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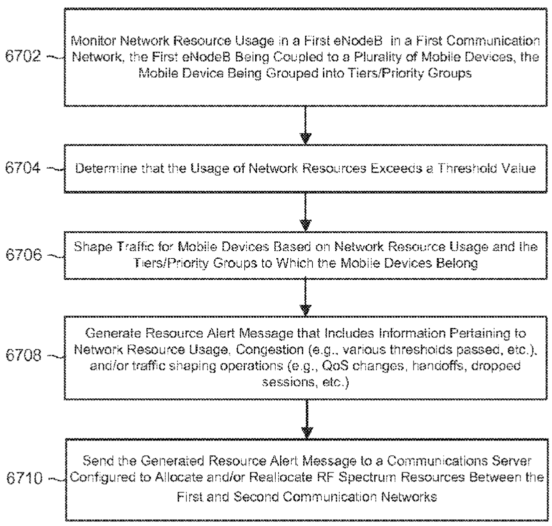

FIG. 67

(57) **Abstract**: Methods and system are provided for managing and monitoring allocation of RF spectrum resources based on time, space and frequency. A network may be enabled to allocate excess spectrum resources for use by other network providers on a real-time basis. Allocated resources may be transferred from one provider with excess resources to another in need of additional resources based on contractual terms or on a real-time purchase negotiations and settlements. A network may be enabled to monitor the use of allocated resources on real-time basis and off-load or allow additional users depending on the spectrum resources availability. Public safety networks may be enabled to make spectrum resources available to general public by allocating spectrum resources and monitoring the use of those resources. During an emergency, when traffic increases on a public safety network, the public safety networks may off-load bandwidth traffic to make available necessary resources for public safety users.

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Methods and Systems for Dynamic Spectrum Arbitrage

CROSS REFERENCE TO RELATED PATENT APPLICATIONS

[0001] This application claims priority to U.S. Patent Application No. 13/773,725 entitled "Methods and Systems for Dynamic Spectrum Arbitrage" filed on February 22, 2013, the entire contents of which is hereby incorporated by reference for all purposes.

BACKGROUND

[0002] With the ever increasing use of wireless communication devices for accessing networks and downloading large files (e.g., video files), there is an increasing demand for radio frequency spectrum. Smart phone users complain about dropped calls, slow access to the Internet and similar problems which are due largely to too many devices trying to access finite RF bandwidth allocated to such services. Yet parts of the RF spectrum, such as the RF bands dedicated to emergency services (e.g., police, fire and rescue, etc.) go largely unused due to the non-continuous and episodic employment of such voice-radio communication bands.

SUMMARY

[0003] According to a first embodiment, a method for dynamically managing radio frequency (RF) spectrum resources in frequency, space and time includes monitoring the use of RF spectrum resources at a first network and determining an amount of unused RF spectrum resources in the first network. The method includes allocating a portion of the amount of unused RF spectrum resources of the first network for use by secondary users and receiving a request for additional RF spectrum resources from a second network. The method includes providing the second network access to the unused RF spectrum resources of the first network. The method may include off-loading a secondary user from the first network.

[0004] According to another embodiment, a communication system comprising a server configured with server-executable instructions to perform operations comprises a dynamic spectrum arbitrage and management. The management enables radio frequency spectrum to be made available to RF devices in frequency, space and time as described herein. In another embodiment, a server configured with server-executable instructions to perform operations comprises a dynamic spectrum arbitrage and management. The management enables radio frequency spectrum to be made available to RF devices in frequency, space and time.

[0005] In another embodiment, radiofrequency spectrum clearinghouse includes a server for monitoring the use of RF spectrum resources. The clearinghouse determines an amount of unused RF spectrum resources in a first communication system and allocates a portion of the amount of unused RF spectrum resources for use by secondary users. The server forms allocated shares of the unused RF spectrum resources of the first communication system. The allocated shares are to be utilized by a second communication system. The server may communicate the availability of the allocated shares to the second communication system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate exemplary embodiments of the invention, and, together with the general description given above and the detailed description given below, serve to explain features of the invention.

[0007] FIG. 1 is a system block diagram illustrating call volume requests made to a cellular communication network under normal conditions.

[0008] FIG. 2 is a system block diagram illustrating call volume requests made to a cellular communication network under an emergency situation condition.

[0009] FIG. 3 is a system block diagram illustrating call volume requests made to a cellular communication network under an emergency situation condition when a first responder arrives on the scene.

[0010] FIG. 4 is a system block diagram illustrating call volume requests made to a cellular communication network as additional emergency response personnel arrive on the scene.

[0011] FIG. 5 is a system block diagram illustrating call volume requests made to a cellular communication network after an emergency situation has been alleviated.

[0012] FIG. 6 is a process flow diagram of an embodiment method for managing Tiered Priority Access (TPA) operations on a network.

[0013] FIG. 7 is a process flow diagram of another embodiment method for managing TPA operations on a network.

[0014] FIG. 8 is an example hierarchical table of classes of users given priority access to emergency communication resources.

[0015] FIG. 9 is a communication system block diagram of a Dynamic Spectrum Arbitrage (DSA) communication system according to an embodiment.

[0016] FIG. 10 is a communication system block diagram of a DSA communication system according to an embodiment.

[0017] FIG. 11 is a communication system block diagram of a DSA communication system according to an embodiment.

[0018] FIG. 12 is a communication system block diagram of a DSA communication system illustrating an embodiment for providing master control for the arbitrage process.

[0019] FIG. 13A is a diagram of RF spectrum illustrating its allocation according to an embodiment.

[0020] FIG. 13B is a diagram illustrating a manner in which RF spectrum may be allocated for use according to an embodiment.

[0021] FIG. 14 is a block diagram illustrating the manner in which RF spectrum may be allocated with a guard band for use according to an embodiment.

[0022] FIG. 15 is a diagram illustrating a manner in which RF spectrum may be pooled for use allocation according to an embodiment.

[0023] FIGs. 16A-16C are block diagrams illustrating a manner in which spectrum is allocated for Mobile Virtual Network Operators (MVNO).

[0024] FIG. 17 is a communication system block diagram of a DSA communication system illustrating communication between components of the system for allocating resources according to an embodiment.

[0025] FIG. 18 is a communication system block diagram illustrating communications between components of two networks in a DSA communication system during resource reservation according to an embodiment.

[0026] FIG. 19 is a communication system block diagram of a DSA communication system illustrating bifurcation of resources at an eNodeB according to an embodiment.

[0027] FIG. 20 is a communication system block diagram of a DSA communication system illustrating Serving Gateway (SGW) and Packet Gateway (PGW) link bandwidth allocation and capacity control according to an embodiment.

[0028] FIG. 21 is a communication system block diagram of a DSA communication system illustrating combining the x-furcation of resources at an eNodeB and SGW and PGW link bandwidth allocation with capacity control according to an embodiment.

[0029] FIG. 22 is a communication system block diagram of a DSA communication system illustrating spectrum allocation based on license and regional area methods according to an embodiment.

[0030] FIG. 23A is a diagram illustrating typical RF spectrum allocation in a licensed area according to an embodiment.

[0031] FIG. 23B is a diagram illustrating RF spectrum allocation in a DSA communication system based on license area according to an embodiment.

[0032] FIG. 24 is a diagram illustrating spectrum allocation in a DSA communication system based on regional area according to an embodiment.

[0033] FIG. 25A is a communication system block diagram of a DSA communication system illustrating a situation where the subscriber is using a first carrier (carrier A) according to an embodiment.

[0034] FIG. 25B is a communication system block diagram of a DSA communication system illustrating a situation in which a subscriber is using a second carrier (carrier B) in a de facto type roaming arrangement for spectrum off-loading according to an embodiment.

[0035] FIG. 26A is a communication system block diagram of a DSA communication system illustrating a situation in which the subscriber is using a first carrier (carrier A) for both public safety and commercial DSA schemes according to an embodiment.

[0036] FIG. 26B is a communication system block diagram of a DSA communication system illustrating a situation in which based on the services being used, geographic location or time the subscriber can use carrier B resources in a de facto short term lease using DSA according to an embodiment.

[0037] FIG. 27A is a communication system block diagram of a DSA communication system illustrating a normal operation situation according to an embodiment.

[0038] FIG. 27B is a communication system block diagram of a DSA communication system illustrating additional capacity and spectrum made available for use by a subscriber according to an embodiment.

[0039] FIG. 28 is a process flow diagram illustrating an embodiment method for network selection and reselection in a DSA communication system.

[0040] FIG. 29 is a communication block diagram of a DSA communication system illustrating TAI routing areas where the home non-DSA user equipment uses one TAI element (TAI) and DSA user equipment use another TAI.

[0041] FIG. 30 is a communication block diagram of a DSA communication system illustrating high level tracking and monitoring of RF spectrum resource allocations and use according to an embodiment.

[0042] FIG. 31 is a communication block diagram of a DSA communication system illustrating integration required for full mobility between visiting and home networks.

[0043] FIG. 32 is a communication block diagram of a DSA communication system illustrating media independent handover of user equipment from one network to another according to an embodiment.

[0044] FIG. 33 is a communication block diagram of a DSA communication system illustrating data flow for initiating a network handover according to an embodiment.

[0045] FIG. 34 is a communication system block diagram of a DSA communication system illustrating providing user equipment access to several Radio Access Terminals (RAT) according to an embodiment.

[0046] FIG. 35 is a message flow diagram illustrating message communications between components of a DSA communication system according to an embodiment.

[0047] FIGs. 36-40 are process flow diagrams of embodiment methods for allocating and accessing resources using the DSA communication system.

[0048] FIG. 41 is a message flow diagram illustrating in more detail message communications between components of a DSA communication system according to an embodiment.

[0049] FIGs. 42-44 are process flow diagrams of embodiment methods for off-loading communication sessions from a host network.

[0050] FIGs. 45-49 are process flow diagrams of embodiment methods for allocating and accessing resources in a public safety network using the DSA communication system.

[0051] FIGs. 50-53 are process flow diagrams of embodiment methods for off-loading communication sessions from a public safety network.

[0052] FIGs. 54-56 are process flow diagrams of embodiment methods for enabling an authorized public safety authority to access the public safety network using a wireless device from another network.

[0053] FIGs. 57A and57B are system block diagrams illustrating network components in an example communication system suitable for use with the various embodiments.

[0054] FIG. 58 is a system block diagram illustrating user classes and tiers in a long term evolution (LTE) cellular communication network in accordance with an embodiment.

[0055] FIGS. 59A and 59B are table diagrams illustrating various combinations of classes and tiers in accordance with various embodiments.

[0056] FIGS. 60A and 60B are example table diagrams illustrating various arrangements of triggers or threshold values for resources.

[0057] FIGS. 61A and 61B are process flow diagrams of embodiment methods of managing internal tiered priority access (ITPA) operations in a network.

[0058] FIG. 62 is a call flow diagram illustrating an embodiment method of performing DSA operations that includes origination and handin restrictions.

[0059] FIG. 63 is a call flow diagram illustrating an embodiment method of performing DSA operations that includes quality of service (QoS) degradation.

[0060] FIG. 64 is a call flow diagram illustrating an embodiment method of performing DSA operations that includes handoffs.

[0061] FIG. 65 is a call flow diagram illustrating an embodiment method of performing DSA operations that includes session termination.

[0062] FIG. 66 is a process flow diagram illustrating an embodiment method of performing DSA operations.

[0063] FIG. 67 is a process flow diagram illustrating an embodiment eNodeB method of performing DSA operations.

[0064] FIG. 68 is a process flow diagram illustrating an embodiment controller method of performing DSA operations.

[0065] FIG. 69 is a component block diagram of an example mobile device suitable for use with the various aspects.

[0066] FIG. 70 is a component block diagram of a server suitable for use with an embodiment.

DETAILED DESCRIPTION

[0067] The 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 implementations are for illustrative purposes, and are not intended to limit the scope of the invention or the claims.

[0068] As used herein, the terms "mobile device," "wireless device" and "user equipment (UE)" may be used interchangeably and refer to any one of various cellular telephones, personal data assistants (PDA's), palm-top computers, laptop computers with wireless modems, wireless electronic mail receivers (e.g., the Blackberry® and Treo® devices), multimedia Internet enabled cellular telephones (e.g., the iPhone®), and similar personal electronic devices. A wireless device may include a programmable processor and memory. In a preferred embodiment, the wireless device is a cellular handheld device (e.g., a mobile device), which can communicate via a cellular telephone communications network.

[0069] As used in this application, the terms "component," "module," "engine," "manager" 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, a computer, a server, network hardware, etc. By way of illustration, both an application running on a computing device and the computing 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.

[0070] 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), long term evolution (LTE) systems, third generation wireless mobile communication technology (3G), fourth generation wireless mobile communication technology (4G), 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, CDMA2000TM), 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), public switched telephone network (PSTN), Wi-Fi Protected Access I & II (WPA, WPA2), Bluetooth®, integrated digital enhanced network (iden), and land mobile radio (LMR). 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.

[0071] A high priority in responding to any emergency or disaster situation is establishing effective communications. In large scale emergency or disaster (both manmade and natural) situations, it is paramount to maintain communications between all first responders and emergency personnel in order to respond, manage, and control the emergency situation effectively. In the absence of effective communication among first responders and other emergency personnel, resources may not be effectively mobilized to the areas which need the resources most. Even in minor emergency situations (e.g., traffic accidents and fires), first responders must be able to call on support assets and coordinate with other services (e.g., public utilities, hospitals, etc.). With the ubiquity of wireless device ownership and usage, emergency communication via wireless devices using commercial cellular communication networks often are the most efficient and effective means to mobilize emergency response personnel and resources. Enabling wireless devices to provide effective emergency communications obviates the technical challenges and expense of coordinating radio frequencies among various first responder agencies (e.g., police, fire, ambulance, FEMA, public utilities, etc.). Also, qualified first responders to an accident who are off duty or not ordinarily equipped with radios (e.g., doctors, nurses, retired police, or military personnel) will have or can quickly borrow a wireless device.

[0072] Emergency communications over cellular communication networks is not without problems, however. As discussed above in the Background, cellular communication networks ("networks") are designed to accommodate access requests from only a fraction of the total number of wireless devices in a particular cell. At times of emergency or crisis, network resources may become overtaxed when predictable human responses to the situation prompt an extraordinary number of wireless device users within a particular cell to access the network at the same time. Wireless device users may be attempting to alert emergency personnel of the emergency situation (such as a 911 emergency call) or to alert friends or family members that the user is safe despite being in the area of an emergency situation. Some users may be transmitting images of the emergency condition (fire, accident, etc.) to news services or friends. In a wide scale situation, emergency responders using wireless devices for emergency communications will add to the call volume. Regardless, the predictable increase in call volume during an emergency situation can overwhelm a commercial cellular communications network, particularly in the cell zone encompassing the emergency, thus rendering the network unreliable for emergency response personnel communication usage.

[0073] To illustrate the problem, consider the case of a traffic accident occurring on the highway. FIG. 1 illustrates a cellular communication network under normal conditions. As illustrated, multiple wireless devices 101(a-g) are wirelessly connect to the cellular communication network via a base station 102 servicing a particular cell 100. The base station 102 connects via a base station controller (BSC)/radio network controller (RNC) 103 to a Mobile Switching Center (MSC) 104. The MSC 104 contains both a public switched telephone network (PSTN) interface and an Internet interface. Calls made to and from any of the multiple wireless devices 101(a-g) may be routed via conventional landlines over the PSTN 105 or Internet 106 using VOIP. Calls between conventional landline telephone stations and any one of wireless devices 101(a-g) may be routed over via the PSTN or Internet. Calls between wireless devices 101(a-g) may be routed over the PSTN or Internet to similar MSC 104, BSC/RNC 103, and base station 102 located near the initiating or intended wireless device 101(a-g).

[0074] FIG. 1 illustrates the typical situation in which a fraction of the wireless devices within a cell access the network at the same time. For example, FIG. 1 shows seven separate wireless devices 101(a-g) located within the cell, only three of which (101c, 101d, and 101e) are currently accessing the network. Thus, the network is operating well within its operating parameters and all requests to the network from wireless devices 101(a-g) are granted. It is noted that all wireless devices 101(a-g) that are turned on but not in use continue to communicate with the base station 102 via a link management channel (not illustrated). The network uses these communications to keep track of the wireless devices 101(a-g) within each cell to support call routing. However, the amount of information communicated between all wireless devices 101(a-g) and the base station 102 for such tracking purposes is small (particularly in contrast to the bandwidth required for a normal telephone call), so the number of on-but-inactive wireless devices 101 within a cell normally will not overwhelm the network.

[0075] This normal functioning of the cellular network can be disrupted when, for example, an accident stops traffic, prompting delayed drivers to simultaneously use their wireless devices to alert emergency personnel of the traffic accident (emergency 911 call) or contact friends, family members, business associates, etc., to inform them of the delay. FIG. 2 illustrates a cellular communication network in such an emergency situation. In this illustration, a truck 107 in the vicinity of base station 102 is on fire. Predictably, the truck 107 fire prompts most of the wireless devices 101(a-g) users within the vicinity to access the cellular network at approximately the same time. This causes an overload condition in the cell by exceeding the bandwidth of the carriers on the local base station 102. Consequently, some of the wireless devices 101b, 101f will not be granted access to the network, and new network access requests may be denied until communication channels open up. This communication bottleneck may worsen the emergency situation by delaying the response by emergency personnel and denying first responders with effective communication over the network.

[0076] This problem is exacerbated in disaster situations involving many victims and large areas, such as wildfires, floods, hurricanes, tornados and terrorist attacks. As witnessed during the September 11th attack and Hurricane Katrina, large disasters can destroy part of the cellular and landline telephone network infrastructure, leaving the remaining network more vulnerable to overload conditions. Network overloads during disaster events are particularly troublesome since such situations naturally involve widespread confusion and require close coordination among a large number of emergency and relief personnel.

[0077] If a disaster situation will persist long enough (e.g., a flood or hurricane situation), additional cellular communication capacity can be added to a region by activating a deployable cellular communication system to provide emergency response teams and personnel with the ability to communicate. Such recently developed deployable units, referred to herein as a "switch on wheels," can include a CDMA2000 base station and switch, Land Mobile Radio (LMR) interoperability equipment, a satellite Fixed Service Satellite (FSS) for remote interconnection to the Internet and PSTN, and, optionally, a source or remote electrical power such as a gasoline or diesel powered generator. A more complete description of an example deployable switch on wheels is provided in U.S. Patent Application No. 12/249,143, filed October 10, 2008, the entire contents of which are hereby incorporated by reference in their entirety.

[0078] These switch on wheels are effectively mobile cellular base stations which may be deployed in a disaster area and operate as a cellular tower antenna. The switch on wheels sends and receives communication signals from a plurality of wireless devices 101 and serves as a gateway portal to the rest of the conventional communications infrastructure. Communications between the switch on wheels and a wireless device 101 is broken down into packets for transport as a VOIP communication, and may be transmitted via satellite to a ground station outside the disaster area from which the call is forwarded through the telephone network to the recipient. Even with the added bandwidth provided by deployable switch on wheels, network overloads may still cause communication delay and frustration to emergency response personnel.

[0079] To overcome such problems in the event of a national emergency, the WPA system was developed. Conventional WPA systems provide selected emergency leadership with preemptive access to cellular communication networks. However, conventional WPA systems do not permit calls made to the wireless device of a registered WPA authority. In other words, while wireless devices registered for WPA service may be given priority access for placing calls on the network, there are no provisions in the WPA system enabling those very same wireless devices to receive calls. Incoming calls to wireless devices in a command center may be just as important as outgoing calls. Also, conventional WPA systems assume that if an authorized user needs to make a call, the call will be made from their pre-registered wireless device. However, there may be instances where the authorized personnel do not have their pre-registered wireless device. Alternatively, the wireless device may be damaged. Provisions must be made to enable the authorized personnel access to an overloaded network. Also, emergency personnel who have not previously registered their wireless device on the WPA system cannot access overloaded cellular communication networks "on the fly." Many times, off duty, junior, volunteer emergency response personnel may be the first responders on the scene on an incident. Such personnel may not be entitled to conventional WPA which is designed to address the needs of the leadership. Thus, precisely the personnel who can quickly alleviate a situation given their proximity on the scene are unlikely not pre-registered and authorized for conventional WPA.

[0080] To overcome these limitations with conventional cellular communication networks and conventional WPA, the various embodiments provide Tiered Priority Access (TPA) capabilities to deliver Quality of Service (QoS)/Grade of Service (GOS) wireless device communications for first responders for calls both originated and terminated at a mobile handset. The various embodiments are particularly aimed at the needs of first responders at the very start of an emergency event.

[0081] TPA as its name implies aims to provide a tiered response to network capacity requirements. The tiered response mirrors typical communication requirements at the incident scene as more responders appear to help resolve the problem(s) at hand. When an incident occurs first responders are either at the incident scene or begin to respond. First responders reporting to an incident initially arrive on scene in small numbers and may grow in direct response to the magnitude and severity of the incident.

[0082] To accommodate this predictable response, TPA enables an escalation and de-escalation process based upon call volume as first responders arrive on scene and depart as the situation is restored to normal.

[0083] In overview, the various embodiments work as follows. During normal operation, cellular call volume through particular base stations is monitored to determine if the network is reaching capacity limits. Call volume may be monitored based on current calls, attempts to access the network, engaged bandwidth, or other methods known to cellular service providers. Call volume may be locally monitored at the base station 102, at a BSC/RNC 103, or an MSC 104 or, in an embodiment, centrally, such as in a Network Operation Center (NOC). Such monitoring is at the cellular level, since normal emergency situations are most likely to impact one or two cell zones, although TPA will work in a similar fashion in the event of a widespread emergency. When call volume in a cell exceeds a threshold value preselected by the service provider and/or emergency response planners, the system allocates one channel in the affected cell tower to TPA operation.

[0084] FIG. 2 illustrates a situation in which call volume has exceeded a threshold indicating that TPA should be implemented. As shown in FIG. 2, more wireless devices 101 in the cell supported by the base station 102 are attempting to access the network than the network can connect. As a result, only some of the wireless devices 101a, 101c, 101d, 101e and 101g will be able to place or receive calls (shown as solid black), while others will be denied access to the network (shown as white). In this situation, call volume within the cell served by the base station 102 has exceeded the threshold, so one of the communication channels on the antenna will be allocated to TPA operation. However, the channel remains available to general public use until a TPA-authorized call is placed. Thus, no change in the communication network is shown in FIG. 2.

[0085] The various embodiments address this overload condition in order to allow emergency personnel to use the cellular communication network as they arrive on scene, as is illustrated in FIG. 3. When an emergency responder 108 arrives on scene, that individual may initiate a wireless telephone call. If a communications channel has been allocated to TPA operation and the emergency responder's wireless device is pre-registered as a TPA-authorized wireless device, the network can recognize the pre-registered TPA authorized wireless device from the wireless device's unique ID and recognizes the call as a TPA-call. The base station 102, BSC/RNC 103 or the MSC 104 may ensure the TPA call is connected. If necessary, the bandwidth allocated to civilian wireless device users is reduced and one or more non-emergency calls may be dropped to enable the TPA call to be connected. This is illustrated in FIG. 3 as the connection to wireless device 101c has been dropped and denied further access to the network (illustrated as a white lightning bolt), and the TPA call (illustrated as a dashed black lightning bolt) by the emergency responder 108 is connected.

[0086] As additional emergency personnel 109 arrive on scene of the emergency, additional TPA calls may need to be connected as illustrated in FIG. 4. To accommodate the increase in TPA calls, additional network resources may be automatically allocated to TPA operation in order to provide emergency responders reliable cellular communications. This is illustrated in FIG. 4 which shows connected TPA calls with police 108 and fire 109 personnel (illustrated as a dashed black lightning bolts), while wireless devices 101c and 101d have been disconnect (illustrated as a white lightning bolts). Automatically allocating more resources to TPA use reduces the bandwidth available to the general public, which will limit general access to the network. However, emergency personnel are provided reliable access to the network so long as the heavy call volume persists.

[0087] Eventually the emergency situation will be resolved and emergency personnel will begin to scene. As conditions return to normal, civilian call volume should return to normal levels while the number of emergency responders requiring TPA-access will also decline. This is illustrated in FIG. 5 which shows that the fire has been extinguished and firemen have left the scene. As traffic begins returning to normal flow fewer general population wireless devices 101a-g access the network simultaneously. With cellular communications returning to normal, cellular communications resources may be released from TPA operations, restoring the network to normal operations. As illustrated, the remaining emergency personnel 108 are connected to the cellular communication network in the normal fashion as the call volume has decreased to the point that TPA operation has been terminated.

[0088] When TPA operation is implemented on one or more communication channels, the cellular system (e.g., locally in the base station , BSC/RNC, or MSC, or in a central location such as a NOC) monitors incoming and outgoing calls to determine whether any calls are coming from or directed to emergency response personnel. This may be accomplished by recognizing an originating or destination wireless device as being TPA pre-registered wireless device. Alternatively, the system may recognize emergency response personnel when they complete a special dialing procedure such as the *272 dialing procedure described below.

[0089] Wireless devices can be pre-registered for TPA use by authorized users. This may be accomplished by registering as a qualified emergency responder (e.g., according to criteria established by governmental authorities) with the cellular network provider. As is well known in the telecommunications art, all wireless devices 101 which access the cellular communication are assigned a unique identification number. In the pre-registration process, the cellular network provider stores the wireless device's unique identification number in a database of authorized TPA personnel. The cellular network provider may also issue the individual a unique Personal Identification Number (PIN) for use in implementing TPA preemption from a non-TPA wireless device as described more fully below.

[0090] If the emergency responder's wireless device is not pre-registered (such as a borrowed phone), and the network is overload, the emergency responder may be unable to access network resources. In this situation, the emergency responder can activate the embodiment TPA from a non-registered wireless device 101 by first dialing *272 followed by a personal identification number (PIN) and the telephone number. The nearest base station 102 to the non-registered wireless device 101 receives the transmission from the wireless device 101 indicating that the wireless device is initiating a call. The base station 102 (or BSC/RNC 103 connected to the receiving base station) recognizes the *272 special dialing prefix and starts to route the call to the appropriate destination. Alternatively, recognition and routing of the #272 dialing prefix may be accomplished at the MSC 104. This destination may be the closest PSAP or central location with a database of PINs. The *272 call is similarly processed at the BSC/RNC 103 and later MSC 104 as the call proceeds through the communication network system. The BSC/RNC 103 and MSC 104 controlling the base station antenna 102 and other associated antennae are programmed to recognize the special dialing procedure using a database of pre-registered first responder PINs. This PIN database may be stored at the MSC 104 or at another central location such as a NOC. If the received PIN matches a record in the PIN database, the MSC 104 may immediately give the caller preemptive access to the network just as if the call had been made from a TPA-registered wireless device as described above. In order to support this capability, a TPA-allocated channel reserves sufficient open capacity during TPA-operation to receive and recognize *272 dialed calls. If the communication channel is at capacity and a dialed number does not begin with *272, the call is promptly dropped with no attempt to complete the call. However, if the dialed number begins with *272, the MSC 104 completes the process of comparing the entered PIN to the PIN database and the temporarily registering the call as a TPA-authorized wireless device. Non-TPA calls may be dropped if necessary in order to retain sufficient capacity to receive and recognize *272 calls.

[0091] While reference is made throughout the application to the MSC 104 monitoring and providing the TPA capability, it should be appreciated by one of skill in the art that other elements of the communication system may implement the various method steps. These elements may include, but are not limited to equipment collocated with the base station antenna 102, the BSC/RNC 103, or a NOC.

[0092] Once a wireless device has been recognized as a TPA-phone by means of the *272 dialing procedure, the MSC 104 will track the wireless device and continue to treat it as if it were a TPA-registered wireless device so long as at least one communication channel is allocated to TPA operation. Using the unique identification number assigned to the wireless device, the MSC 104 will recognize subsequent calls from the wireless device as TPA-calls without the need for the user to repeat the *272 dialing procedure. Similarly, the MSC 104 can identify incoming calls to the first responder that should receive TPA preemption service. Thus, a first responder 108 using a non-registered wireless device can register the wireless device “on the fly” when TPA is implemented for both incoming and outgoing calls by using the *272 dialing procedure to call one number (such as a dispatcher or "911").

[0093] In an embodiment, a TPA authorized user with a PIN can authenticate any number of wireless devices using the *272 dialing procedure described above. This embodiment will enable first responders, such as a policeman, fireman or emergency medical technician, to "deputize" volunteers, such as military personnel, doctors or retired policemen that they find on the scene, thus creating a reliable ad hoc emergency communication network. Since the temporary TPA-authorization of a wireless device established by the *272 dialing procedure is rescinded as all communication channels in the affected area return to normal operation (i.e. cease TPA operation), there is limited concern that the TPA system could be compromised for subsequent emergencies provided the authorized user's PIN is not revealed. Even if the PIN is revealed, the PIN can be easily changed without significant impact since TPA implementation is expected to be an infrequent, random and episodic event.

[0094] In a further embodiment, a user of a TPA-registered wireless device who does not have (or forgot) a PIN can register another phone "on the fly," thereby "deputizing" it for the duration of the TPA event by simply initiating the special dialing procedure on any wireless device. For example, the first responder may use a TPA-registered wireless device to dial the number of the wireless device to be "deputized" followed by *272 (any dialing prefix or postscript may be used). When this call is received by the MSC 104, the *272 prefix or postscript is recognized as indicating that the dialed number is to be treated as a temporary TPA-authorized wireless device, allowing it to store the unique ID of the called wireless device in a database for tracking such temporary TPA authorizations. Using this capability, a first responder can quickly deputize one or more volunteers simply by calling their numbers.

[0095] In still a further embodiment, emergency response personnel whose position does rise to the level of qualifying for pre-registration TPA service or PIN may still be the first emergency personnel on the scene of an emergency situation. The user may use his/her non pre-registered wireless device to initiate a *272 special dialing procedure. The call may be forwarded to a PSAP which may issue a temporary PIN and add the wireless device to the database of temporary TPA authorizations.

[0096] Alternatively, if the user initiates a *272 special dialing (or similar dialing procedure such as 911), the call may be forwarded to a PSAP. In large scale crisis situations, the answering PSAP may be disabled or unable to answer quickly due to the large incoming call volume. In such situations, if the *272 call is not answered by the PSAP within a predetermined time frame a temporary TPA authorization may be automatically issued. Since the circumstances surrounding the issuance of the temporary TPA authorization have not been fully analyzed by a PSAP operator, it is unclear whether the user receiving the temporary TPA authorization is properly authorized. Accordingly, the temporary TPA authorization may be flagged on the PSAP monitor for possible deactivation or investigation.

[0097] In a further embodiment, the cellular network is configured to give calls from a TPA-registered wireless device and (optionally) temporary TPA-authorized wireless devices priority when dialing to a civilian (i.e., non-TPA authorized) wireless device within the cell zone(s) implementing TPA operations. When such a call is made, the MSC 104 is programmed to route the call to the dialed wireless device through the communication channel or channels allocated to TPA operation. If a TPA-allocated channel is at capacity when the call from a TPA-authorized wireless device is received for a civilian wireless device, another civilian wireless device call is dropped in order to provide sufficient capacity to complete the call, with the associated preemption process being used to prevent another 911 call from being dropped. This embodiment gives emergency personnel the ability to dial-into an emergency. For example, emergency personnel can use this capacity to call back a civilian who initially called 911 to report an emergency in order to request an update from a potential eye witness. As another example, a first responder can call volunteers within the emergency scene without deputizing their phones, assured of being able to reach the volunteers even though the communications network is otherwise overwhelmed.

[0098] TPA operations may be implemented in at least two embodiments of the present disclosure. In a first embodiment described below with reference to FIG. 6, one or more cellular communication channels are dedicating to TPA calls, providing emergency personnel with dedicated communication capacity while leaving the remaining communication channels to the general public. In a second embodiment described below with reference to FIG. 7, call preemption for TPA calls is implemented only as a TPA allocated communication channel reaches capacity. These embodiments are described separately below.

[0099] FIG. 6 illustrates an example process flow of steps that may be taken to implement the first embodiment of TPA that may be operable with a computing device having a processor. During normal operations cellular communication network call volume is monitored, block 201. In particular, the cellular communication network call volume (or number of access requests or engaged bandwidth) are compared against a predetermined threshold (for example 85% of maximum capacity), block 202. If the call volume is below the predetermined threshold a normal situation is assumed to exist, so the monitoring process returns to block 201 to continue monitor call volume. If, however, the call volume (or number of access requests or engaged bandwidth) exceeds the predetermined threshold, an abnormal situation exists which may indicate that an emergency situation is unfolding. To prepare for an emergency situation, network resources (e.g., communication channels on a particular base station antenna) are partitioned and reserved for TPA use, block 203. By automatically allocating a communication channel to TPA use, the system permits a TPA-authorized wireless device to gain access to the network, even when the network is otherwise overloaded. However, TPA preemption does not occur until a TPA-qualified caller attempts to access an overloaded network.

[0100] Since the increased call volume may or may not be in response to an emergency situation, a communication channel allocated to TPA continues to function normally, by handling civilian (i.e., non-TPA) calls in the ordinary fashion. In instances where the increased call volume is simply due to coincidental network requests and no TPA-qualified user is attempting to place a call, call preemption enabled by TPA is not needed. Thus, the TPA threshold may be exceeded and TPA implemented even when there is no actual emergency incident. Delaying actual implementation of TPA preemption until the service is required by a first responder increases the reliability of the network under normal circumstances.

[0101] The system may be informed that an actual emergency situation is occurring indicated by a TPA-authorized emergency response personnel placing a TPA call within the affected cell zone. When the communication channel is in TPA mode, the cellular system (be it at the base station, BSC/RNC/MSC, or in a central location such as a NOC) monitors incoming and outgoing calls to determine whether any emergency response personnel is using a TPA-pre-registered wireless device or has completed a special dialing procedure invoking TPA preemption, block 204. If no emergency response personnel has initiated a call using a TPA-authorized wireless device or the special dialing procedure, the system may continue to monitor access requests, in block 204, as well as call volume, in block 201, to determine if the communication channel should be released from TPA operation, block 202.

[0102] If a call is initiated by a TPA-authorized wireless device, or if the call is generated from a non pre-registered wireless device using the *272 dialing procedure, TPA is initiated, block 205. When TPA is initiated, block 205, only emergency personnel previously registered or given clearance “on the fly” will be permitted access to the partitioned and reserved network resources. As noted above, TPA will normally be implemented on a single communication channel initially, leaving the remaining channels to general public use. Then, if TPA-use exceeds the capacity of the TPA-allocated network resources another resource can be converted to TPA operation. By dedicating network resources to emergency personnel use one channel or one resource at a time, the remaining network resources are left available for non-essential general public use. In addition, by dedicating network resources for emergency personnel communication, emergency personnel are able to both send and receive calls on their wireless devices.

[0103] In an optional embodiment, upon the initiation of TPA, block 205, the MSC 104 may survey the wireless devices 101 located within the affected cell or serviced by other base station antennae 102 within the same BSC/RNC 103, to identify all registered or temporarily registered first responders. These first responders may be advised via SMS message (or other methods) that they can utilize the TPA service by placing a call or using the special dialing procedure, block 206.

[0104] In a further optional embodiment, the base station 102, BSC/RNC 103, or MSC 104 may also send messages to all non-emergency wireless devices 101a-g within the affected area/cell 100 advising them to avoid using their wireless device 101a-g except for Emergency 911 calls and to indicate that emergency services have been notified, block 207. This messaging may be initiated by the PSAP responsible for the incident area, by the local incident Command and Control authority, or by the network service provider. Such messages may be delivered via SMS message or other communication means. The system may also notify callers connected to the channel allocated to TPA use that their calls are being terminated prior to disconnecting the calls.

[0105] As the emergency situation continues to unfold and additional emergency response personnel appear on the scene, additional network resources may be required to support emergency personnel communication. Accordingly, the partitioned and dedicated network resource may be monitored to determine if additional network resources should be partitioned and allocated to TPA. This may be accomplished by comparing the call volume on the partitioned and dedicated network resource to a predefined maximum or minimum threshold, block 208. If call volume exceeds a predefined maximum (indicating an escalating situation), for example 25% usage of the partitioned and dedicated network resources in the cell site/sector, additional dedicated network resources may be partitioned to TPA operation, block 211, to allow emergency response personnel to communicate.

[0106] In an embodiment, before terminating calls in order to allocate the additional channel to TPA operation, non-essential (i.e., non-emergency personnel) wireless devices 101 that have a call or data sessions in progress with the allocated channel may be informed with a warning tone and/or recorded announcement that their call is being terminated unless a defined code is entered, block 210. This permits first responders to maintain their calls by quickly entering a code (e.g., their PIN). If an in process call is an emergency 911 call, the defined code may be supplied by a PSAP.

[0107] In an embodiment, the system will continue to automatically retrieve and re-allocate network resources for emergency response personnel communication until all available network resources are dedicated to emergency response personnel use. Such an embodiment will maximize communication capabilities of emergency response personnel. Other embodiments may reserve at least a minimum portion of network resource (e.g., one communication channel) to enable the general public the ability to alert emergency response personnel to new or developing emergency situation, such as by placing 911 calls. Accordingly, other embodiments may impose maximum limits to the amount of network resources that are taken away from the general population and dedicated to emergency response personnel communication. To accomplish this, the MSC 104 may determine whether the maximum amount of network resources have been partitioned and dedicated to emergency response personnel communication, in block 209. If the maximum amount of network resources have already been partitioned and dedicated, the MSC 104 may continue to monitor the level of utilization of the partitioned and dedicated network resources, in block 208. If the maximum amount of network resources that can be partitioned and dedicated has not been reached, the MSC 104 may (optionally) inform current callers that calls are being terminated, block 210, and reallocate network resources from general population usage to emergency response personnel communication use, block 211. Once the additional communication channel has been dedicated, the MCS 104 will return to monitoring the level of utilization of the partitioned and dedicated network resources to determine if the emergency situation is escalating or de-escalating, block 208.

[0108] As emergency response personnel work to alleviate the emergency incident and return conditions to normal, the need for network resources will decrease as emergency personnel exit the scene. To enable the system to return to normal operations, the MSC 104 may continually monitor the call volume on the partitioned and dedicated network resources for an indication of escalation or de-escalation, block 208. When the level of use of the partitioned and dedicated network resource drops below a predefined minimum, the MSC 104 may begin to re-allocate network resources back to general public usage, block 212. Network resources may be automatically re-allocated channel by channel, incrementally reducing the resources allocated to emergency personnel usage, returning to normal operations in a stepwise fashion.

[0109] By demobilizing network resources one channel or network resource at a time, the embodiment provides a flexible communication system which may adapt to the situation as it evolves. If the situation requires more or less network resources for emergency personnel communication, the embodiment system and method can meet the demand while still providing some network resources for the general public to use. The system may wait for a period of time after each release of a TPA-dedicated channel in order to accommodate surges in emergency personnel use during the event wind-down phase, thereby avoiding having to repeat the process of dropping callers, block 210, unnecessarily.

[0110] Once the cellular communication channel has been re-allocated for general public usage, the MSC 104 determines if there are any more network resources that are currently partitioned and dedicated for emergency personnel communication, block 213. If additional network resources are currently partitioned and dedicated for emergency personnel communication, the MSC 104 returns to block 208 to determine whether the emergency situation is escalating or de-escalating. As the emergency situation further de-escalates and returns to normal, emergency response personnel require less and less network resources to support their communications. Thus, the MSC 104 will continue to automatically re-allocate network resources to general public usage in response to call volume, block 212, until all network resources are in normal operating configuration for general public use. The MSC 104 may return to block 201 and may monitor call volume waiting for the next emergency situation.

[0111] In the second embodiment, illustrated in the process flow diagram in FIG. 7, network resources are incrementally allocated to TPA use at level of individual calls by way of call preemption so that public access to the network is maximized while meeting emergency personnel use requirements. During normal operations, cellular communication network usage is monitored, block 302. Network access requests, call volume or engaged bandwidth may be compared to a predetermined threshold (for example 85% of maximum capacity), block 304. If the usage is below the predetermined threshold, a normal situation is assumed to exist, so the monitoring process returns to block 302 to continue monitoring call volume. If, however, the usage exceeds the predetermined threshold, an abnormal situation exists which may indicate that an emergency situation is unfolding. To prepare for an emergency situation, network resources, such as a communication channel on an affected base station antenna, are partitioned and reserved for TPA use, block306. By automatically allocating a communication channel to TPA use, the system permits a TPA-authorized wireless device to gain access to the network, even when the network is otherwise overloaded. However, TPA preemption does not occur until a TPA-qualified caller attempts to access an overloaded network.

[0112] Since the increased call volume may or may not be in response to an emergency situation, a communication channel allocated to TPA continues to function normally by handling civilian (i.e., non-TPA) calls in the ordinary fashion. In instances where the increased call volume is simply due to coincidental call volume and no TPA-qualified user is attempting to place a call, call preemption enabled by TPA is not needed. Thus, the TPA threshold may be exceeded and TPA implemented even when TPA call preemption is not required. Delaying actual implementation of TPA preemption until preemption is required by a first responder increases the reliability of the network under normal circumstances.

[0113] With a network resource allocated to TPA operation, the cellular system (be it at the base station, BSC/RNC or in a central location such as an MSC) monitors incoming and outgoing calls, block 308. The TPA-allocated channel continues to function as a normal cellular communication channel until (a) the channel is at capacity (i.e., current call volume through the channel equals its maximum capacity) and (b) a TPA-qualified wireless device attempts to access the network to place or receive a call. Call volume on the TPA-allocated communication channel is monitored to determine if a call must be dropped in order to connect a TPA-qualified call. Thus, when a new call is received (incoming or outgoing) that will be allocated to the TPA-allocated channel, the system may first determine if that channel is presently at capacity (i.e., has as many calls connected as the channel can reliably maintain), block 310. If the channel is not at capacity (i.e., there is excess capacity on the network), the call may be connected, block 315. This monitoring of the TPA channel may prevent disconnecting a civilian call if sufficient capacity exists on the channel to enable connection of a new incoming or outgoing TPA call.

[0114] As discussed above, the system can recognize a TPA-authorized call by determining if the source or destination wireless device is a TPA-registered wireless device, block 312, and if not by the caller completing a special dialing procedure. The dialing procedure may invoke TPA preemption, block 316. In block 315, the call may be connected. For example, if the caller is using (or the call is placed to) a TPA-registered wireless device the call may be connected. The call may be connected if at least one non-TPA call is connected on the TPA-allocated channel, block 314 and capacity is released to sufficient to connect the TPA call, block 315. This allows the TPA-qualified first responder to make a call without delay even though the network is at capacity. Similarly, if an incoming call is directed to a TPA-qualified wireless device, at least one non-TPA call on the TPA channel is terminated in order to connect the incoming call to the TPA-qualified wireless device. The process of terminating non-TPA calls from the allocated channel may continue as more calls to TPA-qualified wireless devices access the network. If the caller is not using a TPA-registered phone and did not enter a *272 type dialing sequence, the call may be blocked, block 320, as a non-emergency call at a time when system resources are at capacity. If the caller has entered the special dialing sequence (such as *272 plus a PIN), the entered PIN is compared to PIN values stored in a database (e.g., at the base station 102, BSC/RNC 103, or MSC 104,) in block 318. If the PIN matches a registered emergency personnel, a non-TPA call connected on the TPA-allocated channel, block 314, in order to release capacity sufficient to connect the TPA call, block 315.

[0115] The system may also monitor call volume on the TPA-allocated channel, block 322 to ensure sufficient capacity remains to accommodate further emergency personnel requirements. TPA-call volume (i.e., the volume of calls to/from TPA-qualified wireless devices) on a TPA-allocated communication channel may be compared to a threshold value in block 322 to determine when to allocate another communication channel to TPA use. If the TPA call volume threshold is exceeded (i.e., test 322 = "Yes"), another channel will be allocated to TPA functions block 306, which is discussed above.

[0116] TPA-call volume on each TPA-allocated channel, block 322, as well as call volume on all channels, block 324, may continue to be monitored. This may determine when TPA calls are no longer being made, as will occur when the emergency is resolved and first responders leave the scene, or when total call volume returns to a level at which TPA operation is no longer required. If call volume continues to exceed the TPA threshold, the system may continue to operate at least one channel in TPA mode, accepting calls, block 308, checking for TPA channel call volume, block 310 and connecting calls, block 315, if the call is from/to a TPA authorized wireless device block 312 or if call volume is less than capacity. As TPA-call volume declines, the number of channels allocated to TPA-operation can be reduced by releasing a TPA channel, block326. The monitoring call volume and releasing of channels from TPA allocation will continue until all communication channels are returned to normal operations. Also, if call volume on non-TPA channels drops back to normal, the system may deactivate TPA operation on all allocated channels since the normal capacity of the network can accommodate TPA-qualified callers without the need for TPA preemption.

[0117] This second embodiment allows TPA-allocated channels to be operated in a fashion that ensures every TPA-authorized caller can access the network while providing maximum bandwidth possible to the general public. Monitoring of TPA channel call volume allows the system to avoid dropping civilian calls if sufficient capacity exists on the channel to enable connection of a new incoming or outgoing TPA call. If no emergency response personnel initiated a call using a TPA-authorized wireless device or the special dialing procedure, the system may continue to monitor access requests, block 308, and the call volume, block 324, to determine if the communication channel should be released from TPA operation, block 326.

[0118] An additional embodiment provides prioritizing access to TPA-dedicated network resources to enable highest priority callers to use the cellular communication network. In a situation where the number of emergency responders can exceed the capacity of the cellular network resources, this embodiment may enable high priority users, such as national leadership and on-site commanders, to preempt other, lower priority users in order to gain instant access to the network. High priority users can use their pre-registered wireless devices to gain access to the network. The unique ID of their wireless devices can be used to determine the priority of the user from a database of unique IDs. Similarly, high priority users can identify themselves to the network using the special dialing procedure, with a code or PIN providing sufficient information for the network (e.g., the MSC 104) to determine the priority of the user from a database of PINs. Using the priority value determined from a database, the network (e.g., the MSC 104) can determine whether the present caller has a higher priority than any callers already connected to TPA-allocated network resources. Assuming the wireless device 101 is properly authorized, the call may be given priority in the queue on the TPA-allocated network resource so that the emergency personnel member using the pre-registered authorized wireless device may be able to complete the call. If the network resource is at capacity, a call from a person with a lower priority level may be dropped in order to free-up sufficient capacity to complete the call.

[0119] FIG. 8 illustrates an example hierarchy of emergency response personnel. Various other configurations are possible and other personnel may be included, and personnel roles or status may change based on events, for example, the military commander 302 may assume the role of executive leadership, etc. As shown in FIG. 8, Executive Leaders and Policy Makers 301 may be given highest priority status. Members of this class may pre-register their wireless devices 101 such that the wireless device 101 unique identifier is stored in a hierarchy database. If a call is placed from any wireless device pre-registered to a member of the executive leader and policy maker class 301, the call is placed first in any queue of partitioned and dedicated network resources. Similarly, Disaster Response/Military Command and Control personnel 302 may be provided the next highest priority class, followed by Public Health, Safety, and Law Enforcement Command 303, Public Service/Utilities and Public Welfare 304, and Disaster Response Team 305. Lower level priority may be afforded to line police and firefighters 306 and emergency medical technicians 307. In all cases, wireless devices may be pre-registered so their unique identifiers and/or the user's PIN can be stored in a hierarchy database to support this embodiment.

[0120] The foregoing embodiments may also be implemented in a cellular system using a deployable "switch on wheels" cellular communication system. Since such systems may be implemented in large scale emergency/disaster situations with access limited to emergency responders and command authority, network overload will occur from too many authorized (i.e., non-civilian) users placing calls at the same time. To ensure reliable communications in such cases, the deployable switch on wheels can implement the caller priority embodiment so that callers with highest priority (e.g., national and regional commanders) have assured access to cellular communications, while lowest priority authorized users may be disconnected if necessary. In this embodiment, a database of authorized users indicating individual priority (hierarchy) levels (e.g., illustrated in FIG. 8) may be maintained in a server within the deployable switch on wheels.

[0121] The foregoing embodiments have been described as being implemented by the MSC 104. One of skill in the art would appreciate that the foregoing embodiments may be implemented within a number computer switching system elements within the cellular communications network, including but not limited to the base station 102, BSC/RNC 103 or NOC. Monitoring of call volume on communication channels and within a cell is performed automatically already. Such systems may be reprogrammed to implement the foregoing embodiments so that the implementation of TPA operations is performed automatically. Thus, the system can automatically recognize when call volumes exceed thresholds so that a communication channel should be allocated to TPA operation. The system can further recognize TPA authorized calls as described above and dedicate network resources and perform the call connections and disconnections described above automatically. Similarly, as call volume declines below the TPA threshold levels, the systems can automatically return the network to normal configuration. In this manner, the cellular communication network can respond to emergency situations to enable assured communications for emergency personnel without the need for human action or intervention. For example, even if an event goes unreported (e.g., no one bothers to dial 911), the system will nevertheless respond to excess call volume to enable an emergency responder to use the network. This capability also ensures police, fire and EMT personnel (typical individuals who may be authorized to implement TPA) can use the cellular communication network during times of peak usage, such as during rush hour on the freeway or following conclusion of a major sporting event.

[0122] The hardware used to implement the forgoing embodiments may be processing elements and memory elements configured to execute a set of instructions, wherein the set of instructions are for performing method steps corresponding to the above methods. Such processing and memory elements may be in the form of computer-operated switches, servers, workstations and other computer systems used in cellular communications centers and remote facilities (e.g., base station antenna locations). Some steps or methods may be performed by circuitry that is specific to a given function.

[0123] Wireless devices use the portions of radio frequency (RF) spectrum dedicated to cellular telephone communication. This RF spectrum is shrinking at a fast pace primarily due to the increasing number of wireless devices using the already burdened RF bandwidth and inefficient allocation of bandwidth in the marketplace. Since the total RF spectrum is finite, as the number of users of the RF spectrum grows, more efficient methods of RF spectrum management may be required to ensure that the growing need for RF spectrum is properly addressed.

[0124] The currently available RF spectrum is divided among cellular service providers based upon static allocation models such as speculation models and archaic licensing deals. The currently practiced static allocation models rely on a command and control scheme allowing for allocation of spectrum to providers in defined blocks of frequency and space. For example, one static method of leasing RF spectrum includes assigning, based on a leasing agreement, an entire block or sub-block of spectrum to one operator for their exclusive use. Such wholesale allocation of spectrum is inefficient because the licensee provider is purchasing spectrum based on a speculation that the spectrum may be used in the future.

[0125] However, the spectrum usage and traffic are dynamic and may depend upon different variables including the time of the day the spectrum is used and the geographic location of the wireless device using that spectrum. Traffic usage may be time dependent since usage may vary during peak as compared to non peak hours. Traffic may also be geographically based since the location where subscribers use the network may also vary. For instance, during the day, time and geographically based usage of spectrum on a network may vary while subscribers are traveling to work, at work, traveling back from work or during off hours.

[0126] Because spectrum usage and traffic are dynamic and impossible to predict, providers inevitably waste spectrum resources by speculating regarding its future use. Thus, the current spectrum allocation schemes fail to take into consideration real-time data about traffic patterns, encourage under utilization and segmentation of spectrum, and create further inefficiencies through the implementation of guard bands and bandwidth throttling or bandwidth intensive features and services.

[0127] The various embodiment methods and systems provide a Dynamic Spectrum Arbitrage (DSA) system for dynamically managing the availability, allocation, access and use of RF spectrum by using real-time data. Currently, RF spectrum is licensed or purchased in frequency and space based upon speculation of future usage and without taking into account real-time data. The DSA communication system makes RF spectrum available based on frequency, space (i.e., geographical regions) and time, thus, providing a flexible and dynamic spectrum management method and system as compared to the current static command and control methods. Since the RF spectrum resources are available based on time, frequency and space, spectrum allocated through the DSA communication system may be available for short term leases and free from interference. Short term leasing of spectrum may increase competition in a given market area and improve spectrum efficiency without negatively impacting the carriers' ability to deliver service. By efficiently and dynamically managing spectrum availability, allocation, access and use, the DSA communication system may in effect increase the RF spectrum availability.

[0128] In an embodiment, the DSA communication system may be a stand-alone business affiliated with the participating providers. In such a scenario, components of the DSA communication system may be integrated units participating network providers to allow providers to monitor their resources vs. bandwidth traffic and determine whether they need or can provide additional resources. The non-integrated components of the DSA communication system may manage the overall exchange of resources between participating providers. Benefits of using the DSA communication system may include optimizing commercial yield and providing wider and more efficient use of bandwidth on physical (geographic) and time bases.

[0129] In an embodiment, the DSA communication system may enable allocation of/access to RF spectrum resources by requiring that the participating providers subscribe to the DSA communication system. For example, the subscription may be based on a pricing arrangement. As a participant in the DSA communication system, the RF spectrum requesting providers may be enabled to use any available RF spectrum by slipping in and out of the RF spectrum's "swim lanes" in accordance with their need for bandwidth and their preparedness to pay for it. One spectrum's "swim lane" would be the RF spectrum bandwidth that is owned/controlled by one provider.

[0130] To participate in the DSA communication system, initially the carrier or carriers may agree to allow secondary use of their spectrum in the market. DSA communication system may enable each provider to purchase available spectrum in the network of providers or offer to sell additional spectrum to a buyer provider.

[0131] In an embodiment, the DSA communication system may determine the compatibilities of the subscriber wireless devices 101 for using the secondary networks and clusters. Incompatible Radio Access Networks (RAN) may be used if subscriber devices are capable. Thus, if wireless devices 101 are capable of accessing different RANs, the DSA communication system may facilitate the devices' access to spectrum from other RANs even if the switch is between incompatible RANs. DSA communication system is policy based and may offer unique implementations for spectrum and capacity management. The DSA communication system may be based on Long Term Evolution (LTE), Evolution-Data Optimized or Evolution-Data only (EVDO), Evolved High-Speed Packet Access (HSPA) and any known wireless access platform.

[0132] FIG. 9 illustrates a communication component diagram 900 of an embodiment DSA communication system in a wireless access platform based on Long Term Evolution, LTE. The DSA communication system may include the Dynamic Spectrum Policy Controller (DPC) 902 connected to a Home Subscriber Server (HSS) 904 which may communicate with network components of a provider network. The HSS 904 may be a master user database that supports the Dynamic Spectrum Policy Controller (DPC) 902. The HSS 904 may include the subscription-related information (i.e., subscription-profile), perform authentication and authorize the secondary users, and can optionally provide information about subscriber's location and IP information. The HSS 904 may contain users' (SAE) subscription data such as the EPS-subscribed QoS profile and any access restrictions for roaming. It may also hold, store or retain information about the PDNs to which the user can connect. This could be in the form of an access point name (APN) (which is a label according to DNS naming conventions describing the access point to the PDN) or a PDN address (indicating subscribed IP address(es)). In addition the HSS 904 holds dynamic information such as the identity of the Mobility Management Entity ("MME") to which the user is currently attached or registered. The HSS 904 may also integrate the authentication center (AUC), which generates the vectors for authentication and security keys.

[0133] The HSS 904 may be connected to a Signaling Server 7 (SS7) 906. Both the Dynamic Spectrum Policy Controller (DPC) 902 and the HSS 904 may be connected to the Internet 106. The HSS 904 may independently communicate with the in-network components of a network via the SS7 network 906.

[0134] The DPC 902 may also communicate with the network components of a network provider through a commercial or private wireless carrier 903 and Dynamic Spectrum Controller (DSC) 910 or directly through the DSC 910 without using a commercial or private carrier. The DSC 910 component may be added to network components for networks which participate with the DSA communication system and may communicate with the OMC/NMS 910. In various embodiments, the DSC 910 component may include a wired or wireless connection to a Policy Control and Charging Rules Function (PCRF) 905 component/server.

[0135] AVAILABILITY OF SPECTRUM RESOURCES

[0136] In the various embodiments, the DSA communication system may enable a spectrum provider to monitor and assess its RF spectrum usage and availability, and make available unused RF spectrum for use by other providers or unsubscribed users (i.e., secondary users). The DSA communication system may provide different methods to determine RF spectrum availability, such as location and database lookup, signal detectors and spectrum usage beacon. The DSA communication system may enable one provider (host network) to identify spectrum resources which may be offered for use by another provider or provider subscribers (a secondary user), such as on a pay per use or pay per minute basis.

[0137] In an exemplary embodiment, as illustrated in FIG. 9, the DSA communication system 900 may enable a network to determine availability of RF resources. At each network or sub-network, the DSC 910 may monitor call traffic through OMC/NMS 912 to receive detailed status of the various network elements in real-time without inserting another device into the network. The DSC 910 may carry out policy based QoS decisions based on the status of the existing traffic, projected traffic margins and the system policies to determine whether a network or sub-network has resources to allocate for secondary use or requires resources from another provider.

[0138] The DSC 910 may be configured with software to communicate data regarding the availability of spectrum resources to the DPC 902 using capacity policy criteria. The data that is communicated to the DPC 902 may include data relating to current excess capacity and expected future capacity of the network or sub-network.

[0139] The available resources at a network provider may be dynamically allocated and de-allocated. The resource poll information may be controlled by the DSC 910 and relayed to the DPC 902 for central coordination. However, based on rule sets in the DSA communication system, the DSC 910 may identify resources available for secondary use on a system level and cluster level as traffic in the system fluctuates by increasing and decreasing the resource pool for secondary usage may increase and decrease and may be reported to the DPC 902 via the DSC 910.

[0140] ALLOCATION OF AVAILABLE RESOURCES

[0141] In the various embodiments, the Dynamic Spectrum Arbitrager (DSA) system may further manage allocation or assignment of RF spectrum resources of a network provider for specific uses, such as use by secondary users. The DSA communication system may manage RF spectrum allocation based on the providers' varying criteria, such as degrees of prioritization (e.g., low priority or no priority), type of connection (e.g., "always on" and "surge" guaranteed access and bandwidth), and price.

[0142] In contrast to the currently available spectrum allocation techniques, allocation of spectrum resources by the DSA communication system may rely on real-time traffic status of participating providers. The DSA communication system resource allocation may further depend on different factors, such as availability of resources, the type of services that are being delivered and the policies associated with those services. Some of the key policy criteria that may be considered for allocating resources in the DSA communication system may include Radio Access Selection, Capacity Augmentation, Quality of Service (QoS), bearer selection, Congestion Control, Routing, Security, and Rating. The DPC and DSC 910 may perform policy definition and control.

[0143] Radio Access Selection: The DSA communication system may be configured to make the best available spectrum assignment from the available pool of resources. Factors considered in the selection of spectrum assignment may include spectrum bandwidth, location of spectrum in the frequency band, geographic zone along with the requested service, and QoS.

[0144] Capacity Augmentation: The DSA communication system may be configured to make the best available capacity augmentation assignment from the available pool of resources. Factors considered in the decision may include spectrum bandwidth, location of spectrum in the frequency band, geographic zone along with the requested service, and QoS.

[0145] Bearer Selection: The DSA communication system may be configured to select the resources required to support the requested QoS profile at the radio and transport bearer services.

[0146] Admission Control: The DSA communication system may be configured to maintain information of available/allocated resources in both the radio and the IP transport network and perform resource reservation/allocation in response to new service requests.

[0147] Congestion Control: The DSA communication system may be configured to monitor traffic conditions on the primary network, and seek alternative methods for capacity off load. Additionally, The DSA communication system may be configured to monitor the primary network and perform back-off of secondary users as traffic demand increases on the primary network.

[0148] Routing: The DSA communication system may be configured to ensure that the optimum route for the service is used based on the bearer traffic and available network resources.

[0149] Security: The DSA communication system may be configured to provide security for the traffic streams by segregating the traffic into tunnels to ensure no cross pollination of information.

[0150] Rating: The DSA communication system may be configured to coordinate rating schemes including prioritization and carrier usage fee and other metering processes.

[0151] The DSA communication system resource allocation may be based on different methods, such as stateless and stateful methods. By employing different allocation methods, the DSA communication system may enable providers to tailor spectrum allocation and utilization based on their individual spectrum traffic demands. The stateless method may involve coordinating spectrum usage between networks on a real-time basis. The stateful method may include storing and forwarding spectrum resources following defined time intervals. RF spectrum resources may further be allocated on a need basis, which may be based on committed and peak bandwidth/traffic requirements. The need based allocation method may allow for the greatest flexibility and spectrum utilization. The DSA communication system may further employ a just-in-time allocation method in enabling the providers to allocate spectrum resources. By employing the just-in-time allocation method, the DSA communication system may improve the overall spectrum utilization for a given market and provide a revenue source for wireless carriers.

[0152] In an embodiment, the DSA communication system may provide the command and control functions to enable spectrum to be leased for the entire license area or for a defined sub-license area, and for a term. For example, the DSA communication system may facilitate spectrum resource allocation using a sub-spectrum block approach with the ability to increase or decrease the spectrum consumed dynamically.

For example, multiple different communication networks can allocate spectrum to the same user.

[0153] As shown in FIG. 9, the components of the DSA communication system which are not part of a provider's network, such as the DPC 902, may manage spectrum allocation between different networks or sub-networks.

[0154] In an embodiment, the DSA communication system may enable host networks to allocate resources which are currently assigned for use by primary users for use by secondary users. In such a scenario, the secondary users may be granted access to the host networks' spectrum capacity or resources regardless of existing available capacity at of the host network.

[0155] GOVERNANCE AND POLICY MANAGEMENT

[0156] The DSA communication system may operate based on pre-determined rules and parameters which may be based on the statistics of the channel availability. For example, operating rules may enable the DSA communication system to monitor the level of access to RF spectrum at any given time to allow the system to determine whether capacity is available for allocation.

[0157] As described above, resource allocation may be done through the DSA communication system components, such as the DPC 902 and DSC 910 following the rules defined by the business arrangement, device compatibility, target system RAN, and capacity and services requested.

[0158] FIG. 9 further illustrates the network architecture 900 of an embodiment method for implementing DSA policy governance. The DSA communication system may require that the participating parties adhere to the governing rules and policies.

[0159] In implementing the DSA policies, the Policy Control and Charging Rules Function (PCRF) 905 of a participating network may provide the policy and service control rules and the Rivada® Policy Control Network (RPCN) may provide policy changes and corrections based on the DSA rules and DPC 902 requirements. The

PCRF may be responsible for policy control decision-making, as well as for controlling the flow-based charging functionalities in the Policy Control Enforcement Function (PCEF), which resides in the PGW. The PCRF provides the QoS authorization (QoS class identifier [QCI] and bit rates) that decides how a certain data flow will be treated in the PCEF and ensures that the data flow and authorization meets and is in accordance with the user's subscription profile. The RPCN may be a part of each network DSC 910. The RPCN may further maintain a Hot List for public safety users who may also be linked to the commercial system.

[0160] For example, when resources of a host network is depleting, the network PCRF 905/RPCN may instruct the host network to take an action to recover additional resources for the preferred users of the home network. The instructions sent by the PCRF 905/RPCN may be used to determine the course of action needed to be taken to free-up resources for the use of the preferred users. For example, the PCRF 905/RPCN instructions may be to reduce QoS for secondary user wireless devices 101 or certain applications, or shed secondary user wireless devices 101 from the network based on a set of conditions. While managing the level of its resources by reducing traffic, the host network may implement time slot allocations.

[0161] Some optional subcomponents of the EPC may include the MME 914 (Mobility Management Entity), which is a key control-node for the LTE access-network and may be responsible for idle mode UE (User Equipment) tracking and paging procedure including retransmissions and may be involved in the bearer activation/deactivation process and is also responsible for choosing the SGW for a UE at the initial attach and at time of intra-LTE handover involving Core Network (CN) node relocation. MME 914 may be responsible for authenticating the user (by interacting with the HSS). The Non Access Stratum (NAS) signaling terminates at the MME 914 and may also be responsible for generation and allocation of temporary identities to UEs. MME 914 may check the authorization of the UE to camp on the service provider's Public Land Mobile Network (PLMN) and enforces UE roaming restrictions. SGW 922 (Serving Gateway) may route and forward user data packets, while also acting as the mobility anchor for the user plane during inter-eNodeB handovers and as the anchor for mobility between LTE and other 3GPP technologies. The PGW 908 (PDN Gateway) provides connectivity from the UE to external packet data networks by being the point of exit and entry of traffic for the UE. A UE may have simultaneous connectivity with more than one PGW 908 for accessing multiple PDNs. HSS 926 may be a central database that contains user-related and subscription-related information. The functions of the HSS 926 include, for example, mobility management, call and session establishment support, user authentication and access authorization. ANDSF 918 (Access Network Discovery and Selection Function) provides information to the UE about connectivity to 3GPP and non-3GPP access networks (such as Wi-Fi). The purpose of the ANDSF 918 is to assist the UE to discover the access networks in their vicinity and to provide rules (policies) to prioritize and manage connections to these networks. Network 900 may also include ePDG (Evolved Packet Data Gateway) is to secure the data transmission with a UE connected to the EPC over an untrusted non-3GPP access.

[0162] DSA communication system policy and governance may have the same attributes as those found in a commercial network. However, in the DSA communication system, the combination of policy driven QoS with dynamic spectrum arbitrage/allocation may enhance both the primary and secondary (e.g., lessor and lessee) spectrum utilization and reduce the overall costs.

[0163] In an embodiment DSA system, the policy/governance may be set for specific levels of network resources per session, per "pipe," per user or a group of users. The policy may also relate to the priorities, such as emergency calls getting highest priority, or preferences, such as allowing degrading quality for ongoing calls or rejecting new ones at near congestion time. DSA policy and governance may also invoke routine policies which may be applied to facilitate the best route for a particular type of communication session and service offering.

[0164] ACCESS TO ALLOCATED RESOUCES OF ANOTHER NETWORK

[0165] In an embodiment, the DSA communication system may manage the access of users to available RF spectrum resources of a network. For example, the DSA communication system may manage the access of secondary users to spectrum resources of a primary host network that are allocated for secondary use.

[0166] The secondary users may access spectrum resources of a primary host network using different methods such as, by acting as a dynamic roamer or using a coordinated spectrum scheme with compatible access techniques. In allowing the secondary user to access a primary host spectrum resources, the DSA communication system may enable the wireless device 101 of a subscriber of one provider to change bandwidths from the spectrum belonging to the home network provider of the wireless device 101 to one belonging to a host network provider based on different parameters such as price, quality of reception, geographic area and location.

[0167] The DSA communication system may provide access to a secondary user based on different access conditions. The DSA communication system may provide access to available spectrum either temporarily or by sharing traffic throughput for a radio access technique with a primary user of a primary provider. Temporary access may involve accessing defined spectrum that was allocated for usage based on the policies of the DSA communication system. Sharing spectrum may involve allowing the subscribers of one provider to access radio spectrum at a host provider on a secondary basis.

[0168] Secondary users' home network providers may employ different methods to dynamically contract for allocated RF spectrum resources of a primary provider. For example, the primary provider may auction and the secondary provider may bid for available spectrum resources. The bidding may be a fee based process; which may involve managing the reselling of unused spectrum on temporary or permanent basis to efficiently manage excess resources that might otherwise go unused for that time; or managing leasing of excess RF spectrum on temporary or permanent basis.

[0169] FIG. 10 illustrates network architecture 1000 of two wireless network providers using the DSA communication system to share spectrum resources. The DSA communication system may be comprised of two general components: Out-of-network and in-network components. The out-of-network component of the DSA communication system may include a DPC 902 connected to a HSS 904. The DPC 902 may enable the DSA communication system to dynamically manage the access to the allocated spectrum resources of a network. For example, the DPC 902 may manage the access of secondary users of a network provider to the allocated spectrum resources of a primary network provider.

[0170] The DPC 902 may further coordinate DSA communication system policies and effectuate sharing of relative information between network providers. The DPC 902 may further facilitate the charging policy and resource requests which may be communicated with the networks.

[0171] The DPC 902 may be configured to communicate with one or several networks (e.g., Network 1 and Network 2) through in-network DSC 910 component of each DSA communication system participating provider. In an embodiment, each Network 1 and Network 2 may include a DSC 910a, 910b which may be an add-on to the online management center/network management system (OMC/NMS) 912a, 912b of a wireless carrier. At each network, the DSC 910a, 910b may manage traffic and capacity of each network and continuously monitor nodes for capacity constraints based upon commands received from or policies and rule sets of the DPC 902. The DSC 910 may communicate its findings with the DPC 910.

[0172] Each network may include an OMC/NMS 912a, 912b which may be in communication with a wireless network 1002a, 1002b. The wireless network 1002a, 1002b may be in communication with wireless access nodes 102a, 102b. Subscriber wireless devices 101 may communicate with a wireless access node 102a, 102b. The relationship and interconnectivity of these components of the network are known.

[0173] In an embodiment, the DSC 910a of Network 1 may determine that additional resources may be required by Network 1. The DSC 910a of Network 1 may be configured to send a request for additional resources to the DPC 902. The DPC 902 may receive information regarding a secondary user wireless device 101a location and the network.

[0174] The DPC 902 may be configured to also receive data from other affiliated networks such as from the DSC 910b of Network 2. The DSC 910b of Network 2 may be further configured to report to the DPC 902 that specified amounts of resources are available in Network 2.

[0175] The DPC 902 may be configured to process data received from the requesting network (i.e., Network 1) and the supplying network (i.e., Network 2) and facilitate a real-time access to the resources of Network 2 by the requesting Network 1. Once spectrum resources from Network 2 are made available for access by users of Network 1, the DSC 910a may instruct the wireless devices 101a to change networks and access the spectrum resources provided by Network 2. For example, when a wireless device 101a of Network 1 requests communication resources, its rule set may be validated by the DSC 910 of Network 2. Network 2 may receive the wireless device's 101a updated information in the PCRF 905 (shown in FIG. 9). The PCRF 905, with other platforms, may allow the secondary user wireless device 101a to access the allocated resources of Network 2.

[0176] In an embodiment, the accessibility of resources to a secondary user through the DSA communication system may also depend on Host Network Operators policy and use criteria for those resources. The criteria can include both Radio Access and Core Network Resources.

[0177] For example, some of the policy and resource criteria imposed by the Host Network Operator may include: Availability of spectrum (e.g., separate or co-existence); availability of capacity/bandwidth (e.g., RF and Core); overhead criteria (e.g., percent total available capacity versus used capacity); existence of back-off criteria (e.g., reselection, handover (intra system and inter-system), termination); treatment (how specific services/applications are treated/routed); barred treatments (e.g., services/applications which are barred for use); rating (e.g., how services are rated, i.e., possible special discount for off-peak usage); geographic boundary (e.g., defining zones or cells for inclusion); time (e.g., defining time and day(s) for inclusion including); duration (e.g., defining incremental allocation based on time and geographic boundary); user equipment types.

[0178] The DSA communication system may enable a secondary network to request spectrum resources based on: time (e.g., when are resources requested); required capacity/bandwidth; treatment (e.g., what services are desired, including QoS); geographic boundary (e.g., where services are requested); and duration (e.g., for how long are the resources requested).

[0179] In an embodiment, the communications that may be performed by the DSC 910a, 910b may be transparent to the secondary users. In another embodiment, the communication may not be transparent.

[0180] FIG. 11 illustrates a network component diagram 1100 of an embodiment DSA communication system where spectrum usage and traffic data may be processed by a third party or spectrum clearinghouse. The out-of-network component 1102 of the DSA communication system may include sub-components such as the DPC 902 (shown in FIG. 9). The DPC 902 may communicate with the wireless Networks 1 and 2, by communicating with sub-components of the core network 1104a, 1104b. The out-of-network component 1102 may also communicate with one or both networks using the Internet or a private network 106. For example, the DSA communication system out-of-network component 1102 may communicate with the core network 1104b of Network 2 via the Internet 106 while directly communicating with the core network 1104a of Network 1. The core networks 1104a, 1104b may include sub-components such as the DSC 910, Long Term Evolution (LTE), (EVDO), (HSPA) and OMC/NMS 912a.

[0181] When Network 1 becomes overburdened and requires additional spectrum resources, the core network 1104a, may determine a need for spectrum and request for additional spectrum resources from the DSA communication system out-of-network component 1102. Network 2 may determine that it has available an excess amount of spectrum resources due to low call traffic. Network 2 may also report the availability of excess resources to the out-of-network component 1102. Communication between the DSA out-of-network component 1102 and Network 2 may be through the Internet 106. Alternatively, the out-of-network component 1102 and Network 2 may communicate directly as shown by dashed line 1106. The DSA out-of-network component 1102 may facilitate the allocation of spectrum resources from Network 2 to Network 1 which is shown here by the dashed line 1108.

[0182] The wireless device 101b may access the allocated resources by different methods. Network 1 may instruct the wireless device 101b to switch networks to Network 2 to use the allocated resources as a secondary user on Network 2. Alternatively, the allocated resources of Network 2 may be made available through Network 1 enabling the wireless device 101b to use the resources of Network 2 without having to change communications session from Network 1 to Network 2. For example, networks 1, 2, and 3 may pool spectrum that can be allocated for use by multiple entities.

[0183] FIG. 12 illustrates a communication system 1200 of an embodiment DSA network. The DPC 902 may provide the master control for the arbitrage process while serving several different networks. The DPC 902 may include the policy and time dependent arbitrage rules for current allocations. The DSC 910 may be configured to also have a local copy of the policy and time dependent arbitrage rules for the current allocation. The local copy of the policy and time dependent arbitrage rules may ensure that the local control of the network resources may be maintained. In addition, the DSCs 910a-910c may be separate platforms interfacing with the network operations system providing a demarcation point for future network operation issues.

[0184] In an embodiment, to ensure disaster recovery of the system in the event of an incident, the DPC 902 may be configured as a dual mirrored server site (e.g., DPC 902a and DPC 902b) or include several servers in a geographically dispersed cluster. To secure the network, the DPC 902a, 902b may have a secured link to defined and pre-approved network operators 1204a, 1204b, 1204c (e.g., spectrum resource providers) and system resource requesters 1206, 1208, 1210(e.g., bidders).

[0185] In the event of a failure of communication between the DPC 902a, 902b and DSC 910a, 910b, 910c, the DSC 910 a, 910b, 910c may be configured to use its locally saved policy and rule contents to maintain continuity in an arbitrage process that has been initiated by the DPC 902a, 902b. However, because of the lack of connection with the DSC 902a, 902b, the DSC 910a, 910b, 910c may not be able to facilitate additional new resource allocations or bids. To ensure that local control is always maintained, the DSC 910a, 910b, 910c may be further configured to control and locally override components and functions that enable the local operators to prematurely terminate or back-off resources from a secondary user.

[0186] For example, DSC 910a may locally store policy and rules of any communicating DPCs 902a, 902b. As such, if communication between the DPCs 902a, 902b and DSC 910a is compromised after a bid has been processed by a DPC 902a, 902b, the DSC 910a may continue to provide resources to secondary users of bidder 1 1206 without having to terminate the secondary users. Additionally, when Network A 1204a requires more resources to provide service to its own primary users, the DSC 910a may locally control the off-loading of secondary users from Network A to free-up resources based on the policies and rules of the DPC 902a, 902b.

[0187] In an embodiment, the process involved in the DSA communication system may be similar in all cases for flow. As illustrated in FIG. 13A, resources of a block of spectrum 1300A may be categorized based on how they are used by a network. Resources for a given spectrum may be categorized as occupied resources, uncertain resources and available resources. The occupied resources may be those resources which are currently in use by the carrier and may not be allocated by the DSA communication system. The uncertain resources may provide a margin for the carrier to manage peak loads. The uncertain resources may be used up during the peak loads and not used during low peak loads. The available resources may be the subset of resources which are not used at all by the network. The available resources may be made available for allocation to other secondary providers.

[0188] In an embodiment, spectrum resources may be allocated to secondary users by different methods. FIG. 13B illustrates allocation of spectrum resources of a block of spectrum 1300 licensed by a host network, according to an embodiment. The host network may license a RF spectrum block 1300a including four channels. The host network may dedicate three of the four channels of the RF spectrum block for use by the network 1 subscribers. The dedicated channels 1-2 are shaded in the RF spectrum block 1300b. As shown by RF spectrum 1300b, Channel 4 may remain unassigned by the provider. Channel 3 may be partially allocated, partially transitional and partially unassigned as illustrated by spectrum block 1300c. The transitional section of the spectrum block 1300c may be reserved for use during high traffic periods by the provider's subscriber. The unassigned portions of the licensed spectrum 1300c may never be used.

[0189] In an embodiment, the host network may sublicense the unassigned portion of the licensed spectrum to secondary users using the DSA communication system. In such a scenario, the host operator may make available to secondary users the unassigned portion of channel 3 and all of channel 4.

[0190] FIG. 14 illustrates allocation of spectrum resources including a guard band channel of a licensed spectrum 1400, according to an embodiment. The licensed spectrum 1400 may include a guard band 1404 that is either defined or set aside by operators as part of a spectrum deployment policy and program. Such guard bands may include usable resources that currently remain unused. The host network may allow the resources available in the guard bands to be used by secondary users using the DSA communication system. By using the DSA the host network may make available for use the unused guard band resources by combining the guard band into a single usable channel 1402 for resource allocation.

[0191] FIG. 15 illustrates pooling and allocation of spectrum resources of more than one host networks using the DSA communication system, according to an embodiment. In an embodiment, the DSA communication system may be configured to survey the available spectrum from different networks and pool the available together for allocation. In an exemplary embodiment as shown by spectrum block (1), each of the host networks, network A and network B, may license a block of spectrum including four channels each. For example, the block of spectrum 1502A licensed by network A may include channels 1A, 2A, 3A, and 4A. The block of spectrum 1502B licensed by network B may include channels 1B, 2B, 3B, and 4B.

[0192] In the exemplary embodiment as shown by spectrum block (2), the spectrum block 1504A of network A may include available channel 4A and partially assigned channel 3A. Channel 3A may be partially assigned for use by the network, partially transitional and partially available for use by other networks. The spectrum block 1504B of network B may include available channels 1B and 4B and partially assigned channel 3B. Channel 3B may be partially assigned for use by the network, partially transitional and partially available for allocation to other networks.

[0193] In an exemplary embodiment as shown by spectrum block (3), each spectrum block 1506A, 1506B of network A and network B may make available their resources using the DSA communication system. The DSA communication system may pool the available resources from each network and allocate them for secondary use. For example, the DSA communication system may pool the resources available in channels 1B and 4B and make them available to secondary users. The DSA communication system may pool the resources available in channel 4A and the partial resources available in channel 3A and make them available to secondary users.

[0194] The DSA communication system may pool available resources from different networks for allocation to secondary users. In an exemplary embodiment, as shown in spectrum block (4), the DSA communication system may pool available resources from channel 4A in network A, spectrum block 1508A and channels 1B and 4B in network B, spectrum block 1508B, and make them available to secondary users.

[0195] In an exemplary embodiment, as shown by spectrum block (5), the DSA communication system may pool available resources from all channels in different networks, including channels with resources that are fully committed for use by the network and channels which include available resources. The DSA communication system may pool spectrum resources from channels 3A and 4A in network A, spectrum block 1510A, and channels 1B, 3B and 4B in network B, spectrum block 1510B, and make them available to secondary users.

