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NETWORK SLICE NOTIFICATIONS IN WIRELESS COMMUNICATION NETWORKS

Abstract

Various embodiments comprise a wireless communication network to notify wireless user devices of available network slices. The wireless communication network comprises a network analytics service and slice notification system. The network data analytics service receives data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior. The network data analytics service correlates the user behavior to a wireless network slice that the user device is not authorized to use. The slice notification system generates slice notification that identifies the wireless network slice. The slice notification system delivers the slice notification to the wireless user device wherein the wireless user device receives and displays the slice notification.

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Background/Summary

TECHNICAL FIELD

[0001] Various embodiments of the present technology relate to network slicing, and more specifically, to notifying users of available network slices.

BACKGROUND

[0002] Wireless communication networks provide wireless data services to wireless user devices. Exemplary wireless data services include voice calling, video calling, internet-access, media-streaming, online gaming, social-networking, and machine-control. Exemplary wireless user devices comprise phones, computers, vehicles, robots, and sensors. Radio Access Networks (RANs) exchange wireless signals with the wireless user devices over radio frequency bands. The wireless signals use wireless network protocols like Fifth Generation New Radio (5GNR), Long Term Evolution (LTE), Institute of Electrical and Electronic Engineers (IEEE) 802.11 (WIFI), and Low-Power Wide Area Network (LP-WAN). The RANs exchange network signaling and user data with network elements that are often clustered together into wireless network cores over backhaul data links. The core networks execute network functions to provide wireless data services to the wireless user devices.

[0003] Wireless communication networks implement network slicing to serve wireless user devices. A network slice is a type of network partition that groups a set of RAN and core network resources to provide a specific service. Network slices may be configured to provide low-latency services, media streaming services, Internet-of-Things (IoT) services, and the like. Exemplary slice types include Ultra-Reliable Low Latency Communication (URLLC), Enhanced Mobile Broadband (eMBB), and Massive Internet-of-Things (MIoT). By implementing network slicing, wireless communication networks optimize the computing and radio resources for specific service types thereby enhancing the overall user experience. To receive service on a given wireless network slice, the user device must typically be subscribed for service on that network slice. When a user device attempts to access a network slice that it is not subscriber to (e.g., paying for), the wireless communication network blocks the device from accessing that slice. However, user devices may still download or otherwise host user applications configured to use specific network slices that the devices are not subscribed to. For example, a device may host a user application that requires ultra-low latency but may not be authorized to access the network's URLLC slices. This misalignment degrades the overall user experience.

[0004] Unfortunately, wireless communication networks do not efficiently inform wireless user devices of the available network slices on the network. Moreover, wireless communication networks do not effectively create new network slices based on device behavior on the network.

Overview

[0005] This Overview is provided to introduce a selection of concepts in a simplified form that are further described below in the Technical Description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

[0006] Various embodiments of the present technology relate to solutions for network slicing. Some embodiments comprise a method of operating a wireless communication network to notify wireless user devices of available network slices. The method comprises receiving data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior. The method further comprises correlating the user behavior to a wireless network slice that the user device is not authorized to use. The method further comprises generating a slice notification that identifies the wireless network slice. The method further comprises delivering the slice notification to the wireless user device wherein the wireless user device receives and displays the slice notification.

[0007] Some embodiments comprise a wireless communication network to notify wireless user devices of available network slices. The wireless communication network comprises a network

analytics service and a slice notification system. The network data analytics service receives data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior. The network data analytics service correlates the user behavior to a wireless network slice that the user device is not authorized to use. The slice notification system generates a slice notification that identifies the wireless network slice. The slice notification system delivers the slice notification to the wireless user device wherein the wireless user device receives and displays the slice notification.
[0008] Some embodiments comprise one of more non-transitory computer readable storage media having program instructions stored thereon to notify wireless user devices of available network slices. When executed by a computing system, the program instructions direct the computing system to perform operations. The operations comprise receiving data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior. The operations further comprise correlating the user behavior to a wireless network slice that the user device is not authorized to use. The operations further comprise generating a slice notification that identifies the wireless network slice. The operations further comprise delivering the slice notification to the wireless user device wherein the wireless user device receives and displays the slice notification.

Description

DESCRIPTION OF THE DRAWINGS
[0009] Many aspects of the disclosure can be better understood with reference to the following drawings. The components in the drawings are not necessarily drawn to scale. Moreover, in the drawings, like reference numerals designate corresponding parts throughout the several views. While several embodiments are described in connection with these drawings, the disclosure is not limited to the embodiments disclosed herein. On the contrary, the intent is to cover all alternatives, modifications, and equivalents.
[0010] FIG. **1** illustrates a communication network to notify wireless user devices of available network slices.
[0011] FIG. **2** illustrates an exemplary operation of the communication network to notify wireless user devices of available network slices.
[0012] FIG. **3** illustrates a wireless communication network to notify wireless user devices of available network slices.
[0013] FIG. **4** illustrates an exemplary operation of the wireless communication network to notify wireless user devices of available network slices.
[0014] FIG. **5** further network elements in the wireless communication network.
[0015] FIG. **6** illustrates a Fifth Generation (5G) communication network to notify wireless user devices of available network slices.
[0016] FIG. **7** illustrates a 5G User Equipment (UE) in the 5G communication network.
[0017] FIG. **8** illustrates a 5G Radio Access Network (RAN) in the 5G communication network.
[0018] FIG. **9** illustrates network functions in the 5G communication network.
[0019] FIG. **10** illustrates a Network Function Virtualization Infrastructure (NFVI) in the 5G communication network.
[0020] FIG. **11** further illustrates the NFVI in the 5G communication network.
[0021] FIG. **12** illustrates an exemplary operation of the 5G communication network to notify wireless user devices of available network slices.
[0022] The drawings have not necessarily been drawn to scale. Similarly, some components or operations may not be separated into different blocks or combined into a single block for the purposes of discussion of some of the embodiments of the present technology. Moreover, while the technology is amendable to various modifications and alternative forms, specific embodiments

have been shown by way of example in the drawings and are described in detail below. The intention, however, is not to limit the technology to the particular embodiments described. On the contrary, the technology is intended to cover all modifications, equivalents, and alternatives falling within the scope of the technology as defined by the appended claims.

TECHNICAL DESCRIPTION

[0023] The following description and associated figures teach the best mode of the invention. For the purpose of teaching inventive principles, some conventional aspects of the best mode may be simplified or omitted. The following claims specify the scope of the invention. Note that some aspects of the best mode may not fall within the scope of the invention as specified by the claims. Thus, those skilled in the art will appreciate variations from the best mode that fall within the scope of the invention. Those skilled in the art will appreciate that the features described below can be combined in various ways to form multiple variations of the invention. As a result, the invention is not limited to the specific examples described below, but only by the claims and their equivalents.

[0024] FIG. **1** illustrates communication network **100** to notify wireless user devices of available network slices. Communication network **100** delivers services like media-streaming, internet-access, voice/video calling, text messaging, machine communications, or some other wireless communications product. Communication network **100** comprises user device **101**, access network **111**, and core network **120**. User device **101** comprises diagnostics application (APP) **102**. Core network **120** comprises analytics system **121** and slice notification system **122**. In other examples, communication network **100** may comprise additional or different elements than those illustrated in FIG. **1**.

[0025] Various examples of network operation and configuration are described herein. In some examples, user device **101** provides user information (INFO) to core network **120** over access network **111**. The user information is generated by diagnostics application **102** and characterizes the user's behavior while using device **101**. For example, the user information may indicate the applications used by the user, the amount of uplink data transferred by device **101**, the amount of downlink data received by device **101**, and/or other information characterizing the operation of device **101**.

