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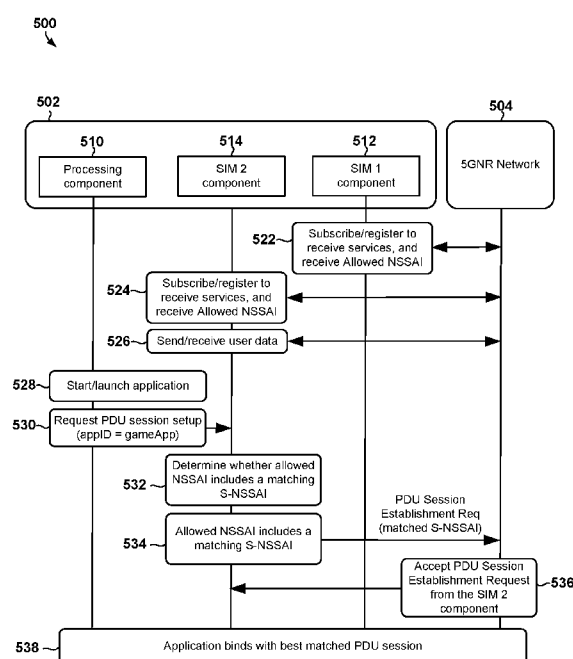


FIG. 5A

(57) Abstract: Embodiments include systems and methods for dynamically determining the designated data service (DDS) SIM in a multi-SIM wireless device. The multi-SIM wireless device may designate a first SIM as the DDS SIM, receive a session establishment request and an application identifier, and determine whether a S-NSSAI element included in a URSP matches a S-NSSAI included in an allowed NSSAI list of the first SIM. In response to determining that the S-NSSAI element is not included in the allowed NSSAI list of the first SIM, the multi-SIM wireless device may determine whether the S-NSSAI element matches a S-NSSAI included in an allowed NSSAI list of the second SIM. The multi-SIM wireless device may designate the second SIM as the DDS SIM if the S-NSSAI is included in the second SIM's allowed NSSAI list. The multi-SIM wireless device may then establish the requested session with the DDS SIM.

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TITLE

Dynamically Determining the Designated Data Service (DDS) Component for Improved Selection of Slicing Resources

BACKGROUND

[0001] Long Term Evolution (LTE), Fifth Generation (5G) new radio (NR)(5G NR), and other recently developed communication technologies allow wireless devices to communicate information at data rates (e.g., in terms of Gigabits per second, etc.) that are orders of magnitude greater than what was available just a few years ago. Today's communication networks are also more secure, resilient to multipath fading, allow for lower network traffic latencies, and provide better communication efficiencies (e.g., in terms of bits per second per unit of bandwidth used, etc.). These and other recent improvements have facilitated the emergence of the Internet of Things (IOT), large scale Machine to Machine (M2M) communication systems, autonomous vehicles, and other technologies that rely on consistent and secure communications.

[0002] In addition, multi-subscriber identity module (SIM) wireless devices have become increasingly popular because of the versatility that such devices provide. For example, a multi-SIM multi-standby (MSMS) wireless device enables at least two SIMs to be in idle mode waiting to begin communications, but only allows one SIM at a time to participate in an active communication due to sharing of a single radio frequency (RF) resource (e.g., a wireless transceiver). As another example, multi-SIM multi-active (MSMA) wireless devices enable at least two SIMs to be in idle mode waiting to begin communications, and allows at least two subscriber identity modules (SIMS) to participate in active communication using at least two RF resources (e.g., two wireless transceivers).

[0003] The different available communication technologies, such as LTE, 5G NR, etc., are enabling many different network implementations and offering different types of networks in the same geographic areas, such as in the same countries. For example,

one implementation option for 5G NR networks being adopted is a 5G NR standalone (SA) network in which a 5G radio access network (RAN) and 5G core network provide 5G NR services in geographic area, such as a country. As such, 5G NR SA networks can overlap coverage in the geographic area, such as the country, with LTE networks.

SUMMARY

[0004] The various aspects include systems and methods, performed by a processor of a wireless device that includes a first Subscriber Identity Module (SIM) and a second SIM, for dynamically determining a designated data service (DDS) SIM for use in a session. Various aspects may include receiving a session establishment request that includes an application identifier while the first SIM is designated as the DDS SIM, determining whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request, designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM, and establishing the requested session with the DDS SIM.

[0005] In some aspects, determining whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request may include determining a preferred wireless communication service based on the application identifier, determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service, determining whether the second SIM has been allocated a network slice that supports the preferred wireless communication service in response to determining that the first SIM has not been allocated a network slice that supports the preferred wireless communication service, determining that the second SIM should be designated as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service. In such aspects, designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM may include

designating the second SIM as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service.

[0006] In some aspects, determining the preferred wireless communication service based on the application identifier may include selecting a wireless communication service from a sorted list of wireless communication services in response to determining that the application identifier identifies a gaming application. In some aspects, determining the preferred wireless communication service based on the application identifier may include determining that the preferred wireless communication service is at least one of an enhanced mobile broadband (eMBB) wireless communication service, an ultra-reliable low latency communications (URLLC) wireless communication service, a millimeter wave (mmW) wireless communication service, a massive machine-type communication (mMTC) wireless communication service, or a massive IOT (mIoT) wireless communication service.

[0007] In some aspects, determining the preferred wireless communication service based on the application identifier may include determining the preferred wireless communication service based on information included in a user equipment route selection policy (URSP) of the first SIM. In some aspects, determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service may include determining whether a slicing service type (SST) of a single network slice selection assistance information (S-NSSAI) element included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM identifies the preferred wireless communication service.

[0008] In some aspects, determining whether the second SIM should be designated as the DDS SIM based on the application identifier may include determining whether a single network slice selection assistance information (S-NSSAI) element included in a user equipment route selection policy (URSP) matches a S-NSSAI included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM in response to receiving the session establishment request and the

application identifier, determining whether the S-NSSAI element included in the URSP matches a S-NSSAI included in an allowed NSSAI list of the second SIM in response to determining that the S-NSSAI element included in the URSP does not match the S-NSSAI included in the allowed NSSAI list of the first SIM, and determining that the second SIM should be designated as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM, and designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM may include designating the second SIM as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM.

[0009] Further aspects include a wireless device having a processor configured to perform one or more operations of any of the methods summarized above. Further aspects include a non-transitory processor-readable storage medium having stored thereon processor-executable instructions configured to cause a processor of a wireless device to perform operations of any of the methods summarized above. Further aspects include a wireless device having means for performing functions of any of the methods summarized above. Further aspects include a system-on-chip for use in a wireless device that includes a processor configured to perform one or more operations of any of the methods summarized above. Further aspects include a system in a package that includes two systems on chip for use in a wireless device that includes a processor configured to perform one or more operations of any of the methods summarized above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate exemplary embodiments of the claims, and together with the general description given above and the detailed description given below, serve to explain the features of the claims.

[0011] FIG. 1 is a system block diagram illustrating an example communication system suitable for implementing any of the various embodiments.

[0012] FIG. 2 is a component block diagram illustrating an example computing and wireless modem system suitable for implementing any of the various embodiments.

[0013] FIG. 3 is a component block diagram illustrating a software architecture including a radio protocol stack for the user and control planes in wireless communications suitable for implementing any of the various embodiments.

[0014] FIG. 4 is a component block diagram illustrating a system configured for wireless communication in accordance with various embodiments.

[0015] FIGs. 5A-5C are activity diagrams illustrating the operations and interactions between components in a multi-SIM wireless device when performing a method for intelligently and dynamically determining the designated data service (DDS) SIM for improved selection of slicing resources based on application requirements in accordance with some embodiments

[0016] FIG. 6 is a process flow diagram illustrating a method for dynamically determining the DDS SIM in a multi-SIM wireless device in accordance with some embodiments.

[0017] FIG. 7 is a component block diagram of a wireless device suitable for use with various embodiments.

DETAILED DESCRIPTION

[0018] Various embodiments will be described in detail with reference to the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts. References made to particular examples and embodiments are for illustrative purposes, and are not intended to limit the scope of the claims.

[0019] In overview, the various embodiments include methods, and wireless devices configured to implement the methods, for dynamically determining the

designated data service (DDS) SIM in a multi-SIM wireless device so that the wireless device may be assigned high-quality network slicing resources and/or receive high quality services in terms of low latency and ultra-reliability.

[0020] A multi-SIM wireless device that includes a first and second SIM may be configured to designate the first SIM as its DDS SIM, and start or launch a software application that requests a communication session, such as a protocol/packet data network (PDN) communication session. The multi-SIM wireless device may be configured to determine whether the second SIM should be designated as the DDS SIM in response to receiving a session establishment request that includes an application identifier in its first SIM.

[0021] For example, the multi-SIM wireless device may determine a preferred wireless communication service based on the application identifier, determine whether the first SIM has been allocated a network slice that supports the preferred wireless communication service, and determine whether the second SIM has been allocated a network slice that supports the preferred wireless communication service in response to determining that the first SIM has not been allocated a network slice that supports the preferred wireless communication service, and determine that the second SIM should be designated as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service

[0022] As another example, the multi-SIM wireless device may determine whether a single network slice selection assistance information (S-NSSAI) element included in a user equipment route selection policy (URSP) matches a S-NSSAI included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM, and determine whether the S-NSSAI element is included in the allowed NSSAI list of the second SIM in response to determining that the S-NSSAI element is not included in the first SIM's allowed NSSAI list, and determine that the second SIM should be designated as the DDS SIM in response to determining that the S-NSSAI element is included in the second SIM's allowed NSSAI list.

[0023] The multi-SIM wireless device may designate the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM. For example, the multi-SIM wireless device may designate the second SIM as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service or that the S-NSSAI element included in URSP matches the S-NSSAI included in the second SIM's allowed NSSAI list.

[0024] The multi-SIM wireless device may establish the requested session with the current DDS SIM (e.g., first or second SIM). For example, the multi-SIM wireless device may determine not to designate the second SIM as the DDS SIM and thus establish the requested session with the first SIM in response to determining that the second SIM has not been allocated a network slice that supports the preferred wireless communication service or that the S-NSSAI element identified from the URSP is not included in the second SIM's allowed NSSAI list.

[0025] The terms “operator,” “network operator,” “mobile network operator,” “carrier,” and “service provider” are used interchangeably herein and refer to a provider of wireless communications services that owns or controls elements to sell and deliver communication services to an end user, and provides necessary provisioning and credentials as policies implemented in wireless device subscriptions.

[0026] The terms “network,” “system,” “wireless network,” “cellular network,” and “wireless communication network” are used interchangeably herein to refer to a portion or all of a wireless network of a carrier associated with a wireless device and/or subscription on a wireless device. The techniques described herein may be used for various wireless communication networks, such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal FDMA (OFDMA), single carrier FDMA (SC-FDMA) and other networks. In general, any number of wireless networks may be deployed in a given geographic area. Each wireless network may support at least one radio access technology, which may operate on one or more frequency or range of frequencies.

For example, a CDMA network may implement Universal Terrestrial Radio Access (UTRA) (including Wideband Code Division Multiple Access (WCDMA) standards), CDMA2000 (including IS-2000, IS-95 and/or IS-856 standards), etc. In another example, a TDMA network may implement GSM Enhanced Data rates for GSM Evolution (EDGE). In another example, an OFDMA network may implement Evolved UTRA (E-UTRA) (including LTE standards), Institute of Electrical and Electronics Engineers (IEEE) 802.11 (WiFi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM®, etc. Reference may be made to wireless networks that use LTE standards, and therefore the terms “Evolved Universal Terrestrial Radio Access,” “E-UTRAN” and “eNodeB” may also be used interchangeably herein to refer to a wireless network. However, such references are provided merely as examples, and are not intended to exclude wireless networks that use other communication standards.

[0027] The term “RF resource” is used herein to refer to the components in a communication device that send, receive, and decode radio frequency (RF) signals. An RF resource typically includes a number of components coupled together that transmit RF signals that are referred to as a “transmit chain,” and a number of components coupled together that receive and process RF signals that are referred to as a “receive chain.”

[0028] The term “wireless device” is used herein to refer to any one or all of cellular telephones, smartphones, portable computing devices, personal or mobile multi-media players, laptop computers, tablet computers, smartbooks, ultrabooks, palmtop computers, wireless electronic mail receivers, multimedia Internet-enabled cellular telephones, wireless router devices, wireless appliances, medical devices and equipment, biometric sensors/devices, wearable devices including smart watches, smart clothing, smart glasses, smart wrist bands, smart jewelry (e.g., smart rings, smart bracelets, etc.), entertainment devices (e.g., wireless gaming controllers, music and video players, satellite radios, etc.), wireless-network enabled Internet of Things (IoT) devices including smart meters/sensors, industrial manufacturing equipment, large and small machinery and appliances for home or enterprise use, wireless

communication elements within autonomous and semiautonomous vehicles, wireless devices affixed to or incorporated into various mobile platforms, global positioning system devices, and similar electronic devices that include a memory, multiple SIMs, wireless communication components and a programmable processor.

[0029] The terms “subscriber identification module,” “subscriber identity module” “SIM,” and “SIM card” may be used interchangeably herein to refer to a memory that may be an integrated circuit or embedded into a removable card, and that stores an International Mobile Subscriber Identity (IMSI), related key, and/or other information used to identify and/or authenticate a wireless device on a network and enable a communication service with the network. Examples of SIMs include the Universal Subscriber Identity Module (USIM), Removable User Identity Module (R-UIM), and Universal Integrated Circuit Card (UICC). The term “SIM” may also refer to a virtual SIM (VSIM), which may be implemented as a remote SIM profile loaded in an application on a wireless device, and enabling normal SIM functions on the wireless device. In addition, because the information stored in a SIM enables the wireless device to establish a communication link for a particular communication service or services with a particular network, the term “SIM” may also be used herein as a shorthand reference to the communication service associated with and enabled by the information stored in a particular SIM. Similarly, the term “SIM” may be used as a shorthand reference to the protocol stack and/or modem stack and communication processes used in establishing and conducting communication services with subscriptions and networks enabled by the information stored in a particular SIM.