[0196] In an embodiment, the DSA communication system may enable Mobile Virtual Network Operators (MVNO) to utilize unused spectrum capacity. For example, the DPC 902 may aggregate multiple MVNO's to utilize unused spectrum capacity in a prioritization scheme. This would enable an MVNO to sell its unused or under used capacity to another MVNO thereby ensuring that both MVNO's operating efficiently.

[0197] FIGs. 16A-16C illustrate MVNO spectrum aggregation according to an embodiment. FIG. 16A illustrates the allocation or capacity of spectrum for MVNO A 1602A and MVNO B 1602B where both operators possess unassigned spectrum capacity. FIG. 16B illustrates an exemplary embodiment method by which the DSA communication system may enable the MVNO B 1604B to increase or augment its available spectrum capacity by receiving unassigned spectrum from MVNO A 1604A. FIG. 16C illustrates an exemplary embodiment method by which the DSA communication system may be enabled one MVNO C 1606C to receive additional spectrum capacity from two other MVNO's 1606A, 1606B. The MVNO C 1606C may be a new or additional MVNO and may obtain the available unassigned spectrum capacity from MVNO A and B 1606A, 1606B for its potential use. In this scenario, MVNO A and MVNO B 1606A, 1606B may or may not operate on the same host carrier and may or may not have the same Radio Access Technology (RAT). In another embodiment, a conversion may be provided to provide access between different RAT.

[0198] In an embodiment, to measure the quantity of the resources that are used by secondary users, the host network may use similar processes as used for pre-paid users to facilitate the time/duration and usage metering of secondary uses which can be done at an individual or global account basis.

[0199] Depending on the method used by secondary users to access available resources, several fundamental types of DSA allocation methods may be implemented, including: 1) virtual-best effort method; 2) virtual-secondary users method; and 3) spectrum allocation method which may include License area and Regional area spectrum allocation. Each of these allocation methods may have several variations. For example, in a virtual-best effort method, the DSA communication system may be configured to make available spectrum resources for an entire license area or on a regional, sub-license area basis. Classes of the users may also be defined in user's wireless devices 101 by their home network providers and may be assigned either secondary user or best effort user statuses.

[0200] In an embodiment, Resources in the virtual-best effort method may be available to the MVNO through a grant of access to the network involved. Prioritization may occur within the host network based on PCRF rules of the home and host networks.

[0201] In the virtual-best effort method, the host network may enable the secondary user wireless devices 101 to use the same network as the host network but on a virtual basis, i.e., an MVNO type of arrangement. Different variations of this arrangement may include situations when 1) the secondary user uses the host network with the same rights as the host network subscribers and 2) the secondary user uses the host network as a secondary user or on a secondary basis where primary users (host subscribers) have higher priority and rights than the secondary user subscribers. Access priority for primary users may be established in networks where the primary users are public safety users. During emergency situations, the host network may drop secondary users due to an increase in use of its spectrum by other users such as public safety primary users.

[0202] FIG. 17 illustrates a communication system 1700 of a DSA communication system for allocating resources according to an embodiment. In a virtual-best effort method, the wireless device 101 may be considered a valid roamer as shown in FIG. 17.

[0203] During the bidding process, the DSA communication system may implement a rule sets which may be used to define the types of services, treatments and duration of services for the wireless devices that are granted access to the host network. The rule sets may include information such as: 1) requested capacity/boundary; 2) treatment of services such as when they are required and the QoS; 3) geographic boundaries based on the requested service; 4) time for when resources are requested; and 5) duration for which requested resources would be used by the secondary user. It is contemplated that all or a sub-set of these rules may be used depending on the arbitrage scheme.

[0204] In the virtual-best effort method, the DSA communication system may follow the industry roaming process in that access to spectrum may be granted to the secondary users provide the service requesting wireless devices meet the required authentication processes. Validation/authentication of the secondary user wireless devices 101 may be performed following standard MAP/IS-41 processes through the use of the host's HSS 926 and AAA.

[0205] Additional criteria that the DSA communication system may add to the process of roaming may include different billing schemes. For example, secondary user's wireless device's 101 access duration or total usage permissions may be governed by the host network. Such governing schemes enable the host network to control the access of the secondary users locally and on a real-time basis. In the virtual-best effort method, the DSA communication system may not reserve resources and merely track the consumption of resources.

[0206] In the virtual-best effort method, the primary or host network provider may not grant prioritization to the secondary users except through differentiation afforded by the PCRF 905 and PDN Gateway (PGW) 908 of the host network provider. To use the resources of a DSA communication system using the virtual-best effort method, the secondary users may either use the PGW(s) 908 of the host network of or the secondary network's PGW which may be either connected to the appropriate Serving Gateway (SGW) 922 of the host network or connected to the PGW of the host through an intermediate PGW 908 that is governed by the host network.

[0207] The PGW is responsible for IP address allocation for the wireless device 101, as well as QoS enforcement and flow-based charging according to rules from the PCRF. It is responsible for the filtering of downlink user IP packets into the different

QoS-based bearers. This is performed based on Traffic Flow Templates (TFTs). The PGW performs QoS enforcement for guaranteed bit rate (GBR) bearers. It may also serve as the mobility anchor for interworking with non-3GPP technologies such as CDMA2000 and WiMAX® networks.

[0208] All user IP packets may be transferred through the SGW, which serves as the local mobility anchor for the data bearers when the wireless device moves between eNodeBs. The local mobility anchor point for inter-eNodeB handover includes downlink packet buffering and initiation of network-triggered service requests, lawful interception, accounting on user and QCI granularity, and UL/DL charging per wireless device. SGW also retains the information about the bearers when the wireless devices are in the idle state (known as "EPS Connection Management — IDLE" [ECM-IDLE]) and temporarily buffers downlink data while the Mobility Management Entity (MME) initiates paging of the wireless devices to reestablish the bearers. In addition, the SGW performs some administrative functions in the visited network such as collecting information for charging (for example, the volume of data sent to or received from the user) and lawful interception. It may also serve as the mobility anchor for interworking with other 3GPP technologies such as general packet radio service (GPRS) and UMTS.

[0209] The MME is the control node that processes the signaling between the wireless device and the CN. The protocols running between the wireless device and the CN are known as the Non Access Stratum (NAS) protocols (eMM, eSM) and security, AS security, tracking area list management, PDN GW and S-GW selection, handovers (intra- and inter-LTE), authentication, bearer management. The MME also contains mechanisms for avoiding and handling overload situations.

[0210] An eNodeB performs Radio Resource Management functions, such as radio bearer control, radio admission control, radio mobility control, scheduling and dynamic allocation of resources to wireless devices in both uplink and downlink. The eNodeB may perform Header Compression which refers to the process of compressing the IP packet headers that could otherwise represent a significant overhead, especially for small packets such as VoIP to help ensure efficient use of the radio interface. The eNodeB may perform Security functions by ensuring that all data sent over the radio interface is encrypted.

[0211] In an embodiment, the virtual-best effort method may enable the DSA communication system to manage resources allocation by using different methods. For example, the host network's PCRF 905 may control the secondary users' wireless devices 101 that access the host network and track the usage of the resources. The host network's billing system may be used to bill the secondary user.

[0212] Alternatively, the host network's billing system may control/track the usage of the resources by the secondary user, and the secondary user's home network PCRF 905 may provide preferred services. In such a scenario, the PCRF 905 of the host network may retain final control.

[0213] Alternatively, the host network may provide access and secondary user's home network's PCRF 905 may define the preferred services. Additionally, as part of the allocation process using the virtual-best effort method, different TAI's may be assigned to the secondary user's wireless devices which roam onto the host network. The TAIs may provide differential service areas or defined geographic zones for potential usage. In an embodiment, the subscriber wireless devices may be allowed to access the home network through identification of a valid PLMN that it has in USIM that is either pre-programmed or provided through OTA provisioning. The home network may direct subscribers to use a host network as secondary users for different reasons. Additionally, if the wireless device 101 is capable of accessing two networks at the same time, the wireless device 101 may potentially use the home network for one type of service and be directed to use a host network for other services.

[0214] In an embodiment, available resources may be allocated to secondary users using a virtual-secondary user method (e.g., an Intra-System (i.e., Intra freq–lessor, or Intra freq prime–lessee)). In the virtual-secondary user method, the primary host network may allow the secondary users of the secondary network to operate using the primary network's system spectrum resources with different usage rights as compared to the primary users, such as on a de facto lease but with a different SID. This may be achieved by allowing the secondary users to include spectrum allocation from the primary host network when there is technology compatibility between the primary network systems and the secondary user wireless device 101. This allocation may be applied to the mobile virtual network operator mobile that provides mobile phone services but does not have its own licensed frequency allocation of radio spectrum, nor infrastructure required to provide mobile telephone service.

[0215] In a virtual-secondary user method, the prioritization of the secondary users may follow the host network's PCRF 905 and PGW 908 rules. The PGW(s) 908 that may be used by the secondary wireless devices 101 may either be controlled by the host network or available through the secondary user's home network. If the PGW 908 is available through the secondary users' home network, it may either be connected to the appropriate SGW 922 or provided through an intermediate PGW 908 that is governed by the host network. In such a scenario, a secondary user may be considered a valid roamer in the DSA communication system using the virtual-secondary user method as shown in FIG. 17.

[0216] In a virtual-secondary user method, the DSA communication system may use five fundamental bidding rule sets, which are used to define the types of services, treatment and duration for the secondary user wireless devices 101. The rule sets may include information such as: 1) requested capacity/boundary; 2) treatment of services such as when they are required and the QoS; 3) geographic boundaries based on the requested service; 4) time for when resources are requested; and 5) duration for which requested resources would be used by the secondary user, and other rule sets as applicable. It is contemplated that all or a sub-set of these rules may be used depending on the arbitrage scheme.

[0217] In an embodiment, when employing the virtual-secondary user method, a host network may grant access to a secondary user wireless device 101 provided it meets a predetermined required authentication process. The host network using a virtual-secondary user method may use different billing schemes where the wireless devices

101 access or usage total is governed by the rules and specifications of the host network, allowing the secondary user devices 101 to be controlled locally. As secondary users in the system, the wireless devices' 101 access to the host network can be restricted, reduced, or barred depending on the conditions of the host network. The restrictions, reduction or barring may be imposed on a call, on a regional or system wide basis depending on the conditions set forth by the host network in the bidding system. The restrictions, reductions or barring may further be performed on dynamic basis by overriding the bidding conditions (e.g., in public safety networks).

[0218] Authentication or validation of the secondary wireless device user may be performed following the standard MAP/IS-41. Using MAP/IS-41, the host HSS 926 and AAA may authenticate secondary user wireless device.

[0219] In an embodiment, when using the virtual-secondary user method, the DSA communication system may require that different components of the host and/or home networks be used for resource allocation. For example, the host network billing system and PCRF 905 may control the secondary user's access to the network and track its usage. Alternatively, the host network's billing system may control and/or track usage and the secondary users' home network PCRF 905 may provide preferred services and the network PCRF 905 may perform the final control. Alternatively, the host network may provide access in the home network PCRF 905 may define the preferred services.

[0220] When resources that are allocated using the virtual-secondary user method are near exhaustion either based on time, usage or other criteria, the DPC 902 may notify the home network operator in the host network that the resources may expire. The home network operator, if allowed, may be enabled to top off or replenish the resources available to the secondary user by requesting foreign bidding on additional resources at the host network or otherwise provide additional RF spectrum resources. To provide additional flexibility to the resource allocation process, different TAI's may be assigned to the secondary user's wireless device that is roaming the host network. The TAI's may provide differential service areas or different geographic zones for potential use.

[0221] In an embodiment, the secondary user's wireless device may be able to access the home network through identification of a valid public land mobile network or PLMN that it may have stored in its universal subscriber identity module ("USIM"). The USIM may be either pre-programmed or provided through OTA provisioning. When using the home network, the secondary user's wireless device 101 may be redirected to search for a host network from which it can receive services. Once a host network is identified, the secondary user wireless device 101 may use the host network for all services, or use the host network for one type of service. Additionally, the use the home network can be for other services if the wireless device 101 has the capability of accessing two networks at the same time. Various configurations are possible and within the scope of the present disclosure.

[0222] FIG. 18 illustrates a communication system block diagram 1800 illustrating communications between components of two networks in a DSA communication system during resource reservation according to an embodiment. In an embodiment, the host network's (i.e., lessor) configuration may be controlled by the OMC 912. Additionally the home network (i.e., lessee) 1802 may be separate from the host network 1804.

[0223] In an embodiment, the host network using the virtual-secondary user method, may reserve resources by using different methods, including: 1) X-furcating of the eNodeB; 2) SGW and PGW link bandwidth; 3) combined resource allocation (PGW and eNodeB); and 4) PCRF (host) control. These resource reservation methods may be used in combination or may be mutually exclusive depending on the host networks requirements and the bidding process.

[0224] By x-furcating the eNodeB, resources may be reserved for secondary users. In an exemplary embodiment, as illustrated in FIG. 19, the eNodeB 916b may be bifurcated to reserve resources for secondary users. The eNodeB 916b may receive bifurcating instructions from the PCRF 905, MME 914 and SGW 922 to partition a percentage if its resources which may be used for another PLMN network. The PGW 908 may be located at the host network or may be located remotely. According to the received instructions, the eNodeB 916b may reserve X% of the resources for the use of the primary users and Y% of the resources for use by secondary users. The eNodeB 916b may transmit an enhanced PLMN (ePLMN) which may be recognizable to the secondary user wireless device 101b and camp on the cell.

[0225] In an embodiment, resources may also be reserved through controlling of the connectivity between the SGW 922 and the PGW 908 to which the secondary user wireless device is assigned.

[0226] FIG. 20 illustrates an embodiment method for controlling the SGW 922 and PGW 908a, 908b link bandwidth allocation scheme according to an embodiment. Resource reservation may be controlled by controlling the host SGW 922 connectivity to the various PGW 908a, 908b. The SGW 922 connectivity to the PGW 908a, 908b may be controlled through altering the available bandwidth between SGW 922 and PGW 908a, 908b on a dynamic basis. The PGW 908a, 908b may be local and/or remote with respect to the host network. The SGW 922 and PGW 908 link bandwidth may be altered through the OMC/NMS 912 which may be connected to the DSC 910. PGW 908a may be located at a host network or remotely.

[0227] In an embodiment, illustrated in FIG. 21, resources may be reserved for allocation purposes by combining eNodeB x-furcation and SGW-PGW link bandwidth control methods.

[0228] In an embodiment, the host PCRF 905 may control resource reservation for allocation to secondary users. The host PCRF 905 may prioritize the secondary user wireless device 101 based on the services requested using a combination of the QCI/ARQ ARQ may be an automatic repeat request. In this scenario, the PCRF 905 may assign a QCI/ARQ to the primary user wireless devices 101a and the secondary user wireless devices 101b.

[0229] In an embodiment, the RF spectrum allocation method may be used to make resources available for allocation. In the spectrum allocation method (e.g., Inter-System (Inter freq–lessor, Inter freq prime –lessee)) the primary network may assign spectrum resources for the use of the secondary users in a geographic region. Based on this, the secondary network providers may make available the primary network resources as channels/spectrum of their own normal operational network (i.e., can be compatible or IRAT). This, also, may be applied to MVNO. Thus, secondary users may access the primary network resources on their home networks and without having to roam onto the primary network.

[0230] The spectrum allocation method may be based on a) licensed area; or b) regional area. In both the license and regional area methods of spectrum allocation, spectrum available for use by the primary network provider operators (i.e., lessor or Network 1) may be programmable through the OMC/NMS 912. Spectrum allocation method may enable the host network to allocate spectrum based on desired bandwidth, geographic boundary of the secondary user, time the secondary user request resources, and duration of time for which the secondary user request resources.

[0231] In an embodiment, the spectrum allocation method may make spectrum resources available to secondary users on a dynamic basis. The billing process for the spectrum allocation method may not involve the use of the host or the visiting networks billing platforms. Instead, the DPC 902 may coordinate the billing for this effort.

[0232] In contrast to the virtual-best effort or virtual-secondary user methods, the spectrum allocation method may enable the home network operator (Network 2) to use the allocated resources for the secondary user wireless device 101 and not share the allocated resources with the primary host network. Therefore, the allocated spectrum resources may be used by the secondary users for the duration of the lease. The secondary user home networks may also be enabled to control the allocated resources for the duration of the lease by using their radio access network nodes 102.

[0233] FIGs. 23A and 23B illustrate an embodiment for allocating spectrum resources to a license area 2300 using the spectrum allocation method. When allocating spectrum resources to a license area 2300, the primary host network may allocate a defined amount of spectrum resources to be used by secondary user home networks. Each network operator of the secondary home network may be granted use of the allocated spectrum over a geographically defined license area. As illustrated in FIG. 23A, a block of spectrum license 2300 may belong to a specific license area 2300.

[0234] The license area spectrum allocation method may involve partitioning the block of spectrum 2302 which may be used over the entire license area. Partitioning may be accomplished in various different channels, by sharing channels, or by other methods. As shown in FIG 23B, the block of spectrum 2302 may be partitioned to provide three channels 2304a, 2304b, 2304c for use by the primary users and channel 2304d for leasing.

[0235] FIG. 24 illustrates an embodiment for allocating spectrum resources to a regional area using the spectrum allocation method. The regional area spectrum allocation may involve allocating spectrum within the host network's defined license area 2300. The primary host network may allocate certain defined geographic areas. The areas border the secondary users which may use the allocated spectrum resources. Therefore, the geographic area designated for the use of the allocated resources may be a sub-area of the entire license area 2300 in which operators have access to the spectrum. The host network (i.e., lessor) may lease, sell, option, or otherwise transfer resources on a temporary basis to other secondary operators for their use in the geographically defined sub-areas. This may allow the primary host operator to reserve the use of other geographic areas to the use of their primary users or for leasing to other secondary networks.

[0236] A single resource allocation may be defined for possible use in an operator's license area 2300. For example, Channel (4) 2302d may be licensed through the DSA communication system to a successful secondary user bidder for regions A 2402. The same Channel 4 may also be licensed to another secondary user bidder for region B

2404. Outside of regions A 2402 and B 2404, the full spectrum (Channels 1-4) 2302 may be used by the primary network. In regions A 2402 and B 2404, only Channels (1-3) 2302a, 2302b, 2302c may be used by the primary network operators. In regions A 2402 and B 2404, the primary user may not use Channel (4) 2302d which is licensed to secondary network providers. For example, a bidder for a resource may engage in many different contractual relationships for spectrum including leasing, buying, optioning, trading, pool, or otherwise transfer spectrum.

[0237] Once available resources are allocated, they may be accessed based on different methods. The spectrum access methods may depend on the method of allocation used by the network which is providing the resources. In general, spectrum access methods may be divided into two categories of roaming and non-roaming methods. When resources are accessed based on a roaming method, a secondary user wireless device 101 may be required to use the available resources by roaming onto the primary network. When resources are accessed based on non-roaming methods, the secondary user wireless device 101 may be allowed to remain on its home network while using the allocated resources.

[0238] FIGs. 25A and 25B illustrate two network diagrams showing access to resources using roaming arrangements to allow a wireless device 101 to use resources of another network according to an embodiment. As illustrated in FIG. 25A, a wireless device 101 may currently use the spectrum of Network 1. Network 1 may communicate to DPC 902 that the additional spectrum resources may be required to continue service to the wireless device 101. DPC 902 may also receive information from Network 2 which may have additional or excess spectrum resources that may be allocated for use to the wireless device 101 from other networks.

[0239] As illustrated in FIG. 25B, once the DPC 902 confirmed that Network 2 has spectrum for allocation, based on the services being used, time and/or geographic location, the wireless device 101 may be instructed to switch carriers from Network 1 to Network 2.

[0240] In an embodiment, a secondary user network provider may license or lease the right to use spectrum resources that are allocated by a primary network. In such a scenario, the secondary user device 101 may not be required to roam onto the primary network to use the allocated spectrum resources. The secondary user device 101 may remain on the secondary home network which may make available the resources of the primary network through the secondary network access points based on the licensing terms.

[0241] FIGs. 26A and 26B illustrate a further spectrum allocation method using short term leasing of resources according to an embodiment. Available spectrum may be leased to other networks by employing the DSA communication system, based on a license area, sub-license area or by individual nodes, cell site. DSA communication system may make available such leased spectrum for secondary use through other networks following a geographic and space boundary determination. In an embodiment, a secondary user may access allocated spectrum of a host network through its own secondary network and without having to switch to the host network.

[0242] FIG. 26A illustrates a wireless device 101 in communication with the wireless access node 102a of Network 1. Network 1 may have a licensing agreement with Network 2 to use a designated block of the spectrum of Network 2. In such a scenario, when the spectrum resources of Network 1 are exhausted and additional resources are required, Network 1 may use the licensed secondary spectrum resources to communicate with the subscriber wireless devices 101. FIG. 26B illustrates a wireless device 101 in communication with Network 1 using licensed secondary spectrum resources of Network 2.

[0243] Licensing of spectrum resources may enhance the capacity of a network as illustrated in FIGs. 27A and 27B. As shown in FIG. 27A, network provider A may serve a wireless device 101 through different wireless access points 102a, 102b, 102c depending on the geographic location of the wireless device 101. The wireless access points 102a, 102b, 102c may serve the wireless device 101 using spectrum resources from network provider A.

[0244] Due to increased traffic, network provider A may requires additional spectrum resources to properly serve its subscribers. Network provider A may license or lease spectrum resources from network provider B to enhanced and augment its available spectrum resources. As illustrated in FIG. 27B, spectrum capacity enhancement of provider A may be achieved through co-use of the radio access platform with provider B. In such a scenario, the wireless access point 102a, 102b, 102c may broadcast spectrum signals received from both providers A and B.

[0245] INITIAL CELL SELECTION

[0246] Cell selection or origination may involve the situation where the wireless device 101 of one network is directed to another network for accessing additional resources available on the new network. Currently, wireless devices 101 are programmed to establish connection with the correct networks for receiving services. To find the correct networks, once the wireless device 101 is powered on, it may search preferred Public Land Mobile Networks (PLMN), preferred roaming list (PRL) and radio carriers that the device is authorized to use. The PLMN/PRL and list of radio carriers may be provisioned on the wireless device. The PLMN/PRL list may include PLMN identifications of authorized networks and carrier in ranked order.

[0247] Because the DSA communication system may provide dynamic and real-time access to spectrum resources, when using the DSA system, spectrum resources may be available at networks which are not listed on the wireless device's PLMN/PRL.

[0248] As part of the DSA communication system process the wireless device 101 may be programmed in advance with the appropriate PLMN list. Further, the wireless device 101 may also be provisioned over-the-air on the secondary home network. The over-the-air provisioning may provide instructions to one or a group of wireless devices 101 to reinitiate the cell selection process with an updated PLMN list.

[0249] Alternatively, the wireless device 101 may be configured with a client application which upon receipt of a WAP/SMS message enables the wireless device 101 to search for a PLMN that has been made available in the DSA process.

[0250] Several methods may be used to allow the wireless devices to access available resources on different networks. In the DSA communication system, there are at least two types of networks or source systems: virtual or existing networks. Virtual networks may include networks that utilize the Radio Access Network (RAN) of the primary network. When wireless devices 101 are required to access virtual networks, the regulatory features and requirements for emergency calls (e.g., 911 calls) and other regulatory stipulations may need to be addressed.

[0251] When connecting to virtual networks, the DPC 902 of the primary network may control the access of the secondary user wireless device 101 and access RF spectrum resources and the subscriber records of the primary system to allow the secondary users to appear as roamers on the primary network. The secondary user wireless devices 101 may use a list of preferred networks to access virtual networks.

[0252] Alternatively, when originating using existing networks, the secondary user wireless device 101 may make a cell selection based upon a priority list of networks participating in the DSA communication system. Once the secondary user wireless device 101 is authenticated, the DPC 902 of the primary host network may validate the secondary user to access resources on the primary network. If authentication or validation is not successful, the DPC 902 of the primary user may send a request to the secondary wireless device 101 via a client in the device to re-originate onto the proper system.

[0253] Wireless devices 101 may include a universal subscriber identity module or USIM. The USIM may be a single or dual USIM. Critical information such as data required to select the correct network may be stored on the USIM. By using a USIM, a wireless device 101 may be enabled to no longer use a PLMN. USIM may have stored upon it information such as home International Mobile Subscriber Identity, or IMSI (HPLMN), prioritization list of permitted VPLMNs and forbidden PLMNs list.

[0254] If a wireless device 101 uses a dual USIM, it may be enabled to immediately access spectrum resources available in an alternative network. The dual USIM may further enable a multiband, multimode wireless device 101 to access a variety of networks in the DSA as well as using standard roaming arrangements.

[0255] FIG. 28 illustrates an embodiment method 2800 for network and cell initialization by a wireless device 101 in the DSA system. The initial network and cell selection may begin with the wireless device 101 when it is either powered on or trying to reestablish connectivity, block 2802. The wireless device 101 may initially search the PLMN/PRL list that is stored on the device, block 2804, and select a cell by receiving, reading and determining the strength of nearby cell site broadcast channels, block 2806.

[0256] The wireless device 101 may read the cell site broadcast channel and determine whether the cell site offers the correct system, determination 2808. The wireless device 101 may select and establish a connection to the best cell site available. To identify the best cell site available, the wireless device 101 may measure the adjacent cells based upon the access technology to determine which cell is the best to utilize.

[0257] If, at initiation, a suitable cell is not available (i.e., determination 2808 = "No"), the wireless device 101 may use the Any Cell Selection process/stage and continue to search for a suitable cell site by selecting the next PLMN/PRL listing until it finds a site that allows normal access following the access protocol in the appropriate PLMN list, block 2810.

[0258] If the correct system is available through the selected cell site (i.e., determination 2808 = "Yes"), the wireless device 101 may receive and read the System Information Block (SIB)/Master Information Block (MIB) transmitted by the selected cell site, block 2812. The SIB/MIB may include information about the network that the cell site is serving and available services through that network.

[0259] In an embodiment, SIB/MIB may include a host of information such as PLMN ID(s), Cell ID, traffic allocation identifiers (TAI) (routing area), LTE neighbor list, LTE non system sites, GSM cCells, UMTS cells, and CDMA cells. This information may be used by the wireless device 101 for different purposes. For example, when the wireless device 101 moves from eNodeB to eNodeB, it may use the SIB/MIB information sent from the new eNodeB to determine that a change has occurred in the serving eNodeB. To detect the change in eNodeB, the wireless device 101 may identify the change in SIB/MIB information which may include a change in change in the PLMN availability and TAI parameters. TAI defines specific routing areas that can further be used to refine a geographic region in which the wireless device 101 can use available resources.

[0260] SIB/MIB information may be transmitted to the cell site by the network. The cell site may receive the network information through the HSS 926 of the network. In addition to the data transmitted through the SIB, the HSS 926 of the network may also provide the information as to which PGW(s) 908 the wireless device 101 may use to access resources on the network.

[0261] Upon reading the SIB/MIB, the wireless device 101 may determine whether reselection is required, at determination block 2814. If no reselection is required (i.e., determination block 2814 = "Yes"), the wireless device 101 may camp on the cell channel, in block 2816. If system reselection is required (i.e., determination block 2814 = "No"), the wireless device 101 may be instructed to reselect a new cell or system based on the cell selection/reselection process, block 2818.

[0262] While camping on the selected cell site, the wireless device 101 may receive additional information and instructions over the air from the selected network, such as updated list of public land mobile network or PLMN/PRL. The wireless device 101 may also continue to monitor the SIB/MIB for any changes or additional information.

[0263] In an embodiment, the SIB/MIB may provide a Secondary Access Class which may enable the wireless device 101 to determine which channels based on the DSA process it can use for access through the reselection process. The SIB/MIB may also include data to enable the camping wireless device 101 to reselect another radio access technology (IRAT) and attempt to acquire a control channel on the new Radio Access Terminal (RAT). The information in the SIB/MIB may, thus, be used to instruct a wireless device 101 to reselect another RAT that is associated with the same or another network which may be on a another frequency band.

[0264] Cell reselection, which may trigger PLMN selection, may be controlled via specific parameters. For example, the DSA communication system may employ barred PLMN-id to prevent a wireless device 101 using resources from one network to attempt to roam on to other networks. For example, the DSA communication system may prevent a secondary user wireless device 101 using resources of a primary host network to roam back to or establish connection with the secondary home network. Similarly, the DSA communication system using a PLMN id prioritization scheme that is over the air (OTA), client activated or dual USIM driven may also prevent a wireless device 101 using resources of a network to reestablish connection with other networks unless the DSA communication system rules permit.

[0265] In an embodiment, a wireless device 101 that is camping at a cell site may be instructed to perform cell reselection when the capacity of the current cell reaches a predetermined level. In such a scenario, the DSC 910 of the current camping network, using the OMC 912, may change the SIB/MIB of the current network to include instructions the camping wireless device 101 to perform a cell reselect and search for another TAI area or system. The instructions to perform a cell reselect may also be forwarded by the WAP/SMS message to the wireless device 101.

[0266] FIG. 29 illustrates an embodiment network diagram for cell reselection using changes in the TAI. When using a network, different wireless devices 101 may be assigned different TAI's depending on their particular uses and device types. For example, a network may assign one TAI to DSA communication system users. The network may also assign another TAI to devices which do not use the DSA communication system. The advantage of using multiple and layered TAI's may enable the TAI assigning network to selectively tailor usage traffic. The multiple and layered TAI's may further enable the TAI assigning networks to prevent the wireless devices 101 that may have correct PLMN-id but are not supposed to use the selected area from selecting the cells but may be denied service or may be forced into cell reselection.

[0267] In an embodiment, a special client may be installed on DSA communication system compatible wireless devices 101 to enable the wireless devices 101 to determine which system and RAT is supposed to use on secondary bases. The PLMN/PRL list of the client application may be updated by receiving an SMS or WAP that may be transmitted to the handset via a text message or through a data (IP) session. The updated client application may instruct the wireless device 101 to go to the proper channel for accessing allocated resources of a primary network.

[0268] Using a client application may facilitate the implementation of the DSA communication system in legacy networks and systems which may or may not possess the ability (e.g., due to software load) to have a secondary access channel defined in the SIB.

[0269] In idle mode, the wireless device 101 may be instructed to perform intra and inter frequency measurements in the cell reselection process. Using information in the SIB/MIB or from the client application, the wireless device 101 may perform intra-frequency search, inter-frequency, or inter-radio access tech (iRAT). This process may be controlled by UTRAN. The Intra and Inter frequency measurements or inter-radio access technologies may be on a region or cell/sector bases, depending on configuration of the wireless device 101.

[0270] AUTHENTICATION OF SECONDARY USER WIRELESS DEVICES:

[0271] Once the wireless device 101 selects the appropriate cell site and before it enters an idle mode, the wireless device may need to be authenticated by the system on which it is camping. The selected network requires validation and authentication of the wireless device 101 to ensure that the device possesses the required permissions to access the network.

[0272] The DSA communication system may authenticate a wireless device 101 using different methods. Authentication of the wireless device with the DSA may depend on the business arrangements between different providers and the DSA system. For example, authentication may be based on general or prioritization levels. The authentication process may be followed using the DPC 902 HSS 904 as the anchor and this may be accessed by the AAA/AuC of the 3G/2.5G networks of the PCRF 904 in LTE or similar platform. The Host Network may authenticate the secondary users by using standard MAP/IS-41 signaling.

[0273] Upon authentication, each entrant may be assigned: (a) defined usage level allowed on host network; duration permitted on system; purchase type (e.g., wholesale or a range of IMI's); HSS would allow redirecting of inbound calls; applications would continue where they relied on a server which is accessible from the backend.

[0274] MONITORING AND TRACKING OF ALLOCATED RESOURCES:

[0275] The DSA communication system may ensure that the primary network provider always has adequate resources to manage traffic on the primary provider network (e.g., Network 2). Therefore, depending on the volume of traffic, the DSA communication system may dynamically on a real-time and/or statistical basis alter the spectrum/capacity available to secondary users.

[0276] For example, at peak hours, call traffic may increase in the primary network. When call traffic increases in the primary network, the DSA communication system may reduce the amount of spectrum available for allocation to secondary users to ensure that the primary users have adequate resources.

[0277] The DSA communication system may manage allocation of and access to resources based on different factors including priority level of the users, time the spectrum is used and the geographic location of the user. In an embodiment, when the secondary access to the primary network is related to certain events such as disasters, emergencies, first responders or public safety, the DSA communication system may manage the secondary use of the primary system by using different prioritization. For example, when secondary users are first responders who are using the primary network resources, the DSA communication system may maintain or increase the resources allocated to the secondary users by the primary network provider to allow the emergency calls to go through successfully, even to the detriment of the primary network users.

[0278] In an embodiment, the use of spectrum resources of one network by a secondary user may be managed and controlled by different components of the DSA communication system such as the DPC 902. For example, the DPC 902 of a primary network may monitor the use of the allocated spectrum resources to ensure appropriate steps are taken when allocated resources are exhausted or no longer available for secondary use.

[0279] The DSC 910 of the primary network may be configured to monitor or receive data regarding the traffic levels associated with the primary network on which the wireless devices 101is operational as a secondary user. The DSC 910 may further be configured to off-load the secondary user by downgrading resources, forcing to terminate (i.e., off-load) a connection of a secondary user or redirecting a secondary user to another carrier or channel set if the primary network capacity threshold is reached.

[0280] The DSC 910 of a primary network may also inform the DPC 902 when off-loading of secondary users may be required. For example, an unexpected surge of primary callers may cause the DSC 910 to request that secondary users be off-loaded to make available resources for the primary users. When off-loading of secondary users is initiated, technical access parameters may be sent to (OTA) to the wireless device 101. Alternatively, the system may dynamically assign resources via LTE using the X2 link instructing the defined wireless device 101 to handover to the new LTE network.

[0281] Off-loading of secondary users may include redirecting the secondary users' connections back to the secondary user's own network, to another provider network or channel or disconnecting the secondary users' connections with the primary provider network. For example, when a primary host network may be required to terminate a secondary user due to increased demand on the primary network, the DPC may be configured to determine whether other networks are available to redirect the secondary user's connection instead of terminating. The DPC 902 may inquire for resources from DSC 910 of other networks. If the resources are available for use in other networks, the DPC 902, using a rule set, may determine the most cost effective connection with another host network which satisfies the resource request requirements. Once the DPC 902 has identified another host network to which the secondary user wireless device 101 may be redirected, the DPC 902 may instruct the wireless device 101 to transition over to the new host network for the communication session. The process of off-loading of secondary users may include handover or back-off processes which are explained in more detail below.

[0282] In a further exemplary embodiment, the DPC 902 of the host network may also be configured to instruct the primary host network to release the secondary user wireless device 101 back to the secondary home network after the use of the primary network resources is completed. The DPC 902 may further be configured to force terminate the secondary user's connection with the primary network if the DPC 902 determines that additional capacity is required for use by primary users.

[0283] If sufficient capacity is available, the DPC 902 may force the secondary user to continue to use the resources of the primary host network until the traffic volume on the primary host network requires additional action based on rule sets.

[0284] In the various embodiments, the DSA may further manage the use of the allocated and accessed spectrum. For example, the DSA communication system may manage the use of the host network's RF spectrum by employing a back-off mechanism. When the host spectrum network is accessed by high priority users, the spectrum may rid of lower priority users to make available spectrum to higher priority users.

[0285] FIG. 30 illustrates a network architecture diagram 3000 for monitoring and tracking of spectrum usage according to an embodiment. Tracking and monitoring of the use of spectrum resources may be performed using different methods. In a DSA communication system using the virtual-best effort method of resource allocation, the

DSC 910 may monitor usage of spectrum resources based on pre-arranged billing information and communication with the primary network billing platform.

[0286] The DSC 910 may monitor the usage level for the group and also track usage level with the PGW 908. The usage may be compared and monitored against what was anticipated or rather successfully bid. Once a predefined amount of the allocated resources are used by a secondary user, the DSC 910 of the primary network may be configured to generate a notice that resources are reaching a critically low level and send it to the secondary network provider through the DPC 902. The secondary user may receive the notice through its own DSC 910. Upon receipt of the notice, the secondary user provider network may rebid for additional resources or simply let the remaining resources to run out.

[0287] In the event that a secondary user is actively using a primary network when allocated resources are fully consumed, the primary network may instruct the secondary user wireless device 101 to reconnect to the home network (secondary user network provider), terminate the wireless device's connection, or charge an overage or supplemental fee to the secondary network based on a previously negotiated contract. Upon termination of connection, the secondary user wireless device may not be able to access the primary network resources unless additional resources are allocated for the secondary user.

[0288] In a DSA communication system using the virtual-secondary user method, the DSC 910 may monitor the usage of the allocated resources based on pre-arranged billing information and communication with the host primary network billing platform. The process of monitoring the usage of the allocated resources based on a virtual-secondary user method may involve mentoring the usage level for the group and also tracking usage of the level with the PGW 908.

[0289] Similar to the DSA communication system using the virtual-best effort method, the DSA communication system using the virtual-secondary user method may monitor the usage by comparing the usage against the amount of resources that was allocated to the secondary user network provider. Once a predefined amount of the allocated resources are used by the secondary user, the DSC 910 of the primary network may be configured to generate a notice that resources are reaching a critically low level and send it to the secondary network provider through the DPC 902. The secondary user may receive the notice through its own DSC 910. Upon receipt of the notice, the secondary user provider network may rebid for additional resources or simply let the remaining resources to run out.

[0290] In the DSA communication system that is using the virtual-secondary user method, after allocated resources are exhausted, the secondary user may be terminated by different methods, for example by 1) No prioritization back-off; or 2) prioritization back-off as discussed below.

[0291] In the no prioritization back-off method, when the allocated spectrum resources at the pre-determined level are consumed, no further usage may be permitted. Once allocated spectrum resources are exhausted, the primary network DSC 910 may instruct the secondary user wireless device to connect to the secondary user home network, terminate the secondary user wireless device's connection with the primary network, or charge an overage free based on previously negotiated contracts. Upon termination from the primary network, the secondary user wireless device may not be able to access the primary network resources unless additional resources are obtained by the secondary home network provider.

[0292] In the prioritization back-off method, when the allocated spectrum resources are at critically low levels and before the resources are completely consumed, the primary network may commence a back-off process during which the primary network may place the secondary user wireless device 101 on another suitable network. If not, other suitable networks are available to accept the secondary user wireless device 101, the primary network may handover the secondary user wireless device 101 back to the secondary user home network. The primary network may credit the secondary network for any allocated resources that were not used by the secondary users.

[0293] When using the resource allocation method, the primary host network may monitor allocated resources differently depending on whether resources are allocated based on a license area or regional area method.

[0294] If the allocation of resources is preformed based upon a license area method, the primary network may monitor the usage of the resources by the secondary users. When the allocated resources are near exhaustion, the DSC 910/DPC 902 may inform the secondary user network that the temporary lease of the resources is about to expire and provide an opportunity to the secondary network to bid for and purchase additional resources.

[0295] If the secondary network fails to or refuses to obtain additional resources, the primary network may terminate or back-off the secondary user from the primary network using different methods, such as, 1) no prioritization back-off; or 2) prioritization method.

[0296] In the no prioritization back-off method, when the lease of the resources is expired, the spectrum resources may no longer be available to the secondary users. The primary network may instruct the secondary user wireless devices 101 to either handover to another radio access system in their network or terminate their use.

[0297] In the prioritization back-off method, the primary network's DSC 910/DPC 902 may coordinate resources with the DSC 910 of the secondary network with respect to the affected sites. The secondary network may attempt to handover the secondary user wireless network to another network, base station, radio access channel or system for the affected area. The primary network may credit the secondary network for unused allocated resources.

[0298] If the allocation of resources is preformed based upon a regional area method, the primary network may monitor the usage of the resources by the secondary users. When the allocated resources are to expire and near a predetermined completion level, the DSC 910/ DPC 902 of the primary host network may inform the secondary home network that the impending termination of resources. The primary network may provide the secondary network an opportunity to rebid for additional resources.

[0299] If the secondary network fails or refuses to obtain additional resources, the primary network may terminate or back-off the secondary user from the primary network using different methods, such as, 1) no prioritization back-off; or 2) prioritization method.

[0300] In the no prioritization back-off method, when the leased term for the allocated resources is expired, the secondary user may no longer have access to the spectrum resources of the primary network. The primary network may either hand over the secondary user to another radio access system in their network, which can be a host network or another network or terminate the secondary user's access to the primary network resources.

[0301] In the prioritization back-off method, the DSC 910 and DPC 902 of the primary network and the DSC 910 of the secondary network may coordinate resources with the affected sites and commence the back-off process before the lease of allocated resources is expired. The secondary network may attempt to handover the secondary user wireless network to another network, base station, radio access channel or system for the affected area. The primary network may credit the secondary network for unused allocated resources.

[0302] HANDOVER OF SECONDARY USERS DURING OFF-LOADING:

[0303] In an embodiment, the DSA communication system may employ handover methods to prevent interruptions during or maintain communication sessions between wireless devices 101, the DSA communication system and/or network providers. For example, a communication session may include a wireless device 101 establishing connection with a network. Handover may occur when the wireless device's 101 connection migrates from the home network to a host network and back to the home network during the period of one communication session. The SIB/MIB generated by the network may include the list of cells and networks that may be used to handover a communication session.

[0304] Outside of the DSA communication system, mobile assisted handovers may involve the wireless device 101 informing the servicing network that a better server is available and changing the connection from the current server to the better server. Such mobile assisted handovers may be performed when wireless devices are roaming on host networks. However, the DSA communication system may not allow such mobile assisted handovers, because the best server for roaming purposes may not be the most optimum cell for capacity relief. Communication sessions with the DSA communication system may involve circuit switch or packet switched services.

[0305] FIG. 31 illustrates a network component diagram of an embodiment network capable of performing handover of communication sessions. To implement a handover of a communication session, certain connectivity between components of the host and home networks (e.g., network A and network B) may exist. For example, the PGW 908 of the host and the home networks may be connected. The PGW 908 of the host and home networks may communicate through the Internet or a private data network. The PGW 908 of the host may also be connected to the SGW 922 of the home network. The ANDSF 918 of the host and home networks may also be connected to allow handover to the legacy system and to invoke the back-off process when the wireless device is required to migrate from the host to the home network.

[0306] Access Network Discovery and Selection Function (ANDSF) is used to manage intersystem mobility policy and access network discovery information stored in a wireless device supporting provisioning of such information from an ANDSF. The ANDSF may initiate the provision of information from the ANDSF to the wireless device as specified in 3GPP TS 24.302 [3AA].

[0307] FIG. 32 illustrates a network diagram of an embodiment method for media independent handover. The ANDSF through the DSA process may initiate the handover by sending a SMS/WAP message to the wireless device 101 instructing it to go a gap or non-gap handover. The handover process may be initiated under different circumstances and for different reasons. For example, a network may commence a handover process based on contract specifications between the host and the home network, based on the level of resources at the host network and whether the resource has reached a predetermined threshold, based on resources leased by the home network being exhausted or based on whether a back-off process is initiated.

[0308] When the host resources are no longer available for use or a back-off process is initiated, the DSA communication system may employ additional components or schemes to handover a communication session. In such a scenario, the eNodeB of the host network may perform a back-off process based on the QCI and ARP designations. The eNodeB 916 back-off may involve handing over the current communication session from the host eNodeB 916b to another eNodeB through the use of the X2 link between the exchanging networks. This process may also be achieved by using the DSMPTA process with the ANDSF.

[0309] To initiate and implement a handover process, the host network may generate and send certain commands to the wireless device 101. For example, three different types of handover include: 1) Interfreq; 2) intrafreq; and 3) IRAT.

[0310] In the interfreq handover, the network currently serving a wireless device 101(i.e., the current network) may initiate handover of the wireless device 101 from the current network to another network. In the intrafreq handover, the current network may initiate a handover of the wireless device 101 from one cell in the one network to another cell in the same network for capability offload. In the IRAT handover, the current network may initiate wireless device 101 handover to another RAT.

[0311] The interfreq handover may be initiated when the current network sends instruction to the secondary user wireless device 101 to begin using the resources of another network. For example, a wireless device 101 on a home network may be instructed to use a host network for large upload/downloads of files.

[0312] The interfreq handover may be used to offload a secondary user from a host network based on the policy decision in place. The interfreq handover may further be used when a wireless device 101 no longer needs to use the services of the host network as a secondary user and thus may be sent back to the its home network. The interfreq handovers may further be used when a wireless device 101 leave the DSA communication system cluster or cell area and requires to continue its communication session. In such a scenario, the wireless device 101 may be either transferred to another network/cluster or sent back to the home network. The interfreq handovers may further be used to relieve network capacity constraints by allowing some primary users to use the services of another network as secondary users.

[0313] The intrafreq handovers may be used in current network to relieve cell congestion by shedding traffic from one cell to another. To avoid a ping-pong effect which may prevent resolving capacity issues, the intrafreq handover commands may bar wireless devices 101 from using the neighboring cell/sector, as appears on the PLMN/PRL list, for defined periods of time.

[0314] IRAT handovers may be used to redirect wireless devices 101 to another RAT. During a handover from one IRAT to another, both ratio access technology and frequency of operation may be changed. This type of handover may be used when the DSA communication system is available and the wireless device 101 is initially active on a particular channel. The current network may instruct the wireless device 101 to change to another RAT through the IRAT handover process. In one embodiment, the handover command may be initiated from a current network, or alternatively the handover command may be initiated from a different network or entity. Thus, if the wireless device 101 communication session is dropped during the handover process, the wireless device 101 may be able to reestablish the communication session with the target RAT and not revert back to the previous network.

[0315] In one non-limiting embodiment, the session may be dropped during INTERFREQ and/or INTRAFREQ handovers. In this embodiment, the device may reestablish connections by reverting back to a previous network.

[0316] FIG. 33 illustrates a network component diagram of an embodiment system required for initiating a network handover as part of the DSA process. The handover process may be initiated by the DSC 910 based on its rule sets which are established prior to the bidding or during the bidding process. The use of the ANDSF 918 may enable both intrafreq, interfreq and IRAT handovers to take place allow for maximum flexibility.

[0317] BACK-OFF OF SECONDARY USERS FROM THE HOST NETWORK:

[0318] The DPC 902 may continuously monitor the host network resources to ensure that sufficient levels of resources are available for the use of the primary users of the host network. When the capacity of available resources at the host network reaches a predefined threshold, the host network may instruct the wireless device 101 to begin a back-off process of the secondary users. The back-off process may be initiated to free-up resources at the hosting network.

[0319] When resources need to be made available to primary users or subscribers of a network, the DSA may initiate a back-off of the secondary users to free-up additional resources. The back-off process may involve different or combined methods depending on the DSA configuration. However, commonality of the back-off policy is done using the wireless device 101 type and any special flags associated with the device, policy decision for redirecting active and idle traffic, policy decision as to whom and the order to shed traffic, and re-provisioning either OTA or via activating a client application.

[0320] In an embodiment, the DSA communication system may be configured to employ tiered priority access (TPA) rules (as explained in detail above with respect to FIGs. 1-8) when initiating back-off processes. For example, the back-off process may be initiated when a resource level reaches a predetermined threshold level which may be user defined. The threshold detection process may include traffic monitoring of the Radio Access Network (RAN) and Core Network resources and determining whether a predetermined threshold level is reached which may trigger QoS or require shedding of secondary users to free-up resources.

[0321] Threshold levels for RAN and Core Network resources may be determined based on the traffic usage that secondary users may generate. For example, when more than 85% of the RAN resources are used, back-off process may be implemented to either reduce the throughput of the secondary users or shed secondary users from the host network or both. By initiating the back-off process, the host network ensures that amount of available RAN and Core Network resources always remain above 15%.

[0322] In an embodiment, the back-off process of the DSA which would allow each host network to maintain certain amount of resources free at all times may be proactive and independent of actual incidents. In the event of an incident, such as a natural disaster, the DSA communication system may have the capacity to make available free resources to first responders and employ the TPA process if additional resources are necessary.

[0323] In an embodiment, the DSA communication system may monitor the traffic during the back-off process and begin to release RAN resources for secondary use at user defined intervals.

[0324] In an embodiment, each host network may employ certain back-off policies and resource criteria in deciding whether to initiate a back-off process. These policy and resource criteria may include: spectrum availability (separate or co-existence); capacity/bandwidth availability (RF and Core); overhead criteria (percent total available capacity vs. used capacity); back-off criteria (reselection, handover – intra system and inter-system) termination); treatment (how specific services/applications are treated/routed); barred treatments (which services/applications are barred for use); rating (how services are rated, i.e., possible special discount for off-peak usage); geographic boundary (define zone or cell for inclusion); time (define time and day(s) for inclusion); duration (define incremental allocation based on time and geographic boundary); user equipment types.

[0325] Back-off process may be implemented differently for different resource allocation methods. In an embodiment, the back-off process for the virtual-best effort (pure roaming) allocation method may be governed by the PCRF 905 policy rules set forth in the (EPC). The eNodeB may also be configured to initiate traffic reducing actions based on capacity loads by using the X2 link. In such a scenario, the eNodeB may enable the host network to shed secondary users by handing off traffic to the adjacent cell sites. In one embodiment, the eNodeB may send instructions to one or more entities including the UE. In another embodiment, the eNodeB may initiate the process.

[0326] Additionally the back-off process for DSA may also involve one or more items which will be governed or instituted through the DSC following the agreed upon policy based rule sets and are meant to ensure session continuity or re-allocation of the UE to another access method in an attempt to ensure the user experience is maintained during the back-off process.

[0327] In an embodiment, the (DSMPTA) back-off process for virtual-best effort may be above and beyond the typical rule sets which are part of the Access and EPC. When traffic reaches a pre-defined threshold, the DSA communication system may initiate one or a combination of processes to implement a DSMPTA back-off process. The PCRF 905 may dynamically adjust the QCI/ARQ values for the secondary user wireless device 101. This may involve restricting the bandwidth or placing usage onto a best effort or lower priority scheme. The cells which are experiencing capacity constraint may be placed on a barred cell list so that no additional secondary user may access the cells. The updates to the barred cell list may be communicated to the wireless devices 101 through re-provisioning the broadcast message that is sent to the wireless devices 101. The broadcast message may be updated with information regarding the barred cells and the neighboring available cells.

[0328] To ensure that the wireless devices 101 receive and read the broadcast messages regarding the barred cells and the available neighboring cells, the DSA communication system may send WAP/SMS messages to the configured wireless devices 101 to force them to reselect. The wireless devices 101 will have to read the broadcast messages when they enter the reselection process.

[0329] In an embodiment, the DSA may initiate close service groups to restrict the use of particular cells sites to the roaming wireless devices 101. The combination of CSG and TAI's which may be involved with the capacity issue may restrict the secondary user wireless device 101 from accessing the network. For example, the CSG and TAI may drop callers, may reduce quality, may expand the network, or may provide other items to deal with the capacity issue.

[0330] In an embodiment, during a back-off session, the ANDSF 918 may facilitate a handover of the secondary users to another network or back to the secondary user home network. ADDSF 918 may initiate a network handover if connectivity is available with another network. The wireless devices 101 may be handed over to another network or another access network (RAT/IRAT).

[0331] In an embodiment, the back-off process in DSA using a virtual-secondary user method of resources allocation may be governed by the PCRF 905 policy rules set forth in the EPC and DPC 902. The PCRF 905 policy rules of a primary host network which apply to the secondary users may take priority over those enforced by the DPC 902. However, the PCRF 905 policy rules of the primary host network may be dynamically changed or amended based on the conditions set forth by the primary host network operations requirements. Additionally, the back-off process in a DSA communication system may involve additional items. The implementation of these additional items may be controlled and governed through the DSC 910 of the primary host network based on the agreed upon policies and rules sets. The DSC 910 policies and rules are designed to ensure communication session continuity and good user experience during the back-off process.

[0332] In the event that the existing policies and rule sets in the Access and EPC fail to apply to a back-off process, the DSA back-off process for secondary users may be implemented. For example, when primary host network traffic reaches a predetermined threshold level, the host DSC 910 may instruct the host eNodeB to handover the secondary user to adjacent cell sites within the host network using the X2 link and based upon the secondary user wireless device 101 QCI/ARQ rule sets.

Alternatively, the DSC 910 may instruct the host eNodeB to handover the secondary user to the home network using the X2 link when the host and home networks are connected for full mobility.

[0333] Based upon instructions received from the host DSC 910, the host PCRF 905 may dynamically adjust the QCI/ARQ values for the secondary user wireless devices 101. For example, the host PCRF 905 may restrict the bandwidth, change resources allocation method to virtual-best effort, or change priority schemes to low priority.

[0334] The DSC 910 may instruct the host network to update or generate a list of barred cells and include the cells which are currently experiencing traffic capacity that is above the predetermined traffic capacity threshold. The DSC 910 may further instruct the host network to broadcast a message to re-provision the secondary user wireless devices 101 with the updated barred cell list. The broadcast message may further include information regarding the next ring or multiple rings of cells adjacent to the constrained cell or group of cells. The broadcast message may include changed and valid PLMN-ids, altered TAI for the cell or cells, and altered neighbor lists for the use of the secondary user wireless device 101 to perform a handover process or network reselection. To ensure that secondary user wireless devices 101 check for the re-provisioning broadcast messages, the host network may send a WAP/SMS message to configured wireless devices 101 to force them to perform network reselection.

[0335] The host DSC 910 may further instruct the host network to initiate Close Service Groups (CGS) to restrict the use of particular cell sites to the roaming secondary user wireless devices 101. The combination of CGS and TAI involved with the network capacity may restrict access of the roaming secondary user wireless devices 101 to the host network. The access restriction effectuated by the combination of CGS and TAI may render the host network only accessible to designated primary users.

[0336] In the event that connectivity exists between the primary host and another network (e.g., the secondary home network), the host DSC 910 may instruct the host

ANDSF 918 to initiate a network handover of the secondary user wireless device 101 to another connected network or access network (RAT/IRAT).

[0337] To reduce capacity overload when eNodeB is x-furcated for resources allocation and access, the host OMC 912 (or other policy based controls configured to manage capacity) may instruct the eNodeB to shed the resources accessible to the secondary user wireless devices 101. Accordingly, the resources designated for secondary use and associated with an eNodeB for the affected area may be reduced. The reduction in available resources of an eNodeB may be force handovers to or reselection of adjacent cell with resources.

[0338] The reallocation of eNodeB resources may be balanced by host network initiated handovers to force the secondary user wireless devices 101 to handover to another network on which they can roam and be provided with adequate resources. For example, the handovers may be interfreq RAT or IRAT handovers.

[0339] The host PGW 908 may also be used as part of the back-off process. The SG of the secondary user wireless devices 101 may be connected to the appropriate host PGW 908 based on the policies and rules of the host HSS 904 and PCRF 905. The host DSC 910 may control the bandwidth of the connection between the host PGW 908 and wireless device's 101 SG. During the back-off process, the host DSC 910 may initiate the host network to reduce the bandwidth between the PGW 908 and secondary user wireless device's 101 SG which are being moved out of the host network. The process by which the DSC 910 may reduce bandwidth between the PGW 908 and SG may be governed by predetermined policy and rules. The host DSC 910 may continue to monitor the host network cells which may be overburdened by high traffic and assess additional bandwidth reduction to the host PGW 908-device SG connection to reduce traffic.

[0340] Not all the processes initiated by the DSC 910 as part of the DSMPT back-off process may be necessary and the implementation of these processes and the order in which they may occur may depend on the agreements between the host and home networks.

[0341] In an embodiment, the back-off process may be implemented in the DSA communication system using a spectrum allocation method of resources allocation. The spectrum allocation method may include the license area and regional area methods for resources allocation.

[0342] In an embodiment, the back-off process for a DSA using a license area method may involve the reallocation of the spectrum resources from the secondary home network (i.e., lessee) to primary host network (i.e., lessor). The host network using the license area method may initiate the back-off process to handover all the existing secondary user wireless devices 101 from the lessor's spectrum to another network or back to the home network. The time frame for the reallocation will be predetermined based on rule sets defined by the lessor and lessee agreements. Depending on the time frame defined in the rule sets, not all the secondary users may be migrated out the host network in time and as a result, some secondary users may be dropped.

[0343] Based upon pre-negotiated agreements between the lessor and the lessee, the host network may determine whether the back-off process may be applied to a portion of or the entire license area. Based on the geographic region involved for capacity relief, spectrum reallocation may not be required for every cell of the entire license area. Accordingly, back-off processes may be implemented in sub-license areas of the licensed area.

[0344] In implementing the back-off process for an entire license area, the host DSC 910 may inform the DPC 902 that the host network has reached a predefined threshold of traffic capacity. The DPC 902 may communicate that message to the home DSC 910. The home DSC 910 may reduce the host resources available to the home eNodeB in a stepwise manner and handover the secondary user traffic to a non-leased spectrum. The steps of reducing the available resources to the eNodeB may be performed on a predefined time intervals basis. If traffic is not migrated in a timely manner, the home DPC 902 may initiate network handovers to migrate the secondary users from the host network to another appropriate channel. Once the resources are freed, the home eNodeB may remove the channel from its available channel lists.

[0345] In implementing the back-off process for sub-license areas (in opposed to the entire license area), the process above may be implemented except that defined cells or TAI's may be used instead of the entire license area.

[0346] Once the capacity restrictions are resolved by the host network, the spectrum may be reallocated to the home network. To reallocate resources, the host DSC 910 may inform the DPC 902 that spectrum resources are again available for use by the home network. The home DPC 902 may inform the home DSC 910 that resources are again available. The resources may be reallocated to the home network based upon predetermined policies and rule sets.

[0347] For back-off processes which are not governed by rules and policies in the Access and EPC, the host may initiate a DSMPTA back-off process. It may be possible that based on the rules sets.

[0348] In an embodiment, the back-off process for a DSA communication system using a Regional area method may depend on the policies and rule sets agreed upon by the lessor and the lessee.

[0349] The back-off process in a DSA using the Regional area method of resources allocation may include handing over all the existing secondary wireless devices 101 using the host spectrum in the regional area or sub-regional area back to the home or another network. The host DSC 910 and DPC 902/DSC 910 rule sets may define whether the secondary users should be moved from the entire or a sub-set of regional area.

[0350] The timeframe for the reallocation of resources during the back-off process may be predetermined based on policies and rule sets agreed upon by the lessor and lessee. Not all the traffic may be successfully migrated to the home or another network during the back-off process if the timelines set forth in the agreement is not met. In such a scenario, some connections may be dropped or lost as soon as the predetermined timeframe is expired.

[0351] Upon initiation of the back-off process, the lessee network resources associated with the home eNodeB may be reduced in a stepwise manner. The home OMC 912 may initiate reduction of the resources by the eNodeB. Other policy based components of the home network, such as the DPC 902 may also initiate the reduction of resources by the eNodeB. The home network may facilitate the handover of the secondary users from the host network spectrum to the home network spectrum. If the home network does not have the capacity to handle the traffic volume or handover is not being performed in a timely fashion, it may either handover the communication session to another network or channel or force the secondary user wireless devices 101 to perform a reselection process. Once the eNodeB has handed over all the secondary users from the host spectrum, it may remove the spectrum channel from the available list of channels accessible to secondary users.

[0352] Once the capacity restrictions are resolved by the host network, the spectrum may be reallocated to the home network. To reallocation resources, the host DSC 910 may inform the DPC 902 that spectrum resources are again available for use by the home network. The home DPC 902 may inform the home DSC 910 that resources are again available. The resources may be reallocated to the home network based upon predetermined policies and rule sets.

[0353] FIG. 34 shows a smart phone 101a, a laptop 101b, and a cell phone 101c communicating with an element 3402 that is connected to a prime 3404 and a secondary 2306 and which communicates with a base station 102a and 102b via a primary RAT and a secondary RAT. The base station 102a connects with a primary network and the base station 102b connects with a secondary network 102b. In an embodiment, as illustrated in FIG. 34, the DSA communication system may allow wireless devices 101a-101c to access several Radio Access Technologies (i.e., primary and secondary RATs) simultaneously. For example, the DSA may enable a wireless device 101 using a primary RAT of a primary network to access a secondary RAT on a secondary network only for certain types of services. For example, when the wireless device 101 use of the primary network causes high volume or bursty traffic, the DSA communication system may enable the primary network to offload and send the high volume and bursty traffic to the secondary network. For example, prime and secondary element 2306 and 3404 may provide data to route traffic over to the primary and secondary wireless networks and base stations using a header. Switching may occur using a DSA to switch between the networks. In another embodiment, the switching may occur using the element 3402, prime component or secondary component 3404 or 3406. In yet another embodiment, the switching may be initiated by the prime or secondary DSA networks, or by another entity that views the capacity of the network.

[0354] FIG. 35 illustrates a message flow diagram 3500 of the arbitrate process in a DSA communication system according to an embodiment. In this embodiment, one bidder (i.e., Network 1) is used for simplicity, however, it is contemplated that multiple bidders may use this process. Network 1 3501 may send a request for resources message 3502 to the DPC 902. The DPC 902 may receive the request message and send queries 3504, 3506 to participating DSCs 910a, 910b of Network 2 and Network 3 based on pre-defined criteria which may include types and capabilities of the user wireless device 101 in addition to the geographic criteria of the requesting wireless device 101. Geographic criteria may include geographic location, geographic polygon or license area of the user wireless device 101. The geographic criteria request may include parameters that are greater than those that the host network may permit. The DPC 902 may receive resource inquiry responses 3508, 35010 from each DSC 910a, 910b that was contacted.

[0355] The DPC 902 may send a resource availability message 3512 to inform Network 1 that the requested resources are available through DSC 910a. Network 1 3501 may receive the resource availability message 3510 and in response send a resources request message 3514 to the DPC 902 to reserve the available resources at DSC 910a. The DPC 902 may the send a resource reservation request 3516 to the DSC 910a. Upon receiving the resource reservation request 3516, the DSC 910a may reserve the required spectrum and send a resources reserved message 3518 back to the DPC 902. The DPC 902 may receive a resource bid message 3520 from Network 1, accept the bid (if the bid complies to the policies and rules of the DPC 902) and send a bid accepted message 3522 to Network 1 3501. Upon accepting the bid from the bidder, the DPC 902 may also send an assign resources request 3524 to the DSC 910a to allocate the reserved resources to Network 1 3501. The DSC 910a may receive the assign resources request 3524, allocate the resources to be used by Network 1 3501 and send a resources allocated message 3526 to the DPC 902. The DPC 902 may inform Network 1 3501 that the requested resources are now allocated to be used by the wireless device 101 subscriber Network 1 3501 by sending a resources allocated message 3528 to Network 1 3501. The resources may be available for use by Network 1 3501. Once the resources are used, the DSC 910a may send a resources consumed/released message 3530 to the DPC 902. The DPC 902 may receive the resources consumed/released message 3530 and send a resources consumed/released message 3532 to Network 1 3501. Network 1 3501 may settle the charges for the spectrum that it used.

[0356] FIGs. 36 – 40 illustrate flow diagrams of an embodiment method for allocating and accessing resources using the DSA communication system. As illustrated in FIG. 36, the Network 1 DSC 910a may monitor call traffic as compared to the total spectrum resources available to Network 1, block 3602. The DSC 910a may record and report the resource status of Network 1to the DPC 902. The DPC 902 may receive the resource status report from Network 1, block 3702, and store it, block 3704. The DSC 910a of Network 1 may determine based on the resources status report whether additional resources may be required to provide service to the existing users of Network 1, determination 3606. If additional resources are not required (i.e., determination 3606 = "No"), the DSC 910a may continue to monitor resources available vs. bandwidth traffic by going back to block 3602. If additional resources are required (i.e., determination 3606 = "Yes"), the DSC 910a may send a request for additional resources to the DPC 902, block 3608.

[0357] The Network 2 DSC 910b may also monitor resources available vs. bandwidth traffic in Network 2, block 3602, and report the resource status to the DPC 902, block 3804. The DPC 902 may receive the resource status report from DSC 910b, block 3702 and store the received data, block 3704. The DSC 910b may determine whether excess amount of resources are available in Network 2, determination 3804. If excess amounts of resources are not available in Network 2 (i.e., determination 3804 = "No"), the DSC 910b may continue to monitor resources available vs. bandwidth traffic by going back to block 3602. If excess amounts of resources are available (i.e., determination 3804 = "Yes"), the DSC 910b may allocate the excess resources or a sub-part of the excess resources for secondary use, block 3806, and report to the DPC 902 that resources are allocated for use by secondary users, block 3808. The DPC 902 may receive the resource allocation report from DSC 910b, block 3702, and store the received data, block 3704.

[0358] The DPC 902 may receive resource status reports from many different networks. However, in this embodiment, for ease of illustration, only interactions of DPC 902 with two networks are shown. The status reports received from the networks may further include additional information such as network rules and policies with respect to access and use to allocated resources. For example, the status reports from Network 2 may include system requirements for Network 2 which must be met before a wireless device 101 can successfully access the allocated resources on Network 2 as a secondary user.

[0359] The DPC 902 receives the request for additional resources from DSC 910a of Network 1, block 3706, and based on data received from other networks selects the best available network from which Network 1 may purchase additional resources, in block 3708. In this example, the DPC 902 may select Network 2 as the most suitable network to provide resources to Network 1. The DPC 902 may send a resource inquiry to the Network 2, block 3710, to determine the availability and quantity of allocated excess resources of Network 2.

[0360] The DSC 910b of Network 2 may receive the resource inquiry, block 3810, and determine resource availability, block 3812. The DSC 910b may send a resource inquiry response to the DPC 902. The resource inquiry response may include information about the quantity and quality of resources available for use by secondary users. The DPC 902 may receive the resources inquiry response, block 3712.

[0361] As illustrated in FIG. 37, the DPC 902 may determine whether resources are available based on the data received from the DSC 910b of Network 2, block 3714. If data is not available (i.e., determination block 3714 = "No"), the DPC 902 may send a no resource available message to Network 1, block 3722. Resources may not be available for use by a network for different reasons. For example, resources may be purchased to other bidders before they were reserved by the network. The DSC 910a of Network 1 may receive the no resource available message, block 3614, and search for other available spectrum resources or terminate connection sessions with users to free-up resources on Network 1, block 3618.

[0362] If data is available (i.e., determination 3714 = "Yes"), the DPC 902 may send a resource available message to the DSC 910a to inform Network 1 about the quality and quantity of resources available for secondary use at Network 2, block 3716. The DSC 910a may receive the resources available message and send a request resource message to reserve the allocated resources of Network 2 for use by subscribers of Network 1, block 3612. The request resource message may include data such as the quantity of resources that Network 1 may require in this transaction.

[0363] The DPC 902 may receive the resources request message, block 3718, and send a reserve resources request message to Network 2, block 3720. The DSC 910b at Network 2 may receive the reserve resource request, block 3816, and reserve the requested quantity of the allocated resources for use by Network 1 subscribers, block 3818. The DSC 910b of Network 2 may confirm that the requested quantity of allocated resources is reserved for use by Network 1 by sending a resource reserved message, block 3820. The DPC 902 may receive the resource reserved message from Network 2 and prepare for the bidding process as described in FIG. 38.

[0364] As illustrated in FIG. 38, the DSC 910a of Network 1 may send a resource bid to negotiate access to the reserved resources of Network 2, block 3620. The DPC 902 may receive the resource bid and process it, block 3726. The DPC 902 may determine whether the bid received from Network 1 may be accepted, at determination block 3728. The DPC 902 may evaluate a bid from a network provider based upon policies and rule sets of the DSA communication system in addition to requirements set forth by the resource offering network, such as prices and allocation or access methods or by other methods. If the bid is accepted (i.e., determination 3728 = "Yes"), the DPC 902 may send an accept bid message to Network 1, block 3730. The DSC 910a may receive the accept bid message and await resource access instructions, in block 3622. Once the bid is accepted, the DPC 902 may also send an assign resources message to the DSC 910b of Network 2, block 3732. The DSC 910b may receive the assign resources message, block 3822, and assign reserved resources for use by Network 1, block 3824. The DSC 910b may send a resources access message to enable Network 1 to access the assigned resources of Network 2, block 3826, and configure to establish communication session with the wireless device 101 of Network 1, block 3828.

[0365] The DPC 902 may relay the resources access message to Network 1, block 3734. The DSC 910a may receive the resources access message, block 3624. The resource access message may include data, such as, access parameters that may be used by secondary user wireless devices 101 to access resources on Network 2. The DSC 910a may send access parameters for Network 2 to wireless devices 101 which have communication sessions with Network 1 and Network 1 has designated to migrate to Network 2, block 3626. The designated wireless devices 101 may receive the access parameters for Network 2, block 3902, and establish a communication session with wireless device 101 of Network 1, steps 3904 and 3830. Network 2 may commence the settlement process as described in more detail below with reference to FIG. 40.

[0366] If the bid is rejected (i.e., determination block 3728 = "No"), the DPC 902 may send a rejected bid message to Network 1, block 3736 (shown in FIG. 39). As illustrated in FIG. 39, the DSC 910a may receive the rejected bid message, block 3736, and determine whether to rebid, determination 3640. If no rebid (i.e., determination 3640 = "No"), the DSC 910a may send a cancel resource request message, block 3644. The DPC 902 may receive the cancel resource request message, block 3742, and send a release of resources message to Network 2, block 3744. The

DSC 910b of Network 2 may receive the release of resources message, block 3832, release the reserved resources for use by other networks, block 3834, and report the allocated resource status to DPC 902 by going back to block 3808 as shown in FIG. 36 and follow the steps as described above with respect to FIG. 36.

[0367] If rebid (i.e., determination 3640 = "Yes"), the DSC 910a may send a new bid for the same resources, block 3642. The DPC 902 may receive the new bid, block 3738, and determine whether to accept the new bid, determination 3740. If the new bid is rejected again (i.e., determination 3740 = "No"), the DPC 902 may send a rejected bid message by going back to block 3736. If the bid is accepted (i.e., determination 3740 = "Yes"), the DPC 902 may send an accept bid message by going back to block 3730 as shown in FIG. 38 and follow the same steps as described above with respect to FIG. 38.

[0368] FIG. 40 illustrates the settlement process after Network 2 provides access to the secondary user wireless devices 101 of Network 1. DSC 910b of Network 2 may send invoices and payment instructions relating to the use of allocated resources by Network 1 to the DPC 902, block 3836. The DPC 902 may relay the invoice and payment instructions from Network 2 to Network 1, block 3746. DSC 910a may receive the invoices and payment instructions, block 3644, and settle the charges with Network 2, steps 3648 and 3840.

[0369] Optionally, the DSC 910b of Network 2 may send usage parameters and payment instructions to the DPC 902, block 3838. The DPC 902 may receive the usage parameters and payment instructions, block 3748, create an invoice, block 3750, and send the invoice to Network 2, block 3752. The DSC 910a may receive the invoice and payment instructions, block 3646, and settle the charges with Network 2, steps 3648 and 3840.

[0370] FIG. 41 illustrates a message flow diagram 4100 of message communication between components of a network provider which is allocating available resources to other resources requesting networks. The DSC 910a at Network 1 3501 may send a request for resources from, message 3502. The DPC 902 may receive the request for resources message and send a resource inquiry to Network 2, message 3504. At Network 2, the resource inquiry may be received at the DSC 910b. The DSC 910b may send a resource inquiry to the OMC 912 in Network 2 to determine whether resources are available for Network 1, message 4106. The OMC 912 may receive the resource inquiry message from the DSC 910b and send a resource inquiry message to the Access Resources 4102, message 4108. The OMC 912 may also send a resource inquiry message to the Core Resources 4204, message 4110. The Access Resource 4102 and the Core Resources 4204 each receive the resource inquiry messages from OMC 912 and send a resource response to the OMC 912, messages 4112, 4114 respectively. The resources response from the Access Resources 4102 may include message parameters. The resources response from the Access Resources 4102 may include other message parameters.

[0371] The OMC 912 may receive the resource responses from the Access Resource 4102 and Core Resource 4104 and send a resource response message to the DSC 910b indicating status of resources availability in Network 2, message 4116. The DSC 910b may receive the resource response message from the OMC 912 and send a resource inquiry response to the DPC 902, message 3508. The DPC 902 may receive the a resource inquiry response from the DSC 910b, determine whether the type of resources requested are available at Network 2 and send a resources available message to the DSC 910a of Network 1, message 3512. The DSC 910a may receive the resources available message and send a resources request message to direct the DPC 902 to request the available resources from Network 2, message 3514. The DPC 902 may receive the resources request message and send a resources reservation request message to the DSC 910b to request that the available resources in Network 2 be reserved for use by Network 1, message 3516. The DSC 910b may receive the resources reservation request message and, via the OMC 912, send a resource reservation request to the Access Resource 4102, message 4118, and a resource reservation request to the Core Resources 4104, message 4120.

[0372] The Access Resource 4102 may receive the resource reservation request from the OMC 912, reserve the available resources and send a resources reserved message back to the DSC 910b via the OMC 912, message 4122. Similarly, the Core Resources 4104 may receive the resource reservation request from the OMC 912, reserve the available resources and send a resources reserved message back to the DSC 910b via the OMC 912, message 4124. The DSC 910b may receive the resources reserved message from the Access Resources 4102 and Core Resources 4104 and send resources reserved message to the DPC 902 to inform the DPC 902 and Network 1 that the requested resources are reserved for use by Network 1, message 3518. The DPC 902 may receive a resource bid message from the DSC 910a of Network 1, message 3520. The DPC 902 may send a bid accepted message to the DSC 910a if the bid received by DPC 902 satisfies the price and contract requirements of Network 2, message 3522. If the bid is accepted, the DPC 902 may send an assign resources request to the DSC 910b, message 3524. The DSC 910b may receive the assign resources request to the Access Resources 4102, message 4126, and an assign resources request to the Core Resources 4104, message 4128. The DSC 910b may further send a policy for resources assigned message to the Policy Controller 905, which can be the same or different relative to the PCFF, message 4130. The DSC 910b may further send a metering for resources assigned to the AAA/AuC 4106, message 4132.

[0373] FIGs. 42 – 44 illustrate process flow diagrams of an embodiment method for backing off secondary users by handing them over back to their home network or terminating their communication session with the host network. A wireless device 101 from Network 1 may establish a secondary user communication session with Network 2 via the DSC 910b, steps 3904, 3830. The DSC 910b of Network 2 may continuously monitor traffic on the network versus the available resources, block 3602, and send a report to the DPC 902, block 3604. DPC 902 may receive the resource status report from the DSC 910b. The DSC 910b may further determine whether the network volume is greater than the capacity of the network based on its available resources, determination 4404. If the network volume is not greater than the capacity of the network (i.e., determination 4404 = "No"), the DSC 910b may continue to monitor the network traffic versus the available resources by returning to block 3602. If the network volume is greater than the capacity of the network (i.e., determination 4404 = "Yes"), the DSC 910b may identify a user on the network, block 4406, and determine whether the user is a secondary user, determination 4408.

[0374] If the user is a secondary user (i.e., determination 4408 = "Yes"), the DSC 910b may send disconnect session at t message, t being the amount of time left before the secondary user communication session will be terminated by Network 2, block 4410. The disconnect session at t message may be received by the DPC 902 as illustrated in FIG. 43, block 4306. Optionally, instead of sending a disconnect session at t message, the DSC 910b may terminate the communication session of the secondary user to immediately provide additional resources for primary or other important users, block 4412. The decision regarding whether to immediately terminate or transmit a warning before termination of a secondary user may be based on contractual terms between the primary and secondary network providers and the DSA communication system policies and rule sets.

[0375] If the user is not a secondary user (i.e., determination 4408 = "No"), the DSC 910b may determine whether any other secondary users are present on the network, step 4414. If there are other secondary users still connected to Network 1 (i.e., determination 4414 = "Yes"), the DSC 910b may send try to disconnect their sessions first before the primary users by returning to steps 4410, 4412. If there are no other secondary users on the primary network (i.e., determination 4414 = "No"), the DSC 910b may keep or drop the primary user communication session based on tiered priority access rules, block 4416. For example, premium primary users (i.e., those with more expensive subscription plans) may be dropped last. Alternatively, in an embodiment (not shown), instead of terminating the primary user communication sessions, the DSC 910b may try to handover the users to another network as secondary users, thus, preserving the communication session connection while reducing volume of Network 1. The DSC 910b may return to monitoring the network volume versus capacity to determine whether additional callers need to be off-loaded by returning to block 4404.

[0376] As illustrated in FIG. 43, the DPC 902 may relay the disconnect session at t message to the DSC 910a, block 4306. The DSC 910a may receive the disconnect session at t message, block 4206, set a timer to count down from t, block 4208, and monitor its available resources, block 4210, to determine whether there is resources available on Network 1 to receive the secondary user communication session from Network 2, determination 4212. If resources are not available on Network 1 (i.e., determination 4212 = "No"), the DSC 910a may send a request for resources to the DPC 902, block 3808, to reserve and purchase available resources from network providers by returning to block 3706 of FIG. 36 and following the resources allocation steps as described above with respect to FIGs. 36 – 40.

[0377] If resources are available on Network 1 (i.e., determination 4212 = "Yes"), the DSC 910a may allocate resources to the secondary user that is going to be terminated from Network 2, block 4212, and send instructions for the wireless device 101 to disconnect from Network 2 and connect to Network 1 to the DPC 902 as shown in FIG. 44, block 4308. The DSC 910a may also configure/prepare the Network 1 system to connect to the secondary user wireless device 101, block 4218.

[0378] As illustrated in FIG. 44, the DPC 902 may relay the instructions for the wireless device 101 to disconnect from Network 2 and connect to Network 1 to the DSC 910b of Network 2, block 4308. The DSC 910b may receive the instructions, block 4418, and send them to the secondary user wireless device 101 which currently has a communication session with Network 2, block 4420. The wireless device 101 may receive the instructions to disconnect from Network 2 and connect to Network 1, block 4220, and end communication session with Network 2, block 4222, and establish communication session with Network 1, steps 4224, 4226.

[0379] PUBLIC SAFETY NETWORK:

[0380] In an embodiment, the primary network provider of the DSA communication system may be a public safety network. A public safety network may be the holder or owner of public safety spectrum. Public safety spectrum is generally reserved for used by public safety authorities. The assigned public safety bandwidth typically includes more spectrum than is used by public safety authorities on an average bases. An excess amount of spectrum is assigned for public safety use in anticipation of its use during public safety emergencies such as disasters.

[0381] In an embodiment, the DSA communication system may allow the public safety networks to lease spectrum resources to other networks when the public safety spectrum is available and not in use. During public safety emergency situations when all of the network resources may be required for use by public safety authorities, the DSA communication system may allow the network to retrieve all of its allocated resources from other networks by off-loading traffic from the public safety network to free-up resources.

[0382] In addition, if the assigned spectrum of a public safety network proves inadequate to handle a large volume of use by public safety authorities during an emergency, the DSA communication system may enable the public safety network to lease or take resources from other networks which are participating in the DSA communication system. For example, the DSA communication system may require that all participating networks to continuously keep a certain percentage (e.g., 10%) of their resources unassigned. The public safety networks may use the unassigned resources of the participating networks to augment their resources for public safety communications during emergencies. The DSA communication system may further off-load primary and/or secondary users of a primary network to free-up resources for use by the public safety authorities.

[0383] In an embodiment, access to public safety spectrum may be based on tiered priority access methods described above with respect to FIGs. 1-8. For example, police dispatchers may always have access to the spectrum. However, access of other non-governmental users of the public safety resources may be limited to certain times periods or dates depending on the contracts between the users and the public safety network providers.