[0026] Core network **120** receives the user information and provides the information to analytics system **121**. Analytics system **121** processes the user information to correlate the user behavior to a network slice. Typically, analytics system **121** will correlate the user behavior to a network slice that the device **101** is not currently subscribed to. In response, analytics system **121** notifies slice notification system **122** of the correlated network slice. Slice notification system **122** generates a slice notification (SLICE NOT.) for device **101** that indicates the network slice and delivers the notification to device **101** over access network **111**. User device **101** receives and displays the notification for the user. For example, the slice notification may comprise an advertisement, promotion, and/or other type of marketing communication that identifies the network slice.

[0027] Communication network **100** provides wireless data services to wireless user devices like user device **101**. Exemplary wireless data services include internet-access, media-streaming, social-networking, and machine-control. Exemplary wireless user devices comprise phones, computers, vehicles, robots, and sensors. Access network **111** comprises an example of a Radio Access Network (RAN). RANs exchange wireless signals with the wireless user devices over radio frequency bands. The wireless signals use wireless network protocols like Fifth Generation New Radio (5GNR), Long Term Evolution (LTE), Institute of Electrical and Electronic Engineers (IEEE) 802.11 (WIFI), and Low-Power Wide Area Network (LP-WAN). The RANs exchange network signaling and user data with network elements that are often clustered together into wireless network cores like core network **120**. The RANs are connected to the wireless network cores over backhaul data links. Access network **111** and core network **120** may communicate via edge networks like internet backbone providers, edge computing systems, or another type of edge system to provide the backhaul data links between node **111** and core network **120**.

[0028] The RANs (e.g., access network **111**) comprise Radio Units (RUs), Distributed Units (DUs) and Centralized Units (CUs). The RUs may be mounted at elevation and have antennas, modulators, signal processors, and the like. The RUs are connected to the DUs which are usually nearby network computers. The DUs handle lower wireless network layers like the Physical Layer (PHY), Media Access Control (MAC), and Radio Link Control (RLC). The DUs are connected to the CUs which are larger computer centers that are closer to the network cores. The CUs handle higher wireless network layers like the Radio Resource Control (RRC), Service Data Adaption Protocol (SDAP), and Packet Data Convergence Protocol (PDCP). The CUs are coupled to network functions in core network **120**.
[0029] Core network **120** is representative of computing systems that provide wireless data services to user device **101** over access network **111**. Exemplary computing systems comprise Network Function Virtualization (NFVI) systems, data centers, server farms, cloud computing networks, hybrid cloud networks, and the like. The computing systems of core network **120** store and execute the network functions to form network analytics system **121** and slice notification system **122**. Analytics system **121** and slice notification system **122** may comprise network functions like Access and Mobility Management Function (AMF), Session Management Function (SMF), User Plane Function (UPF), Network Slice Selection Function (NSSF), Unified Data Management (UDM), Network Slice Management Function (NSMF), Network Data Analytics Function (NWDAF), Network Exposure Function (NEF), Application Function (AF), and the like. Core network **120** may comprise a Fifth Generation Core (5GC) architecture or another type of core network architecture.
[0030] FIG. **2** illustrates process **200**. Process **200** comprises an exemplary operation of communication network **100** to notify wireless user devices of available network slices. The operation may vary in other examples. The operations of process **200** comprise receiving data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior (step **201**). The operations further comprise correlating the user behavior to a wireless network slice that the user device is not authorized to use (step **202**). The operations further comprise generating a slice notification that identifies the wireless network slice (step **203**). The operations further comprise delivering the slice notification to the wireless user device where the wireless user device receives and displays the slice notification (step **204**).
[0031] FIG. **3** illustrates wireless communication network **300** network to notify wireless user devices of available network slices. Wireless communication network **300** is an example of communication network **100**, however network **100** may differ. Wireless communication network **300** comprises User Equipment (UE) **301**, RAN **311**, network circuitry **320**, advertising platform **331**, and data network **341**. UE **301** hosts network applications (NET. APPs), user applications (USER APPs), and a diagnostics application (DIAG. APP). Network circuitry **320** comprises control plane **321**, user plane **322**, analytic system **324**, and slice manager **325**. User plane **322** comprises network slices **323**. In other examples, wireless network communication network **300** may comprise additional or different elements than those illustrated in FIG. **3**.
[0032] In some examples, UE **301** attaches to network circuitry **320** over RAN **311**. Control plane selects one or more of slices **323** for UE **301** and directs user plane **322** to serve UE **301** the selected slices. UE **301** exchanges user data with user plane **322** over the selected network slices. User plane **322** exchanges the user data with data network **341**. The diagnostic application monitors the operation of UE **301** as UE **301** receives wireless data services. The diagnostics application determines information like application usage, application type, uplink/downlink volume, and the like. The diagnostics application generates a usage report that includes the determined information and transfers the usage report to control plane **321** over RAN **311**. Control plane **321** delivers the usage report to analytics system **324**.
[0033] Analytics system **324** processes the usage report to correlate the user behavior to one of network slices **323** that UE **301** is not currently authorized to use. For example, the usage report

may indicate UE **301** utilizes media broadcasting applications that have a high uplink data volume and analytics system **324** may correlate this behavior to one of slices **323** with capabilities for media broadcasting. Analytics system **324** exposes the correlated network slices to advertising platform **331**. Platform **331** generates an advertisement that indicates the network slice for UE **301**. For example, when UE **301** has been categorized as a media streaming device by analytics system **324**, platform may generate an advertisement that identifies a media streaming network slice and includes a link for UE **301** to upgrade their subscription to include access for the media streaming slice. Advertising platform **331** transfers the advertisement to control plane **321** which controls user plane **322** to deliver the advertisement to UE **301**.

[0034] In some examples, analytics system **324** may determine there does not currently exist a slicing option that correlates well with the user behavior identifies in the usage report generated by the diagnostics application hosted by UE **301**. In such cases, analytics system **324** may interface with slice manager **325** to instantiate a new one (or modify an existing one) of slices **323** based on the user behavior. Slice manager **325** interfaces with Orchestration and Management (OAM) systems (not illustrated) to secure the computing resources to instantiate the new slice type. Once instantiated, analytics system **324** drives platform **331** to generate an advertisement for the new slice. Platform **331** generates the advertisement and delivers the advertisement to UE **301** as described above.

[0035] Advantageously, wireless communication network **300** efficiently informs wireless UEs of the available network slices on the network that the UEs are unaware of and/or unauthorized to use. Moreover, wireless communication network **300** effectively creates new network slices based on device behavior on the network.

[0036] UE **301** and RAN **311** communicate over links using wireless/wired technologies like 5GNR, LTE, LP-WAN, WIFI, Bluetooth, and/or some other type of wireless or wireline networking protocol. The wireless technologies use electromagnetic frequencies in the low-band, mid-band, high-band, or some other portion of the electromagnetic spectrum. The wired connections comprise metallic links, glass fibers, and/or some other type of wired interface. RAN **311**, network circuitry **320**, advertising platform **331**, and data network **341** communicate over various links that use metallic links, glass fibers, radio channels, or some other communication media. The links use Fifth Generation Core (5GC), IEEE 802.3 (ENET), Time Division Multiplex (TDM), Data Over Cable System Interface Specification (DOCSIS), Internet Protocol (IP), General Packet Radio Service Transfer Protocol (GTP), 5GNR, LTE, WIFI, virtual switching, inter-processor communication, bus interfaces, and/or some other data communication protocols.