[0030] Modern wireless communication devices may now include a plurality of SIMs that enable a user to connect to different mobile networks while using the same mobile communication device. Examples of such multi-SIM wireless devices include dual-SIM (DS), dual-SIM dual-standby (DSDS), dual-SIM dual-active (DSDA), multi-SIM multi-standby (MSMS), and multi-SIM multi-active (MSMA) wireless device. A MSMS wireless device may be a wireless device that is configured with more than one SIM and allows idle-mode operations to be performed on two

subscriptions simultaneously, as well as selective communication on one subscription while performing idle-mode operations on at least one other subscription. A MSMA wireless device may be a wireless device that is configured with more than one SIM and allows idle-mode and/or active mode operations to be performed on two subscriptions simultaneously using at least two different RF resources (e.g., two different wireless transceivers).

[0031] The term “infrastructure as a service (IaaS)” may be used in this application to refer to a component or a system that provides consumers with basic or fundamental computing infrastructure resources (e.g., computing power, memory, network connectivity, disk space, etc.) via a cloud computing environment or over the Internet. An IaaS system may eliminate the need for network operators and/or equipment manufacturers to buy and manage proprietary computing resources or appliances. An IaaS system may rely on virtualization and/or offer computing infrastructure as virtual machines or as virtualized computing resources.

[0032] The term “software defined networking (SDN)” may be used in this application to refer to components or systems that enable network programmability by utilizing an IaaS system, separating the management and control plane from the data plane, providing a programmable interface to network equipment, giving centralized control over network equipment without requiring physical access, etc.

[0033] The term “network function virtualization (NFV)” may be used in this application to refer to components, systems and technologies that leverage virtualization techniques to enable existing network infrastructure (both user and control plane) to be consolidated (e.g., among elements/functions within each of the user and control planes, etc.) and virtualized so that it may operate in a virtualized environment on commodity hardware or within an IaaS system.

[0034] Network slicing is a type of virtual networking architecture in the same family as software-defined networking (SDN) and network functions virtualization (NFV) that allows for the creation of multiple virtual networks (“network slices”) atop

the shared physical infrastructure, commodity hardware or infrastructure as a service (IaaS) via the partitioning of network architectures into virtual elements.

[0035] Network slices may be identified based on network slice selection assistance information (NSSAI), which may be included in the control plane or signaling messages that are communicated between a wireless device and network components. The NSSAI may include a list or collection of single network slice selection assistance information (S-NSSAI) elements that each identify a specific instance of a network slice. An S-NSSAI may include slicing service type (SST) information element that identifies expected network slice behavior in terms of features and services, a slice differentiator (SD) information element that further differentiates between multiple network slices having the same SST, and a Public Land Mobile Network (PLMN) identifier (PLMN ID) that identifies a network associated with the S-NSSAI that the wireless device may access. For example, an SST value of “1” may indicate enhanced mobile broadband (eMBB), an SST value of “2” may indicate ultra-reliable low latency communications (URLLC), and an SST value of “3” may indicate massive IOT (MIoT).

[0036] Long term evolution (LTE) is a mobile network standard for 4G wireless communication of high-speed data developed by 3GPP and specified in its Release 8 document series. In contrast to the circuit-switched (CS) model of cellular network standards, LTE has been designed to support only packet-switched (PS) services. Data services in LTE may be provided over the Internet, while multimedia services may be supported by the internet protocol multimedia core network subsystem (IMS) framework. The LTE standard is based on the evolution of the universal mobile telecommunications system (UMTS) radio access through the evolved universal terrestrial radio access network (E-UTRAN). The E-UTRAN together with the evolved packet core (EPC) network (core network accommodating LTE) make up an evolved packet system (EPS). While the access network in UMTS emulates a circuit-switched connection for real time services and a packet-switched connection for datacom services, the EPS is purely internet protocol (IP) based, and both real time

services and datacom services are carried by the IP protocol.

[0037] 5G NR is an advancement of the technology in 4G LTE that provides a new radio access technology (RAT) through the evolution of the existing mobile communication network structure, and which supports various new or improved wireless communication services, such as enhanced mobile broadband (eMBB) targeting wide bandwidth (e.g. 80 MHz beyond), millimeter wave (mmW) targeting high carrier frequency (e.g. 60 GHz), massive machine-type communication (mMTC) targeting non-backward compatible machine-type communication (MTC) techniques, mission critical targeting ultra-reliable low latency communications (URLLC), and/or massive IOT (MIoT). A 5G system may support, for example, extended LTE (eLTE) as well as non-3GPP access (e.g., WLAN, etc.). One implementation option for 5G NR networks being adopted is a 5G NR standalone (5G NR SA) network in which a 5G radio access network (RAN) and 5G core network provide 5G NR services in geographic area, such as a country. As such, 5G NR SA networks can overlap coverage in the geographic area, such as the country, with LTE networks.

[0038] In order to access network slices in a 5G NR network, a wireless device first performs a registration request procedure in which it provides a Requested NSSAI message to a core access and mobility management function (AMF) component in the network. In response, the AMF component performs various authentication operations, which may include performing certain checks based on local policies, the wireless device's subscriptions, information stored in the wireless device's SIM card, etc., and verifying the network slices that can be provided to the wireless device (e.g., provisioned for access and use by the wireless device). If these operations are successful, the AMF component may generate and send an Allowed NSSAI message to the wireless device that informs the wireless device of the verified network slices that the wireless device may access and use. In response to receiving the Allowed NSSAI message, the wireless device may perform various protocol/packet data unit (PDU) session establishment operations to establish a connectivity to the network

slices.

[0039] A wireless device may receive and use a user equipment route selection policy (URSP) to determine how a certain application should be handled in the context of an existing or new protocol/packet data unit (PDU) session. For example, a wireless device may receive and use the URSP to determine whether a detected application may be associated with an established PDU session, whether the detected application may be offloaded to non-3GPP access outside the PDU session, whether to trigger the establishment of a new PDU session.

[0040] A URSP may include a rule precedence value, a traffic descriptor, and route selection descriptor(s). The rule precedence value may indicate the order in which the URSP rules are enforced in the wireless device. The traffic descriptor may include application identifiers, IP descriptors (e.g., destination IP address, destination port number, a protocol ID, etc.) and/or non-IP descriptors. The route selection descriptor(s) may each include a route selection descriptor precedence value and a route selection component. The route selection component may include a session and service continuity (SSC) mode (e.g., SSC Mode 1, SSC Mode 2, SSC Mode 3, etc.), S-NSSAI values, data network names (DNNs), and the preferred access type for a matching application.

[0041] FIG. 1 is a system block diagram illustrating an example communication system 100 suitable for implementing any of the various embodiments. The communications system 100 may be a 5G New Radio (5G NR) network, or any other suitable network such as an LTE network, 5G NR SA network, etc.

[0042] The communications system 100 may include a heterogeneous network architecture that includes a core network 140 and a variety of wireless devices 120a-120e. The communications system 100 may also include a number of base stations (illustrated as the BS 110a, the BS 110b, the BS 110c, and the BS 110d) and other network entities. A base station is an entity that communicates with wireless devices (mobile devices), and also may be referred to as a Node B, an LTE Evolved nodeB

(eNodeB or eNB), an access point (AP), a Radio head, a transmit receive point (TRP), a New Radio base station (NR BS), a 5G NodeB (NB), a Next Generation NodeB (gNodeB or gNB), or the like. Each base station may provide communication coverage for a particular geographic area. In 3GPP, the term “cell” can refer to a coverage area of a base station, a base station Subsystem serving this coverage area, or a combination thereof, depending on the context in which the term is used.

[0043] A base station 110a-110d may provide communication coverage for a macro cell, a pico cell, a femto cell, another type of cell, or a combination thereof. A macro cell may cover a relatively large geographic area (for example, several kilometers in radius) and may allow unrestricted access by mobile devices with service subscription. A pico cell may cover a relatively small geographic area and may allow unrestricted access by mobile devices with service subscription. A femto cell may cover a relatively small geographic area (for example, a home) and may allow restricted access by mobile devices having association with the femto cell (for example, mobile devices in a closed subscriber group (CSG)). A base station for a macro cell may be referred to as a macro BS. A base station for a pico cell may be referred to as a pico BS. A base station for a femto cell may be referred to as a femto BS or a home BS. In the example illustrated in FIG. 1, a base station 110a may be a macro BS for a macro cell 102a, a base station 110b may be a pico BS for a pico cell 102b, and a base station 110c may be a femto BS for a femto cell 102c. A base station 110a-110d may support one or multiple (for example, three) cells. The terms “eNB”, “base station”, “NR BS”, “gNB”, “TRP”, “AP”, “node B”, “5G NB”, and “cell” may be used interchangeably herein.

[0044] In some examples, a cell may not be stationary, and the geographic area of the cell may move according to the location of a mobile base station. In some examples, the base stations 110a-110d may be interconnected to one another as well as to one or more other base stations or network nodes (not illustrated) in the communications system 100 through various types of backhaul interfaces, such as a

direct physical connection, a virtual network, or a combination thereof using any suitable transport network.

[0045] The base station 110a-110d may communicate with the core network 140 over a wired or wireless communication link 126. The wireless device 120a-120e may communicate with the base station 110a-110d over a wireless communication link 122.

[0046] The wired communication link 126 may use a variety of wired networks (e.g., Ethernet, TV cable, telephony, fiber optic and other forms of physical network connections) that may use one or more wired communication protocols, such as Ethernet, Point-To-Point protocol, High-Level Data Link Control (HDLC), Advanced Data Communication Control Protocol (ADCCP), and Transmission Control Protocol/Internet Protocol (TCP/IP).

[0047] The communications system 100 also may include relay stations (e.g., relay BS 110d). A relay station is an entity that can receive a transmission of data from an upstream station (for example, a base station or a mobile device) and transmit the data to a downstream station (for example, a wireless device or a base station). A relay station also may be a mobile device that can relay transmissions for other wireless devices. In the example illustrated in FIG. 1, a relay station 110d may communicate with macro the base station 110a and the wireless device 120d in order to facilitate communication between the base station 110a and the wireless device 120d. A relay station also may be referred to as a relay base station, a relay base station, a relay, etc.

[0048] The communications system 100 may be a heterogeneous network that includes base stations of different types, for example, macro base stations, pico base stations, femto base stations, relay base stations, etc. These different types of base stations may have different transmit power levels, different coverage areas, and different impacts on interference in communications system 100. For example, macro base stations may have a high transmit power level (for example, 5 to 40 Watts)

whereas pico base stations, femto base stations, and relay base stations may have lower transmit power levels (for example, 0.1 to 2 Watts).

[0049] A network controller 130 may couple to a set of base stations and may provide coordination and control for these base stations. The network controller 130 may communicate with the base stations via a backhaul. The base stations also may communicate with one another, for example, directly or indirectly via a wireless or wireline backhaul.

[0050] The wireless devices 120a, 120b, 120c may be dispersed throughout communications system 100, and each wireless device may be stationary or mobile. A wireless device also may be referred to as an access terminal, a terminal, a mobile station, a subscriber unit, a station, user equipment (UE), etc.

[0051] A macro base station 110a may communicate with the communication network 140 over a wired or wireless communication link 126. The wireless device 120a, 120b, 120c may communicate with a base station 110a-110d over a wireless communication link 122.

[0052] The wireless communication links 122, 124 may include a plurality of carrier signals, frequencies, or frequency bands, each of which may include a plurality of logical channels. The wireless communication links 122 and 124 may utilize one or more Radio access technologies (RATs). Examples of RATs that may be used in a wireless communication link include 3GPP LTE, 3G, 4G, 5G (e.g., NR), GSM, CDMA, WCDMA, Worldwide Interoperability for Microwave Access (WiMAX), Time Division Multiple Access (TDMA), and other mobile telephony communication technologies cellular RATs. Further examples of RATs that may be used in one or more of the various wireless communication links 122, 124 within the communication system 100 include medium range protocols such as Wi-Fi, LTE-U, LTE-Direct, LAA, MuLTEfire, and relatively short range RATs such as ZigBee, Bluetooth, and Bluetooth Low Energy (LE).

[0053] Certain wireless networks (e.g., LTE) utilize orthogonal frequency division multiplexing (OFDM) on the downlink and single-carrier frequency division multiplexing (SC-FDM) on the uplink. OFDM and SC-FDM partition the system bandwidth into multiple (K) orthogonal subcarriers, which are also commonly referred to as tones, bins, etc. Each subcarrier may be modulated with data. In general, modulation symbols are sent in the frequency domain with OFDM and in the time domain with SC-FDM. The spacing between adjacent subcarriers may be fixed, and the total number of subcarriers (K) may be dependent on the system bandwidth. For example, the spacing of the subcarriers may be 15 kHz and the minimum Resource allocation (called a “resource block”) may be 12 subcarriers (or 180 kHz). Consequently, the nominal Fast Fourier Transform (FFT) size may be equal to 128, 256, 512, 1024 or 2048 for system bandwidth of 1.25, 2.5, 5, 10 or 20 megahertz (MHz), respectively. The system bandwidth may also be partitioned into subbands. For example, a subband may cover 1.08 MHz (i.e., 6 Resource blocks), and there may be 1, 2, 4, 8 or 16 subbands for system bandwidth of 1.25, 2.5, 5, 10 or 20 MHz, respectively.

[0054] While descriptions of some embodiments may use terminology and examples associated with LTE technologies, various embodiments may be applicable to other wireless communications systems, such as a new Radio (NR) or 5G network. NR may utilize OFDM with a cyclic prefix (CP) on the uplink (UL) and downlink (DL) and include support for half-duplex operation using time division duplex (TDD). A single component carrier bandwidth of 100 MHz may be supported. NR Resource blocks may span 12 sub-carriers with a sub-carrier bandwidth of 75 kHz over a 0.1 millisecond (ms) duration. Each Radio frame may consist of 50 subframes with a length of 10 ms. Consequently, each subframe may have a length of 0.2 ms. Each subframe may indicate a link direction (i.e., DL or UL) for data transmission and the link direction for each subframe may be dynamically switched. Each subframe may include DL/UL data as well as DL/UL control data. Beamforming may be supported and beam direction may be dynamically configured. Multiple Input Multiple Output

(MIMO) transmissions with precoding may also be supported. MIMO configurations in the DL may support up to eight transmit antennas with multi-layer DL transmissions up to eight streams and up to two streams per wireless device. Multi-layer transmissions with up to 2 streams per wireless device may be supported. Aggregation of multiple cells may be supported with up to eight serving cells. Alternatively, NR may support a different air interface, other than an OFDM-based air interface.