[0384] In an embodiment, off-loading of non-public safety users from the public safety or other networks may be performed using a tiered priority access methods described above with respect to FIGs. 1-8. For example, in a public safety network, when resources are required for public safety use, the DSA communication system may enable the public safety network to off-load users in order of preferences such as first, off-loading secondary non-public safety users, second, off-loading primary non-public safety users, third, off-loading, lower ranked public safety users, etc. Similar tiered priority access method may be used to off-load users of another network the resources of which may be used by the public safety network.

[0385] In an embodiment, during an emergency, the DSA communication system may restrict access to any resources of a public safety network which is allocated for secondary use. For example, once the DSA communication system determines that there is a public safety emergency, the DSA communication system may no longer consider the allocated resources from the public safety network which is involved in the emergency as available resources for use by other networks.

[0386] In an embodiment, the DSA communication system policies and rule sets may require that participating networks allocate a percent of their resources for public safety use and disasters response purposes. During an emergency, the DSA communication system may enable public safety networks to access additional resources which each non-public safety network may allocate for public safety use. In this scenario, if the allocated resources are in use, tiered priority access methods may be used to off-load users from the allocated resources. Other resources of the non-public safety network may not be used for public safety unless properly negotiated.

[0387] FIGs. 45 – 49 illustrate flow diagrams of an embodiment method for allocating and accessing resources of a public safety network using the DSA communication system. As illustrated in FIG. 45, the DSC 910a may monitor resources versus bandwidth traffic in Network 1, block 3602. The DSC 910a may record and report the resource status of Network 1to the DPC 902. The DPC 902 may receive the resource status report from Network 1, block 3702, and store it, block 3704. The DSC 910a of Network 1 may determine, based on the resources status report, whether additional resources may be required to provide service to the existing users of Network 1, determination 3606. If additional resources are not required (i.e., determination 3606 = "No"), the DSC 910a may continue to monitor available resources as versus bandwidth traffic by going back to block 3602. If additional resources are required (i.e., determination 3606 = "Yes"), the DSC 910a may send a request for additional resources to the DPC 902, block 3608.

[0388] The public safety network DSC 910b may reserve a predetermined amount of unused spectrum resources as a back-up for use only by public safety authorities, in block 4502. This may ensure that if there is a need for resources during an emergency, such as a natural disaster, resources are readily available to be dedicated for public safety use until additional resources are released by off-loading secondary users from the network. The Public safety network DSC 910b may also monitor resources available vs. bandwidth traffic in Public safety network, block 3602, and report the resource status to the DPC 902, block 3804. The DPC 902 may receive the resource status report from DSC 910b, block 3702 and store the received data, block 3704. The DSC 910b may determine whether excess amount of resources are available in Public safety network, determination 3804. If excess amounts of resources are not available in Public safety network (i.e., determination 3804 = "No"), the DSC 910b may continue to monitor resources available vs. bandwidth traffic by going back to block 3602. If excess amounts of resources are available (i.e., determination 3804 = "Yes"), the DSC 910b may allocate the excess resources or a sub-part of the excess resources for secondary use, block 3806, and report to the DPC 902 that resources are allocated for use by secondary users, block 3808. The DPC 902 may receive the resource allocation report from DSC 910b, block 3702, and store the received data, block 3704.

[0389] The status reports received from the networks may further include information such as network rules and policies with respect to access and use to allocated resources. For example, the status reports from Public safety network may include system requirements for Public safety network which must be met before a wireless device 101 can successfully access the allocated resources on Public safety network as a secondary user.

[0390] The DPC 902 receives the request for additional resources from DSC 910a of Network 1, block 3706, and based on data received from other networks selects the best available network from which Network 1 may purchase additional resources, block 3708. In this example, the DPC 902 may select Public safety network as the most suitable network to provide resources to Network 1. The DPC 902 may send a resource inquiry to the Public safety network, in block 3710, to determine the availability and quantity of allocated excess resources of Public safety network.

[0391] The DSC 910b of Public safety network may receive the resource inquiry, block 3810, and determine resource availability, block 3812. The DSC 910b may send a resource inquiry response to the DPC 902. The resource inquiry response may include information about the quantity and quality of resources available for use by secondary users. The DPC 902 may receive the resources inquiry response, block 3712.

[0392] As illustrated in FIG. 46, the DPC 902 may determine whether resources are available based on the data received from the DSC 910b of Public safety network, block 3714. If data is not available (i.e., determination 3714 = "No"), the DPC 902 may send a no resource available message to Network 1, block 3722. Resources may not be available for use by a network for different reasons. For example, resources may be sold to other bidders before they were reserved by a requesting network. The DSC 910a of Network 1 may receive the no resource available message, block 3614, and search for other available spectrum resources or terminate connection sessions with users to free-up resources on Network 1, block 3618.

[0393] If data is available (i.e., determination 3714 = "Yes"), the DPC 902 may send a resource available message to the DSC 910a to inform Network 1 about the quality and quantity of resources available for secondary use at Public safety network, block 3716. The DSC 910a may receive the resources available message and send a request resource message to reserve the allocated resources of Public safety network for use by subscribers of Network 1, block 3612. The request resource message may include data such as the quantity of resources that Network 1 may require in this transaction.

The DPC 902 may receive the resources request message, block 3718, and send a reserve resources request message to Public safety network, block 3720. The DSC 910b at Public safety network may receive the reserve resource request, block 3816, and reserve the requested quantity of the allocated resources for use by Network 1 subscribers, block 3818. The DSC 910b of Public safety network may confirm that the requested quantity of allocated resources is reserved for use by Network 1 by sending a resource reserved message, block 3820. The DPC 902 may receive the resource reserved message from Public safety network and prepare for the bidding process as described in FIG. 47.

[0394] As illustrated in FIG. 47, the DSC 910a of Network 1 may send a resource bid to negotiate access to the reserved resources of Public safety network, block 3620. The DPC 902 may receive the resource bid and process it, block 3726. The DPC 902 may determine whether the bid received from Network 1 may be accepted, in determination block 3728. The DPC 902 may evaluate a bid from a network provider based upon policies and rule sets of the DSA communication system in addition to requirements set forth by the resource offering network, such as prices and allocation or access methods.

[0395] If the bid is accepted (i.e., determination 3728 = "Yes"), the DPC 902 may send an accept bid message to Network 1, block 3730. The DSC 910a may receive the accept bid message and await resource access instructions, block 3622. Once the bid is accepted, the DPC 902 may also send an assign resources message to the DSC 910b of Public safety network, block 3732. The DSC 910b may receive the assign resources message, block 3822, and assign reserved resources for use by Network 1, block 3824. The DSC 910b may send a resources access message to enable Network 1 to access the assigned resources of Public safety network, block 3826, and configure to establish communication session with the wireless device 101 of Network 1, block 3828.

[0396] The DPC 902 may relay the resources access message to Network 1, block 3734. The DSC 910a may receive the resources access message, block 3624. The resource access message may include data such as access parameters that may be used by secondary user wireless devices 101 to access resources on Public safety network. It should be appreciated that other data may be included in the resources access message. The DSC 910a may send access parameters for Public safety network to wireless devices 101 which have communication sessions with Network 1 and Network 1 has designated to migrate to Public safety network, block 3626. The designated wireless devices 101 may receive the access parameters for Public safety network, block 3902, and establish a communication session with wireless device 101 of Network 1, steps 3904 and 3830. Public safety network may commence the settlement process as described in more detail below with reference to FIG. 49.

[0397] If the bid is rejected (i.e., determination 3728 = "No"), the DPC 902 may send a rejected bid message to Network 1, block 3736 (shown in FIG. 48). As illustrated in FIG. 48, the DSC 910a may receive the rejected bid message, block 3736, and determine whether to rebid, determination 3640. If no rebid (i.e., determination 3640 = "No"), the DSC 910a may send a cancel resource request message, block 3644. The DPC 902 may receive the cancel resource request message, block 3742, and send a release of resources message to Public safety network, block 3744. The DSC 910b of Public safety network may receive the release of resources message, block 3832, release the reserved resources for use by other networks, block 3834, and report the allocated resource status to DPC 902 by going back to block 3808 as shown in FIG. 45 and follow the steps as described above with respect to FIG. 45.

[0398] If rebid (i.e., determination 3640 = "Yes"), the DSC 910a may send a new bid for the same resources, block 3642. The DPC 902 may receive the new bid, block 3738, and determine whether to accept the new bid, determination 3740. If the new bid is rejected again (i.e., determination 3740 = "No"), the DPC 902 may send a rejected bid message by going back to block 3736. If the bid is accepted (i.e., determination 3740 = "Yes"), the DPC 902 may send an accept bid message by going back to block 3730 as shown in FIG. 47 and follow the same steps as described above with respect to FIG. 47.

[0399] FIG. 49 illustrates the settlement process after Public safety network provides access to the secondary user wireless devices 101 of Network 1. DSC 910b of Public safety network may send invoices and payment instructions relating to the use of allocated resources by Network 1 to the DPC 902, block 3836. The DPC 902 may relay the invoice and payment instructions from Public safety network to Network 1, block 3746. DSC 910a may receive the invoices and payment instructions, block 3644, and settle the charges with Public safety network, steps 3648 and 3840.

[0400] Optionally, the DSC 910b of Public safety network may send usage parameters and payment instructions to the DPC 902, block 3838. The DPC 902 may receive the usage parameters and payment instructions, block 3748, create an invoice, block 3750, and send the invoice to Public safety network, block 3752. The DSC 910a may receive the invoice and payment instructions, block 3646, and settle the charges with Public safety network, steps 3648 and 3840.

[0401] FIGs. 50 – 53 illustrate process flow diagrams of an embodiment method for backing off secondary users by handing them over back to their home network or terminating their communication session with the host network. A wireless device 101 from Network 1 may establish a secondary user communication session with Public safety network via the DSC 910b, steps 3904, 3830. The DSC 910b of Public safety network may continuously monitor traffic on the network versus the available resources, block 3602, and send a report to the DPC 902, block 3604. DPC 902 may receive the resource status report from the DSC 910b. The DSC 910b may further determine whether the network volume is greater than the capacity of the network based on its available resources, determination 4404. If the network volume is not greater than the capacity of the network (i.e., determination 4404 = “No”), the DSC 910b may continue to monitor the network traffic versus the available resources by returning to block 3602. If the network volume is greater than the capacity of the network (i.e., determination 4404 = “Yes”), the DSC 910b may identify a user on the network, block 4406, and determine whether the user is a secondary user, determination 4408.

[0402] If the network volume exceeds the allocated capacity threshold of the network (i.e., determination 4408 = "Yes"), an abnormal situation exists which may indicate that an emergency situation is unfolding. In this scenario, the DSC 910b may follow the processes illustrated in the process flow diagrams of FIG. 50 to free-up resources for public safety use and FIG. 54 to incrementally allocate network resources based on a Tiered Priority Access regime.

[0403] As shown in FIG. 50, to free-up resources for public safety use, the Public safety network may send disconnect session at t message, t being the amount of time left before the secondary user communication session will be terminated by Public safety network, block 4410. The disconnect session at t message may be received by the DPC 902 as illustrated in FIG. 43, block 4306. Optionally, instead of sending a disconnect session at t message, the DSC 910b may terminate the communication session of the secondary user to immediately provide additional resources for primary or other important users, block 4412. The decision regarding whether to immediately terminate or transmit a warning before termination of a secondary user may be based on contractual terms between the primary and secondary network providers and the DSA communication system policies and rule sets.

[0404] If the user is not a secondary user (i.e., determination 4408 = "No"), the DSC 910b may determine whether any other secondary users are present on the network, block 4414. If there are other secondary users still connected to Network 1 (i.e., determination 4414 = "Yes"), the DSC 910b may send try to disconnect their sessions first before the primary users by returning to steps 4410, 4412. If there are no other secondary users on the primary network (i.e., determination 4414 = "No"), the DSC 910b may keep or drop the primary user communication session based on tiered priority access rules, block 4416. For example, premium primary users (i.e., those with more expensive subscription plans) may be dropped last. Alternatively, in an embodiment (not shown), instead of terminating the primary user communication sessions, the DSC 910b may try to handover the users to another network as secondary users, thus, preserving the communication session connection while reducing volume of Network 1. The DSC 910b may return to monitoring the network volume versus capacity to determine whether additional callers need to be off-loaded by returning to block 4404.

[0405] As illustrated in FIG. 51, the DPC 902 may relay the disconnect session at t message to the DSC 910a, block 4306. The DSC 910a may receive the disconnect session at t message, block 4206, set a timer to count down from t, block 4208, and monitor its available resources, block 4210, to determine whether there is resources available on Network 1 to receive the secondary user communication session from Public safety network, determination 4212. If resources are not available on Network 1 (i.e., determination 4212 = "No"), the DSC 910a may send a request for resources to the DPC 902, block 3808, to reserve and purchase available resources from network providers by returning to block 3706 of FIG. 45 and following the resources allocation steps as described above with respect to FIGs. 45 – 49.

[0406] If resources are available on Network 1 (i.e., determination 4212 = "Yes"), the DSC 910a may allocate resources to the secondary user that is going to be terminated from Public safety network, block 4212, and send instructions for the wireless device 101 to disconnect from Public safety network and connect to Network 1 to the DPC 902 as shown in FIG. 52, block 4308. The DSC 910a may also configure/prepare the Network 1 system to connect to the secondary user wireless device 101, block 4218.

[0407] As illustrated in FIG. 52, the DPC 902 may relay the instructions for the wireless device 101 to disconnect from Public safety network and connect to Network 1 to the DSC 910b of Public safety network, block 4308. The DSC 910b may receive the instructions, block 4418, and send them to the secondary user wireless device 101 which currently has a communication session with Public safety network, block 4420. The wireless device 101 may receive the instructions to disconnect from Public safety network and connect to Network 1, block 4220, and end communication session with Public safety network, block 4222, and establish communication session with Network 1, steps 4224, 4226.

[0408] In a further embodiment, the Public safety network may monitor all new reserve resource requests and inquiries received from the DPC 902 to ensure that resources are provided only to those requests that are initiated by public safety authorities based on TPA at least until resource capacity is back to below the threshold levels. The Public safety network may receive a reserve resource request at the DSC 910b, block 3810, and determine whether the resources inquiry is from a TPA-authorized device, determination 312. If the resources requested are from a TPA-authorized device (i.e., determination 312 = "Yes"), the DSC 910b may disconnect a non-TPA communication session, such as a secondary user communication session, block 314, and connect the TPA call, block 315. The DSC 910b may again monitor the resources versus bandwidth available by returning to block 3602 of FIG. 50. If the resource reserve message is received from a wireless device 101 other than an authorized device (i.e., determination 312 = "No"), the Public safety network may block the call until excess resources are again available for use by secondary users, block 5302.

[0409] In an embodiment, for TPA-authorized personnel who may try to establish a communication session with the Public safety network using a wireless device which is subscribed to a network provider other than the public safety network provider, the Public safety authorities may be provided a prefix number which may alert the receiving network provider about a request to transfer communication session to a public safety network and an access PIN. By using the prefix number and PIN, a Public safety user may access the Public safety network using any device, even if the device is considered a secondary user wireless device 101 on the Public safety network.

[0410] As illustrated in FIG. 54 to FIG. 56, when an authorized public safety officer requires to establish connection with a specific public safety network, he may place a call using any unauthorized wireless device 101 of Network 1 and dialing a special prefix number, such as *272, block 5402. The DSC 910a may receive and process the call, block 5404, and identify the prefix number as a request to transfer the communication session to a public safety network, block 5406. The DSC 910a may send a PIN request to the wireless device 101, block 5408. The wireless device 101 may receive the PIN request, block 5410, display the PIN request to the user using

Graphical User Interface (GUI) and receive the user's PIN input, block 5412. The wireless device 101 may send the inputted PIN to the DSC 910a for processing, block 5414. The DSC 910a may receive the PIN, block 5416, and send a request for a network transfer along with the PIN to the DPC 902, block 5418. The DPC 902 may receive the request for network transfer, block 5420, and determine whether the PIN matches a PIN database, determination 318. If the PIN does not match an entry in the PIN database (i.e., determination 318 = "No"), the DPC 902 may block the call, block 5302. If the PIN matches an entry in the PIN database (i.e., determination 318 = "No"), the DPC 902 may identify the target Public safety network based on the received PIN, block 5422.

[0411] As illustrated in FIG. 55, the DPC 902 may determine whether the wireless device 101 of Network 1 includes compatible technology with the target Public safety network, block 5424. If the device and the public safety network are not technologically compatible (i.e., determination 5424 = "No"), the DPC 902 may send a network incompatible message back to the device via the DSC 910a, block 5426. The DSC 910a may relay the network incompatibility message, block 5428, and terminate connection with the wireless device 101, block 5432. The wireless device 101 may receive the network incompatible message, block 5430, display the message to the user, block 5434, and terminate connection with the Network 1, block 5436. If the device and the public safety network technologies are compatible (i.e., determination 5424 = "Yes"), the DPC 902 may send a reserve resources request with PIN to the public safety network DSC 910b, block 5438. The DSC 910b may receive the reserve resources request with PIN, block 5440.

[0412] In an embodiment, as illustrated in FIG. 56, access to a public safety networks by authorized public safety authorities may be on a priority level. For example, the higher ranking officials of a public safety organization may have priority access to the network as compared lower ranking officials from the same organization. At any given time, depending on the level of traffic and resources available, the public safety network may determine what level of authority may have access to the network. Accordingly, the DSC 910b may be configured to allow those with required levels of priority and reject those with levels of priority lower than required. The DSC 910b may continuously reevaluate the resource availability and change the access level of officials based on the availability of resources. The DSC910b may determine, based on the PIN, the level of priority of the user of the wireless device 101, block 5442. The DSC 910b may determine whether the level of priority of the device 101 is allowed to access the public safety network at that time, determination 5444. If the device 101 priority level is authorized (i.e., determination 5444 = "Yes"), the DSC 910b may disconnect a non-TPA session or a lower priority TPA session to free-up resources for the new request for resources, block 5446, and connect the new TPA session, block 5448, and return back to monitoring the resources of the network versus the bandwidth traffic, block 3602 of FIG. 45. If the request is from a TPA-authorized device which does not have the priority level to access the network at that time (i.e., determination 5444 = "No"), the DSC 910b may block the call, block 5302.

[0413] As discussed above, the various embodiments overcome the limitations of conventional Wireless Priority Access (WPA) systems by performing Tiered Priority Access (TPA) operations, which may include monitoring a wireless network's call volume, determining whether the call volume exceeds a threshold, partitioning network resources for use by emergency personnel when the call volume exceeds the threshold, reserving a portion of the partitioned resources for the emergency personnel, monitoring calls to determine whether calls are being made to or from mobile devices associated with emergency personnel, and restricting general access to the reserved resources when there are calls are being made to or from the mobile devices associated with emergency personnel. In various embodiments, these and other TPA operations may be performed by a processor coupled to a base station component (e.g., base transceiver station, NodeB, eNodeB, etc.) and outside of the core network.

[0414] In an embodiment, the Tiered Priority Access (TPA) operations may be performed at or on an Evolved Node B (eNodeB), such as by an eNodeB processor, a processor coupled to the eNodeB component, or in a server or agent (e.g., Diameter agent, a specialized server, a software application, a process, a computing system, etc.) in communication with the eNodeB component.

[0415] In various embodiments, a network component responsible for performing Tiered Priority Access (TPA) operations (e.g., an eNodeB, eNodeB processor or agent, etc.) may be configured to interact with one or more components responsible for performing dynamic spectrum arbitrage (DSA) operations. For example, an eNodeB may be configured to communicate the status of one or more resources and/or the results of TPA operations to a dynamic spectrum controller (DSC) and/or to a dynamic spectrum policy controller (DPC). In an embodiment, a DSA server or system may be configured to use information communicated between the TPA network component (e.g., eNodeB) and the controller (e.g., DSC, DPC, etc.) to make better and more informed spectrum arbitrage determinations (e.g., whether spectrum should be leased, how much spectrum should be shared, etc.).

[0416] In various embodiments, spectrum arbitrage determinations (e.g., whether and how much spectrum and/or radio resources should be leased or shared from one network to another network) may occur substantially while the networks are operating under normal traffic conditions.

[0417] When a network experiences an increase in resource usage, such as a sudden increase in traffic in response to a public safety incident, one or more eNodeBs may begin shaping traffic locally. The eNodeBs may report the increase in resource usage (e.g., traffic exceeding certain thresholds, etc.) or the result of the local traffic shaping (e.g., hand-offs, dropped connections, etc.) to a DSC and/or DPC server. The DPC may record or store these reports in memory for use in future spectrum arbitrage determination operations. For example, a DPC may be configured to grant spectrum or radio resources to a network experiencing a traffic surge and deny future requests for spectrum from other networks. Similarly, the DPC may be configured to revoke previous grants of spectrum or radio resources from other networks and/or a network experiencing the traffic surge.

[0418] In an embodiment, mobile device users may be ranked or organized into priority groups, and the system may be configured to determine the priorities and/or access rights of the mobile device based on the rankings or priority groups to which the mobile device user belongs. In an embodiment, the rankings/priority groups may be determined in a network server, with the rankings/priority information being sent to a base station component (e.g., eNodeB, etc.) for enforcement. In another embodiment, the base station component may be configured to generate the rankings/priorities locally in the base station component. For example, in various embodiments, rankings or priority information may be based on assigned QoS class identifier (QCI) or Allocation and Retention Priority (ARP) values.

[0419] In various embodiments, traffic shaping, such as dynamic QoS alteration, may be applied across one or more priority groups, to one or more specific mobile devices, or to a combination of classes and devices. Traffic shaping may be applied sequentially, such as in steps to a first set of one or more priority groups or devices, then to second set, then to a third set, etc. Embodiments may include any sequence of traffic shaping applied to any number of sets of priority groups or mobile devices. The sequence may include repeatedly shaping traffic of one or more groups prior to shaping the traffic of other groups.

[0420] FIG. 57A illustrates network components and information flows in an example Long Term Evolution (LTE or 4G LTE) communication system 5700 suitable for implementing the various embodiments. A typical LTE communication system 5700 includes a plurality of eNodeB 5704 components coupled to a mobility management entity (MME) 5706 component and serving gateway (SGW) 5708. The MME 5706 and SGW 5708 may be part of a core network 5716, such as a system architecture evolution (SAE) or evolved packet core (EPC) network. The eNodeB 5704 may be outside of the core network 5716.

[0421] The eNodeB 5704 may be configured to communicate voice, data, and control signals between mobile devices 5702 (e.g., cell phones) and to other network destinations. The eNodeB 5704 may act as a bridge (e.g., layer 2 bridge) between the mobile device 5702 and the core network 5716 by serving as the termination point of all radio protocols towards the mobile devices 5702 and relaying voice (e.g., VoIP, etc.), data, and control signals to network components in the core network 5716. The eNodeB 5704 may be configured to perform various radio resource management operations, such as controlling the usage of radio interfaces, allocating resources based on requests, prioritizing and scheduling traffic according to various quality of server (QoS) requirements, monitoring the usage of network resources, etc. The eNodeB 5704 may also be configured to collect radio signal level measurements, analyze the collected radio signal level measurements, and handover mobile devices 5702 (or connections to the mobile devices) to another base station (e.g., a second eNodeB) based on the results of the analysis.

[0422] Generally, mobile devices 5702 send and receive voice, data and/or control signals to and from an eNodeB 5704 via a wireless communication link 5722. The eNodeB 5704 may send signaling/control information (e.g., information pertaining to call setup, security, authentication, etc.) to the MME 5706 via the S1-AP protocol on the S1-MME interface. The MME 5706 may request user/subscription information from a home subscriber server (HSS) 5714 via the S6-a interface, communicate with other MME components via the S10 interface, perform various administrative tasks (e.g., user authentication, enforcement of roaming restrictions, etc.), select a SGW 5708, and send authorization and administrative information to the eNodeB 5704 and/or SGW 5708 (e.g., via the S1-MME and S11 interfaces).

[0423] Upon receiving the authorization information from the MME 5706 (e.g., an authentication complete indication, an identifier of a selected SGW, etc.), the eNodeB 5704 may send data received from the mobile device 5702 to a selected SGW 5708 via GTP-U protocol on the S1-U interface. The SGW 5708 may store information about the received data (e.g., parameters of the IP bearer service, network internal routing information, etc.) and forward user data packets to packet data network gateway (PGW) and/or a policy control enforcement function (PCEF) 5710 via the S11 interface.

[0424] The PGW/PCEF 5710 component(s) may include a PCEF component coupled to a PGW component, a PCEF component included in a PGW component, or a PCEF component configured to perform operations typically associated with a PGW component. Since these structures are well known, certain details have been omitted in order to focus the descriptions on the most relevant features. Detailed information about policy and charging enforcement function operations may be found in "3rd Generation Partnership Project Technical Specification Group Services and System Aspects, Policy and Charging Control Architecture," TS 23.203 (updated June 12, 2011), the entire contents of which are incorporated herein by reference.

[0425] The PCEF/PGW 5710 may send signaling information (e.g., control plane information) to a policy control rules function (PCRF) 5712 component, such as over a Gx interface. The PCRF 5712 component may be responsible for identifying the appropriate policy rules for a given communication session. The PCRF 5712 component may communicate with external PCRF components (not illustrated) via the S9 interface, access subscriber databases, create policy rules, and/or send policy rules to the PCEF/PGW 5710 component(s) for enforcement.

[0426] The PCEF/PGW 5710 may receive policy rules from the PCRF 5712 component and enforce the received policy rules to control the bandwidth, the quality of service (QoS), and/or other characteristics of the data that is to be communicated between the service network 5720 and the mobile devices 5702. The PCEF/PGW 5710 may also coordinate, allocate, add, remove, and/or adjust various resources (e.g., network resources, subscriber resources, etc.) based on the received policy rules.

[0427] As discussed above, network activity/traffic is typically controlled from within the core network 5716 by the PCEF/PGW 5710 component(s). In contrast to existing solutions, various embodiments may include an eNodeB 5704 component configured to perform TPA operations to control network activity/traffic from outside the core network 5716. The eNodeB 5704 may be configured to monitor network activity (e.g., call volume, etc.) and partition, allocate, and/or adjust network resources based on the current network conditions. The eNodeB 5704 may also be configured to dynamically "shape" the network activity of a mobile device 5702 based on the network conditions. Shaping the network activity of a mobile device may include reducing bandwidth, reducing QoS, restricting the number of services, shedding a connection, transferring a connected device to another tower (e.g., the second eNodeB, etc.), performing handoffs, and/or other similar traffic management activities or operations.

[0428] In an embodiment, the core network 5716 may be part of (or may include) a dynamic service arbitrage communication system, such as any of the various DSA systems discussed above. For example, FIG. 57A illustrates that the core network 5716 may include a DSC 5722 component suitable for performing DSA operations. The inclusion of the DSC 5722 component in the core network 5716 may enable one or more eNodeBs 5804a, 5804b to send information concerning network activity and/or the various steps taken to shape network activity to the DSC 5722, which may use this information to make more informed spectrum arbitrage determinations (e.g., whether spectrum should be leased, how much spectrum should be shared, etc.).

[0429] In the example illustrated in FIG. 57A, the DSC 5722 is connected directly to the PCRF 5712. In various embodiments, the DSC 5722 may be connected directly or indirectly to the PCEF/PGW 5710 and/or various other components in the core network 5716. In various embodiments, the DSC 5722 may be connected directly or indirectly with one or more eNodeBs 5704, such as via a direct communication link 5730.

[0430] In an embodiment, the DSC 5722 may be connected to a DPC 5722 outside of the core network 5716. The DSC 5722 may be configured with software to communicate data regarding the availability of spectrum resources to the DPC 5724 using capacity policy criteria. The data that is communicated to the DPC 5724 may include data relating to current excess capacity and expected future capacity of the network or sub-network, such as data received from one or more eNodeBs 5804a, 5804b.

[0431] In various embodiments, the DSC 5722 and/or DPC 5724 may rely on data from one or more eNodeB in the dynamic spectrum arbitrage process. For example, when a network has one or more eNodeBs 5804a, 5804b actively shaping traffic and/or reporting high network activity, the DSC 5722 and/or DPC 5724 may reallocate the spectrum resources based on the traffic shaping and/or network activity information.

[0432] In an embodiment, an eNodeB 5704 may be configured to classify or organize the mobile devices 5702 into priority groups or classes, such as primary users (e.g., first responders or other priority users) and secondary users (e.g., non-priority users).

[0433] In an embodiment, an eNodeB 5704 may be configured to shape the network activity of mobile devices based on the priority groups/classes. In an embodiment, the eNodeB 5704 may shape the network activity such that mobile devices belonging to a higher priority group are allocated a larger percentage of the available network resources (e.g., bandwidth, etc.) as the network activity increases.

[0434] FIG. 57B illustrates network components and information flows in an LTE communication system 5750 that includes an embodiment eNodeB 5704a configured to perform TPA operations and/or shape the network activity of mobile devices based on the priority groups/classes. In the example illustrated in FIG. 57B, the LTE communication system 5750 includes an MME 5706, an SGW 5708, a HSS 5714, a PGW/PCEF 5710, and a PCRF 5712, all of which are logically inside the core network 5716. The LTE system 5750 may also be part of (or include) a DSA communication system.

[0435] The LTE system 5750 may include DSC 5722 and/or DPC 5724 components, either of which may be logically inside or outside of the core network 5716. The LTE communication system 5750 may include a first mobile device 5702a, a second mobile device 5702b, a first eNodeB 5704a, and a second eNodeB 5704b, all of which are logically outside of the core network 5716. The first mobile device 5702a may be classified as a primary user's mobile device 5702a and the second mobile device 5702b may be classified as a secondary user's mobile device 5702b. In the example illustrated in FIG. 57B, the primary user's mobile device 5702a is connected to the first eNodeB 5704a via a first wireless communication link 5722a. The secondary user's mobile device 5702b is connected to the first eNodeB 5704a via a second wireless communication link 5722b.

[0436] The first eNodeB 5704a may be configured to monitor network activity (e.g., call volume, resource usage, congestion, number of active connections, etc.) to determine whether the network activity exceeds two or more thresholds. When the network activity exceeds a first threshold, the first eNodeB 5704a may reserve a communication channel for the primary user's mobile device 5702a. When the network activity exceeds a second (or subsequent) threshold, the first eNodeB 5704a may dynamically "shape" the network activity of the secondary user's mobile device 5702b. Shaping the network activity of a mobile device may include performing operations to control one or more characteristics of the wireless communication link 5722b and/or the data being communicated, such as reducing bandwidth, reducing QoS, restricting the number of services, shedding a connection (e.g., wireless communication link 5722b, etc.), transferring a connected device to another eNodeB (e.g., the second eNodeB 5704b), performing handoffs, etc.

[0437] There are a number of advantages to shaping the network activity of the mobile devices via an eNodeB 5704, including faster detection and response times, improved efficiency, and more focused application of solutions. For example, since the eNodeB 5704 is outside of the core network 5716, it can detect and respond to changes in network activity much faster than the PCEF/PGW 5710 component or any other component that is inside the core network 5716. In an addition, the eNodeB 5704 may respond to changes in network activity and/or resource availability on a cell-by-cell or tower-by-tower basis, whereas existing solutions typically require applying the changes to an entire geographical area, updating network wide policies/controls, or applying restrictions to a specific subscriber or mobile device.

[0438] Further, by shaping the network activity on an eNodeB 5704, restrictions applied to a mobile device 5702 apply only when the mobile device 5702 attempts to communicate via a specific eNodeB 5704, and do not follow the mobile device 5702 after a handoff. For example, when a first eNodeB 5704a restricts the amount of bandwidth available to a mobile device, then hands off the mobile device to a second eNodeB 5704b, the bandwidth restrictions applied by the first eNodeB 5704a would not be enforced on the mobile device by the second eNodeB 5704b (as it would if the restriction were applied centrally by a component within the core network 5716, such as a PCEF/PGW 5710). This eliminates additional messages or operations that would otherwise be necessary to restore a mobile device's restricted properties (e.g., bandwidth, QoS, etc.), and thus improves efficiency.

[0439] As discussed above, an eNodeB may be configured to classify or organize the mobile devices into classes. In an embodiment, the eNodeB may be configured to perform internal tiered priority access (ITPA) operations, which may include subdividing the classes into a plurality of tiers. The eNodeB 5704 may then shape the network activity of the mobile devices based on the priority classes/tiers to more precisely control the allocation of network resources.

[0440] FIG. 58 illustrates network components and information flows in an example LTE cellular communications network 5800 that includes an eNodeB 5804a configured to perform ITPA operations in accordance with various embodiments. The first eNodeB 5804a may be configured to classify or organize the mobile devices into classes, then subdivide the classes into a plurality of tiers. In the example illustrated in FIG. 58, mobile devices 5802a-c are classified as primary mobile devices, the mobile device 5802d is classified as a secondary mobile device, and the primary mobile devices 5802a-c are subdivided into first, second, and third tiers. While two classes and three tiers are illustrated, it should be understood that the eNodeB 5804a may classify the mobile devices 5802 into any number of classes, and that each class maybe subdivided into any number of tiers.

[0441] The first eNodeB 5804a may be configured to monitor network activity (e.g., call volume, etc.) to determine whether the network activity exceeds any one of a plurality of thresholds. The plurality of thresholds may include any number of thresholds and each threshold may store any value relating to any measureable network activity or event (congestion, bandwidth, usage trends, availability of resources, QoS, etc.).

[0442] The first eNodeB 5804a may be configured to reserve communication channels and/or dynamically shape the network activity of one or more of the mobile devices 5802a-d in response to determining that a threshold is exceeded. The shaping operations may be performed such that higher priority mobile devices are allocated a larger percentage of the available network resources (e.g., bandwidth, etc.) as the network activity increases or resources become scarce. In an embodiment, this may be achieved by progressively reducing the number of network resources available to lower priority mobile devices.

[0443] In an embodiment, the plurality of thresholds may include a series of progressive threshold values. For example, the plurality of thresholds may include a first threshold value that is exceeded when 50% of the network resources are in use, a second threshold value that is exceeded when 75% of the network resources are in use, a third threshold value that is exceeded when 85% of the network resources are in use, a fourth threshold value that is exceeded when 95% of the network resources are in use, etc.

[0444] When the first eNodeB 5804a determines that the monitored network activity exceeds the first threshold value, the first eNodeB 5804a may reserve bandwidth or radio frequency (RF) resources for the primary mobile devices 5802a-c.

[0445] When the network activity exceeds the second threshold value, the first eNodeB 5804a may dynamically shape the network activity of the secondary mobile device 5802d by reducing the amount of bandwidth or RF resources that is made available to the secondary user's mobile device 5802d.

[0446] When the network activity exceeds the third threshold, the eNodeB 5804a may further shape the network activity of the secondary mobile device 5802d by shedding/terminating the wireless communication link 5822d and/or transferring the wireless communication link 5822d to the second eNodeB 5804b. In an embodiment, transferring the wireless communication link 5822d to the second eNodeB 5804b may include the first eNodeB 5804a communicating with the second eNodeB 5804b via the X2 interface, the second eNodeB 5804b establishing a new wireless communication link 5823d with the secondary mobile device 5802d, and the first eNodeB 5804a shedding/terminating the wireless communication link 5822d.

[0447] When the network activity exceeds a fourth threshold, the first eNodeB 5804a may begin shaping the network activity of the primary mobile devices 5802a-c by, for example, reducing the amount of bandwidth or radio resources made available to the tier three primary mobile devices 5802c. This process may continue until only the tier one primary mobile devices 5802a are connected to the first eNodeB 5804a, or until there are no mobile devices connected to the first eNodeB 5804a (i.e., to preserve resources for additional emergency personal who may arrive in the future, etc.).

[0448] In an embodiment, one or more eNodeBs 5804a, eNodeB 5804b may be configured to communicate with the DSC 5722 and/or the DPC 5724. For example, the first eNodeB 5804a may be configured to send an alert message to the DSC 5722 and/or DPC 5724 each time network activity exceeds one or more thresholds and/or when a traffic shaping actions (e.g., hand-offs, QoS adjustments, disconnections, etc.) occur.

[0449] While the above examples are described with reference to a specific set of shaping operations, a specific number of classes/tiers, and specific threshold values, it should be understood that any combination of shaping operations may be performed based on any combination of classes/tiers and for any number of threshold values.

[0450] FIGs. 59A-B illustrate that an eNodeB may classify the mobile devices into any number of classes, and that each class may be subdivided into any number of tiers. Specifically, FIG. 59A illustrates that eNodeB may classify the mobile devices into a primary class and a secondary class, the primary class may be subdivided into four tiers (e.g., platinum, gold, silver, copper), and a secondary class may be subdivided into multiple tiers (e.g., tiers 1-x). FIG. 59B illustrates an alternative arrangement with three classes, each of which is subdivided into multiple tiers.

[0451] As discussed above, shaping operations may include adjusting, controlling, and/or allocating any of a number of resources (radio links, bandwidth, resource blocks, CPU time, etc) available in the communications network. As also discussed above, the eNodeB may perform shaping operations based on one or more triggers or threshold values. A trigger may be any event that indicates network activity has changed and/or which may initiate shaping operations, and a threshold may store any value relating to any measureable network activity or event (congestion, bandwidth, usage trends, availability of resources, QoS, etc.). One or more triggers or threshold values may be assigned to, or associated with, any or all of the resources available in the communications network. Similarly, a single trigger/threshold value may be associated with multiple resources, and multiple triggers/threshold values may be associated with a single resource. For example, the eNodeB may monitor multiple resources, generate a composite value representative of the general availability of the resources, compare the generated composite value to a threshold value to determine whether shaping operations are to be performed, and shape the network activity of one of more mobile devices based on the results of the comparison.

[0452] FIGs. 60A-B illustrate example threshold values and triggers suitable for use in various embodiments. FIG. 60A illustrates that a first trigger may be activated when the eNodeB determines that the usage of an available resource (e.g., radio links, resource blocks, etc.) exceeds a threshold value of 75% usage, for example. A second trigger may be activated when it is determined that the usage of the available resource exceeds a threshold value of 90% usage, for example. The activation of the first trigger may cause an eNodeB to perform a first group of operations (e.g., QoS degradation, handoffs, etc.). The activation of the second trigger may cause the eNodeB to perform a second group of operations (e.g., traffic shedding, etc.).

[0453] FIG. 60B illustrates an alternate arrangement of triggers with four triggers (A, B, C, and D) assigned at different percentages or levels of resource usage. Alternate embodiments may include any number of triggers, and each trigger may be assigned any threshold value representing any percentage or level of resource usage.

[0454] In an embodiment, a network server in the communication network may determine the threshold values and/or triggers. In an embodiment, the eNodeB may be configured to dynamically determine and set the threshold values and/or triggers based on network conditions, such as the availability of resources, number of connections, bandwidth availability, number of services, number of classes, number of tiers, etc. In this manner, the eNodeB may quickly adjust to changing network conditions to ensure that the resources are allocated efficiently.

[0455] As discussed above the classes and/or tiers to which mobile devices belong may be determined in the eNodeB or a network server. In an embodiment, the classes to which the mobile devices belong may be determined in the eNodeB based on the home PLMN to which the mobile devices belong. In an embodiment, the classes to which the mobile devices belong may be determined in a network server of their respective home PLMNs, and made available to an eNodeB of a visiting network via an MME component.

[0456] In an embodiment, the eNodeB may be configured to dynamically determine and set the threshold values and/or triggers based on network conditions, such as the availability of resources, number of connections, bandwidth availability, number of services, number of classes, number of tiers, etc. In this manner, the eNodeB may quickly adjust to changing network conditions to ensure that the resources are allocated efficiently.

[0457] Generally, a mobile device may maintain several operational bearer channels at a time. In an embodiment, the eNodeB may be configured to shape the network activity of a mobile device by adjusting the characteristics of any or all of the operational bearer channels. In an embodiment, the eNodeB may be configured to adjust the characteristics of a bearer channel locally, based on the home PLMN, and/or independent of the PGW/PCEF and PCRF settings or operations. In this manner, the eNodeB may quickly ensure that higher priority users (e.g., primary users, etc.) have resources available.

[0458] FIGs. 61A and 61B illustrate an embodiment eNodeB method 6100 of shaping network resources based on triggers/threshold values. The operations of method 6100 may be performed by an eNodeB processor, a processor coupled to the eNodeB component, or in a server or agent (e.g., Diameter agent, a specialized server, a software application, a process, a computing system, etc.) in communication with the eNodeB component. The shaping of network resources may be performed in any of the DSA systems or networks discussed herein.

[0459] In operation 6102 of method 6100, the eNodeB may monitor resource usage. In an embodiment, the eNodeB may monitor one or more resources (e.g., radio links, resource operations, bandwidth, etc.) in real time as they are allocated by a scheduler (e.g., an eNodeB scheduler, etc.).

[0460] In determination operation 6104, the eNodeB may determine whether the quantity of resources (e.g., radio links, resource operations, bandwidth, etc.) being utilized exceeds the first threshold value (e.g., a value indicative of the percentage of total available resources, etc.). When the eNodeB determines that the quantity of resources being utilized does not exceed the first threshold value (i.e., determination operation 6104 = "No"), the eNodeB may continue monitoring resources in operation 6102. On the other hand, when the eNodeB determines that the quantity of resources being utilized does exceed the first threshold value (i.e., determination operation 6104 = "Yes"), in operation 6106, the eNodeB may set and start a first timer.

[0461] In operation 6108, the eNodeB may send a trigger 1 alert message to an MME to notify the MME to restrict transfers, originations and handins of mobile devices to the eNodeB. In an embodiment, as part of operation 6108, the eNodeB may also send a trigger 1 alert message to a DSC (e.g., DSC 5722) which could also restrict transfers, originations, and handins . The eNodeB may send the message over a direct communication link (e.g., connection 5730) or communicate the information indirectly via the components in the network (e.g., SGW 5708, PGW 5710, etc.).

[0462] In an embodiment, the DSC may be configured to communicate with a DPC (e.g., DPC 5724) in response to receiving an alert message from the eNodeB. In an embodiment, the DSC may be configured to relay alert messages received from the eNodeB (e.g., trigger 1 alert message) to the DPC. In another embodiment, the DSC may include data corresponding to the received trigger 1 alert message in a resource status report message, which may be sent to the DPC at various times, such as when reporting the status of resources (e.g., operation 3604 illustrated in FIG. 36, etc.). In any case, the DPC may receive a communication message from the DSC and record information pertaining to the trigger 1 alert message the included in the alert message (e.g., status of network resources, etc.) for later use in performing spectrum arbitrage determination operations.

[0463] In operation 6110, eNodeB may restrict originations (e.g., session originations, establishment of new communication links, requests for new or additional services, requests for additional bandwidth, etc.) and/or handins. In operations 6108 and 6110, the transfers, handins, and/or originations may be restricted based on priorities or rankings of the mobile devices. For example, the eNodeB may restrict originations and handins to and from mobile devices in lower classes or tiers, while allowing originations and handins for higher classes/tiers. As a further example, originations and handins for average civilians may be completely stopped while originations and handins for primary devices operated by first responders or other emergency personnel may remain unrestricted.

[0464] In various embodiments, the operations of operations 6108 and 6110 may be performed multiple times. That is, although restrictions on handins and/originations are applied only once in the example illustrated in FIG. 61A, the eNodeB may gradually restrict originations and handins by applying any number of restrictions to any number of different classes or tiers in response to any number of triggers/thresholds.

[0465] In an embodiment, as part of operations 6108 and 6110, the eNodeB may wait for a predetermined or variable amount of time after restricting handins and/originations for the network congestion to be alleviated or resolved.

[0466] In determination operation 6112, the eNodeB may determine whether additional resources have become available and/or the network congestion has otherwise been alleviated or resolved (e.g., resource usage has dropped back under trigger 1 or another acceptable level). When the eNodeB determines that the congestion has been resolved (i.e., determination operation 6112 = "Yes"), in operation 6126, the eNodeB may send a trigger cancel message to the MME to inform the MME to stop restricting transfers, originations and handins. The eNodeB could also inform the DSC to stop restricting transfers, originations and handins. The eNodeB may also send a trigger cancel message to the DSC or DPC to report the new resource status. In operation 6102, the eNodeB may return to monitoring resource usage.

[0467] When the eNodeB determines that the congestion has not resolved (i.e., determination operation 6112 = "No"), in operation 6114 the eNodeB may degrade the local quality of service (QoS) associated with one or more mobile devices, wireless communications links, and/or sessions. In an embodiment, the degradation of the local QoS may be performed by a scheduler (e.g., the eNodeB scheduler). In an embodiment, the local QoS may be degraded based on priorities/rankings (e.g., classes, tiers, etc.) so that the wireless communications links associated with mobile devices in the lowest tiers or classes are degraded first, followed by the wireless communications links to mobile devices in the second lowest tier/class, etc. To ensure that primary users or users in the highest tier always have adequate QoS, in an embodiment the eNodeB may be configured to not to degrade the local QoS of mobile devices in the higher classes and/or tiers.

[0468] In determination operation 6116, the eNodeB may determine whether the congestion has been resolved (e.g., due to the degradation of local QoS of low priority mobile devices, etc.). When the eNodeB determines that the network congestion has been resolved (i.e., determination operation 6116 = "Yes"), in operation 6122 the eNodeB may restore the local QoS of one or more of the degraded wireless communications links or mobile devices. In an embodiment, the eNodeB may restore the local QoS in the reverse order in which the local QoS was degraded and/or in accordance with the priorities/rankings.

[0469] In determination operation 6124, the eNodeB may determine whether there are sufficient network resources available and/or the network congestion remains resolved (e.g., in view of the additional network resources utilized by the restoration of the local QoS of lower priority mobile devices). When the eNodeB determines that there are sufficient network resources available and/or the network congestion remains resolved (i.e., determination operation 6124 = "Yes"), in operation 6126, the eNodeB may send a trigger cancel message to restore QoS and/or originations and handing based on the trigger threshold. In an embodiment, the eNodeB may send the trigger cancel message to the MME informing the MME to stop restricting handins, originations and transfers, and return to monitoring resources in operation 6102. The eNodeB may also send a message to the DSC informing it to stop restricting originations, transfers and handins. The eNodeB may also send a trigger cancel message to the DSC or DPC to report the new resource status in operation 6126.

[0470] When the eNodeB determines that the network is congested (i.e., determination operation 6124 = "No"), in operation 6114 the eNodeB may degrade the local QoS of additional wireless communication links/sessions/mobile devices or undue (or partially undue) the restoration operations performed in operation 6122 for one or more wireless communication links/mobile devices.

[0471] In various embodiments, the illustrated operations 6114, 6116, 6122, and 6124 may be performed repeatedly (e.g., when the congestion is relatively close to being resolved) until an optimal level of network resources are allocated to the mobile devices. Repeating operations 6114, 6116, 6122, and 6124 may be desirable to resolve the network congestion via QoS adjustments (as opposed to shedding, termination, and/or handoff operations).

[0472] In various embodiments, the eNodeB may be configured to avoid repeatedly performing the operations 6114, 6116, 6122, and 6124 by, for example, identifying the number of iterations through these operations, increasing the quantity by which the local QoS is degraded in operation 6114, decreasing the quantity by which the local QoS is restored in operation 6122, updating parameters used to measure network congestion, etc.

[0473] As discussed above, in determination operation 6116, the eNodeB may determine whether the network congestion has been resolved (e.g., due to the degradation of local QoS of low priority mobile devices, availability of additional resources, etc.). When the eNodeB determines that the congestion has not yet been resolved (i.e., determination operation 6116 = "No"), in determination operation 6118 the eNodeB may determine whether the first timer (i.e., timer 1) has expired. When the eNodeB determines that the first timer (i.e., timer 1) has not expired (i.e., determination operation 6118 = "No"), in determination operation 6120 the eNodeB may determine whether the quantity of resources being utilized exceeds a second trigger. When the eNodeB determines that consumption of network resources does not exceed the second trigger (i.e., determination operation 6120 = "No"), in operation 6114 the eNodeB may degrade the local QoS of one or more mobile devices, wireless communication links, sessions, etc.

[0474] When the eNodeB determines that the first timer has expired (i.e., determination operation 6118 = "Yes") or that the resources exceed a second trigger (i.e., determination operation 6120 = "Yes"), in operation 6132 (illustrated in FIG. 61B), the eNodeB may start a second timer.

[0475] With reference to FIG. 61B, in operation 6134, the eNodeB may send a trigger 2 alert message to the MME to indicate to the MME to begin coordinating transfers or handoffs, which may be preformed based on priorities and/or rankings. The eNodeB may also send a trigger 2 alert message to the DSC to indicate to, or cause, the DSC to begin coordinating transfers or handoffs, which may be preformed based on priorities and/or rankings. When the handover is to another network, the DSC may coordinate the handover request through the DPC to the potential target DSC in the other network. Additionally the eNodeB may also send a trigger 2 alert message to the DSC or DPC to report the new resource status. As discussed above, the DPC may rely on the new resource status report in later spectrum arbitrage determinations. In operation 6136, the eNodeB may handoff or transfer wireless communication links to mobile devices in the lowest tier or class to a second eNodeB.

[0476] In an embodiment, the handoffs may be ranked and/or performed based on the properties of the destination components to which mobile devices are handed off. For example, eNodeB may first attempt to handoff a mobile device to a second eNodeB owned or leased by the same operator, service provider, lessor, etc. When a second eNodeB belonging to the same operator, service provider, lessor, etc. is not available, the eNodeB may handoff the mobile device to a network component affiliated with the lessor, operator, service provider (e.g., to another radio access system with which an operator has a usage agreement), etc. When a network component affiliated with the lessor, operator, service provider is not available, the eNodeB may handoff the mobile device to network component that is owned/operated by a different lessee, operator, service provider, etc.

[0477] In determination operation 6138, the eNodeB may determine whether the congestion has been resolved. When the eNodeB determines that the congestion has been resolved (i.e., determination operation 6138 = "Yes"), in operation 6122 the eNodeB may restore the QoS of one or more of the degraded wireless communications links that have not been handed off. When the eNodeB determines that the congestion has not been resolved (i.e., determination operation 6138 = "No"), in determination operation 6140 the eNodeB may determine whether the second timer has expired.

[0478] When the eNodeB determines that the second timer has not expired (i.e., determination operation 6140 = "No"), in determination operation 6142 the eNodeB may determine whether the consumption of network resources exceeds a third trigger or threshold value. When the eNodeB determines that the consumption of network resources does not exceed the third trigger/ threshold value (i.e., determination operation 6142 = "No"), in operation 6136 the eNodeB may handoff or transfer additional mobile devices (e.g., in another tier or class) to another eNodeB.

[0479] When the eNodeB determines that the second timer has expired (i.e., determination operation 6140 = "Yes") or that the consumption of network resources exceeds the third trigger/threshold value (i.e., determination operation 6142 = "Yes"), in operation 6144 the eNodeB may begin terminating wireless communication links or sessions. In an embodiment, the wireless communication links/sessions may be terminated based on priorities or rankings.

[0480] As discussed above, the priorities or rankings of connections/mobile devices according to classes/tiers may be used by the eNodeB to determine the sessions that are to be terminated first. For example, the eNodeB may terminate sessions associated with mobile devices in the lowest class/tier before terminating sessions associated with mobile devices in the higher classes/tiers.

[0481] In operation 6150, the eNodeB may send a trigger 3 alert message to the DSC or DPC to report the new resource status. As discussed above, the DPC may rely on the new resource status report in later spectrum arbitrage determinations.

[0482] In determination operation 6146, the eNodeB may determine whether the network congestion has been resolved. When the eNodeB determines that the congestion is not resolved (i.e., determination operation 6146 = "No"), in operation 6144 the eNodeB may terminate additional wireless communication links or sessions. When the eNodeB determines that the congestion has been resolved (i.e., determination operation 6146 = "Yes"), in operation 6122 the eNodeB may restore the QoS of one or more of the degraded wireless communications links or sessions of mobile devices that have not yet been handed off.

[0483] FIGS. 62-65 illustrate various embodiment eNodeB methods 6200, 6300, 6400, 6500 of performing TPA and iTPA operations in an eNodeB and reporting these operations to a DSC or DPC for use in performing DSA operations in accordance with various embodiments. In the examples illustrated in FIGs. 62-65, a mobile device 6252 may maintain active data sessions 6202 with a PGW 6260 component in a first communication network or a PGW2 6261 component in a second communication network.

[0484] The establishment and/or maintance of the active data sessions 6202 may be achieved via eNodeB (eNB) 6254 and/or MME 6256 components, as is described above with reference to FIG. 57A. In addition to establishing and maintanting the sessions, the eNodeB 6254 may also mediate the active data sessions 6202 between mobile device 6252 and the PGW 6260, and perform various radio resource management (RRM) operations (e.g., monitoring the availability of network resources, etc.). The eNodeB 6254 may also communicate with a DSC 6262 and/or DPC 6264 to report resource status. In various embodiments, the eNodeB 6254 may communicate with the DSC 6262 and/or DPC 6264 directly (e.g., via connection 5730 or other direct communication links) or indirectly, such as via various components (e.g., MME 6256, PGW 6260, etc.) in the core network. The DSC/DPC 6262, 6264 components may be configured to use information generated by the eNodeB 6254 (and included in the alert messages and/or resource status reports) to make more intelligent spectrum arbitrage decisions/determinations.

[0485] Referring to FIG. 62, in operation 6204 of method 6200, the eNodeB 6254 may determine that the network is congested by, for example, determining whether the quantity of resources being utilized exceeds a threshold value (e.g., a value indicative of the percentage of total available resources, etc.). In operation 6206, the eNodeB 6254 may set and start a congestion timer. In operation 6208, the eNodeB 6254 may send a first congestion trigger alert message to the MME 6256 component to notify the MME 6256 to restrict transfers and/or handoffs of additional mobile devices to the eNodeB 6254. As part of operation 6208, the eNodeB 6254 may also send an alert to the DSC 6262 or DPC 6264. In various embodiments, the alerts may be sent directly or indirectly to the destination.

[0486] In operation 6210, the eNodeB 6254 may restrict originations (e.g., session originations, establishment of new communication links, requests for new or additional services, requests for additional bandwidth, etc.) and handins (i.e., stop accepting handoffs from other base stations).

[0487] In operation 6212, the eNodeB 6254 may determine that additional resources have become available and/or the network congestion has otherwise been alleviated or resolved (e.g., resource usage has dropped down to an acceptable level, etc.). In operation 6214, the eNodeB 6254 may send a trigger cancel message to the MME 6256 to inform the MME 6256 to stop restricting transfers and handoffs, and send an alert directly or indirectly to the DSC 6262 and/or DPC 6264. In operation 6216, the eNodeB 6254 may return to its normal steady state operating mode.

[0488] FIG. 63 illustrates an embodiment eNodeB method 6300 for resolving network congestion by degrading the local QoS of one or more mobile devices 6252. The mobile device 6252 may be engaged in an active data session 6302 with a PGW2 6261 in another (i.e., second) network.

[0489] In operation 6304 of method 6300, the eNodeB 6254 may determine that the network is congested (e.g., by determining whether the quantity of resources being utilized exceeds a threshold value). In operation 6306, the eNodeB 6254 may set and/or start a congestion timer.

[0490] In operation 6308, the eNodeB 6254 may send a first congestion trigger alert message to the MME 6256 component to notify the MME 6256 to restrict transfers and/or handoffs of additional mobile devices to the eNodeB 6254. As part of operation 6308, the eNodeB 6254 may also send an alert to the DSC 6262 and/or DPC 6264.

[0491] In operation 6310, the eNodeB 6254 may restrict originations and handins. In operation 6312, the eNodeB 6254 may determine that the network congestion has not yet been alleviated or resolved. In operation 6314, the eNodeB 6254 may select one or more mobile devices 6252 for localized degradation of QoS, which may be performed in accordance to priorities/rankings (e.g., classes, tiers, etc.). In operation 6316, the eNodeB 6254 may degrade the QoS of the selected mobile devices 6252.

[0492] In operation 6318, the eNodeB 6254 may determine that additional resources have become available and/or the network congestion has otherwise been alleviated or resolved (e.g., resource usage has dropped down to an acceptable level, etc.). In operations 6320-6322, the eNodeB 6254 may restore the local QoS of one or more of the degraded mobile devices 6252.

[0493] In operation 6324, the eNodeB 6254 may determine that resources are still available and/or the network congestion remains resolved. In operation 6326, the eNodeB 6254 may send a trigger cancel message to the MME 6256 to inform the MME 6256 to stop restricting transfers and handoffs, and send an alert message to the DSC 6262 and/or DPC 6264.

[0494] In operation 6328, the eNodeB 6254 may lift the restrictions on originations and handins. In operation 6330, the eNodeB 6254 and the system may return to normal operating conditions (e.g., steady state operating mode).

[0495] FIG. 64 illustrates an embodiment method 6400 for resolving network congestion by performing handoff operations to transfer mobile devices to a second base station. In operation 6402, a first eNodeB 6254a may detect network congestion. In operation 6404, the eNodeB 6254a may start a congestion timer. In operation 6406, the eNodeB 6254a may send a first congestion trigger alert message to the MME 6256 component to notify the MME 6256 to restrict transfers and/or handoffs of additional mobile devices to the eNodeB 6254. As part of operation 6406, the eNodeB 6254 may also send an alert to the DSC 6262 and/or DPC 6264.

[0496] In operation 6408, the eNodeB 6254a may restrict originations and handins. In operation 6412, the eNodeB 6254a may select one or more mobile devices 6252 for localized degradation of QoS, which may be performed in accordance to priorities/rankings (e.g., classes, tiers, etc.). In operation 6412, the eNodeB 6254a may determine that the network congestion has not yet been alleviated or resolved. In operation 6414, the eNodeB 6254a may degrade the QoS of the selected mobile devices 6252.

[0497] In operation 6416, the eNodeB 6254a may determine that the network congestion has not yet been alleviated or resolved (i.e., despite the degradation of the local QoS of one or more mobile devices). In operation 6418, the eNodeB 6254a may send a second trigger alert message to the MME 6256, and an alert message to the DSC 6262 and/or DPC 6264.

[0498] In operation 6420, the eNodeB 6254a may select one or more mobile devices 6252 for transfer to another base station, which may be performed in accordance to priorities/rankings (e.g., classes, tiers, etc.). In various embodiments, operation 6420 may comprise exchanging a list of candidate mobile devices between the eNodeB 6254a and the DSC 6262.

[0499] In various embodiments, the MME 6256 and/or the DSC 6262 may target an eNodeB not under congestion or in a backoff condition for a handoff in operation 6440. If an infrasystem eNodeB is targeted, operation 6440 may comprise sending a message cancelling an inter system handoff process, such as an intersystem handoff process coordinated in the operation 6420. The canceling messages may be sent to a DSC 6262, a DPC 6264, or a DSC in a second network (e.g., DSC2 6272) directly or indirectly via any connection.

[0500] In an embodiment, the selection of mobile devices for handoff may be performed in cooperation/coordination with the MME 6256. For example, in operation 6420, the MME 6256 may identify a second eNodeB (eNB-2) 6254b to which the selected mobile devices may be transferred based on the properties of the destination components to which mobile devices are to be handed off. Preference may be given to a second eNodeB that owned or leased by the same operator, service provider, or lessor as the first eNodeB 6254a, followed by an eNodeB affiliated with the same operator, service provider, or lessor (e.g., to another radio access system with which an operator has a usage agreement, etc.). When the eNodeB 6254a and/or MME 6256 determine that a network component owned or affiliated with the lessor (or operator, service provider, etc.) is not available for transferring a mobile device 6252, the eNodeB 6254a and/or MME 6256 may select a network component that is owned/operated by a different lessee (or operator, service provider, etc).

[0501] In operation 6422 of method 6400, the first eNodeB 6254a may handoff one or more selected mobile devices 6252 to a targeted/identified second eNodeB 6254b.

[0502] In operation 6424, the eNodeB 6254a may determine that the network congestion has not yet been alleviated or resolved (i.e., despite handing off mobile devices to the second eNodeB 6254b). In operation 6426, the first eNodeB 6254a may handoff additional mobile devices 6252 to a targeted/identified second eNodeB 6254b.

[0503] In operation 6428, the eNodeB 6254a may determine that additional resources have become available and/or the network congestion has otherwise been alleviated or resolved. In operation 6430, the eNodeB 6254 may send a trigger cancel message to the MME 6256, and send an alert message to the DSC 6262 and/or DPC 6264.

[0504] In operation 6432, the eNodeB 6254 and the system may return to normal operating conditions (e.g., steady state operating mode).

[0505] In various embodiments, the DPC 6264 may communicate with a DSC in a second network (e.g., DSC-2 6272) via messages 6442 that include information that may be used to coordinate dynamic spectrum arbitrage operations. The messages 6442 include information generated in the eNodeB 6254a, such as information concerning network resource usage, congestion (i.e., various thresholds passed), or traffic shaping (e.g., QoS changes, handoffs, dropped sessions, etc.). In this manner, the DPC 6264 may make more intelligent spectrum arbitrage decisions that better account for the existing network conditions.

[0506] FIG. 65 illustrates an embodiment method 6500 for resolving network congestion by performing traffic shedding operations. In operation 6502, a first eNodeB 6254a may detect network congestion. In operation 6504, the eNodeB 6254a may start a congestion timer.

[0507] In operation 6506, the eNodeB 6254a may send a first congestion trigger alert message to the MME 6256 and/or the DSC 6262 component to notify the MME 6256 and/or the DSC 6262 to restrict transfers and/or handoffs of additional mobile devices to the eNodeB 6254a. The eNodeB 6254 may also send an alert to the DSC 6262 and/or DPC 6264. Operation 6506 is illustrated as a chain of messages as opposed to multiple separate messages as shown in FIGS. 62, 63, and 64, although either method may be used in various embodiments. For example, rather than the eNodeB sending three messages to three separate destinations, the eNodeB may send one message to the MME 6256, the MME may forward a copy of the message to the DSC 6262, and the DSC may forward a copy to the DPC 6264.

[0508] In operation 6508, the eNodeB 6254a may restrict originations and handins. In operation 6510, the eNodeB 6254a may determine that the network congestion has not yet been alleviated or resolved (i.e., despite the restrictions on handins, etc.). In operation 6512, the eNodeB 6254a may select one or more mobile devices 6252 for localized degradation of QoS, which may be performed in accordance to priorities/rankings (e.g., classes, tiers, etc.). In operation 6514, the eNodeB 6254a may degrade the QoS of the selected mobile devices 6252.

[0509] In operation 6516, the eNodeB 6254a may determine that the network congestion has not yet been alleviated or resolved (i.e., despite the degradation of the local QoS of one or more mobile devices). In operation 6518, the eNodeB 6254a may send a second trigger alert message to the MME 6256, and an alert message to the DSC 6262 and/or DPC 6264.

[0510] In operation 6520, the eNodeB 6254a may select one or more mobile devices 6252 for transfer to another base station, which may be performed in accordance to priorities/rankings (e.g., classes, tiers, etc.) and various properties of the mobile devices and/or destination components to which mobile devices are to be handed off.

[0511] In operation 6550, the MME 6256 may target an eNodeB not under congestion or in back-off condition with assistance from the DSC 6262. In various embodiments, the MME 6256 may coordinate a inter-system handoff by communicating with an

MME in a second network (e.g., MME-2 6580) through DSC 6262 and the DSC in the secondary system. As discussed above, the second eNodeB (i.e., eNB-2 6254) may be in a second network, such as the same network as MME-2, and receive handoff instructions from MME-2.

[0512] In operation 6550, the DSC 6262 may target an eNodeB not under congestion or in backoff condition. In various embodiments, the DSC 6262 may coordinate an inter-system handoff by communicating with an MME in a second network (e.g., MME-2 6580). The communication may also occur between the DSC in the primary and secondary systems via the DPC 6264. The second eNodeB (i.e., eNB-2 6254) may be in a second network and receive handoff instructions from MME-2.

[0513] In operation 6522, the eNodeB 6254a may handoff selected devices to a second eNodeB 6254b. The second eNodeB 6254b may be selected from the same network or a different network. If the second eNodeB 6254b is from a second network, the MME 6256 may coordinate with an MME in the second network or the coordination may take place via the DSC. As discussed above, preference may be given to a second eNodeB that owned or leased by the same operator, service provider, or lessor as the first eNodeB 6254a, followed by an eNodeB affiliated with the same operator, service provider, or lessor (e.g., to another radio access system with which an operator has a usage agreement, etc.). When the eNodeB 6254a and/or MME 6256 are informed that a network component owned or affiliated with the lessor (or operator, service provider, etc.) is not available for transferring a mobile device 6252, the eNodeB 6254a, MME 6256 and/or DSC 6262 may select a network component that is owned/operated by a different lessee (or operator, service provider, etc).

[0514] In operation 6524, the eNodeB 6254a may determine that the congestion timer has expired. In operation 6526, the eNodeB 6254a may begin terminating mobile device sessions, which may be performed in accordance to priorities/rankings (e.g., classes, tiers, etc.). In operation 6528, one or more sessions of one or more mobile devices 6252 may be terminated. In operation 6540, the eNodeB 6254 may send an alert to the MME 6256, DSC 6262, and/or DPC 6264.

[0515] In operations 6530-6532, the eNodeB 6254a may continue terminating mobile device sessions and monitoring the availability of network resources to determine whether the network congestions has been resolved. In operation 6542, the eNodeB 6254 may send an alert to the MME 6256, DSC 6262 and/or DPC 6264. In operation 6534, the eNodeB 6254a may determine that the network congestion has been resolved. In operation 6536, the eNodeB 6254a may send a trigger cancellation message to the MME 6256 and/or DSC 6262, and send an alert to the DSC 6262 and/or DPC 6264. In operation 6538, the eNodeB 6254 and the system may return to normal operating conditions (e.g., steady state operating mode).

[0516] As discussed above with reference to FIG. 64, the DPC 6264 may communicate with a DSC in a second network via messages (not shown in FIG. 65) to coordinate dynamic spectrum arbitrage operations based on messages received directly or indirectly from the eNodeB concerning network resource usage, congestion (i.e., various thresholds passed), or traffic shaping (e.g., QoS changes, handoffs, dropped sessions, etc.).

[0517] FIG. 66 illustrates an embodiment method 6600 of performing DSA operations. In operation 6602, a server, such as a DPC, may establish a communication link to a first communication network having a first plurality of base towers, cell sites, and/or eNodeBs. In operation 6604, the server may establish a communication link to a second communication network having a second plurality of base towers, cell sites, and/or eNodeBs.

[0518] In operation 6606, the server may determine whether RF spectrum resources of the first communication network are available for allocation (e.g., the server may use any of the DSA methods discussed above). In operation 6608, the server may determine the amount or number of RF spectrum resources available for allocation. In operation 6610, the sever may initiate an allocation process to allocate a portion of the RF resources determined to be available for allocation. In operation 6612, the server may inform the second communication network that the use of the allocated RF spectrum resources may begin. In operation 6614, the server may record a transaction in a transaction database identifying an amount of RF spectrum resources allocated for use by the second communication network.

[0519] In operation 6616, a system component, such as an eNodeB, may monitor network resource usage by a plurality of mobile devices grouped into tiers or priority groups as discussed above. In an embodiment, the eNodeB may be in the first communication network. In another embodiment, the eNodeB may be in the second communication network.

[0520] In operation 6618, the eNodeB may determine whether the usage of network resources exceeds a threshold. In operations 6620, the eNodeB may shape traffic based on the priority groups or rankings, such as by performing any of the embodiment methods (e.g., method 6100, etc.) discussed above. In operation 6622, the server may determine whether the allocated RF spectrum resources are required by the first communication network based on whether the threshold is exceeded (i.e., based on the eNodeB's determination in operation 6618). In operation 6624, the server may inform the second communication network that use of allocated RF spectrum resources should be terminated in response to determining that at least some of the allocated RF spectrum resources are required by the first communication network in operation. In operation 6626, the server may update the transaction database to include information identifying a time when use of the allocated RF spectrum resources was terminated by the second communication network.

[0521] FIG. 67 illustrates an embodiment method from the perspective of an eNodeB. In operation 6702, the eNodeB (or any agent, processor, hardware component, or software component in communication with the eNodeB) may monitor network resource usage. In an embodiment, the eNodeB may monitor the amount of network resources used by a plurality of mobile devices, which may be grouped into tiers or priority groups.

[0522] In operation 6704, the eNodeB may determine whether the usage of network resources exceeds a threshold value. In operation 6706, the eNodeB may shape traffic based on the priority groups or rankings (e.g., via embodiment method 6100, etc.).

[0523] In operation 6708, the eNodeB may transmit a resource alert message to a communications server (e.g., a DPC). The communication server may be configured to allocate a portion of available RF spectrum resources between a first communication network that includes the first eNodeB, and a second communication network.

[0524] FIG. 68 illustrates an embodiment method from the perspective of a DPC. In operation 6802, a DPC may establish a communication link to a first communication network. In operation 6804, the DPC may establish a communication link to a second communication network. In operation 6806, the DPC may determine an amount of radio frequency (RF) spectrum resources available for allocation within a first communication network in operation.

[0525] In operation 6808, the DPC may determine the amount of RF spectrum resources available for allocation. A portion of the RF resources available may be allocated in operation 6810. In operation 6812, the DPC may inform the second communication network that the use of RF spectrum resources allocated in operation 6810 may begin. The DPC may record a transaction in a transaction database identifying an amount of RF spectrum resources allocated for use by the second communication network in operation 6814.

[0526] In operation 6816, the DPC may receive a resource alert message from an eNodeB on the first communication network. In operation 6818, the DPC may determine whether the allocated RF spectrum resources are required by the first communication network based on the resource alert message. The DPC may inform the second communication network that use of allocated RF spectrum resources should be terminated in response to determining that at least some of the allocated RF spectrum resources are required by the first communication network in operation 6820. In operation 6822, the DPC may update the transaction database to include information identifying a time when use of the allocated RF spectrum resources was terminated by the second communication network.

[0527] The various aspects may be implemented on a variety of mobile computing devices, an example of which is illustrated in FIG. 69. Specifically, FIG. 69 is a system block diagram of a mobile transceiver device in the form of a smartphone/cell phone 6900 suitable for use with any of the aspects. The cell phone 6900 may include a processor 6901 coupled to internal memory 6902, a display 6903, and to a speaker 6908. Additionally, the cell phone 6900 may include an antenna 6904 for sending and receiving electromagnetic radiation that may be connected to a wireless data link and/or cellular telephone transceiver 6905 coupled to the processor 6901. Cell phones 6900 typically also include menu selection buttons or rocker switches 6906 for receiving user inputs.

[0528] A typical cell phone 6900 also includes a sound encoding/decoding (CODEC) circuit 6913 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 6908 to generate sound. Also, one or more of the processor 6901, wireless transceiver 6905 and CODEC 6913 may include a digital signal processor (DSP) circuit (not shown separately). The cell phone 6900 may further include a ZigBee transceiver (i.e., an IEEE 802.15.4 transceiver) for low-power short-range communications between wireless devices, or other similar communication circuitry (e.g., circuitry implementing the Bluetooth® or WiFi protocols, etc.).

[0529] The embodiments described above, including the spectrum arbitrage functions, may be implemented within a broadcast system on any of a variety of commercially available server devices, such as the server 7000 illustrated in FIG. 70. Such a server 7000 typically includes a processor 7001 coupled to volatile memory 7002 and a large capacity nonvolatile memory, such as a disk drive 7003. The server 7000 may also include a floppy disc drive, compact disc (CD) or DVD disc drive 7011 coupled to the processor 7001. The server 7000 may also include network access ports 7006 coupled to the processor 7001 for establishing data connections with a network 7005, such as a local area network coupled to other communication system computers and servers.

[0530] The processors 6901, 7001, 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 aspects described below. In some mobile devices, multiple processors 7001 may be provided, such as one processor dedicated to wireless communication functions and one processor dedicated to running other applications. Typically, software applications may be stored in the internal memory 6902, 7002, before they are accessed and loaded into the processor 6901, 7001. The processor 6901, 7001may include internal memory sufficient to store the application software instructions. In some servers, the processor 5701 may include internal memory sufficient to store the application software instructions. In some receiver devices, the secure memory may be in a separate memory chip coupled to the processor 5701. The internal memory 5702 may be a volatile or nonvolatile memory, such as flash memory, or a mixture of both. For the purposes of this description, a general reference to memory refers to all memory accessible by the processor 5701, including internal memory 5702, removable memory plugged into the device, and memory within the processor 5701 itself.

[0531] Embodiments include methods for managing, allocating and arbitraging RF bandwidth as described above. Embodiments also include the communication systems that enable the DPC methods. Embodiments also include the non-transitory computer-readable storage media storing computer-executable instructions for performing the methods described above.

[0532] 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 steps of the various embodiments must be performed in the order presented. As will be appreciated by one of skill in the art the order of steps 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 steps; these words are simply 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.

[0533] The various illustrative logical blocks, modules, circuits, and algorithm steps 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 steps 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 implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[0534] The hardware used to implement the 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 (DPC), 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 computing devices, e.g., a combination of a DPC and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a DPC core, or any other such configuration. Alternatively, some steps or methods may be performed by circuitry that is specific to a given function.

[0535] In one or more exemplary embodiments, the functions described may be implemented in hardware, software, firmware, or any combination thereof. If implemented in software, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. The steps of a method or algorithm disclosed herein may be embodied in a processor-executable software module which may reside on a tangible, non-transitory computer-readable storage medium. Tangible, non-transitory computer-readable storage media may be any available media that may be accessed by a computer. By way of example, and not limitation, such as, non-transitory computer-readable media may comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, 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 should also be included within the scope of non-transitory computer-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 tangible, non-transitory machine readable medium and/or computer-readable medium, which may be incorporated into a computer program product.

[0536] The preceding description of the disclosed embodiments is provided to enable any person skilled in the art to make or use the present invention. 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 spirit or scope of the invention. Thus, the present invention 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 dynamic spectrum arbitrage method, comprising:

determining in a communications server an amount of radio frequency (RF) spectrum resources available for allocation within a first communication network;

allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network;

informing the second communication network that use of allocated RF spectrum resources may begin;

recording a transaction in a transaction database identifying an amount of RF spectrum resources allocated for use by the second communication network;

receiving a resource alert message that includes information collected by an eNodeB from the first communication network;

determining in the communications server whether at least some of the allocated RF spectrum resources are required by the first communication network based on the information included in the received resource alert message;

informing the second communication network that use of allocated RF spectrum resources should be terminated in response to determining that at least some of the allocated RF spectrum resources are required by the first communication network; and

updating the transaction database to include information identifying a time when use of the allocated RF spectrum resources was terminated by the second communication network.

2. The dynamic spectrum arbitrage method of claim 1, wherein the first communication network is dedicated to one or more of police, fire, emergency medical service or government agencies.

3. The dynamic spectrum arbitrage method of claim 1, further comprising:

conducting an auction for available RF spectrum resources within the first communication network among a plurality of network operators wherein the auction is accomplished according to bidding rules related to at least one of a requested capacity of a network, a network boundary, a network quality of service, a network geographic parameter, a time for when resources are requested, and a duration of services parameter,

wherein dynamically allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises dynamically allocating the portion of available RF spectrum resources to a communication network selected by the auction.

4. The dynamic spectrum arbitrage method of claim 1, further comprising:

receiving a request for additional RF spectrum resources from the second communication network,

wherein allocating a portion of available RF spectrum resources is accomplished in response to receiving the request for additional RF spectrum resources from the second communication network.

5. The dynamic spectrum arbitrage method of claim 1, wherein allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises handing off a communication session established within the second communication network to a portion of the allocated RF spectrum resources.

6. The dynamic spectrum arbitrage method of claim 1, wherein allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises allocating available RF spectrum resources based on one or more of a time of day, bandwidth, communication capacity, service treatment, geographic boundary and duration.

7. The dynamic spectrum arbitrage method of claim 1, further comprising pooling available resources from the first communication network and at least one other communication network, wherein allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises allocating to the second communication network RF spectrum resources from a pool of RF spectrum resources.

8. The dynamic spectrum arbitrage method of claim 1, further comprising sending payment information relating to use of allocated resources to the second communication network in response to allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network.

9. A communications server for accomplishing dynamic spectrum arbitrage of available radio frequency (RF) spectrum resources between a first communication network and a second communication network, comprising:

network communications circuitry for communicating with the first and second communication networks;

a memory; and

a processor coupled to the memory and the network communications circuitry, wherein the processor is configured with processor-executable instructions to perform operations comprising:

determining an amount of RF spectrum resources available for allocation within the first communication network;

allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network;

informing the second communication network that use of allocated of RF spectrum resources may begin;

recording a transaction in a transaction database identifying an amount of RF spectrum resources allocated for use by the second communication network;

receiving a resource alert message that includes information collected by an eNodeB from the first communication network;

determining whether at least some of the allocated RF spectrum resources are required by the first communication network based on the information included in the received resource alert message;

informing the second communication network that use of allocated RF spectrum resources should be terminated in response to determining that at least some of the allocated RF spectrum resources are required by the first communication network; and

updating the transaction database to include information identifying a time when use of the allocated RF spectrum resources was terminated by the second communication network.

10. The communications server of claim 9, wherein the processor is configured with processor-executable instructions to perform operations such that determining an amount of RF spectrum resources available for allocation within the first communication network comprises:

determining the amount of RF spectrum resources available for allocation within a network dedicated to one or more of police, fire, emergency medical service or government agencies.

11. The communications server of claim 9,

wherein the processor is configured with processor-executable instructions to perform operations further comprising conducting an auction for available RF spectrum resources of the first communication network among a plurality of network operators, wherein the auction is accomplished according to bidding rules related to at least one of a requested capacity of a network, a network boundary, a network quality of service, a network geographic parameter, a time for when resources are requested, and a duration of services parameter; and

wherein the processor is configured with processor-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises allocating the portion of available RF spectrum resources to a communication network selected by the auction.

12. The communications server of claim 9,

wherein the processor is configured with processor-executable instructions to perform operations further comprising receiving a request for additional RF spectrum resources from the second communication network, and

wherein the processor is configured with processor-executable instructions such that allocating a portion of available RF spectrum resources is accomplished in response to receiving the request for additional RF spectrum resources from the second communication network.

13. The communications server of claim 9, wherein the processor is configured with processor-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises:

handing off a communication session established within the second communication network to a portion of the allocated RF spectrum resources.

14. The communications server of claim 9, wherein the processor is configured with processor-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises:

allocating available RF spectrum resources based on one or more of a time of day, bandwidth, communication capacity, service treatment, geographic boundary and duration.

15. The communications server of claim 9,

wherein the processor is configured with processor-executable instructions to perform operations further comprising pooling available resources from the first communication network and at least one other communication network, and

wherein the processor is configured with processor-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises allocating to the second communication network RF spectrum resources from a pool of RF spectrum resources.

16. The communications server of claim 9, wherein the processor is configured with processor-executable instructions to perform operations further comprising:

sending payment information relating to use of allocated resources to the second communication network in response to allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network.

