media which can be used to store desired information. Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

[0081] Communications media can embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and includes any information delivery or transport media. The term "modulated data signal" or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media include wired media,

such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

[0082] In order to provide additional context for various embodiments described herein, FIG. 10 and the following discussion are intended to provide a brief, general description of a suitable computing environment 1000 in which the various embodiments of the embodiment described herein can be implemented. While the embodiments have been described above in the general context of computer-executable instructions that can run on one or more computers, those skilled in the art will recognize that the embodiments can be also implemented in combination with other program modules and/or as a combination of hardware and software.

[0083] Generally, program modules include routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the methods can be practiced with other computer system configurations, including single-processor or multiprocessor computer systems, minicomputers, mainframe computers, Internet of Things (IoT) devices, distributed computing systems, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

[0084] The illustrated embodiments of the embodiments herein can be also practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

[0085] Computing devices typically include a variety of media, which can include computer-readable storage media, machine-readable storage media, and/or communications media, which two terms are used herein differently from one another as follows. Computer-readable storage media or machine-readable storage media can be any available storage media that can be accessed by the computer and includes both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media or machine-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable or machine-readable instructions, program modules, structured data or unstructured data.

[0086] Computer-readable storage media can include, but are not limited to, random access memory (RAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM), flash memory or other memory technology, compact disk read only memory (CD-ROM), digital versatile disk (DVD), Blu-ray disc (BD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, solid state drives or other solid state storage devices, or other tangible and/or non-transitory media which can be used to store desired information. In this regard, the terms “tangible” or “non-transitory” herein as applied to storage, memory or computer-readable media, are to be understood to exclude only propagating transitory signals per se as modifiers and do not relinquish rights to all standard storage, memory or computer-readable media that are not only propagating transitory signals per se.

[0087] Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

[0088] Communications media typically embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and includes any information delivery or transport media. The term “modulated data signal” or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media include wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

[0089] With reference again to FIG. 10, the example environment 1000 for implementing various embodiments of the aspects described herein includes a computer 1002, the computer 1002 including a processing unit 1004, a system memory 1006 and a system bus 1008. The system bus 1008 couples system components including, but not limited to, the system memory 1006 to the processing unit 1004. The processing unit 1004 can be any of various commercially available processors. Dual microprocessors and other multi-processor architectures can also be employed as the processing unit 1004.

[0090] The system bus 1008 can be any of several types of bus structure that can further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and a local bus using any of a variety of commercially available bus architectures. The system memory 1006 includes ROM 1010 and RAM 1012. A basic input/output system (BIOS) can be stored in a non-volatile memory such as ROM, erasable programmable read only memory (EPROM), EEPROM, which BIOS contains the basic routines that help to transfer information between elements within the computer 1002, such as during startup. The RAM 1012 can also include a high-speed RAM such as static RAM for caching data.

[0091] The computer 1002 further includes an internal hard disk drive (HDD) 1014 (e.g., EIDE, SATA), one or more external storage devices 1016 (e.g., a magnetic floppy disk drive (FDD) 1016, a memory stick or flash drive reader, a memory card reader, etc.) and an optical disk drive 1020 (e.g., which can read or write from a CD-ROM disc, a DVD, a BD, etc.). While the internal HDD 1014 is illustrated as located within the computer 1002, the internal HDD 1014 can also be configured for external use in a suitable chassis (not shown). Additionally, while not shown in environment 1000, a solid state drive (SSD) could be used in addition to, or in place of, an HDD 1014. The HDD 1014, external storage device(s) 1016 and optical disk drive 1020 can be connected to the system bus 1008 by an HDD interface 1024, an external storage interface 1026 and an optical drive interface 1028, respectively. The interface 1024 for external drive implementations can include at least one or both of Universal Serial Bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394 interface technologies. Other external drive connection technologies are within contemplation of the embodiments described herein.

[0092] The drives and their associated computer-readable storage media provide nonvolatile storage of data, data structures, computer-executable instructions, and so forth. For the computer 1002, the drives and storage media accommodate the storage of any data in a suitable digital format. Although the description of computer-readable storage media above refers to respective types of storage devices, it should be appreciated by those skilled in the art that other types of storage media which are readable by a computer, whether presently existing or developed in the future, could also be used in the example operating environment, and further, that any such storage media can contain computer-executable instructions for performing the methods described herein.