[0055] Some mobile devices may be considered machine-type communication (MTC) or Evolved or enhanced machine-type communication (eMTC) mobile devices. MTC and eMTC mobile devices include, for example, robots, drones, remote devices, sensors, meters, monitors, location tags, etc., that may communicate with a base station, another device (for example, remote device), or some other entity. A wireless node may provide, for example, connectivity for or to a network (for example, a wide area network such as Internet or a cellular network) via a wired or wireless communication link. Some mobile devices may be considered Internet-of-Things (IoT) devices or may be implemented as NB-IoT (narrowband internet of things) devices. A wireless device 120a-e may be included inside a housing that houses components of the wireless device, such as processor components, memory components, similar components, or a combination thereof.

[0056] In general, any number of communication systems and any number of wireless networks may be deployed in a given geographic area. Each communications system and wireless network may support a particular Radio access technology (RAT) and may operate on one or more frequencies. A RAT also may be referred to as a Radio technology, an air interface, etc. A frequency also may be referred to as a carrier, a frequency channel, etc. Each frequency may support a single RAT in a given geographic area in order to avoid interference between communications systems of different RATs. In some cases, 4G/LTE and/or 5G/NR RAT networks may be deployed.

[0057] In some embodiments, two or more wireless devices 120a-e may communicate directly using one or more sidelink channels 124 (for example, without using a base station 110 as an intermediary to communicate with one another). For example, the wireless devices 120a-e may communicate using peer-to-peer (P2P) communications, device-to-device (D2D) communications, a vehicle-to-everything (V2X) protocol (which may include a vehicle-to-vehicle (V2V) protocol, a vehicle-to-infrastructure (V2I) protocol, or similar protocol), a mesh network, or similar networks, or combinations thereof. In this case, the wireless device 120a-e may perform scheduling operations, resource selection operations, as well as other operations described elsewhere herein as being performed by the base station 110a

[0058] FIG. 2 is a component block diagram illustrating an example computing and wireless modem system 200 suitable for implementing any of the various embodiments. Various embodiments may be implemented on a number of single processor and multiprocessor computer systems, including a system-on-chip (SOC) or system in a package (SIP).

[0059] With reference to FIGS. 1 and 2, the illustrated example computing and wireless modem system 200 (which may be a SIP in some embodiments) includes a two SOC 202, 204 coupled to a clock 206, a voltage regulator 208, at least one SIM 268 and/or a SIM interface and a wireless transceiver 266 configured to send and receive wireless communications via an antenna (not shown) to/from network wireless devices, such as a base station 110a. In some embodiments, the first SOC 202 operate as central processing unit (CPU) of the wireless device that carries out the instructions of software application programs by performing the arithmetic, logical, control and input/output (I/O) operations specified by the instructions. In some embodiments, the second SOC 204 may operate as a specialized processing unit. For example, the second SOC 204 may operate as a specialized 5G processing unit responsible for managing high volume, high speed (e.g., 5 Gbps, etc.), and/or very high frequency short wave length (e.g., 28 GHz mmWave spectrum, etc.) communications.

[0060] The first SOC 202 may include a digital signal processor (DSP) 210, a modem processor 212, a graphics processor 214, an application processor (AP) 216, one or more coprocessors 218 (e.g., vector co-processor) connected to one or more of the processors, memory 220, custom circuitry 222, system components and resources 224, an interconnection/bus module 226, one or more temperature sensors 230, a thermal management unit 232, and a thermal power envelope (TPE) component 234. The second SOC 204 may include a 5G modem processor 252, a power management unit 254, an interconnection/bus module 264, the plurality of mmWave transceivers 256, memory 258, and various additional processors 260, such as an applications processor, packet processor, etc.

[0061] Each processor 210, 212, 214, 216, 218, 252, 260 may include one or more cores, and each processor/core may perform operations independent of the other processors/cores. For example, the first SOC 202 may include a processor that executes a first type of operating system (e.g., FreeBSD, LINUX, OS X, etc.) and a processor that executes a second type of operating system (e.g., MICROSOFT WINDOWS 10). In addition, any or all of the processors 210, 212, 214, 216, 218, 252, 260 may be included as part of a processor cluster architecture (e.g., a synchronous processor cluster architecture, an asynchronous or heterogeneous processor cluster architecture, etc.).

[0062] The first and second SOC 202, 204 may include various system components, resources and custom circuitry for managing sensor data, analog-to-digital conversions, wireless data transmissions, and for performing other specialized operations, such as decoding data packets and processing encoded audio and video signals for rendering in a web browser. For example, the system components and resources 224 of the first SOC 202 may include power amplifiers, voltage regulators, oscillators, phase-locked loops, peripheral bridges, data controllers, memory controllers, system controllers, access ports, timers, and other similar components used to support the processors and software clients running on a wireless device. The system components and resources 224 and/or custom circuitry 222 may also include

circuitry to interface with peripheral devices, such as cameras, electronic displays, wireless communication devices, external memory chips, etc.

[0063] The first and second SOC 202, 204 may communicate via interconnection/bus module 250. The various processors 210, 212, 214, 216, 218, may be interconnected to one or more memory elements 220, system components and resources 224, and custom circuitry 222, and a thermal management unit 232 via an interconnection/bus module 226. Similarly, the processor 252 may be interconnected to the power management unit 254, the mmWave transceivers 256, memory 258, and various additional processors 260 via the interconnection/bus module 264. The interconnection/bus module 226, 250, 264 may include an array of reconfigurable logic gates and/or implement a bus architecture (e.g., CoreConnect, AMBA, etc.). Communications may be provided by advanced interconnects, such as high-performance networks-on chip (NoCs).

[0064] The first and/or second SOC 202, 204 may further include an input/output module (not illustrated) for communicating with resources external to the SOC, such as a clock 206, a voltage regulator 208, one or more wireless transceivers 266, and at least one SIM 268 and/or SIM interface (i.e., an interface for receiving one or more SIM cards). Resources external to the SOC (e.g., clock 206, voltage regulator 208) may be shared by two or more of the internal SOC processors/cores. The SIM 268 (or one or more SIM cards coupled to one or more SIM interfaces) may store information supporting multiple subscriptions, including a first 5G NR subscription and a second 5G NR subscription in which the first 5G NR subscription and the second 5G NR subscription support service on a 5G NR SA network.

[0065] In addition to the example SIP discussed above, various embodiments may be implemented in a wide variety of computing systems, which may include a single processor, multiple processors, multicore processors, or any combination thereof.

[0066] FIG. 3 is a component block diagram illustrating a software architecture 300 including a radio protocol stack for the user and control planes in wireless

communications suitable for implementing any of the various embodiments. With reference to FIGS. 1–3, the wireless device 320 may implement the software architecture 300 to facilitate communication between a wireless device 320 (e.g., the wireless device 120a-120e, 200) and the base station 350 (e.g., the base station 110a) of a communication system (e.g., 100). In various embodiments, layers in software architecture 300 may form logical connections with corresponding layers in software of the base station 350. The software architecture 300 may be distributed among one or more processors (e.g., the processors 212, 214, 216, 218, 252, 260). While illustrated with respect to one radio protocol stack, in a multi-SIM wireless device, the software architecture 300 may include multiple protocol stacks, each of which may be associated with a different SIM (e.g., two protocol stacks associated with two SIMs, respectively, in a dual-SIM wireless communication device). While described below with reference to LTE communication layers, the software architecture 300 may support any of variety of standards and protocols for wireless communications, and/or may include additional protocol stacks that support any of variety of standards and protocols wireless communications.

[0067] The software architecture 300 may include a non-access stratum 302 and an access stratum 304. The non-access stratum 302 may include functions and protocols to support packet filtering, security management, mobility control, session management, and traffic and signaling between a SIM(s) of the wireless device and its core network 140. The access stratum 304 may include functions and protocols that support communication between the SIM(s) and entities of supported access networks (e.g., a base station). In particular, the access stratum 304 may include at least three layers (Layer 1, Layer 2, and Layer 3), each of which may contain various sub-layers.

[0068] In the user and control planes, Layer 1 (L1) of the access stratum 304 may be a physical layer (PHY) 306, which may oversee functions that enable transmission and/or reception over the air interface. Examples of such physical layer 306 functions may include cyclic redundancy check (CRC) attachment, coding blocks, scrambling and descrambling, modulation and demodulation, signal measurements, MIMO, etc.

The physical layer may include various logical channels, including the Physical Downlink Control Channel (PDCCH) and the Physical Downlink Shared Channel (PDSCH).

[0069] In the user and control planes, Layer 2 (L2) of the access stratum 304 may be responsible for the link between the wireless device 320 and the base station 350 over the physical layer 306. In the various embodiments, Layer 2 may include a Media Access Control (MAC) sublayer 308, a Radio Link Control (RLC) sublayer 310, and a Packet Data Convergence Protocol (PDCP) 312 sublayer, each of which form logical connections terminating at the base station 350.

[0070] In the control plane, Layer 3 (L3) of the access stratum 304 may include a Radio Resource Control (RRC) sublayer 3. While not shown, the software architecture 300 may include additional Layer 3 sublayers, as well as various upper layers above Layer 3. In various embodiments, the RRC sublayer 313 may provide functions including broadcasting system information, paging, and establishing and releasing an RRC signaling connection between the wireless device 320 and the base station 350.

[0071] In various embodiments, the PDCP sublayer 312 may provide uplink functions including multiplexing between different radio bearers and logical channels, sequence number addition, handover data handling, integrity protection, ciphering, and header compression. In the downlink, the PDCP sublayer 312 may provide functions that include in-sequence delivery of data packets, duplicate data packet detection, integrity validation, deciphering, and header decompression.

[0072] In the uplink, the RLC sublayer 310 may provide segmentation and concatenation of upper layer data packets, retransmission of lost data packets, and Automatic Repeat Request (ARQ). In the downlink, while the RLC sublayer 310 functions may include reordering of data packets to compensate for out-of-order reception, reassembly of upper layer data packets, and ARQ.

[0073] In the uplink, MAC sublayer 308 may provide functions including multiplexing between logical and transport channels, random access procedure, logical channel priority, and hybrid-ARQ (HARQ) operations. In the downlink, the MAC layer functions may include channel mapping within a cell, de-multiplexing, discontinuous reception (DRX), and HARQ operations.

[0074] While the software architecture 300 may provide functions to transmit data through physical media, the software architecture 300 may further include at least one host layer 314 to provide data transfer services to various applications in the wireless device 320. In some embodiments, application-specific functions provided by the at least one host layer 314 may provide an interface between the software architecture and the general purpose processor.

[0075] In other embodiments, the software architecture 300 may include one or more higher logical layer (e.g., transport, session, presentation, application, etc.) that provide host layer functions. For example, in some embodiments, the software architecture 300 may include a network layer (e.g., IP layer) in which a logical connection terminates at a PDN gateway (PGW). In some embodiments, the software architecture 300 may include an application layer in which a logical connection terminates at another device (e.g., end user device, server, etc.). In some embodiments, the software architecture 300 may further include in the access stratum 304 a hardware interface 316 between the physical layer 306 and the communication hardware (e.g., one or more radio frequency (RF) transceivers).

[0076] FIG. 4 is a component block diagram illustrating a communication system 400 configured for wireless communication in accordance with various embodiments. With reference to FIGS. 1–4, the communication system 400 may include a wireless device 120, such as a multi-SIM wireless device, and one or more base stations 110 forming a wireless communication network 454, which may provide connections to external resources 422. External resources 422 may include sources of information outside of system 400, external entities participating with the system 400, and/or other resources.

[0077] A wireless device 120 may be configured by machine-readable instructions 406. Machine-readable instructions 406 may include one or more instruction modules. The instruction modules may include computer program modules. The instruction modules may include one or more of a DDS SIM designating module 408, session establishment request module 410, SIM designation determination module 412 and session establishment module 414.

[0078] The wireless device 120, base station 110, and/or external resources 422 may be operatively linked via one or more electronic communication links of the wireless communication network. For example, the wireless communication network may establish links via a network such as the Internet and/or other networks.

[0079] The wireless device 120 may include electronic storage (e.g., electronic storage 424), one or more processors 426 (e.g., an AP processor 216, modem processor 212, 252, etc.), one or more wireless transceivers 266, at least one SIM 268 (or SIM interfaces configured to connect to one or more SIM cards), and/or other components. The wireless device 120 may include communication lines, or ports to enable the exchange of information with a network and/or other wireless device. The illustration of the wireless device 120 is not intended to be limiting. The wireless device 120 may include a plurality of hardware, software, and/or firmware components operating together to provide the functionality attributed herein to wireless device 120.

[0080] Electronic storage 424 may include non-transitory storage media that electronically stores information. The electronic storage media of electronic storage 424 may include one or both of system storage that is provided integrally (i.e., substantially non-removable) with the wireless device 120 and/or removable storage that is removably connectable to the wireless device 120 via, for example, a port (e.g., a universal serial bus (USB) port, a firewire port, etc.) or a drive (e.g., a disk drive, etc.). Electronic storage 424 may include one or more of optically readable storage media (e.g., optical disks, etc.), magnetically readable storage media (e.g., magnetic tape, magnetic hard drive, floppy drive, etc.), electrical charge-based storage media

(e.g., EEPROM, RAM, etc.), solid-state storage media (e.g., flash drive, etc.), and/or other electronically readable storage media. Electronic storage 424 may store software algorithms, information determined by processor(s) 426, information received from the wireless device 120, information received from remote platform(s) (e.g., the base station 110), and/or other information that enables the wireless device 120 to function as described herein.