17. A non-transitory computer readable storage medium having stored thereon processor-executable software instructions configured to cause a processor to perform dynamic spectrum arbitrage (DSA) operations comprising:

determining an amount of radio frequency (RF) spectrum resources available for allocation within a first communication network;

allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network;

informing the second communication network that use of allocated RF spectrum resources may begin;

recording a transaction in a transaction database identifying an amount of RF spectrum resources allocated for use by the second communication network;

receiving a resource alert message that includes information collected by an eNodeB from the first communication network;

determining whether at least some of the allocated RF spectrum resources are required by the first communication network based on the information included in the received resource alert message;

informing the second communication network that use of allocated RF spectrum resources should be terminated in response to determining that at least some of the allocated RF spectrum resources are required by the first communication network; and

updating the transaction database to include information identifying a time when use of the allocated RF spectrum resources was terminated by the second communication network.

18. The non-transitory computer readable storage medium of claim 17, wherein the stored processor-executable software instructions are configured to cause a processor to perform operations such that determining an amount of RF spectrum resources available for allocation within a first communication network comprises:

determining an amount of RF spectrum resources available for allocation within a network dedicated to one or more of police, fire, emergency medical service, and government agencies.

19. The non-transitory computer readable storage medium of claim 17,

wherein the stored processor-executable software instructions are configured to cause a processor to perform operations further comprising conducting an auction for available RF spectrum resources within the first communication network among a plurality of network operators, wherein the auction is accomplished according to bidding rules related to at least one of a requested capacity of a network, a network boundary, a network quality of service, a network geographic parameter, a time for when resources are requested, and a duration of services parameter, and

wherein the stored processor-executable software instructions are configured to cause a processor to perform operations such that allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises allocating the portion of available RF spectrum resources to a communication network selected by the auction.

20. The non-transitory computer readable storage medium of claim 17,

wherein the stored processor-executable software instructions are configured to cause a processor to perform operations further comprising receiving a request for additional RF spectrum resources from the second communication network, and

wherein the stored processor-executable software instructions are configured to cause a processor to perform operations such that allocating a portion of available RF spectrum resources is accomplished in response to receiving the request for additional RF spectrum resources from the second communication network.

21. The non-transitory computer readable storage medium of claim 17, wherein the stored processor-executable software instructions are configured to cause a processor to perform operations such that allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises:

handing off a communication session established within the second communication network to a portion of the allocated RF spectrum resources.

22. The non-transitory computer readable storage medium of claim17, wherein the stored processor-executable software instructions are configured to cause a processor to perform operations such that allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises:

allocating available RF spectrum resources based on one or more of a time of day, bandwidth, communication capacity, service treatment, geographic boundary and duration.

23. The non-transitory computer readable storage medium of claim 17,

wherein the stored processor-executable software instructions are configured to cause a processor to perform operations comprising pooling available resources from the first communication network and at least one other communication network, and

wherein the stored processor-executable software instructions are configured to cause a processor to perform operations such that allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network comprises allocating to the second communication network RF spectrum resources from a pool of RF spectrum resources.

24. The non-transitory computer readable storage medium of claim 17, wherein the stored processor-executable software instructions are configured to cause a processor to perform operations further comprising sending payment information relating to use of allocated resources to the second communication network in response to allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network.

25. A system, comprising:

an eNodeB comprising a transmitter and an eNodeB processor coupled to the transmitter; and

a server comprising a server memory, network communications circuitry, and a server processor coupled to the server memory and network communications circuitry,

wherein the server processor is configured with server-executable instructions to perform operations comprising:

determining an amount of RF spectrum resources available for allocation within a first communication network;

allocating a portion of available RF spectrum resources of the first communication network for access and use by a second communication network;

informing the second communication network that use of allocated of RF spectrum resources may begin;

recording a transaction in a transaction database identifying an amount of RF spectrum resources allocated for use by the second communication network;

receiving a resource alert message that includes information collected by an eNodeB from the first communication network;

determining whether at least some of the allocated RF spectrum resources are required by the first communication network based on the information included in the received resource alert message;

informing the second communication network that use of allocated RF spectrum resources should be terminated in response to determining that at least some of the allocated RF spectrum resources are required by the first communication network; and

updating the transaction database to include information identifying a time when use of the allocated RF spectrum resources was terminated by the second communication network, and

wherein the eNodeB processor is configured with processor-executable instructions to perform operations comprising:

establishing communication links with the first communication network;

establishing wireless communication links with a plurality of mobile devices;

grouping the mobile devices into one of a plurality of tiers, each tier being associated with a priority;

monitoring network resource usage of the first communication network;

determining whether usage of network resources exceeds a first threshold;

restricting originations of new sessions and handins of additional mobile devices when it is determined that the usage of network resources exceeds the first threshold, wherein restricting originations of new sessions comprises restricting originations of new sessions for mobile devices grouped into a low priority tier;

generating the resource alert message based on monitoring of network resource usage and restricting originations and handins; and

transmitting the resource alert message to the server.

26. The system of claim 25, wherein the eNodeB processor is configured with processor-executable instructions to perform operations further comprising:

degrading a local quality of service (QoS) of one or more mobile devices when it is determined that the usage of network resources exceeds the first threshold,

wherein degrading the local QoS of the mobile devices comprises degrading the local QoS of at least one mobile device based on priorities associated with the tiers into which the mobile devices are grouped.

27. The system of claim 26, wherein the eNodeB processor is configured with processor-executable instructions to perform operations further comprising:

continuing monitoring network resource usage to determine whether the usage of network resources exceeds a second threshold; and

handing off one or more coupled mobile devices to a second eNodeB when it is determined that the usage of network resources exceeds the second threshold,

wherein handing off one or more coupled mobile devices to a second eNodeB comprises handing off mobile devices in an order determined based on the priorities associated with the tiers into which the mobile devices are grouped.

28. The system of claim 27, wherein the eNodeB processor is configured with processor-executable instructions to perform operations such that handing off one or more coupled mobile devices to a second eNodeB further comprises:

handing off mobile devices based on a network to which the second eNodeB belongs.

29. The system of claim 28, wherein the eNodeB processor is configured with processor-executable instructions to perform operations such that handing off one or more coupled mobile devices to a second eNodeB further comprises:

determining whether the eNodeB belongs to a lessor network;

determining whether the second eNodeB belongs to the lessor network; and

determining whether the second eNodeB belongs to a radio access system corresponding to the lessor network when it is determined that the second eNodeB does not belong to the lessor network.

30. The system of claim 27, wherein the eNodeB processor is configured with processor-executable instructions to perform operations further comprising:

further continuing monitoring network resource usage to determine whether the usage of network resources exceeds a third threshold; and

terminating existing sessions of one or more mobile devices when it is determined that the usage of network resources exceeds the third threshold,

wherein terminating existing sessions of one or more mobile devices comprises terminating existing sessions based on the priorities associated with the tiers into which the mobile devices are grouped.

31. The system of claim 25, wherein determining an amount of RF spectrum resources available for allocation within a first communication network comprises determining the amount of RF spectrum resources available for allocation within a communication network dedicated to one or more of police, fire, emergency medical service or government agencies.

32. The system of claim 25,

wherein the server processor is configured with server-executable instructions to perform operations further comprising conducting an auction for available RF spectrum resources of the first communication network among a plurality of network operators, wherein the auction is accomplished according to bidding rules related to at least one of a requested capacity of a network, a network boundary, a network quality of service, a network geographic parameter, a time for when resources are requested, and a duration of services parameter, and wherein the server processor is configured with server-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises allocating the portion of available RF spectrum resources to a communication network selected by the auction.

33. The system of claim 25,

wherein the server processor is configured with server-executable instructions to perform operations further comprising receiving a request for additional RF spectrum resources from the second communication network, and

wherein the server processor is configured with server-executable instructions such that allocating a portion of available RF spectrum resources is accomplished in response to receiving the request for additional RF spectrum resources from the second communication network.

34. The system of claim 25, wherein the server processor is configured with server-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises:

handing off a communication session established within the second communication network to a portion of the allocated RF spectrum resources.

35. The system of claim 25, wherein the server processor is configured with server-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises:

allocating available RF spectrum resources based on one or more of a time of day, bandwidth, communication capacity, service treatment, geographic boundary and duration.

36. The system of claim 25,

wherein the server processor is configured with server-executable instructions to perform operations further comprising pooling available resources from the first communication network and at least one other communication network, and

wherein the server processor is configured with server-executable instructions such that allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network comprises allocating to the second communication network RF spectrum resources from a pool of RF spectrum resources.

37. The system of claim 25, wherein the server processor is configured with server-executable instructions to perform operations further comprising:

sending payment information relating to use of allocated resources to the second communication network in response to allocating a portion of available RF spectrum resources of the first communication network for access and use by the second communication network.

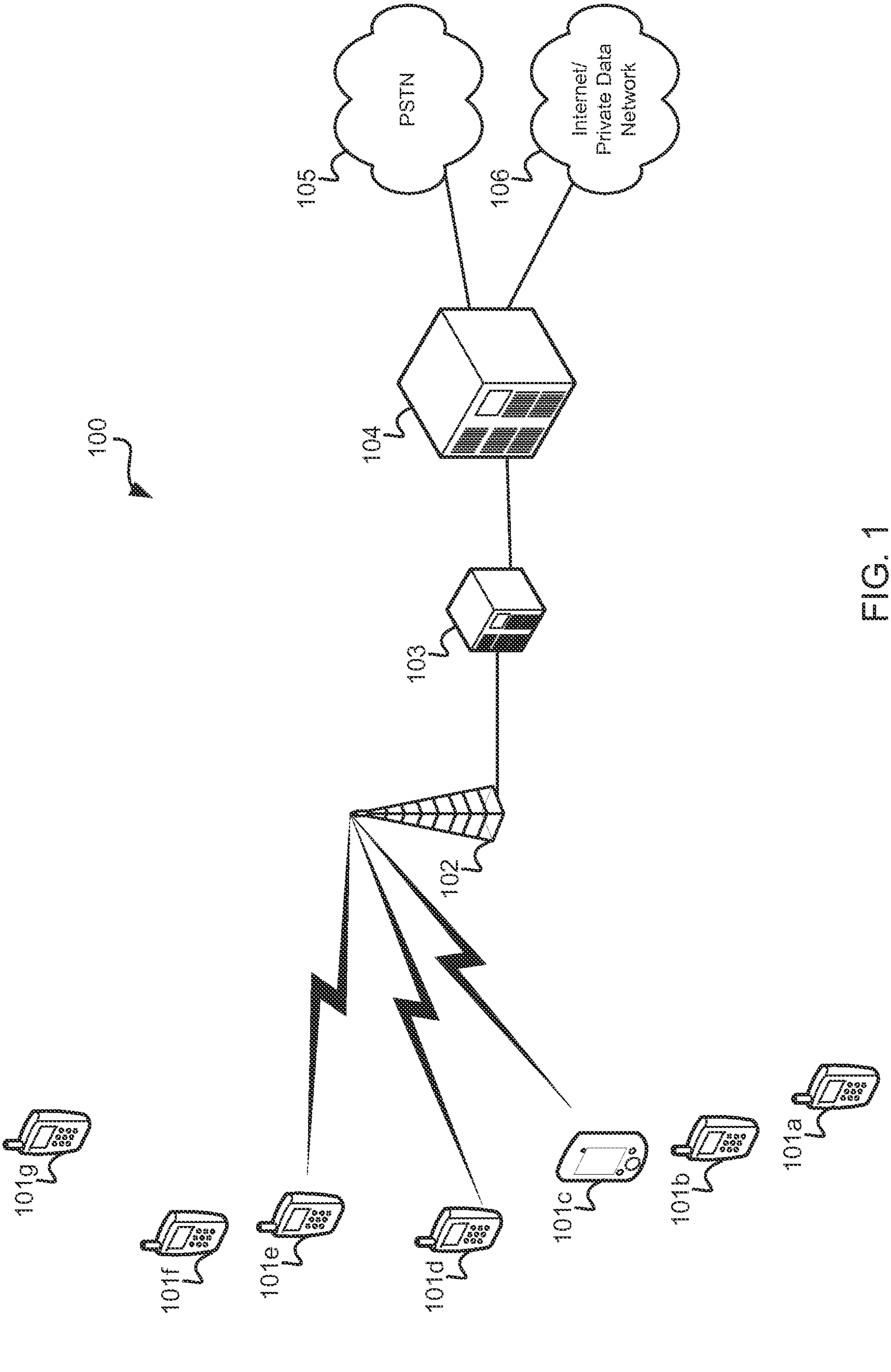

100
PSTN
105
Internet/
Private Data
Network
106
104
103
102
101a
101b
101c
101d
101e
101f
101g

FIG. 1

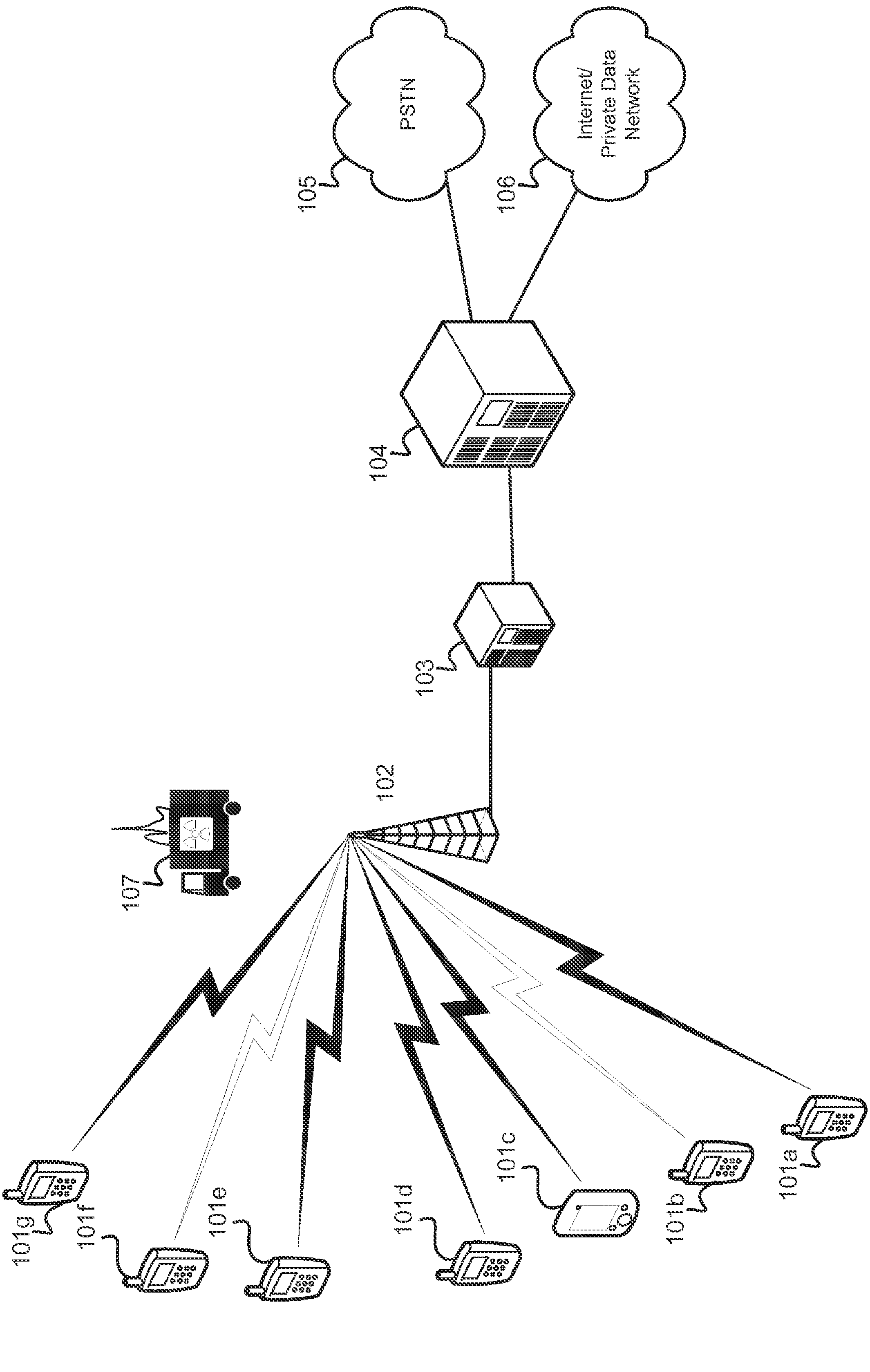

PSTN
Internet/
Private Data
Network
105
106
104
103
102
107
101a
101b
101c
101d
101e
101f
101g

Fig. 2

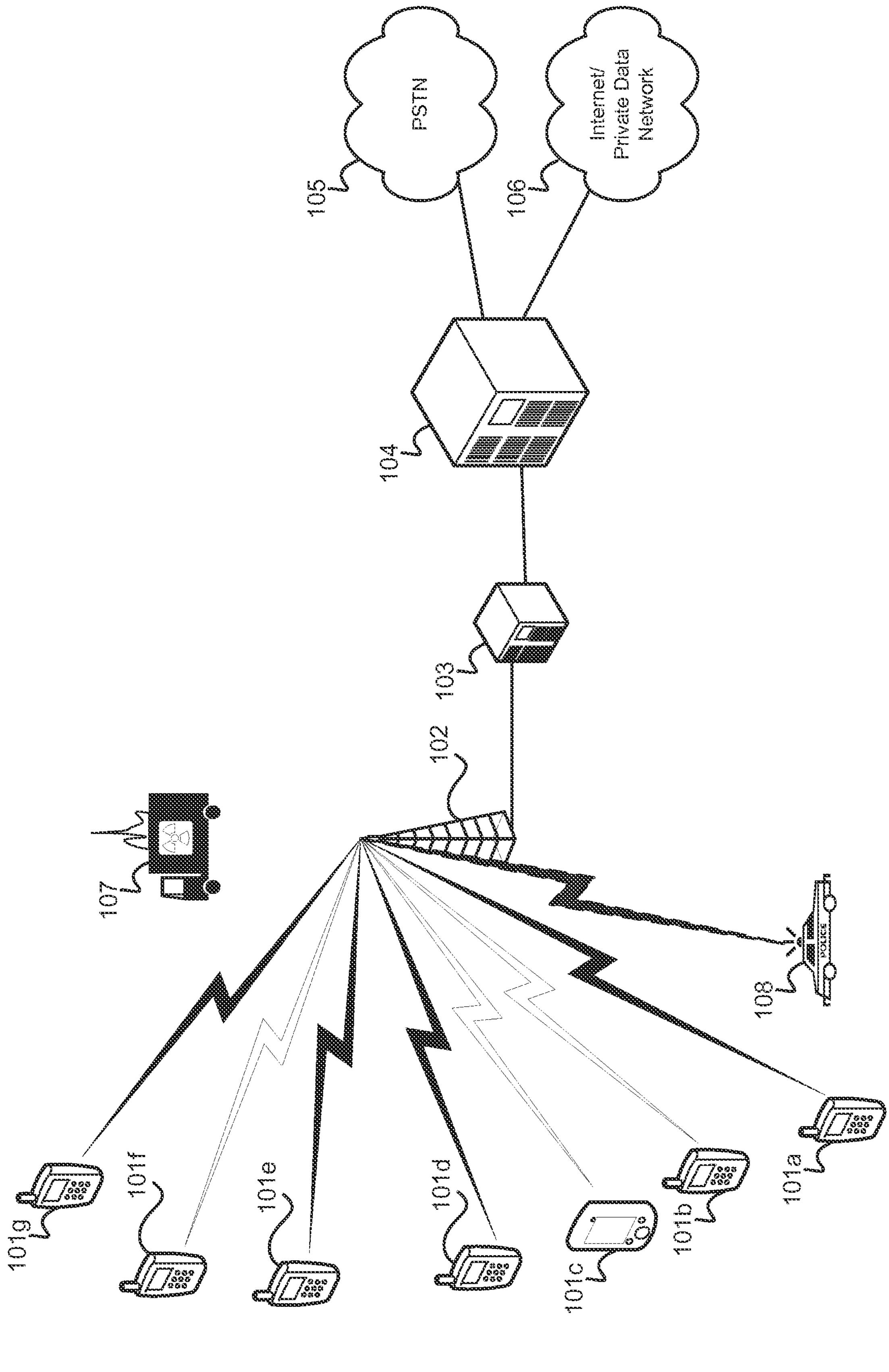
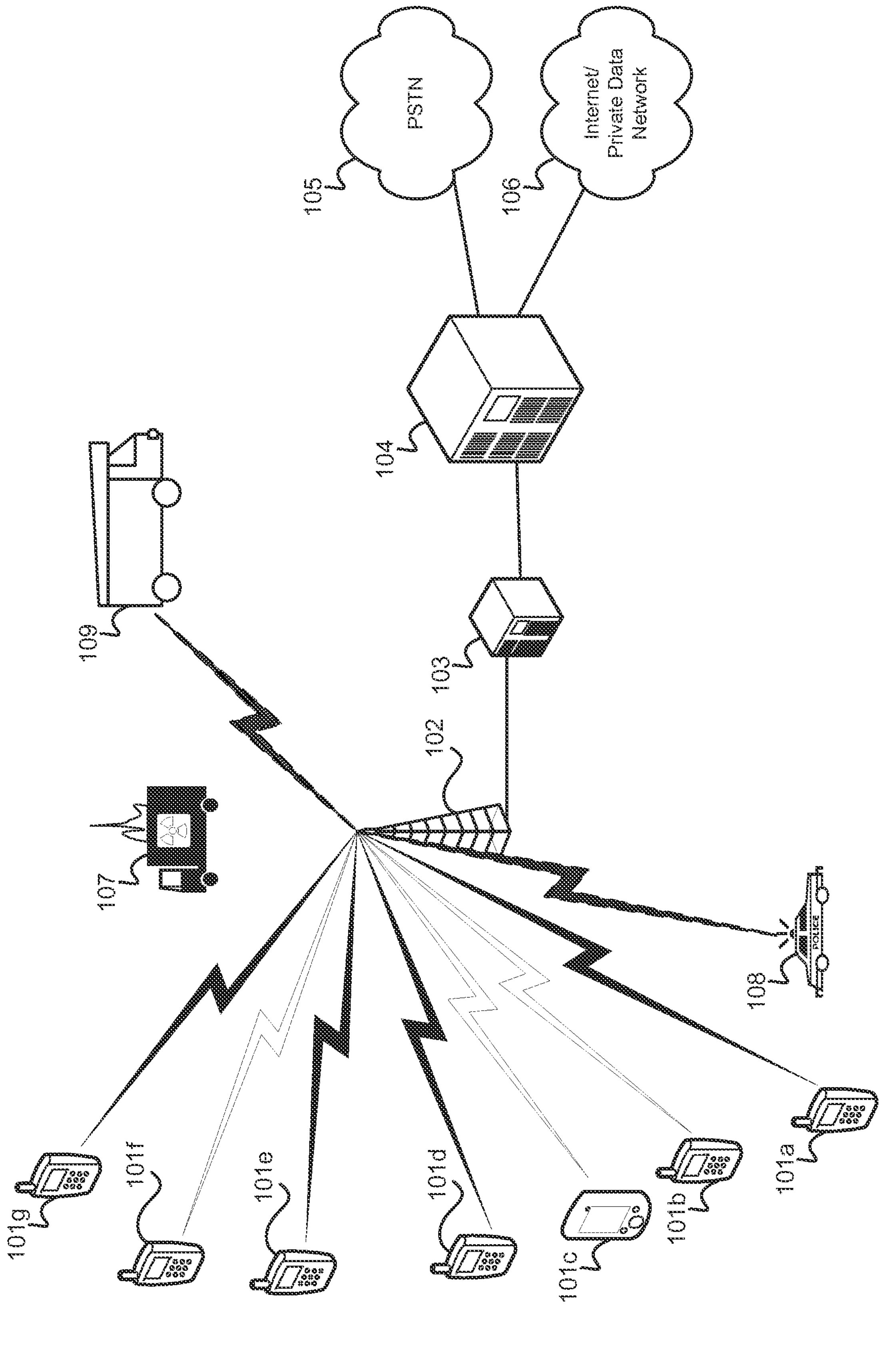

PSTN
Internet/
Private Data
Network
105
106
104
103
102
107
108
101a
101b
101c
101d
101e
101f
101g

FIG. 3



PSTN
Internet/
Private Data
Network
105
106
104
103
102
109
107
108
101a
101b
101c
101d
101e
101f
101g

FIG. 4

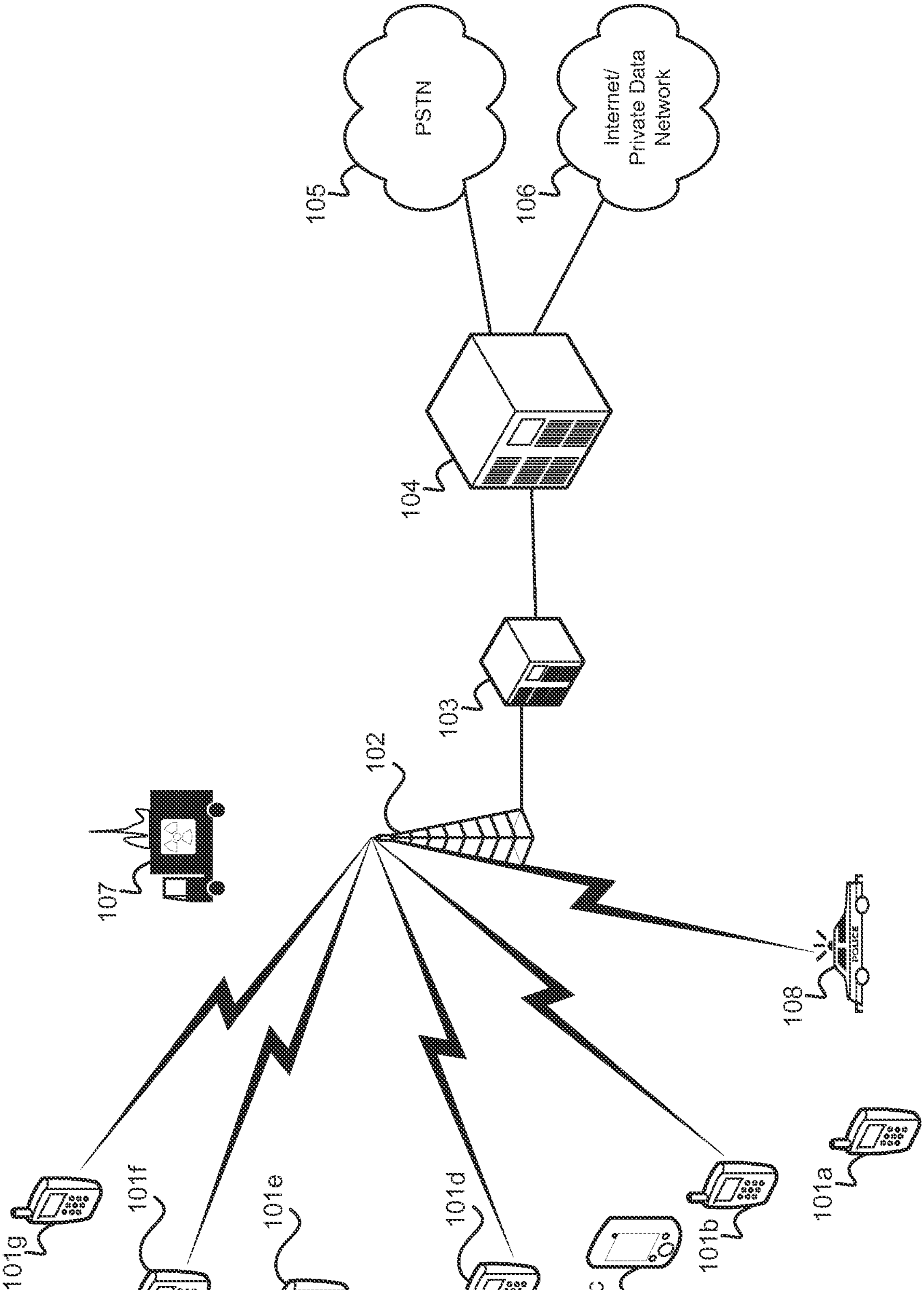

105
PSTN
106
Internet/
Private Data
Network
104
103
102
107
108
101a
101b
101c
101d
101e
101f
101g
POLICE

FIG. 5

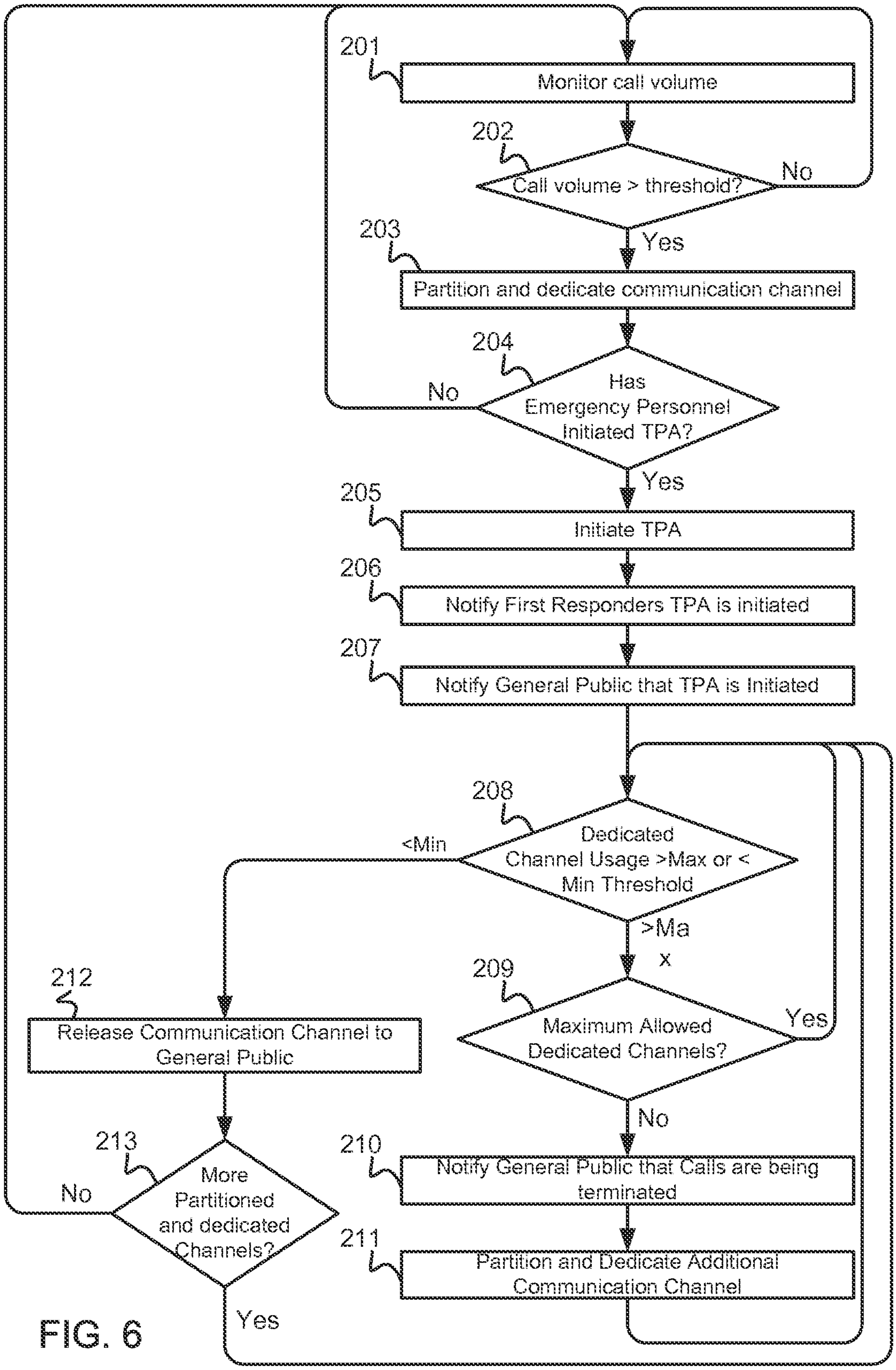

201
Monitor call volume
202
Call volume > threshold?
No
Yes
203
Partition and dedicate communication channel
204
Has Emergency Personnel Initiated TPA?
No
Yes
205
Initiate TPA
206
Notify First Responders TPA is initiated
207
Notify General Public that TPA is Initiated
208
Dedicated Channel Usage >Max or < Min Threshold
<Min
>Max
209
Maximum Allowed Dedicated Channels?
Yes
No
210
Notify General Public that Calls are being terminated
211
Partition and Dedicate Additional Communication Channel
212
Release Communication Channel to General Public
213
More Partitioned and dedicated Channels?
No
Yes

FIG. 6

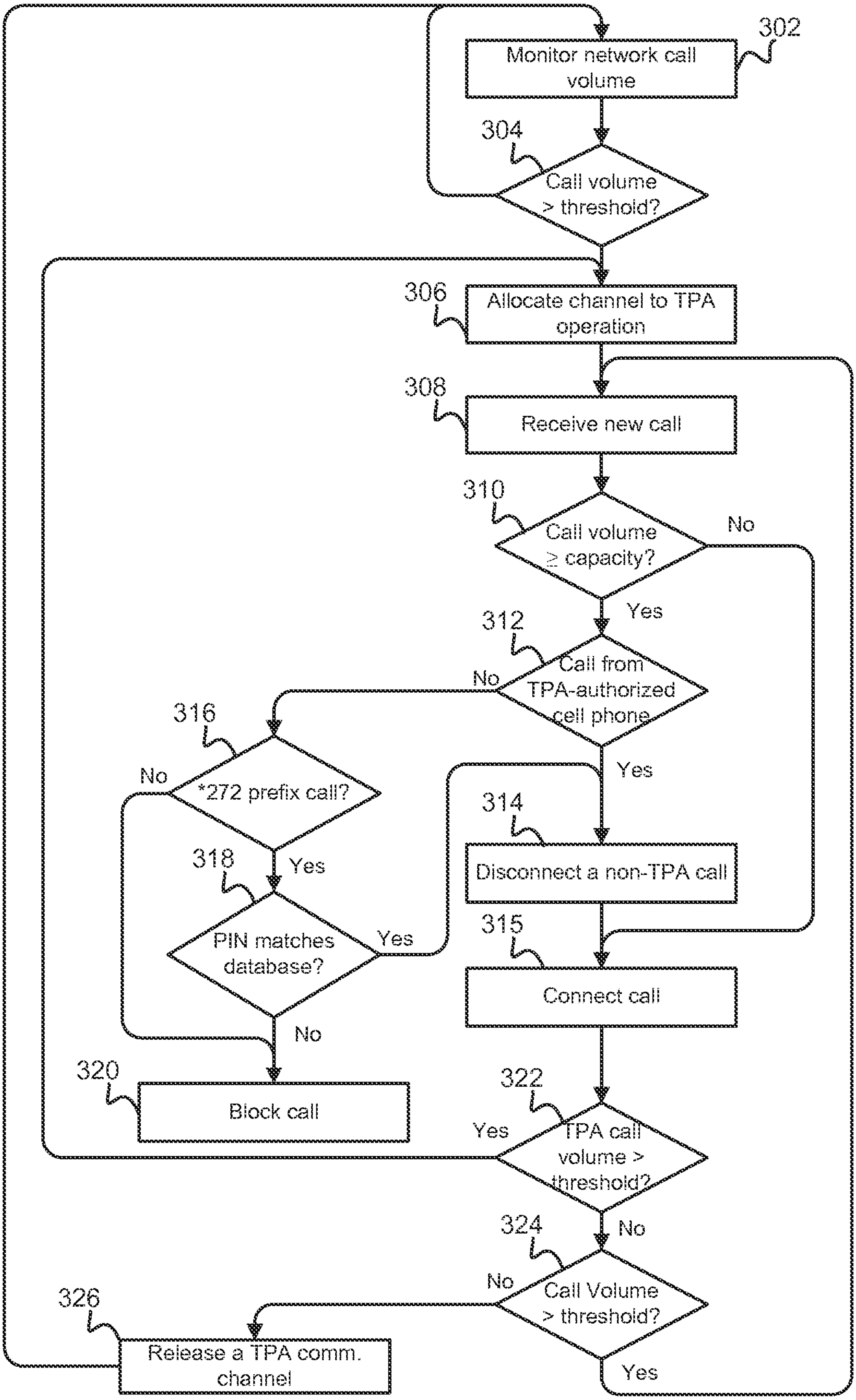

Monitor network call volume
302
304
Call volume > threshold?
306
Allocate channel to TPA operation
308
Receive new call
310
Call volume ≥ capacity?
No
Yes
312
Call from TPA-authorized cell phone
No
Yes
316
*272 prefix call?
No
Yes
318
PIN matches database?
Yes
No
314
Disconnect a non-TPA call
315
Connect call
320
Block call
322
TPA call volume > threshold?
Yes
No
324
Call Volume > threshold?
No
Yes
326
Release a TPA comm. channel

FIG. 7

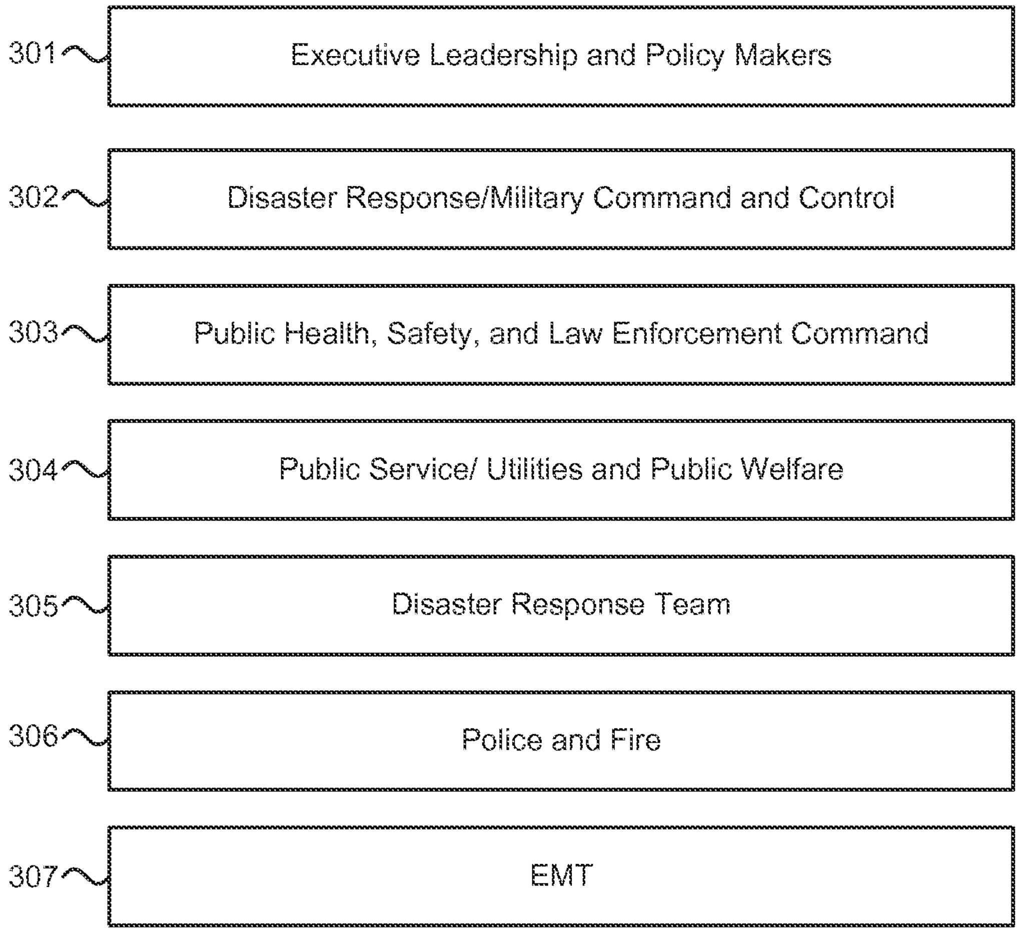

301
Executive Leadership and Policy Makers
302
Disaster Response/Military Command and Control
303
Public Health, Safety, and Law Enforcement Command
304
Public Service/ Utilities and Public Welfare
305
Disaster Response Team
306
Police and Fire
307
EMT

FIG. 8

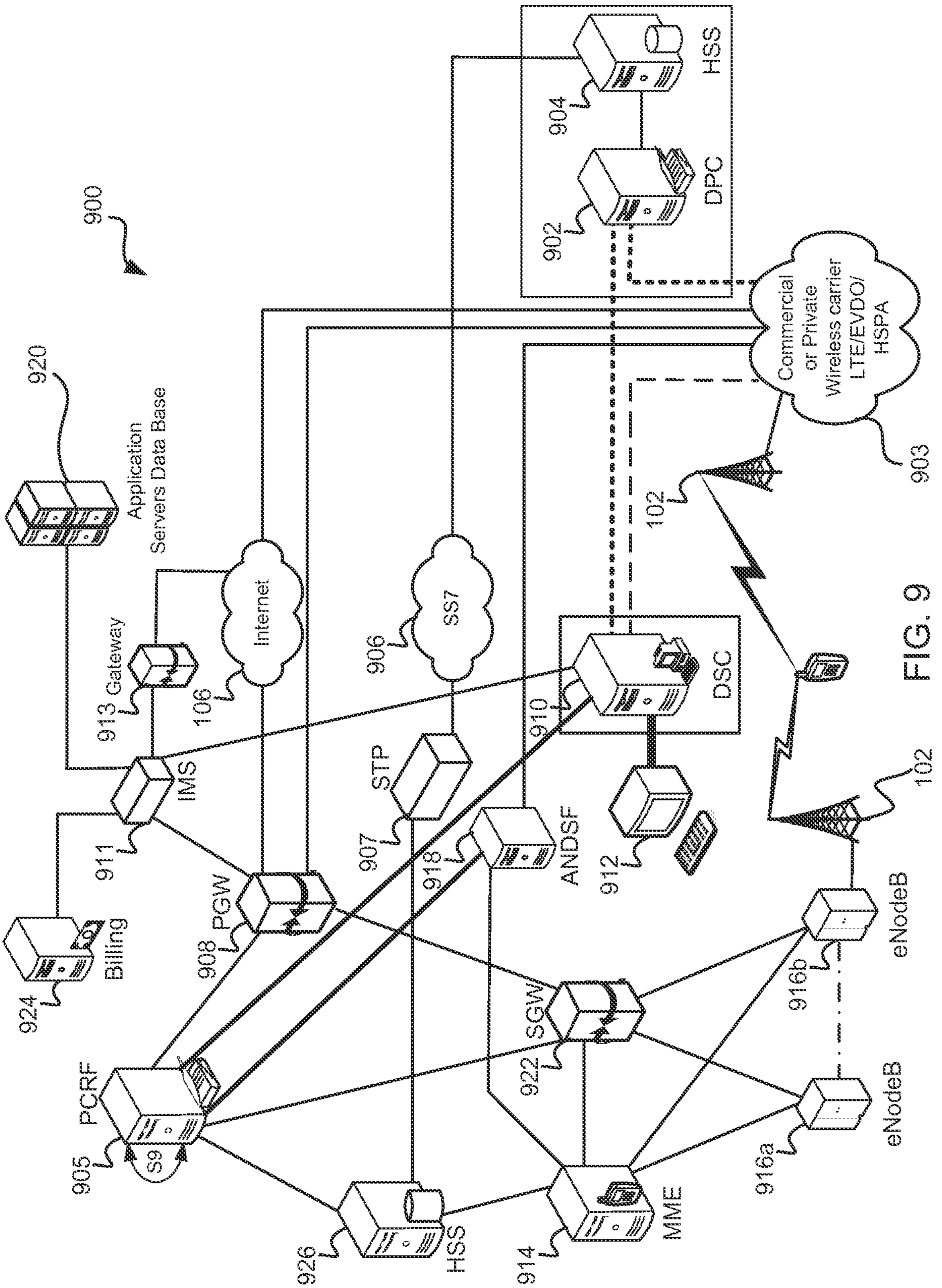

900
920
Application Servers Data Base
913
Gateway
106
Internet
906
SS7
907
STP
911
IMS
924
Billing
908
PGW
918
ANDSF
912
910
DSC
902
DPC
904
HSS
Commercial or Private Wireless carrier LTE/EVDO/ HSPA
903
102
102
905
PCRF
S9
922
SGW
926
HSS
914
MME
916a
eNodeB
916b
eNodeB

FIG. 9

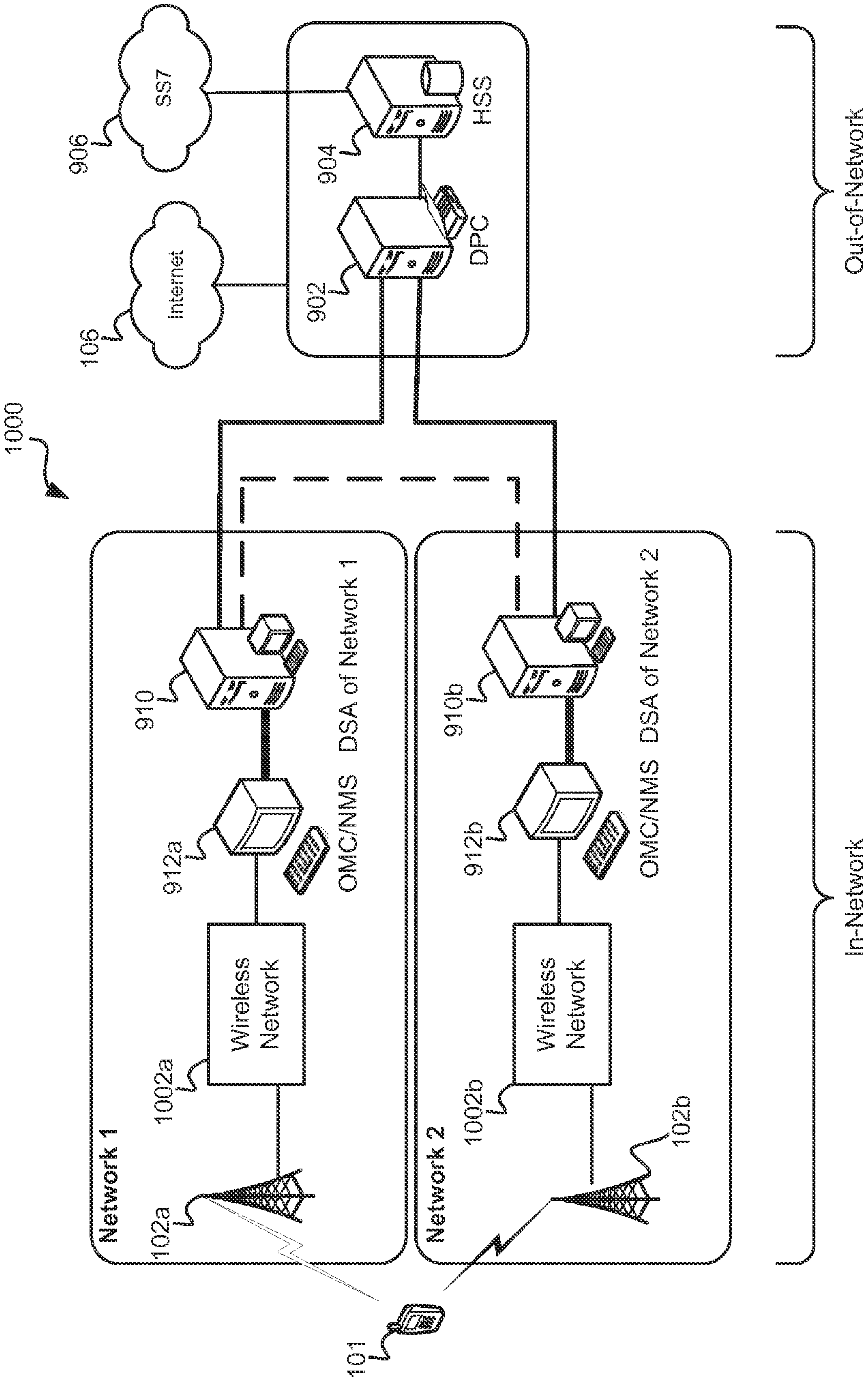

1000
106
Internet
906
SS7
902
DPC
904
HSS
Out-of-Network
Network 1
102a
1002a
Wireless Network
912a
OMC/NMS
910
DSA of Network 1
Network 2
102b
1002b
Wireless Network
912b
OMC/NMS
910b
DSA of Network 2
In-Network
101

FIG. 10

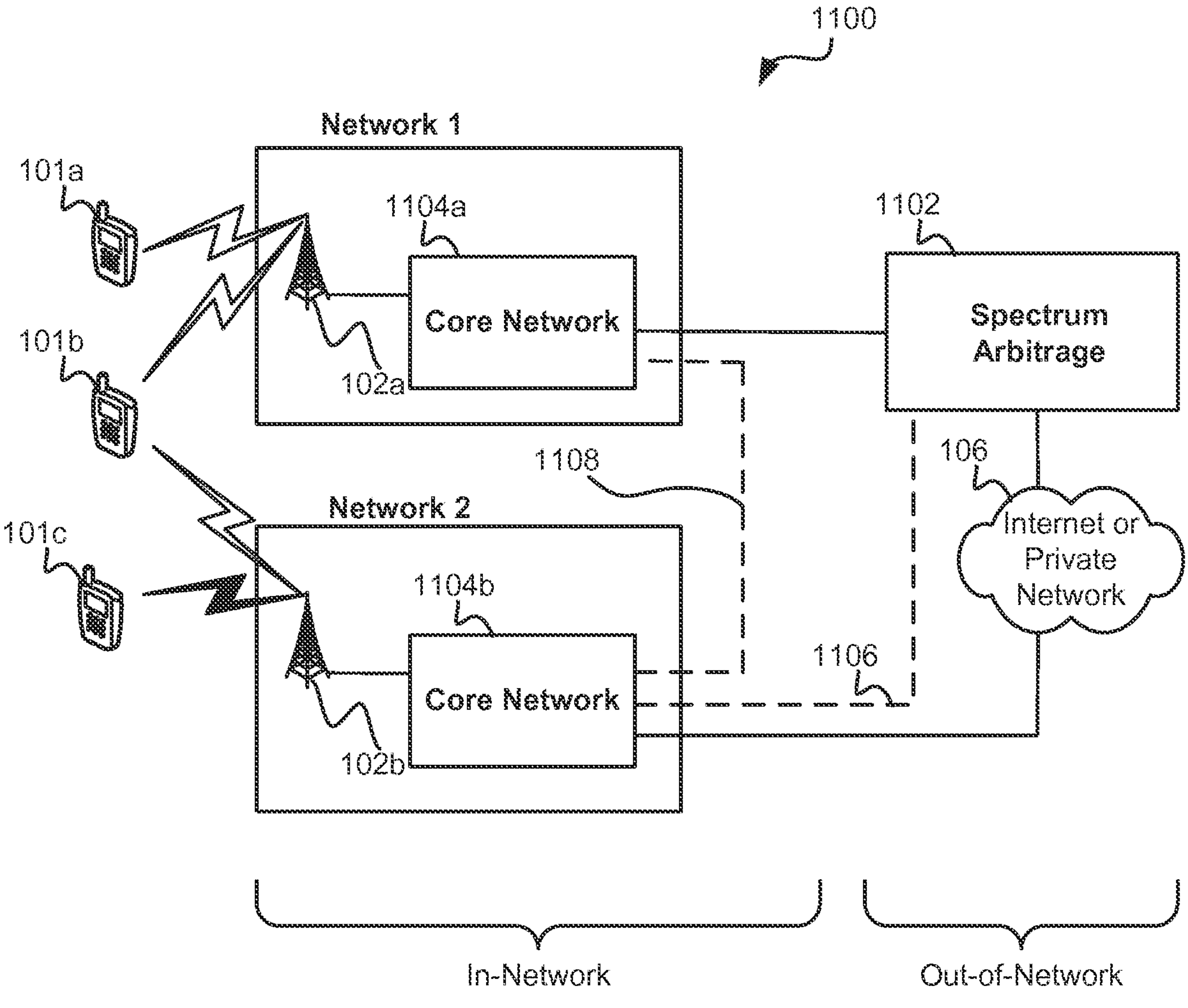

1100
Network 1
101a
1104a
1102
Core Network
Spectrum
Arbitrage
101b
102a
106
1108
Network 2
Internet or
Private
Network
101c
1104b
1106
Core Network
102b
In-Network
Out-of-Network

FIG. 11

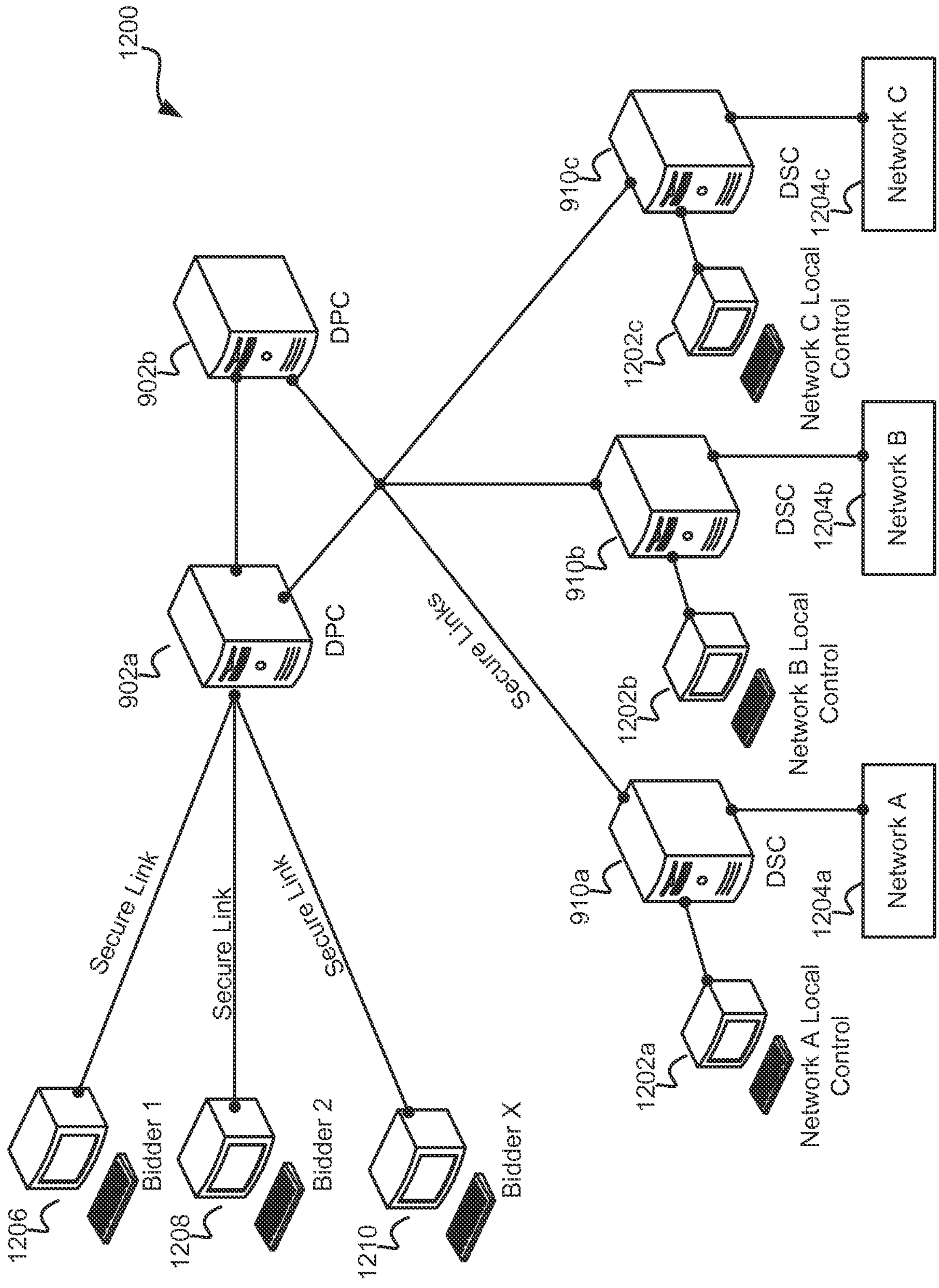

1200
902a
DPC
902b
DPC
Secure Links
Secure Link
Secure Link
Secure Link
1206
Bidder 1
1208
Bidder 2
1210
Bidder X
910a
DSC
910b
DSC
910c
DSC
1202a
Network A Local Control
1202b
Network B Local Control
1202c
Network C Local Control
1204a
Network A
1204b
Network B
1204c
Network C

FIG. 12

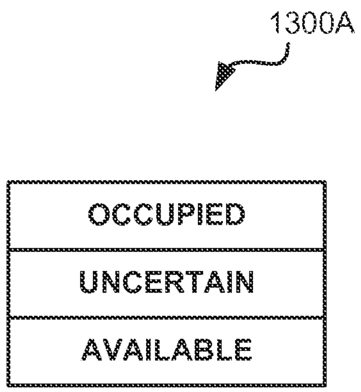


FIG. 13A

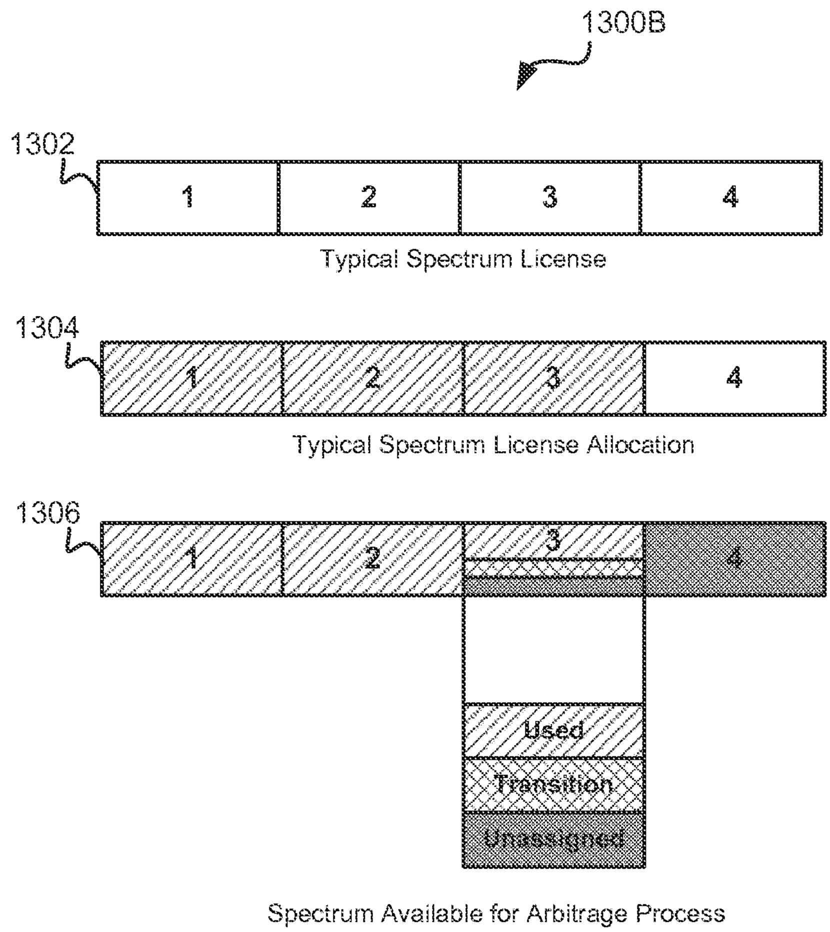


FIG. 13B

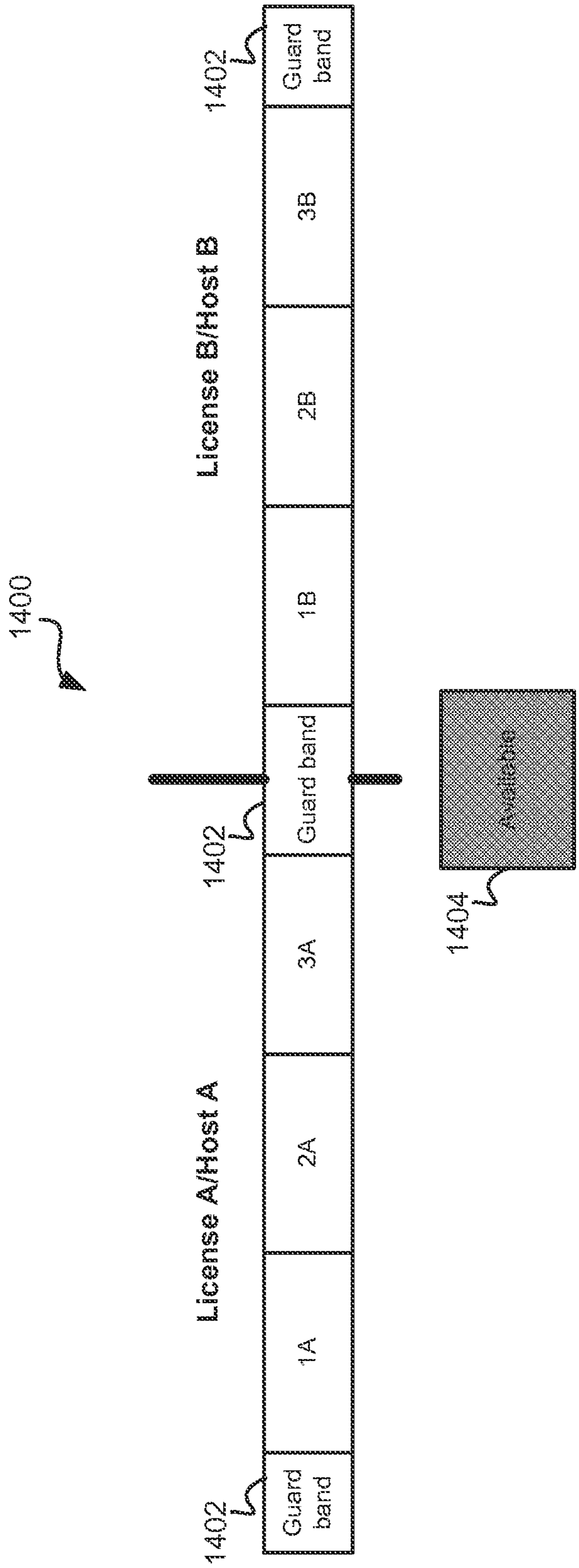

1400
License A/Host A
License B/Host B
1402
Guard band
1A
2A
3A
Guard band
1B
2B
3B
Guard band
1404
Available

FIG. 14

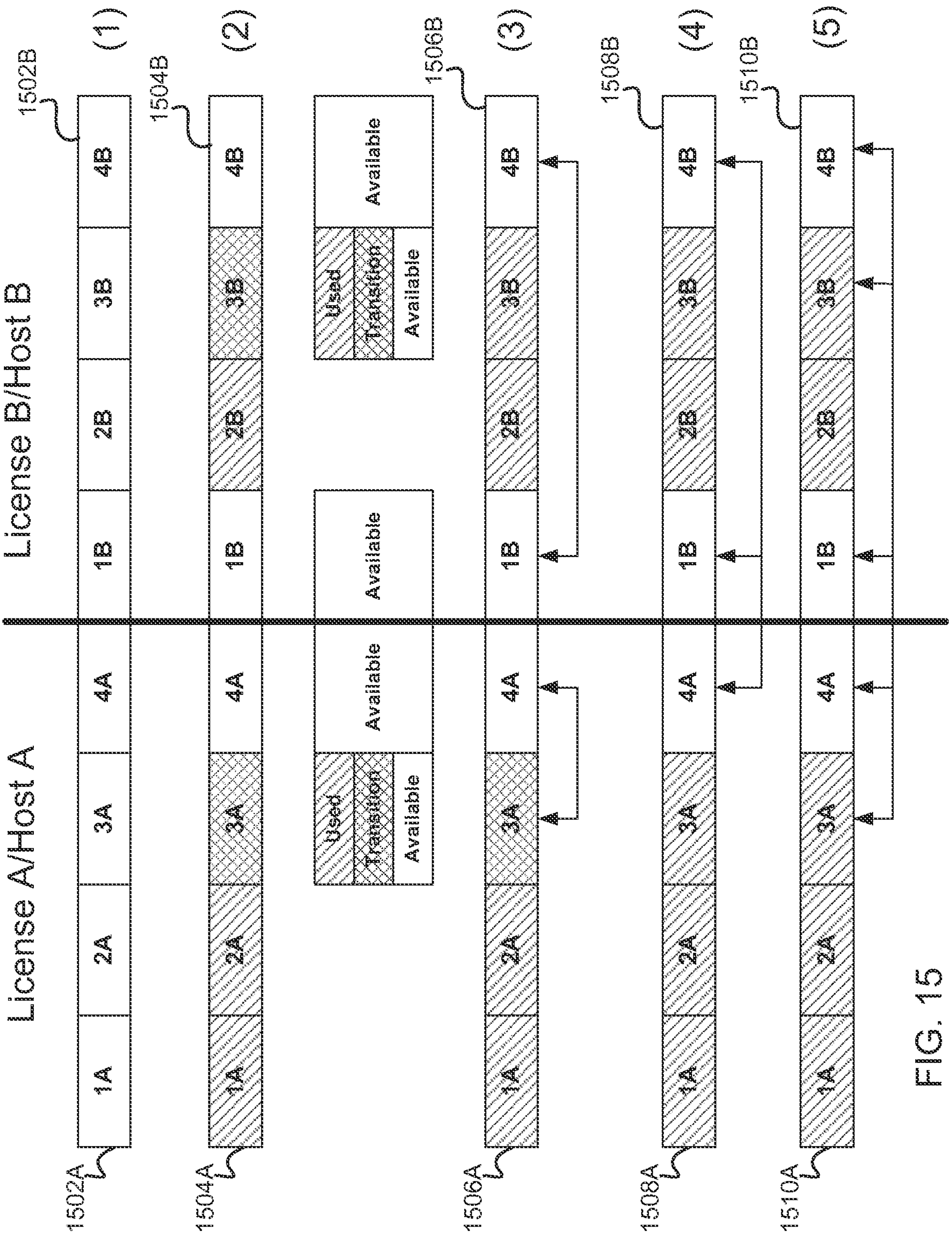

License A/Host A
License B/Host B
1502A
1502B
1504A
1504B
1506A
1506B
1508A
1508B
1510A
1510B
(1)
(2)
(3)
(4)
(5)
1A
2A
3A
4A
1B
2B
3B
4B
Used
Transition
Available
Available
Available
Used
Transition
Available
Available

FIG. 15

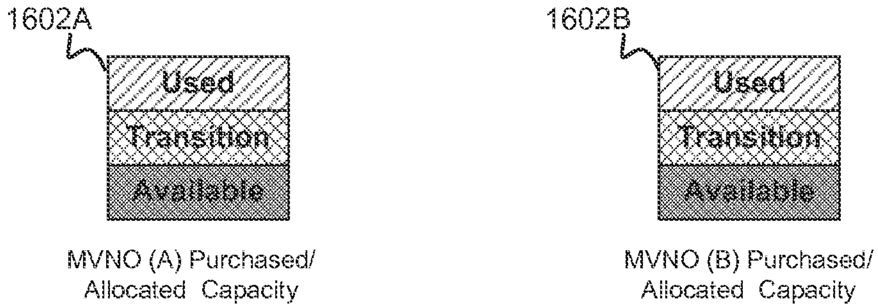


FIG. 16A

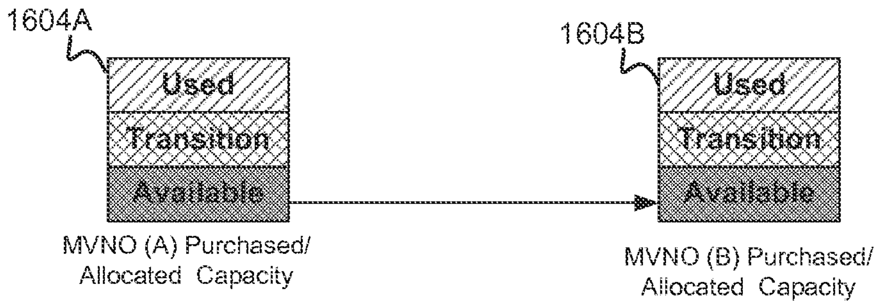


FIG. 16B

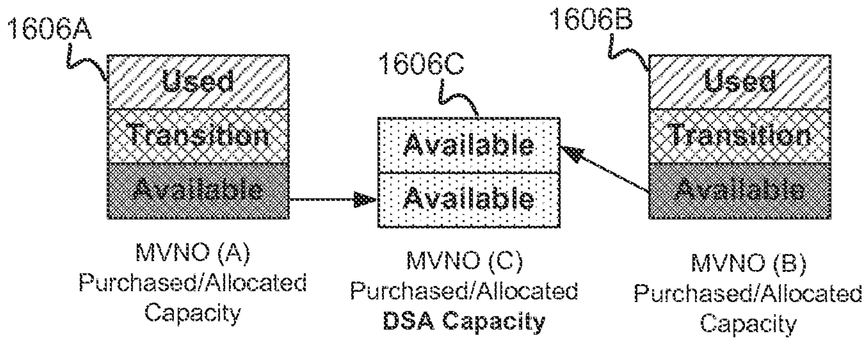


FIG. 16C

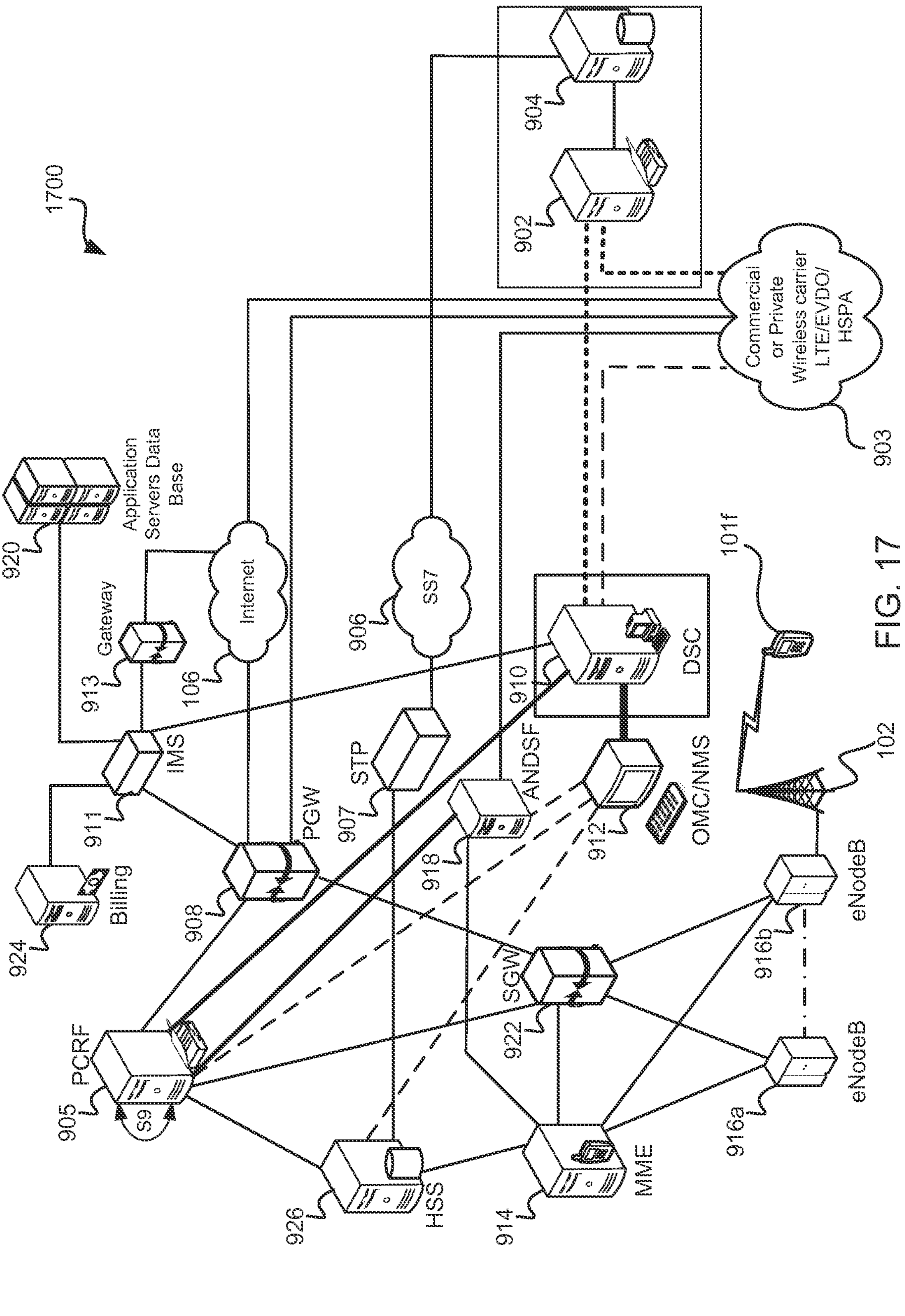

1700
902
904
903
Commercial
or Private
Wireless carrier
LTE/EVDO/
HSPA
920
Application
Servers Data
Base
913
Gateway
106
Internet
906
SS7
101f
910
DSC
924
Billing
911
IMS
908
PGW
907
STP
918
ANDSF
912
OMC/NMS
102
905
PCRF
S9
922
SGW
916b
eNodeB
916a
eNodeB
926
HSS
914
MME

FIG. 17

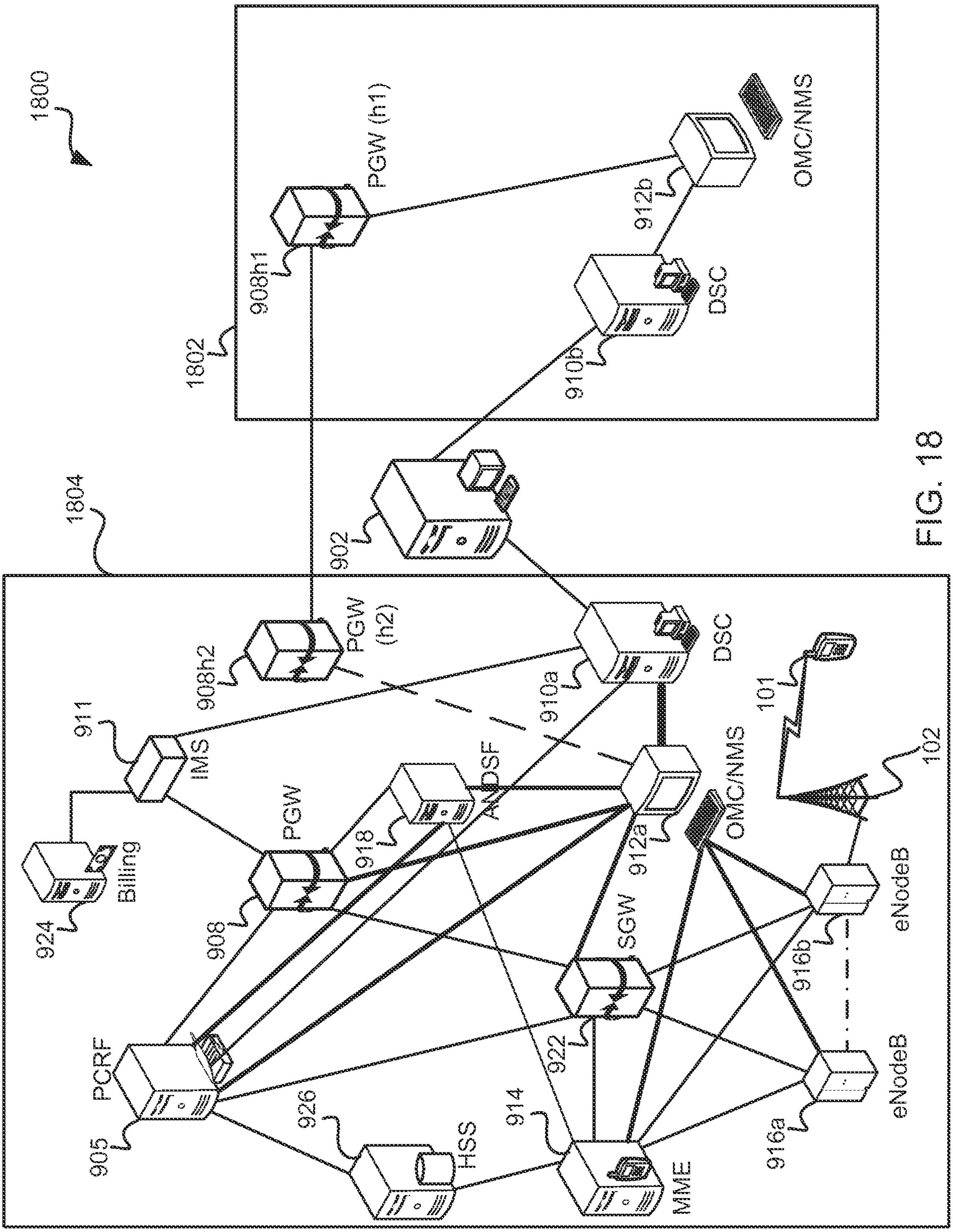
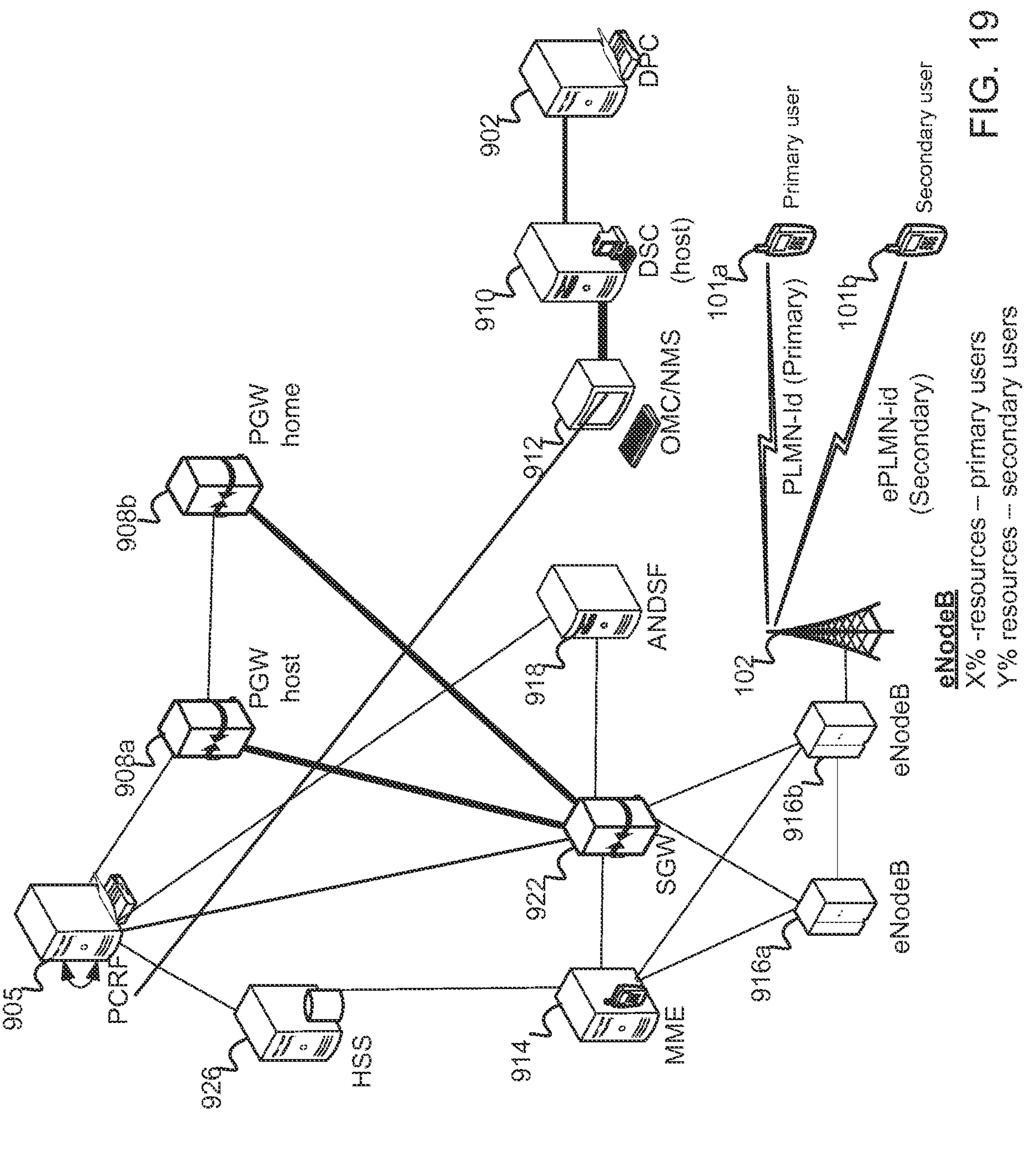