[0093] A number of program modules can be stored in the drives and RAM 1012, including an operating system 1030, one or more application programs 1032, other program modules 1034 and program data 1036. All or portions of the operating system, applications, modules, and/or data can also be cached in the RAM 1012. The systems and methods described herein can be implemented utilizing various commercially available operating systems or combinations of operating systems.

[0094] Computer 1002 can optionally comprise emulation technologies. For example, a hypervisor (not shown) or other intermediary can emulate a hardware environment for operating system 1030, and the emulated hardware can optionally be different from the hardware illustrated in FIG. 10. In such an embodiment, operating system 1030 can comprise one virtual machine (VM) of multiple VMs hosted at computer 1002. Furthermore, operating system 1030 can provide runtime environments, such as the Java runtime environment or the .NET framework, for applications 1032. Runtime environments are consistent execution environments that allow applications 1032 to run on any operating system that includes the runtime environment. Similarly, operating system 1030 can support containers, and applications 1032 can be in the form of containers, which are lightweight, standalone, executable packages of software that include, e.g., code, runtime, system tools, system libraries and settings for an application.

[0095] Further, computer 1002 can be enable with a security module, such as a trusted processing module (TPM). For instance with a TPM, boot components hash next in time boot components, and wait for a match of results to secured values, before loading a next boot component. This process can take place at any layer in the code execution stack of computer 1002, e.g., applied at the application execution level or at the operating system (OS) kernel level, thereby enabling security at any level of code execution.

[0096] A user can enter commands and information into the computer 1002 through one or more wired/wireless input devices, e.g., a keyboard 1038, a touch screen 1040, and a pointing device, such as a mouse 1042. Other input devices (not shown) can include a microphone, an infrared (IR) remote control, a radio frequency (RF) remote control, or other remote control, a joystick, a virtual reality controller and/or virtual reality headset, a game pad, a stylus pen, an image input device, e.g., camera(s), a gesture sensor input device, a vision movement sensor input device, an emotion or facial detection device, a biometric input device, e.g., fingerprint or iris scanner, or the like. These and other input devices are often connected to the processing unit 1004 through an input device interface 1044 that can be coupled

to the system bus 1008, but can be connected by other interfaces, such as a parallel port, an IEEE 1394 serial port, a game port, a USB port, an IR interface, a BLUETOOTH® interface, etc.

[0097] A monitor 1046 or other type of display device can be also connected to the system bus 1008 via an interface, such as a video adapter 1048. In addition to the monitor 1046, a computer typically includes other peripheral output devices (not shown), such as speakers, printers, etc.

[0098] The computer 1002 can operate in a networked environment using logical connections via wired and/or wireless communications to one or more remote computers, such as a remote computer(s) 1050. The remote computer(s) 1050 can be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment appliance, a peer device or other common network node, and typically includes many or all of the elements described relative to the computer 1002, although, for purposes of brevity, only a memory/storage device 1052 is illustrated. The logical connections depicted include wired/wireless connectivity to a local area network (LAN) 1054 and/or larger networks, e.g., a wide area network (WAN) 1056. Such LAN and WAN networking environments are commonplace in offices and companies, and facilitate enterprise-wide computer networks, such as intranets, all of which can connect to a global communications network, e.g., the Internet.

[0099] When used in a LAN networking environment, the computer 1002 can be connected to the local network 1054 through a wired and/or wireless communication network interface or adapter 1058. The adapter 1058 can facilitate wired or wireless communication to the LAN 1054, which can also include a wireless access point (AP) disposed thereon for communicating with the adapter 1058 in a wireless mode.

[0100] When used in a WAN networking environment, the computer 1002 can include a modem 1060 or can be connected to a communications server on the WAN 1056 via other means for establishing communications over the WAN 1056, such as by way of the Internet. The modem 1060, which can be internal or external and a wired or wireless device, can be connected to the system bus 1008 via the input device interface 1044. In a networked environment, program modules depicted relative to the computer 1002 or portions thereof, can be stored in the remote memory/storage device 1052. It will be appreciated that the network connections shown are example and other means of establishing a communications link between the computers can be used.

[0101] When used in either a LAN or WAN networking environment, the computer 1002 can access cloud storage systems or other network-based storage systems in addition to, or in place of, external storage devices 1016 as described above. Generally, a connection between the computer 1002 and a cloud storage system can be established over a LAN 1054 or WAN 1056 e.g., by the adapter 1058 or modem 1060, respectively. Upon connecting the computer 1002 to an associated cloud storage system, the external storage interface 1026 can, with the aid of the adapter 1058 and/or modem 1060, manage storage provided by the cloud storage system as it would other types of external storage. For instance, the external storage interface 1026 can be configured to provide access to cloud storage sources as if those sources were physically connected to the computer 1002.