[0081] The processor(s) 426 may be configured to provide information processing capabilities in the wireless device 120. As such, the processor(s) 426 may include one or more of a digital processor, an analog processor, a digital circuit designed to process information, an analog circuit designed to process information, a state machine, and/or other mechanisms for electronically processing information. Although the processor(s) 426 is illustrated as a single entity, this is for illustrative purposes only. In some embodiments, the processor(s) 426 may include a plurality of processing units and/or processor cores. The processing units may be physically located within the same device, or processor(s) 426 may represent processing functionality of a plurality of devices operating in coordination. The processor(s) 426 may be configured to execute modules 408, 410, 412, and/or 414 and/or other modules by software; hardware; firmware; some combination of software, hardware, and/or firmware; and/or other mechanisms for configuring processing capabilities on processor(s) 426. As used herein, the term “module” may refer to any component or set of components that perform the functionality attributed to the module. This may include one or more physical processors during execution of processor readable instructions, the processor readable instructions, circuitry, hardware, storage media, or any other components.

[0082] It should be appreciated that although modules 408, 410, 412, and/or 414 are illustrated as being implemented within a single processing unit, in embodiments in which the processor(s) 426 includes multiple processing units and/or processor cores. The description of the functionality provided by the different modules 408, 410, 412, and/or 414 described below is for illustrative purposes, and is not intended

to be limiting, as any of modules 408, 410, 412, and/or 414 may provide more or less functionality than is described. For example, one or more of the modules 408, 410, 412, and/or 414 may be eliminated, and some or all of its functionality may be provided by other modules 408, 410, 412, and/or 414. As another example, the processor(s) 426 may be configured to execute one or more additional modules that may perform some or all of the functionality attributed below to one of the modules 408, 410, 412, and/or 414.

[0083] FIGs. 5A-5C are activity diagrams illustrating the operations and interactions between components in multi-SIM wireless device 502 and a 5G NR network 504 for performing a method 500 for intelligently designating a new SIM as the DDS based on application requirements in accordance with some embodiments. In the examples illustrated in FIG. 5A-5C, the multi-SIM wireless device 502 includes a processing component 510, a SIM 1 component 512, and a SIM 2 component 514. The multi-SIM wireless device 502 may be any wireless device (e.g., 120, 120a-120e, 200, 320) discussed in this application, and each of the processing component 510, SIM 1 component 512, and SIM 2 component 514 may include, use, be, communicate with, or work in conjunction with one or more processors (e.g., 210, 212, 214, 216, 218, 252, 260, 426) of the wireless device to accomplish or perform the operations described herein. In some embodiments, the 5G NR network 504 may be a 5G NR SA network.

[0084] The SIM 1 component 512 and the SIM 2 component 514 may each be configured with their own mobile subscription identification number (MSIN) (also called the mobile identification number (MIN) and/or mobile station identification (MSID)), which is a 10-digit unique number that the wireless carrier uses to identify the multi-SIM wireless device 502 under standards for cellular and personal communications service (PCS) technologies. An internet protocol multimedia core network subsystem (IMS) protocol/packet data network (PDN) connection may be established for each SIM (e.g., the SIM 1 component 512 and SIM 2 component 514) in order to enable real-time communications associated with each of the different

MSINs. In contrast, data-centric applications, such as gaming application, are not associated with a particular MSIN. Since such services are generally accessed through an Internet PDN, an Internet PDN connection only needs to be established for one SIM of the multi-SIM wireless device 502. This one SIM, referred to as the designated data service (DDS), may be selected by a user through a settings menu or other interface on the wireless communication device. The user's selection may be based on any of several factors, such as the relative billing rates for data on each SIM. In the example illustrated in FIG. 5, the SIM 2 component 514 is initially designated as the DDS SIM.

[0085] With reference to FIGs. 5A-5C, in block 522, the SIM 1 component 512 may subscribe to receive wireless communication service(s), such as ultra-reliable low latency communications (URLLC) and/or enhanced mobile broadband (eMBB) services. For example, the SIM 1 component 512 may perform a registration request procedure in which it provides a Requested NSSAI message to a core access and mobility management function (AMF) component (not illustrated separately in FIG. 5) in the 5G NR network 504. In response, the AMF component may perform various authentication operations, which may include performing certain checks based on local policies, the wireless device's subscriptions, information stored in the SIM 1 component 512, etc., and verifying the network slices that can be provided to (e.g., provisioned for access and use by) the SIM 1 component 512 or multi-SIM wireless device 502. If these operations are successful, the AMF component in the 5G NR network 504 may generate and send a user equipment route selection policy (URSP) and/or an Allowed NSSAI message to the SIM 1 component 512 to inform the SIM 1 component 512 of the verified network slices that it may access and use for request services (e.g., URLLC and/or eMBB services). In response to receiving the Allowed NSSAI message, the SIM 1 component 512 may perform various protocol/packet data unit (PDU) session establishment operations to establish a connectivity to the relevant

network slices in the 5G NR network 504.

[0086] In block 524, the SIM 2 component 514 may subscribe to receive wireless communication service(s) by performing the same or similar operations discussed above with reference to operation block 502. For example, the SIM 2 component 514 may perform registration request procedure, receive a user equipment route selection policy (URSP) and/or an Allowed NSSAI message from the 5G NR network 504 that identifies the verified network slices that the SIM 2 component 514 may access and use for the requested services, and perform various PDU session establishment operations to establish a connectivity to the relevant network slices in the 5G NR network 504.

[0087] It should be understood that, in various embodiments, the operations in block 524 may be performed before, during, or after the operations in block 522.

[0088] In block 526, the SIM 2 component 514, which is designated as the DDS SIM, may commence sending and received user data via the established PDU session as per normal operation of the wireless device.

[0089] In block 528, the processing component may start, launch or commence executing a data centric application, which may be a mission-critical service or a gaming application for which low latency and ultra-high reliability are important.

[0090] In block 530, the processing component may request that the SIM 2 component 514, which is designated as the DDS SIM, setup, establish or assign a PDU session for the application. The processing component may also identify the application or application type via an application identifier (e.g., appID = gameApp) that is included in the PDU session setup request sent to the SIM 2 component 514.

[0091] In block 532, the SIM 2 component 514 may determine whether the Allowed NSSAI message includes a suitable or matching S-NSSAI. In some embodiments, this may be accomplished by the SIM 2 component 514 determining whether a single network slice selection assistance information (S-NSSAI) element included in the user equipment route selection policy (URSP) matches any of S-

NSSAIs included in the Allowed NSSAI message received by the SIM 2 component 514. For example, the multi-SIM wireless device 502 may use the application identifier (e.g., appID = gameApp, etc.) from block 530 to lookup the URSP for the SIM 2 component 514, determine whether the URSP includes a suitable or matching S-NSSAI, and/or determine whether any of the S-NSSAIs included in the URSP are included in the Allowed NSSAI message. As is discussed in more detail with reference to FIGs. 5A-5C, the multi-SIM wireless device 502 may establish the PDU session and commence sending and received user data via the established PDU session (e.g., in block 534) in response to determining that an S-NSSAI is present in the Allowed NSSAI message. On the other hand, in response to determining that the URSP does not include a suitable or matching S-NSSAI or that the S-NSSAIs included in the URSP are not included in the Allowed NSSAI message (e.g., in block 540, etc.), the multi-SIM wireless device 502 may select another SIM (e.g., SIM 1 component 512) and repeat any or all of the operations discussed above (e.g., lookup the URSP of the selected SIM, determine whether the URSP includes a suitable or matching S-NSSAI, etc.) to determine whether another SIM should be designated as the DDS SIM.

[0092] In some embodiments, in block 532, the SIM 2 component 514 may determine the preferred or suitable services (e.g., eMBB, URLLC, etc.) for the application or application type, whether the SIM 2 component 514 includes an existing PDU session that supports the determined services, and/or whether the SIM 2 component 514 is registered/allowed to establish a PDU session that supports the determined services.

[0093] In some embodiments, the SIM 2 component 514 may determine whether the Allowed NSSAI message includes a suitable or matching S-NSSAI in block 532 by determining a preferred wireless communication service based on the application identifier and determining whether the SIM 2 component 514 has been allocated a network slice that supports the preferred wireless communication service.

[0094] In the example illustrated in FIG. 5A, in block 534 the SIM 2 component 514 determines that the Allowed NSSAIs include a matching S-NSSAI and sends a PDU session establishment request with the matched S-NSSAI to the 5G NR network 504. In block 536, a component in the 5G NR network 504 (e.g., AMF component) may accept the PDU session establishment request from the SIM 2 component 514. For example, the component may perform various authentication operations, verify the network slices that can be provided to the SIM 2 component 514, and send the SIM 2 component 514 PDU session establishment request accept message. In block 538, the SIM 2 component 514 may perform various PDU session establishment operations to establish a connectivity to the relevant network slices in the 5G NR network 504, and the application may bind to the network with best matched PDU session.

[0095] In the examples illustrated in FIG. 5B and 5C, in block 540 the SIM 2 component 514 determines that Allowed NSSAIs does not include a matching S-NSSAI, and requests that the SIM 1 component 512 determine whether its Allowed NSSAIs include a suitable or matching S-NSSAI. In block 542, the SIM 1 component 512 performs the same or similar operations performed in block 532 to determine whether the Allowed NSSAIs of the SIM 1 component 512 include a suitable or matching S-NSSAI.

[0096] In the example illustrated in FIG. 5B, in block 544, the SIM 1 component 512 determines that the Allowed NSSAIs of the SIM 1 component 512 do not include a suitable or matching S-NSSAI and notifies the SIM 2 component 514 that the S-NSSAI is not included in its Allowed NSSAIs. In block 546, the SIM 2 component 514 may send a PDU session establishment request with the best available S-NSSAI to the 5G NR network 504. In blocks 536 and 538, the 5G NR network 504 and the SIM 2 component 514 perform the same operation discussed above with reference to FIG. 5A.

[0097] In the example illustrated in FIG. 5C, in block 550, the SIM 1 component 512 determines that the Allowed NSSAIs of the SIM 1 component 512 include a

suitable or matching S-NSSAI, and sends a DDS switch request to the processing component 510.

[0098] In block 552, the processing component 510 may designate the SIM 1 component 512 as the DDS and notify the SIM 1 component 512 of the switch.

[0099] In block 554, the processing component 510 may request that the SIM 1 component 512, which is now designated as the DDS SIM, setup, establish or assign a PDU session for the application, and identifies the application or application type via an application identifier (e.g., appID = gameApp), by sending PDU session setup request to the SIM 1 component 512.

[0100] In block 556, the SIM 1 component 512 may receive the request to setup, establish or assign a PDU session from the processing component 510, and in response, send a PDU session establishment request with the matched S-NSSAI to the 5G NR network 504.

[0101] In block 558, a component in the 5G NR network 504 (e.g., AMF component) may accept the PDU session establishment request from the SIM 1 component 512 and work in conjunction with the SIM 1 component 512 to establish a connectivity to the relevant network slices in the 5G NR network 504.

[0102] In block 560, the application may bind to the network with best matched PDU session.

[0103] FIG. 6 illustrates a method 600 for dynamically determining the designated data service (DDS) SIM in a multi-SIM wireless device that includes a first SIM and a second SIM in accordance with some embodiments. Method 600 may be performed by one or more processors (e.g., 210, 212, 214, 216, 218, 252, 260, 426) in a multi-SIM wireless device (e.g., 120, 120a-120e, 200, 320).

[0104] In block 602, the multi-SIM wireless device may designate the first SIM (e.g., the SIM 2 component 514 in FIGs. 5A-5C) as the DDS SIM. That is, the first and second SIMs may each be configured with their own MSIN and an IMS PDN

connection may be established for each SIM in order to enable real-time communications associated with each of the different MSINs. Since data-centric applications, such as gaming application, are not associated with a particular MSIN, the wireless services for such applications are often accessed through an Internet PDN. However, an Internet PDN connection only needs to be established for one SIM of the multi-SIM wireless device, which is known as the designated data service (DDS) SIM. The initial designation of the DDS SIM in block 602 may be performed based on default configuration, user inputs, and/or previous executions of the method 600.

[0105] In block 604, the multi-SIM wireless device may receive a session establishment request that includes an application identifier. The session establishment request may be a PDN session establishment request to support the application associated with the application identifier. The session establishment request may request setup, establish or assign a PDU session for a recently launched application. For example, the application identifier may identify the recently launched application as a gaming application, a data centric application, and/or a mission-critical service for which low latency and ultra-high reliability are important. Some applications may have special demands for connectivity, responsiveness, latency, etc. that may be provided by one service but not another.

[0106] In determination block 606, the multi-SIM wireless device may determine whether the second SIM should be designated as the DDS SIM. In some embodiments, the multi-SIM wireless device may determine whether the second SIM should be designated as the DDS SIM in determination block 606 in response to receiving the session establishment request that includes the application identifier in block 604. The multi-SIM wireless device may determine whether the second SIM should be designated as the DDS SIM in determination block 606 by determining a preferred wireless communication service for supporting the application based on the application identifier. In some embodiments, determining whether the second SIM should be designated as the DDS SIM in determination block 606 may include

determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service. In some embodiments, determining whether the second SIM should be designated as the DDS SIM in determination block 606 may include determining whether the second SIM has been allocated a network slice that supports the preferred wireless communication service in response to determining that the first SIM has not been allocated a network slice that supports the preferred wireless communication service. In some embodiments, determining whether the second SIM should be designated as the DDS SIM in determination block 606 may include determining that the second SIM should be designated as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service. In some embodiments, determining whether the second SIM should be designated as the DDS SIM in determination block 606 may include determining that the second SIM should not be designated as the DDS SIM in response to determining that the second SIM has not been allocated a network slice that supports the preferred wireless communication service.

[0107] In some embodiments, the multi-SIM wireless device may determine the preferred wireless communication service based on the information included in the URSP. In some embodiments, the multi-SIM wireless device may determine the preferred wireless communication service based on the application identifier by selecting a wireless communication service from a sorted list of wireless communication services in response to determining that the application identifier identifies a gaming application. For example, the list of wireless communication services may be sorted based on performance, latency, cost, or any other similar factor. In an embodiment, the list of wireless communication services may be sorted so that the first preferred wireless communication service is URLLC, the second most preferred wireless communication service is eMBB, and the third most preferred wireless communication service is mMTC or mMTC or mMTC.