1800
1802
1804
PGW (h1)
908h1
OMC/NMS
912b
DSC
910b
902
PGW (h2)
908h2
DSC
910a
911
IMS
924
Billing
PGW
908
ANDSF
918
OMC/NMS
912a
101
102
PCRF
905
SGW
922
eNodeB
916b
eNodeB
916a
HSS
926
MME
914

FIG. 18



902
DPC
910
DSC
(host)
912
OMC/NMS
908b
PGW
home
908a
PGW
host
918
ANDSF
905
PCRF
926
HSS
914
MME
922
SGW
916a
eNodeB
916b
eNodeB
102
101a
Primary user
PLMN-Id (Primary)
101b
Secondary user
ePLMN-id
(Secondary)
eNodeB
X% -resources – primary users
Y% resources -- secondary users

FIG. 19

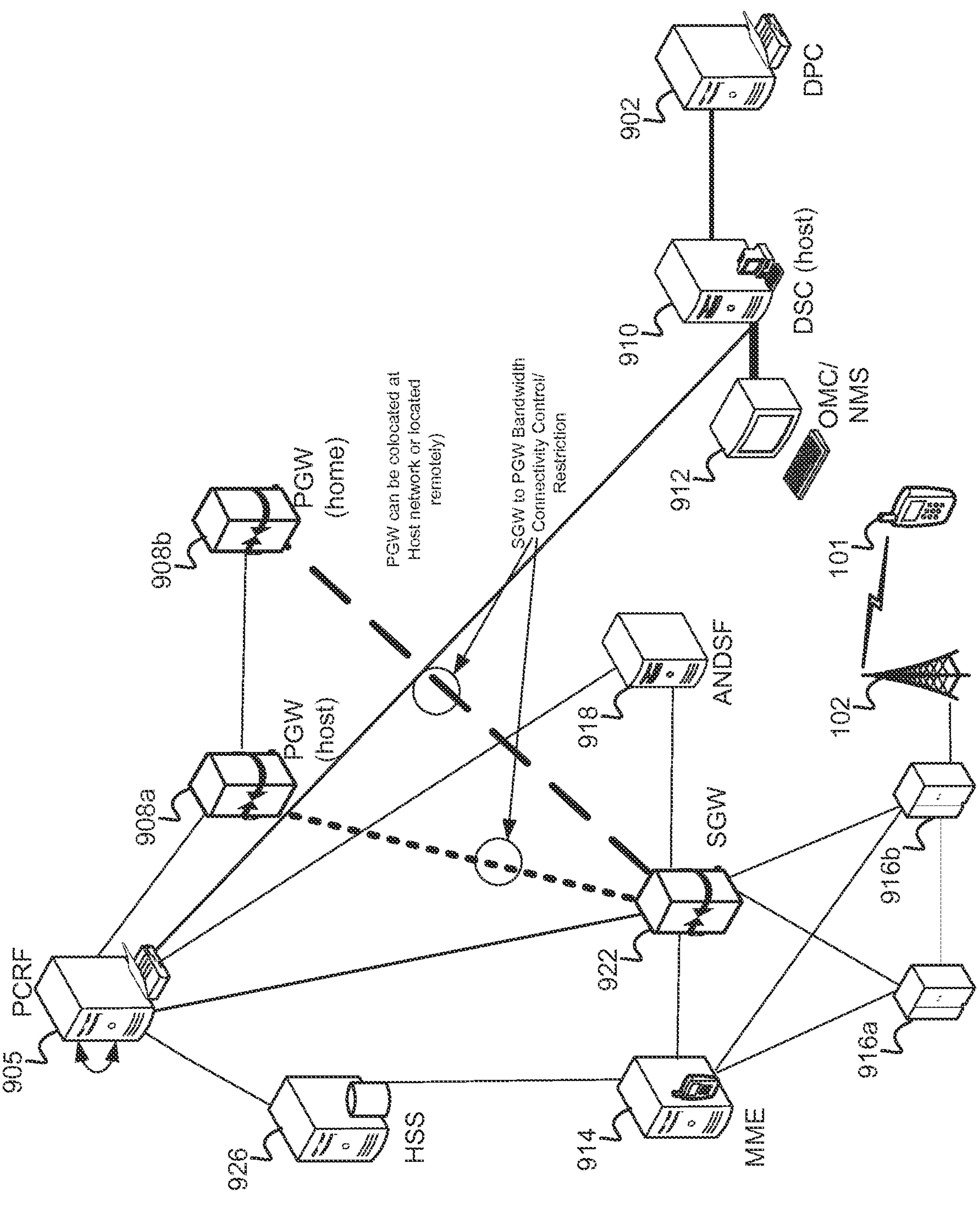

902
DPC
910
DSC (host)
912
OMC/
NMS
908b
PGW
(home)
PGW can be colocated at
Host network or located
remotely)
SGW to PGW Bandwidth
Connectivity Control/
Restriction
908a
PGW
(host)
918
ANDSF
101
102
905
PCRF
922
SGW
926
HSS
914
MME
916a
eNodeB
916b
eNodeB

FIG. 20

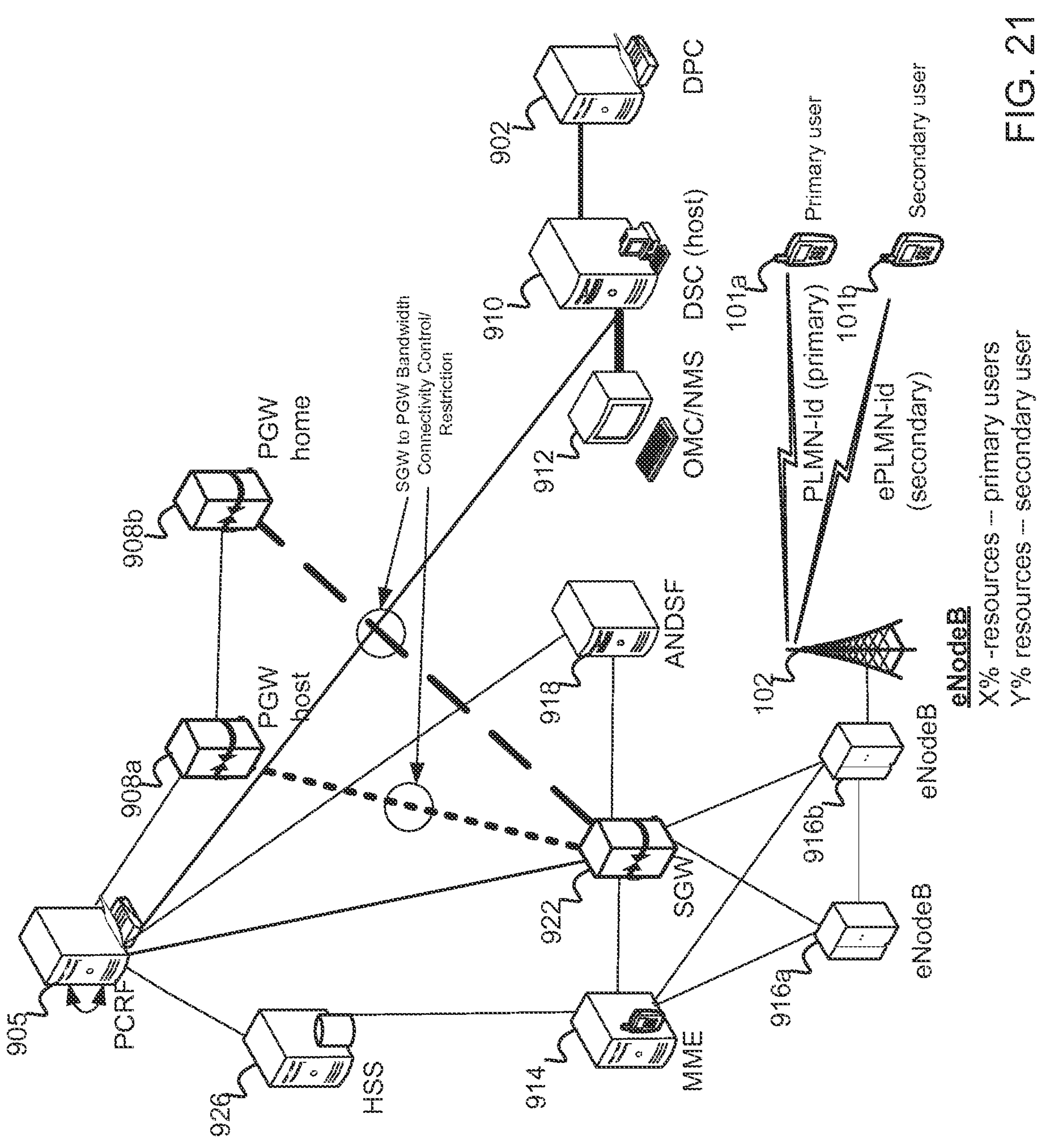

905
PCRF
926
HSS
914
MME
916a
eNodeB
916b
eNodeB
922
SGW
908a
PGW
host
908b
PGW
home
918
ANDSF
SGW to PGW Bandwidth
Connectivity Control/
Restriction
912
OMC/NMS
910
DSC (host)
902
DPC
101a
Primary user
101b
Secondary user
PLMN-id (primary)
ePLMN-id
(secondary)
102
eNodeB
X% -resources -- primary users
Y% resources -- secondary user

FIG. 21

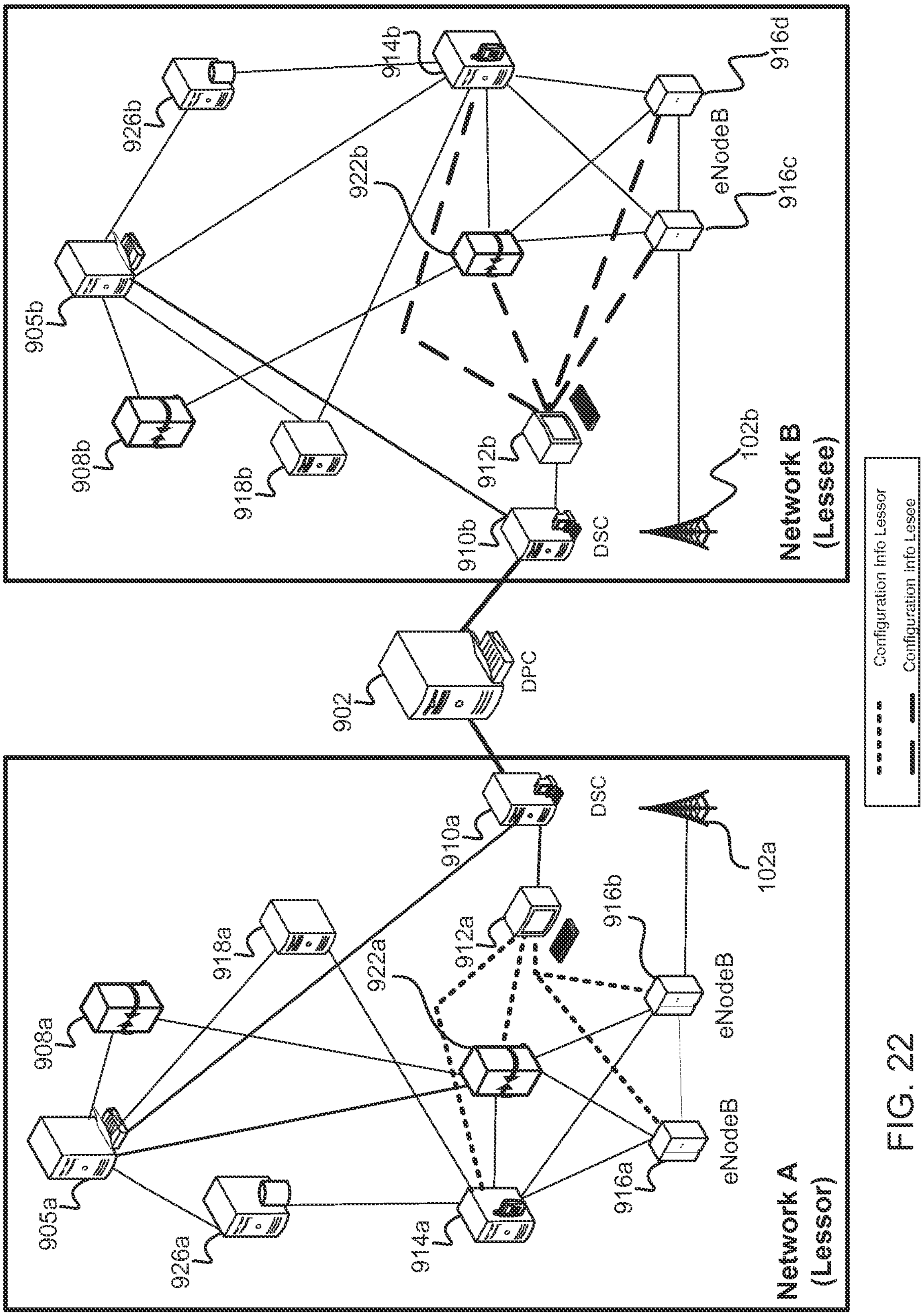

Network A
(Lessor)
905a
926a
914a
908a
918a
922a
912a
910a
DSC
916a
eNodeB
916b
eNodeB
102a
902
DPC
Network B
(Lessee)
905b
926b
914b
908b
918b
922b
912b
910b
DSC
916c
eNodeB
916d
102b
Configuration Info Lessor
Configuration Info Lessee

FIG. 22

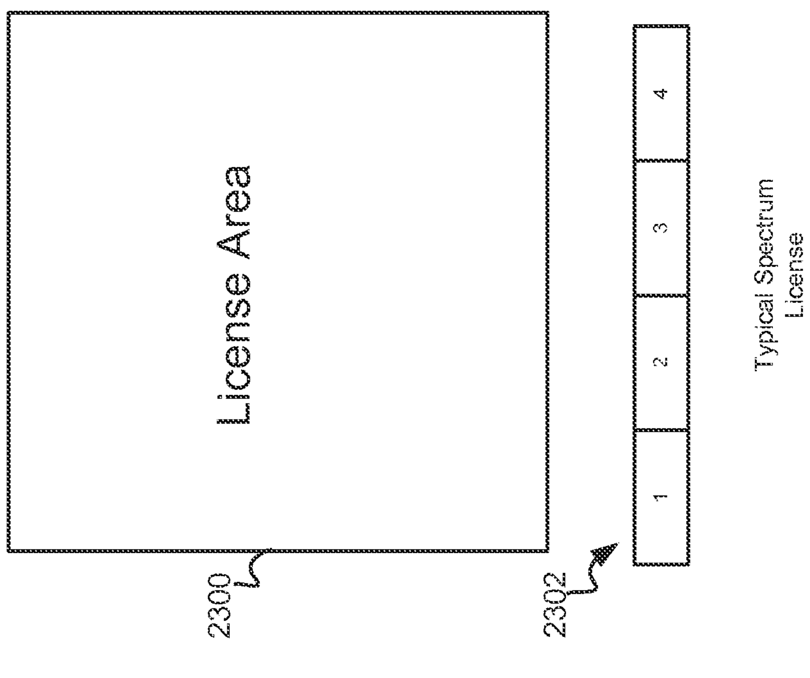


FIG. 23A

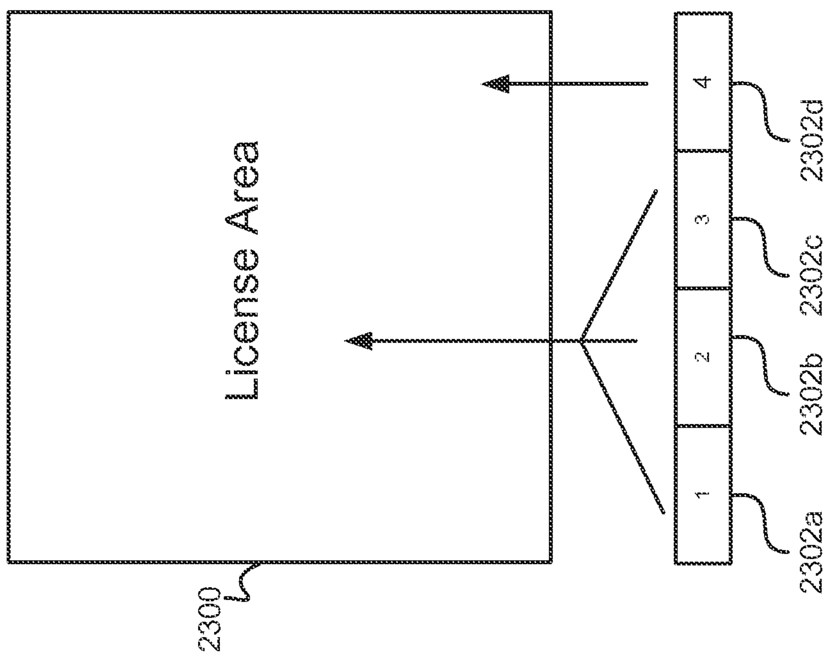


FIG. 23B

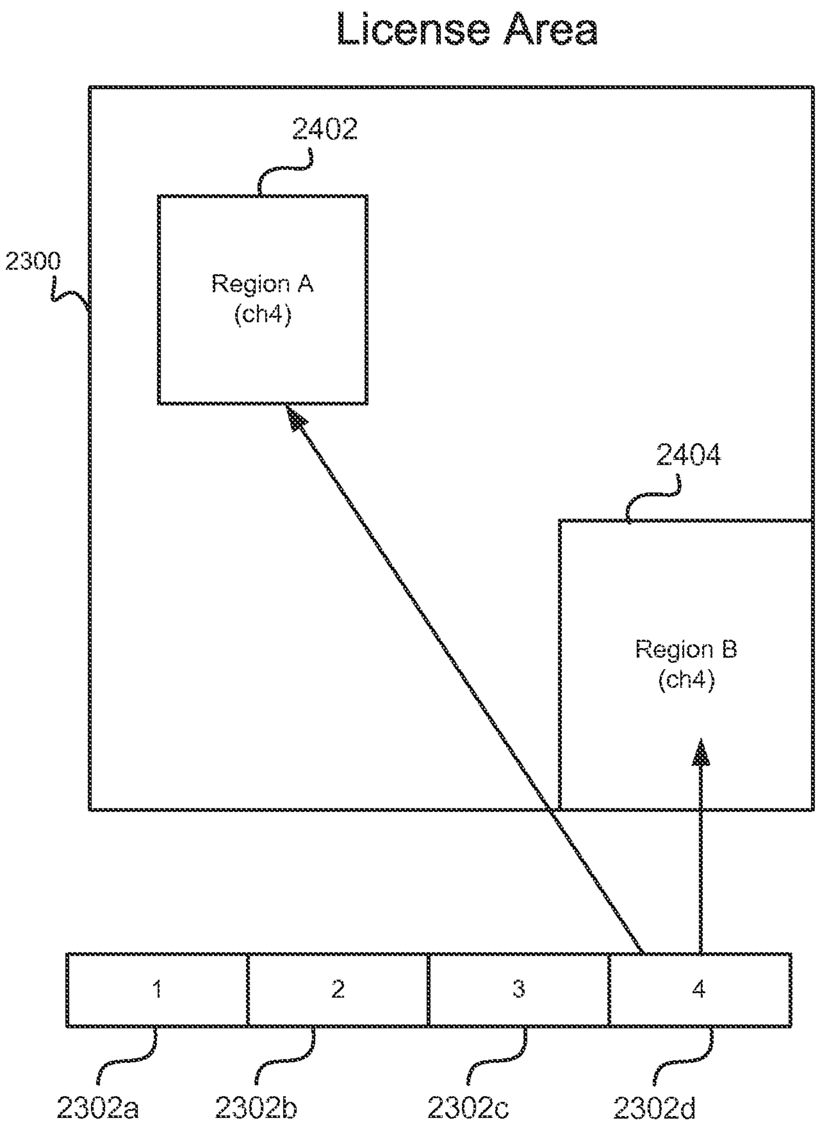

License Area
2402
2300
Region A
(ch4)
2404
Region B
(ch4)
1
2
3
4
2302a
2302b
2302c
2302d

FIG. 24

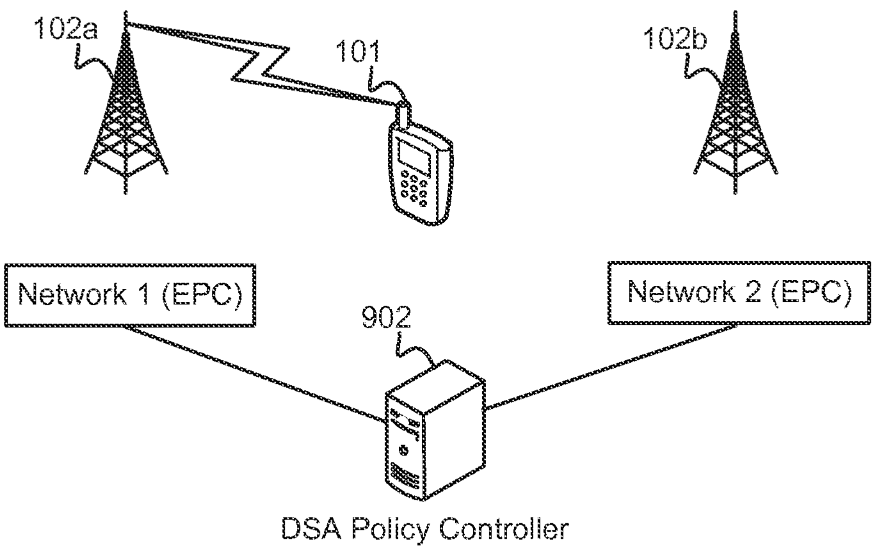


FIG. 25A

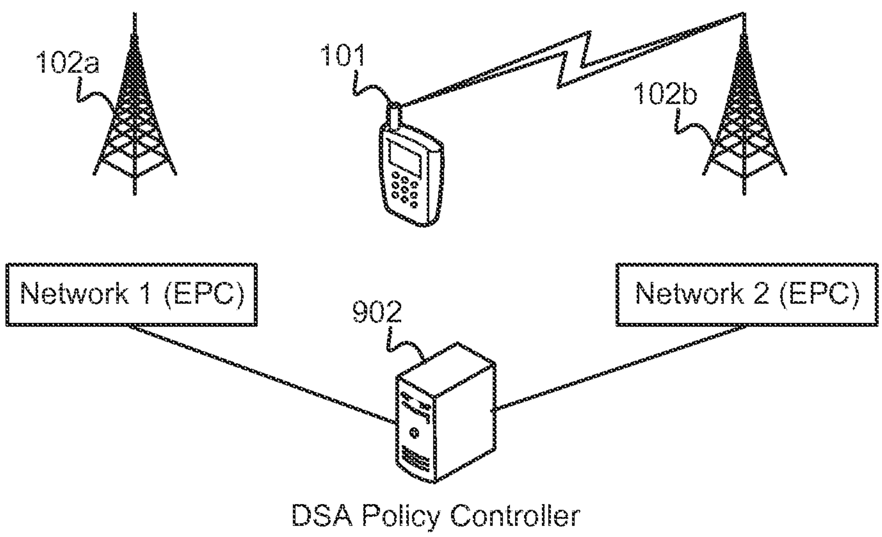


FIG. 25B

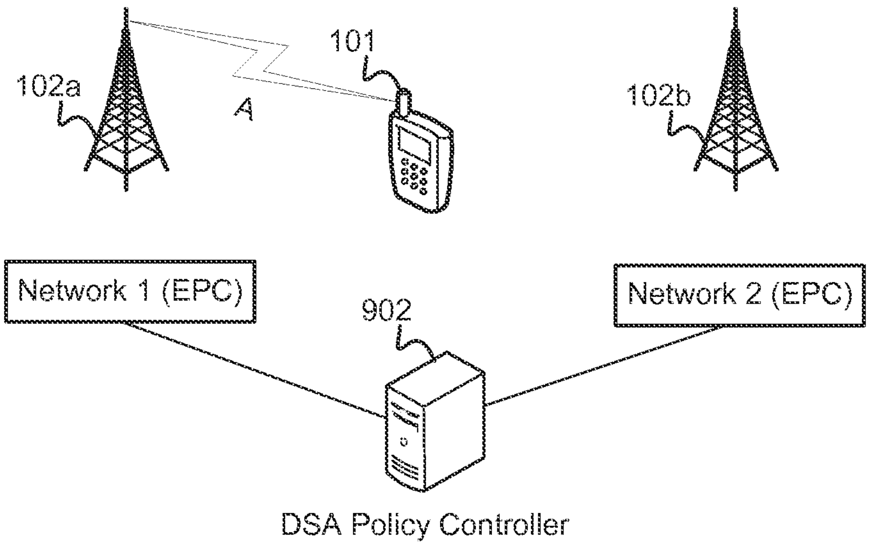


FIG. 26A

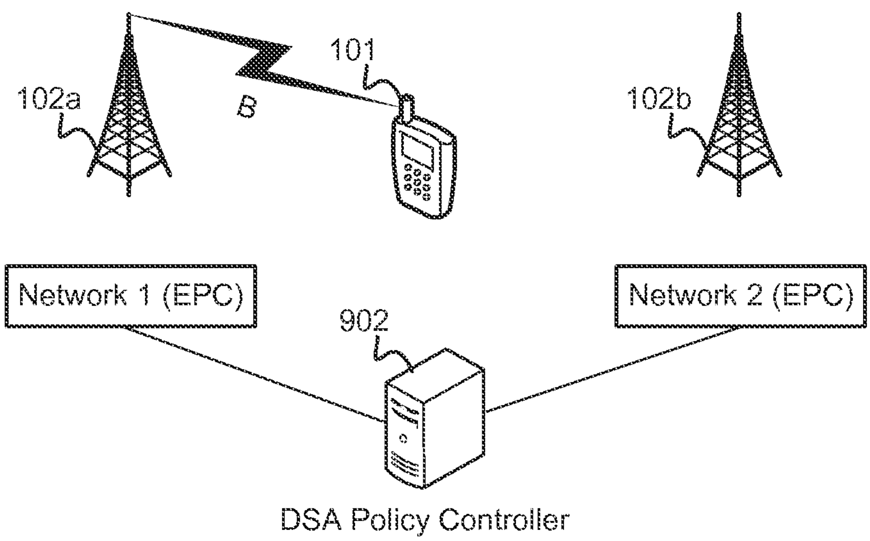


FIG. 26B

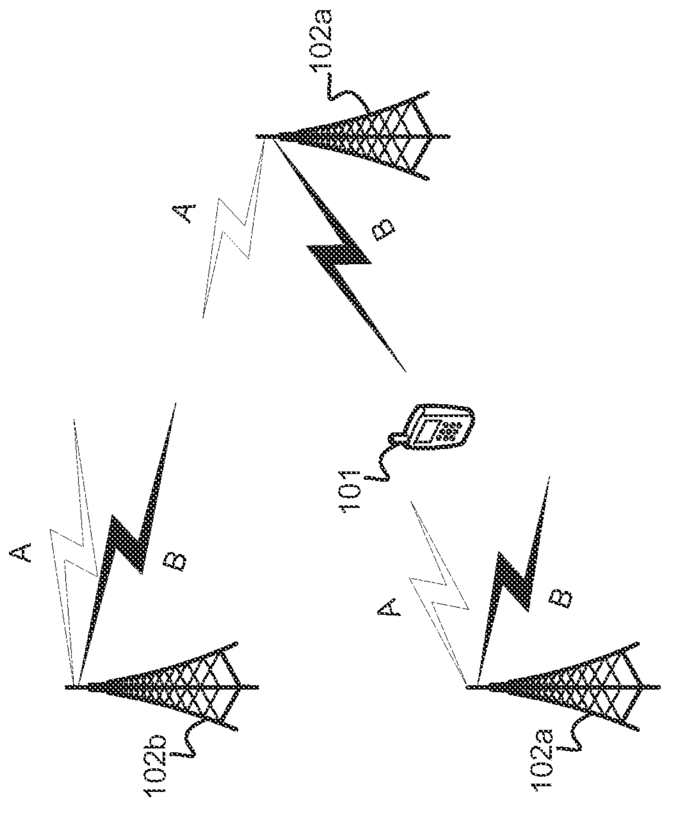


FIG. 27B

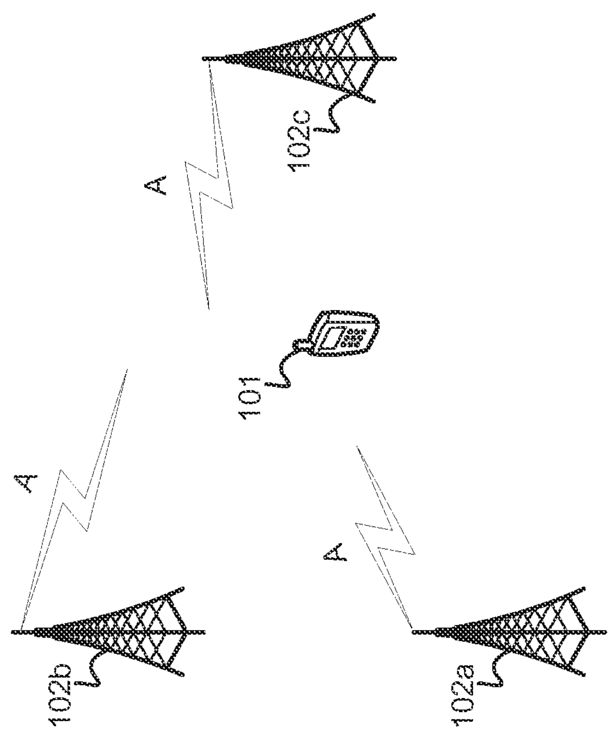


FIG. 27A

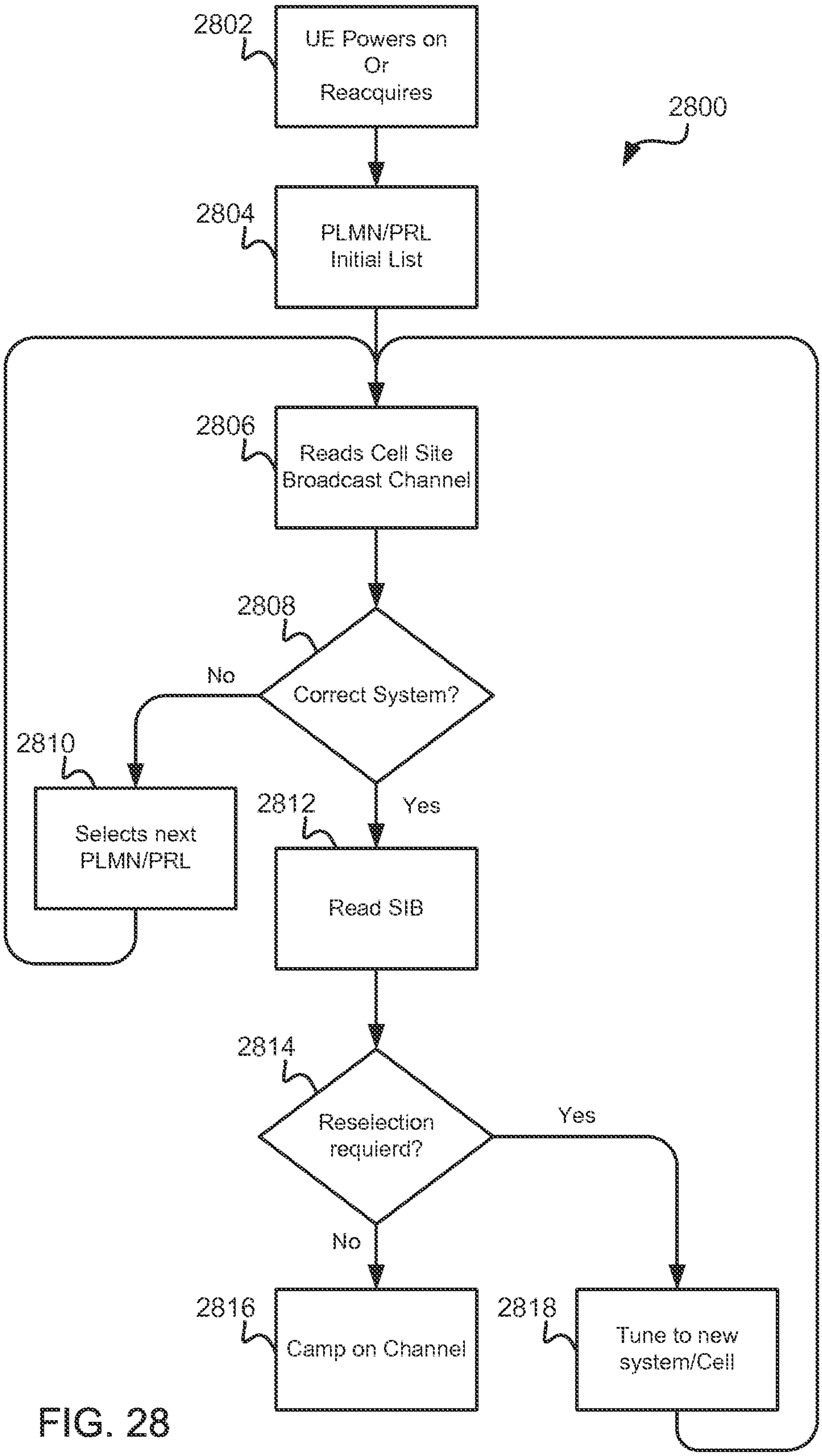

2800
2802
UE Powers on
Or
Reacquires
2804
PLMN/PRL
Initial List
2806
Reads Cell Site
Broadcast Channel
2808
Correct System?
No
2810
Selects next
PLMN/PRL
Yes
2812
Read SIB
2814
Reselection
requierd?
Yes
No
2816
Camp on Channel
2818
Tune to new
system/Cell

FIG. 28

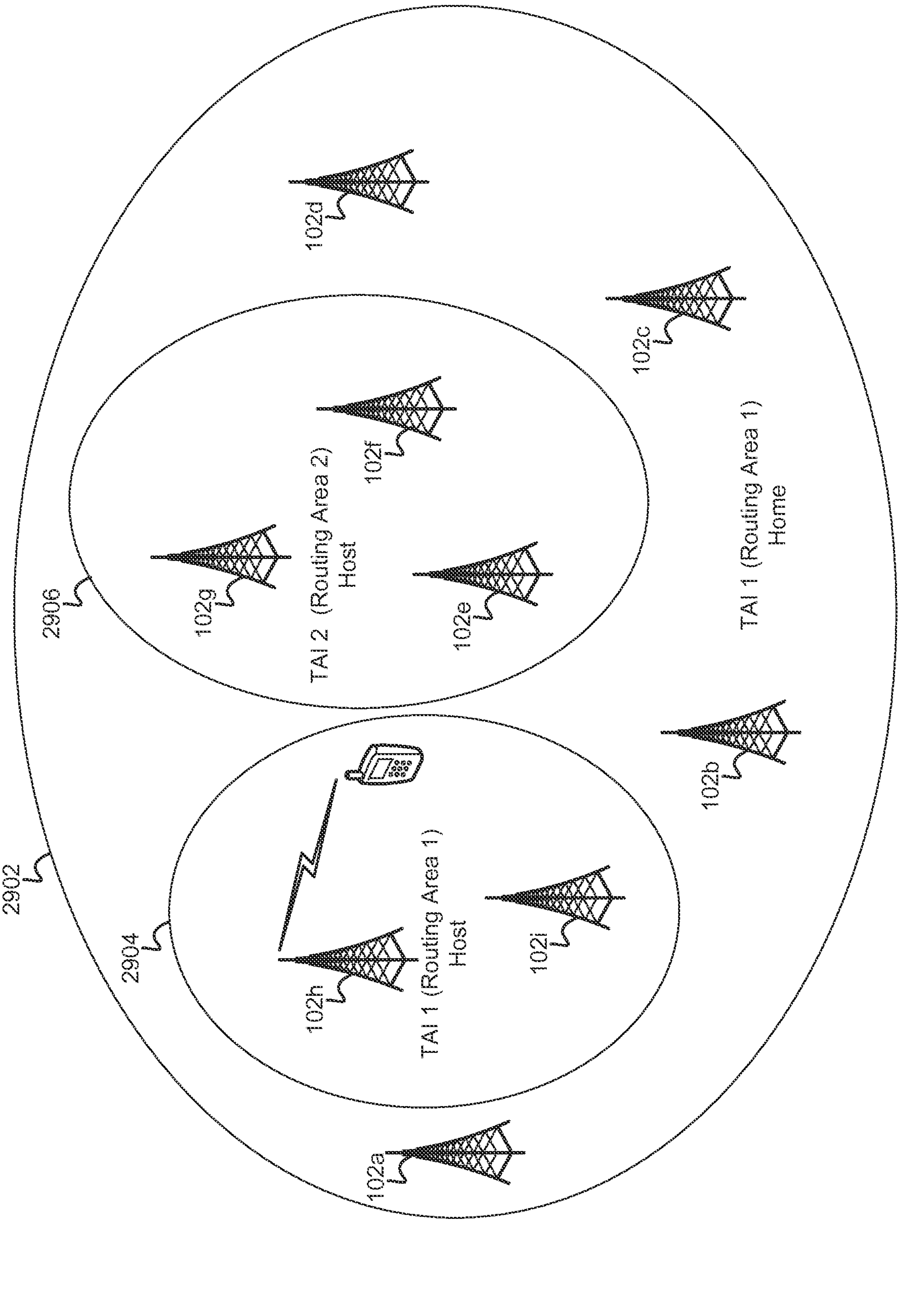
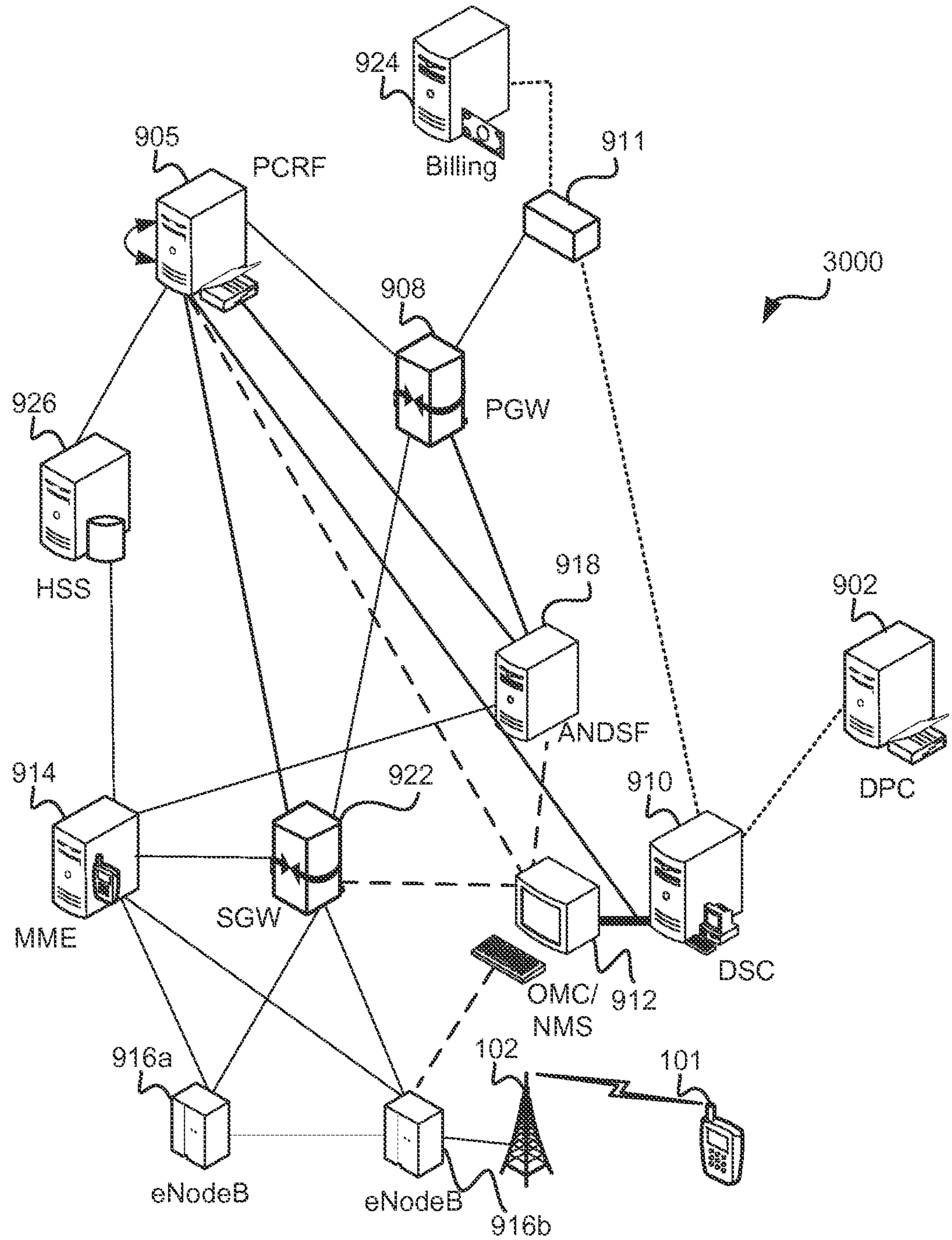

2902
2904
2906
102a
102b
102c
102d
102e
102f
102g
102h
102i
TAI 1 (Routing Area 1)
Host
TAI 2 (Routing Area 2)
Host
TAI 1 (Routing Area 1)
Home

FIG. 29



924
Billing
905
PCRF
911
3000
908
PGW
926
HSS
918
ANDSF
902
DPC
914
922
910
MME
SGW
DSC
OMC/
NMS
912
916a
102
101
eNodeB
eNodeB
916b

FIG. 30

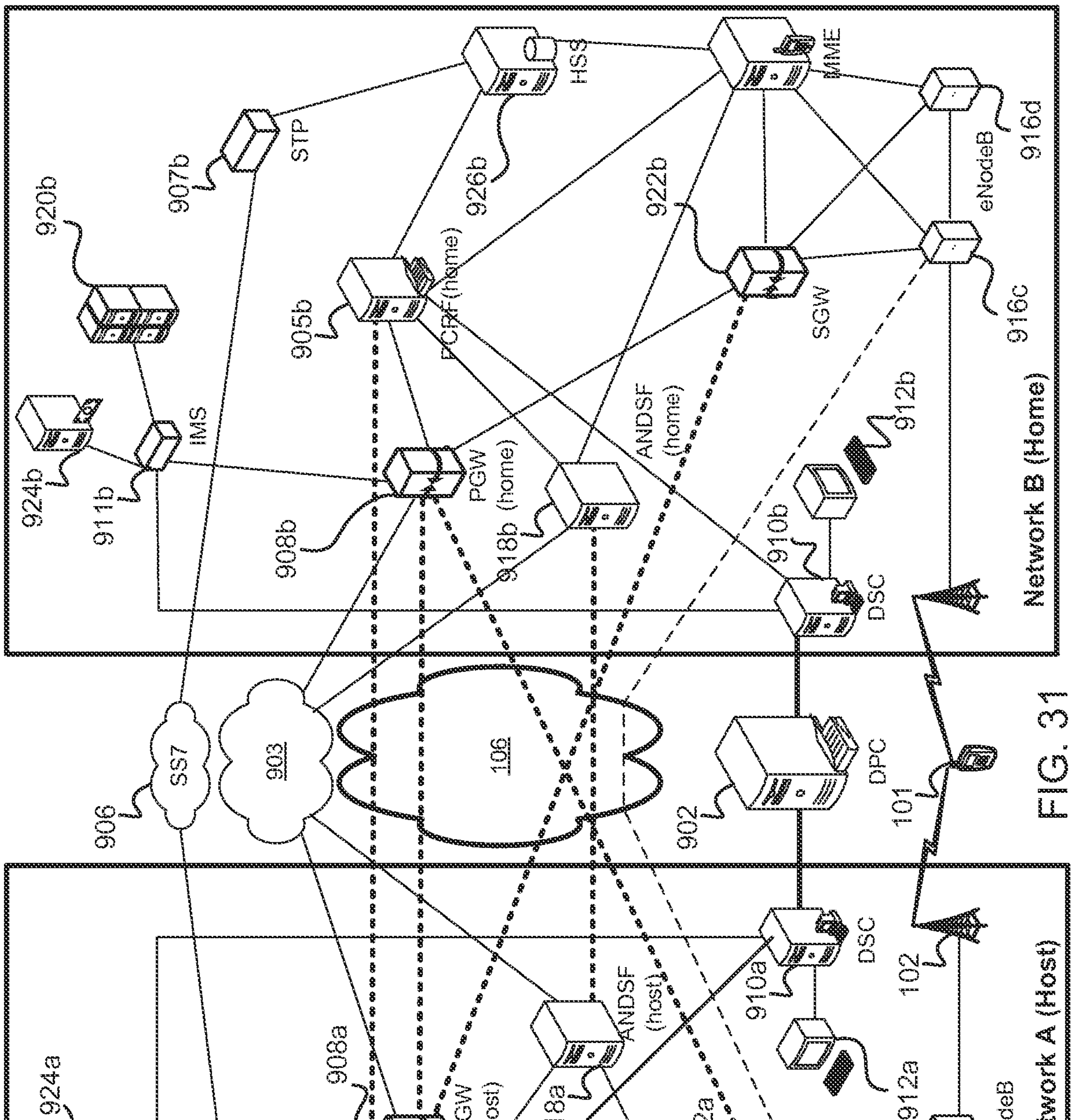

Network B (Home)
Network A (Host)
920b
924b
911b
IMS
907b
STP
926b
HSS
MME
905b
PCRF (home)
908b
PGW
918b (home)
ANDSF (home)
922b
SGW
910b
DSC
912b
916c
916d
eNodeB
eNodeB
906
SS7
903
106
902
DPC
101
102
920a
924a
911a
IMS
907a
STP
905a
PCRF (host)
908a
PGW (host)
926a
926
HSS
914
MME
918a
ANDSF (host)
922a
SGW
910a
DSC
912a
916a
916b
eNodeB
eNodeB

FIG. 31

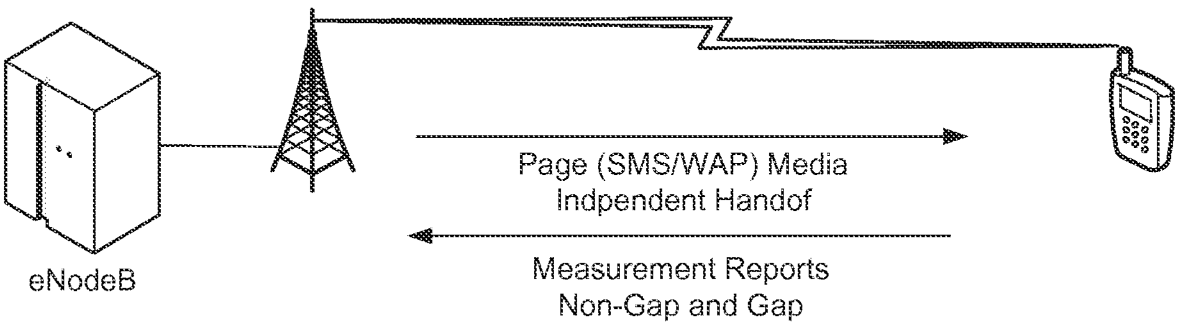

eNodeB
Page (SMS/WAP) Media
Indpendent Handof
Measurement Reports
Non-Gap and Gap

FIG. 32

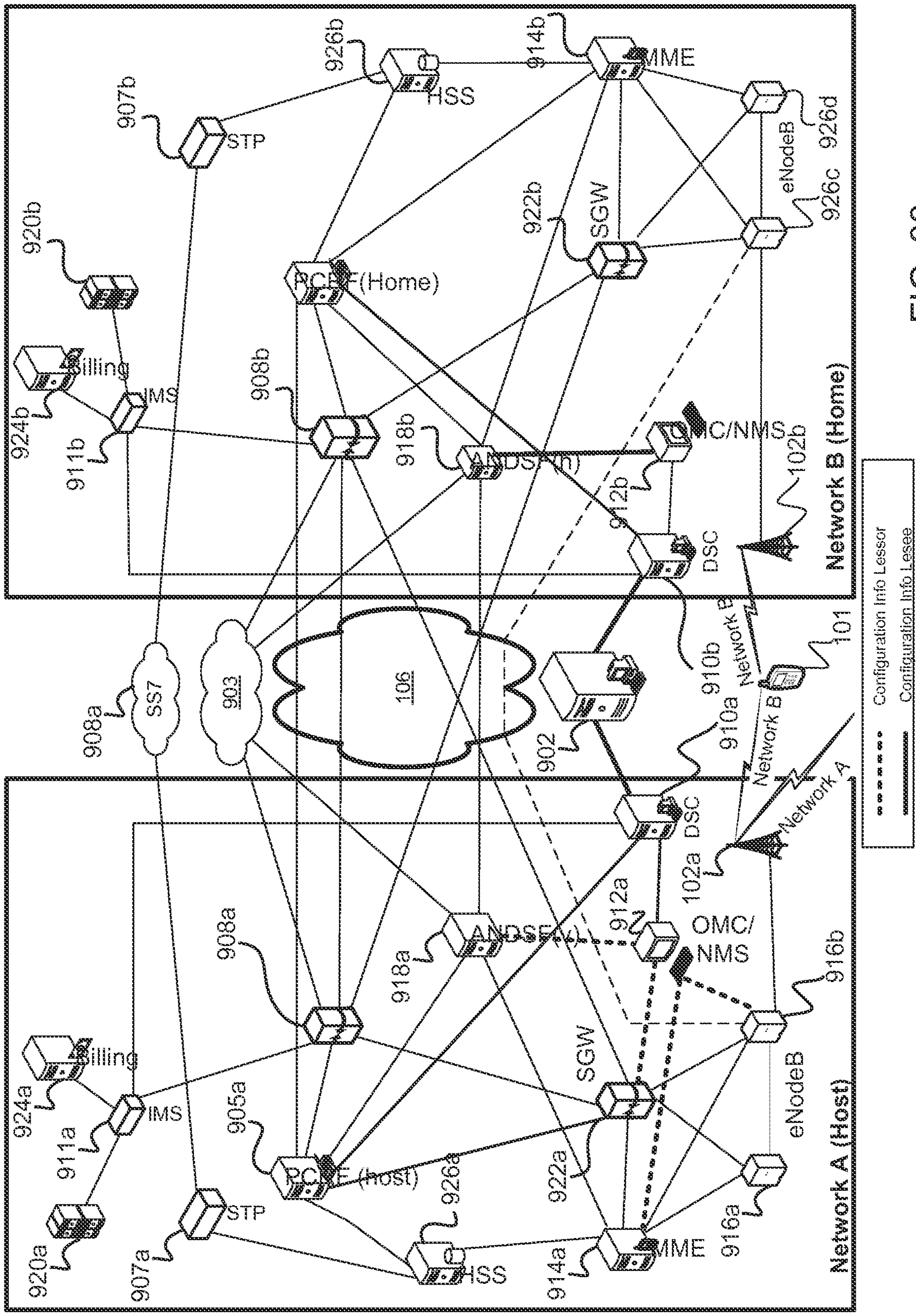

Network A (Host)
Network B (Home)
920a
907a
STP
924a
Billing
911a
IMS
905a
PCRF(host)
908a
926a
HSS
914a
MME
922a
SGW
918a
ANDSF(v)
912a
OMC/
NMS
916a
916b
eNodeB
DSC
102a
Network A
Network B
910a
902
106
903
SS7
908a
910b
101
920b
924b
Billing
911b
IMS
907b
STP
926b
HSS
908b
PCRF(Home)
918b
ANDSF(h)
912b
OMC/NMS
914b
MME
922b
SGW
926c
eNodeB
926d
102b
DSC
Configuration Info Lessor
Configuration Info Lesee

FIG. 33

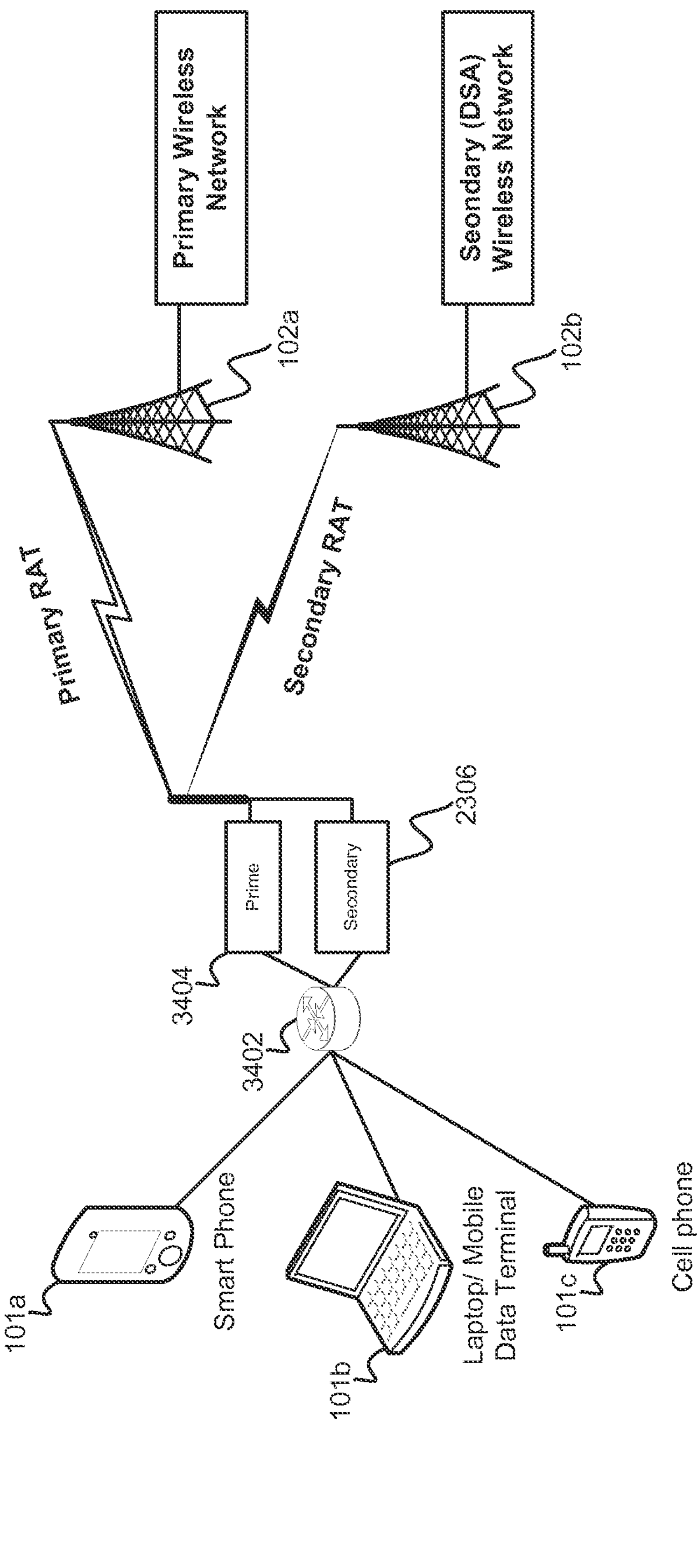

Primary Wireless Network
Seondary (DSA) Wireless Network
102a
102b
Primary RAT
Secondary RAT
Prime
Secondary
2306
3404
3402
101a
Smart Phone
101b
Laptop/ Mobile Data Terminal
101c
Cell phone

FIG. 34

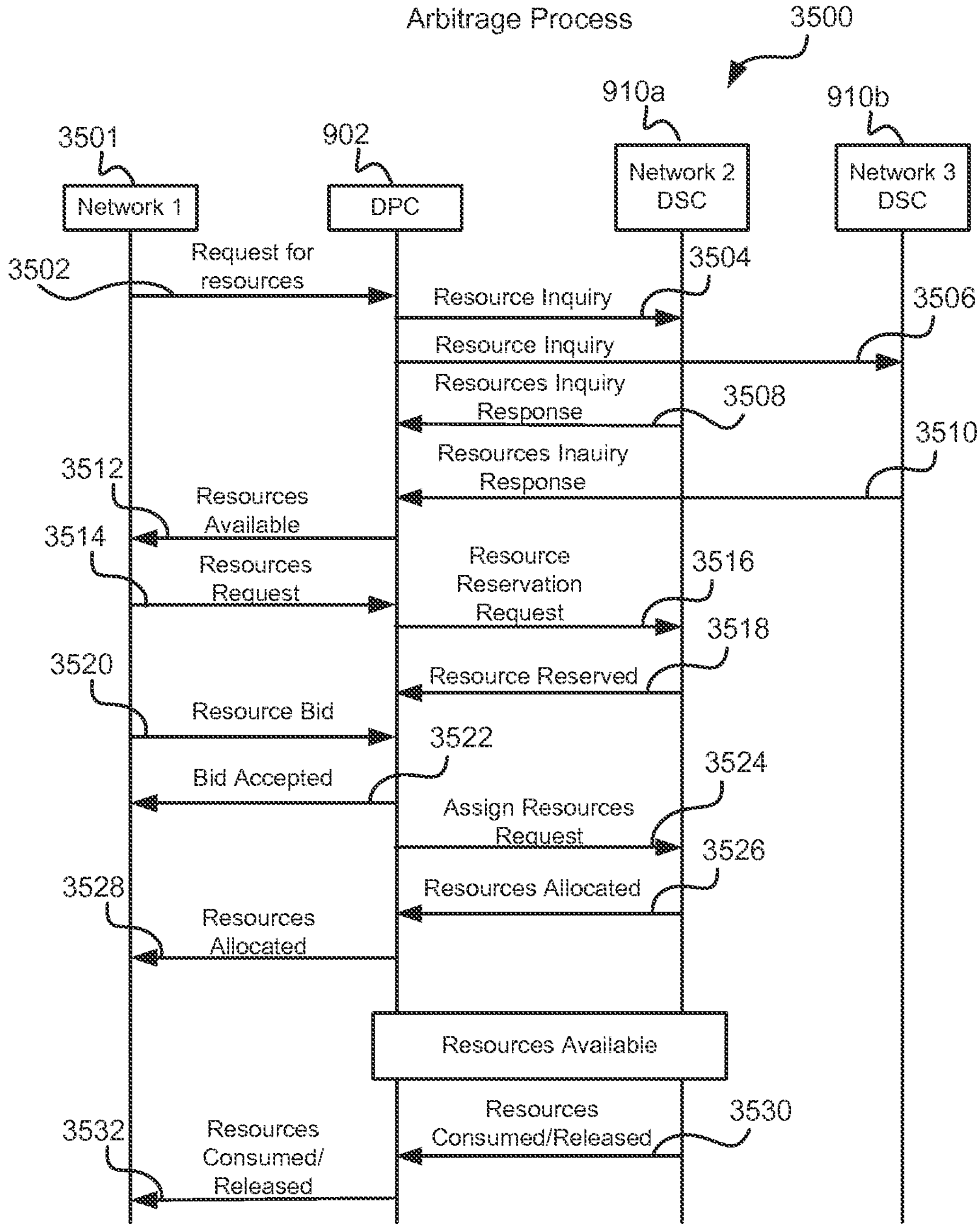
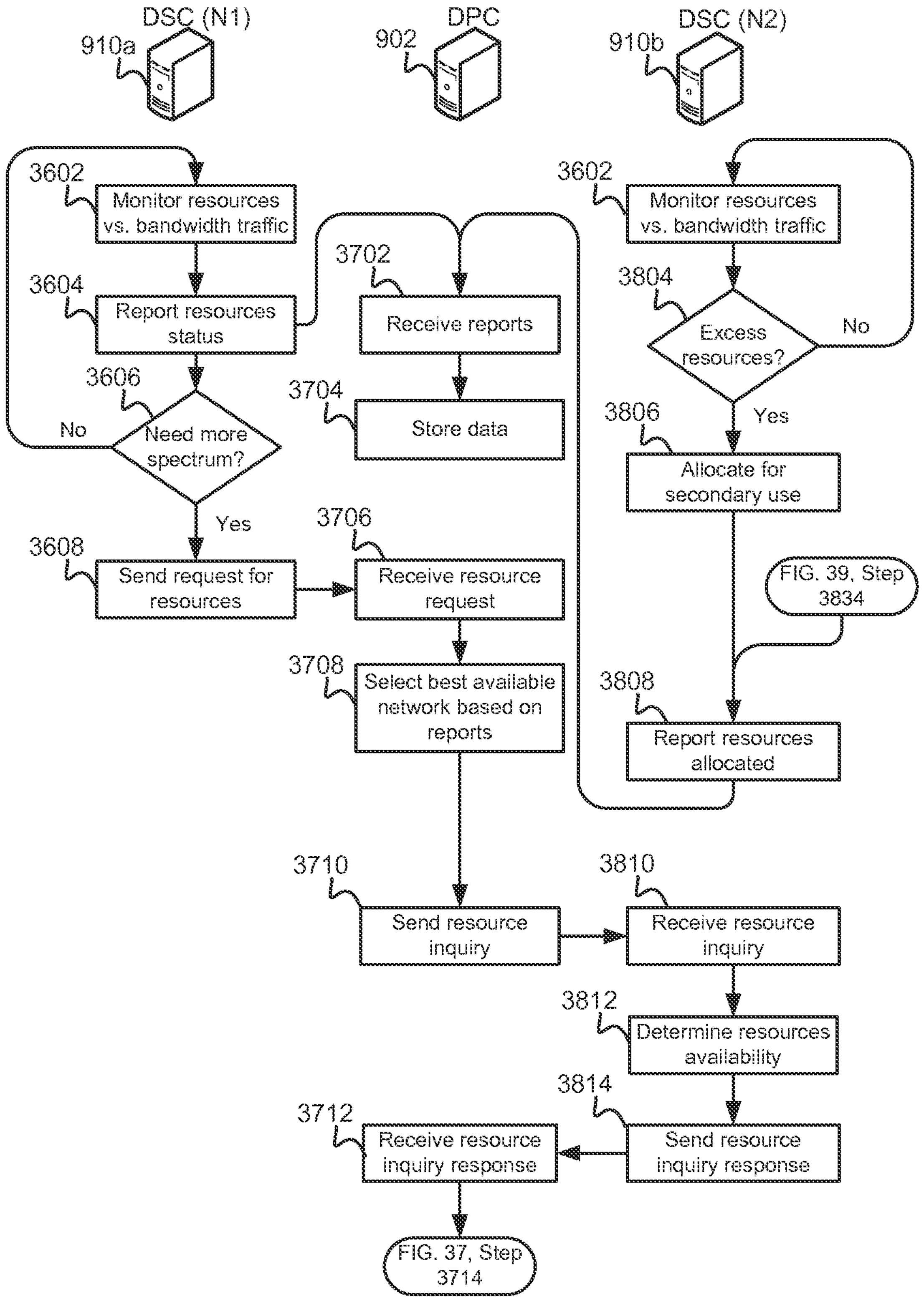

Arbitrage Process
3500
910a
910b
3501
902
Network 1
DPC
Network 2 DSC
Network 3 DSC
Request for resources
3502
3504
Resource Inquiry
3506
Resource Inquiry
Resources Inquiry Response
3508
3510
Resources Inauiry Response
3512
Resources Available
3514
Resources Request
Resource Reservation Request
3516
3518
Resource Reserved
3520
Resource Bid
3522
Bid Accepted
3524
Assign Resources Request
3526
Resources Allocated
3528
Resources Allocated
Resources Available
Resources Consumed/Released
3530
3532
Resources Consumed/ Released

FIG. 35



DSC (N1)
910a
DPC
902
DSC (N2)
910b
3602
Monitor resources vs. bandwidth traffic
3604
Report resources status
3606
Need more spectrum?
No
Yes
3608
Send request for resources
3702
Receive reports
3704
Store data
3706
Receive resource request
3708
Select best available network based on reports
3602
Monitor resources vs. bandwidth traffic
3804
Excess resources?
No
Yes
3806
Allocate for secondary use
FIG. 39, Step 3834
3808
Report resources allocated
3710
Send resource inquiry
3810
Receive resource inquiry
3812
Determine resources availability
3814
Send resource inquiry response
3712
Receive resource inquiry response
FIG. 37, Step 3714

FIG. 36

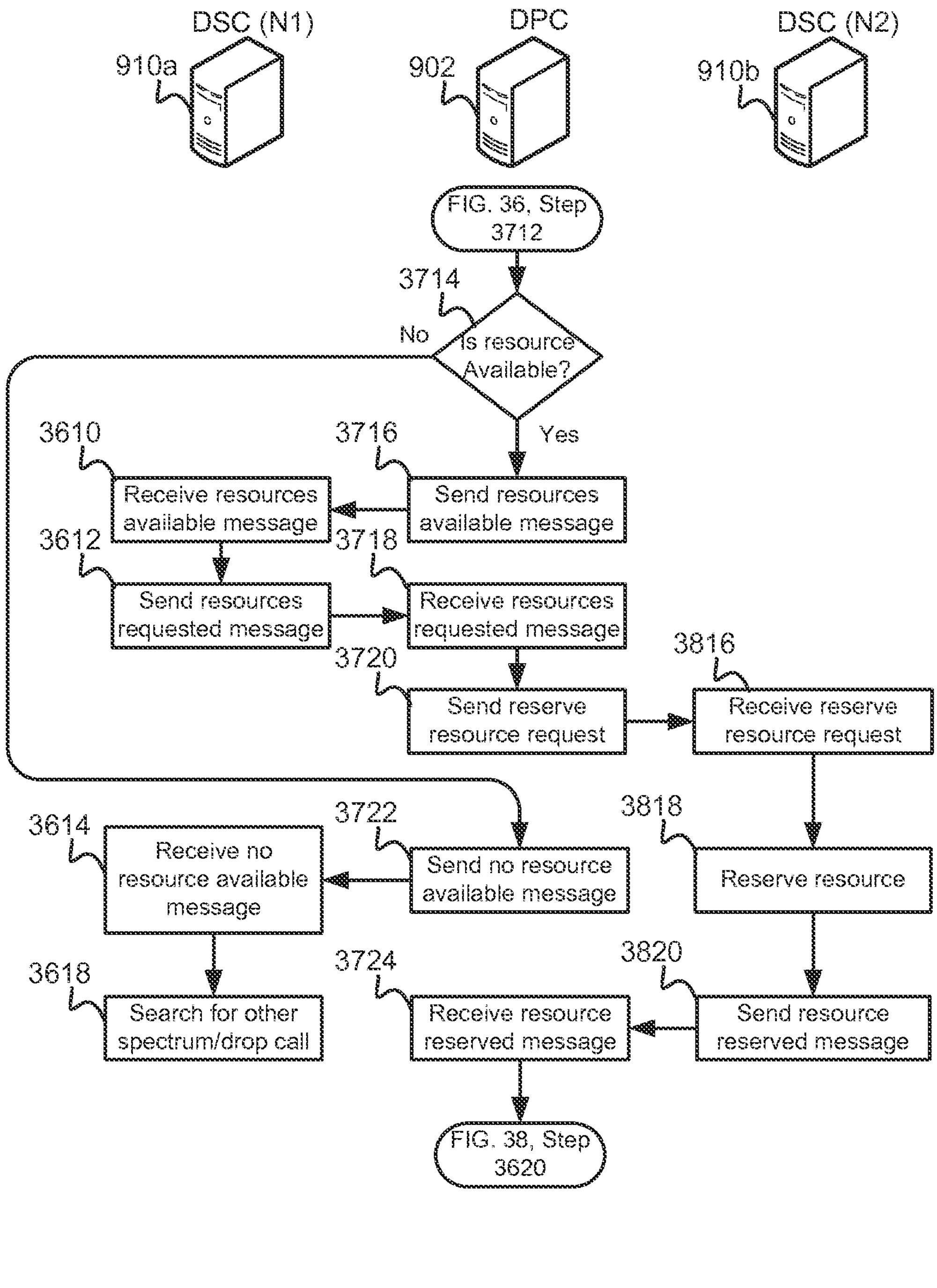

DSC (N1)
910a
DPC
902
DSC (N2)
910b
FIG. 36, Step 3712
3714
Is resource Available?
No
Yes
3610
Receive resources available message
3716
Send resources available message
3612
Send resources requested message
3718
Receive resources requested message
3720
Send reserve resource request
3816
Receive reserve resource request
3614
Receive no resource available message
3722
Send no resource available message
3818
Reserve resource
3618
Search for other spectrum/drop call
3724
Receive resource reserved message
3820
Send resource reserved message
FIG. 38, Step 3620

FIG. 37

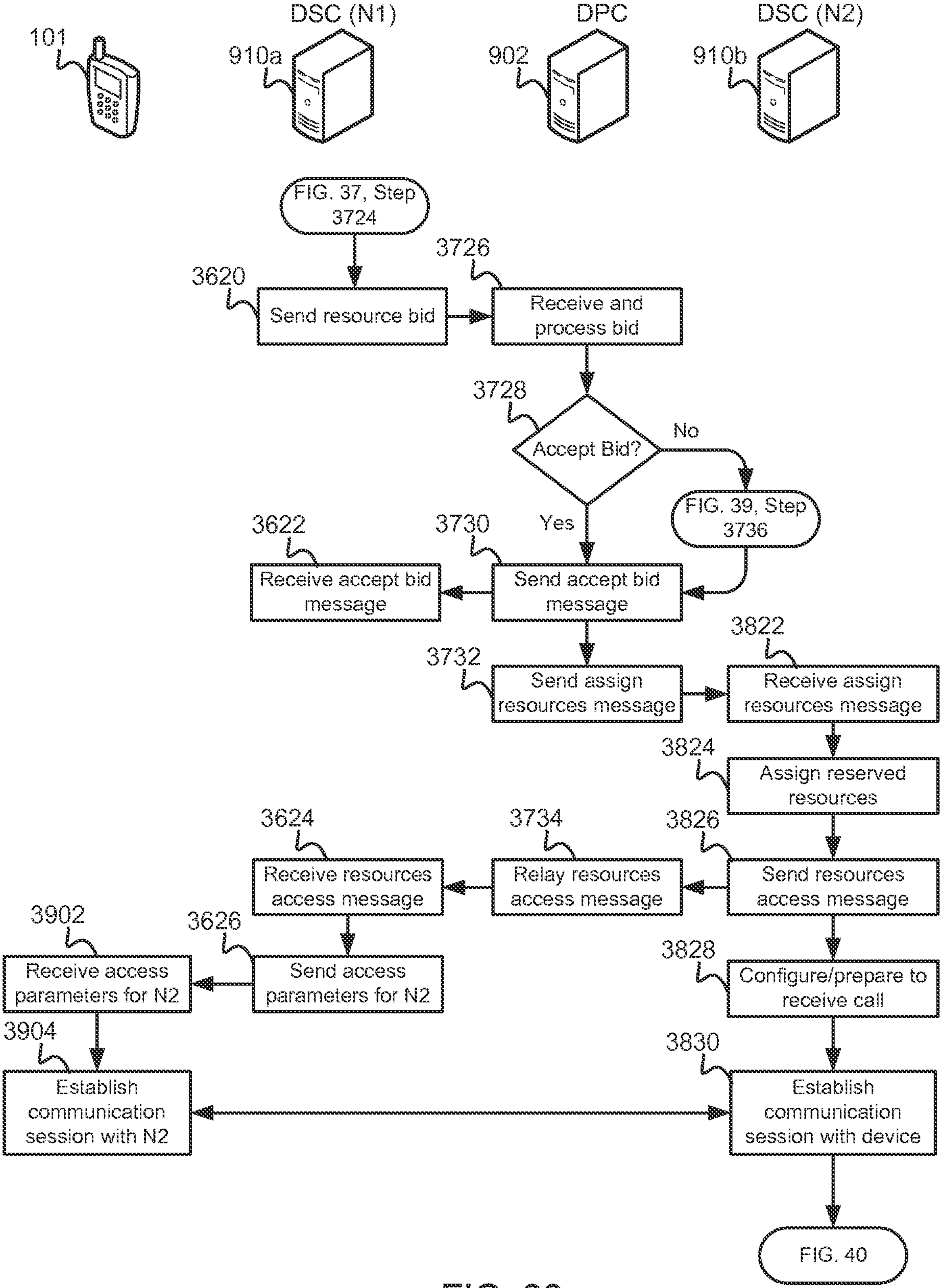

DSC (N1)
DPC
DSC (N2)
101
910a
902
910b
FIG. 37, Step 3724
3726
3620
Send resource bid
Receive and process bid
3728
Accept Bid?
No
Yes
FIG. 39, Step 3736
3622
3730
Receive accept bid message
Send accept bid message
3732
3822
Send assign resources message
Receive assign resources message
3824
Assign reserved resources
3624
3734
3826
Receive resources access message
Relay resources access message
Send resources access message
3902
3626
3828
Receive access parameters for N2
Send access parameters for N2
Configure/prepare to receive call
3904
3830
Establish communication session with N2
Establish communication session with device
FIG. 40

FIG. 38

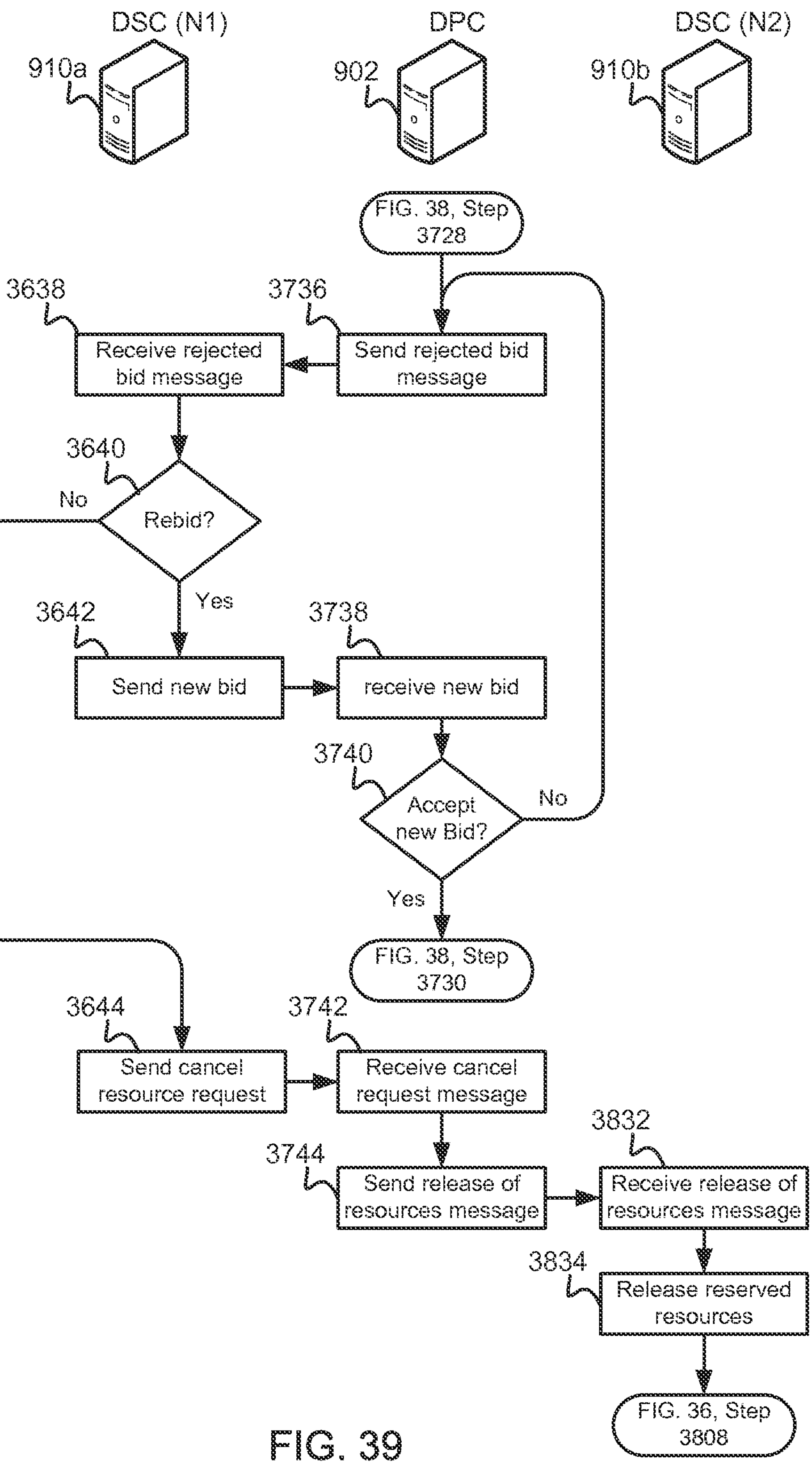

DSC (N1)
910a
DPC
902
DSC (N2)
910b
FIG. 38, Step 3728
3638
Receive rejected bid message
3736
Send rejected bid message
3640
Rebid?
No
Yes
3642
Send new bid
3738
receive new bid
3740
Accept new Bid?
No
Yes
FIG. 38, Step 3730
3644
Send cancel resource request
3742
Receive cancel request message
3744
Send release of resources message
3832
Receive release of resources message
3834
Release reserved resources
FIG. 36, Step 3808