[0037] UE **301** comprises a vehicle, drone, robot, computer, phone, sensor, or another type of data appliance with wireless and/or wireline communication circuitry. Although RAN **311** is illustrated as a tower, RAN **311** may comprise another type of mounting structure (e.g., a building), or no mounting structure at all. RAN **311** comprises a Fifth Generation (5G) RAN, LTE RAN, gNodeB, eNodeB, NB-IoT access node, trusted non-Third Generation Partnership Project (3GPP) access node, untrusted non-3GPP access node, LP-WAN base station, wireless relay, WIFI hotspot, Bluetooth access node, and/or another wireless or wireline network transceiver. UE **301** and RAN **311** comprise antennas, amplifiers, filters, modulation, analog/digital interfaces, microprocessors, software, memories, transceivers, bus circuitry, and the like. The control plane network functions comprise network functions like AMF, SMF, NSSF, NEF, AF, and the like. The user plane network functions comprise network functions like UPF and the like. Advertising platform **331** comprises an application server to generate ads the identify network slices available for purchase by UE **301**. Data network **341** comprises an application server that hosts applications (e.g., media streaming applications) for UE **301**.

[0038] UE **301**, RAN **311**, network circuitry **320**, advertising platform **331**, and data network **341** comprise microprocessors, software, memories, transceivers, bus circuitry, and the like. The microprocessors comprise Digital Signal Processors (DSP), Central Processing Units (CPU), Graphical Processing Units (GPU), Application-Specific Integrated Circuits (ASIC), Field Programmable Gate Array (FPGA), and/or the like. The memories comprise Random Access Memory (RAM), flash circuitry, disk drives, and/or the like. The memories store software like operating systems, user applications, radio applications, and network functions. The microprocessors retrieve the software from the memories and execute the software to drive the operation of wireless communication network **300** as described herein.

[0039] FIG. **4** illustrates process **400**. Process **400** comprises an exemplary operation of wireless communication network **300** to notify wireless user devices of available network slices. The operation may vary in other examples. In some examples, UE **301** wirelessly attaches to RAN **311** and the network application hosted by UE **301** interface with RAN **311** to establish a signaling link. UE **301** transfers a registration request (REG. RQ.) to control plane (CP) **321** over RAN **311**. Control plane **321** registers UE **301** for wireless data services and selects a set of network slices **323** for UE **301**. For example, control plane **321** may access the subscriber profile for UE **301** that indicates ones of slice **323** that UE **301** is authorized to use and may select authorized ones of slice **323** to serve UE **301**. Once the slices are selected, control plane **321** directs user plane (UP) **322** and transfers a registration approval (REG. APR.) message to UE **301** over RAN **301**.

[0040] UE **301** receives the registration approval message and launches a user application. Exemplary user applications include media streaming applications, media broadcasting applications, social media applications, low-latency applications, voice/video conferencing applications, online gaming applications, extended/virtual reality applications, and the like. UE **301** exchanges user data with user plane **322**. User plane **322** exchanges the user data with data network (DN) **341**. As UE **301** participates in the session, the diagnostics application generates analytics that characterize the session of UE **301**. The analytics may include metrics like uplink traffic volume, downlink traffic volume, application usage, application type, session length, session number, and the like. The diagnostics application transfers the analytics data to analytics system (AN. SYS.) **324** over RAN **324** and control plane **321**.

[0041] Analytics system **324** correlates the received analytics data to slice requirements. For example, analytics system **324** may correlate data like uplink traffic volume, downlink traffic volume, application usage, application type, session length, and session number to slice service values like latency, uplink/downlink throughput, uplink/downlink data rate, Guaranteed Bit Rate (GBR) requirements, Quality-of-Service Class Indicator (QCI), and/or other service values that define the capabilities of a network slice. Analytics system **324** transfers a slice command to slice manager (SLICE MGR.) **325** to generate a new network slice that comprises the correlated service values. Slice manager **325** receives the command and generates the new network slice using the correlated service values. For example, slice manager **325** may interface with OAM to instantiate a set of control plane and user plane network functions that have capabilities to support the latency, uplink/downlink throughput, uplink/downlink data rate, GBR requirements, QCI, and/or other service values correlated by system **324**. Slice manager **325** notifies analytics system **324** of the slice creation.

[0042] Analytics system **324** receives the notification and categorizes the user of UE **301** based on the analytics generated by the diagnostics application. Analytics system **324** correlates the user behavior depicted by the analytics to the newly created network slice. In response, analytics system **324** transfers an advertisement command to advertisement platform (AD PLF.) **331** to push ads to UE **301** that indicate the newly generated network slice. Platform **331** generates and transfers the advertisement to control plane **321**. Control plane **321** identifies the UE for the advertisement and delivers the advertisement to UE **301** over user plane **322**. UE **322** displays the advertisement for the user.

[0043] FIG. **5** illustrates further illustrates UE **301**, analytics system **324**, slice manager **325**, and advertising platform **331**. In some examples, analytics system **324** receives user information generated by the diagnostics application hosted by UE **301**. Analytics system **324** hosts a data structure that implements the correlation tables illustrated in FIG. **5**. The data structure correlates user behavior data to slice metrics to generate new network slices. As illustrated in FIG. **5**, analytics system **324** correlates the user behavior inputs uplink (UL) volume, downlink (DL) volume, application type, and application usage to the slice metrics throughput, latency, bit rate, and GBR requirement (REQ.). For example, the input user behavior data may comprise an uplink data volume of 7 Gb, a downlink data volume of 3 Gb, a gaming application type and a media broadcasting application type, a 70% usage time for the gaming application, and a 30% usage time for the media broadcasting application. Analytics system **324** delivers the correlated slice metrics to slice manager **325** to instantiate new network slices.

[0044] As illustrated in FIG. **5**, the data structure also categorizes the user into the user categories type A-D based on the behavior inputs of uplink volume, downlink volume, application type, and application usage. Exemplary user types include standard internet access user, media streamer, media broadcaster, gamer, live video/voice conference user, and the like. Analytics system **324** then selects a network slice of type A-D for promotion to UE **301** based on the user categorization. Exemplary slice types include Ultra-Reliable Low Latency Communications slices (URLLC), Enhanced Mobile Broadband (eMBB) slices, Massive Internet-of-Things (MIoT) slices, metaverse slices, media streaming slices, security slices, gaming slices, and the like. When the behavior of UE **301** is associated with a slice type that it is not currently authorized to use, analytics system **324** transfers a request to advertising platform **331** to create a slice advertisement for UE **301** that indicates the network slice type. Platform **331** may then forward the advertisement to control plane **321** and/or user plane **322** to deliver the advertisement to UE **301** via Non-Access Stratum (NAS) signaling, Short Message Service (SMS), downlink data packets, and the like.

[0045] FIG. **6** illustrates 5G communication network **600** to notify wireless user devices of available network slices. 5G communication network **600** comprises an example of communication network **100** illustrated in FIG. **1** and wireless communication network **300** illustrated in FIG. **3**, however networks **100** and **300** may differ. 5G Communication network **600** comprises 5G UEs **601** and **602**, 5G RAN **610**, 5G network core **620**, advertising platform **631**, Orchestration and Management **641** (OAM), and data network **651**. 5G RAN **610** comprises Radio Unit (RU) **611**, Distributed Unit (DU) **612**, and Centralized Unit (CU) **613**. 5G network core **620** comprises Access and Mobility Management Function (AMF) **621**, Session Management Function (SMF) **622**, User Plane Functions (UPFs) **623**, Network Slice Selection Function (NSSF) **624**, Unified Data Management (UDM) **625**, Network Slice Management Function (NSMF) **626**, Network Data Analytics Function (NWDAF) **627**, Network Exposure Function (NEF) **628**, and Application Function (AF) **629**. UPF **623***s* form a variety of network slices. Other network functions and network entities like Authenticating Server Function (AUSF), Unified Data Registry (UDR), Network Repository Function (NRF), Policy Control Function (PCF), Service Communication Proxy (SCP), and Equipment Identity Registry (EIR), are typically present in 5G network core **620** but are omitted for clarity. In other examples, 5G communication network **600** may comprise different or additional elements than those illustrated in FIG. **6**.