[0108] In some embodiments, the multi-SIM wireless device may determine whether the first SIM has been allocated a network slice that supports the preferred wireless communication service by determining whether a slicing service type (SST) of a single network slice selection assistance information (S-NSSAI) element included in the allowed NSSAI list of the first SIM identifies the preferred wireless communication service.

[0109] In some embodiments, the multi-SIM wireless device may determine whether the second SIM should be designated as the DDS SIM in determination block 606 by determining whether a single network slice selection assistance information (S-NSSAI) element included in a user equipment route selection policy (URSP) matches an S-NSSAI included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM. In some embodiments, the multi-SIM wireless device may determine whether the S-NSSAI element included in URSP matches a S-NSSAI included in an allowed NSSAI list of the second SIM in response to determining that the S-NSSAI element included in the URSP does not match the S-NSSAI included in the allowed NSSAI list of the first SIM. In some embodiments, the multi-SIM wireless device may determine that the second SIM should be designated as the DDS SIM in response to determining that the S-NSSAI element included in URSP matches a S-NSSAI included in an allowed NSSAI list of the second SIM. In some embodiments, the multi-SIM wireless device may determine that the second SIM should not be designated as the DDS SIM in response to determining that the S-NSSAI element included in URSP does not match a S-NSSAI included in an allowed NSSAI list of the second SIM.

[0110] In response to determining that the second SIM should be designated as the DDS SIM (i.e., determination block 606 = “Yes”), the multi-SIM wireless device may designate the second SIM as the DDS SIM in block 608 and establish the requested session with the newly designated DDS SIM in block 610. For example, the multi-SIM wireless device may designate the second SIM as the DDS SIM in block 608 in response to determining that the second SIM has been allocated a network slice that

supports the preferred wireless communication service and/or in response to determining that the S-NSSAI element included in URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM.

[0111] In response to determining that the second SIM should not be designated as the DDS SIM (i.e., determination block 606 = “No”), the multi-SIM wireless device may not change the DDS SIM, and thus the wireless device may establish the requested session with the previously designated DDS SIM in block 610.

[0112] FIG. 8 is a component block diagram of a wireless device 700 suitable for use with various embodiments. With reference to FIGS. 1–7, various embodiments may be implemented on a variety of wireless devices 700 (e.g., the wireless device 120a-120e, 200, 320, 120a-120e), an example of which is illustrated in FIG. 7 in the form of a smartphone. The wireless device 700 may include a first SOC 202 (e.g., a SOC-CPU) coupled to a second SOC 204 (e.g., a 5G capable SOC). The first and second SOC 202, 204 may be coupled to internal memory 424, 716, a display 712, and to a speaker 714. The first and second SOC 202, 204 may also be coupled to at least one SIM 268 and/or a SIM interface that may store information supporting a first 5G NR subscription and a second 5G NR subscription, which support service on a 5G non-standalone (NSA) network. Additionally, the wireless device 700 may include an antenna 704 for sending and receiving electromagnetic radiation that may be connected to a wireless transceiver 266 coupled to one or more processors in the first and/or second SOC 202, 204. The wireless device 700 may also include menu selection buttons or rocker switches 720 for receiving user inputs.

[0113] The wireless device 700 also includes a sound encoding/decoding (CODEC) circuit 710, which digitizes sound received from a microphone into data packets suitable for wireless transmission and decodes received sound data packets to generate analog signals that are provided to the speaker to generate sound. Also, one or more of the processors in the first and second SOC 202, 204, wireless transceiver 266 and CODEC 710 may include a digital signal processor (DSP) circuit (not shown separately).

[0114] The processors of the wireless device 700 may be any programmable microprocessor, microcomputer or multiple processor chip or chips that can be configured by software instructions (applications) to perform a variety of functions, including the functions of the various embodiments described below. In some mobile devices, multiple processors may be provided, such as one processor within an SOC 204 dedicated to wireless communication functions and one processor within an SOC 202 dedicated to running other applications. Software applications may be stored in the memory 424, 716 before they are accessed and loaded into the processor. The processors may include internal memory sufficient to store the application software instructions.

[0115] As used in this application, the terms “component,” “module,” “system,” and the like are intended to include a computer-related entity, such as, but not limited to, hardware, firmware, a combination of hardware and software, software, or software in execution, which are configured to perform particular operations or functions. For example, a component may be, but is not limited to, a process running on a processor, a processor, an object, an executable, a thread of execution, a program, and/or a computer. By way of illustration, both an application running on a wireless device and the wireless device may be referred to as a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one processor or core and/or distributed between two or more processors or cores. In addition, these components may execute from various non-transitory computer readable media having various instructions and/or data structures stored thereon. Components may communicate by way of local and/or remote processes, function or procedure calls, electronic signals, data packets, memory read/writes, and other known network, computer, processor, and/or process related communication methodologies.

[0116] A number of different cellular and mobile communication services and standards are available or contemplated in the future, all of which may implement and benefit from the various embodiments. Such services and standards include, e.g.,

third generation partnership project (3GPP), LTE systems, third generation wireless mobile communication technology (3G), fourth generation wireless mobile communication technology (4G), fifth generation wireless mobile communication technology (5G), global system for mobile communications (GSM), universal mobile telecommunications system (UMTS), 3GSM, general Packet Radio service (GPRS), code division multiple access (CDMA) systems (e.g., cdmaOne, CDMA1020TM), enhanced data rates for GSM evolution (EDGE), advanced mobile phone system (AMPS), digital AMPS (IS-136/TDMA), evolution-data optimized (EV-DO), digital enhanced cordless telecommunications (DECT), Worldwide Interoperability for Microwave Access (WiMAX), wireless local area network (WLAN), Wi-Fi Protected Access I & II (WPA, WPA2), and integrated digital enhanced network (iDEN). Each of these technologies involves, for example, the transmission and reception of voice, data, signaling, and/or content messages. It should be understood that any references to terminology and/or technical details related to an individual telecommunication standard or technology are for illustrative purposes only, and are not intended to limit the scope of the claims to a particular communication system or technology unless specifically recited in the claim language.

[0117] Various embodiments illustrated and described are provided merely as examples to illustrate various features of the claims. However, features shown and described with respect to any given embodiment are not necessarily limited to the associated embodiment and may be used or combined with other embodiments that are shown and described. Further, the claims are not intended to be limited by any one example embodiment.

[0118] The foregoing method descriptions and the process flow diagrams are provided merely as illustrative examples and are not intended to require or imply that the operations of various embodiments must be performed in the order presented. As will be appreciated by one of skill in the art the order of operations in the foregoing embodiments may be performed in any order. Words such as “thereafter,” “then,” “next,” etc. are not intended to limit the order of the operations; these words are used

to guide the reader through the description of the methods. Further, any reference to claim elements in the singular, for example, using the articles “a,” “an,” or “the” is not to be construed as limiting the element to the singular.

[0119] Various illustrative logical blocks, modules, components, circuits, and algorithm operations described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. To clearly illustrate this interchangeability of hardware and software, various illustrative components, blocks, modules, circuits, and operations have been described above generally in terms of their functionality. Whether such functionality is implemented as hardware or software depends upon the particular application and design constraints imposed on the overall system. Skilled artisans may implement the described functionality in varying ways for each particular application, but such embodiment decisions should not be interpreted as causing a departure from the scope of the claims.

[0120] The hardware used to implement various illustrative logics, logical blocks, modules, and circuits described in connection with the embodiments disclosed herein may be implemented or performed with a general purpose processor, a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field programmable gate array (FPGA) or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but, in the alternative, the processor may be any conventional processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of receiver smart objects, e.g., a combination of a DSP and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration. Alternatively, some operations or methods may be performed by circuitry that is specific to a given function.

[0121] In one or more embodiments, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored as one or more instructions or code on a non-transitory computer-readable storage medium or non-transitory processor-readable storage medium. The operations of a method or algorithm disclosed herein may be embodied in a processor-executable software module or processor-executable instructions, which may reside on a non-transitory computer-readable or processor-readable storage medium. Non-transitory computer-readable or processor-readable storage media may be any storage media that may be accessed by a computer or a processor. By way of example but not limitation, such non-transitory computer-readable or processor-readable storage media may include RAM, ROM, EEPROM, FLASH memory, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage smart objects, or any other medium that may be used to store desired program code in the form of instructions or data structures and that may be accessed by a computer. Disk and disc, as used herein, includes compact disc (CD), laser disc, optical disc, digital versatile disc (DVD), floppy disk, and Blu-ray disc where disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of non-transitory computer-readable and processor-readable media. Additionally, the operations of a method or algorithm may reside as one or any combination or set of codes and/or instructions on a non-transitory processor-readable storage medium and/or computer-readable storage medium, which may be incorporated into a computer program product.

[0122] The preceding description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the claims. Various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other embodiments without departing from the scope of the claims. Thus, the present disclosure is not intended to be limited to the embodiments shown herein but is to be accorded the widest scope

consistent with the following claims and the principles and novel features disclosed herein.

CLAIMS

What is claimed is:

1. A method performed by a processor of a wireless device that includes a first Subscriber Identity Module (SIM) and a second SIM for dynamically determining a designated data service (DDS) SIM for use in a session, comprising:

receiving a session establishment request that includes an application identifier while the first SIM is designated as the DDS SIM;

determining whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request;

designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM; and

establishing the requested session with the DDS SIM.

2. The method of claim 1, wherein:

determining whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request comprises:

determining a preferred wireless communication service based on the application identifier;

determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service;

determining whether the second SIM has been allocated a network slice that supports the preferred wireless communication service in response to determining that the first SIM has not been allocated a network slice that supports the preferred wireless communication service; and

determining that the second SIM should be designated as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service; and

designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM comprises designating the second SIM as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service.

3. The method of claim 2, wherein determining the preferred wireless communication service based on the application identifier comprises selecting a wireless communication service from a sorted list of wireless communication services in response to determining that the application identifier identifies a gaming application.

4. The method of claim 2, wherein determining the preferred wireless communication service based on the application identifier comprises determining that the preferred wireless communication service is at least one of:

- an enhanced mobile broadband (eMBB) wireless communication service;
- an ultra-reliable low latency communications (URLLC) wireless communication service;

- a millimeter wave (mmW) wireless communication service;
- a massive machine-type communication (mMTC) wireless communication service; or

- a massive IOT (mIoT) wireless communication service.

5. The method of claim 2, wherein determining the preferred wireless communication service based on the application identifier comprises determining the preferred wireless communication service based on information included in a user equipment route selection policy (URSP) of the first SIM.

6. The method of claim 2, wherein determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service comprises:

determining whether a slicing service type (SST) of a single network slice selection assistance information (S-NSSAI) element included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM identifies the preferred wireless communication service.

7. The method of claim 1, wherein:

determining whether the second SIM should be designated as the DDS SIM based on the application identifier comprises:

determining whether a single network slice selection assistance information (S-NSSAI) element included in a user equipment route selection policy (URSP) matches a S-NSSAI included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM in response to receiving the session establishment request and the application identifier;

determining whether the S-NSSAI element included in the URSP matches a S-NSSAI included in an allowed NSSAI list of the second SIM in response to determining that the S-NSSAI element included in the URSP does not match the S-NSSAI included in the allowed NSSAI list of the first SIM; and

determining that the second SIM should be designated as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM; and

designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM comprises designating the second SIM as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM.

8. A wireless device, comprising:

a first Subscriber Identity Module (SIM);

a second SIM; and

a processor coupled to the first SIM and the second SIM, wherein the processor is configured to processor-executable instructions to:

receive a session establishment request that includes an application identifier while the first SIM is designated as a designated data service (DDS) SIM;

determine whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request;

designate the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM; and

establish a requested session with the DDS SIM.

9. The wireless device of claim 8, wherein the processor is further configured with processor-executable instructions to:

determine whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request by:

determining a preferred wireless communication service based on the application identifier;

determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service;

determining whether the second SIM has been allocated a network slice that supports the preferred wireless communication service in response to determining that the first SIM has not been allocated a network slice that supports the preferred wireless communication service; and

determining that the second SIM should be designated as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service; and designate the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM by designating the second SIM as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service.

10. The wireless device of claim 9, wherein the processor is further configured with processor-executable instructions to determine the preferred wireless communication service based on the application identifier by selecting a wireless communication service from a sorted list of wireless communication services in response to determining that the application identifier identifies a gaming application.

11. The wireless device of claim 9, wherein the processor is further configured with processor-executable instructions to determine the preferred wireless communication service based on the application identifier by determining that the preferred wireless communication service is at least one of:

- an enhanced mobile broadband (eMBB) wireless communication service;
- an ultra-reliable low latency communications (URLLC) wireless communication service;
- a millimeter wave (mmW) wireless communication service;
- a massive machine-type communication (mMTC) wireless communication service; or
- a massive IOT (mIoT) wireless communication service.

12. The wireless device of claim 9, wherein the processor is further configured with processor-executable instructions to determine the preferred wireless communication service based on the application identifier by determining the preferred wireless

communication service based on information included in a user equipment route selection policy (URSP) of the first SIM.

13. The wireless device of claim 9, wherein the processor is further configured with processor-executable instructions to determine whether the first SIM has been allocated a network slice that supports the preferred wireless communication service by:

determining whether a slicing service type (SST) of a single network slice selection assistance information (S-NSSAI) element included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM identifies the preferred wireless communication service.

14. The wireless device of claim 8, wherein the processor is further configured with processor-executable instructions to:

determine whether the second SIM should be designated as the DDS SIM based on the application identifier by:

determining whether a single network slice selection assistance information (S-NSSAI) element included in a user equipment route selection policy (URSP) matches a S-NSSAI included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM in response to receiving the session establishment request and the application identifier;

determining whether the S-NSSAI element included in the URSP matches a S-NSSAI included in an allowed NSSAI list of the second SIM in response to determining that the S-NSSAI element included in the URSP does not match the S-NSSAI included in the allowed NSSAI list of the first SIM; and

determining that the second SIM should be designated as the DDS SIM in response to determining that the S-NSSAI element included in the URSP

matches the S-NSSAI included in the allowed NSSAI list of the second SIM;
and

designate the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM by designating the second SIM as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM.