FIG. 39

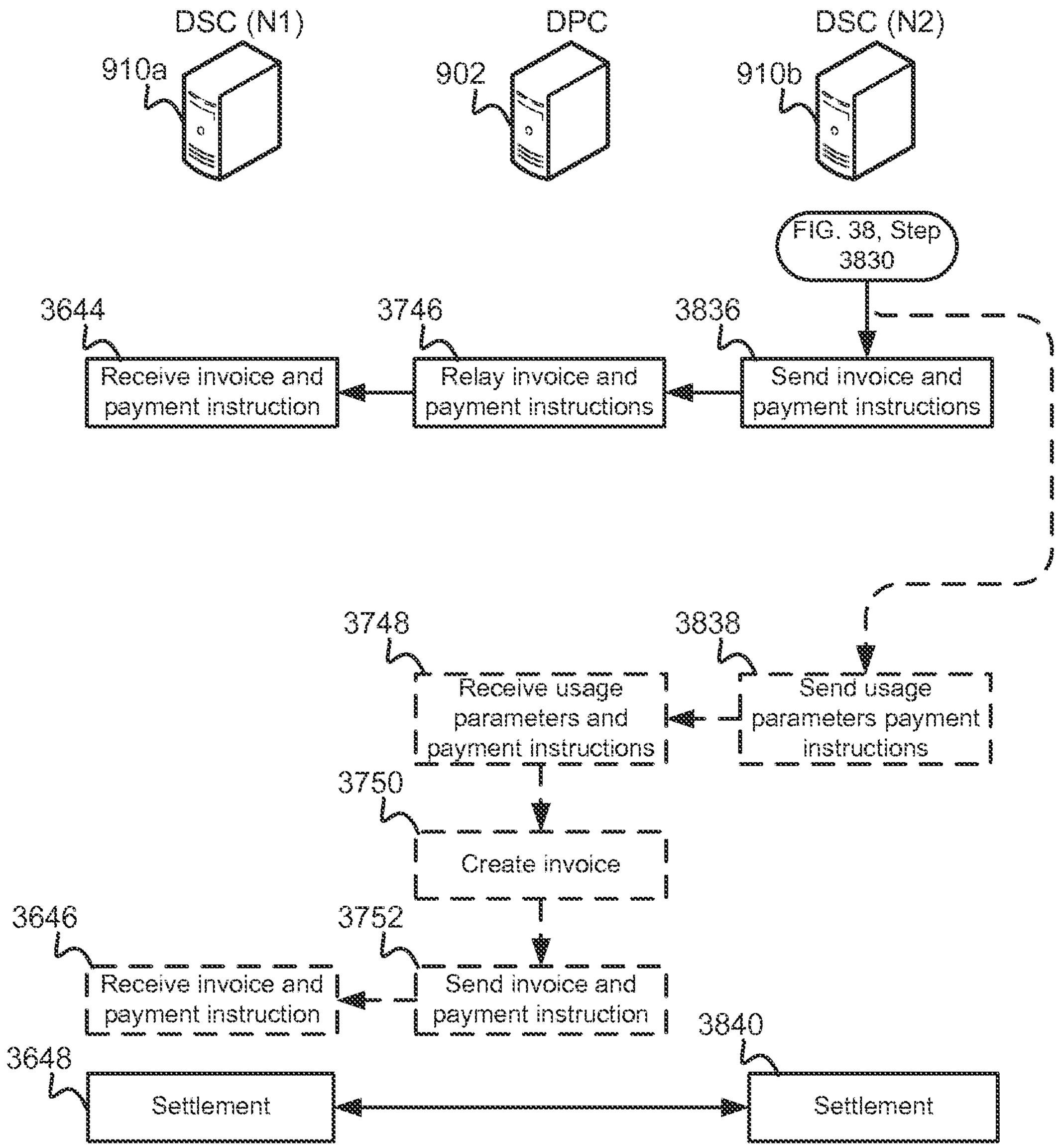

DSC (N1)
910a
DPC
902
DSC (N2)
910b
FIG. 38, Step 3830
3644
Receive invoice and payment instruction
3746
Relay invoice and payment instructions
3836
Send invoice and payment instructions
3748
Receive usage parameters and payment instructions
3838
Send usage parameters payment instructions
3750
Create invoice
3646
Receive invoice and payment instruction
3752
Send invoice and payment instruction
3840
3648
Settlement
Settlement

FIG. 40

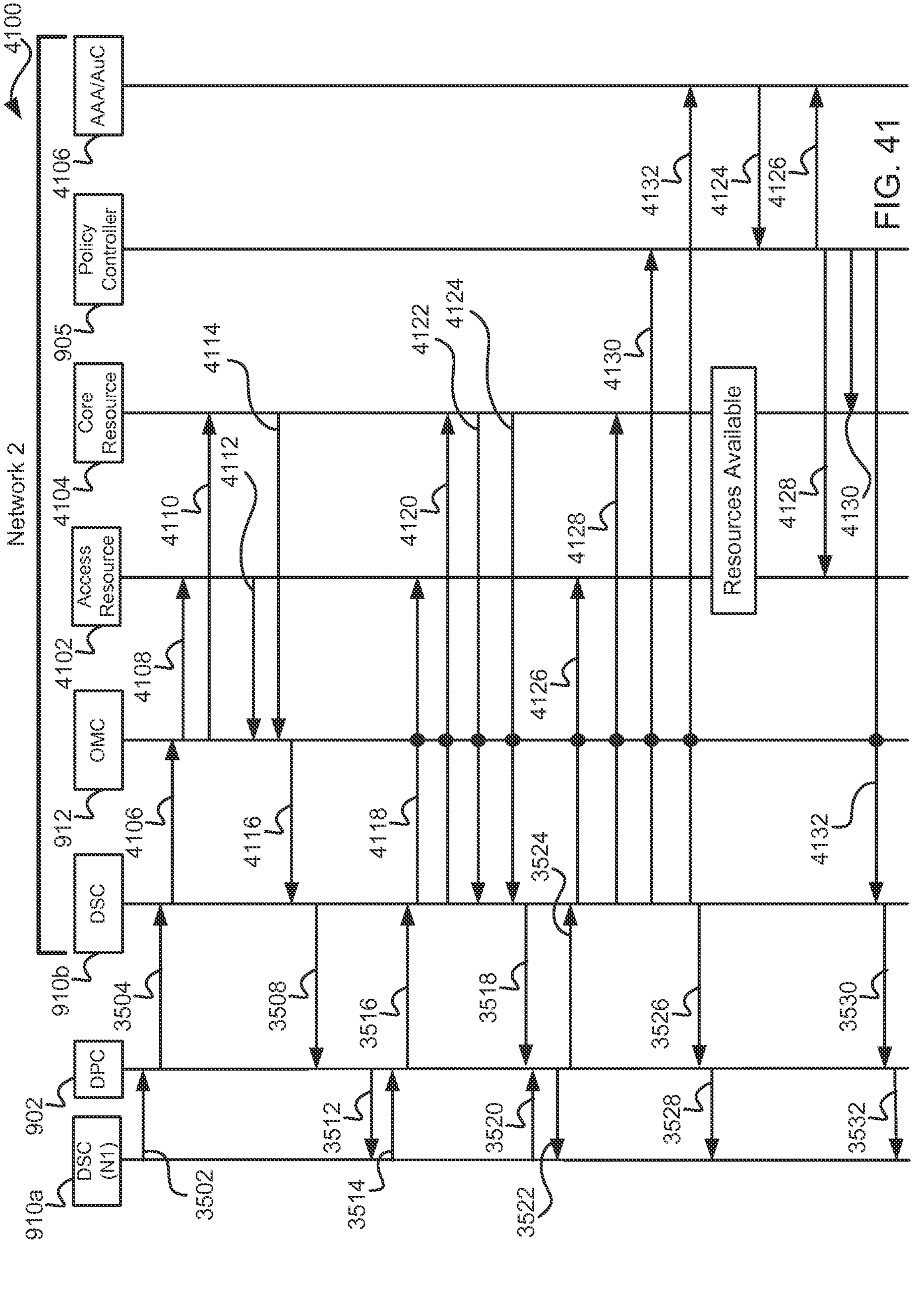
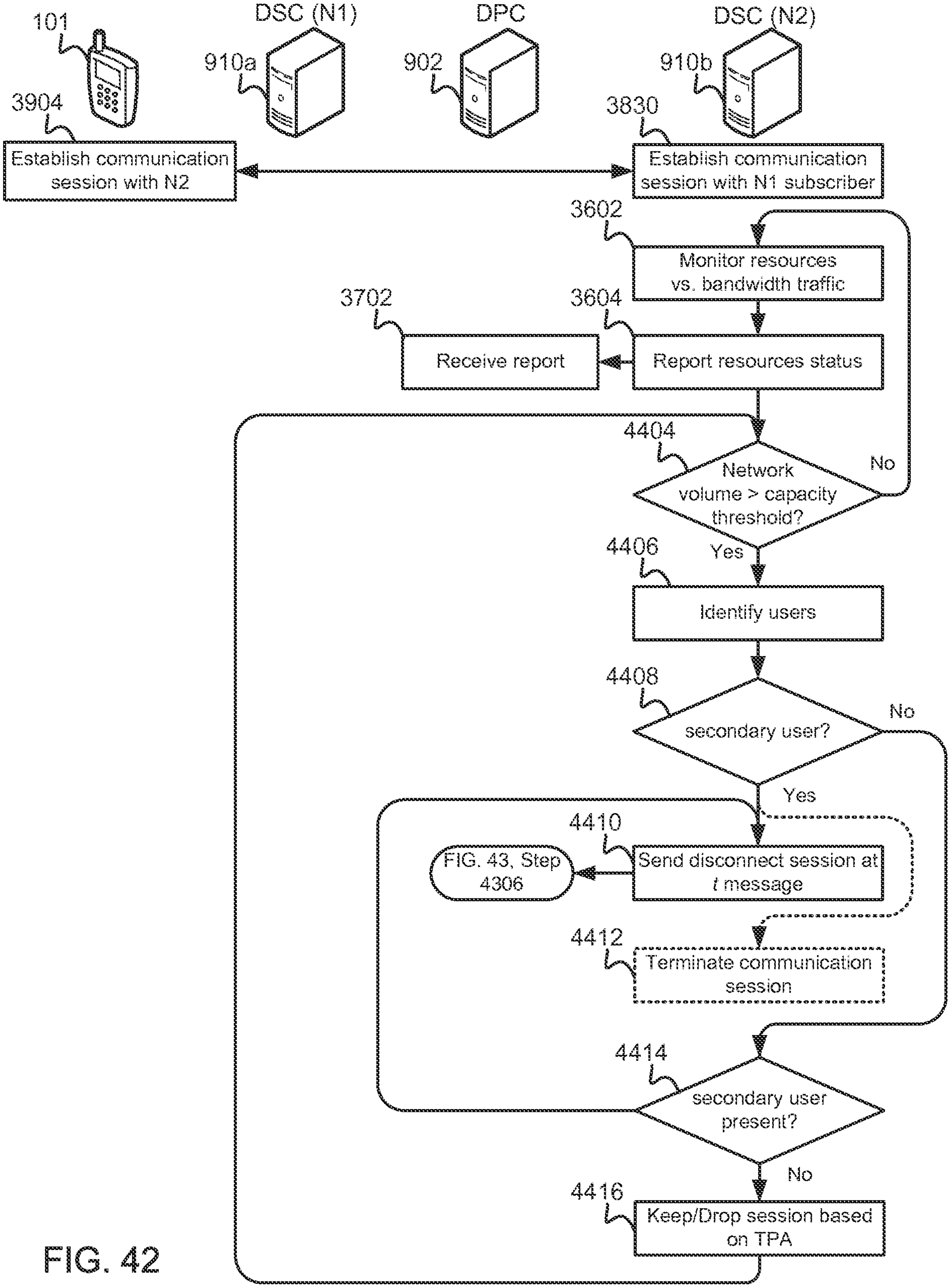

4100
Network 2
DSC (N1)
DPC
DSC
OMC
Access Resource
Core Resource
Policy Controller
AAA/AuC
Resources Available
910a
902
910b
912
4102
4104
905
4106
3502
3504
3508
3512
3514
3516
3518
3520
3522
3524
3526
3528
3530
3532
4106
4108
4110
4112
4114
4116
4118
4120
4122
4124
4126
4128
4130
4132

FIG. 41



101
DSC (N1)
910a
DPC
902
DSC (N2)
910b
3904
Establish communication session with N2
3830
Establish communication session with N1 subscriber
3602
Monitor resources vs. bandwidth traffic
3702
3604
Receive report
Report resources status
4404
Network volume > capacity threshold?
No
4406
Yes
Identify users
4408
secondary user?
No
Yes
4410
FIG. 43, Step 4306
Send disconnect session at t message
4412
Terminate communication session
4414
secondary user present?
No
4416
Keep/Drop session based on TPA

FIG. 42

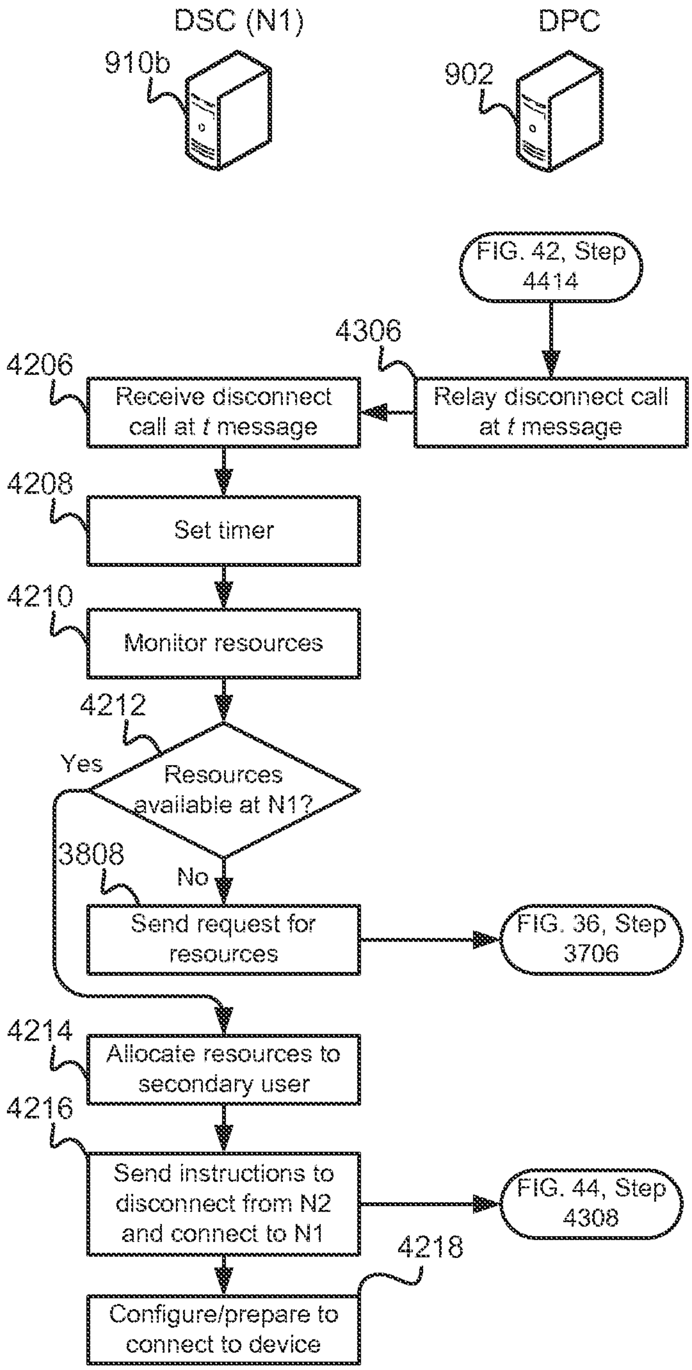

DSC (N1)
910b
DPC
902
FIG. 42, Step 4414
4306
Relay disconnect call at t message
4206
Receive disconnect call at t message
4208
Set timer
4210
Monitor resources
4212
Yes
Resources available at N1?
3808
No
Send request for resources
FIG. 36, Step 3706
4214
Allocate resources to secondary user
4216
Send instructions to disconnect from N2 and connect to N1
FIG. 44, Step 4308
4218
Configure/prepare to connect to device

FIG. 43

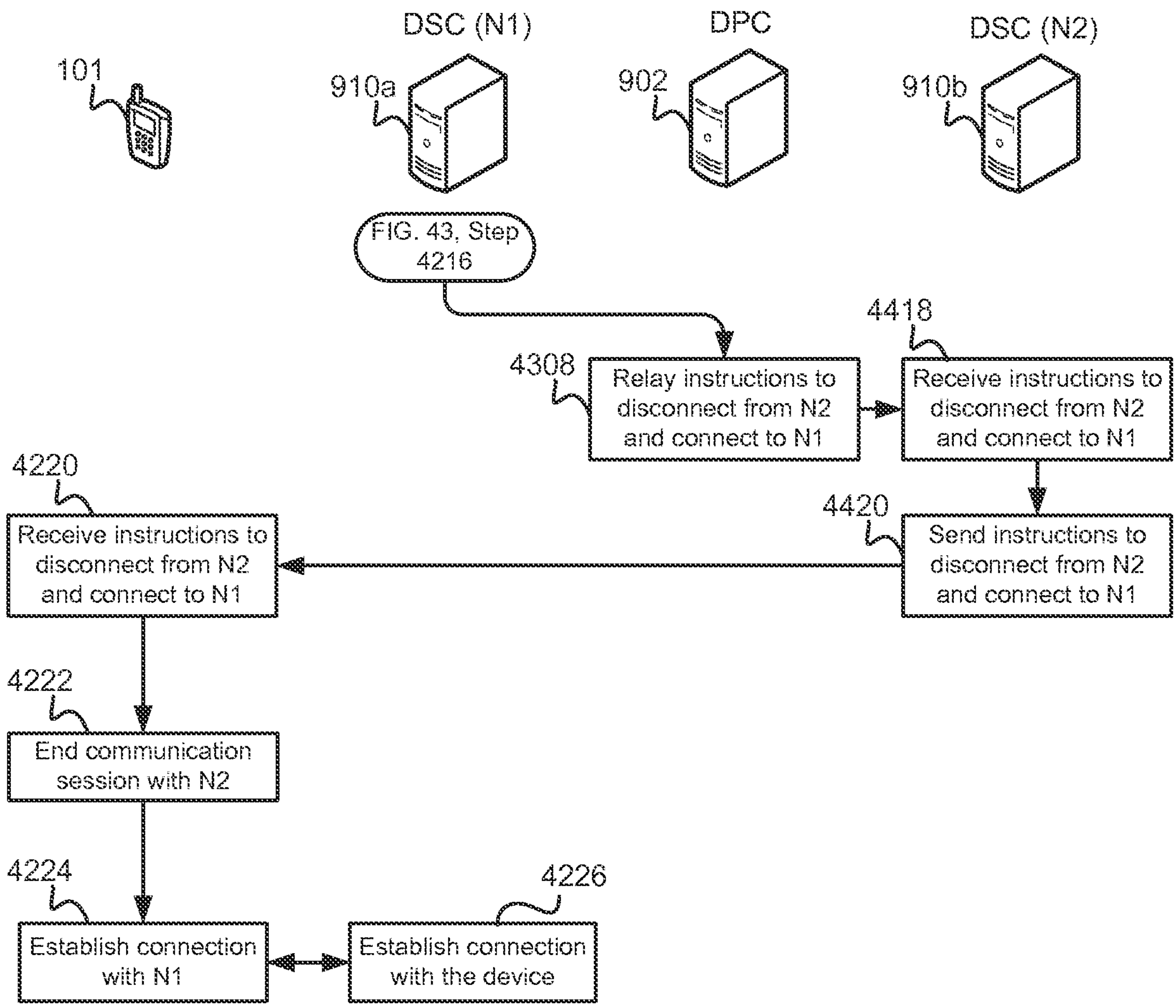

DSC (N1)
DPC
DSC (N2)
101
910a
902
910b
FIG. 43, Step 4216
4308
Relay instructions to disconnect from N2 and connect to N1
4418
Receive instructions to disconnect from N2 and connect to N1
4420
Send instructions to disconnect from N2 and connect to N1
4220
Receive instructions to disconnect from N2 and connect to N1
4222
End communication session with N2
4224
Establish connection with N1
4226
Establish connection with the device

FIG. 44

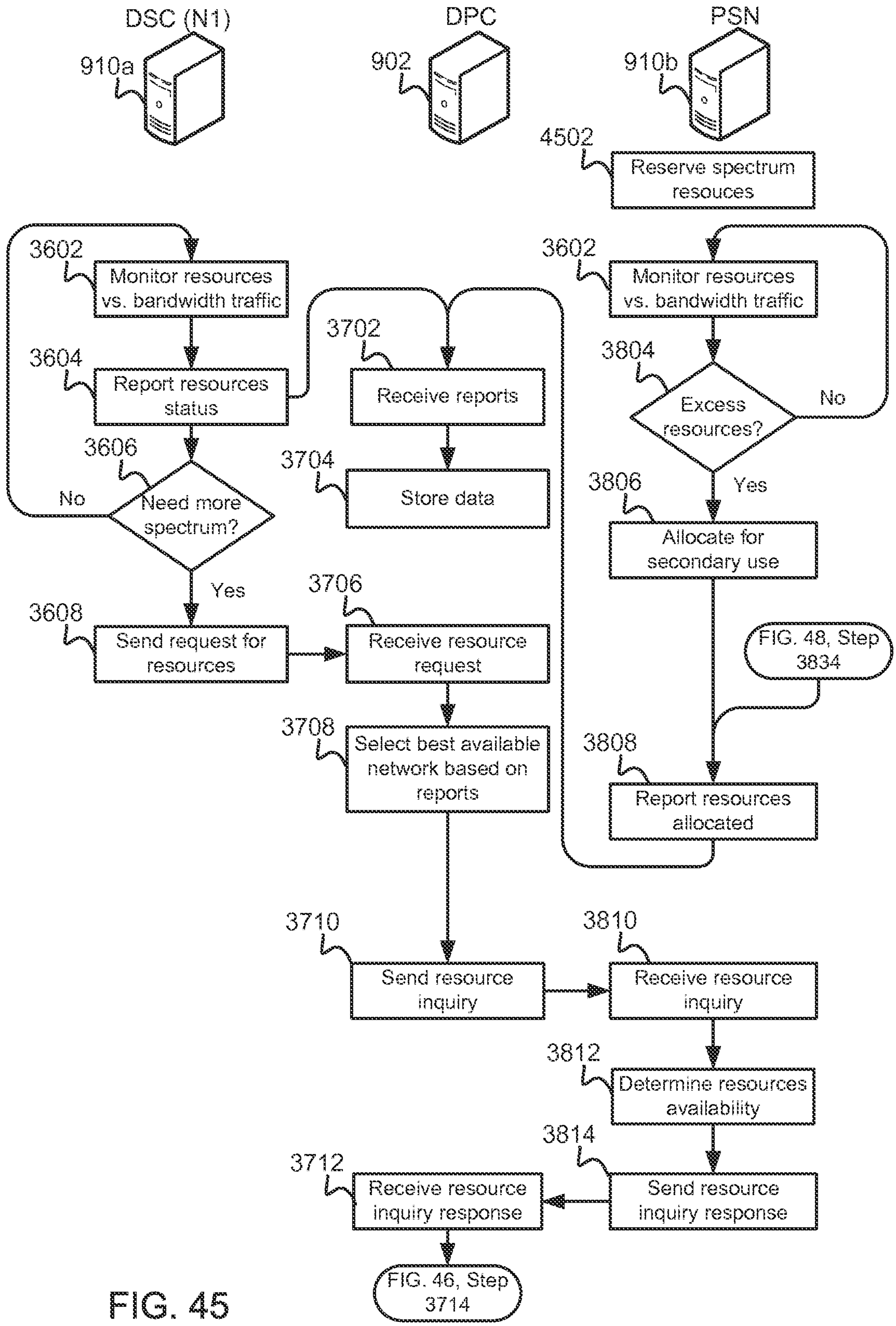
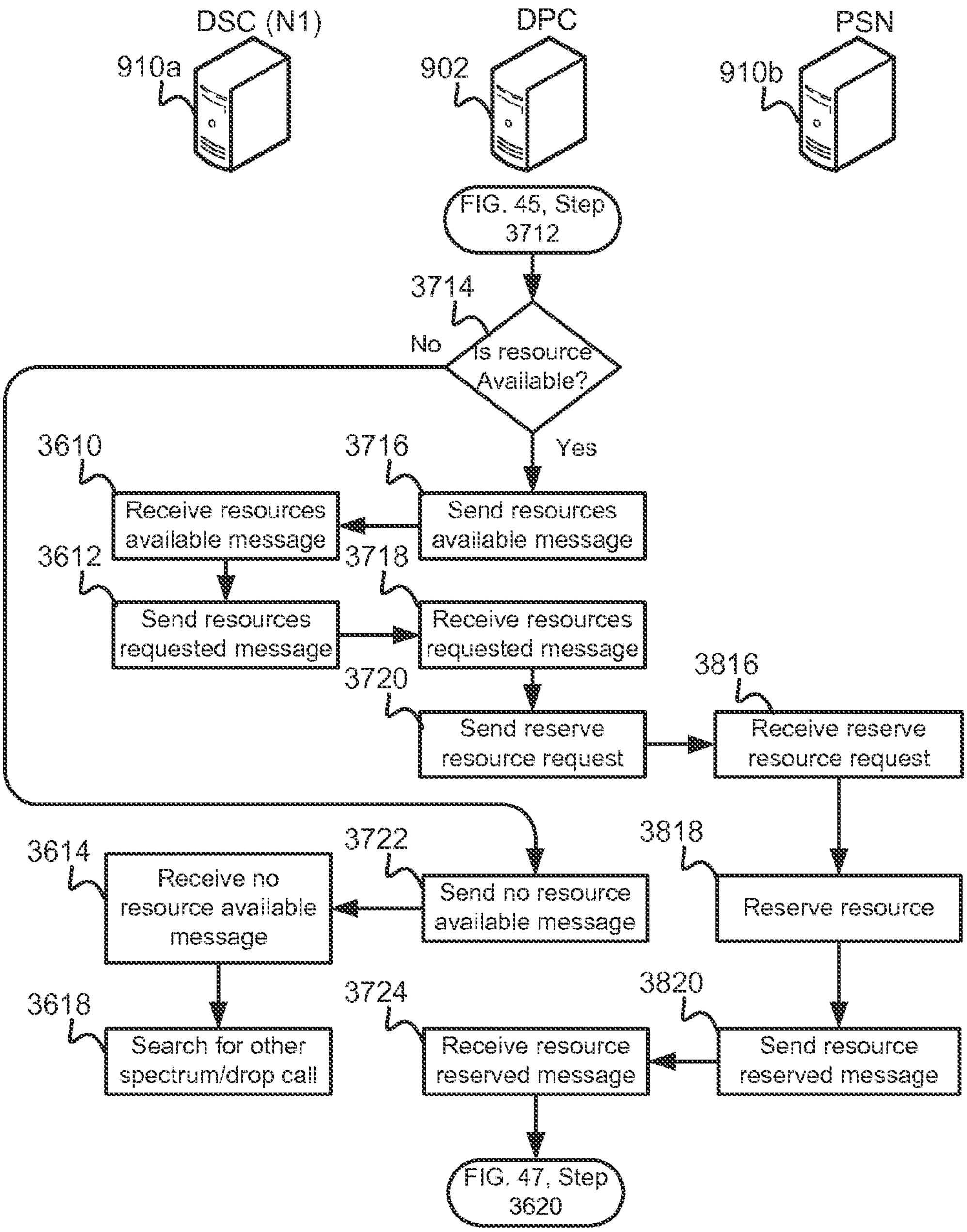

DSC (N1)
910a
DPC
902
PSN
910b
4502
Reserve spectrum resouces
3602
Monitor resources vs. bandwidth traffic
3604
Report resources status
3606
Need more spectrum?
No
Yes
3608
Send request for resources
3702
Receive reports
3704
Store data
3706
Receive resource request
3708
Select best available network based on reports
3710
Send resource inquiry
3712
Receive resource inquiry response
FIG. 46, Step 3714
3602
Monitor resources vs. bandwidth traffic
3804
Excess resources?
No
Yes
3806
Allocate for secondary use
FIG. 48, Step 3834
3808
Report resources allocated
3810
Receive resource inquiry
3812
Determine resources availability
3814
Send resource inquiry response

FIG. 45



DSC (N1)
910a
DPC
902
PSN
910b
FIG. 45, Step 3712
3714
Is resource Available?
No
Yes
3610
Receive resources available message
3716
Send resources available message
3612
Send resources requested message
3718
Receive resources requested message
3720
Send reserve resource request
3816
Receive reserve resource request
3614
Receive no resource available message
3722
Send no resource available message
3818
Reserve resource
3618
Search for other spectrum/drop call
3724
Receive resource reserved message
3820
Send resource reserved message
FIG. 47, Step 3620

FIG. 46

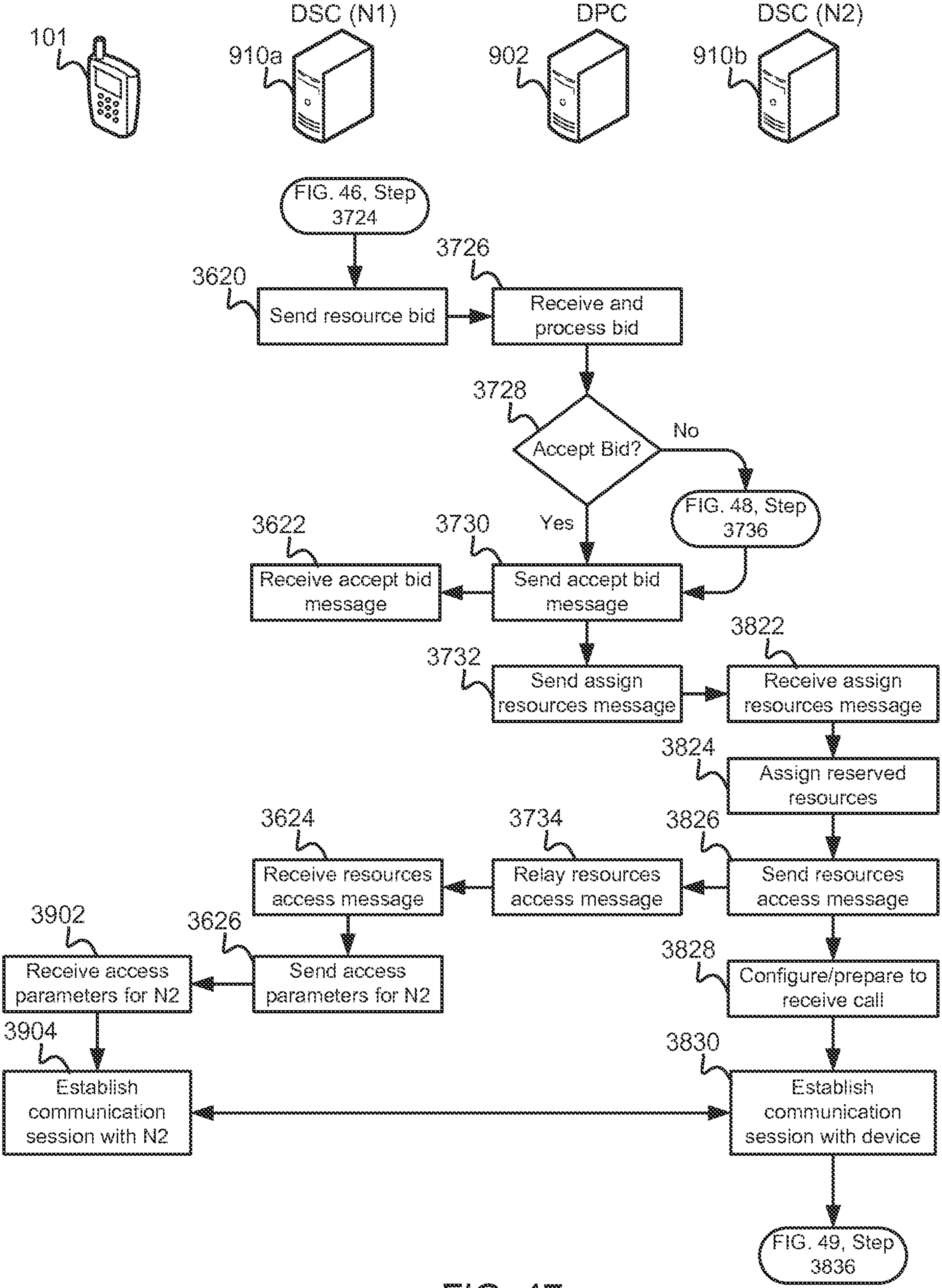
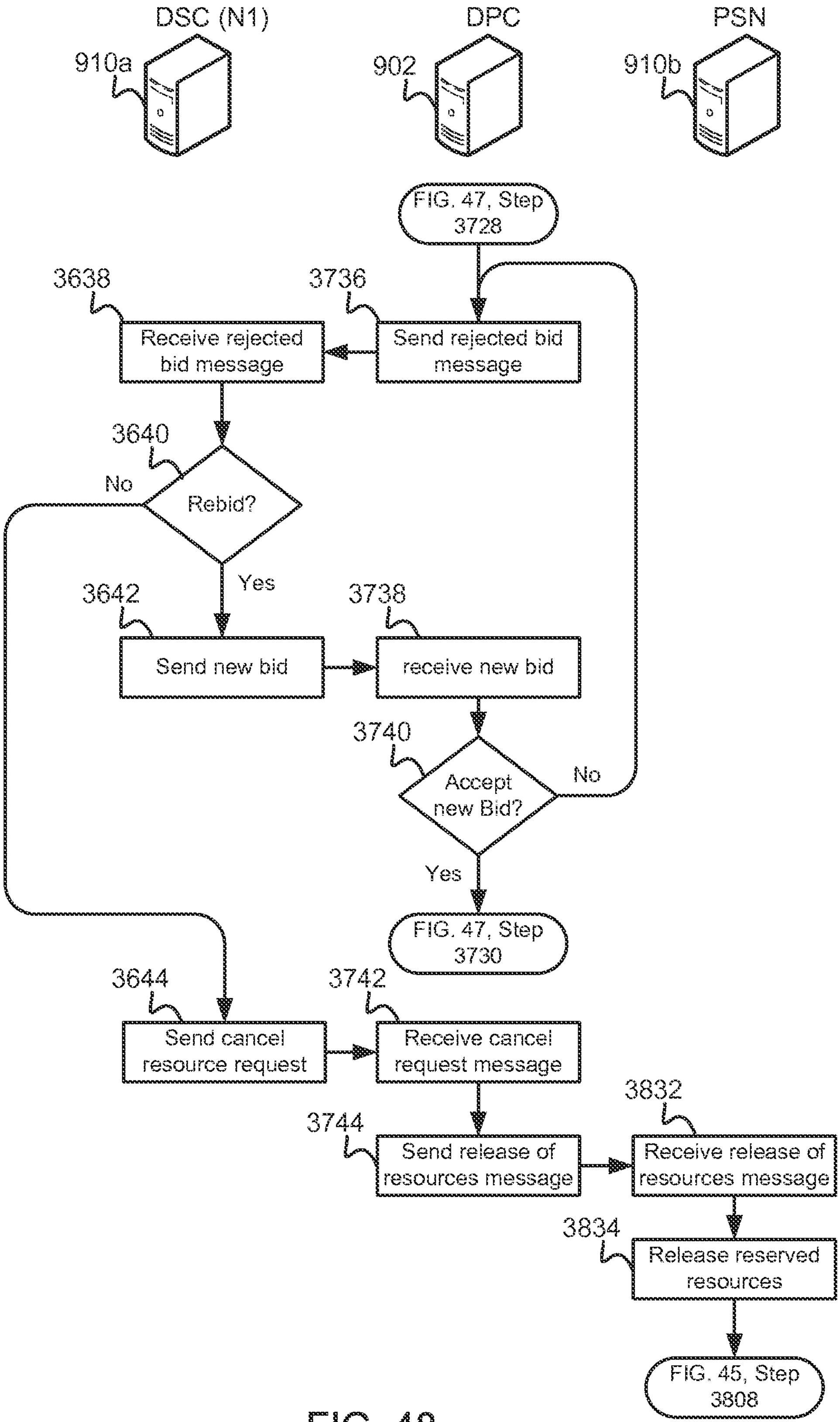

DSC (N1)
DPC
DSC (N2)
101
910a
902
910b
FIG. 46, Step 3724
3620
Send resource bid
3726
Receive and process bid
3728
Accept Bid?
No
Yes
FIG. 48, Step 3736
3622
Receive accept bid message
3730
Send accept bid message
3732
Send assign resources message
3822
Receive assign resources message
3824
Assign reserved resources
3624
Receive resources access message
3734
Relay resources access message
3826
Send resources access message
3902
Receive access parameters for N2
3626
Send access parameters for N2
3828
Configure/prepare to receive call
3904
Establish communication session with N2
3830
Establish communication session with device
FIG. 49, Step 3836

FIG. 47



DSC (N1)
DPC
PSN
910a
902
910b
FIG. 47, Step 3728
3638
3736
Receive rejected bid message
Send rejected bid message
3640
No
Rebid?
Yes
3642
3738
Send new bid
receive new bid
3740
Accept new Bid?
No
Yes
FIG. 47, Step 3730
3644
3742
Send cancel resource request
Receive cancel request message
3832
3744
Send release of resources message
Receive release of resources message
3834
Release reserved resources
FIG. 45, Step 3808

FIG. 48

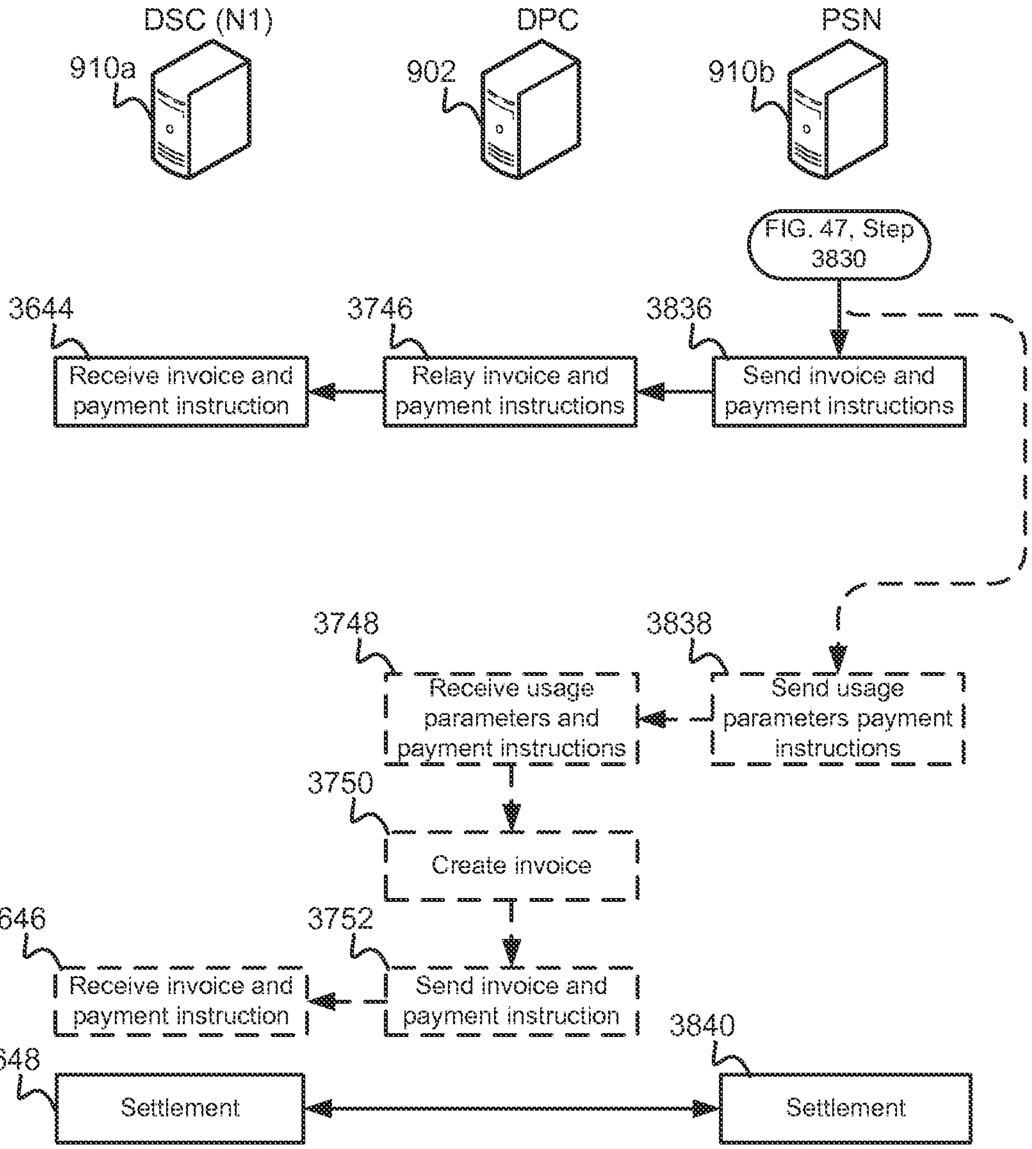
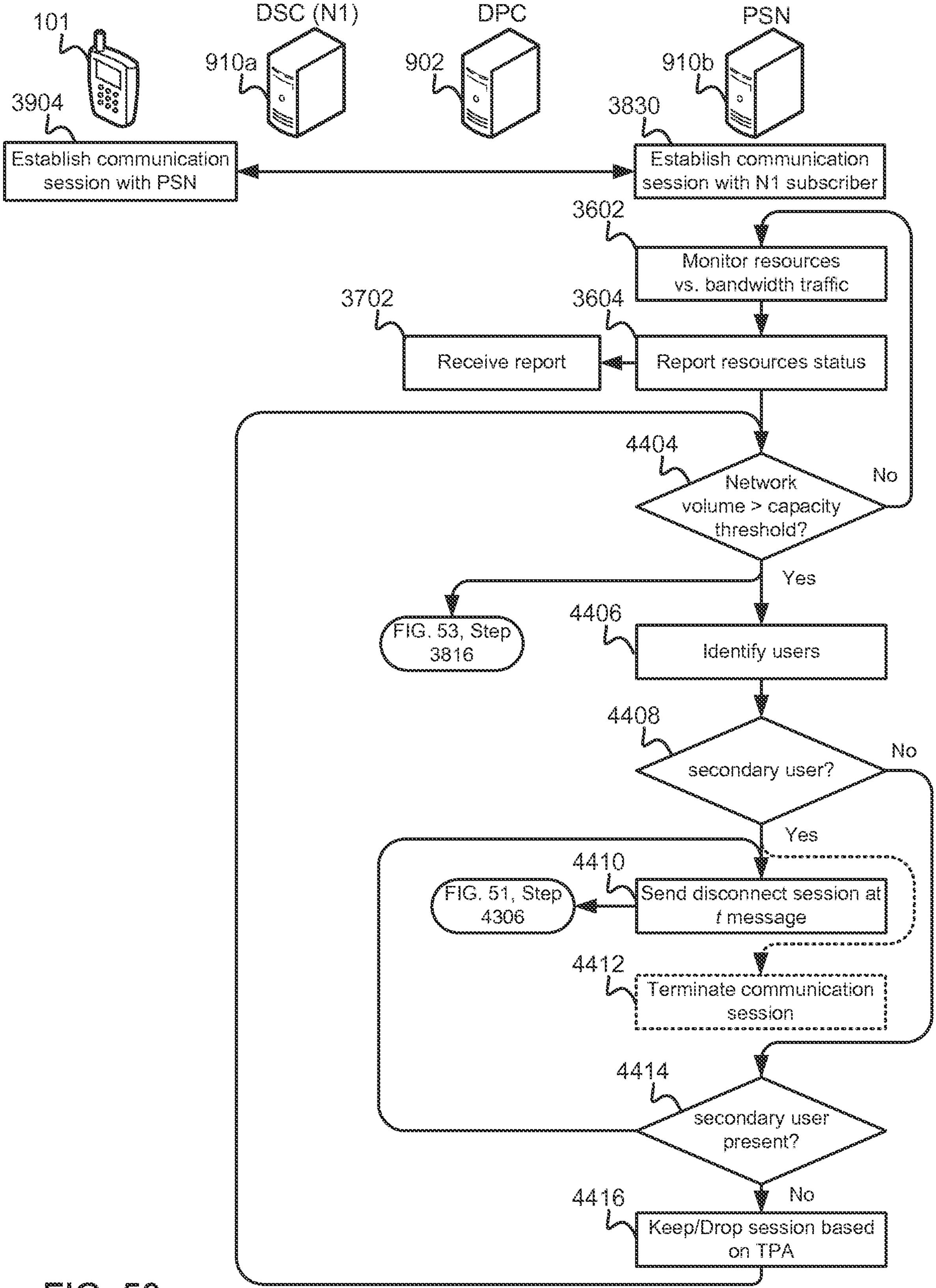
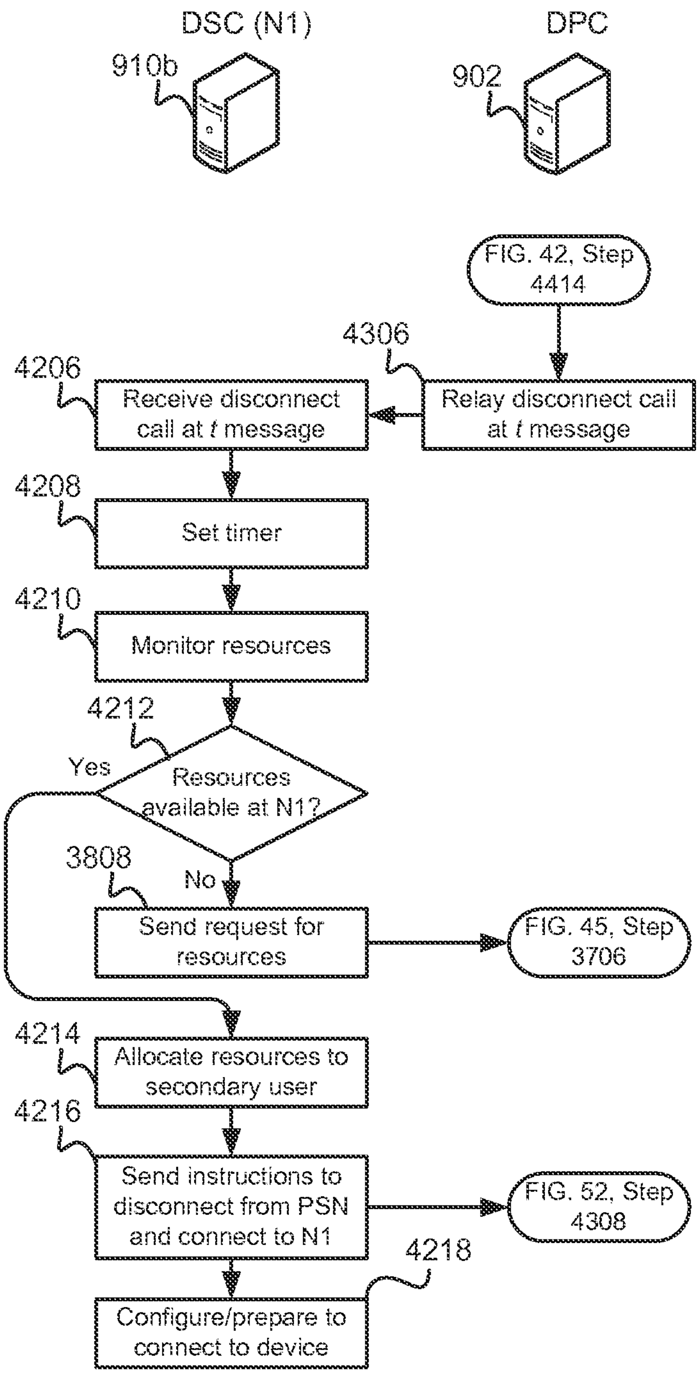

DSC (N1)
DPC
PSN
910a
902
910b
FIG. 47, Step 3830
3644
3746
3836
Receive invoice and payment instruction
Relay invoice and payment instructions
Send invoice and payment instructions
3748
3838
Receive usage parameters and payment instructions
Send usage parameters payment instructions
3750
Create invoice
3646
3752
Receive invoice and payment instruction
Send invoice and payment instruction
3840
3648
Settlement
Settlement

FIG. 49



101
DSC (N1)
DPC
PSN
910a
902
910b
3904
3830
Establish communication session with PSN
Establish communication session with N1 subscriber
3602
Monitor resources vs. bandwidth traffic
3702
3604
Receive report
Report resources status
4404
Network volume > capacity threshold?
No
Yes
FIG. 53, Step 3816
4406
Identify users
4408
secondary user?
No
Yes
4410
FIG. 51, Step 4306
Send disconnect session at t message
4412
Terminate communication session
4414
secondary user present?
No
4416
Keep/Drop session based on TPA

FIG. 50



DSC (N1)
910b
DPC
902
FIG. 42, Step 4414
4306
Relay disconnect call at t message
4206
Receive disconnect call at t message
4208
Set timer
4210
Monitor resources
4212
Yes
Resources available at N1?
No
3808
Send request for resources
FIG. 45, Step 3706
4214
Allocate resources to secondary user
4216
Send instructions to disconnect from PSN and connect to N1
FIG. 52, Step 4308
4218
Configure/prepare to connect to device

FIG. 51

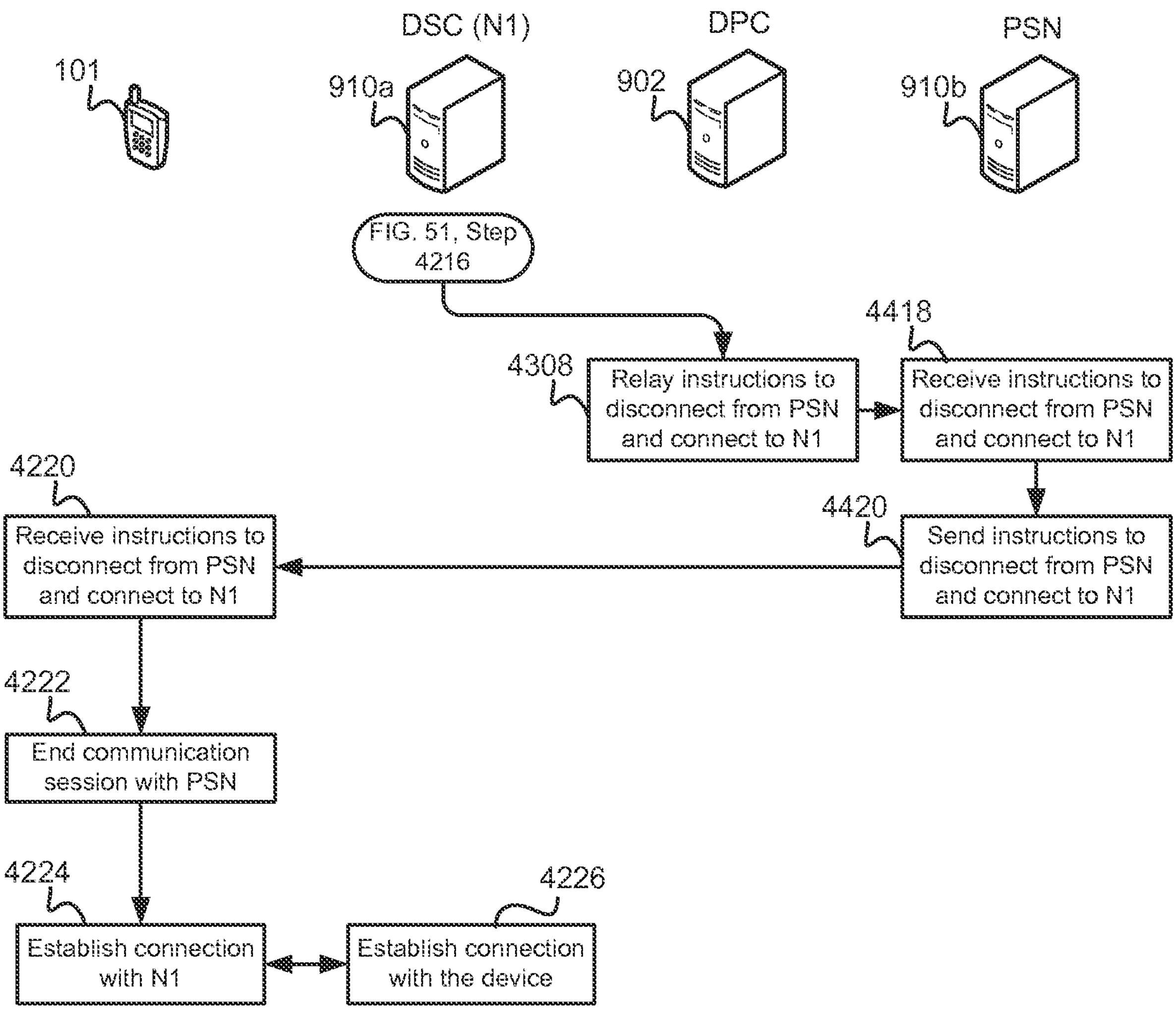

DSC (N1)
DPC
PSN
101
910a
902
910b
FIG. 51, Step 4216
4418
4308
Relay instructions to disconnect from PSN and connect to N1
Receive instructions to disconnect from PSN and connect to N1
4220
4420
Receive instructions to disconnect from PSN and connect to N1
Send instructions to disconnect from PSN and connect to N1
4222
End communication session with PSN
4224
4226
Establish connection with N1
Establish connection with the device

FIG. 52

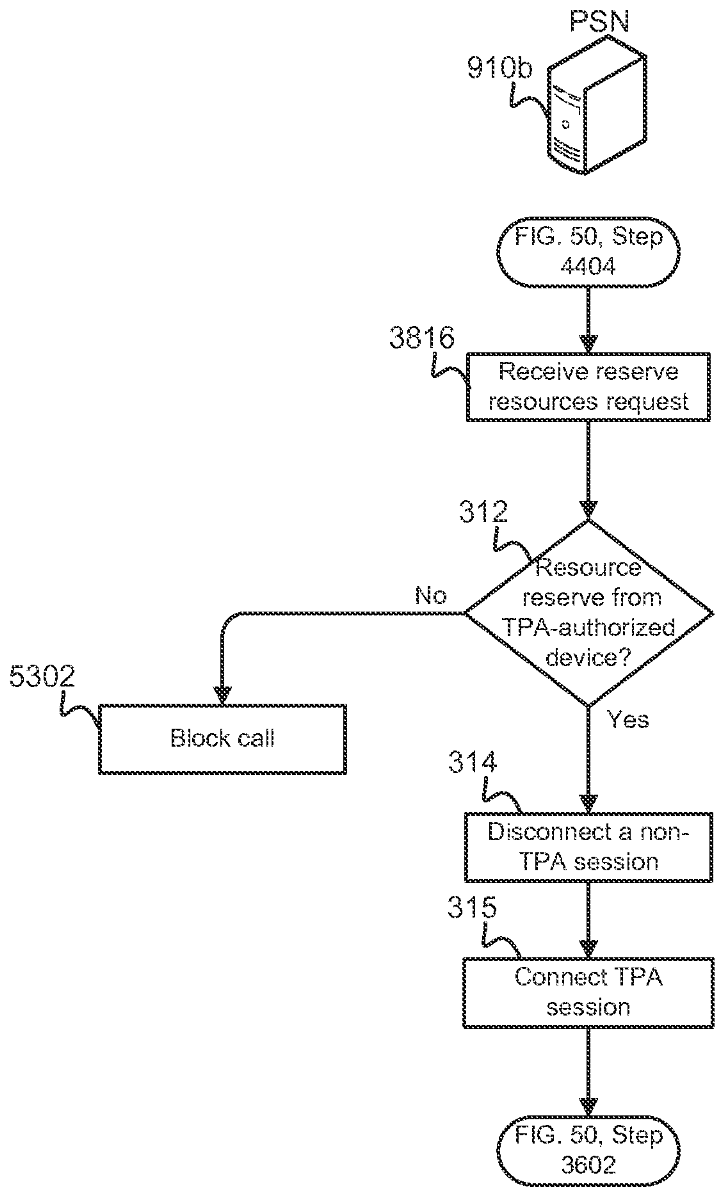

PSN
910b
FIG. 50, Step 4404
3816
Receive reserve resources request
312
Resource reserve from TPA-authorized device?
No
Yes
5302
Block call
314
Disconnect a non-TPA session
315
Connect TPA session
FIG. 50, Step 3602

FIG. 53

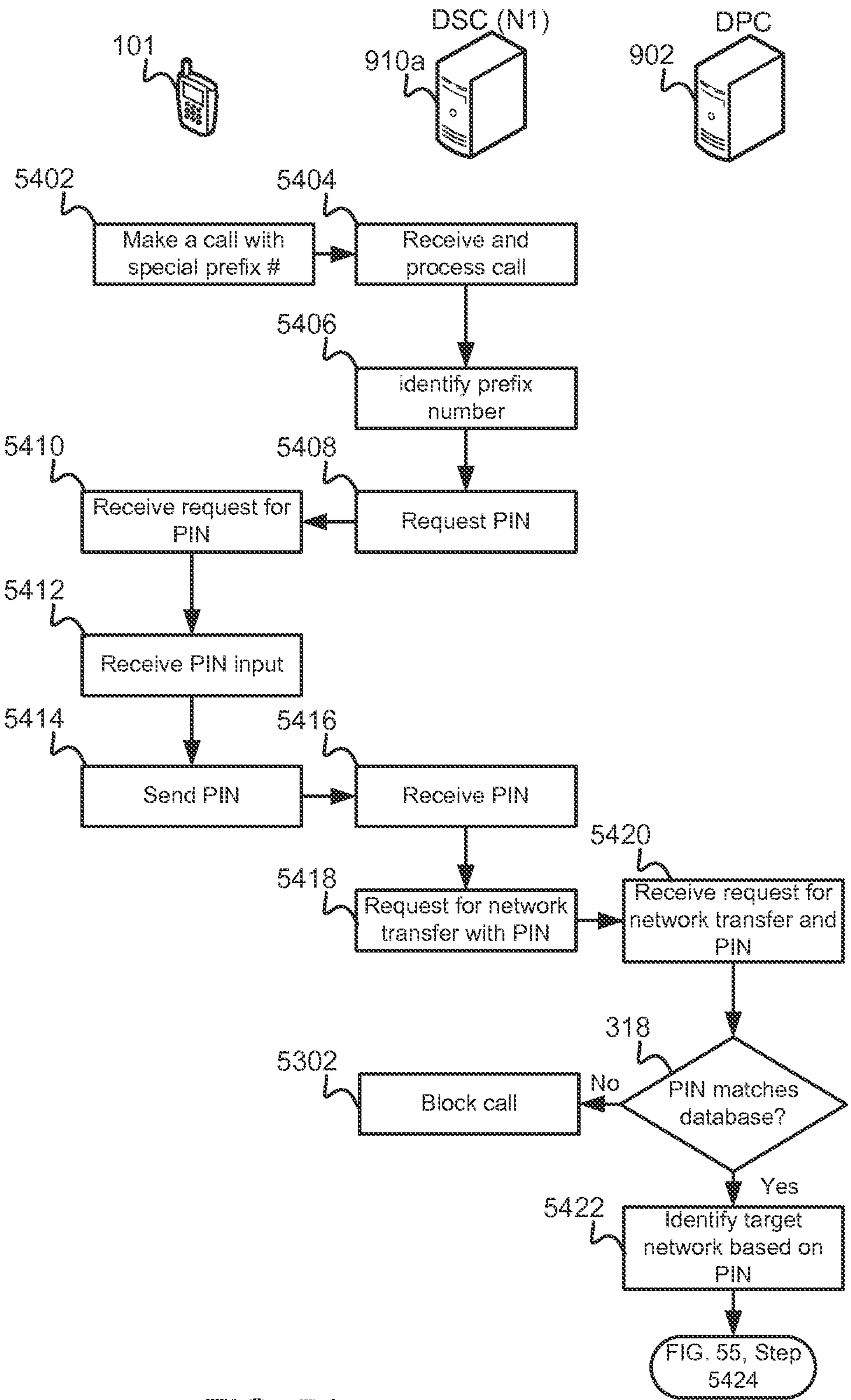

101
DSC (N1)
910a
DPC
902
5402
Make a call with special prefix #
5404
Receive and process call
5406
identify prefix number
5410
Receive request for PIN
5408
Request PIN
5412
Receive PIN input
5414
Send PIN
5416
Receive PIN
5420
5418
Request for network transfer with PIN
Receive request for network transfer and PIN
318
5302
Block call
No
PIN matches database?
Yes
5422
Identify target network based on PIN
FIG. 55, Step 5424

FIG. 54

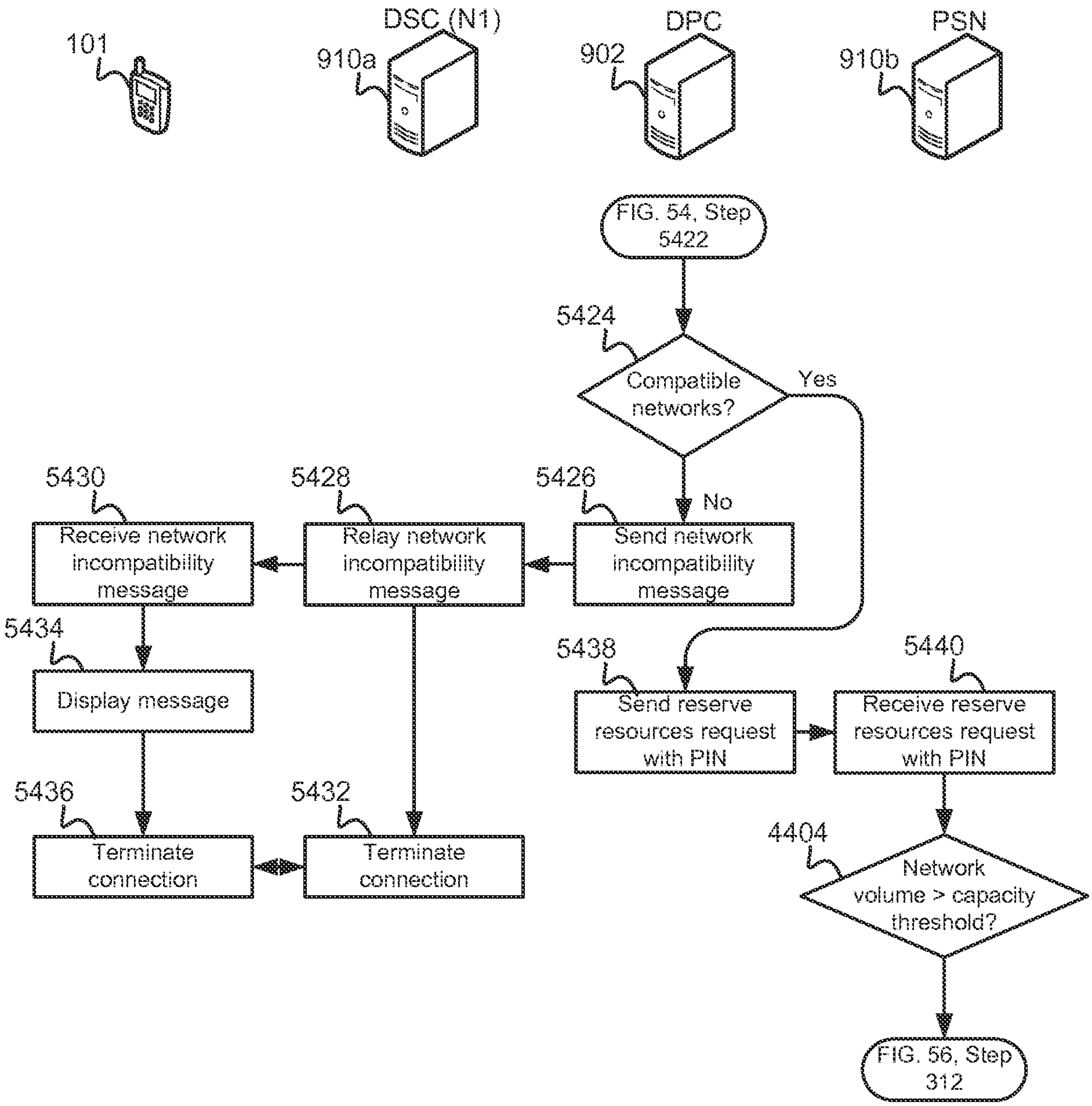

101
DSC (N1)
910a
DPC
902
PSN
910b
FIG. 54, Step 5422
5424
Compatible networks?
Yes
No
5430
Receive network incompatibility message
5428
Relay network incompatibility message
5426
Send network incompatibility message
5434
Display message
5438
Send reserve resources request with PIN
5440
Receive reserve resources request with PIN
5436
Terminate connection
5432
Terminate connection
4404
Network volume > capacity threshold?
FIG. 56, Step 312

FIG. 55

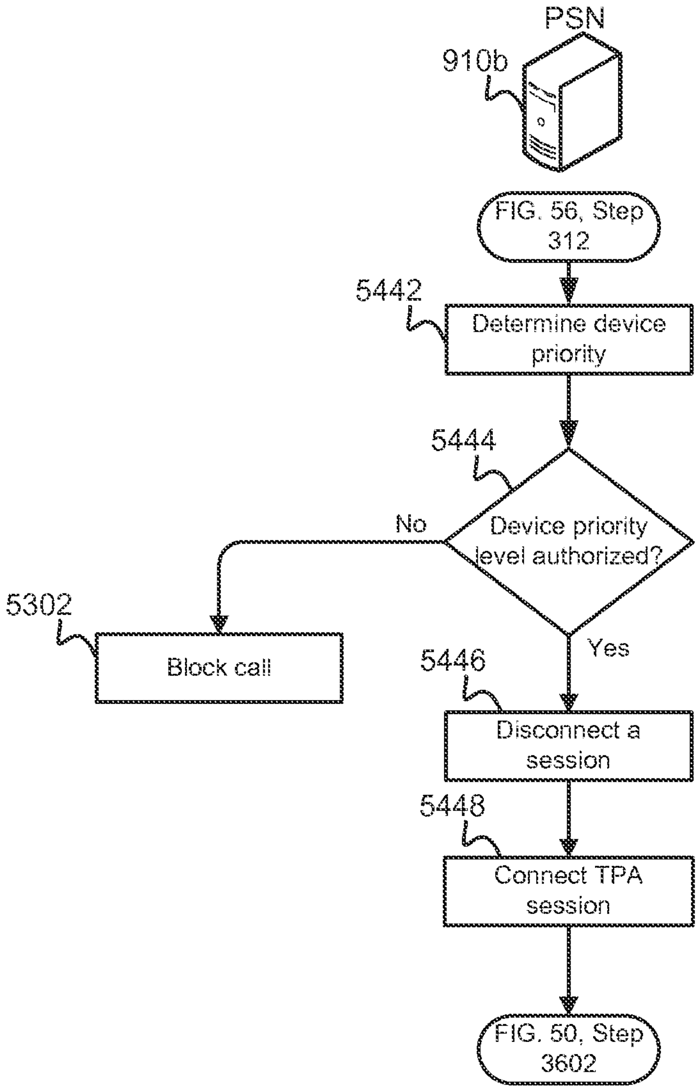

PSN
910b
FIG. 56, Step 312
5442
Determine device priority
5444
Device priority level authorized?
No
5302
Block call
Yes
5446
Disconnect a session
5448
Connect TPA session
FIG. 50, Step 3602

FIG. 56

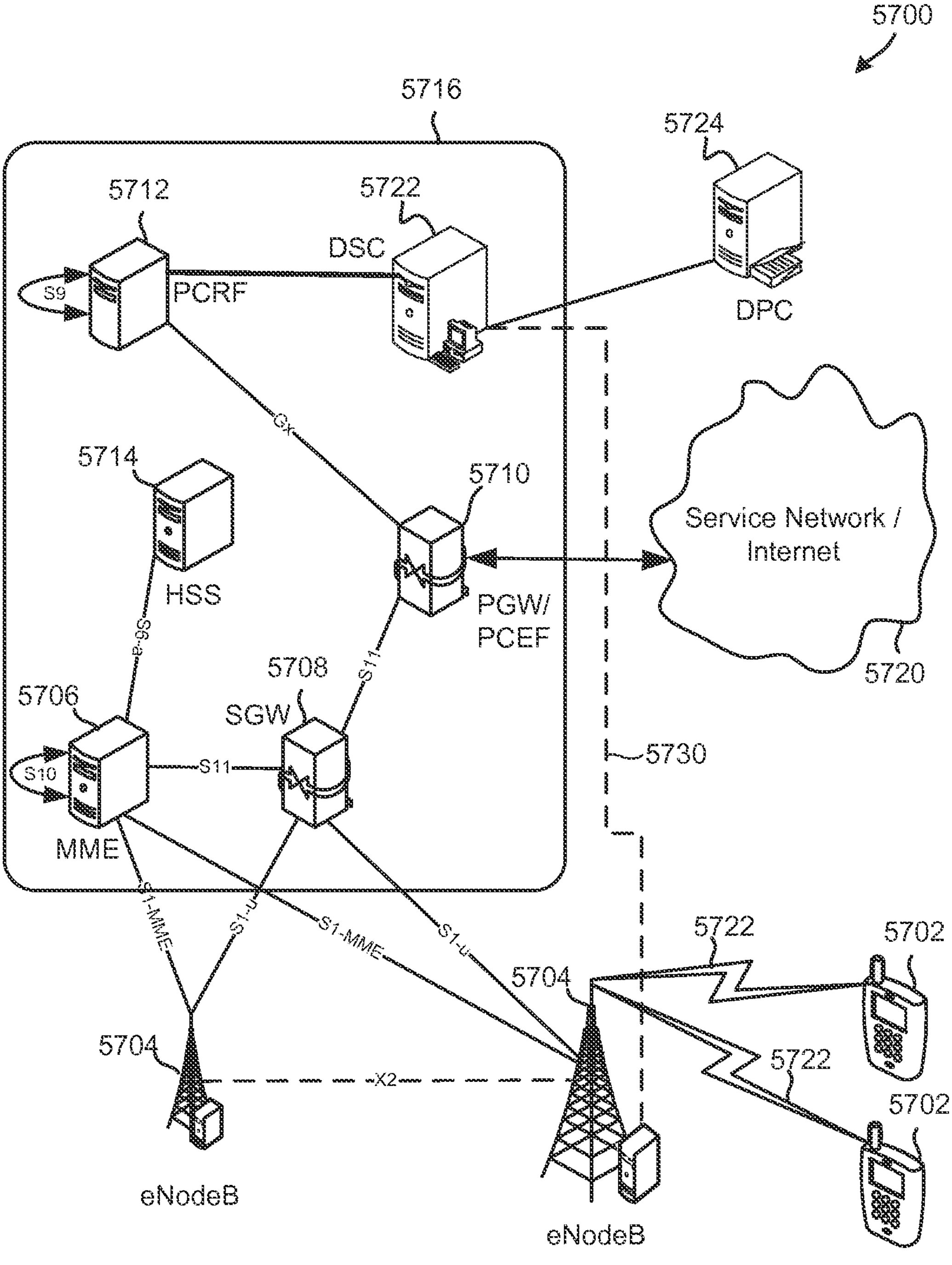
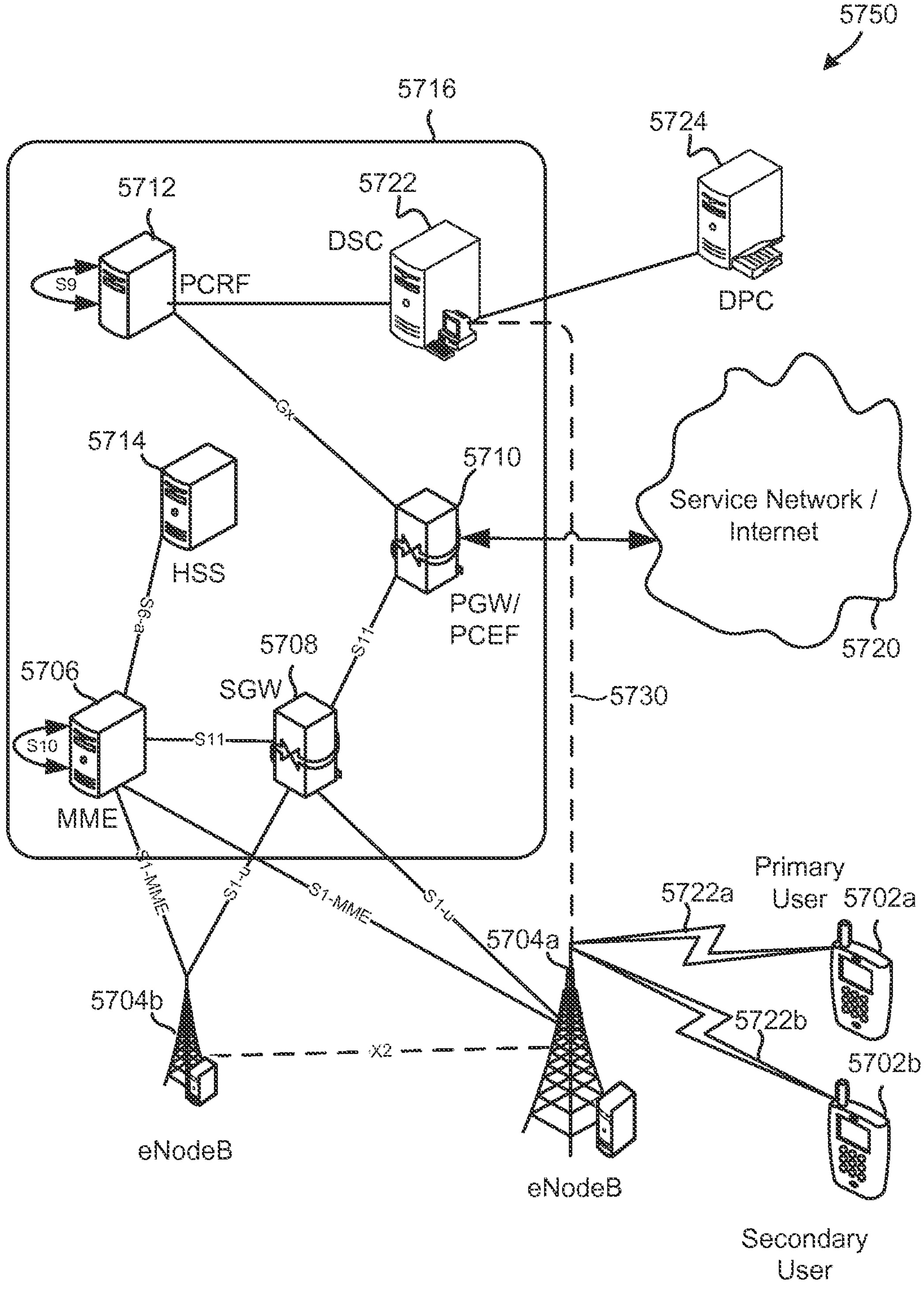
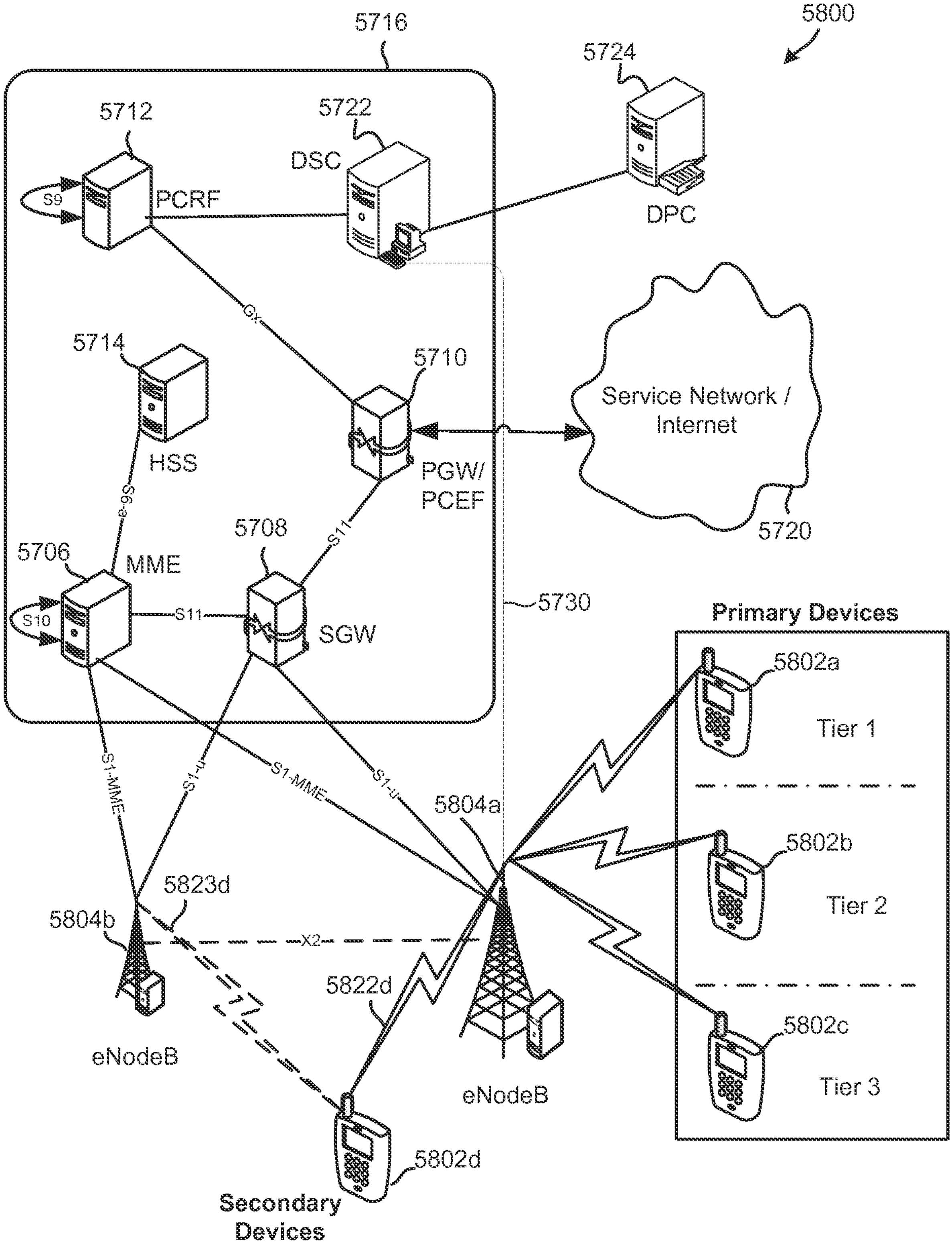

5700
5716
5724
5712
5722
DSC
S9
PCRF
DPC
Gx
5714
5710
Service Network / Internet
HSS
S6a
PGW/ PCEF
5708
5706
S11
SGW
5720
S11
S10
5730
MME
S1-MME
S1-U
S1-MME
S1-U
5722
5702
5704
5704
X2
5722
5702
eNodeB
eNodeB

FIG. 57A



5750
5716
5724
5712
5722
DSC
S9
PCRF
DPC
Gx
5714
5710
Service Network / Internet
HSS
S6-a
PGW/ PCEF
S11
5708
5706
SGW
5720
5730
S10
S11
MME
S1-MME
S1-u
S1-MME
S1-u
Primary User
5722a
5702a
5704a
5704b
5722b
X2
5702b
eNodeB
eNodeB
Secondary User