[0102] The computer **1002** can be operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, store shelf, etc.), and telephone. This can include Wireless Fidelity (Wi-Fi) and BLUETOOTH® wireless technologies. Thus, the communication can be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

[0103] The computer is operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, restroom), and telephone. This includes at least Wi-Fi and Bluetooth™ wireless technologies. Thus, the communication can be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

[0104] Wi-Fi, or Wireless Fidelity, allows connection to the Internet from a couch at home, in a hotel room, or a conference room at work, without wires. Wi-Fi is a wireless technology similar to that used in a cell phone that enables such devices, e.g., computers, to send and receive data indoors and out; anywhere within the range of a base station. Wi-Fi networks use radio technologies called IEEE 802.11 (a, b, g, etc.) to provide secure, reliable, fast wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which use IEEE 802.3 or Ethernet). Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands, at an 7 Mbps (802.11a) or 54 Mbps (802.11b) data rate, for example, or with products that contain both bands (dual band), so the networks can provide real-world performance similar to the basic 16BaseT wired Ethernet networks used in many offices.

[0105] An aspect of 5G, which differentiates from previous 4G systems, is the use of NR. NR architecture can be designed to support multiple deployment cases for independent configuration of resources used for RACH procedures. Since the NR can provide additional services than those provided by LTE, efficiencies can be generated by leveraging the pros and cons of LTE and NR to facilitate the interplay between LTE and NR, as discussed herein.

[0106] Reference throughout this specification to “one embodiment,” or “an embodiment,” means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, the appearances of the phrase “in one embodiment,” “in one aspect,” or “in an embodiment,” in various places throughout this specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics can be combined in any suitable manner in one or more embodiments.

[0107] As used in this disclosure, in some embodiments, the terms “component,” “system,” “interface,” and the like are intended to refer to, or comprise, a computer-related entity or an entity related to an operational apparatus with one or more specific functionalities, wherein the entity can be either hardware, a combination of hardware and software, software, or software in execution, and/or firmware. As an

example, a component can be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, computer-executable instructions, a program, and/or a computer. By way of illustration and not limitation, both an application running on a server and the server can be a component.

[0108] One or more components can reside within a process and/or thread of execution and a component can be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components can communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems via the signal). As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry, which is operated by a software application or firmware application executed by one or more processors, wherein the processor can be internal or external to the apparatus and can execute at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts, the electronic components can comprise a processor therein to execute software or firmware that confer(s) at least in part the functionality of the electronic components. In an aspect, a component can emulate an electronic component via a virtual machine, e.g., within a cloud computing system. While various components have been illustrated as separate components, it will be appreciated that multiple components can be implemented as a single component, or a single component can be implemented as multiple components, without departing from example embodiments.

[0109] In addition, the words “example” and “exemplary” are used herein to mean serving as an instance or illustration. Any embodiment or design described herein as “example” or “exemplary” is not necessarily to be construed as preferred or advantageous over other embodiments or designs. Rather, use of the word example or exemplary is intended to present concepts in a concrete fashion. As used in this application, the term “or” is intended to mean an inclusive “or” rather than an exclusive “or.” That is, unless specified otherwise or clear from context, “X employs A or B” is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then “X employs A or B” is satisfied under any of the foregoing instances. In addition, the articles “a” and “an” as used in this application and the appended claims should generally be construed to mean “one or more” unless specified otherwise or clear from context to be directed to a singular form.

[0110] Moreover, terms such as “mobile device equipment,” “mobile station,” “mobile,” “subscriber station,” “access terminal,” “terminal,” “handset,” “communication device,” “mobile device” (and/or terms representing similar terminology) can refer to a wireless device utilized by a subscriber or mobile device of a wireless communication service to receive or convey data, control, voice, video, sound, gaming or substantially any data-stream or signaling-stream. The foregoing terms are utilized interchangeably

herein and with reference to the related drawings. Likewise, the terms “access point (AP),” “Base Station (BS),” BS transceiver, BS device, cell site, cell site device, “Node B (NB),” “evolved Node B (eNode B),” “home Node B (HNB)” and the like, are utilized interchangeably in the application, and refer to a wireless network component or appliance that transmits and/or receives data, control, voice, video, sound, gaming or substantially any data-stream or signaling-stream from one or more subscriber stations. Data and signaling streams can be packetized or frame-based flows.