15. A non-transitory computer readable storage medium having stored thereon processor-executable software instructions configured to cause a processor of a wireless device that includes a first Subscriber Identity Module (SIM) and a second SIM to perform operations for dynamically determining a designated data service (DDS) SIM for use in a session, the operations comprising:

receiving a session establishment request that includes an application identifier while the first SIM is designated as the DDS SIM;

determining whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request;

designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM; and

establishing the requested session with the DDS SIM.

16. The non-transitory computer readable storage medium of claim 15, wherein the stored processor-executable software instructions are further configured to cause a processor to perform operations such that:

determining whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request comprises:

determining a preferred wireless communication service based on the application identifier;

determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service;

determining whether the second SIM has been allocated a network slice that supports the preferred wireless communication service in response to determining that the first SIM has not been allocated a network slice that supports the preferred wireless communication service; and

determining that the second SIM should be designated as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service; and

designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM comprises designating the second SIM as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service.

17. The non-transitory computer readable storage medium of claim 16, wherein the stored processor-executable software instructions are further configured to cause a processor to perform operations such that determining the preferred wireless communication service based on the application identifier comprises selecting a wireless communication service from a sorted list of wireless communication services in response to determining that the application identifier identifies a gaming application.

18. The non-transitory computer readable storage medium of claim 16, wherein the stored processor-executable software instructions are further configured to cause a processor to perform operations such that determining the preferred wireless communication service based on the application identifier comprises determining that the preferred wireless communication service is at least one of:

an enhanced mobile broadband (eMBB) wireless communication service;

an ultra-reliable low latency communications (URLLC) wireless communication service;
a millimeter wave (mmW) wireless communication service;
a massive machine-type communication (mMTC) wireless communication service; or
a massive IOT (mIoT) wireless communication service.

19. The non-transitory computer readable storage medium of claim 16, wherein the stored processor-executable software instructions are further configured to cause a processor to perform operations such that determining the preferred wireless communication service based on the application identifier comprises determining the preferred wireless communication service based on information included in a user equipment route selection policy (URSP) of the first SIM.

20. The non-transitory computer readable storage medium of claim 16, wherein the stored processor-executable software instructions are further configured to cause a processor to perform operations such that determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service comprises determining whether a slicing service type (SST) of a single network slice selection assistance information (S-NSSAI) element included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM identifies the preferred wireless communication service.

21. The non-transitory computer readable storage medium of claim 15, wherein the stored processor-executable software instructions are further configured to cause a processor to perform operations such that:

determining whether the second SIM should be designated as the DDS SIM based on the application identifier comprises:

determining whether a single network slice selection assistance information (S-NSSAI) element included in a user equipment route selection policy (URSP) matches a S-NSSAI included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM in response to receiving the session establishment request and the application identifier;

determining whether the S-NSSAI element included in the URSP matches a S-NSSAI included in an allowed NSSAI list of the second SIM in response to determining that the S-NSSAI element included in the URSP does not match the S-NSSAI included in the allowed NSSAI list of the first SIM; and

determining that the second SIM should be designated as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM; and

designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM comprises designating the second SIM as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM.

22. A wireless device, comprising:

means for receiving a session establishment request that includes an application identifier while a first Subscriber Identity Module (SIM) of the wireless device is designated as a designated data service (DDS) SIM;

means for determining whether a second SIM of the wireless device should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request;

means for designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM; and
means for establishing a requested session with the DDS SIM.

23. The wireless device of claim 22, wherein:

means for determining whether the second SIM should be designated as the DDS SIM based on the application identifier in response to receiving the session establishment request comprises:

means for determining a preferred wireless communication service based on the application identifier;

means for determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service;

means for determining whether the second SIM has been allocated a network slice that supports the preferred wireless communication service in response to determining that the first SIM has not been allocated a network slice that supports the preferred wireless communication service; and

means for determining that the second SIM should be designated as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service; and
means for designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM comprises
means for designating the second SIM as the DDS SIM in response to determining that the second SIM has been allocated a network slice that supports the preferred wireless communication service.

24. The wireless device of claim 23, wherein means for determining the preferred wireless communication service based on the application identifier comprises means for selecting a wireless communication service from a sorted list of wireless

communication services in response to determining that the application identifier identifies a gaming application.

25. The wireless device of claim 23, wherein means for determining the preferred wireless communication service based on the application identifier comprises means for determining that the preferred wireless communication service is at least one of:

- an enhanced mobile broadband (eMBB) wireless communication service;
- an ultra-reliable low latency communications (URLLC) wireless communication service;
- a millimeter wave (mmW) wireless communication service;
- a massive machine-type communication (mMTC) wireless communication service; or
- a massive IOT (mIoT) wireless communication service.

26. The wireless device of claim 23, wherein means for determining the preferred wireless communication service based on the application identifier comprises means for determining the preferred wireless communication service based on information included in a user equipment route selection policy (URSP) of the first SIM.

27. The wireless device of claim 23, wherein means for determining whether the first SIM has been allocated a network slice that supports the preferred wireless communication service comprises means for determining whether a slicing service type (SST) of a single network slice selection assistance information (S-NSSAI) element included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM identifies the preferred wireless communication service.

28. The wireless device of claim 22, wherein:

means for determining whether the second SIM should be designated as the DDS SIM based on the application identifier comprises:

means for determining whether a single network slice selection assistance information (S-NSSAI) element included in a user equipment route selection policy (URSP) matches a S-NSSAI included in an allowed network slice selection assistance information (allowed NSSAI) list of the first SIM in response to receiving the session establishment request and the application identifier;

means for determining whether the S-NSSAI element included in the URSP matches a S-NSSAI included in an allowed NSSAI list of the second SIM in response to determining that the S-NSSAI element included in the URSP does not match the S-NSSAI included in the allowed NSSAI list of the first SIM; and

means for determining that the second SIM should be designated as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM; and

means for designating the second SIM as the DDS SIM in response to determining that the second SIM should be designated as the DDS SIM comprises means for designating the second SIM as the DDS SIM in response to determining that the S-NSSAI element included in the URSP matches the S-NSSAI included in the allowed NSSAI list of the second SIM.