[0046] In some examples, UEs **602** wirelessly attach to RAN **610**. UEs **602** transfer registration requests to AMF **621** over RAN **610**. The registration requests include information like registration type, UE capabilities, Network Slice Selection Assistance Information (NSSAI) requests, Protocol Data Unit (PDU) session requests, and the like. In response to the registration request, AMF **621** transfers identity requests to UEs **602** over RAN **610**. UEs **602** indicate their identities to AMF **621** over RAN **610**. For example, UEs **602** may signal their Subscriber Concealed Identifiers (SUCIs) to AMF **621** over RAN **610**. AMF **621** interacts with other network functions to authenticate the identities of UEs **602** and authorize UEs **602** for wireless data service. For example, AMF **621** may transfer an authentication request to an AUSF that includes the SUCI for one of UEs **602**. The AUSF may then interface with UDM **625** to retrieve authentication data to verify the SUCI of the UE. The authentication data typically comprises the Subscriber Permanent Identifier (SUPI) for the

UE and authentication vectors like an authentication challenge, key selection criteria, and a random number. The AUSF then transfers the authentication data and SUPI to AMF **621**. AMF **621** may transfer an authentication challenge, key selection criteria, and random number to the one of UEs **602** over RAN **610**. The UE may hash the random number using its copy of the secret key to generate an authentication response and transfer the response to AMF **621** over RAN **610**. AMF **621** may authenticate the UE by matching the authentication response generated by the UE with the expected result.

[0047] Responsive to the authentication, AMF **621** registers UEs **602** for service on network **600**. AMF **621** accesses subscriber profiles for UEs **602** to generate UE context to serve UEs **602**. For example, AMF **621** may select UDM **625** to retrieve subscriber information for one of UEs **602**. AMF **621** may transfer a context get request to UDM **625** to retrieve data like QoS metrics, allowed NSSAI, service attributes, service authorizations, and the like from UDM **625**. UDM **625** returns the requested information to AMF **621** which generates UE context comprising the information retrieved from UDM **625**. AMF **621** may additionally select and register with a PCF to create network policy associations for UEs **602**.

[0048] As illustrated in FIG. **6**, the network slices comprise UPFs **623**. The slices may comprise URLLC slices, eMBB slices, MIoT slices, metaverse slices, media streaming slices, security slices, gaming slices, and the like. Although the slices are illustrated as comprising only UPFs **623**, in other examples the slices may comprise additional network functions or RAN elements in network **600**. For example, network core **620** may comprise multiple AMFs and SMFs and the slices may each comprise an AMF and an SMF in addition to UPFs **623**. When the slices comprise multiple network functions, some of the network functions may be shared between the network slices. For example, two slices may each comprise SMF **622** while a third slice may comprise another SMF. It should be appreciated that the slices illustrated in FIG. **6** are exemplary and the slice configuration implemented by network core **620** may differ in other examples.

[0049] Once the context is generated, AMF **621** selects NSSF **624** to select network slices for UEs **602**. AMF **621** transfers a get request to NSSF **624** to map the NSSAI requested by UEs **602** to available network slices in network core **620**. NSSF **624** receives the request and maps the NSSAI included in the get request to one or more of the network slices. NSSF **624** returns the slice mappings to AMF **621** which then selects network slices requested by UEs **602**. For example, the slices may comprise an URLLC slice, an eMBB slice, an MIoT slice a GBR network slice, and the like. UEs **602** may include S-NSSAI for the URLLC slice, the eMBB slice, the MIoT slice, and the GBR slice in the initial registration requests. NSSF **624** may map the S-NSSAIs in the get request to these slices to identify network slices for UEs **602**.

[0050] AMF **621** selects SMF **622** to serve UEs **602** based on the selected network slice, QOS metrics, requested PDU sessions, service attributes, and the like. AMF **621** directs SMF **622** to establish PDU sessions for UEs **602** and indicates the S-NSSAIs for the selected network slices to SMF **622**. SMF **622** selects corresponding ones of UPFs **623** to serve UEs **602**. SMF **622** indicates the network addresses for the selected ones of UPFs **623** to AMF **621**. AMF **621** includes the network addresses in the UE contexts and transfers the contexts to UEs **602** over RAN **610**. UEs **602** launch user applications and use their received UE context to establish PDU sessions over their network slices. The application may comprise a media streaming application, social media application, low-latency application, voice/video conferencing application, online gaming application, extended/virtual reality application, and the like. The user applications in UEs **602** generate uplink data and wireless transfer the uplink data to corresponding ones of UPFs **623** over RAN **610**. The corresponding ones of UPFs **623** transfer the uplink user data to data network **651**. Data network **651** generates downlink data for the PDU sessions and transfers the downlink data to corresponding ones of UPFs **623**. The corresponding ones of UPFs **623** transfer the downlink user data to UEs **602** over RAN **610**.

[0051] UEs **602** host diagnostics applications that generate data characterizing user behavior while

UEs **602** are attached to the network. As UEs **602** participate in their PDU sessions, their diagnostics applications track the application types used by UEs **602**, the usage amounts for the applications, the total throughput, uplink-to-downlink data ratio, and the data latency. The diagnostics applications generate usage reports that include the measured data. UEs **602** generate and transfer NAS signaling that carries the usage reports to AMF **621** over RAN **610**. AMF **621** is subscribed to NWDAF **627** for user analytics reporting. AMF **621** receives the usage reports and forwards the reports to NWDAF **627** based on the subscription.

[0052] NWDAF **627** hosts a data structure to correlate the user behavior metrics generated by the diagnostics applications of UEs **602** to slice service values like Quality-of-Service (QOS), latency, data rate, data throughput, location/geographic availability, credential requirements, charging information, and/or other metrics that define the service provided by a network slice. For each of UEs **602**, NWDAF **627** inputs the user behavior metrics into the data structure to determine slice service values tailored to the user behavior for each of UEs **602**. NWDAF **627** transfers the tailored slice service values to NSMF **626** to adjust the service values of existing network slices or to form new slice options.

[0053] NSMF **626** manages the available network slices in core **620** and instantiates new network slices when required. NSMF **626** compares the service values derived by NWDAF **627** to the service values in the currently available network slices. If the existing network slices comprise the same or similar service values than those derived by NWDAF **627**, NSMF **626** forgoes new slice creation (e.g., to inhibit redundancy) or slice adjustment. When NSMF **626** determines the existing network slices do not meet the service value requirements (e.g., by using a similarity threshold), NSMF **626** adjusts the service values of existing network slices to align with the service values derived by NWDAF **627**. For example, NSMF **627** may decrease the latency of the currently available URLLC slices based on the service values derived by NWDAF **627** to create the new slicing option.

[0054] When new slice instantiation is required, (e.g., existing slice capacity is insufficient), NSMF **626** transfers a request to OAM **641** to reserve computing resources for the new network slices. The request includes the service values for the new slice. OAM **641** receives the request and reserves the hardware resources in network core **620** to create additional UPF(s) (and potentially other network functions) for the new network slices. OAM **641** transfers an instantiation command to network core **620** to instantiate the UPFs. Network core **620** forms the UPFs using the hardware resources allocated by OAM **641**. OAM **641** transfers a slice creation command to NSMF **626** to create the network slice. NSMF **626** generates the new network slices using the one(s) of UPFs **623** spun up by OAM **641**. NSMF **626** assigns S-NSSAIs (e.g., slice identifiers) for the new slices. NSMF **626** notifies NWDAF **627** of the new slicing options. For each of the slicing options, NWDAF **627** determines user types based on the service values that correspond to the slice types. For example, NWDAF **627** may define a user type as high-uplink data user and correlate this user type to a network slice with high-uplink data throughput capabilities.