FIG. 57B



5800
5716
5724
5712
5722
DSC
S9
PCRF
DPC
Gx
5714
5710
Service Network / Internet
HSS
S6-a
PGW/ PCEF
5708
5720
5706
MME
S11
S10
S11
SGW
5730
Primary Devices
5802a
Tier 1
S1-MME
S1-u
S1-MME
S1-u
5804a
5802b
Tier 2
5823d
5804b
X2
5822d
5802c
Tier 3
eNodeB
eNodeB
5802d
Secondary Devices

FIG. 58

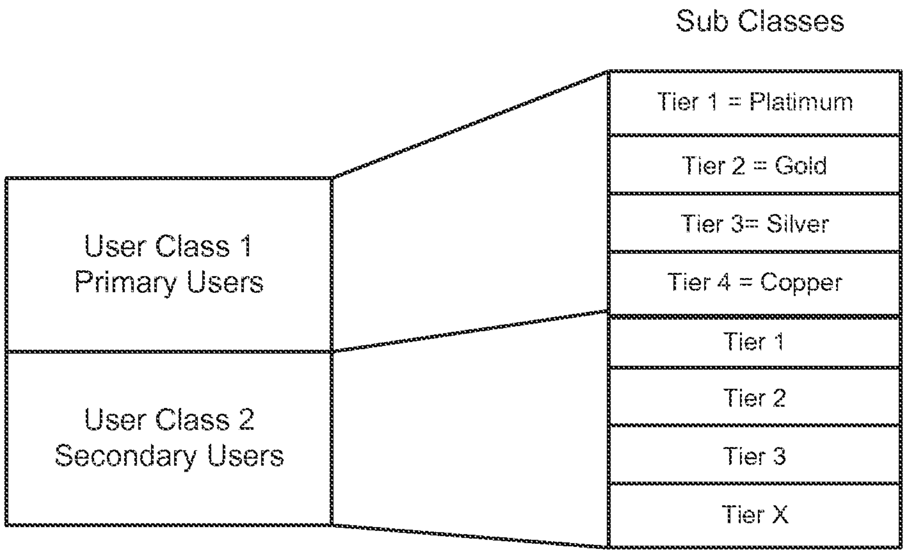


FIG. 59A

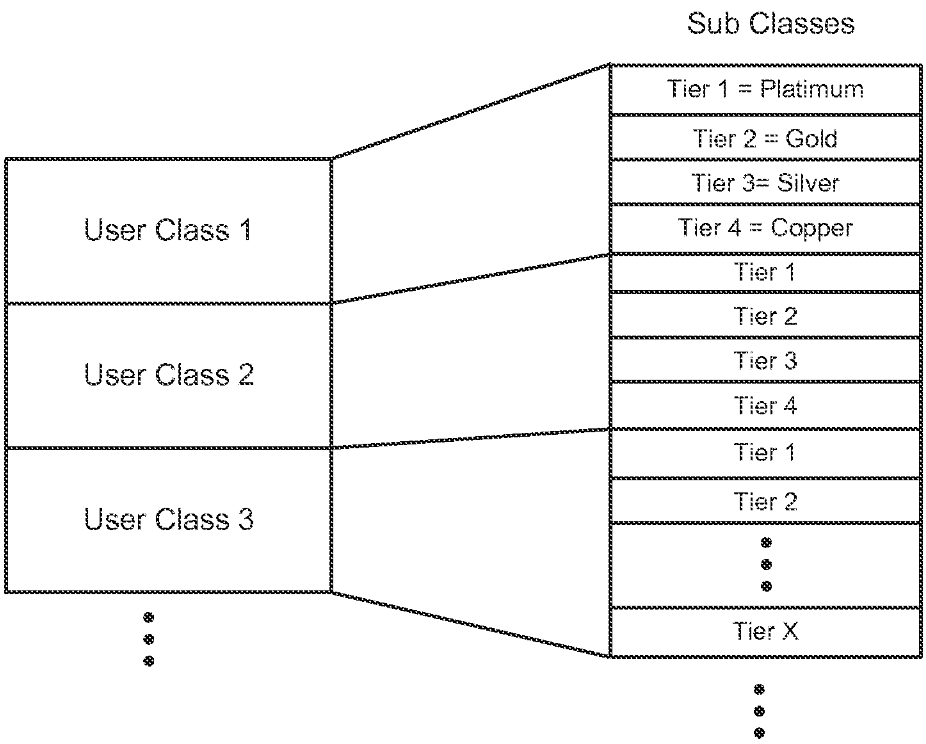


FIG. 59B

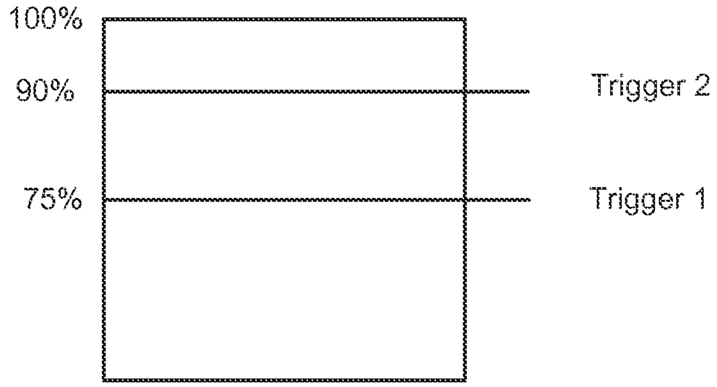


FIG. 60A

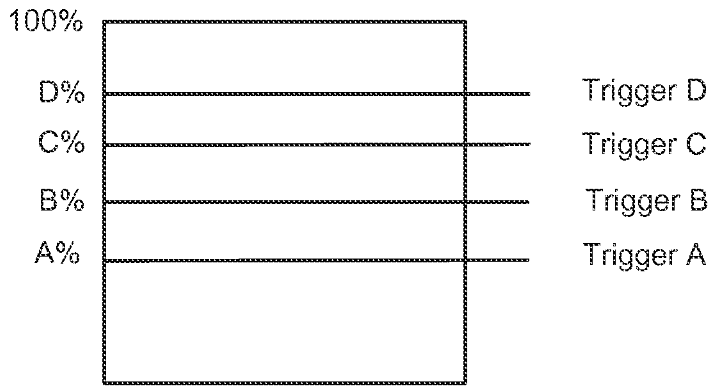


FIG. 60B

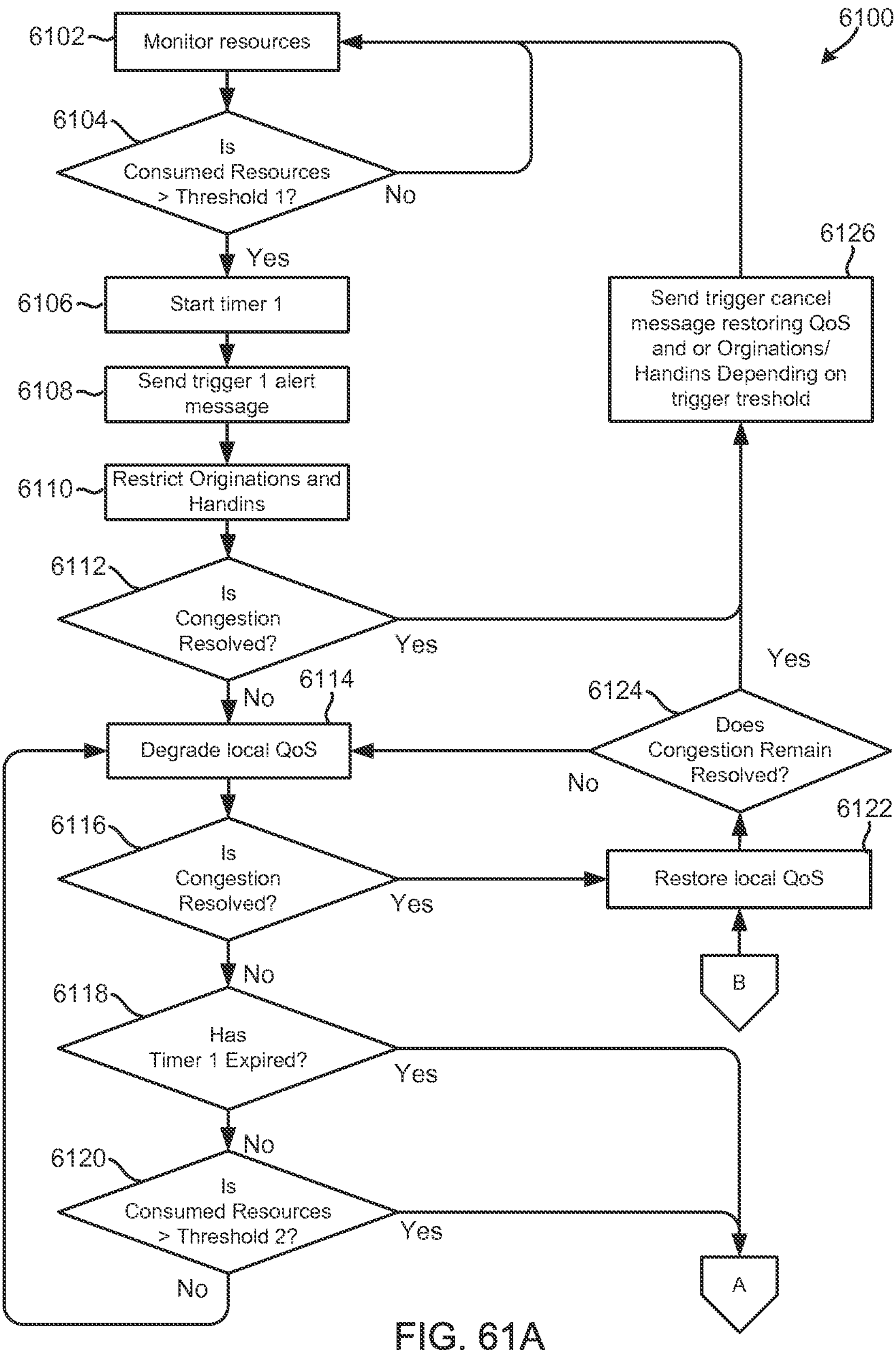

6100
6102
Monitor resources
6104
Is Consumed Resources > Threshold 1?
No
Yes
6106
Start timer 1
6108
Send trigger 1 alert message
6110
Restrict Originations and Handins
6112
Is Congestion Resolved?
Yes
No
6114
Degrade local QoS
6116
Is Congestion Resolved?
Yes
No
6118
Has Timer 1 Expired?
Yes
No
6120
Is Consumed Resources > Threshold 2?
Yes
No
6126
Send trigger cancel message restoring QoS and or Orginations/ Handins Depending on trigger treshold
6124
Does Congestion Remain Resolved?
Yes
No
6122
Restore local QoS
B
A

FIG. 61A

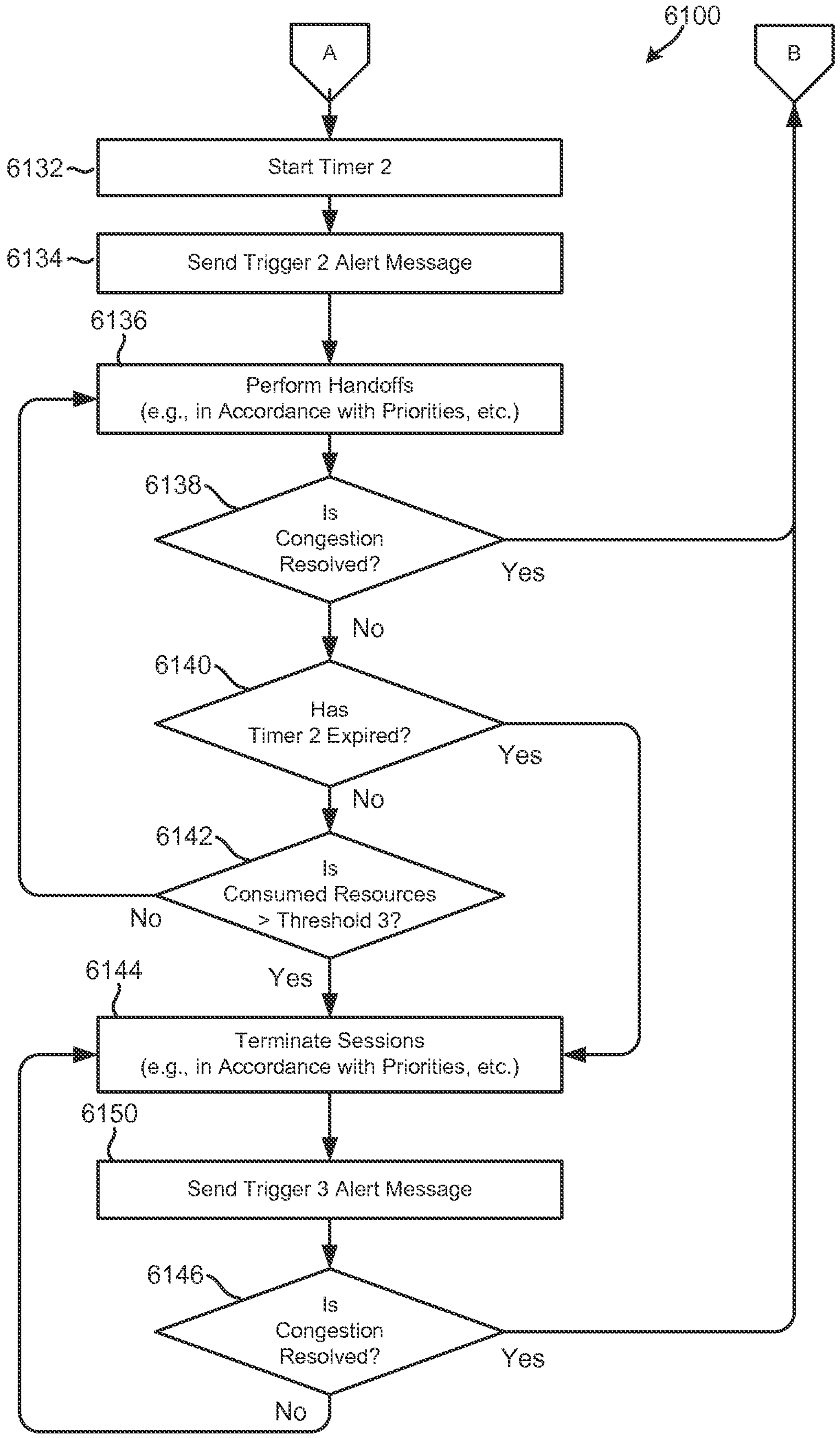

6100
A
B
6132
Start Timer 2
6134
Send Trigger 2 Alert Message
6136
Perform Handoffs
(e.g., in Accordance with Priorities, etc.)
6138
Is
Congestion
Resolved?
Yes
No
6140
Has
Timer 2 Expired?
Yes
No
6142
Is
Consumed Resources
> Threshold 3?
No
Yes
6144
Terminate Sessions
(e.g., in Accordance with Priorities, etc.)
6150
Send Trigger 3 Alert Message
6146
Is
Congestion
Resolved?
Yes
No

FIG. 61B

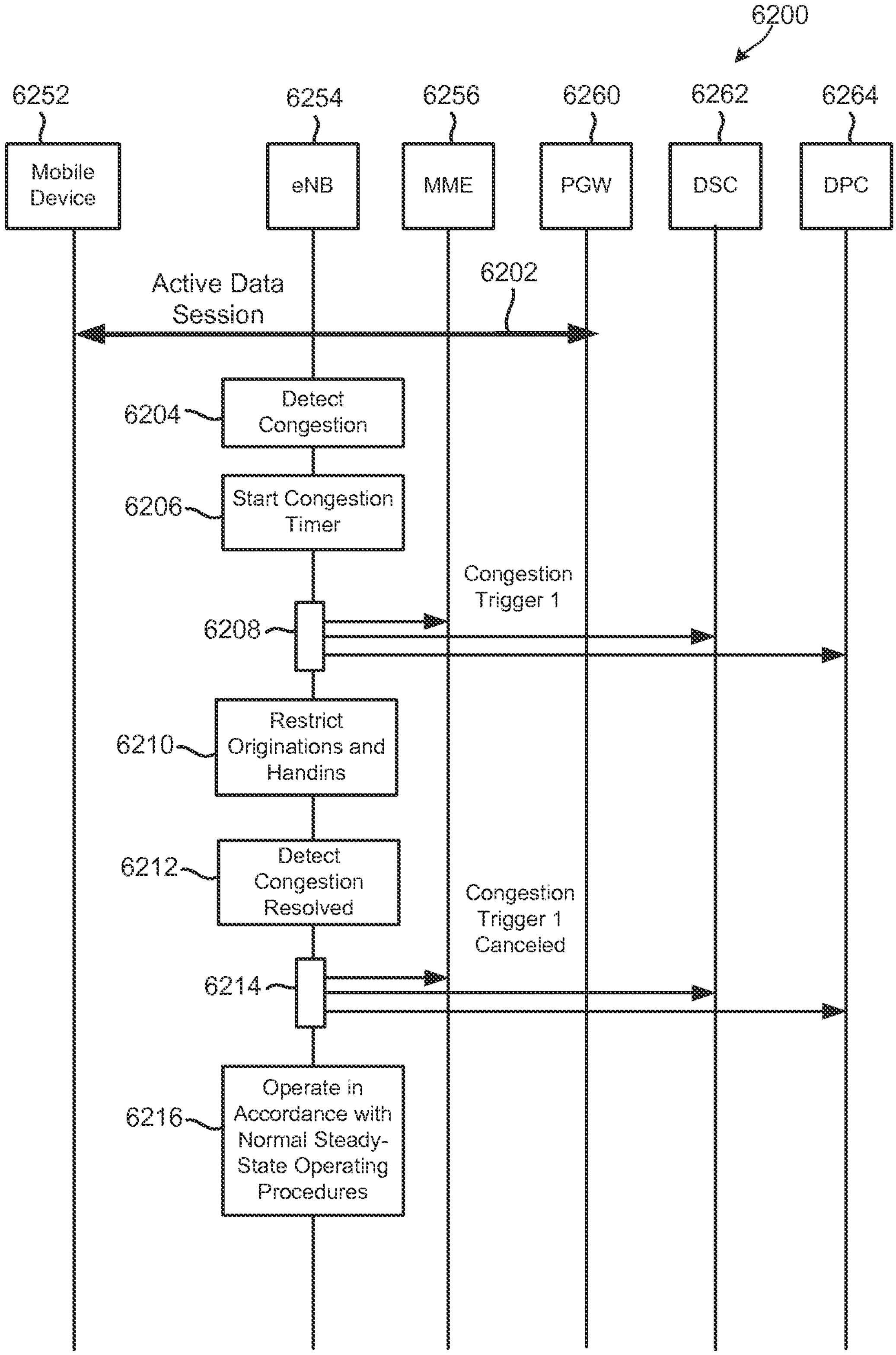

6200
6252
6254
6256
6260
6262
6264
Mobile Device
eNB
MME
PGW
DSC
DPC
Active Data Session
6202
6204
Detect Congestion
6206
Start Congestion Timer
Congestion Trigger 1
6208
6210
Restrict Originations and Handins
6212
Detect Congestion Resolved
Congestion Trigger 1 Canceled
6214
6216
Operate in Accordance with Normal Steady-State Operating Procedures

FIG. 62

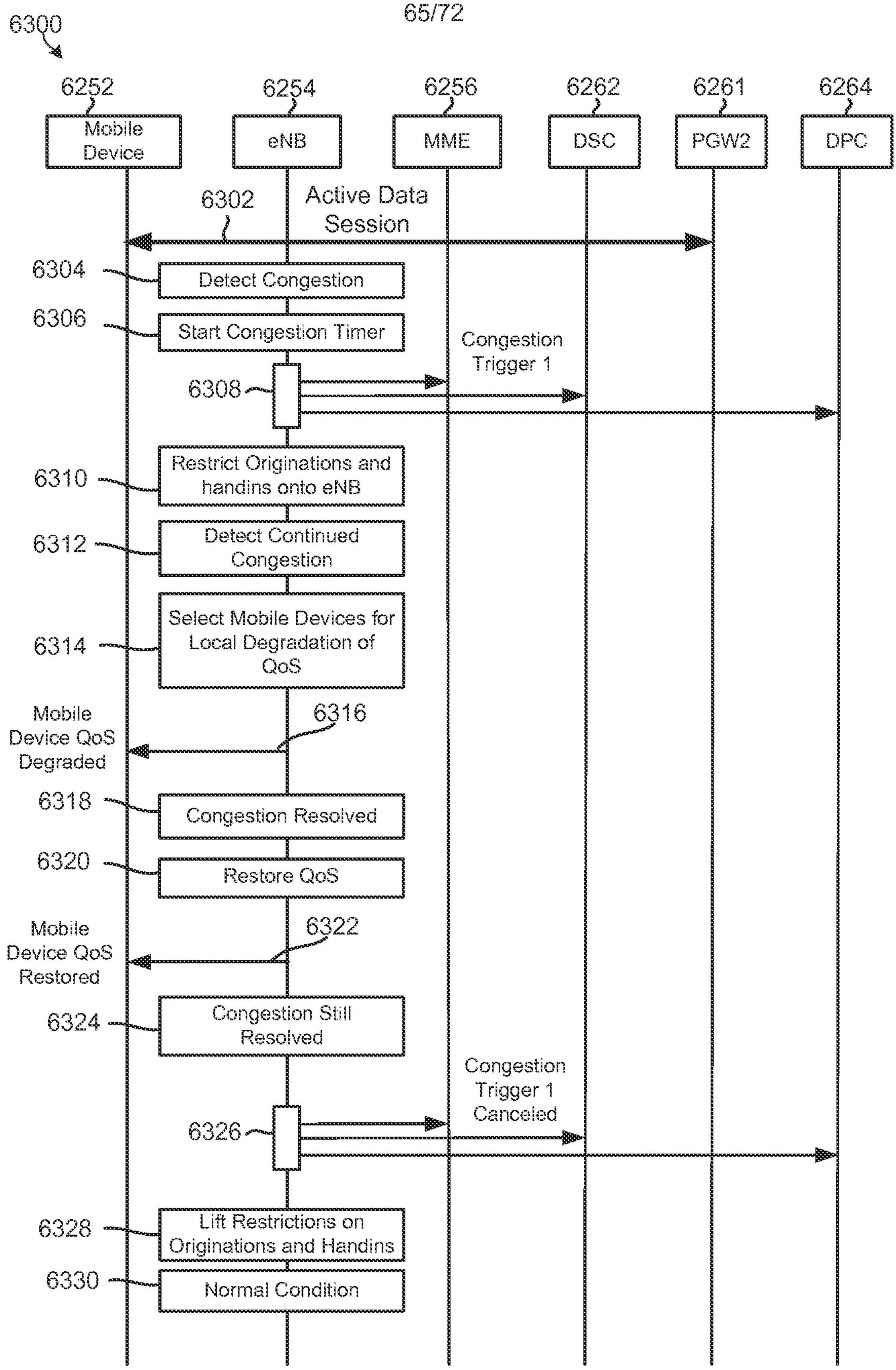

6300
6252
Mobile Device
6254
eNB
6256
MME
6262
DSC
6261
PGW2
6264
DPC
6302
Active Data Session
6304
Detect Congestion
6306
Start Congestion Timer
Congestion Trigger 1
6308
6310
Restrict Originations and handins onto eNB
6312
Detect Continued Congestion
6314
Select Mobile Devices for Local Degradation of QoS
Mobile Device QoS Degraded
6316
6318
Congestion Resolved
6320
Restore QoS
Mobile Device QoS Restored
6322
6324
Congestion Still Resolved
Congestion Trigger 1 Canceled
6326
6328
Lift Restrictions on Originations and Handins
6330
Normal Condition

FIG. 63

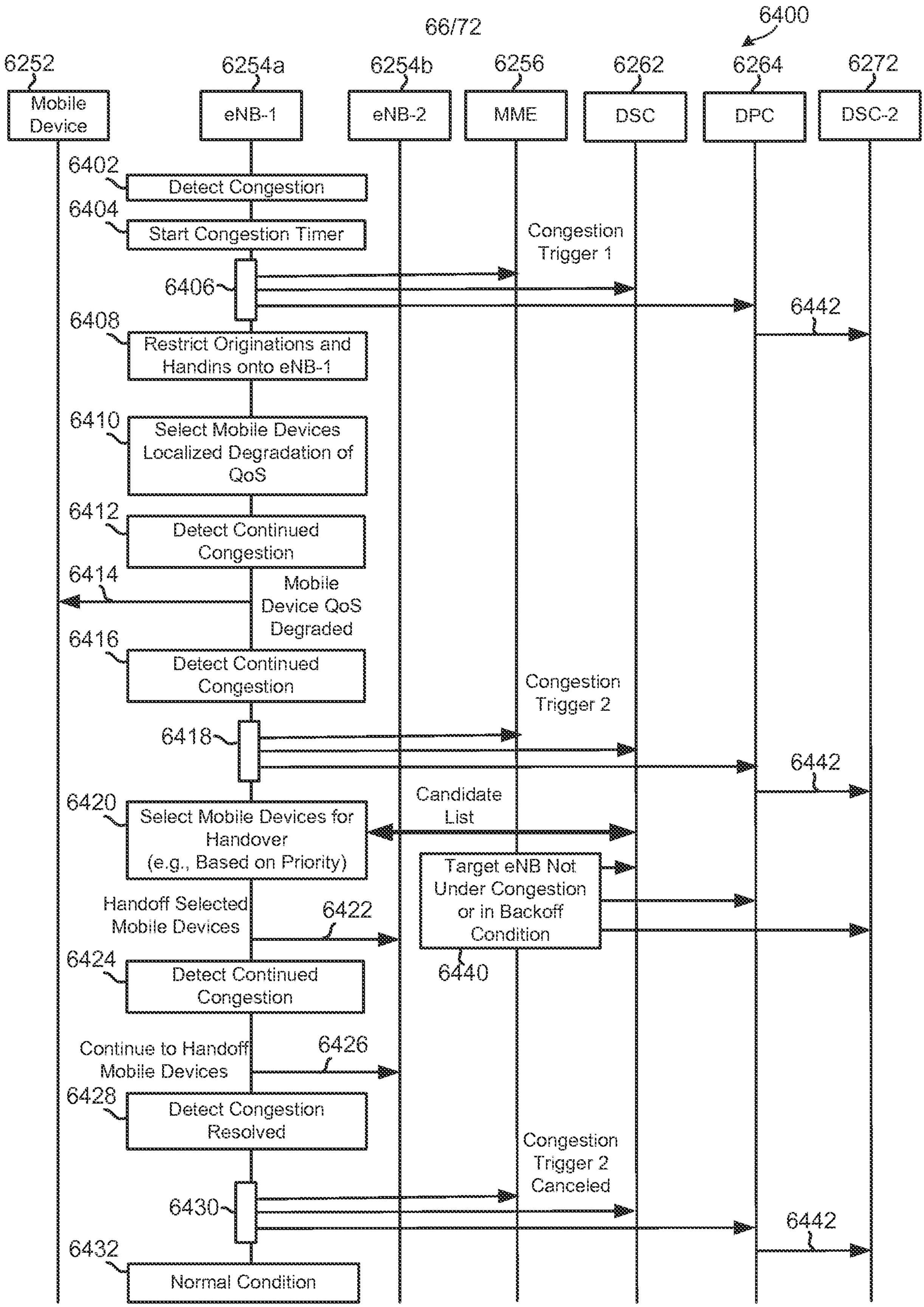
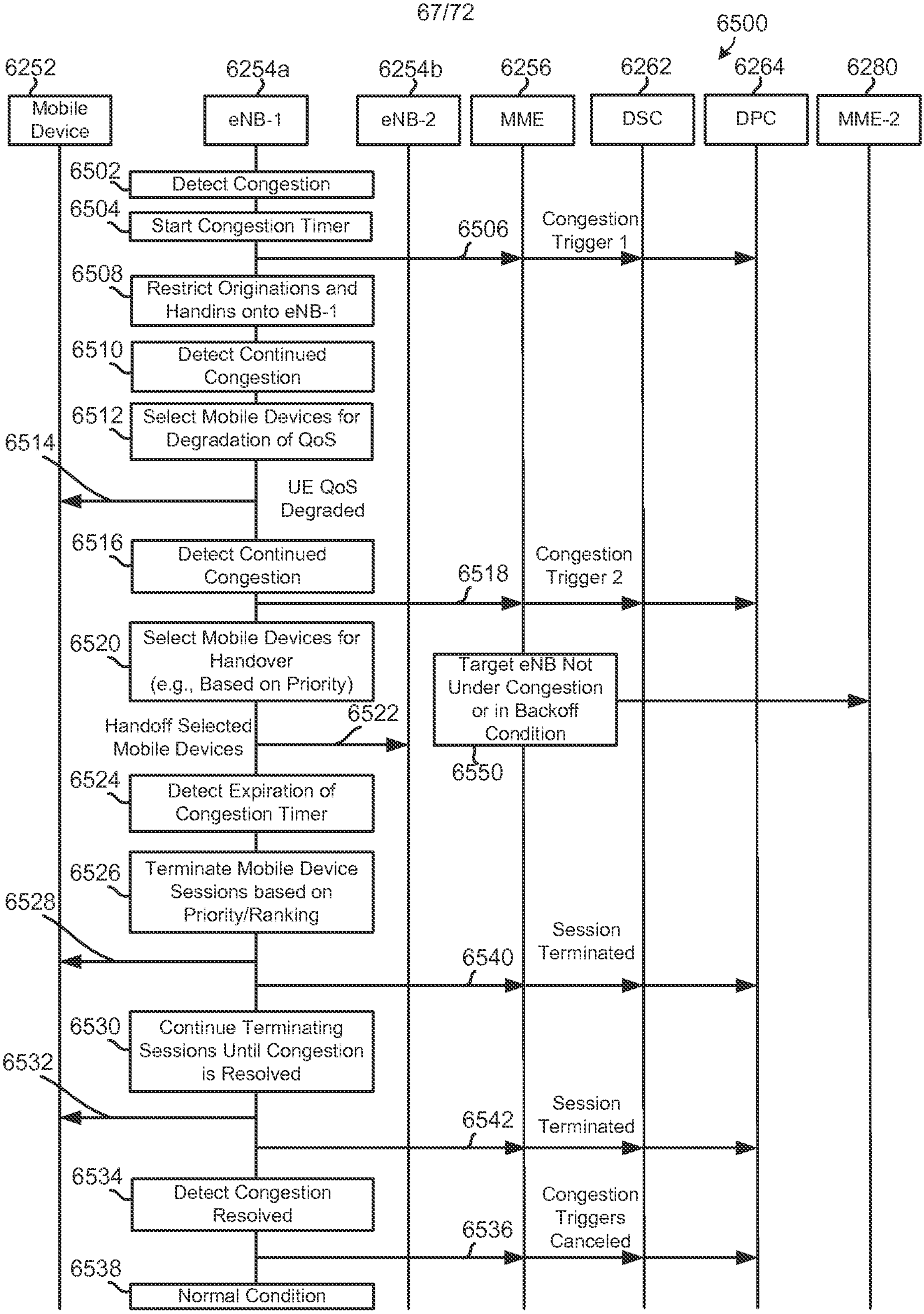

6400
6252
Mobile Device
6254a
eNB-1
6254b
eNB-2
6256
MME
6262
DSC
6264
DPC
6272
DSC-2
6402
Detect Congestion
6404
Start Congestion Timer
Congestion Trigger 1
6406
6442
6408
Restrict Originations and Handins onto eNB-1
6410
Select Mobile Devices Localized Degradation of QoS
6412
Detect Continued Congestion
6414
Mobile Device QoS Degraded
6416
Detect Continued Congestion
Congestion Trigger 2
6418
6442
6420
Select Mobile Devices for Handover (e.g., Based on Priority)
Candidate List
Target eNB Not Under Congestion or in Backoff Condition
6440
Handoff Selected Mobile Devices
6422
6424
Detect Continued Congestion
Continue to Handoff Mobile Devices
6426
6428
Detect Congestion Resolved
Congestion Trigger 2 Canceled
6430
6442
6432
Normal Condition

FIG. 64



6500
6252
Mobile Device
6254a
eNB-1
6254b
eNB-2
6256
MME
6262
DSC
6264
DPC
6280
MME-2
6502
Detect Congestion
6504
Start Congestion Timer
6506
Congestion Trigger 1
6508
Restrict Originations and Handins onto eNB-1
6510
Detect Continued Congestion
6512
Select Mobile Devices for Degradation of QoS
6514
UE QoS Degraded
6516
Detect Continued Congestion
6518
Congestion Trigger 2
6520
Select Mobile Devices for Handover (e.g., Based on Priority)
Target eNB Not Under Congestion or in Backoff Condition
6550
Handoff Selected Mobile Devices
6522
6524
Detect Expiration of Congestion Timer
6526
Terminate Mobile Device Sessions based on Priority/Ranking
6528
6540
Session Terminated
6530
Continue Terminating Sessions Until Congestion is Resolved
6532
6542
Session Terminated
6534
Detect Congestion Resolved
6536
Congestion Triggers Canceled
6538
Normal Condition

FIG. 65

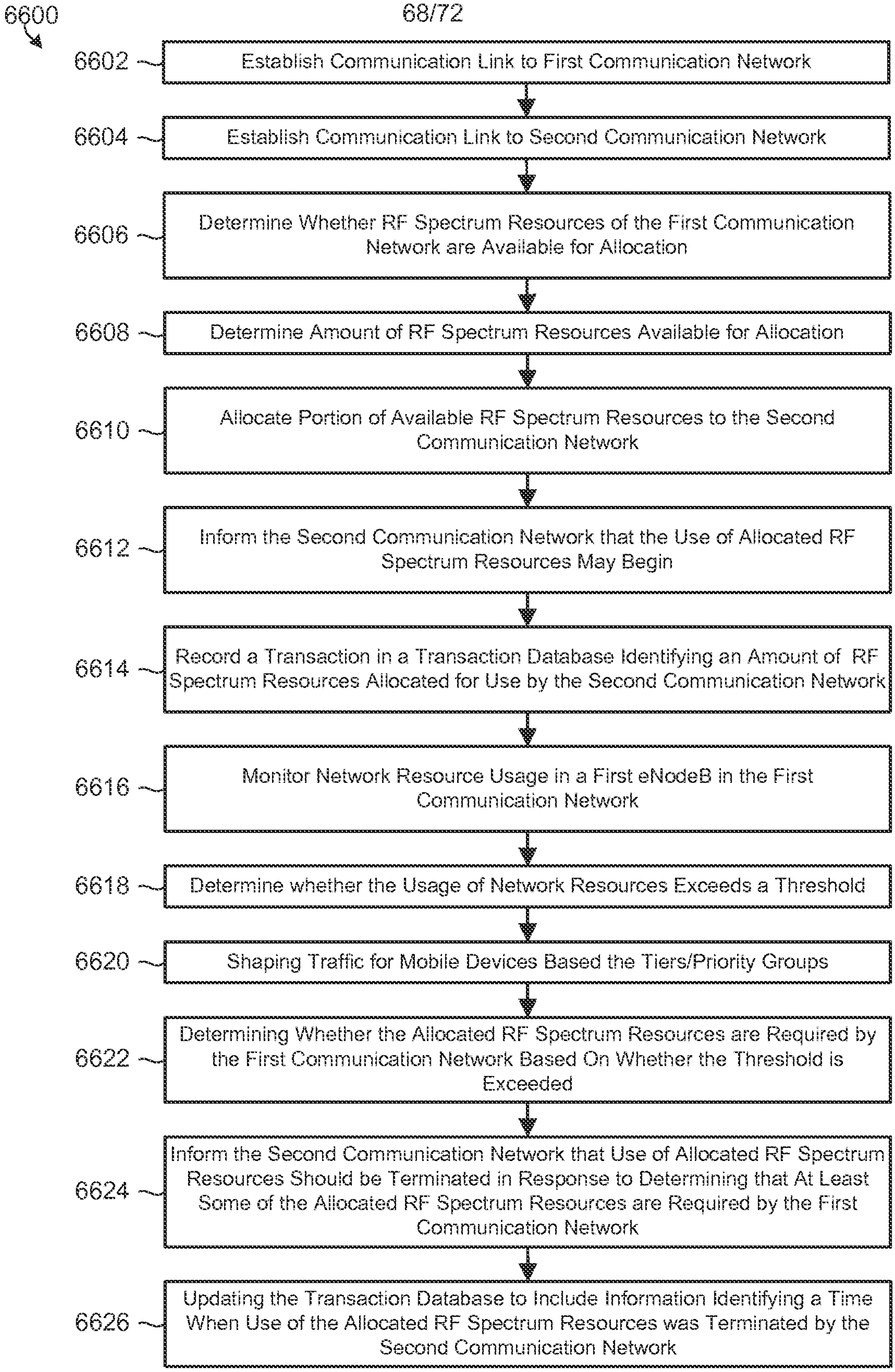

6600
6602
Establish Communication Link to First Communication Network
6604
Establish Communication Link to Second Communication Network
6606
Determine Whether RF Spectrum Resources of the First Communication Network are Available for Allocation
6608
Determine Amount of RF Spectrum Resources Available for Allocation
6610
Allocate Portion of Available RF Spectrum Resources to the Second Communication Network
6612
Inform the Second Communication Network that the Use of Allocated RF Spectrum Resources May Begin
6614
Record a Transaction in a Transaction Database Identifying an Amount of RF Spectrum Resources Allocated for Use by the Second Communication Network
6616
Monitor Network Resource Usage in a First eNodeB in the First Communication Network
6618
Determine whether the Usage of Network Resources Exceeds a Threshold
6620
Shaping Traffic for Mobile Devices Based the Tiers/Priority Groups
6622
Determining Whether the Allocated RF Spectrum Resources are Required by the First Communication Network Based On Whether the Threshold is Exceeded
6624
Inform the Second Communication Network that Use of Allocated RF Spectrum Resources Should be Terminated in Response to Determining that At Least Some of the Allocated RF Spectrum Resources are Required by the First Communication Network
6626
Updating the Transaction Database to Include Information Identifying a Time When Use of the Allocated RF Spectrum Resources was Terminated by the Second Communication Network

FIG. 66

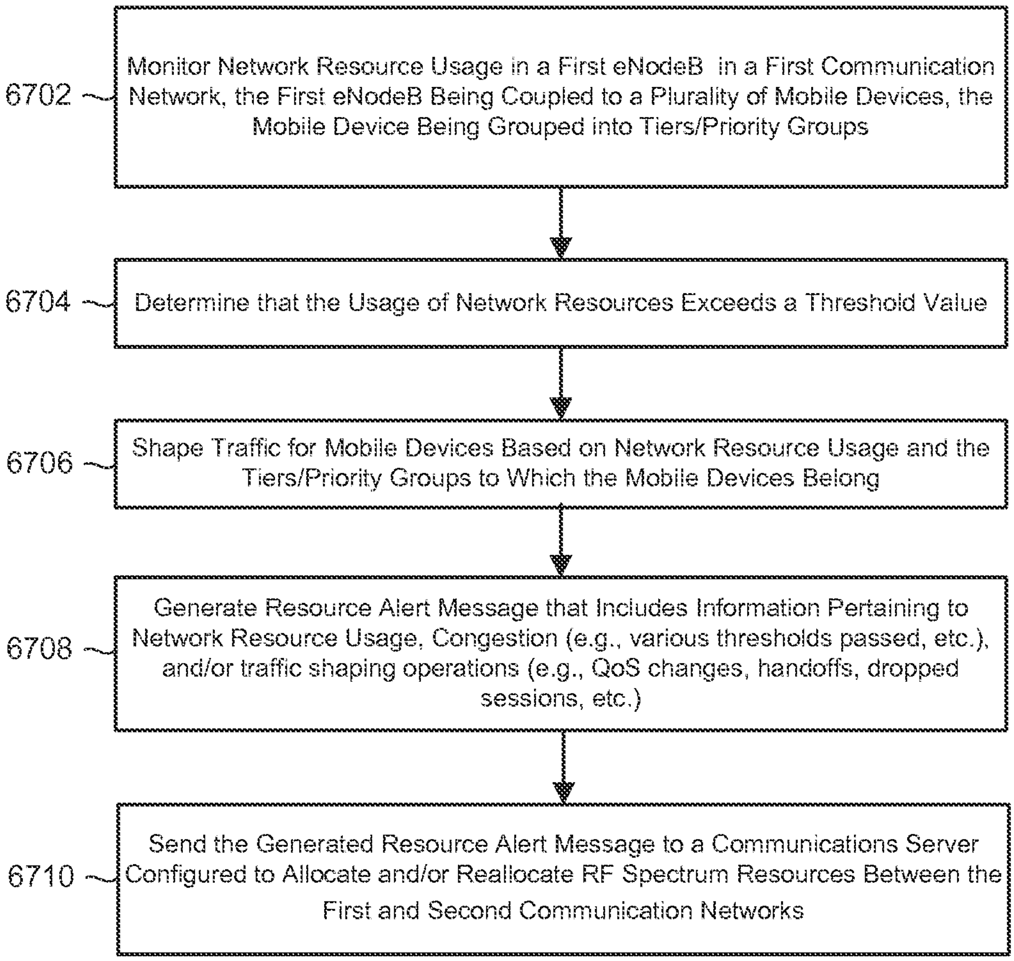

6702
Monitor Network Resource Usage in a First eNodeB in a First Communication Network, the First eNodeB Being Coupled to a Plurality of Mobile Devices, the Mobile Device Being Grouped into Tiers/Priority Groups
6704
Determine that the Usage of Network Resources Exceeds a Threshold Value
6706
Shape Traffic for Mobile Devices Based on Network Resource Usage and the Tiers/Priority Groups to Which the Mobile Devices Belong
6708
Generate Resource Alert Message that Includes Information Pertaining to Network Resource Usage, Congestion (e.g., various thresholds passed, etc.), and/or traffic shaping operations (e.g., QoS changes, handoffs, dropped sessions, etc.)
6710
Send the Generated Resource Alert Message to a Communications Server Configured to Allocate and/or Reallocate RF Spectrum Resources Between the First and Second Communication Networks

FIG. 67

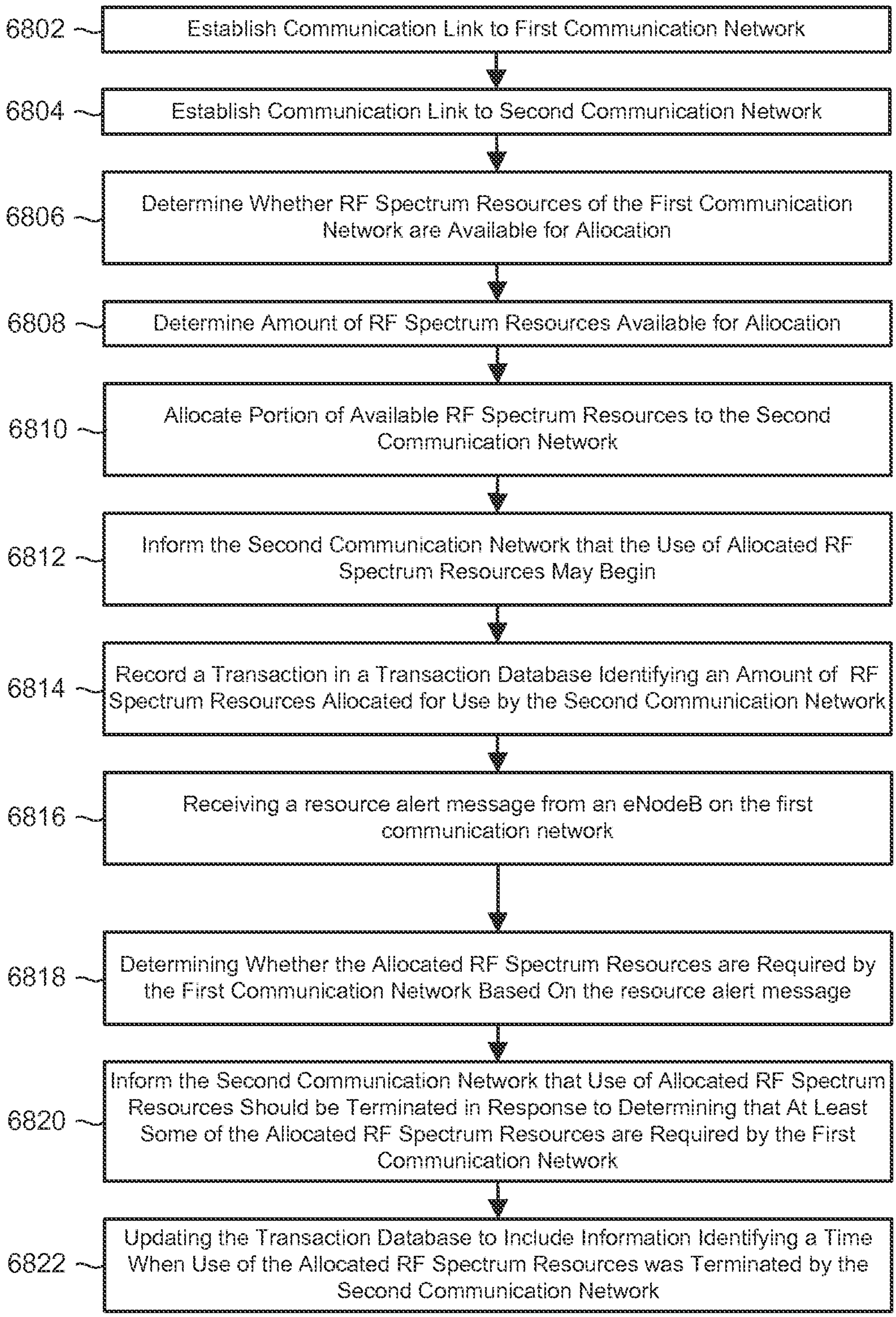

6802
Establish Communication Link to First Communication Network
6804
Establish Communication Link to Second Communication Network
6806
Determine Whether RF Spectrum Resources of the First Communication Network are Available for Allocation
6808
Determine Amount of RF Spectrum Resources Available for Allocation
6810
Allocate Portion of Available RF Spectrum Resources to the Second Communication Network
6812
Inform the Second Communication Network that the Use of Allocated RF Spectrum Resources May Begin
6814
Record a Transaction in a Transaction Database Identifying an Amount of RF Spectrum Resources Allocated for Use by the Second Communication Network
6816
Receiving a resource alert message from an eNodeB on the first communication network
6818
Determining Whether the Allocated RF Spectrum Resources are Required by the First Communication Network Based On the resource alert message
6820
Inform the Second Communication Network that Use of Allocated RF Spectrum Resources Should be Terminated in Response to Determining that At Least Some of the Allocated RF Spectrum Resources are Required by the First Communication Network
6822
Updating the Transaction Database to Include Information Identifying a Time When Use of the Allocated RF Spectrum Resources was Terminated by the Second Communication Network

FIG. 68

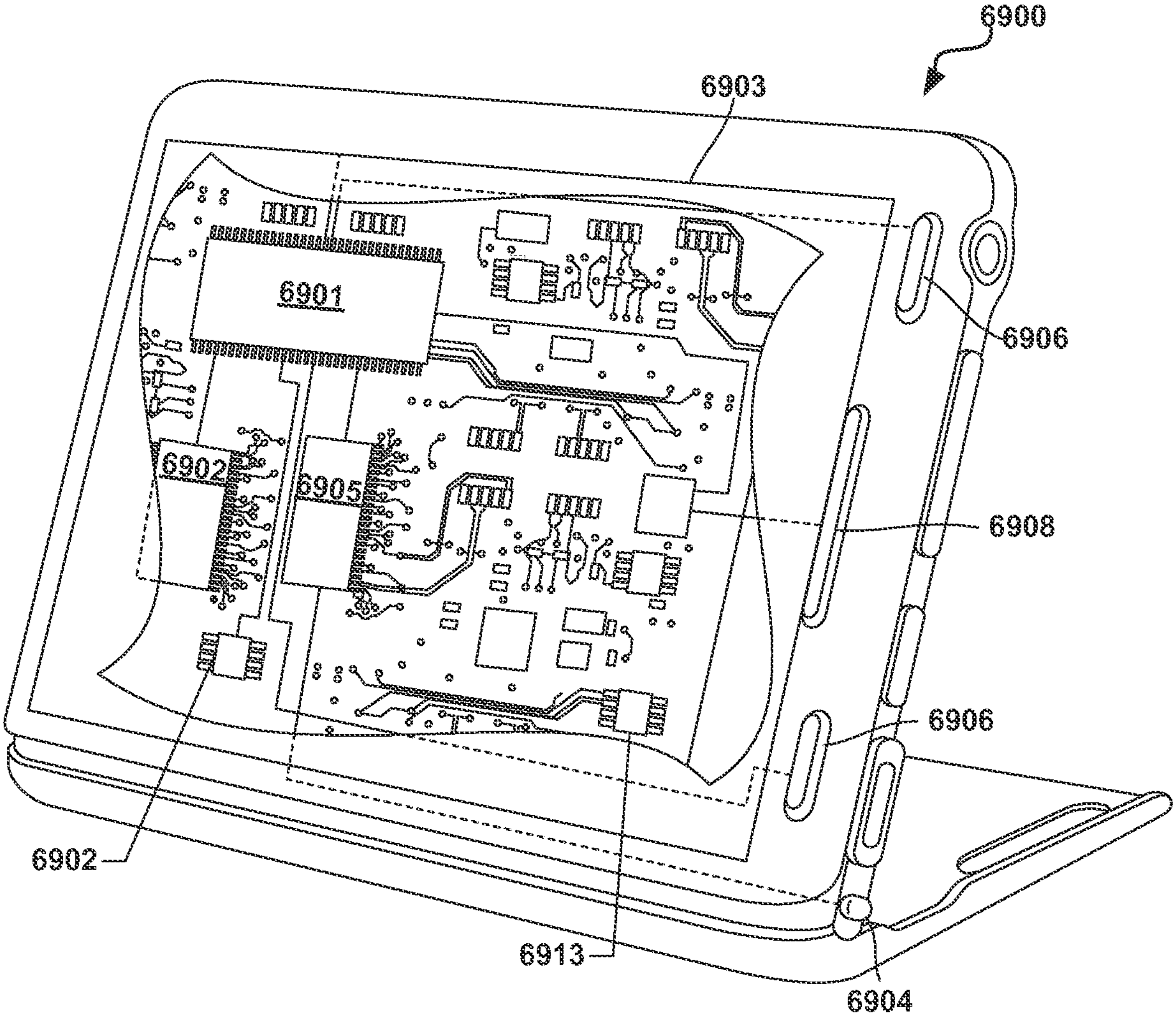


FIG. 69

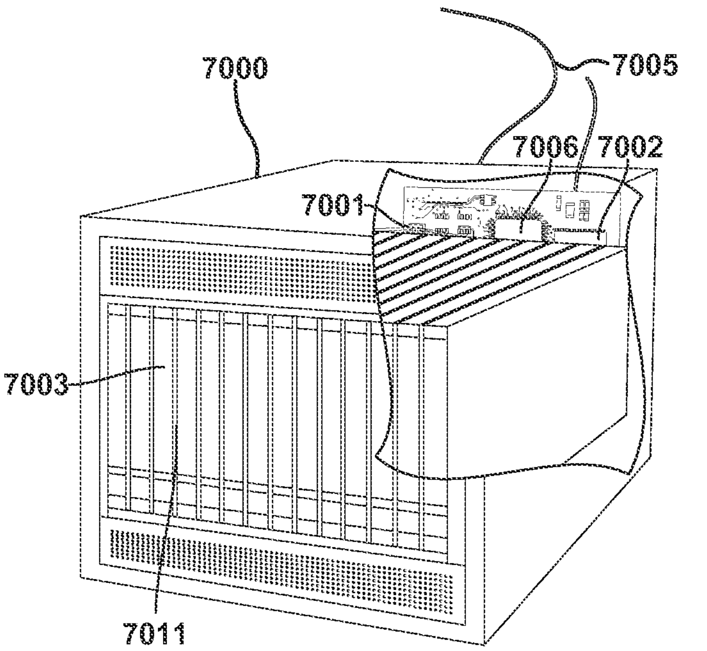


FIG. 70

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2014/017574

A. CLASSIFICATION OF SUBJECT MATTER

H04W 16/02(2009.01)i, H04W 16/14(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)
H04W 16/02; H04B 7/00; H04W 16/10; H04W 72/08; H04W 72/04; H04W 16/14; H04N 21/24

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: dynamic spectrum arbitage, communications server, RF spectrum resource, transaction database, eNodeB, resource alert message

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 8279786 B1 (CLINT SMITH et al.) 02 October 2012 See paragraph [0199]; figure 17; and claims 1-4, 6-8, 17.	1-4,6-12,14-20,22-24 5,13,21 25-37
Y	WO 2012-009557 A2 (RIVADA NETWORKS LLC.) 19 January 2012 See paragraph [0313]; figure 33; and claim 9.	5,13,21
A	US 2010-0009695 A1 (TAE SOO KWON et al.) 14 January 2010 See paragraphs [0115]-[0122]; and figure 8.	1-37
A	WO 2012-134023 A1 (LG ELECTRONICS INC.) 04 October 2012 See paragraphs [0083], [0087], [0097], [0141], [0147]; figures 4, 6(b), 12; and claims 1-4.	1-37
A	US 2012-0304213 A1 (JIHYUN LEE et al.) 29 November 2012 See paragraph [0116]; and figure 10.	1-37

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
09 July 2014 (09.07.2014)	**09 July 2014 (09.07.2014)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
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Facsimile No. +82-42-472-7140

Authorized officer
YANG, Jeong Rok
Telephone No. +82-42-481-5709

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 8279786 B1	02/10/2012	CA 2805607 A1	19/01/2012
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		EP 2594097 A2	22/05/2013
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		KR 10-2014-0009966 A	23/01/2014
		MX 2013000570 A	22/07/2013
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		CA 2805607 A1	19/01/2012
		CN 103370956 A	23/10/2013
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		WO 2012-057569 A3	26/07/2012
		WO 2012-057584 A2	03/05/2012
		WO 2012-057584 A3	26/07/2012

(19) 中华人民共和国国家知识产权局

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(85) PCT国际申请进入国家阶段日
2015.08.21

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PCT/US2014/017574 2014.02.21

(87) PCT国际申请的公布数据
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(51) Int. Cl.
H04W 16/02(2006.01)
H04W 16/14(2006.01)

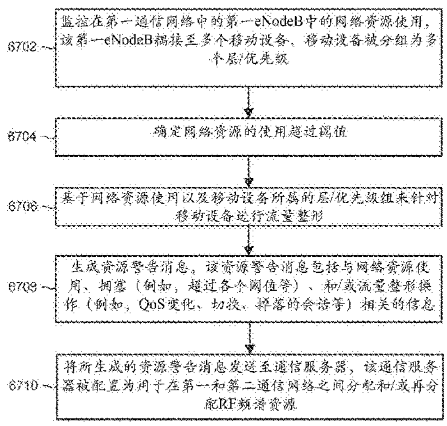
权利要求书7页 说明书65页 附图73页

(54) 发明名称

用于动态频谱仲裁的方法和系统

(57) 摘要

本文提供了用于基于时间、空间和频率来管理和监控RF频谱资源的分配的方法和系统。可使网络能够在实时的基础上分配过剩频谱资源以供其他网络提供商使用。可基于合同条款或实时购买协商及清偿将所分配的资源从具有过剩资源的一个提供商转移到需要额外资源的另一提供商。可使网络能够在实时的基础上监控所分配的资源的使用并且取决于频谱资源的可用性来分流或允许额外用户。可使公共安全网络能够通过分配频谱资源并且监控那些资源的使用来使频谱资源可用于一般公众。在紧急情况期间,当公共安全网络上的流量增加时,公共安全网络可分流带宽流量来使必要的资源可用于公共安全用户。



CN 105075308 A

1.一种动态频谱仲裁方法，包括：

在一个通信服务器中确定在一个第一通信网络之内可用于分配的射频（RF）频谱资源的量；

分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用；

通知该第二通信网络可开始使用所分配的 RF 频谱资源；

在一个交易数据库中记录一次交易，该交易对被分配以供该第二通信网络使用的 RF 频谱资源的量进行标识；

接收一个资源警告消息，该资源警告消息包括由一个 eNodeB 从该第一通信网络采集的信息；

在该通信服务器中基于包括在所接收的该资源警告消息中的该信息确定该第一通信网络是否来要求所分配的 RF 频谱资源中的至少一些资源；

响应于确定该第一通信网络要求所分配的 RF 频谱资源中的至少一些资源，通知该第二通信网络应该终止使用所分配的 RF 频谱资源；以及

更新该交易数据库以包括对该第二通信网络终止使用所分配的 RF 频谱资源的时间进行标识的信息。

2.如权利要求 1 所述的动态频谱仲裁方法，其中，该第一通信网络专用于警察、消防、紧急医疗服务或政府机构中的一项或多项。

3.如权利要求 1 所述的动态频谱仲裁方法，进一步包括：

在多个网络运营商之间进行对该第一通信网络之内的可用 RF 频谱资源的拍卖，其中，该拍卖是根据涉及网络的请求容量、网络边界、网络服务质量、网络地理参数、何时请求资源的时间和服务持续时间参数中的至少一项的竞标规则来完成的，

其中，动态地分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括向通过该拍卖选择的一个通信网络动态地分配可用 RF 频谱资源的该部分资源。

4.如权利要求 1 所述的动态频谱仲裁方法，进一步包括：

从该第二通信网络接收对额外 RF 频谱资源的一个请求，

其中，响应于从该第二通信网络接收对额外 RF 频谱资源的该请求而完成对可用 RF 频谱资源的一部分资源的分配。

5.如权利要求 1 所述的动态频谱仲裁方法，其中，分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括将建立在该第二通信网络之内的一个通信会话切换至所分配的 RF 频谱资源的一部分资源。

6.如权利要求 1 所述的动态频谱仲裁方法，其中，分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括基于当天时间、带宽、通信容量、服务处理、地理边界和持续时间中的一项或多项来分配可用 RF 频谱资源。

7.如权利要求 1 所述的动态频谱仲裁方法，进一步包括：从该第一通信网络和至少一个其他通信网络汇聚可用资源，其中，分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括向该第二通信网络分配来自一个 RF 频谱资源池的多个 RF 频谱资源。

8. 如权利要求 1 所述的动态频谱仲裁方法，进一步包括响应于分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用而向该第二通信网络发送与所分配的资源的使用相关的支付信息。

9. 一种用于完成第一通信网络与第二通信网络之间的可用射频 (RF) 频谱资源的动态频谱仲裁的通信服务器，该通信服务器包括：

网络通信电路，用于与该第一通信网络和该第二通信网络进行通信；

一个存储器；以及

一个处理器，该处理器耦接到该存储器和该网络通信电路上，其中，该处理器配置有多条处理器可执行指令以执行多个操作，这些操作包括：

确定在该第一通信网络之内可用于分配的 RF 频谱资源的量；

分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用；

通知该第二通信网络可开始使用所分配的 RF 频谱资源；

在一个交易数据库中记录一次交易，该交易对被分配以供该第二通信网络使用的 RF 频谱资源的量进行标识；

接收一个资源警告消息，该资源警告消息包括由一个 eNodeB 从该第一通信网络采集的信息；

基于包括在所接收的该资源警告消息中的该信息确定该第一通信网络是否要求所分配的 RF 频谱资源中的至少一些资源；

响应于确定该第一通信网络要求所分配的 RF 频谱资源中的至少一些资源，通知该第二通信网络应该终止使用所分配的 RF 频谱资源；以及

更新该交易数据库以包括对该第二通信网络终止使用所分配的 RF 频谱资源的时间进行标识的信息。

10. 如权利要求 9 所述的通信服务器，其中，该处理器配置有多条处理器可执行指令以执行多个操作，从而使得确定在该第一通信网络之内可用于分配的 RF 频谱资源的量包括：

确定在专用于警察、消防、紧急医疗服务或政府机构中的一项或多项的一个网络之内的可用于分配的 RF 频谱资源的量。

11. 如权利要求 9 所述的通信服务器，

其中，该处理器配置有多条处理器可执行指令以执行多个操作，这些操作进一步包括在多个网络运营商之间进行对该第一通信网络的可用 RF 频谱资源的拍卖，其中，该拍卖是根据涉及网络的请求容量、网络边界、网络服务质量、网络地理参数、何时请求资源的时间和服务持续时间参数中的至少一项的竞标规则来完成的；并且

其中，该处理器配置有多条处理器可执行指令从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括向通过该拍卖选择的一个通信网络分配可用 RF 频谱资源的一部分资源。

12. 如权利要求 9 所述的通信服务器，

其中，该处理器配置有多条处理器可执行指令以执行多个操作，这些操作进一步包括从该第二通信网络接收对额外 RF 频谱资源的一个请求，并且

其中，该处理器配置有多条处理器可执行指令从而使得响应于从该第二通信网络接收

对额外 RF 频谱资源的该请求而完成对可用 RF 频谱资源的一部分资源的分配。

13. 如权利要求 9 所述的通信服务器，其中，该处理器配置有多条处理器可执行指令从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括：

将在该第二通信网络之内所建立的一个通信会话切换至所分配的 RF 频谱资源的一部分资源。

14. 如权利要求 9 所述的通信服务器，其中，该处理器配置有多条处理器可执行指令从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括：

基于当天时间、带宽、通信容量、服务处理、地理边界和持续时间中的一项或多项分配可用 RF 频谱资源。

15. 如权利要求 9 所述的通信服务器，

其中，该处理器配置有多条处理器可执行指令以执行多个操作，这些操作进一步包括从该第一通信网络和至少一个其他通信网络汇聚可用资源，并且

其中，该处理器配置有多条处理器可执行指令从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括向该第二通信网络分配来自一个 RF 频谱资源池的多个 RF 频谱资源。

16. 如权利要求 9 所述的通信服务器，其中，该处理器配置有多条处理器可执行指令以执行多个操作，这些操作进一步包括：

响应于分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用而向该第二通信网络发送与所分配的资源的使用相关的支付信息。

17. 一种在其上存储有处理器可执行软件指令的非瞬态计算机可读存储介质，这些指令被配置成用于致使一个处理器执行多个动态频谱仲裁 (DSA) 操作，这些操作包括：

确定在一个第一通信网络之内可用于分配的射频 (RF) 频谱资源的量；

分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用；

通知该第二通信网络可开始使用所分配的 RF 频谱资源；

在一个交易数据库中记录一次交易，该交易对被分配以供该第二通信网络使用的 RF 频谱资源的量进行标识；

接收一个资源警告消息，该资源警告消息包括由一个 eNodeB 从该第一通信网络采集的信息；

基于包括在所接收的该资源警告消息中的该信息确定该第一通信网络是否要求所分配的 RF 频谱资源中的至少一些资源；

响应于确定该第一通信网络要求所分配的 RF 频谱资源中的至少一些资源，通知该第二通信网络应该终止使用所分配的 RF 频谱资源；以及

更新该交易数据库以包括对该第二通信网络终止使用所分配的 RF 频谱资源的时间进行标识的信息。

18. 如权利要求 17 所述的非瞬态计算机可读存储介质，其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作从而使得确定在一个第一通信网络之

内可用于分配的 RF 频谱资源的量包括 ：

确定在专用于警察、消防、紧急医疗服务和政府机构中的一项或多项的一个网络之内的可用于分配的 RF 频谱资源的量。

19. 如权利要求 17 所述的非瞬态计算机可读存储介质，

其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作，这些操作进一步包括在多个网络运营商之间进行对该第一通信网络之内的可用 RF 频谱资源的拍卖，其中，该拍卖是根据涉及网络的请求容量、网络边界、网络服务质量、网络地理参数、何时请求资源的时间和服务持续时间参数中的至少一项的竞标规则来完成的，并且

其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括向通过该拍卖选择的一个通信网络分配可用 RF 频谱资源的一部分资源。

20. 如权利要求 17 所述的非瞬态计算机可读存储介质，

其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作，这些操作进一步包括从该第二通信网络接收对额外 RF 频谱资源的一个请求，并且

其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作从而使得响应于从该第二通信网络接收对额外 RF 频谱资源的该请求而完成对可用 RF 频谱资源的一部分资源的分配。

21. 如权利要求 17 所述的非瞬态计算机可读存储介质，其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括 ：

将在该第二通信网络之内所建立的一个通信会话切换至所分配的 RF 频谱资源的一部分资源。

22. 如权利要求 17 所述的非瞬态计算机可读存储介质，其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括 ：

基于当天时间、带宽、通信容量、服务处理、地理边界和持续时间中的一项或多项分配可用 RF 频谱资源。

23. 如权利要求 17 所述的非瞬态计算机可读存储介质，

其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作，这些操作包括从该第一通信网络和至少一个其他通信网络汇聚可用资源，并且

其中，所存储的处理器可执行软件指令被配置成用于使一个处理器执行多个操作从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用包括向该第二通信网络分配来自一个 RF 频谱资源池的多个 RF 频谱资源。

24. 如权利要求 17 所述的非瞬态计算机可读存储媒质，其中，所存储的处理器可执行指令被配置成用于使一个处理器执行多个操作，这些操作进一步包括响应于分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用而向该第二通信网络发送与所分配的资源的使用相关的支付信息。

25. 一种系统，包括 ：

一个 eNodeB，该 eNodeB 包括一个发射器和耦接到该发射器上的一个 eNodeB 处理器 ；

以及

一个服务器，该服务器包括一个服务器存储器、网络通信电路、和耦接到该服务器存储器和该网络通信电路的一个服务器处理器，

其中，该服务器处理器配置有多条服务器可执行指令以执行多个操作，这些操作包括：

确定在一个第一通信网络之内可用于分配的 RF 频谱资源的量；

分配该第一通信网络的可用 RF 频谱资源的一部分资源以供一个第二通信网络接入和使用；

通知该第二通信网络可开始使用所分配的 RF 频谱资源；

在一个交易数据库中记录一次交易，该交易对被分配以供该第二通信网络使用的 RF 频谱资源的量进行标识；

接收一个资源警告消息，该资源警告消息包括由一个 eNodeB 从该第一通信网络采集的信息；

基于包括在所接收的该资源警告消息中的该信息确定该第一通信网络是否要求所分配的 RF 频谱资源中的至少一些资源；

响应于确定该第一通信网络要求所分配的 RF 频谱资源中的至少一些资源，通知该第二通信网络应该终止使用所分配的 RF 频谱资源；并且

更新该交易数据库以包括对该第二通信网络终止使用所分配的 RF 频谱资源的时间进行标识的信息，并且

其中，该 eNodeB 处理器配置有多条处理器可执行指令以执行多个操作，这些操作包括：

建立与该第一通信网络的多条通信链路；

建立与多个移动设备的多条无线通信链路；

将这些移动设备分组到多个层之一中，每一个层均与一个优先级相关联；

监控该第一通信网络的网络资源使用；

确定网络资源使用是否超过一个第一阈值；

当确定网络资源使用超过了该第一阈值时，限制新会话的起呼和附加移动设备的切入，其中，限制新会话的起呼包括限制用于分组到一个低优先级层的移动设备的新会话的起呼；

基于监控网络资源使用和限制起呼和切入来生成该资源警告消息；以及

将该资源警告消息传输至该服务器。

26. 如权利要求 25 所述的系统，其中，该 eNodeB 处理器配置有多条处理器可执行指令以执行多个操作，这些操作进一步包括：

当确定网络资源使用超过该第一阈值时，使一个或多个移动设备的本地服务质量 (QoS) 降级，

其中，使这些移动设备的本地 QoS 降级包括基于与这些移动设备所分组到的那些层相关联的优先级使至少一个移动设备的本地 QoS 降级。

27. 如权利要求 26 所述的系统，其中，该 eNodeB 处理器配置有多条处理器可执行指令以执行多个操作，这些操作进一步包括：

继续监控网络资源使用以确定网络资源使用是否超过一个第二阈值；以及

当确定网络资源使用超过该第二阈值时，将一个或多个耦接的移动设备切换至一个第二 eNodeB，

其中，将一个或多个耦接的移动设备切换至一个第二 eNodeB 包括以基于与这些移动设备所分组到的这些层相关联的优先级确定的一个顺序来切换移动设备。

28. 如权利要求 27 所述的系统，其中，该 eNodeB 处理器配置有多条处理器可执行指令以执行多个操作从而使得将一个或多个耦接的移动设备切换至一个第二 eNodeB 进一步包括：

基于该第二 eNodeB 所属的一个网络切换移动设备。

29. 如权利要求 28 所述的系统，其中，该 eNodeB 处理器配置有多条处理器可执行指令以执行多个操作从而使得将一个或多个耦接的移动设备切换至一个第二 eNodeB 进一步包括：

确定该 eNodeB 是否属于一个出租者网络；

确定该第二 eNodeB 是否属于该出租者网络；以及

当确定该第二 eNodeB 不属于该出租者网络时，确定该第二 eNodeB 是否属于对应于该出租者网络的一个无线电接入系统。

30. 如权利要求 27 所述的系统，其中，该 eNodeB 处理器配置有多条处理器可执行指令以执行多个操作，这些操作进一步包括：

进一步继续监控网络资源使用以确定网络资源使用是否超过一个第三阈值；以及

当确定网络资源使用超过该第三阈值时，终止一个或多个移动设备的现有会话，

其中，终止一个或多个移动设备的现有会话包括基于与这些移动设备所分组到的那些层相关联的优先级终止现有会话。

31. 如权利要求 25 所述的系统，其中，确定在一个第一通信网络中可用于分配的 RF 频谱资源的量包括确定在专用于警察、消防、紧急医疗服务或政府机构中的一项或多项的一个通信网络中可用于分配的 RF 频谱资源的量。

32. 如权利要求 25 所述的系统，

其中，该服务器处理器配置有多条服务器可执行指令以执行多个操作，这些操作进一步包括在多个网络运营商之间进行对该第一通信网络的可用 RF 频谱资源的拍卖，其中，该拍卖是根据涉及网络的请求容量、网络边界、网络服务质量、网络地理参数、何时请求资源的时间和服务持续时间参数中的至少一项的竞标规则来完成的，并且

其中，该服务器处理器配置有多条服务器可执行指令从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括向通过该拍卖选择的一个通信网络分配可用 RF 频谱资源的一部分资源。

33. 如权利要求 25 所述的系统，

其中，该服务器处理器配置有多条服务器可执行指令以执行多个操作，这些操作进一步包括从该第二通信网络接收对额外 RF 频谱资源的一个请求，并且

其中，该服务器处理器配置有多条服务器可执行指令从而使得响应于从该第二通信网络接收对额外 RF 频谱资源的该请求而完成对可用 RF 频谱资源的一部分资源的分配。

34. 如权利要求 25 所述的系统，其中，该服务器处理器配置有多条服务器可执行指令

从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括：

将在该第二通信网络之内所建立的一个通信会话切换至所分配的 RF 频谱资源的一部分资源。

35. 如权利要求 25 所述的系统，其中，该服务器处理器配置有多条服务器可执行指令从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括：

基于当天时间、带宽、通信容量、服务处理、地理边界和持续时间中的一项或多项分配可用 RF 频谱资源。

36. 如权利要求 25 所述的系统，

其中，该服务器处理器配置有多条服务器可执行指令以执行多个操作，这些操作进一步包括从该第一通信网络和至少一个其他通信网络汇聚可用资源，并且

其中，该服务器处理器配置有多条服务器可执行指令从而使得分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用包括向该第二通信网络分配来自一个 RF 频谱资源池的多个 RF 频谱资源。

37. 如权利要求 25 所述的系统，其中，该服务器处理器配置有多条服务器可执行指令以执行多个操作，这些操作进一步包括：

响应于分配该第一通信网络的可用 RF 频谱资源的一部分资源以供该第二通信网络接入和使用而向该第二通信网络发送与所分配的资源的使用相关的支付信息。

用于动态频谱仲裁的方法和系统

相关专利申请的交叉引用

[0001] 本申请要求2013年2月22日提交的题为“用于动态频谱仲裁的方法和系统(Methods and Systems for Dynamic Spectrum Arbitrage)”第13/773,725号美国专利申请的优先权，该美国专利申请的全部内容出于所有的目的通过引用结合于此。

背景

[0002] 随着用于接入网络并且下载大文件(例如，视频文件)的无线通信设备的持续增加的使用，存在对无线电频谱增加的需求。智能电话用户抱怨挂断的呼叫、对互联网的缓慢接入和类似问题，这很大程度是由于过多设备尝试接入分配给此类设备的有限的RF带宽。然而由于此类语音无线电通信频带的不连续并且插话式的使用，如专用于紧急服务(例如，警察、消防和救援等)的RF频带的RF频谱的某些部分大量地闲置。

概述

[0003] 根据第一实施例，一种用于在频率、空间和时间中动态地管理射频(RF)频谱资源的方法包括监控在第一网络处的RF谱资源的使用和确定在该第一网络中未使用的RF频谱资源的量。该方法包括将该第一网络的未使用的RF频谱资源的一部分量分配供次要用户使用并且从第二网络接收对额外RF频谱资源的请求。该方法包括向该第二网络提供对该第一网络的未使用的RF频谱资源的接入。该方法可包括从该第一网络分流次要用户。

[0004] 根据另一个实施例，包括配置有服务器可执行指令以执行多个操作的服务器的一种通信系统包括动态频谱仲裁(arbitrage)和管理。管理能够在如本文描述的频率、空间和时间中使射频频谱可用于RF设备。在另一个实施例中，配置有服务器可执行指令以执行多个操作的服务器包括动态频谱仲裁和管理。管理能够使射频频谱在频率、空间和时间中可用于RF设备。

[0005] 在另一个实施例中，射频频谱清算所包括用于监控RF频谱资源的使用的服务器。清算所确定在第一通信系统中的未使用的RF频谱资源的量并且将未使用RF频谱资源中的一部分量分配供次要用户使用。服务器形成第一通信系统的未使用的RF频谱资源的分配份额。第二通信系统将利用分配份额。服务器可将分配份额的可用性通信到第二通信系统。

附图简要说明

[0006] 本文结合的并且构成此说明书的一部分的附图展示本发明的示例性实施例，并且连同以上给出的一般描述以及以下给出的详细描述来解释本发明的特征。

[0007] 图1是展示在正常条件下向蜂窝通信网络作出的呼叫量请求的系统框图。

[0008] 图2是展示在紧急情况条件下向蜂窝通信网络作出的呼叫量请求的系统框图。

[0009] 图3是展示当第一响应者到达现场时在紧急情况条件下向蜂窝通信网络作出的呼叫量请求的系统框图。

[0010] 图4是展示随着额外的紧急响应人员到达现场而向蜂窝通信网络做出的呼叫量请求的系统框图。

[0011] 图5是展示在紧急情况已经被缓和以后向蜂窝通信网络做出的呼叫量请求的系统框图。

[0012] 图 6 是用于管理网络上的分层优先接入 (TPA) 操作的实施例方法的过程流程图。

[0013] 图 7 是用于管理网络上的 TPA 操作的另一个实施例方法的过程流程图。

[0014] 图 8 是考虑到向紧急通信资源的优先接入的用户的级别的示例层级表。

[0015] 图 9 是根据一个实施例的动态频谱仲裁 (DSA) 通信系统的通信系统框图。

[0016] 图 10 是根据一个实施例的 DSA 通信系统的通信系统框图。

[0017] 图 11 是根据一个实施例的 DSA 通信系统的通信系统框图。

[0018] 图 12 是展示用于为仲裁过程提供主控制的一个实施例的 DSA 通信系统的通信系统框图。

[0019] 图 13A 是根据一个实施例展示其分配的 RF 频谱的图。

[0020] 图 13B 是根据一个实施例展示一种可将 RF 频谱分配供使用的方式的图。

[0021] 图 14 是根据一个实施例展示在其中可具有保护频带地分配 RF 频谱供使用的方式的框图。

[0022] 图 15 是根据一个实施例展示可将 RF 频谱汇聚以供使用分配的方式的图。

[0023] 图 16A 至图 16C 是展示为移动虚拟网络运营商 (MVNO) 分配频谱的方式的框图。

[0024] 图 17 是根据一个实施例展示用于分配资源的系统的组件之间的通信的 DSA 通信系统的通信系统框图。

[0025] 图 18 是根据一个实施例展示在资源预留期间 DSA 通信系统中的两个网络的组件之间的通信的通信系统框图。

[0026] 图 19 是根据一个实施例展示在基站 (eNodeB) 处的资源分叉的 DSA 通信系统的通信系统框图。

[0027] 图 20 是根据一个实施例展示服务网关 (SGW) 和分组网关 (PGW) 链路带宽分配和容量控制的 DSA 通信系统的通信系统框图。

[0028] 图 21 是根据一个实施例展示将在 eNodeB 处的资源的 x 分叉和具有容量控制的 SGW 和 PGW 链路带宽分配组合的 DSA 通信系统的通信系统框图。

[0029] 图 22 是根据一个实施例展示基于许可区和局部区方法的频谱分配的 DSA 通信系统的通信系统框图。

[0030] 图 23A 是根据一个实施例展示在许可区中的典型 RF 频谱分配的图。

[0031] 图 23B 是根据一个实施例展示基于许可区在 DSA 通信系统中的 RF 频谱分配的图。

[0032] 图 24 是根据一个实施例展示基于局部区在 DSA 通信系统中的频谱分配的图。

[0033] 图 25A 是根据一个实施例展示订户使用第一运营商 (运营商 A) 的情况的 DSA 通信系统的通信系统框图。

[0034] 图 25B 是根据一个实施例展示订户使用用于频谱分流的实际类型漫游设置中的第二运营商 (运营商 B) 的情况的 DSA 通信系统的通信系统框图。

[0035] 图 26A 是根据一个实施例展示订户使用用于公共安全和商业 DSA 方案的第一运营商 (运营商 A) 的情况的 DSA 通信系统的通信系统框图。

[0036] 图 26B 是根据一个实施例展示基于所使用的服务、地理位置和时间订户可以使用 DSA 以实际短期租用方式使用运营商 B 的情况的 DSA 通信系统的通信系统框图。