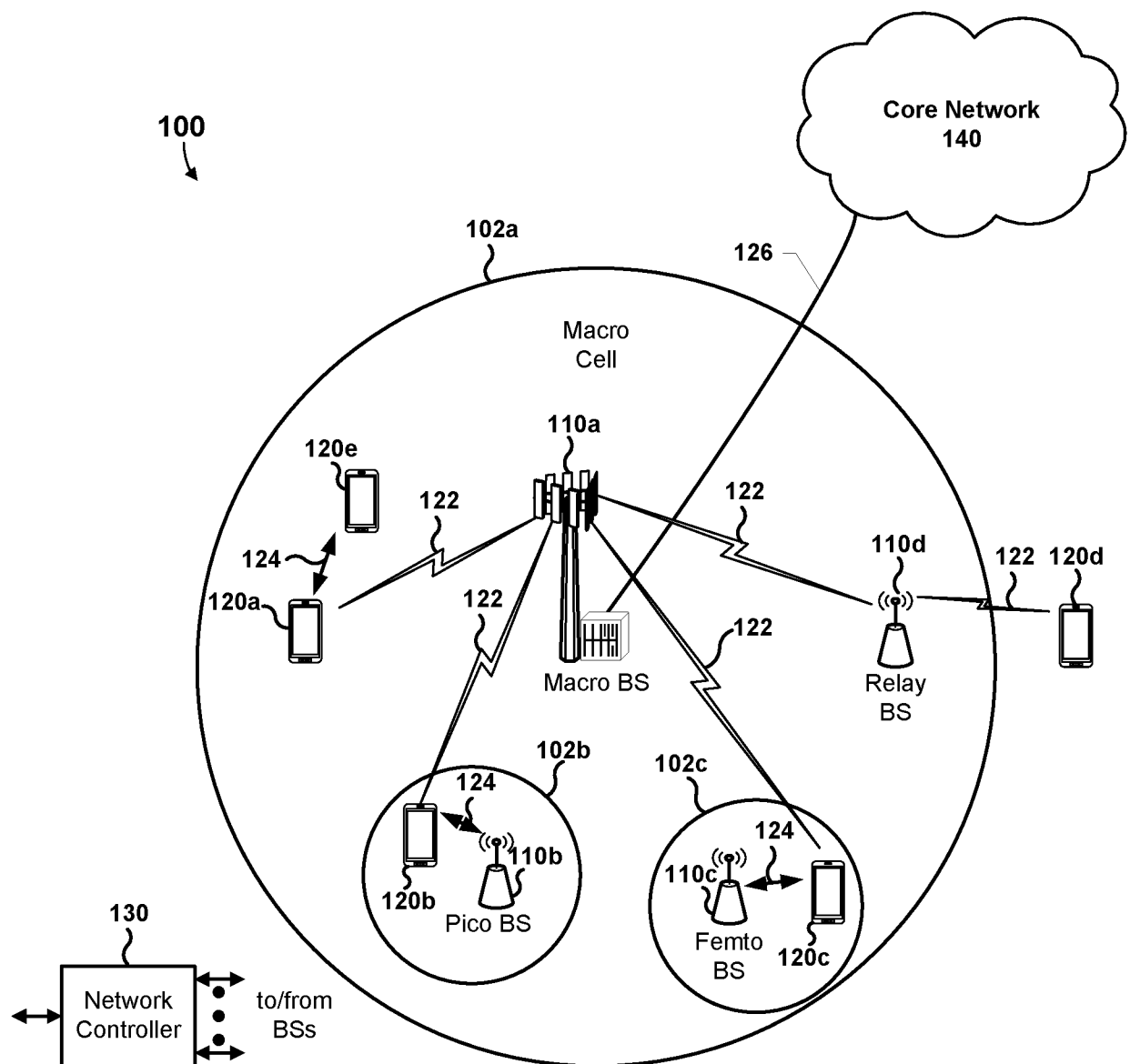


FIG. 1

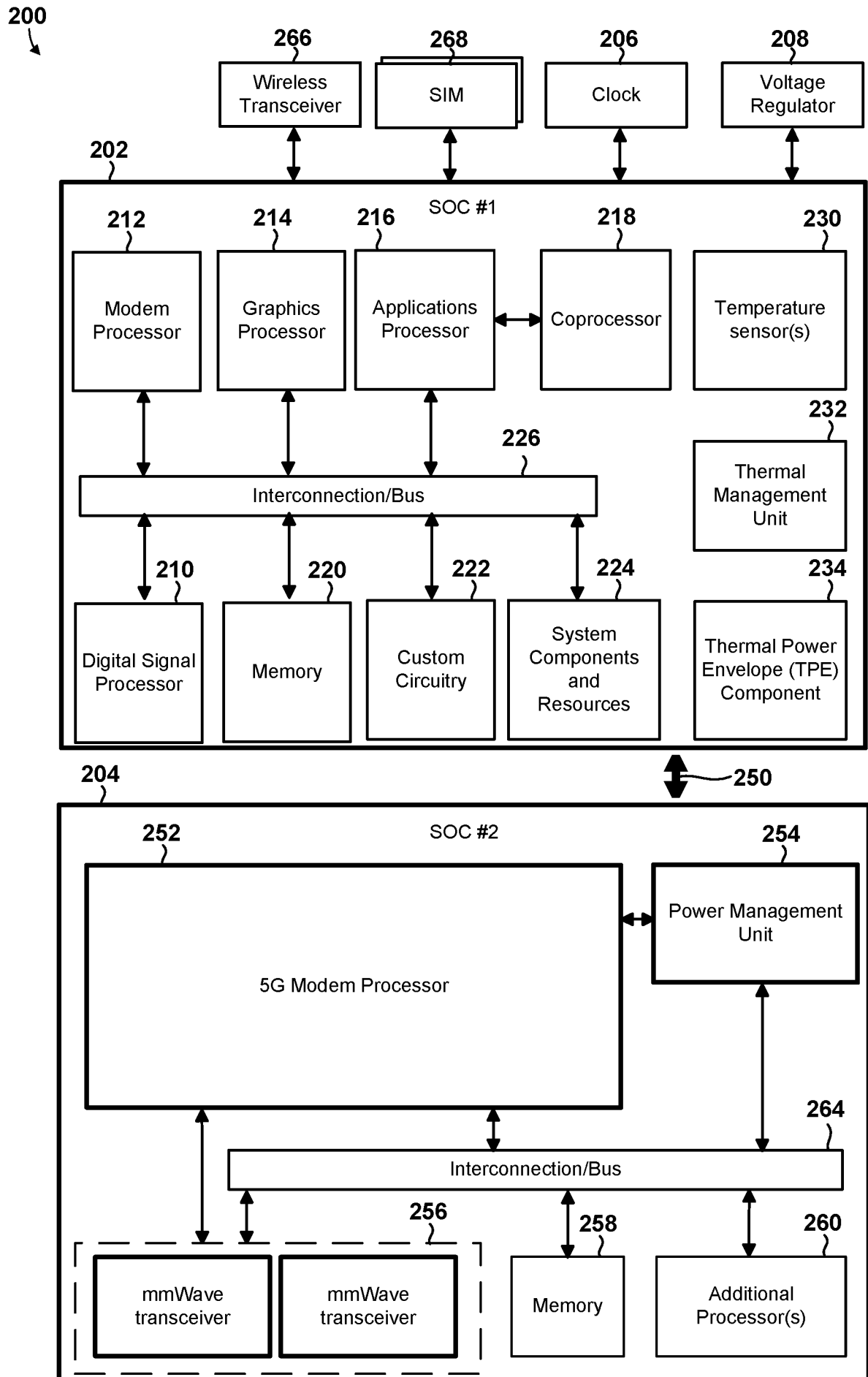


FIG. 2

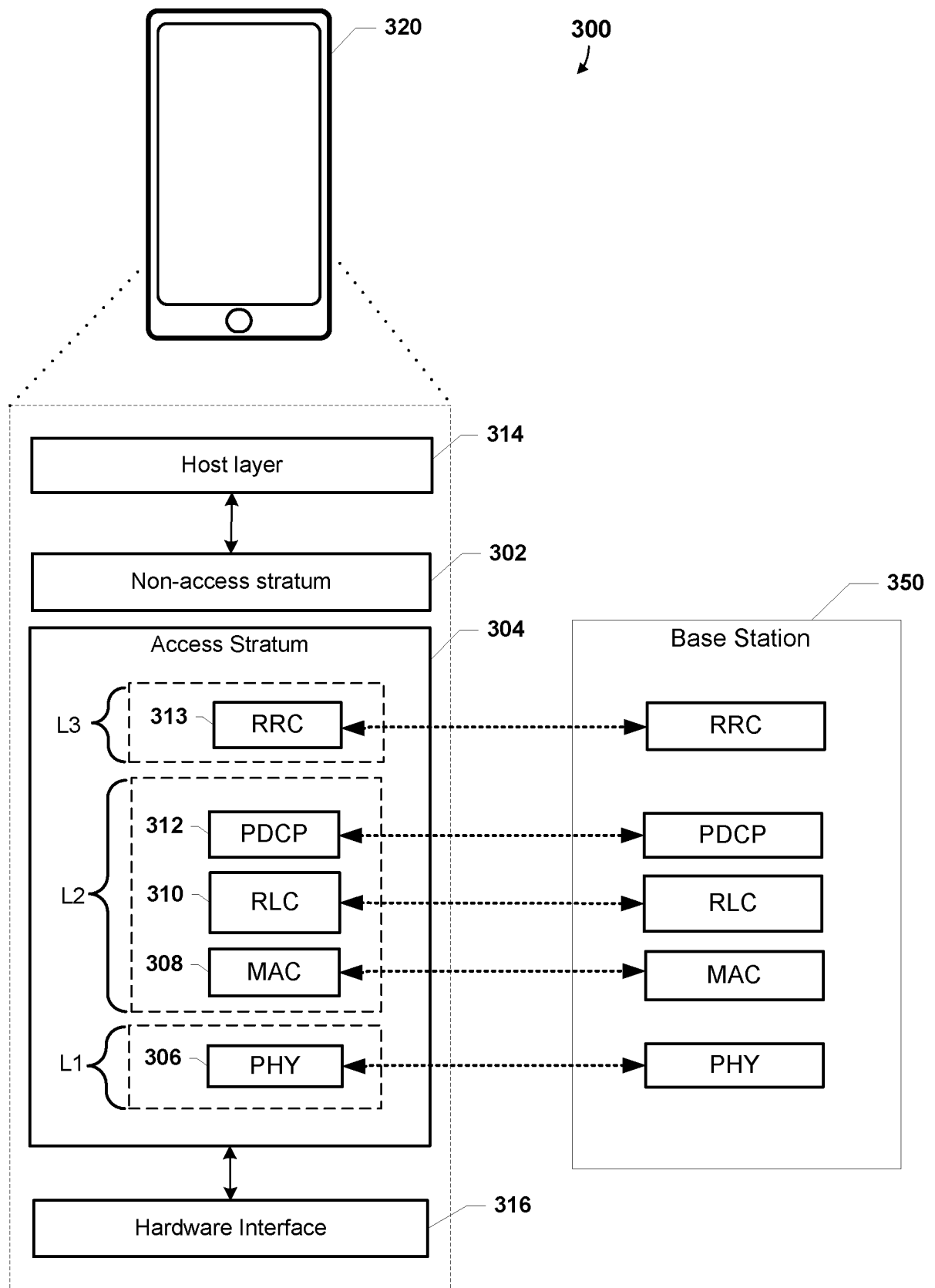


FIG. 3

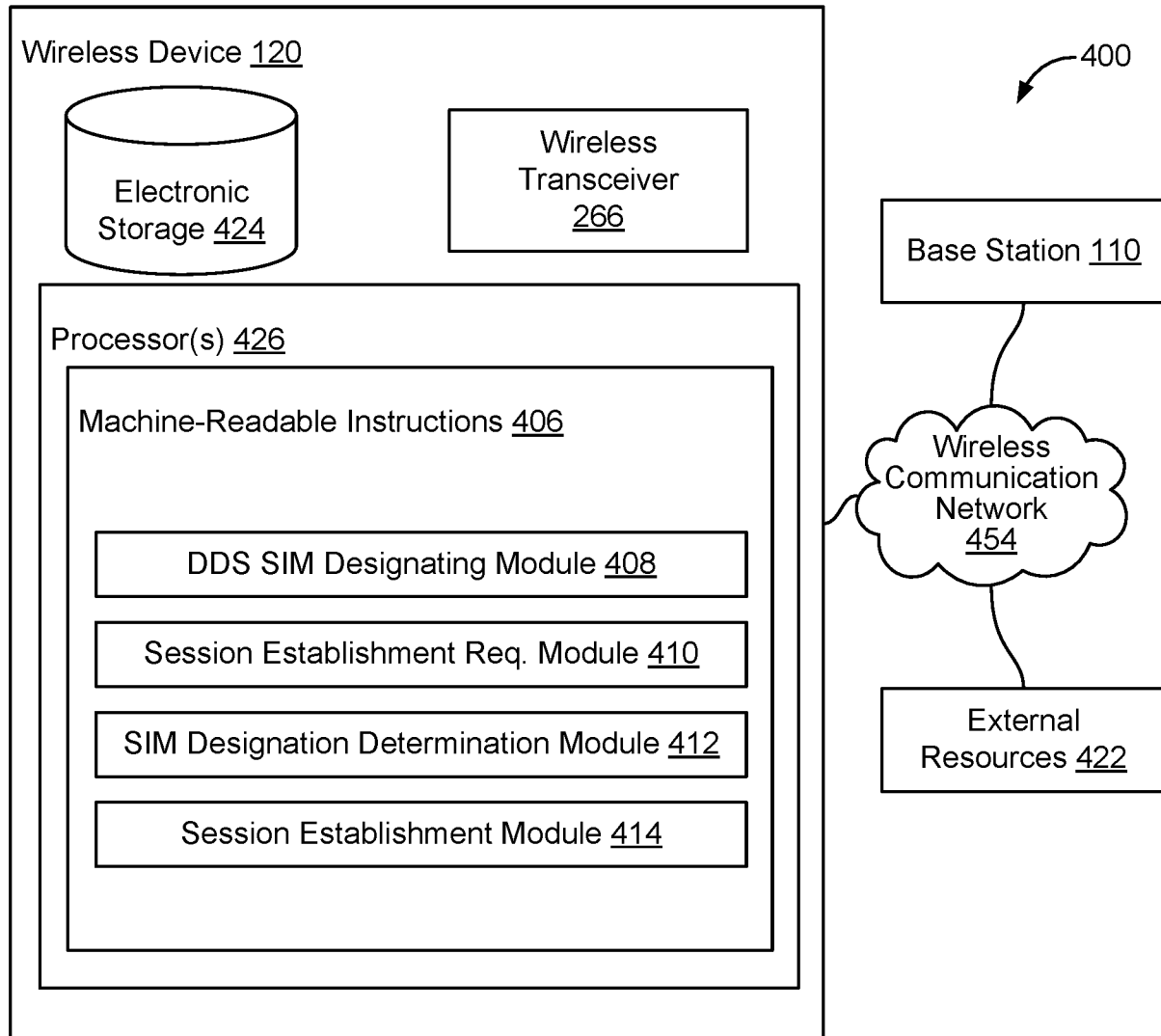


FIG. 4

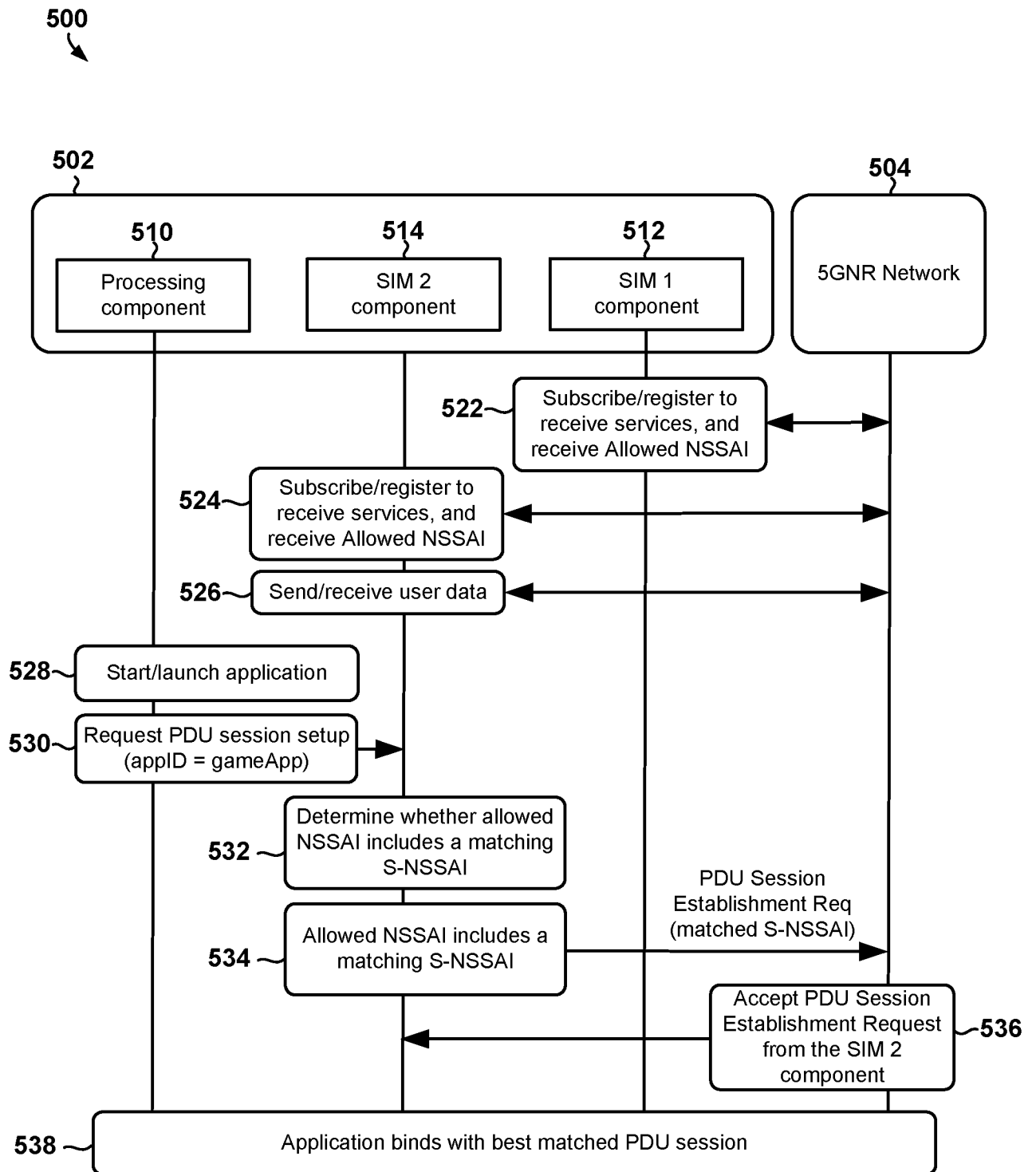


FIG. 5A

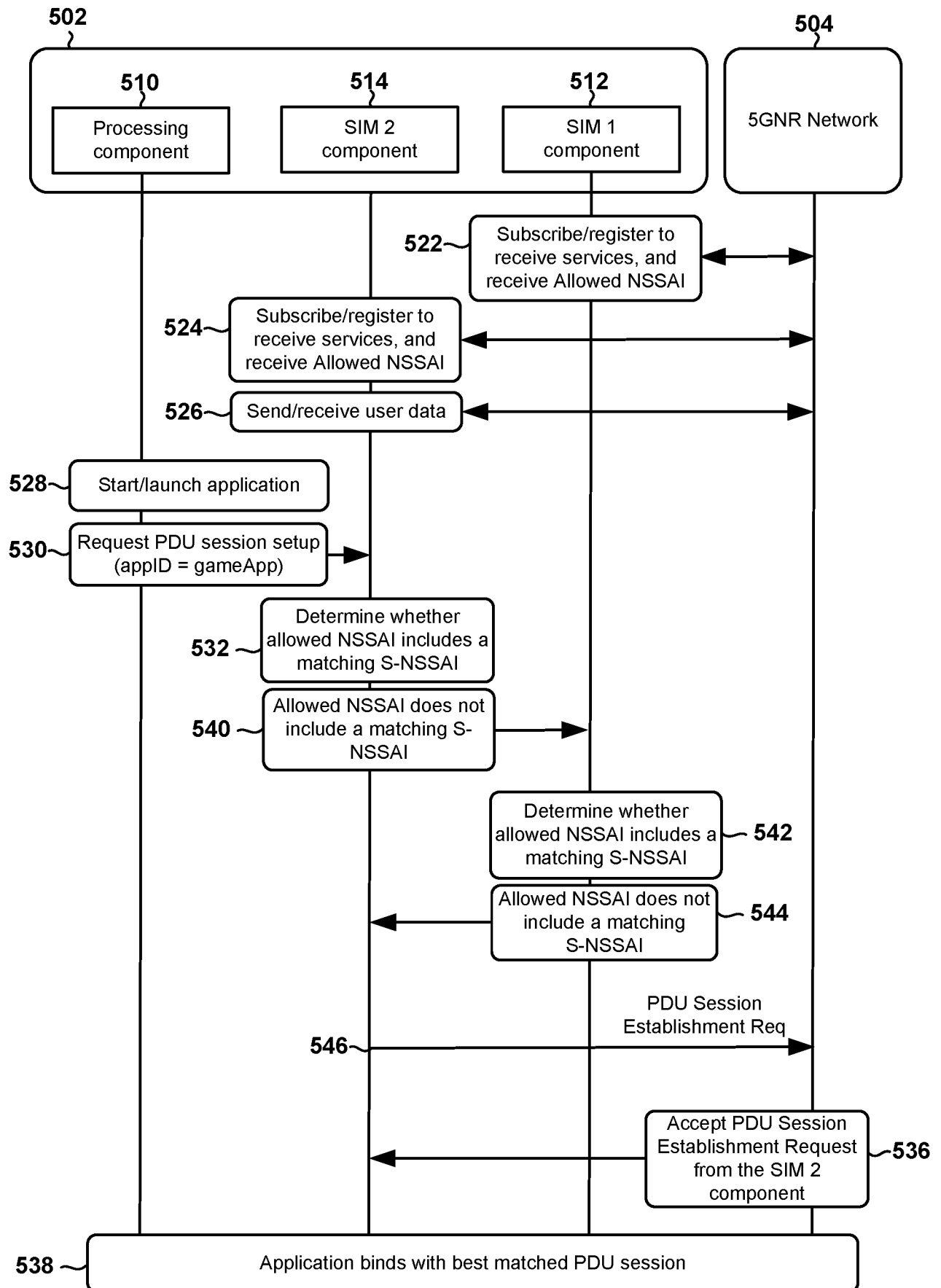


FIG. 5B

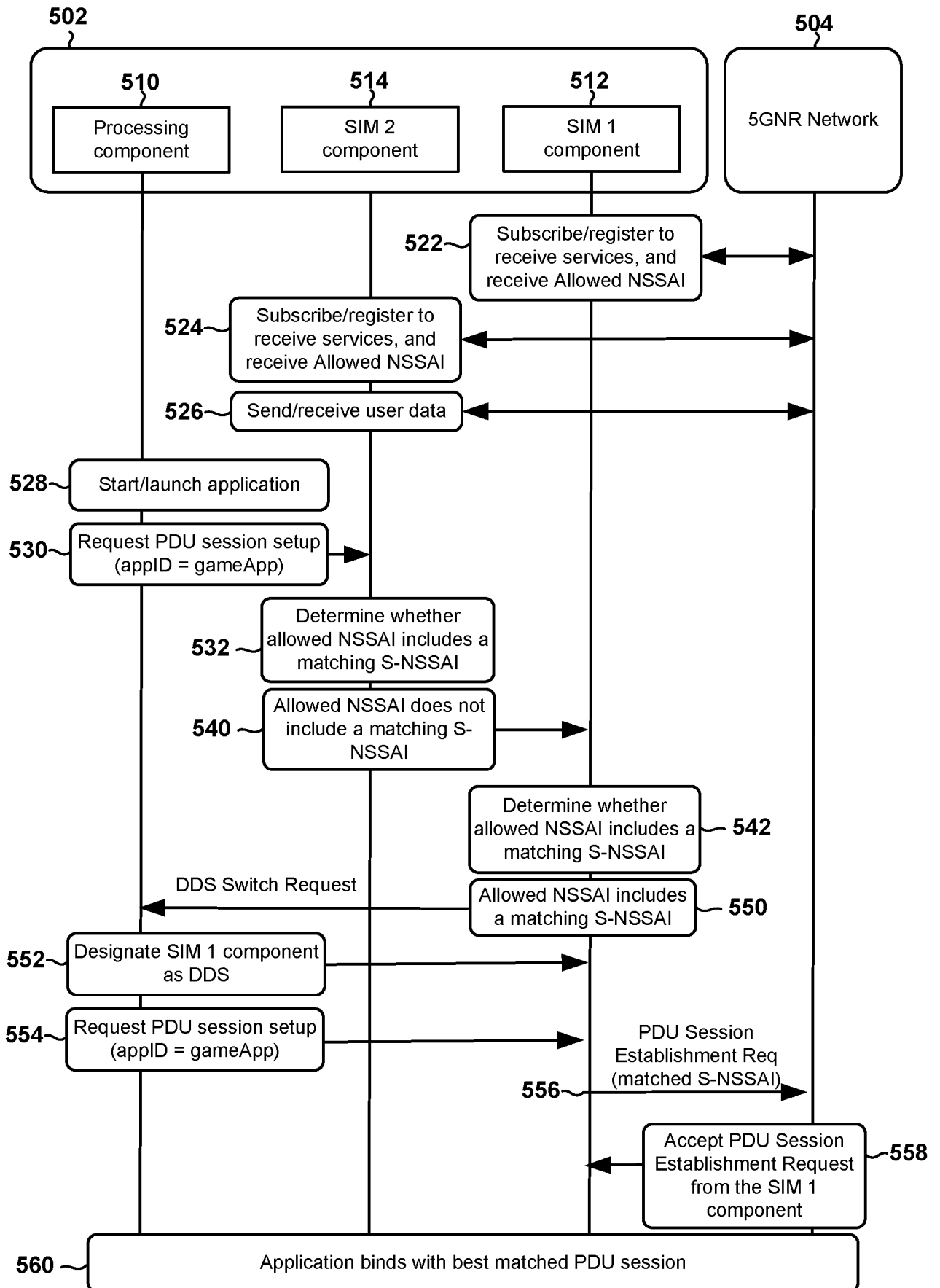


FIG. 5C

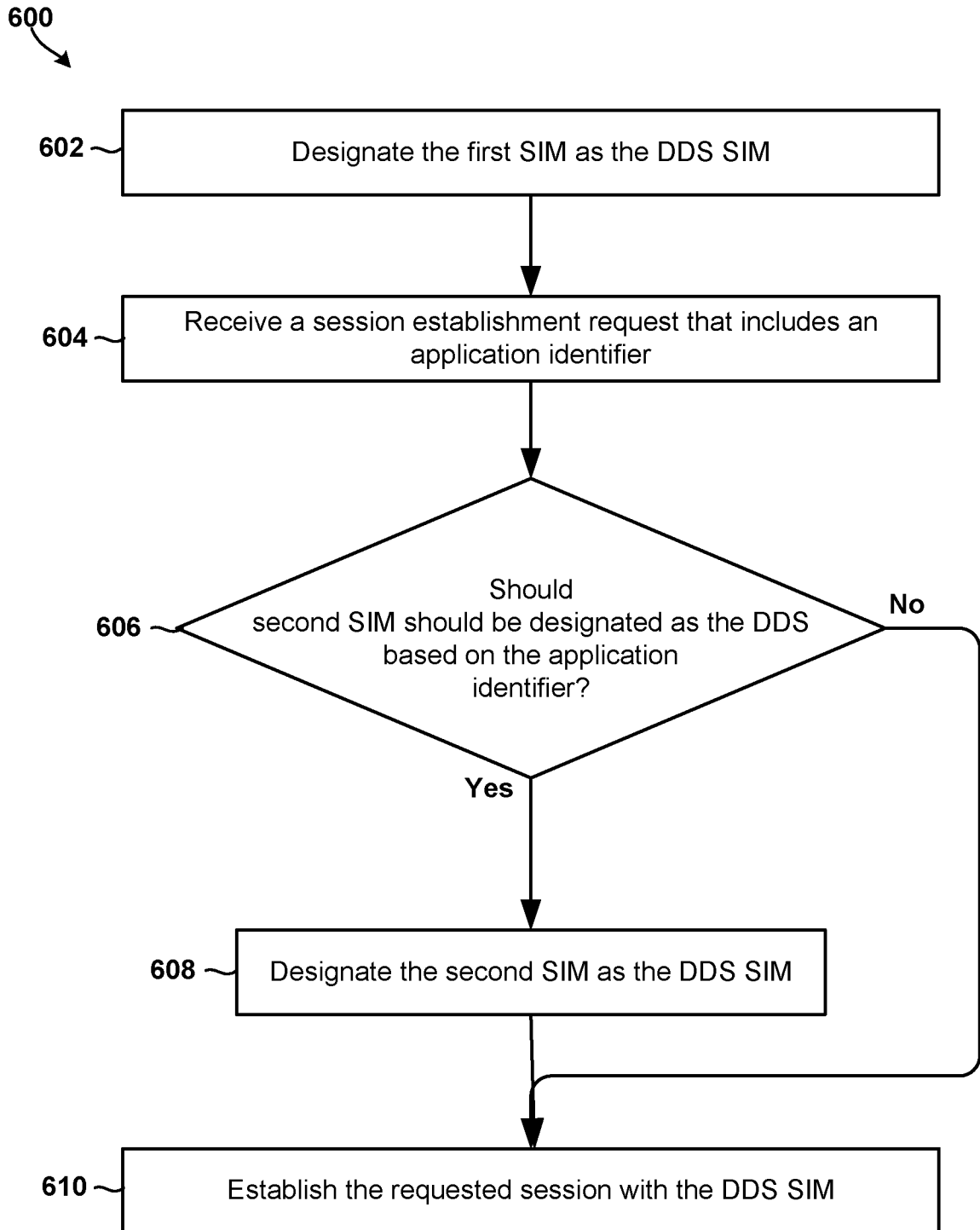


FIG. 6

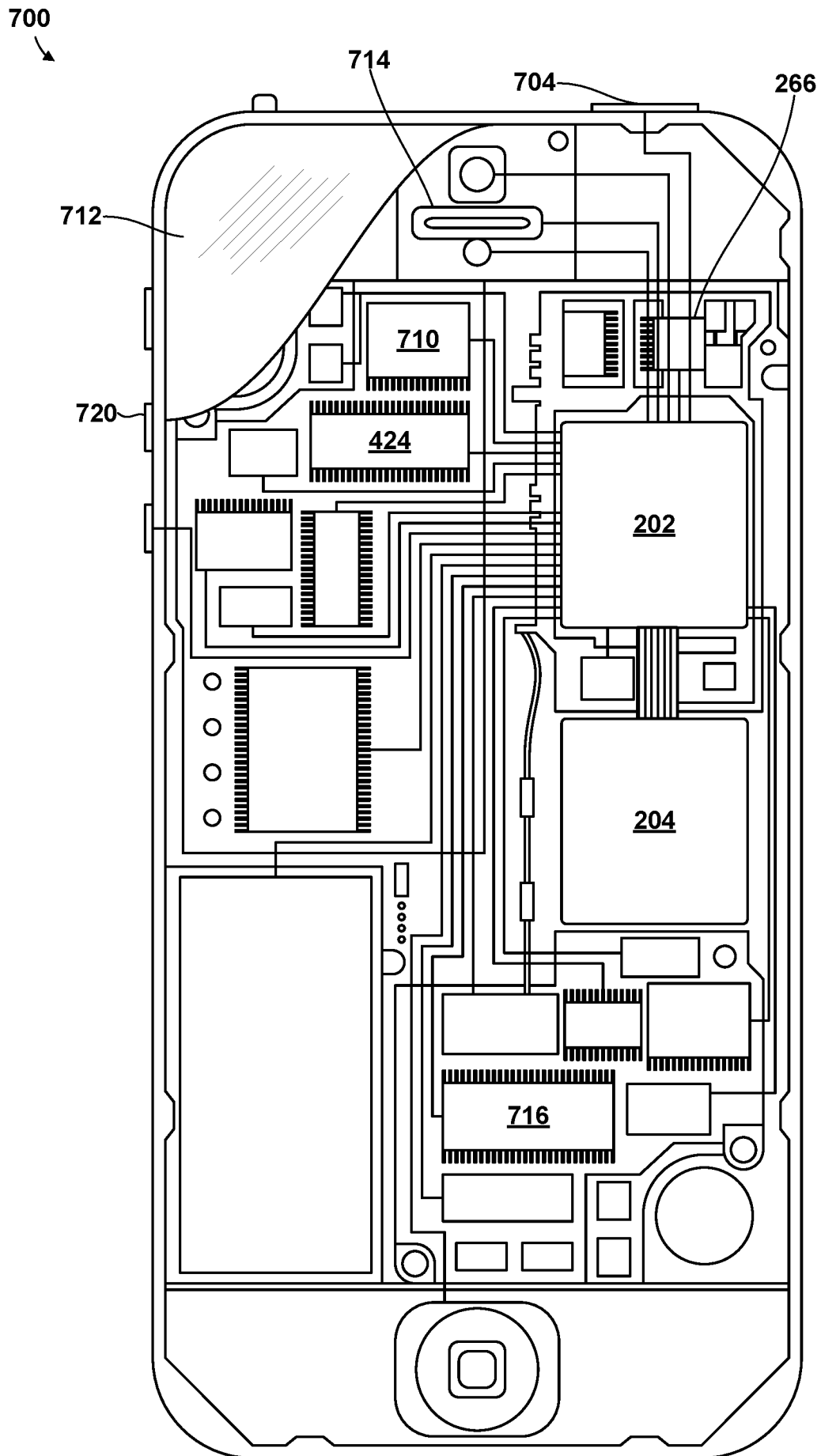


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2020/097713

A. CLASSIFICATION OF SUBJECT MATTER

H04W 8/18(2009.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04L; H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, VEN, USTXT, WOTXT, EPTXT, 3GPP: SIM, subscriber identity module, first, second, two, more, multi+, DDS, application, ID, identifier, determin+, designat+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 108848492 A (OPPO CHONGQING INTELLIGENT TECHNOLOGY CO) 20 November 2018 (2018-11-20) the description paragraphs [0044]-[0054] and [0109]	1-28
A	CN 107846678 A (ZTE CORP) 27 March 2018 (2018-03-27) the whole document	1-28
A	CN 107295594 A (GUANGDONG OPPO MOBILE COMMUNICATION CO L) 24 October 2017 (2017-10-24) the whole document	1-28
A	US 2020008143 A1 (QUALCOMM INC) 02 January 2020 (2020-01-02) the whole document	1-28



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

02 March 2021

Date of mailing of the international search report

11 March 2021

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Facsimile No. (86-10)62019451

Telephone No. 86-(010)-62088427

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2020/097713

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	108848492	A	20 November 2018	None			
CN	107846678	A	27 March 2018	WO	2018049859	A1	22 March 2018
CN	107295594	A	24 October 2017	CN	107295594	B	11 January 2019
US	2020008143	A1	02 January 2020	US	10708858	B2	07 July 2020