[0055] Subsequently, UE **601** wirelessly attaches to RAN **610**. UE **601** transfers a registration request to AMF **621** over RAN **610**. AMF **621** interacts with the other network functions in core **620** to authenticate and authorize UE **601** for wireless data services as described above for UEs **602**. Responsive to the authentication, AMF **621** registers UE **601** for service on network **600** and generates UE context for UE **601** using subscriber information retrieved from UDM **625**. AMF **621** may additionally select and register with a PCF to create network policy associations for UE **601**. Once the context is generated, AMF **621** interfaces with NSSF **624** to select network slices for UE **601**. AMF **621** selects SMF **622** to serve UE **601** and directs SMF **622** to establish the PDU sessions for UE **601**. SMF **622** selects ones of UPFs **623** to serve UE **601** based on the selected slices. SMF **622** indicates the network addresses for the selected ones of UPFs **623** to AMF **621**. AMF **621** includes the network addresses in the UE context and transfers the context to UE **601** over RAN **610**. UE **601** launches a user application and uses the UE context to establish PDU sessions over the selected network slices. The user application in UE **601** generates uplink data and wireless transfer the uplink data to corresponding ones of UPFs **623** over RAN **610**. The corresponding ones of UPFs **623** transfer the uplink user data to data network **651**. Data network **651** generates downlink data for the PDU sessions and transfers the downlink data to the corresponding ones of UPFs **623**. The corresponding ones of UPFs **623** transfer the downlink user data to UE **610** over RAN **610**.

[0056] UE **601** also hosts a diagnostic application that generates data characterizing user behavior while UE **601** is attached to the network. As UE **601** participates in its PDU sessions, the diagnostics application tracks the application types used by UE **601**, the usage amounts for the applications, the total throughput, uplink-to-downlink data ratio, and the data latency. The diagnostics application generates a usage report that includes the measured data. UE **601** generates and transfers NAS signaling that carries the usage report to AMF **621** over RAN **610**. AMF **621** forwards the usage report to NWDAF **627**.

[0057] NWDAF **627** hosts a data structure that categorizes UE **601** based on the user behavior metrics generated by the diagnostics application of UE **601** and correlates the user type to a slice type. NWDAF **627** inputs the user behavior metrics into the data structure to determine a user type (e.g., high uplink throughput user) for UE **601**. NWDAF **627** inputs the resulting user type into the data structure to determine a slice type for UE **601**. Once the slice type is determined, NWDAF **627** queries UDM **625** to determine if UE **601** is currently subscribed to (e.g., authorized to receive service) the slice type. When UE **601** is subscribed to the resulting slice type, NWDAF **627** may forego slice advertising. When UE **601** is not subscribed for service on the correlated slice type, NWDAF **627** generates an advertisement request that identifies UE **601** and the slice type. NWDAF **627** transfers the advertisement request to NEF **628** which exposes the request to advertisement platform **631** over AF **629**.

[0058] Advertisement platform **631** generates an advertisement for UE **601** that indicates the correlated network slice for UE **601**. The advertisement may comprise a pop-up ad, SMS/text message ad, email ad, or another type of advertisement. The advertisement may include graphics and/or textual information to identify the network slice as well as monetary information to subscribe to the slice. The advertisement may additionally include selectable link that may direct UE **601** to a webpage to purchase a subscription for the network slice. Once the advertisement is generated, platform **631** transfers the advertisement to NEF **628** over AF **629**. NEF **628** exposes the advertisement for UE **601** to AMF **621**. AMF **621** may deliver the advertisement to UE **601** in either control plane or user plane signaling. For example, if the advertisement comprises an SMS advertisement, AMF **621** may transfer NAS signaling the carries the SMS advertisement to UE **601** over RAN **610**. For example, if the advertisement comprises a pop-up advertisement, AMF **621** may forward the advertisement to UPFs **623** which then include the advertisement in the downlink data stream to UE **601**. UE **601** receives the advertisement from network core **620** and responsively displays the advertisement for review by the user.

[0059] FIG. **7** illustrates 5G UE **601** in 5G communication network **600**. UE **601** comprises an example of user device **101** and UE **301**, although user device **101** and UE **301** may differ. UEs **602** comprise a similar architecture to UE **601**. UE **601** comprises 5G radio **701** and user circuitry **702**. Radio **701** comprises antennas, amplifiers, filters, modulation, analog-to-digital interfaces, Digital Signal Processers (DSP), memory, and transceivers (XCVRs) that are coupled over bus circuitry. User circuitry **702** comprises memory, CPU, user interfaces and components, and transceivers that are coupled over bus circuitry. The memory in user circuitry **702** stores an operating system (OS), user application (U-APP) **703**, diagnostics application (D-APP) **704**, and 5GNR network applications for Physical Layer (PHY), Media Access Control (MAC), Radio Link Control (RLC), Packet Data Convergence Protocol (PDCP), Service Data Adaptation Protocol (SDAP), and Radio Resource Control (RRC). The antenna in radio **701** is wirelessly coupled to 5G RAN **610** over a 5GNR link. A transceiver in radio **701** is coupled to a transceiver in user circuitry **702**. A transceiver in user circuitry **702** is typically coupled to the user interfaces and components like displays, controllers, and memory.

[0060] In radio **701**, the antennas receive wireless signals from 5G RAN **610** that transport downlink 5GNR signaling and data. The antennas transfer corresponding electrical signals through duplexers to the amplifiers. The amplifiers boost the received signals for filters which attenuate unwanted energy. Demodulators down-convert the amplified signals from their carrier frequency. The analog/digital interfaces convert the demodulated analog signals into digital signals for the DSPs. The DSPs transfer corresponding 5GNR symbols to user circuitry **702** over the transceivers. In user circuitry **702**, the CPU executes the network applications to process the 5GNR symbols and recover the downlink 5GNR signaling and data. The 5GNR network applications receive new uplink signaling and data from the user applications. The network applications process the uplink user signaling and the downlink 5GNR signaling to generate new downlink user signaling and new uplink 5GNR signaling. The network applications transfer the new downlink user signaling and data to the user applications. The 5GNR network applications process the new uplink 5GNR signaling and user data to generate corresponding uplink 5GNR symbols that carry the uplink 5GNR signaling and data.

[0061] In radio **701**, the DSP processes the uplink 5GNR symbols to generate corresponding digital signals for the analog-to-digital interfaces. The analog-to-digital interfaces convert the digital uplink signals into analog uplink signals for modulation. Modulation up-converts the uplink analog signals to their carrier frequency. The amplifiers boost the modulated uplink signals for the filters which attenuate unwanted out-of-band energy. The filters transfer the filtered uplink signals through duplexers to the antennas. The electrical uplink signals drive the antennas to emit corresponding wireless 5GNR signals to 5G RAN **610** that transport the uplink 5GNR signaling and data.

[0062] RRC functions comprise authentication, security, handover control, status reporting, QoS, network broadcasts and pages, and network selection. SDAP functions comprise QoS marking and flow control. PDCP functions comprise security ciphering, header compression and decompression, sequence numbering and re-sequencing, de-duplication. RLC functions comprise Automatic Repeat Request (ARQ), sequence numbering and resequencing, segmentation and resegmentation. MAC functions comprise buffer status, power control, channel quality, Hybrid ARQ (HARQ), user identification, random access, user scheduling, and QoS. PHY functions comprise packet formation/deformation, windowing/de-windowing, guard-insertion/guard-deletion, parsing/de-parsing, control insertion/removal, interleaving/de-interleaving, Forward Error Correction (FEC) encoding/decoding, channel coding/decoding, channel estimation/equalization, and rate matching/de-matching, scrambling/descrambling, modulation mapping/de-mapping, layer mapping/de-mapping, precoding, Resource Element (RE) mapping/de-mapping, Fast Fourier Transforms (FFTs)/Inverse FFTs (IFFTs), and Discrete Fourier Transforms (DFTs)/Inverse DFTs (IDFTs). User application **703** comprises a user application like a media streaming application, social media application, low-latency application, voice/video conferencing application, online gaming application, extended/virtual reality application, and the like. Diagnostics application **704** functions comprise application usage monitoring, uplink/downlink data throughput monitoring, and user behavior data reporting.