[0111] Furthermore, the terms “device,” “communication device,” “mobile device,” “subscriber,” “customer entity,” “consumer,” “customer entity,” “entity” and the like are employed interchangeably throughout, unless context warrants particular distinctions among the terms. It should be appreciated that such terms can refer to human entities or automated components supported through artificial intelligence (e.g., a capacity to make inference based on complex mathematical formalisms), which can provide simulated vision, sound recognition and so forth.

[0112] Embodiments described herein can be exploited in substantially any wireless communication technology, comprising, but not limited to, wireless fidelity (Wi-Fi), global system for mobile communications (GSM), universal mobile telecommunications system (UMTS), worldwide interoperability for microwave access (WiMAX), enhanced general packet radio service (enhanced GPRS), third generation partnership project (3GPP) long term evolution (LTE), third generation partnership project 2 (3GPP2) ultra mobile broadband (UMB), high speed packet access (HSPA), Z-Wave, Zigbee and other 802.xx wireless technologies and/or legacy telecommunication technologies.

[0113] The various aspects described herein can relate to New Radio (NR), which can be deployed as a standalone radio access technology or as a non-standalone radio access technology assisted by another radio access technology, such as Long Term Evolution (LTE), for example. It should be noted that although various aspects and embodiments have been described herein in the context of 5G, Universal Mobile Telecommunications System (UMTS), and/or Long Term Evolution (LTE), or other next generation networks, the disclosed aspects are not limited to 5G, a UMTS implementation, and/or an LTE implementation as the techniques can also be applied in 3G, 4G, or LTE systems. For example, aspects or features of the disclosed embodiments can be exploited in substantially any wireless communication technology. Such wireless communication technologies can include UMTS, Code Division Multiple Access (CDMA), Wi-Fi, Worldwide Interoperability for Microwave Access (WiMAX), General Packet Radio Service (GPRS), Enhanced GPRS, Third Generation Partnership Project (3GPP), LTE, Third Generation Partnership Project 2 (3GPP2) Ultra Mobile Broadband (UMB), High Speed Packet Access (HSPA), Evolved High Speed Packet Access (HSPA+), High-Speed Downlink Packet Access (HSDPA), High-Speed Uplink Packet Access (HSUPA), Zigbee, or another IEEE 802.xx technology. Additionally, substantially all aspects disclosed herein can be exploited in legacy telecommunication technologies.

[0114] As used herein, the term “infer” or “inference” refers generally to the process of reasoning about, or inferring states of, the system, environment, user, and/or intent from a set of observations as captured via events and/or data.

Captured data and events can include user data, device data, environment data, data from sensors, sensor data, application data, implicit data, explicit data, etc. Inference can be employed to identify a specific context or action, or can generate a probability distribution over states of interest based on a consideration of data and events, for example.

[0115] Inference can also refer to techniques employed for composing higher-level events from a set of events and/or data. Such inference results in the construction of new events or actions from a set of observed events and/or stored event data, whether the events are correlated in close temporal proximity, and whether the events and data come from one or several event and data sources. Various classification procedures and/or systems (e.g., support vector machines, neural networks, expert systems, Bayesian belief networks, fuzzy logic, and data fusion engines) can be employed in connection with performing automatic and/or inferred action in connection with the disclosed subject matter.

[0116] In addition, the various embodiments can be implemented as a method, apparatus, or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware, or any combination thereof to control a computer to implement the disclosed subject matter. The term “article of manufacture” as used herein is intended to encompass a computer program accessible from any computer-readable device, machine-readable device, computer-readable carrier, computer-readable media, machine-readable media, computer-readable (or machine-readable) storage/communication media. For example, computer-readable media can comprise, but are not limited to, a magnetic storage device, e.g., hard disk; floppy disk; magnetic strip(s); an optical disk (e.g., compact disk (CD), a digital video disc (DVD), a Blu-ray Disc™ (BD)); a smart card; a flash memory device (e.g., card, stick, key drive); and/or a virtual device that emulates a storage device and/or any of the above computer-readable media. Of course, those skilled in the art will recognize many modifications can be made to this configuration without departing from the scope or spirit of the various embodiments.

[0117] The above description of illustrated embodiments of the subject disclosure, including what is described in the Abstract, is not intended to be exhaustive or to limit the disclosed embodiments to the precise forms disclosed. While specific embodiments and examples are described herein for illustrative purposes, various modifications are possible that are considered within the scope of such embodiments and examples, as those skilled in the relevant art can recognize.