[0063] FIG. **8** illustrates 5G RU **611**, 5G DU **612**, and 5G CU **613** in 5G communication network **600**. RU **611**, DU **612**, and CU **613** comprise an example of the access network **111** and RAN **311**, although access network **111** and RAN **311** may differ. RU **611** comprises antennas, amplifiers, filters, modulation, analog-to-digital interfaces, DSP, memory, and transceivers (XCVRs) that are coupled over bus circuitry. UE **601** is wirelessly coupled to the antennas in RU **611** over 5GNR links. Transceivers in 5G RU **611** are coupled to transceivers in 5G DU **612** over fronthaul links like enhanced Common Public Radio Interface (eCPRI). The DSPs in RU **611** executes their operating systems and radio applications to exchange 5GNR signals with UE **601** and to exchange

5GNR data with DU **612**.

[0064] For the uplink, the antennas receive wireless signals from UE **601** that transport uplink 5GNR signaling and data. The antennas transfer corresponding electrical signals through duplexers to the amplifiers. The amplifiers boost the received signals for filters which attenuate unwanted energy. Demodulators down-convert the amplified signals from their carrier frequencies. The analog/digital interfaces convert the demodulated analog signals into digital signals for the DSPs. The DSPs transfer corresponding 5GNR symbols to DU **612** over the transceivers.

[0065] For the downlink, the DSPs receive downlink 5GNR symbols from DU **612**. The DSPs process the downlink 5GNR symbols to generate corresponding digital signals for the analog-to-digital interfaces. The analog-to-digital interfaces convert the digital signals into analog signals for modulation. Modulation up-converts the analog signals to their carrier frequencies. The amplifiers boost the modulated signals for the filters which attenuate unwanted out-of-band energy. The filters transfer the filtered electrical signals through duplexers to the antennas. The filtered electrical signals drive the antennas to emit corresponding wireless signals to UE **601** that transport the downlink 5GNR signaling and data.

[0066] DU **612** comprises memory, CPU, and transceivers that are coupled over bus circuitry. The memory in 5G DU **612** stores operating systems and 5GNR network applications like PHY, MAC, and RLC. CU **613** comprises memory, CPU, and transceivers that are coupled over bus circuitry. The memory in CU **613** stores an operating system and 5GNR network applications like PDCP, SDAP, and RRC. Transceivers in 5G DU **612** are coupled to transceivers in RU **611** over front-haul links. Transceivers in DU **612** are coupled to transceivers in CU **613** over mid-haul links. A transceiver in CU **613** is coupled to network core **620** over backhaul links.

[0067] RLC functions comprise ARQ, sequence numbering and resequencing, segmentation and resegmentation. MAC functions comprise buffer status, power control, channel quality, HARQ, user identification, random access, user scheduling, and QoS. PHY functions comprise packet formation/deformation, guard-insertion/guard-deletion, parsing/de-parsing, control insertion/removal, interleaving/de-interleaving, FEC encoding/decoding, channel coding/decoding, channel estimation/equalization, and rate matching/de-matching, scrambling/descrambling, modulation mapping/de-mapping, layer mapping/de-mapping, precoding, RE mapping/de-mapping, FFTs/IFFTs, and DFTs/IDFTs. PDCP functions include security ciphering, header compression and decompression, sequence numbering and re-sequencing, de-duplication. SDAP functions include QoS marking and flow control. RRC functions include authentication, security, handover control, status reporting, QoS, network broadcasts and pages, and network selection.

[0068] FIG. **9** illustrates NSMF **626**, NWDAF **627**, NEF **629**, and advertising platform **631** in 5G communication network **600**. In some examples, NSMF **627** comprises modules for slice management, slice orchestration, and Application Programming Interface (API) interfacing. The slice management model manages the resources allocated to the network slices in core **620**. The slice orchestration module handles network slice instantiation and governs the RAN resources and network functions allocated to an instantiated slice. NWDAF **627** comprises modules for API interfacing, network analytics, and stores a data structure that correlates user behavior to slice metrics and correlates user types to slice types. The analytics module processes metrics received from subscribing network functions, RANs, and UEs in network **600** to generate network analytics data. The data structure correlates the user behavior metrics of uplink data volume, downlink data volume, application type, and application usage to the slice metrics of uplink/downlink throughput, latency, bit rate, and GBR requirement. The data structure correlates the user types A-D to the slice types of URLLC, eMBB, IoT, and GBR. Based on the outputs from the data structure, the analytics module may transfer requests to NSMF **626** to create new slices using the correlated metrics and to advertise network slices (including new slice created by NSMF **626**) to UE based on the user type.

[0069] NEF **629** comprises modules for event exposure and API interfacing. The event exposure module exposes network events and third-party requests to the other functions resident in core **620**.

For example, the exposure module may expose slice advertisement requests generated by NWDAF **627** and/or NSMF **626** to advertising platform **631**. Advertising platform **631** comprises modules for API interfacing and advertising. The advertising module generates ads for UE that indicate available network slices that the UE are not currently subscribed to. The ads may comprise pop-up ads for display on the UE, text message/SMS message ads, and/or other advertisement types. The ads may comprise links to mobile pages that allow the UE to upgrade or otherwise purchase a subscription for the advertised network slice. The interfacing modules allow NSMF **626**, NWDAF **627**, NEF **629**, and platform **631** to communicate with each other and other elements in network **600**.

[0070] FIG. **10** illustrates Network Function Virtualization Infrastructure (NFVI) **1000** in 5G wireless communication network **600**. NFVI **1000** comprises an example of core network **120** illustrated in FIG. **1** and network circuitry **320** illustrated in FIG. **3**, although core network **120** and network circuitry **320** may differ. NFVI **1000** comprises NFVI hardware **1001**, NFVI hardware drivers **1002**, NFVI operating systems **1003**, NFVI virtual layer **1004**, and NFVI Virtual Network Functions (VNFs) **1005**. NFVI hardware **1001** comprises Network Interface Cards (NICs), CPU, GPU, RAM, Flash/Disk Drives (DRIVE), and Data Switches (SW). NFVI hardware drivers **1002** comprise software that is resident in the NIC, CPU, GPU, RAM, DRIVE, and SW. NFVI operating systems **1003** comprise kernels, modules, applications, containers, hypervisors, and the like. NFVI virtual layer **1004** comprises vNIC, vCPU, vGPU, vRAM, vDRIVE, and vSW. NFVI VNFs **1005** comprise AMF **1021**, SMF **1022**, UPFs **1023**, NSSF **1024**, UDM **1025**, NSMF **1026**, NWDAF **1027**, NEF **1028**, and AF **1029**. Additional VNFs and network elements like AUSF, UDR, NRF, PCF, SCP, and EIR are typically present but are omitted for clarity. NFVI **1000** may be located at a single site or be distributed across multiple geographic locations. The NIC in NFVI hardware **1001** is coupled to RAN **610**, to advertising platform **631**, to OAM **641**, and to data network **651**. NFVI hardware **1001** executes NFVI hardware drivers **1002**, NFVI operating systems **1003**, NFVI virtual layer **1004**, and NFVI VNFs **1005** to form AMF **611**, SMF **622**, UPFs **623**, NSSF **624**, NSMF **626**, CF **626**, NEF **628**, and AF **629**.