[0118] In this regard, while the subject matter has been described herein in connection with various embodiments and corresponding figures, where applicable, it is to be understood that other similar embodiments can be used or modifications and additions can be made to the described embodiments for performing the same, similar, alternative, or substitute function of the disclosed subject matter without deviating therefrom. Therefore, the disclosed subject matter should not be limited to any single embodiment described herein, but rather should be construed in breadth and scope in accordance with the appended claims below.

What is claimed is:

1. A method, comprising:

receiving, by a wireless network device comprising a processor, node data representative of a node device of a wireless network;

- in response to the receiving the node data, determining, by the wireless network device, a first neighbor node device, wherein the first neighbor node device is on a same hierarchical level of a hierarchy as the node device; and
- in response to the determining the first neighbor node device is on the same hierarchical level, adding, by the wireless network device, an antenna element to the wireless network comprising adding a second neighbor node device to the same hierarchy as the node device.
2. The method of claim 1, wherein the node data is first node data, and further comprising:
- storing, by the wireless network device, the first node data and second node data representative of the second neighbor node in a hash table.
3. The method of claim 2, further comprising:
- removing, by the wireless network device, a neighbor node relationship between the node device and the first neighbor node device to delete a radio element from the wireless network.
4. The method of claim 1, further comprising:
- adding, by the wireless network device, a radio element to the wireless network by the adding the second neighbor node device to the same hierarchical level as the node device.
5. The method of claim 1, further comprising:
- receiving, by the wireless network device, scheduler data representative of a scheduler update to facilitate a scheduled data transmission.
6. The method of claim 5, further comprising:
- in response to the adding the second neighbor node device, modifying, by the wireless network device, the scheduler data in accordance with a functionality provided by the second neighbor node device, resulting in modified scheduler data.
7. The method of claim 6, further comprising:
- in response to the modifying the scheduler data, sending, by the wireless network device, the modified scheduler data to a base station device.
8. A system, comprising:
- a processor; and
- a memory that stores executable instructions that, when executed by the processor, facilitate performance of operations, comprising:
- accessing node data representative of a first node device of a wireless network;
- in response to the accessing the node data, determining a second node device, wherein the second node device is a neighboring node device of the first node device, and wherein the first node device is device is on a same hierarchical level as a hierarchy of the neighboring node device; and
- in response to the determining the neighboring node device is on the same hierarchical level, adding an antenna element to a map of the wireless network based on the neighboring node device being determined to be at the same hierarchy as the first node device.
9. The system of claim 8, wherein the operations further comprise:
- comparing a first data set received from a service provider identity to a second data set received from a network device.
10. The system of claim 9, wherein the comparing the first data set to the second data set results in a data mismatch.
11. The system of claim 10, wherein the operations further comprise:
- based on the data mismatch, generating an error message associated with the data mismatch.
12. The system of claim 11, wherein the network device is a first network device, and wherein the operations further comprise:
- in response to the generating the error message, sending the error message to a second network device.
13. The system of claim 8, wherein a determination of the same hierarchical level is based on an attribute of the neighboring node device.
14. The system of claim 13, wherein the attribute of the neighboring node device is a location of the neighboring node device in relation to the first node device.
15. A machine-readable storage medium, comprising executable instructions that, when executed by a processor, facilitate performance of operations, comprising:
- obtaining node data representative of a first node device of a wireless network;
- in response to the obtaining the node data, determining that a second node device is a neighbor node is device on a same hierarchical level of a hierarchy as the first node device; and
- based on the determining that the second node device is a neighbor node device, the machine-readable storage medium can perform the operations comprising adding a radio element to a graphical representation of the wireless network by adding a third node device to the same hierarchical level of the hierarchy as the first node device.
16. The machine-readable storage medium of claim 15, wherein the neighbor node is a first neighbor node, and wherein the third node device is a second neighbor node.
17. The machine-readable storage medium of claim 15, wherein the node data is first node data, and wherein the operations further comprise:
- receiving second node data from an edge cloud computing device operable to receive the second node data from a base station device of a service provider identity.
18. The machine-readable storage medium of claim 17, wherein the second node data is determined to have been cached at the edge cloud computing device.
19. The machine-readable storage medium of claim 15, disassociating the second node device with the wireless network.
20. The machine-readable storage medium of claim 19, wherein the operations further comprise:
- in response to the disassociating the second node device with the wireless network, removing the radio element from the graphical representation of the wireless network.