[0071] FIG. **11** further illustrates NFVI **1000** and advertising platform **631** in 5G communication network **600**. AMF **621** comprises capabilities for UE registration, UE connection management, UE mobility management, authentication, authorization, and slice advertisement delivery. SMF **622** comprises capabilities for session establishment, session management, UPF selection, UPF control, and network address allocation. UPFs **623** comprise capabilities for packet routing, packet forwarding, QoS handling, PDU serving, and slice advertisement serving. NSSF **624** comprises capabilities for network slice selection, NSSAI allowance, and NSSAI mapping. UDM **625** comprises capabilities for UE subscription management, UE credential generation, and UE access authorization. NSMF **626** comprises capabilities for Network Slice Instance (NSI) management and network slice creation. NWDAF **627** comprises capabilities for network data collection, network data analytics, user behavior slice metric correlation, new slice requesting, user categorization, and slice advertisement requesting. NEF **628** comprises capabilities for network event exposure and third-party event exposure. AF **629** comprises capabilities for AS interfacing. Advertising platform **631** comprises capabilities for slice advertisement generation and slice advertisement delivery.

[0072] FIG. **12** illustrates an exemplary operation of 5G communication network **600** to notify wireless user devices of available network slices. In this example, OAM **641** comprises a Virtual Infrastructure Manager (VIM), a Network Function Virtualization Orchestrator (NFVO), and a Virtual Network Function Manager (VNFM). The VNFM comprises capabilities for network function interfacing, orchestration interfacing, network function instantiation, and network function deactivation. The NFVO comprises capabilities for network service management and network function request validation. The VIM comprises capabilities for network infrastructure management. The operation of network **600** may vary in other examples. In some examples, UEs

602 wirelessly attach to RAN **610**. The RRCs in UEs **602** transfer registration requests to the RRC in CU **613** over the PDCPs, RLCs, MACs, and PHYs. AMF **621** responds to the request by transferring identity requests to the RRC in CU **613**. The RRC in CU **613** forwards the identity requests to the RRCs in UEs **602** over the PDCPs, RLCs, MACs, and PHYs. The RRCs return their respective SUCIs to the RRC in CU **613** over the PDCPs, RLCs, MACs, and PHYs which forwards the SUCIs to AMF **621**. AMF **621** interacts with other network functions (e.g., AUSF and UDM **625**) to authenticate the identities of UEs **602** and authorize UEs **602** for wireless data service. Responsive to the authentication, AMF **621** registers UEs **602**. AMF **621** accesses subscriber profiles managed by UDM **625** for UEs **602** to generate UE context to serve UEs **602**. Once the context is generated, AMF **621** selects NSSF **624** to select network slices for UEs **602**. AMF **621** transfers a get request to NSSF **624** to map the NSSAI requested by UEs **602** to available network slices in network core **620**. NSSF **624** maps the NSSAI to the network slices. NSSF **624** returns the slice mappings to AMF **621** which then selects the network slices for UEs **602**.

[0073] AMF **621** selects SMF **622** to serve UEs **602** and directs SMF **622** to establish PDU sessions for UEs **602**. AMF **621** indicates the S-NSSAIs for the selected network slices to SMF **622**. SMF **622** selects ones of UPFs **623** to serve UEs **602** based on the S-NSSAIs. SMF **622** indicates the network addresses for the selected ones of UPFs **623** to AMF **621**. AMF **621** includes the network addresses in the UE contexts and transfers the contexts to the RRC in CU **613**. The RRC forwards the contexts to the RRCs in UEs **602** over the PDCPs, RLCs, MACs, and PHYs. In response to user inputs, UEs **602** launch user applications **703**. The RRCs use the received UE contexts to establish PDU sessions. The RRCs direct their corresponding SDAPs to begin the PDU sessions for applications **703** over their network slices. User applications **703** generate uplink data and the SDAPs transfer the uplink data to the SDAP in CU **613** over the PDCPs, RLCs, MACs, and PHYs which transfers the uplink data to corresponding ones of UPFs **623**. The corresponding ones of UPFs **623** transfer the uplink user data to data network **651**.

[0074] Data network **651** generates downlink data for the PDU sessions and transfers the downlink data to corresponding ones of UPFs **623**. The corresponding ones of UPFs **623** transfer the downlink user data to the SDAP in CU **613**. The SDAP transfers the downlink data to the SDAPs in UEs **602** over the PDCPs, RLCs, MACs, and PHYs.

[0075] UEs **602** launch diagnostics applications **704**. Diagnostics applications **704** generate data characterizing user behavior while UEs **602** are attached to the network. As UEs **602** participate in their PDU sessions, diagnostics applications **704** track the application types used by UEs **602**, the usage amounts for the applications, the total throughput, uplink-to-downlink data ratio, and the data latency. The diagnostics applications generate usage reports that include the measured data and transfer the reports to the RRCs. The RRCs transfers the usage reports to the RRC in CU **613** over the PDCPs, RLCs, MACs, and PHYs. The RRC forwards the usage reports to AMF **621**. AMF **621** forwards the reports to NWDAF **627** based on the subscription.

[0076] For each of UEs **602**, NWDAF **627** inputs the user behavior metrics into the data structure to determine slice service values tailored to the user behavior for each of UEs **602**. NWDAF **627** transfers the tailored slice service values to NSMF **626** to adjust the service values of existing network slices or to form new slice options. When NSMF **626** determines the existing network slices do not meet the service value requirements (e.g., by using a similarity threshold), NSMF **626** transfers a request to the VNFM in OAM **641** to reserve computing resources for new network slices. The request includes the service values for the new slice. The NFVO in OAM **641** receives the request and interfaces with the VIM in OAM **641** to reserve the hardware resources in network core **620** to create additional UPF(s) (and potentially other network functions) for the new network slices. The VIM reserves the hardware resources and notifies the NFVO. In response, the NFVO directs the VNFM to instantiate the UPFs using the hardware resource reserved by the VIM. The VNFM transfers an instantiation command to network core **620** to instantiate the UPFs. Network core **620** forms the UPFs using the hardware resources allocated by the VIM. The NFVO generates and transfers to a slice creation command NSMF **626** that specifies the network address for the UPFs and directs NSMF **626** to create the network slice. NSMF **626** generates the new network slices using the ones of UPFs **623** spun up by OAM **641**. NSMF **626** assigns S-NSSAIs for the new slices and notifies NWDAF **627** of the new slicing options. For each of the slicing options, NWDAF **627** determines user types based on the service values that correspond to the slice types.

[0077] Subsequently, UE **601** wirelessly attaches to RAN **610**. The RRC in UE **601** transfers a registration request to the RRC in CU **613** over the PDCPs, RLCs, MACs, and PHYs. The RRC transfers the request to AMF **621**. AMF **621** interacts with the other network functions in core **620** to authenticate and authorize UE **601** for wireless data services. Responsive to the authentication, AMF **621** registers UEs **601** for service on network **600** and generates UE context for UE **601** using subscriber information retrieved from UDM **625**. Once the context is generated, AMF **621** interfaces with NSSF **624** to select network slices for UE **601**. AMF **621** selects SMF **622** to serve UE **601** and directs SMF **622** to establish the PDU sessions for UE **601**. SMF **622** selects ones of UPFs **623** to serve UE **601** and indicates the network addresses for the selected ones of UPFs **623** to AMF **621**. AMF **621** includes the network addresses in the UE context and transfers the context to the RRC in CU **613**. The RRC transfers the context to the RRC in UE **601** over the PDCPs, RLCs, MACs, and PHYs. UE **601** launches user application **703**. The RRC in UE **601** directs the SDAP to begin the PDU session based on the UE context. User application **703** generates uplink data for the PDU session. The SDAP transfers the uplink data to the SDAP in CU **613** over the PDCPs, RLCs, MACs, and PHYs. The SDAP in CU **613** transfers the uplink data to corresponding ones of UPFs **623** over RAN **610**. The corresponding ones of UPFs **623** transfer the uplink user data to data network **651**. Data network **651** generates downlink data for the PDU sessions and transfers the downlink data to corresponding ones of UPFs **623**. The corresponding ones of UPFs **623** transfer the downlink user data to the SDAP in CU **613** which transfers the downlink data to the SDAP in UE **601** over the PDCPs, RLCs, MACs, and PHYS.

[0078] UE **601** launches diagnostic application **704** to generate data characterizing user behavior while UE **601** is attached to the network. Diagnostics application **704** tracks the application types used by UE **601**, the usage amounts for the applications, the total throughput, uplink-to-downlink data ratio, and the data latency. Diagnostics application **704** generates a usage report that includes the measured data and provides the report to the RRC in UE **601**. The RRC transfers the report to the RRC in CU **613** over the PDCPs, RLCs, MACs, and PHYs. The RRC forwards the usage report to AMF **621** which in turn forwards the usage report to NWDAF **627**. NWDAF **627** categorizes UE **601** based on the user behavior metrics generated by diagnostics application **704** and correlates the user type to a slice type. Once the slice type is determined, NWDAF **627** queries UDM **625** to determine if UE **601** is currently subscribed to the slice type. UDM **625** accesses the subscriber profile for UE **601** and notifies NWDAF **627** that UE **601** is not subscribed for service on the correlated slice type. In response, NWDAF **627** generates an advertisement request that identifies UE **601** and the slice type and transfers the request to NEF **628**. NEF **628** exposes the request to advertisement platform **631** over AF **629**.

[0079] Advertisement platform **631** generates an advertisement for UE **601** that indicates the correlated network slice for UE **601**. Once the advertisement is generated, platform **631** transfers the advertisement to NEF **628** over AF **629**. NEF **628** exposes the advertisement for UE **601** to AMF **621**. AMF **621** generates an SMS message that includes the add and transfers the message to the RRC in CU **613**. The RRC forwards the SMS message to the RRC in UE **601** over the PDCPs, RLCs, MACs, and PHYs. The RRC in UE **601** receives the SMS message and responsively displays the advertisement for network slice.

[0080] The wireless data network circuitry described above comprises computer hardware and software that form special-purpose network circuitry to notify wireless user devices of available network slices. The computer hardware comprises processing circuitry like CPUs, DSPs, GPUs, transceivers, bus circuitry, and memory. To form these computer hardware structures,

semiconductors like silicon or germanium are positively and negatively doped to form transistors. The doping comprises ions like boron or phosphorus that are embedded within the semiconductor material. The transistors and other electronic structures like capacitors and resistors are arranged and metallically connected within the semiconductor to form devices like logic circuitry and storage registers. The logic circuitry and storage registers are arranged to form larger structures like control units, logic units, and Random-Access Memory (RAM). In turn, the control units, logic units, and RAM are metallically connected to form CPUs, DSPs, GPUs, transceivers, bus circuitry, and memory.
[0081] In the computer hardware, the control units drive data between the RAM and the logic units, and the logic units operate on the data. The control units also drive interactions with external memory like flash drives, disk drives, and the like. The computer hardware executes machine-level software to control and move data by driving machine-level inputs like voltages and currents to the control units, logic units, and RAM. The machine-level software is typically compiled from higher-level software programs. The higher-level software programs comprise operating systems, utilities, user applications, and the like. Both the higher-level software programs and their compiled machine-level software are stored in memory and retrieved for compilation and execution. On power-up, the computer hardware automatically executes physically-embedded machine-level software that drives the compilation and execution of the other computer software components which then assert control. Due to this automated execution, the presence of the higher-level software in memory physically changes the structure of the computer hardware machines into special-purpose network circuitry to notify wireless user devices of available network slices.
[0082] The above description and associated figures teach the best mode of the invention. The following claims specify the scope of the invention. Note that some aspects of the best mode may not fall within the scope of the invention as specified by the claims. Those skilled in the art will appreciate that the features described above can be combined in various ways to form multiple variations of the invention. Thus, the invention is not limited to the specific embodiments described above, but only by the following claims and their equivalents.

Claims

1. A method, the method comprising: receiving data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior; correlating the user behavior to a wireless network slice that the user device is not authorized to use; generating a slice notification that identifies the wireless network slice; and delivering the slice notification to the wireless user device wherein the wireless user device receives and displays the slice notification.
2. The method of claim 1 further comprising: determining service attributes for the wireless network slice based on the user behavior; and generating the wireless network slice that comprises the service attributes.
3. The method of claim 2 wherein the service attributes comprise at least one of a Quality-of-Service (QOS), a latency, an uplink throughput, a downlink throughput, a bit rate, or a Guaranteed Bit Rate (GBR) requirement.
4. The method of claim 1 wherein the data generated by the diagnostics application hosted by the wireless user device comprises application usage, application type, uplink data volume, and downlink data volume.
5. The method of claim 4 wherein correlating the user behavior to the wireless network slice comprises categorizing the wireless user device based on the application usage, application type, uplink data volume, and downlink data volume and selecting the wireless network slice based on the categorization.
6. The method of claim 5 wherein the categorization associates a user type with a wireless network slice type.

7. The method of claim 1 wherein the slice notification comprises a link to purchase a subscription for the wireless network slice.
8. A wireless communication network, the wireless communication network comprising: a network analytics service to: receive data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior; correlate the user behavior to a wireless network slice that the user device is not authorized to use; and a slice notification system to: generate a slice notification that identifies the wireless network slice; and deliver the slice notification to the wireless user device wherein the wireless user device receives and displays the slice notification.
9. The wireless communication network of claim 8 wherein the network analytics service is to: determine service attributes for the wireless network slice based on the user behavior; and further comprising: a network slice manager to: generate the wireless network slice that comprises the service attributes.
10. The wireless communication network of claim 9 wherein the service attributes comprise at least one of a Quality-of-Service (QOS), a latency, an uplink throughput, a downlink throughput, a bit rate, or a Guaranteed Bit Rate (GBR) requirement.
11. The wireless communication network of claim 8 wherein the data generated by the diagnostics application hosted by the wireless user device comprises application usage, application type, uplink data volume, and downlink data volume.
12. The wireless communication network of claim 11 wherein the network analytics service is to categorize the wireless user device based on the application usage, application type, uplink data volume, and downlink data volume and select the wireless network slice based on the categorization.
13. The wireless communication network of claim 12 wherein the categorization associates a user type with a wireless network slice type.
14. The wireless communication network of claim 8 wherein the slice notification comprises a link to purchase a subscription for the wireless network slice.
15. One of more non-transitory computer readable storage media having program instructions stored thereon, wherein the program instruction, when executed by a computing system, direct the computing system to perform operations, the operations comprising: receiving data generated by a diagnostics application hosted by a wireless user device that characterizes user behavior; correlating the user behavior to a wireless network slice that the user device is not authorized to use; generating a slice notification that identifies the wireless network slice; and delivering the slice notification to the wireless user device wherein the wireless user device receives and displays the slice notification.
16. The computer readable storage media of claim 15, wherein the operation further comprise: determining service attributes for the wireless network slice based on the user behavior; and generating the wireless network slice that comprises the service attributes.
17. The computer readable storage media of claim 16 wherein the service attributes comprise at least one of a Quality-of-Service (QOS), a latency, an uplink throughput, a downlink throughput, a bit rate, or a Guaranteed Bit Rate (GBR) requirement.
18. The computer readable storage media of claim 15 wherein the data generated by the diagnostics application hosted by the wireless user device comprises application usage, application type, uplink data volume, and downlink data volume.
19. The computer readable storage media of claim 18 wherein correlating the user behavior to the wireless network slice comprises categorizing the wireless user device based on the application usage, application type, uplink data volume, and downlink data volume and selecting the wireless network slice based on the categorization.
20. The computer readable storage media of claim 19 wherein the categorization associates a user type with a wireless network slice type.