[0037] 图 27A 是根据一个实施例展示正常操作情况的 DSA 通信系统的通信系统框图。

[0038] 图 27B 是根据一个实施例展示可供订户使用的额外的容量和频谱的 DSA 通信系统

的通信系统框图。

[0039] 图28是展示用于DSA通信系统中的网络选择和重选的实施例方法的过程流程图。

[0040] 图29是展示归属非DSA用户设备使用一个TAI元件(TAI)而DSA用户设备使用另一TAI的TAI路由区的DSA通信系统的通信框图。

[0041] 图30是根据一个实施例展示RF频谱资源分配和使用的高级追踪和监控的DSA通信系统的通信框图。

[0042] 图31是展示用于拜访网络和归属网络之间的完全移动性所需要的集成的DSA通信系统的通信框图。

[0043] 图32是根据一个实施例展示从一个网络到另一个网络的用户设备的不依赖于介质的切换的DSA通信系统的通信框图。

[0044] 图33是根据一个实施例展示用于发起网络切换的数据流的DSA通信系统的通信框图。

[0045] 图34是根据一个实施例展示向用户设备提供对若干无线电接入终端(RAT)的接入的DSA通信系统的通信系统框图。

[0046] 图35是根据一个实施例展示在DSA通信系统的组件之间的消息通信的消息流图。

[0047] 图36至图40是用于使用DSA通信系统分配和接入资源的实施例方法的过程流程图。

[0048] 图41是根据一个实施例更详细地展示在DSA通信系统的组件之间的消息通信的消息流图。

[0049] 图42至图44是用于从主机网络分流通信会话的实施例方法的过程流程图。

[0050] 图45至图49是使用DSA通信系统分配并接入公共安全网络中的资源的实施例方法的过程流程图。

[0051] 图50至图53是用于从公共安全网络分流通信会话的实施例方法的过程流程图。

[0052] 图54至图56是用于使授权的公共安全当局能够使用无线设备从另一网络接入公共安全网络的实施例方法的过程流程图。

[0053] 图57A和图57B是展示适合与各个实施例一起使用的示例通信系统中的网络组件的系统框图。

[0054] 图58是展示在根据一个实施例的长期演进(LTE)蜂窝通信网络中的用户级别和层的系统框图。

[0055] 图59A和图59B是展示根据各个实施例的级别和层的各种组合的图表。

[0056] 图60A和图60B是展示用于资源的触发器或阈值的各种安排的示例图表。

[0057] 图61A和图61B是管理网络中的内部分层优先接入(ITPA)操作的实施例方法的过程流程图。

[0058] 图62是展示执行DSA操作的实施例方法的呼叫流程图,该实施例方法包括起呼和切入限制。

[0059] 图63是展示执行DSA操作的实施例方法的呼叫流程图,该实施例方法包括服务质量(QoS)降级。

[0060] 图64是展示执行DSA操作的实施例方法的呼叫流程图,该实施例方法包括切换。

[0061] 图65是展示执行DSA操作的实施例方法的呼叫流程图,该实施例方法包括会话终

止。

[0062] 图66是展示执行DSA操作的实施例方法的过程流程图。

[0063] 图67是展示执行DSA操作的实施例eNodeB方法的过程流程图。

[0064] 图68是展示执行DSA操作的实施例控制器方法的过程流程图。

[0065] 图69是适合与各个方面一起使用的示例移动设备的组件框图。

[0066] 图70是适合与一个实施例一起使用的服务器的组件框图。

详细说明

[0067] 将参照附图详细地描述各种实施例。只要有可能，在附图中使用的相同参考数字来指代相同或相似的部分。对特定示例和实现方式的引用是用于说明的目的，而不意在限制本发明或权利要求书的范围。

[0068] 如本文使用的，术语“移动设备”、“无线设备”和“用户设备(UE)”可以互换使用，并且是指各种蜂窝电话、个人数据助理(PDA)、掌上计算机、具有无线调制解调器的笔记本计算机、无线电子邮件接收器（例如，蓝莓(Blackberry)®和Treo®设备）、实现多媒体互联网的蜂窝电话（例如iPhone®）以及类似的个人电子设备中的任一者。无线设备可包括可编程处理器和存储器。在优选的实施例中，无线设备是可以经由蜂窝电话通信网络通信的蜂窝手持设备（例如移动设备）。

[0069] 如本申请中所使用的，术语“组件”、“模块”、“引擎”、“管理器”旨在包括计算机相关实体，如但不限于硬件、固件、硬件与软件的组合、软件、或执行中的软件，这些被配置为用于执行特定操作或功能。例如，组件可以是但不限于在处理器上运行的进程、处理器、对象、可执行文件、执行的线程、程序、计算机、服务器、网络硬件等。通过图示的方式，在计算设备上运行的应用和计算设备两者均可被称为组件。一个或多个组件可驻留在执行的进程和/或线程内，并且组件可位于一个处理器或核上和/或分布在两个或更多个处理器或核之间。另外，这些组件可从其上存储有各种指令和/或数据结构的各种非瞬态计算机可读介质执行。

[0070] 多个不同的蜂窝和移动通信服务和标准在未来是可用的或可预期的，所有这些都可以从各个实施例中实现并受益。这种服务和标准包括例如第三代合作伙伴计划(3GPP)、长期演进(LTE)系统、第三代无线移动通信技术(3G)、第四代无线移动通信技术(4G)、全球移动通信系统(GSM)、通用移动电信系统(UMTS)、3GSM、通用分组无线服务(GPRS)、码分多址(CDMA)系统（例如cdmaOne、CDMA2000TM)、GSM演进的增强型数据率(EDGE)、高级移动电话系统(AMPS)、数字AMPS(IS-136/TDMA)、演进数据最优化(EV-DO)、数字增强型无绳通信(DECT)、全球微波接入互操作性(WiMAX)、无线局域网(WLAN)、公共交换电话网(PSTN)、Wi-Fi保护接入I&II(WPA、WPA2)、蓝牙®、综合数字加强网络(iden)、以及地面移动无线电(LMR)。这些技术中的每一种都涉及例如对语音消息、数据消息、信令消息和/或内容消息的传送和接收。应理解的是，对与单独的电信标准或技术相关的术语和/或技术细节的任何引用都仅仅是出于说明的目的，而并非旨在将权利要求书的范围限制到特定的通信系统或技术，除非在权利要求语言中明确叙述。

[0071] 响应于任何紧急或灾难情况的高优先级是建立有效的通信。在大规模紧急或灾难（人为和自然两种情况）情况中，重要的是维持所有第一响应者和紧急人员之间的通信以便有效地响应、管理和控制紧急情况。在第一响应者和其他紧急人员之间的有效通信缺失

的情况下，可能无法将资源有效地移动到最需要资源的区。即使是轻微的紧急情况下（例如，交通事故和火灾），第一响应者必须能够号召支持资产并配合其他服务（例如，公共设施、医院等）。无处不在的无线设备的所有权和使用，经由使用商用蜂窝移动通信网络的无线设备的应急通信通常是调动应急响应人员和资源的最有效率和最有效的手段。使得无线设备能够提供有效的紧急通信避免在各种第一响应者机构（例如警察、消防、救护车、FEMA、公共设施等）之间协调无线电频率的技术挑战和代价。此外，未值班的或通常未配备无线电的第一响应者（例如，医生、护士、退休警察或军事人员）将具有无线设备或可以迅速地借到无线设备。

[0072] 然而，通过蜂窝通信网络的紧急通信不是没有问题的。如以上在背景中讨论的，将蜂窝通信网络（“网络”）设计成适应来自特定小区中的无线设备的总数中的只一部分设备的接入请求。在紧急情况或危机的时候，网络资源可变得负担过重，当对该情况的可预测的人类响应促使在特定小区之内的大量数量的无线设备用户同时接入网络。无线设备用户可能正在试图向紧急人员警告紧急情况（如 911 紧急呼叫）或警告朋友或家庭成员虽然正处于紧急情况的地区但该用户是安全的。一些用户可能正在向新闻服务或朋友传送紧急情况（火灾、事故等）的图像。在大规模的情况中，使用用于紧急通信的无线设备的紧急响应者将增加呼叫量。无论如何，在紧急情况期间呼叫量的可预测的增加可以压倒商业蜂窝通信网络，尤其在包围紧急情况的小区区域中，因此使网络对于紧急响应人员通信使用是不可靠的。

[0073] 为说明该问题，考虑发生在高速公路上的交通事故的情况。图 1 展示正常条件下的蜂窝通信网络。如所示，多个无线设备 101(a-g) 经由为特定小区 100 服务的基站 102 无线地连接到蜂窝通信网络。基站 102 经由基站控制器 (BSC)/ 无线电网络控制器 (RNC)103 连接到移动交换中心 (MSC)104。MSC 104 包含公共交换电话网 (PSTN) 接口和互联网接口。做出的到或来自于该多个无线设备 101(a-g) 中的任何设备的呼叫可以经由常规的地上通讯线 PSTN 105 上或使用 VOIP 在互联网 106 上路由。在常规固定电话站和无线设备 101(a-g) 中的任何一个设备之间的呼叫可以经由 PSTN 或互联网路由。在无线设备 101(a-g) 之间的呼叫可以在 PSTN 或互联网上路由到位于接近发起或意图的无线设备 101(a-g) 的类似的 MSC 104、BSC/RNC 103 和基站 102。

[0074] 图 1 展示典型的情况，其中小区之内的无线设备中的部分设备同时接入网络。例如，图] 示出位于小区之内的七个分离的无线设备 101(a-g)，其中只有三个 (101c、101d 和 101e) 当前正接入网络。因此，网络正在它的操作参数之内良好地操作，并且授权所有来自无线设备 101(a-g) 的对网络的请求。注意到，被打开但并未使用的所有无线设备 101(a-g) 继续经由链路管理信道（未示出）与基站 102 通信。网络使用这些通信来保持对每个小区之内的无线设备 101(a-g) 的追踪以支持呼叫路由。然而，在所有无线设备 101(a-g) 和用于此类追踪目的基站 102 之间通信的信息量是较小的（尤其相比于进行正常电话呼叫所需要的带宽)，所以在小区之内打开但不活跃 (on-but-inactive) 的无线设备 101 的数量通常将不会压倒网络。

[0075] 当例如事故停止了交通促使延时的司机来同时使用他们的无线设备来提醒交通事故（紧急 911 呼叫）的紧急人员或联系朋友、家庭成员、商业伙伴等来通知他们的迟到，蜂窝网络的这种常规功能会被扰乱。图 2 展示在此类紧急情况中的蜂窝通信网络。在该图

示中，在基站102的附近的卡车107着火了。可预测地，卡车107火灾促使在附近的大部分无线设备101(a-g)用户几乎同时接入蜂窝网络。这导致小区中的过载情况，由于超过在本地基站102上的运营商的带宽。结果，一些无线设备101b、101f将不被授权对网络的接入，并且新网络接入请求可被拒绝直到通信信道开放。此通信瓶颈可使紧急情况变得更差，由于延时了由紧急人员做出的响应并拒绝第一响应者的有效的网络通信。

[0076] 此问题在涉及许多受害者和较大面积的灾难情况中更为严重，如野火、洪水、飓风、龙卷风和恐怖袭击。如在9月11日袭击和卡特里娜(Katrina)飓风期间见证的，大灾难可以摧毁部分蜂窝和固定电话网络基础设施，使剩下的网络更易受过载情况的影响。在灾难事件期间的网络过载尤其麻烦，因为此类情况很自然地涉及广泛的混乱并且要求在大量紧急和救济人员之间的紧密协调。

[0077] 如果灾难情况将持续足够长（例如洪水或飓风情况），可以通过激活可部署蜂窝通信系统将额外的蜂窝通信容量增加到一个区域以提供给紧急响应小组和人员通信的能力。此类最近发展的可部署单元（本文也称为“轮上交换机(switch on wheels)”）可以包括用于远程连接到互联网和PSTN的CDMA2000基站和交换机、地面移动无线电(LMR)互用性设备、卫星固定服务卫星(FSS)、以及可选地包括源或远程电力如汽油或柴油驱动的发电机。在2008年10月10日提交的美国专利申请号12/249,143中提供了示例可部署的轮上交换机的更彻底的描述，该申请的全部内容通过引用以其整体结合在此。

[0078] 这些轮上交换机是有效移动蜂窝基站，其可在灾难地区部署并作为蜂窝天线塔操作。轮上交换机发送并接收来自多个无线设备101的通信信号并且充当剩下的常规通信基础设施的网关入口。在轮上交换机和无线设备101之间的通信被分解成用于作为VOIP通信传输的数据包，并且可经由卫星向灾难区以外的地面站传送，在此通过电话网络将呼叫转发到接收者。即使由可部署的轮上交换机提供增加的带宽，网络过载仍然可导致对紧急响应人员的通信延时和挫败。

[0079] 为克服国家紧急情况的事件中的此类问题，部署WPA系统。常规WPA系统向所选择的紧急领导提供对蜂窝通信网络的抢先接入。然而，常规WPA系统并不允许对注册的WPA当局的无线设备进行呼叫。换言之，在可给予注册WPA服务的无线设备在网络上拨打呼叫的优先接入的同时，在WPA系统中不存在使那些非常相同的无线设备能够接收呼叫的供应。对命令中心中的无线设备的来电呼叫可与去电呼叫一样重要。而且，常规WPA系统假设如果授权的用户需要做出呼叫，将从他们预先注册的无线设备做出呼叫。然而，可能的情况是被授权的人员并不具有其预先注册的无线设备。或者，无线设备可能被毁坏。必须使得被授权的人员能够接入到过载的网络。而且，先前没有在WPA系统上注册他们的无线设备的紧急人员不可以“匆忙地(on the fly)”接入过载的蜂窝通信网络。很多时候，不在值班的初级志愿紧急响应人员可能是事件现场的第一响应者。此类人员可能没有使用被设计成解决领导的需求的常规WPA的权利。因此，更确切地说考虑到他们在现场的附近可以快速缓和情况的人员可能未预注册并且对常规WPA授权。

[0080] 为克服常规蜂窝通信网络和常规WPA的这些局限，各种实施例对于在移动手机处起始和终止的呼叫都向第一响应者提供分层优先接入(TPA)能力来传递服务质量(QoS)/服务等级(GOS)无线设备通信。各种实施例尤其针对在紧急事件的刚刚开始时的第一响应者的需求。

[0081] 正如其名称所暗示的，TPA旨在向网络容量要求提供分层响应。由于更多响应者出现来帮助解决在手边的问题，分层响应反映在事件现场的典型通信要求。当事件发生时，第一响应者或者在事件现场或者开始响应。首先到达现场报告事件的第一响应者数量较少，并且可直接响应于事件的量级和严重性而增长。

[0082] 为适应此可预测的响应，TPA 能够实现随着第一响应者到达现场和由于情况被恢复到正常而离开的基于呼叫量的升级和降级过程。

[0083] 大体上，各种实施例工作如下。在正常操作期间，监控通过特定基站的蜂窝呼叫量以及确定网络是否接近容量限制。可基于当前呼叫、接入网络的尝试、使用中的带宽或蜂窝服务提供商已知的其他方法来监控呼叫量。可在基站 102、在 BSC/RNC 103 或 MSC 104 本地或在一个实施例中中心地如在网络操作中心 (NOC) 中监控呼叫量。此类监控是在蜂窝等级，由于正常紧急情况最可能影响一个或两个小区区域，虽然 TPA 将在广泛紧急的事件中以类似形式工作。当小区中的呼叫量超过由服务提供商和 / 或紧急响应计划者预选的阈值时，系统向 TPA 操作分配受影响的小区塔中的一个信道。

[0084] 图 2 展示呼叫量已经超过指示应该实施 TPA 的阈值的情况。如图 2 所示，由基站 102 支持的小区中的比网络可以连接的更多的无线设备 101 正试图接入网络。结果，只有无线设备 101a、101c、101d、101e 和 101g 中的一些将能够拨打或接收呼叫 (如实黑所示)，而将拒绝其他无线设备到网络的接入 (如白所示)。在此情况中，由基站 102 服务的小区中的呼叫量已经超过阈值，所以将天线上的通信信道中的一个信道分配给 TPA 操作。然而，信道仍然保持对一般公众使用的可用直到拨打被授权 TPA 的呼叫。因此，在通信网络中没有改变被示出在图 2 中。

[0085] 各种实施例解决此过载情况以便允许紧急人员在他们到达现场时能够使用蜂窝通信网络，如图 3 中所示。当紧急响应者 108 到达现场时，该个体可发起无线电话呼叫。如果通信信道已经被分配到 TPA 操作并且紧急响应者的无线设备是预注册为被授权 TPA 的无线设备，网络可以从无线设备的唯一的 ID 识别预注册的被授权 TPA 的无线设备并将该呼叫识别为 TPA 呼叫。基站 102、BSC/RNC 103 或 MSC 104 可保证 TPA 呼叫是连接的。必要的话，减少分配到民用无线设备用户的带宽并且可以挂断一个或多个非紧急呼叫从而使得能够接通 TPA 呼叫。这在图 3 中表示为已经挂断到无线设备 101c 的连接并且拒绝向网络的进一步接入 (示为白闪电)，并且连接由紧急响应者 108 做出的 TPA 呼叫 (示为虚黑闪电)。

[0086] 如图 4 所示，随着额外的紧急人员 109 到达紧急情况的现场，可能需要连接额外的 TPA 呼叫。为适应 TPA 呼叫的增加，可以自动地向 TPA 操作分配额外的网络资源以便向紧急响应者提供可靠的蜂窝通信。这被展示在图 4 中，其示出了与警察 108 和消防 109 人员连接的 TPA 呼叫 (示为虚黑闪电)，而已经将无线设备 101c 和 101d 断开连接 (示为白闪电)。自动向 TPA 使用分配更多资源减少对一般公众可用的带宽，这将限制对网络的一般接入。然而，只要大呼叫量持续，就向紧急人员提供对网络的可靠接入。

[0087] 最终将解决紧急情况并且紧急人员将开始到现场。当情况恢复正常，民用呼叫量应返回正常水平而要求 TPA 接入紧急响应者的数量也将下降。这展示在图 5 中，该图示出火已经被熄灭并且消防员已经离开了现场。随着交通开始返回正常流动，更小的一般人口无线设备 101a-101g 同时接入网络。随着蜂窝通信返回正常，可从 TPA 操作释放蜂窝通信资源，将网络恢复到正常操作。如所示，因为呼叫量已经降低到 TPA 操作已经被终止的点，

所以以正常形式将剩余的紧急人员 108 连接到蜂窝通信网络。

[0088] 当在一个或多个通信信道上实现 TPA 操作时，蜂窝系统（例如，本地基站、BSC/RNC 或 MSC 中或如 NOC 的中心位置中）监控来电和去电呼叫来确定是否任何呼叫是直接来自或到紧急响应人员。这可通过将起始或目的无线设备识别为预注册 TPA 的无线设备来完成。可替代地，系统可识别紧急响应人员他们何时完成特殊拨号过程，如以下描述的 *272 拨号过程。

[0089] 无线设备可以被预注册为由通过授权用户的 TPA 使用。这可通过向蜂窝网络提供商注册为有资格的紧急响应者（例如根据由政府当局建立的标准）来实现。如在电信领域中众所周知的，向接入蜂窝通信的所有无线设备 101 指派唯一的标识号。在预注册过程中，蜂窝网络提供商在被授权的 TPA 人员的数据库中存储无线设备的唯一标识号。如以下更完全地描述的一样，蜂窝网络提供商还可为个人下发唯一个人标识号 (PIN)，用于在实现从非 TPA 无线设备的 TPA 抢占中使用。

[0090] 如果紧急响应者的无线设备不是预注册的（如借来的电话），并且网络过载，那么紧急响应者可能不能接入网络资源。在此情况下，紧急响应者可以通过首先拨 *272 再接着拨个人标识号 (PIN) 和电话号码从非注册的无线设备 101 激活实施例 TPA。离非注册的无线设备 101 最近的基站 102 接收来自无线设备 101 的传送，指示该无线设备正发起呼叫。基站 102（或连接到接收基站的 BSC/RNC 103）识别 *272 特殊拨号前缀并开始将呼叫路由到适当的目的地。可替代地，#272 拨号前缀的识别和路由可在 MSC 104 处完成。这个目的地可以是最近的具有 PIN 的数据库的 PSAP 或中心位置。随着呼叫通过通信网络系统进行，在 BSC/RNC 103 处并且稍后在 MSC 104 处类似地处理 *272 呼叫。控制基站天线 102 和其他相关联的天线的 BSC/RNC 103 或 MSC 104 被编程成使用预注册的第一响应者 PIN 数据库识别特殊拨号过程。此 PIN 数据库可被存储在 MSC 104 处或在如 NOC 的另一中心位置。如果所接收的 PIN 与 PIN 数据库中的记录匹配，MSC 104 可立即给予呼叫者向网络的抢先接入，就像呼叫是从如上述注册有 TPA 的无线设备做出的一样。为了支持此能力，分配有 TPA 的信道在 TPA 操作期间预留充足的开放容量来接收并识别 *272 拨号呼叫。如果通信信道处于最高容量并且拨打的号码并不以 *272 开头，则迅速地挂断呼叫而不尝试完成呼叫。然而，如果拨打的号码以 *272 开头，MSC 104 完成将输入的 PIN 和 PIN 数据库进行比较的过程，并且暂时将呼叫注册为被授权 TPA 的无线设备。如果必要的话，非 TPA 呼叫可被挂断以便为接收和识别 *272 呼叫保留充足的容量。

[0091] 虽然贯穿本申请，提到 MSC 104 监控并提供该 TPA 能力，本领域的普通技术人员应认识到通信系统的其他元件可实现各种方法步骤。这些元件可包括但不限于与基站天线 102、BSC/RNC 103 或 NOC 搭配的设备。

[0092] 一旦借助于 *272 拨号过程将无线设备识别为 TPA 电话，MSC 104 将跟踪无线设备，并继续把它看作注册有 TPA 的无线设备，只要至少有一个通信信道被分配给 TPA 操作。使用指派给无线设备的唯一标识号，MSC 104 将来自无线设备的随后呼叫识别为 TPA 呼叫，而无需用户重复 *272 拨号过程。类似地，MSC 104 可以标识向应接收 TPA 抢占服务的第一响应者的来电呼叫。因此，当通过使用 *272 拨号过程呼叫一个号码（如调度员或“911”）来为来电呼叫和去电呼叫都实现 TPA 时，使用非注册的无线设备的第一响应者 108 可以“匆忙地”注册无线设备。

[0093] 在一个实施例中，具有PIN的TPA授权用户可以使用如上所述的*272的拨号程过程认证任何数目的无线设备。在本实施例将使第一响应者如警察、消防员或紧急医疗技术人员能够将如他们在现场发现的军事人员、医生或退休警察的志愿者“指定为代理”，因此创建可靠的临时应急通信网络。由于在受影响区中的所有通信信道返回正常操作时撤销通过*272的拨号过程建立的无线设备的临时TPA授权（即中止TPA操作），有限的考虑是假如不透露被授权的用户的PIN，可为随后的紧急情况妥协TPA系统。即使透露PIN，由于TPA实现被预期是罕见的、随机的、偶发的事件，可以很容易地改变PIN而没有显著的影响。

[0094] 在又一个实施例中，没有（或忘记）PIN的注册有TPA的无线设备的用户可以“匆忙地”注册另一电话，从而通过简单地在任何无线设备上发起特殊拨号过程来对于TPA事件的持续时间将它“指定为代理”。例如，第一响应者可使用注册有TPA的无线设备来拨打将被“指定为代理”的无线设备的号码跟着拨打*272（可使用任何拨号前缀或附言）。当MSC 104接收到此呼叫时，将*272前缀或附言识别为指示所拨打的号码被视为临时被授权TPA的无线设备，允许它将被叫无线移动设备的唯一ID存储在用于跟踪此类临时被授权TPA的数据库中。使用此能力，第一响应者可以快速地通过呼叫他们的号码来将一个或多个志愿者指定为代理。

[0095] 在又一个实施例中，其地位已经上升到对预注册TPA服务或PIN有资格的等级的紧急响应人员可能仍然是紧急情况现场的第一紧急人员。用户可以使用他/她的非预注册的无线设备来发起*272特殊拨号过程。可以将该呼叫转发到可下发临时PIN并且将无线设备添加到临时TPA数据库的PSAP。

[0096] 可替代地，如果用户发起*272特殊拨号（或如911的类似的拨号过程），可将该呼叫转发到PSAP。在大规模的危机情况下，由于来电呼叫量大，应答PSAP可能会被禁用或无法迅速回答。在此类情况下，如果PSAP未在预定的时间帧之内应答*272呼叫，可自动地下发临时TPA授权。由于PSAP运营商没有完全地分析围绕临时TPA授权的下发的环境，所以不清楚是否合适地授权接收临时TPA授权的用户。因此，在用于可能的去激活或调查的PSAP监控器上可标志临时TPA授权。

[0097] 在又一个实施例中，当向实现TPA操作的小区区域之内的民用（即，非被授权TPA的）无线设备拨号时，蜂窝网络被配置成给来自注册有TPA的无线设备以及（可选地）临时被授权TPA的无线设备的呼叫优先级。当做出此类呼叫时，将MSC 104编程成通过分配到TPA操作的通信信道将呼叫路由拨号的无线设备。如果分配有TPA的信道处于最高容量，当来自被授权TPA的无线设备的呼叫被接收用于民用无线设备时，另一民用无线设备呼叫被挂断以便提供充足的容量来完成呼叫，使用相关联的抢占过程来阻止另一911呼叫被挂断。本实施例给予紧急人员进入紧急拨打的能力。例如，紧急人员可以使用此容量来回叫最初呼叫911报告紧急情况的民众以便请求来自潜在目击者的更新。作为另一示例，第一响应者可以呼叫紧急现场之内的志愿者而将他们的电话指定为代理，保证即使以其他方式压倒通信网络也能够联系到志愿者。

[0098] 可以在本披露的至少两个实施例中实现TPA操作。在以下参照图6描述的第一实施例中，一个或多个蜂窝通信信道专用于TPA呼叫，向紧急人员提供专用的通信容量，而将剩下的信道留给一般公众。在以下参照图7描述的第二实施例中，只有当分配有TPA的通信信道到达容量时，才为TPA呼叫实现呼叫抢占。以下分开描述这些实施例。

[0099] 图6展示了可用来实现可用具有处理器的计算设备操作的TPA的第一实施例的步骤的示例的过程流。在正常操作期间，监控蜂窝通信网络呼叫量（框201）。尤其是，蜂窝通信网络呼叫量（或接入请求的数量或使用中的带宽）被与预定的阈值（例如最大容量的85％）相比较（框202）。如果呼叫量低于预定阈值，假设正常情况存在，则监控过程返回到框201以继续监控呼叫量。然而，如果呼叫量（或接入请求的数量或使用中的带宽）超过预定阈值时，异常情况存在，这可表明紧急情况正在展开。为了对紧急情况作好准备，网络资源（例如特定基站天线上的通信信道）被划分并且为TPA使用而预留（框203）。通过向TPA使用自动地分配通信信道，该系统允许被授权TPA的无线设备获得对网络的接入，即使当网络以其他方式过载时。然而，TPA抢占直到具有TPA资格的呼叫者试图接入过载的网络才发生。

[0100] 由于增加的呼叫量可能会或可能不会响应于紧急情况，分配给TPA的通信信道继续正常运作，以普通的形式处理民用（即，非TPA）呼叫。在增加的呼叫量仅仅是由于巧合的网络请求并且无TPA资格的用户正尝试拨打呼叫的情况下，不需要通过TPA实现的呼叫抢占。因此，可超过TPA阈值，并且即使当不存在实际紧急事件时也实现TPA。将TPA抢占的实际实现延时直到第一响应者要求该服务在正常环境下增加了网络的可靠性。

[0101] 可通知系统实际紧急情况正在发生，由在受影响的小区区域之内拨打TPA呼叫的被授权TPA的紧急响应人员指示。当该通信信道是在TPA模式下，蜂窝系统（无论是在基站处、BSC/RNC/MSC、或在中央位置，如NOC）监控来电呼叫和去电呼叫，以确定是否有任何紧急响应人员正使用预注册TPA的无线设备或已经完成了调用TPA抢占的特殊拨号过程（框204）。如果没有紧急响应人员已经使用被授权TPA的无线设备或特殊拨号过程发起了呼叫，系统可继续监控接入请求（在框204中）以及呼叫量（在框201中）以确定是否应从TPA操作释放通信信道（框202）。

[0102] 如果通过被授权TPA的无线设备发起呼叫，或者如果从非预先注册的无线设备使用*272拨号过程生成该呼叫，发起TPA（框205）。框205，当发起TPA，只有先前注册的或给予“匆忙地”许可的紧急人员将被允许接入所划分的并预留的网络资源。正如以上指出的，将通常首先会在单个通信信道实现TPA，将剩余信道留给一般公众使用。然后，如果TPA使用超过分配有TPA的网络资源的容量，可以将另一资源转换成TPA操作。通过一次将一个信道或一个资源的网络资源专用于紧急人员使用，将剩余的网络资源留供非必要的一般公众使用。此外，通过将网络资源专用于紧急人员通信，紧急人员能够在他们的无线设备上发送和接收呼叫。

[0103] 在一个可选的实施例中，当发起TPA时（框205），MSC 104可调查位于受影响的小区或由在相同BSC/RNC 103之内的其他基站天线102服务的无线设备101，以标识所有已注册的或暂时注册的第一响应者。可经由SMS消息（或其他方法）建议这些第一响应者他们可以通过拨打呼叫或使用特殊拨号过程来利用TPA服务（框206）。

[0104] 在另一可选实施例中，基站102、BSC/RNC 103或MSC 104还可以向受影响的区/小区100之内的所有非紧急无线设备101a-101g发送消息，建议他们避免使用他们的无线设备101a-101g，除了用于紧急911呼叫外并且指示已经通知紧急服务（框207）。此消息传送可以由负责事件区的PSAP、由本地事件命令和控制当局、或由网络服务提供商发起。可经由SMS消息或其他通信手段来传递此类消息。该系统还可在断开呼叫之前通知连接到分

配给 TPA 使用的信道的呼叫者他们的呼叫正被终止。

[0105] 随着紧急情况继续展开并且额外的紧急响应人员出现在现场，可能要求额外的网络资源来支持紧急人员通信。因此，可监控所划分的并专用的网络资源来确定是否应将额外的网络资源划分并向 TPA 分配。这可以通过将所划分的并专用的网络资源上的呼叫量与预定义的最大或最小阈值相比较来完成（框 208）。如果呼叫量超过预定义的最大值（指示加剧的情况），例如小区站点/扇区中所划分的并专用的网络资源的 25％使用，可将额外的专用网络资源划分到 TPA 操作（框 211），以允许紧急响应人员来通信。

[0106] 在一个实施例中，在终止呼叫以便向 TPA 操作分配额外的信道之前，可用警告音和/或录音发音通知具有与所分配的信道正进行的呼叫或会话的非必要的（即，非紧急人员）无线设备 101 正在终止他们的呼叫除非输入定义的代码（框 210）。这允许第一响应者通过快速输入代码（例如他们的 PIN）来维持他们的呼叫。如果进行中的呼叫是紧急 911 呼叫，可通过 PSAP 来提供定义代码。

[0107] 在一个实施例中，系统将继续自动地获取并为紧急响应人员通信重新分配网络资源直到所有可用的网络资源专用于紧急响应人员使用。此实施例将最大化紧急响应人员的通信能力。其他实施例可预留至少最少部分的网络资源（例如，一个通信信道）来实现一般公众提醒紧急响应人员新的或发展的紧急情况的能力，如通过拨打 911 呼叫。因此，其他实施例可对从一般人口拿走并专用于紧急响应人员通信的网络资源的量施加最大限制。为完成这一点，在框 209 中，MSC 104 可确定是否已经划分了最大量的网络资源并专用于紧急响应人员通信。如果已经划分并专用最大量的网络资源，在框 208 中，MSC 104 可继续监控划分并专用的网络资源的利用等级。如果还没有达到可以划分并专用的网络资源的最大量，MSC 104 可（可选地）告知当前呼叫者正在终止呼叫（框 210），并且将网络资源从一般人口使用向紧急响应人员通信重新分配（框 211）。一旦已经专用额外的通信信道，MCS 104 将返回监控所划分的并专用的网络资源的利用等级来确定紧急情况是正在升级或降级（框 208）。

[0108] 随着紧急响应人员工作以减轻紧急事件并将情况返回到正常，对网络资源的需要将随着紧急人员撤离现场而降低。为使系统能够返回到正常操作，MSC 104 可为升级或降级的指示连续地监控划分并专用的网络资源上的呼叫量（框 208）。当所划分的并专用的网络资源使用等级降到低于预定义的最小值，MSC 104 可开始将网络资源重新分配回一般公众使用（框 212）。可一个信道一个信道地自动重新分配网络资源，逐步减少向紧急人员使用所分配的资源，以逐步方式返回到正常操作。

[0109] 通过一次一个信道或网络资源地遣散网络资源，该实施例提供了灵活的可适应情况发展的通信系统。如果情况要求更多或更少的用于紧急人员通信的网络资源，该实施例系统和方法能够满足需求，同时还提供一些网络资源供一般公众使用。该系统可以在 TPA 专用信道的每次释放之后等待一段时间以便适应在事件逐渐停止阶段期间紧急人员使用中的激增，从而避免必须不必要地重复挂断呼叫者的过程（框 210）。

[0110] 一旦蜂窝通信信道已经被重新分配给一般公众使用，MSC 104 确定是否有任何更多当前划分并专用于紧急人员通信的网络资源（框 213）。如果当前将额外的网络资源划分并专用于紧急人员通信，MSC 104 返回框 208 来确定紧急情况是正升级还是降级。随着紧急情况进一步降级并返回正常，紧急响应人员要求越来越少的网络资源来支持他们的通

信。因此，MSC 104 将继续响应于呼叫量自动地将网络资源重新分配到一般公众使用(框 212)，直到所有的网络资源是在用于一般公众使用的正常的操作配置中。MSC 104 可返回到框 201 并且可监控等待下一紧急情况的呼叫量。

[0111] 在第二实施例中，在图 7 的过程流程中展示的，通过呼叫抢占方式在各个呼叫等级上将网络资源递增地分配到 TPA 使用以便在满足紧急人员使用要求的同时将对网络的公共接入最大化。在正常操作期间，监控蜂窝通信网络使用(框 302)。可将网络接入请求、呼叫量或使用中的带宽与预定的阈值(例如最大容量的 85%)进行比较(框 304)。如果使用低于预定的阈值，假设存在正常情况，故监控过程返回框 302 以继续监控呼叫量。然而，如果使用超过预定的阈值，异常情况存在，这可指示紧急情况正在展开。为了对紧急情况作好准备，将如在受影响的基站天线上的通信信道的网络资源为 TPA 使用而划分并预留(框 306)。通过向 TPA 使用自动地分配通信信道，该系统允许被授权 TPA 的无线设备获得对网络的接入，即使当网络以其他方式过载时。然而，TPA 抢占直到具有 TPA 资格的呼叫者试图接入过载的网络才发生。

[0112] 因为增加的呼叫量可能或可能不响应于紧急情况，分配给 TPA 的通信信道继续通过以普通形式处理民用(即，非 TPA)呼叫来正常运作。在增加的呼叫量简单地由于巧合呼叫量造成并且无 TPA 资格用户正试图拨打呼叫的情况中，不需要通过 TPA 实现的呼叫抢占。因此，可超过 TPA 阈值并且即使当不要求 TPA 呼叫抢占时也实现 TPA。延时 TPA 抢占的实际实现直到第一响应者要求抢占增加了在正常环境下的网络的可靠性。

[0113] 具有分配给 TPA 操作的网络资源，蜂窝系统(无论在基站、BSC/RNC 或在如 MSC 的中心位置中)监控来电呼叫和去电呼叫(框 308)。分配有 TPA 的信道继续作为正常蜂窝通信信道来运作直到 (a) 该信道处于最高容量(即，通过信道的当前呼叫量等于它的最大容量)和 (b) 具有 TPA 资格的无线设备试图接入网络来拨打或接收呼叫。监控在分配有 TPA 的通信信道上的呼叫量以确定是否必须挂断呼叫以便连接具有 TPA 资格的呼叫。因此，当接收也将分配给分配有 TPA 的信道的新呼叫(来电或去电)时，系统可首先确定该信道是否目前处于最高容量(即，具有和信道可以可靠地维持的一样多的呼叫连接)(框 310)。如果信道未处于最高容量(即，在网络上存在过剩容量)，可接通呼叫(框 315)。如果在信道上存在充足的容量来实现来电或去电的 TPA 呼叫的连接，TPA 信道的此监控可阻止断开连接民用呼叫。

[0114] 如以上讨论的，系统可以通过确定源或目的无线设备是否是注册有 TPA 的无线设备(框 312)以及呼叫是否是由完成特殊的拨号过程的呼叫者做出的来识别被授权 TPA 的呼叫。拨号过程可调用 TPA 抢占(框 316)。在框 315 中，可接通呼叫。例如，如果呼叫者正使用(或将呼叫拨打到)注册有 TPA 的无线设备，可接通呼叫。如果在分配有 TPA 的信道上连接有至少一个非 TPA 呼叫，则可接通呼叫(框 314)，并且释放容量到足以接通 TPA 呼叫(框 315)。这允许具有 TPA 资格的第一响应者没有延时地进行呼叫，即使网络处于最高容量。类似地，如果将来电呼叫导向到具有 TPA 资格的无线设备，在 TPA 信道上终止至少一个非 TPA 呼叫以便将来电呼叫连接到具有 TPA 资格的无线设备。终止来自所分配的信道的非 TPA 呼叫的过程可随着更多到具有 TPA 资格的无线设备的呼叫接入网络而继续。如果呼叫者未正在使用注册有 TPA 的电话并且未输入 *272 类型拨号序列，则当系统处于最高容量时，此时该呼叫可作为非紧急呼叫被阻止(框 320)。如果呼叫者已经输入特殊的拨号序列

(如*272加PIN),则将输入的PIN与存储在数据库中(例如在基站102、BSC/RNC 103或MSC 104处)的PIN值进行比较(框318)。如果PIN匹配注册的紧急人员,在分配有TPA的信道上接通非TPA呼叫(框314),以便释放容量足以接通TPA呼叫(框315)。

[0115] 系统还可以监控分配有TPA的信道上的呼叫量(框322),以保证留下充足的容量来适应进一步紧急人员要求。可以将分配有TPA的通信信道上的TPA呼叫量(即,向/来自具有TPA资格的无线设备的呼叫量)与框322中的阈值比较来确定何时向TPA使用分配另一通信信道。如果超过TPA呼叫量阈值(即,测试322 =“是”),将向TPA功能框306分配另一信道,这在以上讨论。

[0116] 可继续监控每个分配有TPA的信道上的TPA呼叫量(框322),以及在所有信道上的呼叫量(框324)。这可确定何时不再做出TPA呼叫,如当解决了紧急情况并且第一响应者离开现场时或者当总的呼叫量回到不再要求TPA操作的水平时将会发生。如果呼叫量继续超过该TPA阈值,系统可继续以TPA模式操作至少一个信道,接受呼叫(框308),检查TPA信道呼叫量(框310),和接通呼叫(框315),如果该呼叫是来自/到被授权TPA的无线设备(框312)或如果呼叫量小于容量。随着TPA呼叫量下降,可以通过释放TPA信道来减少分配给TPA操作的信道的数量(框326)。监控呼叫量和从TPA分配释放信道将继续直到所有通信信道被返回到正常操作。此外,如果在非TPA信道上的呼叫量降回到正常,系统可去激活所有分配信道上的TPA操作,由于网络的正常容量可以适应具有TPA资格的呼叫者而不需要TPA抢占。

[0117] 此第二实施例允许以保证每一被授权TPA的呼叫者可以接入网络而同时向一般公众提供最大的可能带宽的形式来操作分配有TPA的信道。监控TPA信道呼叫量允许系统避免如果在信道上存在充足容量来实现新的来电或去电TPA呼叫的连接时挂断民用呼叫。如果没有紧急响应人员使用被授权TPA的无线设备或特殊拨号过程发起呼叫,系统可继续监控接入请求(框308),和呼叫量(框324),来确定是否应从TPA操作释放通信信道(框326)。

[0118] 额外的实施例提供将到TPA专用的网络资源的优先化的接入来使最高优先级呼叫者能够使用蜂窝通信网络。在紧急响应者的数量会超过蜂窝网络资源的容量的情况下,此实施例可使高优先级的用户如国家领导和现场指挥官能够抢占其他更低优先级用户,以便获得对网络的即时接入。高优先级用户可以使用他们的预注册的无线设备来获得到网络的接入。可以使用他们的无线设备的唯一的ID来从唯一ID的数据库中确定用户的优先级。类似地,高优先级用户可以使用特殊拨号过程用为网络(例如MSC 104)从PIN数据库中确定用户的优先级提供充足信息的代码或PIN将他们自己标识到网络。使用从数据库中确定的优先级值,网络(例如,MSC 104)可以确定目前的呼叫者是否具有比任何已经连接到分配有TPA的网络资源的呼叫更高的优先级。假设适当地授权无线设备101,可给予呼叫在分配有TPA的网络资源上的队列中的优先级,以便使用预注册授权的无线设备的紧急人员成员可能够完成呼叫。如果网络资源处于最高容量,可以挂断来自具有更低优先级等级的人的呼叫以便空出来充足的容量来完成呼叫。

[0119] 图8展示紧急响应人员的示例层级。各种其他的配置是可能的并且可能包括其他人员,而且人员的角色或地位可基于事件而改变,例如,军事指挥官302可能承担行政领导的角色等。如图8所示,可给予行政领导者和策略制定者301最高优先地位。此级别的成

员可预注册他们的无线设备 101 以便将无线设备 101 的唯一标识符存储在层级数据库中。如果将呼叫从任何预注册的无线设备拨打到行政领导和策略制定者级别 301 的成员，首先在所划分的并专用的网络资源的任何队列中拨打呼叫。类似地，可向灾难响应 / 军事命令或控制人员 302 提供次高优先级级别，接着是公共健康、安全、以及法律强制执行命令 303、公共服务 / 公共设施和公共福利 304、以及灾难响应团队 305。更低级别的优先级可被提供给一线警察和消防员 306 以及紧急医务技术人员 307。在所有情况中，无线设备可被预注册，这样可以将他们唯一的标识符和 / 或用户的 PIN 存储在层级数据库中以支持此实施例。

[0120] 还可使用可部署的“轮上交换机”蜂窝通信系统在蜂窝系统中实现前述实施例。由于可在大规模紧急 / 灾难情况中实现此类系统，将接入限制到紧急响应者和命令当局，网络过载将发生自在同一时刻拨打呼叫的过多被授权的（即，非民用）用户。为保证在此类情况中可靠的通信，可部署的轮上交换机可以实现呼叫者优先级实施例从而使得具有最高优先级（例如国家和区域指挥官）的呼叫者具有向蜂窝通信保证的接入，而最低优先级被授权的用户可被断开连接，如果需要的话。在此实施例中，可在可部署轮上交换机之内的服务器中维持指示各个优先级（层级）等级（例如，图 8 所示的）的被授权的用户的数据库。

[0121] 已经将前述实施例描述为通过 MSC 104 来实现。本领域普通技术人员将认识到前述实施例可在蜂窝通信网络之内的多个计算机交换系统元件之内实现，包括但不限于基站 102、BSC/RNC 103 或 NOC。已经自动地执行通信信道上的和小区之内呼叫量的监控。可将此类系统重新编程来实现前述实施例从而使得自动地执行 TPA 操作的实现。因此，系统可以自动地识别呼叫量何时超过阈值从而使得应向 TPA 操作分配通信信道。该系统可以进一步识别上述被授权 TPA 的呼叫和专用网络资源并且自动地执行上述呼叫连接和断开连接。类似地，随着呼叫量下降到 TPA 阈值等级以下，系统可以自动地将网络返回到正常配置。以此方式，蜂窝通信网络可以向紧急情况响应，从而能够实现用于紧急人员的保证的通信而不需要人为动作或干涉。例如，即使未报告事件（例如没人操心去拨 911)，系统将还是响应于过剩呼叫量来使紧急响应者能够使用网络。此能力也保证警察、消防和 EMT 人员（可能被授权实现 TPA 的典型人群）可以在高峰使用的时间期间使用蜂窝通信网络，如在高速公路上的拥堵时段或主要体育事件结束之后。

[0122] 用来实现前述实施例的硬件可以是被配置成用于执行指令集的处理元件和存储器元件，其中该指令集是用于执行对应于以上方法的方法步骤。此类处理和存储器元件可以采用在蜂窝通信中心以及远程设施（例如基站天线位置）中使用的计算机操作的交换机、服务器、工作站和其他计算机系统的形式。可通过专用于给定功能的电路来执行一些步骤或方法。

[0123] 无线设备使用专用于蜂窝电话通信的射频 (RF) 频谱的部分频谱。此 RF 频谱正以快节奏缩小，主要是由于使用已经有负担的 RF 带宽的无线设备的增加的数量以及在市场中带宽的低效率的分配。由于总 RF 频谱是有限的，随着 RF 频谱的用户数量的增长，要求更有效率的 RF 频谱管理方法来保证合适地解决对于 RF 频谱的增长的需求。

[0124] 基于静态分配模型如推测模型和古典许可交易来在蜂窝服务提供商之间划分当前可用的 RF 频谱。当前实践的静态分配模型依靠允许在定义的频率和空间块中向提供商分配频谱的命令和控制方案。例如，租用 RF 频谱的一种静态方法包括基于租用协议向一个运营商指派整个频谱块或子块供他们的排他的使用。此类频谱的成批分配是低效率的，因

为获得许可的提供商正在基于频谱可在未来使用的推测购买该频谱。

[0125] 然而，频谱使用和流量是动态的并且可取决于包括使用频谱的时间信息和使用该频谱的无线设备的地理位置的不同变量。流量使用可以是取决于时间的，由于使用可在高峰期间相对于非高峰时段变化。由于订户使用网络的位置也可变化，流量还可基于地理。例如，在一天中，当订户正向工作行进、在工作或从工作返回时或在下班时间期间，网络上的频谱的基于时间和地理的使用可变化。

[0126] 因为频谱使用和流量是动态的并且不可预测，提供商通过预测关于它的未来使用会不可避免地浪费频谱资源。因此，当前频谱分配方案未将关于流量模式的实时数据考虑进来，鼓励在频谱的利用和细分之下，并通过保护频带和带宽节流或带宽密集的特征和服务的实现创建进一步的无效率。

[0127] 各种实施例方法和系统提供了用于通过使用实时数据动态管理 RF 频谱的可用性、分配、接入和使用的动态频谱仲裁 (DSA) 系统。当前，基于未来使用的预测在频率和空间中许可或购买 RF 频谱而无需将实时数据考虑在内。DSA 通信系统使 RF 频谱基于频率、空间 (即，地理区域) 和时间可用，因此，提供了与当前静态命令和控制方法相比灵活和动态的频谱管理方法及系统。由于 RF 频谱资源是基于时间、频率和空间可用的，通过 DSA 通信系统分配的频谱可用于短期租用并且不受干扰。频谱的短期租用可增加在给定的市场领域的竞争并提高频谱效率而不会负面影响运营商的传递服务的能力。通过高效且动态地管理频谱可用性、分配、接入和使用，DSA 通信系统可以实际上增加 RF 频谱的可用性。

[0128] 在一个实施例中，DSA 通信系统可以是隶属于参与的提供商的独立的业务。在此类场景中，DSA 通信系统的组件可以是参与网络提供商的集成单元以允许提供商监控他们的资源 vs. 带宽流量并且确定他们是否需要或能够提供额外的资源。DSA 通信系统的非集成的组件可管理参与的提供商之间的资源的全面交换。使用 DSA 通信系统的益处可包括优化商业收益和提供在物理 (地理) 和时间基础上更广泛和更高效的带宽的使用。

[0129] 在一个实施例中，通过要求参与的提供商订阅 DSA 通信系统，DSA 通信系统可实现分配 / 接入 RF 频谱资源。例如，订阅可以基于定价安排。作为 DSA 通信系统的参与者，可使 RF 频谱请求提供商能够通过依据他们对于带宽的需求和他们为支付它做的准备在频谱的“泳道 (swim lanes)”内和外滑动来使用任何可用的 RF 频谱。一个频谱的“泳道”将是由一个提供商具有 / 控制的 RF 频谱带宽。

[0130] 为参与 DSA 通信系统，一个或多个运营商初始地可同意允许在市场中对其频谱进行次要使用。DSA 通信系统可使每个提供商能够购买提供商的网络中的可用的频谱或报价以向买者提供商售卖额外的频谱。

[0131] 在一个实施例中，DSA 通信系统可确定使用次要网络和集群的订户无线设备 101 的兼容性。如果订户设备能胜任，可使用不兼容的无线接入网络 (RAN)。因此，如果无线设备 101 能够接入不同的 RAN，DSA 通信系统可促成这些设备接入来自其他 RAN 的频谱，即使交换机是在不兼容的 RAN 之间。DSA 通信系统是基于策略的并且可为频谱和容量管理提供独特的实现方式。DSA 通信系统可基于长期演进 (LTE)、演进数据优化或只演进数据 (EVDO)、演进的高速分组接入 (HSPA) 和任何已知的无线接入平台。

[0132] 图 9 展示了基于长期演进 LTE 的无线接入平台中的实施例 DSA 通信系统的通信组件图 900。DSA 通信系统可包括动态频谱策略控制器 (DPC)902，该控制器连接到可以与提供

商网络的网络组件进行通信的归属订户服务器（HSS）904。HSS 904可以是一个主用户数据库，该数据库支持动态频谱策略控制器（DPC）902。HSS 904可以包括订阅相关的信息（即，订阅简档），执行认证并授权次要用户，并可以可选地提供关于订户的位置的信息和IP信息。HSS 904可包含用户的（SAE）订阅数据，如EPS订阅QoS文件或用于漫游的任何接入限制。它还可保持、存储或保留关于用户可以连接到其上的PDN的信息。这可以采用接入点名称（APN）（这是根据描述到PDN的接入点的DNS命名惯例的标签）或PDN地址（指示订阅的一个或多个IP地址）的形式。此外，HSS 904保持动态信息，如用户当前连接到其上或在其注册的移动性管理实体（“MME”）的身份。HSS 904还可以集成认证中心（AUC），该认证中心生成用于认证和安全密钥的向量。

[0133] 可将HSS 904连接到信令服务器7（SS7）906。可将动态频谱策略控制器（DPC）902和HSS 904都连接到互联网106。HSS 904可独立地经由SS7网络906与网络的网络内组件通信。

[0134] DPC 902还可通过商业或私有无线运营商903和动态频谱控制器（DSC）910或直接通过DSC 910而不使用商业或私有运营商与网络提供商的网络组件通信。可以将DSC 910组件添加到用于参与DSA通信系统并可与OMC/NMS 910通信的网络的网络组件。在各个实施例中，DSC 910组件可以包括至策略控制和收费规则功能（PCRF）905组件/服务器的有线或无线连接。

[0135] 频谱资源的可用性

[0136] 在各种实施例中，DSA通信系统可使频谱提供商能够监控并评估它的RF频谱使用和可用性，并且使未使用的RF频谱可供其他提供商或未订阅的用户（即，次要用户）使用。DSA通信系统可提供不同的方法来确定RF频谱可用性，如位置和数据库查找、信号检测器和频谱使用信标。DSA通信系统可使一个提供商（主机网络）能够标识可供另一提供商或提供商订户（次要用户）使用的频谱资源，如在每使用或每分钟的基础上的支付。

[0137] 在一个示例性实施例中，如图9中所示，DSA通信系统900可使网络能够确定RF资源的可用性。在每个网络或子网络，DSC 910可通过OMC/NMS 912监控呼叫流量以实时地接收各种网络元件的详细状态而不向网络插入另一设备。DSC 910可基于现有的业务的状态、计划的流量余量和系统策略执行基于策略的QoS决定以便确定网络或子网络是否具有资源来为次要使用分配或要求来自另一提供商的资源。

[0138] DSC 910可配置有软件以使用容量策略标准向DPC 902通信关于频谱资源的可用性的数据。通信到DPC 902的数据可包括涉及网络或子网络的当前过剩容量和预期的未来容量的数据。

[0139] 可动态地分配和解除分配在网络提供商处可用的资源。可通过DSC 910控制资源轮询信息并将其转发到用于中心协调的DPC 902。然而，基于DSA通信系统中的规则集，DSC 910可标识可用于系统等级和集群等级上的次要使用的资源，因为系统中的流量通过增加和降低而波动，用于次要使用的资源池可增加和降低并可经由DSC 910被报告给DPC 902。

[0140] 可用资源的分配

[0141] 在各种实施例中，动态频谱仲裁（DSA）系统可为特定使用进一步管理网络提供商的RF频谱资源的分配或指派，如由次要用户使用。DSA通信系统可基于提供商的变化的标准来管理RF频谱分配，如优先的程度（例如低优先级或无优先级）、连接的类型（例如，“总

是在线”和“激增”担保的接入和带宽）以及价格。

[0142] 相比于当前可用的频谱分配技术，由DSA通信系统进行的频谱资源的分配可依赖于参与的提供商的实时流量状态。DSA通信系统资源分配可进一步取决于不同的因素，如资源的可用性、正在传递的服务的类型以及与那些服务相关联的策略。可考虑用于分配在DSA通信系统中的资源的一些关键策略标准可包括无线电接入选择、容量增大、服务质量(QoS)、承载选择、拥塞控制、路由、安全和分级。DPC和DSC 910可执行策略定义和控制。

[0143] 无线电接入选择：DSA通信系统可以被配置成用于从可用的资源池进行最佳可用频谱指派。在频谱指派的选择中考虑的因素可包括频谱带宽、频谱在频带中的位置、沿着所请求的服务的地理区域和QoS。

[0144] 容量增大：DSA通信系统可以被配置成用于从可用的资源的池进行最佳可用容量增大指派。决定中考虑的因素可包括频谱带宽、频谱在频带中的位置、沿着所请求的服务的地理区域和QoS。

[0145] 承载选择：DSA通信系统可以被配置成用于选择支持在无线电和传输承载服务处的所请求的QoS简档所要求的资源。

[0146] 接纳控制：DSA通信系统可以被配置成用于在无线电和IP传输网络中都维持可用/所分配的资源的信息并且响应于新的服务请求执行资源预留/分配。

[0147] 拥塞控制：DSA通信系统可以被配置成用于在主网络上监控流量情况并且为容量分流寻找备选的方法。此外，DSA通信系统可以被配置成用于监控主网络并且随着在主网络上的流量需要增加执行次要用户的退避。

[0148] 路由：DSA通信系统可以被配置成用于保证基于承载流量和可用的网络资源为服务使用最优路由。

[0149] 安全：DSA通信系统可以被配置成用于通过将流量分成多个隧道为流量流提供安全从而保证没有信息的交叉作用。

[0150] 分级：DSA通信系统可以被配置成用于协调分级方案，包括优先化和运营商使用费以及其他计量过程。

[0151] DSA通信系统资源分配可基于不同方法，如无国家的方法的和有国家的方法。通过采用不同的分配方法，DSA通信系统可使提供商能够基于他们各自的频谱流量需要来定制频谱分配和利用。无国家的方法可涉及在实时基础上在网络之间协调频谱使用。有国家的方法可包括跟随定义的时间间隔存储并转发频谱资源。可在需要的基础上进一步分配RF频谱资源，这可基于承诺的和峰值的带宽/流量要求。基于需要的分配方法可允许最大的灵活性和频谱利用。DSA通信系统可进一步采用刚好及时的分配方法使提供商能够分配频谱资源。通过采用刚好及时的分配方法，DSA通信系统可为给定的市场改进全面的频谱利用并为无线运营商提供收益源。

[0152] 在一个实施例中，DSA通信系统可提供命令和控制功能来实现为整个许可区或为定义的子许可区并且对于一定期限租用频谱。例如，DSA通信系统可使用子频谱块方法促成频谱资源分配，具有增加或降低动态消耗的频谱的能力。例如，多个不同的通信网络可以向相同的用户分配频谱。

[0153] 如图9中所示，不是提供商网络的一部分的DSA通信系统的组件如DPC 902可管理在不同网络或子网络之间的频谱分配。

[0154] 在一个实施例中，DSA 通信系统可使主机网络能够将分配当前指派为供主用户使用的资源分配供给次要用户使用。在此场景中，可授权次要用户接入到主机网络的频谱容量或资源，无论主机网络的现有可用容量如何。

[0155] 管理和策略管理

[0156] DSA 通信系统可基于预定的规则和参数操作，该规则和参数可基于信道可用性的统计。例如，操作规则可使 DSA 通信系统能够监控向在任何给定时间 RF 频谱接入的等级以允许系统确定容量是否可用于分配。

[0157] 如上所述，可通过遵循由业务安排、设备兼容性、目标系统 RAN 和容量和所请求的服务定义的规则的 DSA 通信系统组件（如 DPC 902 和 DSC 910）进行资源分配。

[0158] 图 9 进一步展示一种用于实现 DSA 策略管理的实施例方法的网络架构 900。DSA 通信系统可要求参与方遵守管理规则和策略。

[0159] 在实现 DSA 策略时，参与网络的策略控制和收费规则功能 (PCRF)905 可提供策略和服务控制规则并且 Rivada® 策略控制网络 (RPCN) 可基于 DSA 规则和 DPC 902 要求提供策略改变和校正。PCRF 可负责策略控制决定制定，以及在策略控制执行功能 (PCEF) 中控制基于流的收费功能性，该策略控制执行功能驻留在 PGW 中。PCRF 提供 QoS 授权 (QoS 级别标识符 [QCI] 和位速率)，该 QoS 授权决定在 PCEF 中将如何对待某一数据流并保证数据流和授权相符并且符合用户的订阅简档。RPCN 可以是每个网络 DSC 910 的一部分。RPCN 可为还可链接到商业系统的公共安全用户进一步维持热表 (Hot List)。

[0160] 例如，当主机网络的资源耗尽，网络 PCRF 905/RPCN 可指令主机网络采取行动来为归属网络的优选用户恢复额外的资源。由 PCRF 905/RPCN 发送的指令可用来确定需要采取来为优选用户的使用释放资源的动作的过程。例如，PCRF 905/RPCN 指令可降低次要用户无线设备 101 或某些应用的 QoS 或基于条件集从网络甩掉次要用户无线设备 101。当通过减少流量来管理它的资源的等级时，主机网络可实现时隙分配。

[0161] EPC 的一些可选的子组件可包括 MME 914（移动性管理实体），这是对于 LTE 接入网的关键控制节点，并可负责空闲模式 UE（用户设备）跟踪和寻呼过程，包括重传，并可参与承载激活 / 去激活过程并且还负责在初始附着并在涉及核心网 (CN) 节点迁移的 LTE 内切换的时间为 UE 选取 SGW。MME 914 可负责对用户进行认证（通过与 HSS 交互）。非接入层 (NAS) 信令在 MME 914 终止并还可负责生成和向 UE 分配暂时身份。MME 914 可以检查 UE 的授权以预占服务提供商的公共陆地移动网 (PLMN) 并强制执行 UE 漫游限制。SGW 922（服务网关）可路由和转发用户数据包，同时也作为在 eNodeB 间切换期间用于用户平面的移动锚点，并且作为用于在 LTE 和其他 3GPP 技术之间的移动锚点。PGW 908(PDN 网关）通过作为用于 UE 的流量离开点和进入点提供从 UE 到外部分组数据网络的连接。UE 可同时具有与多于一个 PGW 908 的连接用于接入多个 PDN。HSS 926 可以是一个中央数据库，该中央数据库包含与用户相关的信息和订阅相关的信息。HSS 926 的功能包括例如移动性管理、呼叫和会话建立支持、用户认证和接入授权。ANDSF 918（接入网络发现和选择功能）向 UE 提供有关向 3GPP 和非 3GPP 接入网络（如 Wi-Fi）连接的信息。ANDSF 918 的目的是促成 UE 在其附近发现接入网络，并提供规则（策略）以便优先化并管理到这些网络的连接。网络 900 还可以包括 ePDG（演进的分组数据网关）从而确保与通过不可信的非 3GPP 接入网连接到 EPC 的 UE 数据传输安全。

[0162] DSA 通信系统策略和管理可具有与在商业网络中发现的那些属性相同的属性。然而，在 DSA 通信系统中，策略驱动的 QoS 与动态频谱仲裁 / 分配的组合既可以提高主要和次要（例如，出租者和承租者）频谱利用率两者又可以降低整体成本。

[0163] 在一个实施例 DSA 系统中，可为每会话、每“管道”、每用户或用户组的特定等级的网络资源设置策略 / 管理。策略还可涉及优先级，如取得最高优先级的紧急呼叫，或偏好，如允许降级正在进行的呼叫的质量或在接近拥塞时拒绝新的呼叫。DSA 策略和管理还可调用可用来促成用于特定类型的通信会话和服务供给的最佳路由的日常策略。

[0164] 接入另一网络的分配资源

[0165] 在一个实施例中，DSA 通信系统可管理用户到网络的可用 RF 频谱资源的接入。例如，DSA 通信系统可管理次要用户到分配给次要使用的主要主机网络的频谱资源的接入。

[0166] 次要用户可使用不同的方法如通过充当动态漫游者或使用与兼容的接入技术协调的频谱方案来接入主要主机网络的频谱资源。在允许次要用户接入主要主机频谱资源时，DSA 通信系统可基于不同的参数（如价格、接收质量、地理区和位置）使一个提供商的订户的无线设备 101 能够将带宽从属于无线设备 101 的归属网络提供商的频谱改变到属于主机网络提供商的频谱。

[0167] DSA 通信系统可基于不同的接入条件向次要用户提供接入。DSA 通信系统可或者暂时地或者通过与主要提供商的主要用户共享用于无线电接入技术的流量吞吐量来提供对可用频谱的接入。暂时接入可涉及接入基于 DSA 通信系统的策略为使用而分配的定义频谱。共享频谱可涉及允许一个提供商的订户在次要基础上在主机提供商处接入无线电频谱。

[0168] 次要用户的归属网络提供商可采用不同的方法为主提供商的所分配的 RF 频谱资源动态地签订合同。例如，主要提供商可拍卖而次要提供商则可为可用的频谱资源竞标。竞标可以是基于费用的过程 ；可涉及在暂时或永久的基础上管理未使用的频谱的转卖来高效地管理当时以其他方式未使用的过剩资源 ；或在暂时或永久的基础上管理过剩 RF 频谱的租用。

[0169] 图 10 展示使用 DSA 通信系统来共享频谱资源的两个无线网络提供商的网络架构 1000。DSA 通信系统可以包括两个通用组件 ：网络外组件和网络内组件。DSA 通信系统的网络外组件可包括连接到 HSS 904 的 DPC 902。DPC 902 可使 DSA 通信系统能够动态地管理对网络的分配的频谱资源的接入。例如，DPC 902 可管理网络提供商的次要用户向主要网络提供商的分配的频谱资源的接入。

[0170] DPC 902 可进一步协调 DSA 通信系统策略并且实行网络提供商之间的相关信息的共享。DPC 902 可进一步促成收费策略和可与网络通信的资源请求。

[0171] DPC 902 可以被配置成用于通过每个 DSA 通信系统参与提供商的网络内 DSC 910 组件与一个或若干个网络（例如，网络 1 和网络 2）通信。在一个实施例中，每个网络 1 和网络 2 可包括 DSC 910a、910b，其可到无线运营商的在线管理中心 / 网络管理系统（OMC/NMS）912a、912b 的附加组件。在每个网络，DSC 910a、910b 可管理每个网络的流量和容量并且为基于从 DPC 902 的接收的命令或其策略和规则集容量约束连续地监控节点。DSC 910 可将它的发现通信给 DPC 910。

[0172] 每个网络可包括 OMC/NMS 912a、912b，其可与无线网络 1002a、1002b 通信。无线网

络 1002a、1002b 可与无线接入节点 102a、102b 通信。订户无线设备 101 可与无线接入节点 102a、102b 通信。网络的这些组件的关系和互连是已知的。

[0173] 在一个实施例中，网络 1 的 DSC 910a 可确定网络 1 可能要求额外的资源。网络 1 的 DSC 910a 可以被配置成用于向 DPC 902 发送用于额外的资源的请求。DPC 902 可接收关于次要用户无线设备 101a 位置和网络的信息。

[0174] DPC 902 可以被配置成还接收来自其他附属的网络如来自网络 2 的 DSC 910b 的数据。网络 2 的 DSC 910b 可以被进一步配置成用于向 DPC 902 报告指定量的资源可用于网络 2 中。

[0175] DPC 902 可以被配置成用于处理从请求网络（即，网络 1）和供应网络（即，网络 2）接收的数据并且通过请求网络 1 促成实时接入网络 2 的资源。一旦使来自网络 2 的频谱资源可用于由网络 1 的用户的接入，DSC 910a 可指令无线设备 101a 改变网络并接入由网络 2 提供的频谱资源。例如，当网络 1 的无线设备 101a 请求通信资源时，可由网络 2 的 DSC 910 验证它的规则集。网络 2 可在 PCRF 905 中（图 9 所示）接收无线设备 101a 的更新信息。使用其他平台的 PCRF 905 可允许次要用户无线设备 101a 接入网络 2 的所分配的资源。

[0176] 在一个实施例中，通过 DSA 通信系统向次要用户的资源的可接入性还可取决于主机网络运营商策略以及用于那些资源的使用标准。该标准可包括无线电接入和核心网络资源两者。

[0177] 例如，由主机网络运营商施加的一些策略和资源标准可包括：频谱的可用性（例如，分开或共同存在）；容量 / 带宽的可用性（例如，RF 和核心）；开销标准（例如，总可用容量 vs. 使用的容量的百分比）；退避标准的存在（例如，重选、切换（系统内和系统间）、终止）；对待（如何对待 / 路由特定的服务 / 应用）；禁止对待（例如，禁止使用服务 / 应用）；分级（例如，如何对服务进行分级，即，对于非高峰使用可能的特殊折扣）；地理边界（例如，定义要包含的区域或小区）；时间（例如，定义要包含的时间和日期）；持续时间（例如，基于时间和地理边界定义增量分配）；用户设备类型。

[0178] DSA 通信系统可使次要网络能够基于以下内容请求频谱资源：时间（例如，何时请求资源）；所要求的容量 / 带宽；对待（例如，期望什么服务，包括 QoS）；地理边界（例如，在哪里请求服务）；和持续时间（例如，请求资源多长时间）。

[0179] 在一个实施例中，由 DSC 910a、910b 执行的通信对次要用户可以是透明的。在另一个实施例中，通信可以不是透明的。

[0180] 图 11 展示可通过第三方或频谱清算所处理频谱使用和流量数据的实施例 DSA 通信系统的网络组件图 1100。DSA 通信系统的网络外组件 1102 可包括多个子组件，如 DPC 902（图 9 中所示）。DPC 902 可通过与核心网 1104a、1104b 的子组件通信而与无线网络 1 和 2 通信。网络外组件 1102 还可使用互联网或私有网络 106 与一个或两个网络都通信。例如，DSA 通信系统网络外组件 1102 可经由互联网 106 与网络 2 的核心网 1104b 通信，同时直接与网络 1 的核心网 1104a 通信。核心网 1104a、1104b 可包括多个子组件，如 DSC 910、长期演进 (LTE)、(EVDO)、(HSPA) 和 OMC/NMS 912a。

[0181] 当网络 1 变得负担过重并且需要额外的频谱资源时，核心网络 1104a 可确定对于频谱的要求并从 DSA 通信系统网络外组件 1102 请求额外的频谱资源。由于低呼叫流量，网

络 2 可确定它具有可用的过剩量的频谱资源。网络 2 还可向网络外组件 1102 报告过剩资源的可用性。在 DSA 网络外组件 1102 和网络 2 之间的通信可通过互联网 106。可替代地，网络外组件 1102 和网络 2 可如虚线 1106 所示直接通信。DSA 网络外组件 1102 可促成在此通过虚线 1108 所示的从网络 2 到网络 1 分配频谱资源。

[0182] 无线设备 101b 可通过不同方法来接入所分配的资源。网络 1 可指令无线设备 101b 将网络切换到网络 2 来作为网络 2 上的次要用户使用所分配的资源。可替代地，可使网络 2 的所分配的资源通过网络 1 可用，使无线设备 101b 能够使用网络 2 的资源而不必改变从网络 1 到网络 2 的通信会话。例如，网络 1、2 和 3 可汇聚可分配供多个实体使用的频谱。

[0183] 图 12 展示一个实施例 DSA 网络的通信系统 1200。当为若干不同的网络服务时，DPC 902 可为仲裁过程提供主控制。DPC 902 可包括用于当前分配的策略和取决于时间的仲裁规则。DSC 910 可以被配置成还具有用于当前分配的策略和取决于时间的仲裁规则的本地副本。策略和取决于时间的仲裁规则的本地副本可保证可维持网络资源的本地控制。此外，DSC 910a-910c 可以是与为未来网络操作问题提供分界点的网络操作系统进行接口连接的分离的平台。

[0184] 在一个实施例中，为保证在发生事件时的系统的灾难恢复，可将 DPC 902 配置为双重镜像服务器站点（例如，DPC 902a 和 DPC 902b）或在地理上分散的集群中包括若干服务器。为保护网络，DPC 902a、902b 可具有到定义并预批准的网络运营商 1204a、1204b、1204c（例如，频谱资源提供商）和系统资源请求者 1206、1208、1210（例如，竞标者）的安全链路。

[0185] 在 DPC 902a、902b 和 DSC 910a、910b、910c 之间的通信的失败的情况中，DSC 910a、910b、910c 可被配置成用于使用它的本地保存的策略和规则内容来维持已经由 DPC 902a、902b 发起的仲裁过程中的连续性。然而，由于缺乏与 DSC 902a、902b 的连接，DSC 910a、910b、910c 可能不能促成额外的新资源分配或竞标。为保证总是维持本地控制，DSC 910a、910b、910c 可以被进一步配置成用于控制并且本地覆写使本地运营商能够过早地从次要用户终止或退避资源的多个组件和功能。

[0186] 例如，DSC 910a 可本地存储任何通信 DPC 902a、902b 的策略和规则。如此，如果 DPC 902a、902b 和 DSC 910a 之间的通信在已经由 DPC 902a、902b 处理的竞标之后妥协，DSC 910a 可继续向竞标者 11206 的次要用户提供资源而无需终止次要用户。此外，当网络 A 1204a 要求更多资源来向它自己的主要用户提供服务时，DSC 910a 可本地控制次要用户从网络 A 分流以基于 DPC 902a、902b 的策略和规则释放资源。

[0187] 在一个实施例中，DSA 通信系统中涉及的过程可与用于流的所有情况类似。如图 13A 中所示，可基于网络怎样使用它们而将频谱块 1300A 的资源分类。可将用于给定频谱的资源分类成占用的资源、不确定的资源和可用的资源。占用的资源可以是当前由运营商使用的那些资源并且可能不是由 DSA 通信系统分配的。不确定的资源可为运营商提供余量来管理高峰负载。可在高峰负载期间用光不确定的资源并且在低峰负载期间不使用。可用的资源可以是网络根本未使用的资源的子集。可使可用的资源可用于向其他次要提供商分配。

[0188] 在一个实施例中，可通过不同方法向次要用户分配频谱资源。图 13B 展示根据一个实施例由主机网络许可的频谱块 1300 的频谱资源的分配。主机网络可许可包括四个信

道的 RF 频谱块 1300a。主机网络可将 RF 频谱块的四个信道中的三个专用于供网络 1 订户使用。在 RF 频谱块 1300b 将专用信道 1-2 阴影化。如由 RF 频谱 1300b 所示,信道 4 可保持未由提供商指派。可部分地分配、部分地过渡并且部分地未指派信道 3,如由频谱块 1300c 所示。可为在高流量时期期间由提供商的订户使用而预留频谱块 1300c 的过渡部分。可从不使用许可的频谱 1300c 的未指派的部分。

[0189] 在一个实施例中,主机网络可使用 DSA 通信系统来将许可的频谱的未指派的部分从属许可到次要用户。在此场景中,主机运营商可使信道 3 的未指派部分和信道 4 的所有可用于次要用户。

[0190] 图 14 展示根据一个实施例的包括许可的频谱 1400 的保护频带信道的频谱资源的分配。许可的频谱 1400 可包括或者由运营商定义或者留出作为频谱部署策略和程序的一部分的保护频带 1404。此类保护频带可包括当前仍未使用的有用资源。主机网络可使用 DSA 通信系统允许次要用户使用在保护频带中可用的资源。通过使用 DSA,主机网络可通过将保护频带组合成用于资源分配的单个有用信道 1402 使可用于使用未使用的保护频带资源。

[0191] 图 15 展示根据一个实施例使用 DSA 通信系统的多于一个主机网络的频谱资源的汇聚和分配。在一个实施例中,DSA 通信系统可以被配置成用于从不同的网络调查可用的频谱并将可用的频谱汇聚起来用于分配。在由频谱块 (1) 所示的示例性实施例中,主机网络中的每个即网络 A 和网络 B 可许可包各自包括四个信道的频谱块。例如,由网络 A 许可的频谱块 1502A 可包括信道 1A、2A、3A 和 4A。由网络 B 许可的频谱块 1502B 可包括信道 1B、2B、3B 和 4B。

[0192] 在如由频谱块 (2) 所示的示例性实施例中,网络 A 的频谱块 1504A 可包括可用信道 4A 和部分指派的信道 3A。可部分指派信道 3A 供网络使用、部分过渡并部分可供其他网络使用。网络 B 的频谱块 1504B 可包括可用信道 1B 和 4B 以及部分指派的信道 3B。信道 3B 可部分地指派供网络使用、部分地过渡并且部分地可用于向其他网络分配。

[0193] 在如由频谱块 (3) 所示的一个示例性实施例中,网络 A 和网络 B 的每个频谱块 1506A、1506B 可通过使用 DSA 通信系统来使它们的资源可用。DSA 通信系统可从每个网络汇聚可用的资源并将其分配给次要用户。例如,DSA 通信系统可汇聚信道 1B 和 4B 中可用的资源并使它们对次要用户可用。DSA 通信系统可汇聚信道 4A 中可用的资源和信道 3A 中可用的部分资源并且使它们可用于次要用户。

[0194] DSA 通信系统可从不同网络汇聚可用资源用于向次要用户分配。在一个示例性实施例中,如频谱块 (4) 中所示,DSA 通信系统可从网络 A 中的信道 4A、频谱块 1508A 和网络 B 中的信道 1B 和 4B、频谱块 1508B 汇聚可用的资源并且使它们可用于次要用户。

[0195] 在一个示例性实施例中,如由频谱块 (5) 所示,DSA 通信系统可从不同网络中的所有信道汇聚可用资源,包括具有完全供网络使用的资源的信道和包括可用资源的信道。DSA 通信系统可从网络 A 中的信道 3A 和 4A(频谱块 1510A) 和网络 B 的信道 1B、3B 和 4B(频谱块 1510B) 汇聚频谱资源并且使它们对次要用户可用。

[0196] 在一个实施例中,DSA 通信系统可使移动虚拟网络运营商 (MVNO) 能够利用未使用的频谱容量。例如 DPC 902 可聚合多个 MVNO 来以优先化方案利用未使用的频谱容量。这将使 MVNO 能够向另一 MVNO 出售它的未使用的或未用尽的容量,从而保证 MVNO 的操作都高

效。

[0197] 图 16A 至图 16C 展示根据一个实施例的 MVNO 频谱聚合。图 16A 展示用于 MVNO A 1602A 和 MVNO B 1602B 的频谱的分配或容量，其中两个运营商都拥有未指派的频谱容量。图 16B 展示示例性实施例方法，通过此方法 DSA 通信系统可使 MVNO B 1604B 能够通过从 MVNO A 1604A 接收来指派的频谱来增加或增大它的可用的频谱容量。图 16C 展示一个示例性实施例方法，通过该方法 DSA 通信系统可使一个 MVNO C 1606C 能够从两个其他的 MVNO 的 1606A、1606B 接收额外的频谱容量。MVNO C 1606C 可以是新的或额外的 MVNO 并且可从 MVNO A 和 MVNO B 1606A、1606B 为它的潜在使用获得可用的未指派的频谱容量。在此场景中，MVNO A 和 MVNO B 1606A、1606B 可以或可以不在相同的主机运营商上操作并且可以或可以不具有相同的无线电接入技术（RAT）。在另一个实施例中，可提供转换来提供在不同 RAT 之间的接入。

[0198] 在一个实施例中，为测量次要用户使用的资源的数量，主机网络可以使用与用于预支付用户相似的过程从而促成次要使用的时间 / 持续时间和使用计量，这可以在单独或全局计费基础上进行。

[0199] 取决于由次要用户用来接入可用的资源的方法，可实现 DSA 分配方法的若干基础类型，包括 :1) 虚拟最佳努力方法 ;2) 虚拟次要用户方法 ;和 3) 可包括许可区和局部区频谱分配的频谱分配方法。这些分配方法中的每个方法可具有若干变体。例如，在虚拟最佳努力方法中，DSA 通信系统可以被配置成用于使频谱资源可用于整个许可区或在局部的、子许可区基础上。还可在用户的无线设备 101 中由他们的归属网络提供商定义用户的级别并且可被指派或者次要用户或者最佳努力用户状态。

[0200] 在一个实施例中，虚拟最佳努力方法可以是通过向所涉及的网络的接入的授权对 MVNO 可用。可在主机网络之内基于归属网络和主机网络的 PCRF 规则发生优先化。

[0201] 在虚拟最佳努力方法中，主机网络可使次要用户无线设备 101 能够使用与主机网络相同的网络，但在虚拟的基础上，即，MVNO 类型的安排。此安排的不同变化可包括多种情况，当 :1) 次要用户用与主机网络订户相同的权限使用主机网络并且 2) 次要用户作为次要用户或在主要用户（主机订户）比次要用户订户具有更高优先级和权限的次要的基础上使用主机网络。可在主要用户是公共安全用户的网络中建立对于主要用户的接入优先级。在紧急情况期间，由于通过如公共安全主用户的其他用户对其频谱使用的增加，主机网络可挂断次要用户。

[0202] 图 17 根据一个实施例展示用于分配资源的 DSA 通信系统的通信系统 1700。如图 17 中所示，在虚拟最佳努力方法中，可将无线设备 101 看作有效漫游者。

[0203] 在竞标过程中，DSA 通信系统可实现可用来为被授权接入主机网络的无线设备定义服务类型、对待和服务的持续时间的规则集。规则集可包括信息，如 :1) 所请求的容量 / 边界 ;2) 服务的对待，如，何时要求它们以及 QoS ;3) 基于所请求的服务的地理边界 ;4) 请求资源的时间 ;和 5) 将由次要用户使用的请求资源的持续时间。设想到可取决于仲裁方案使用这些规则的所有或子集。

[0204] 在虚拟最佳努力方法中，DSA 通信系统可遵循行业漫游过程，因为假如请求服务的无线设备满足所要求的认证过程则可向次要用户授权到频谱的接入。可遵循标准的 MAP/IS-41 过程通过主 HSS 926 和 AAA 的使用来执行次要用户无线设备 101 的验证 / 认证。

[0205] DSA通信系统可增加到漫游的过程的额外的标准可包括不同的计费方案。例如，主机网络可管理次要用户的无线设备 101 的接入持续时间或总使用许可。此类管理方案使主机网络能够本地并且在实时基础上控制次要用户的接入。在虚拟最佳努力方法中，DSA 通信系统可能不预留资源并且仅跟踪资源的消耗。

[0206] 在虚拟最佳努力方法中，主要或主机网络提供商可不授权次要用户优先化，除了通过由主机网络提供商的 PCRF 905 和 PDN 网关 (PGW)908 所提供的差异。为利用使用虚拟最佳努力方法的 DSA 通信系统的资源，次要用户可使用或者主机网络的 PGW 908 或者次要网络的 PGW，该 PGW 可或者被连接到主机网络的适当的服务网关 (SGW)922 或者通过由主机网络管理的中间 PGW 908 连接到主机的 PGW。

[0207] PGW 负责根据来自 PCRF 的规则用于无线设备 101 的 IP 地址分配、以及 QoS 强制执行和基于流的计费。它负责将下行链路用户 IP 分组过滤为不同的基于 QoS 的承载。这是基于流量流模板 (TFT) 来执行的。PGW 为有保证的比特速率 (GBR) 承载执行 QoS 强制执行。它还可用作与非 3GPP 技术如 CDMA 2000 和 WiMAX® 网络交互工作的移动锚点。

[0208] 可通过 SGW 传输所有用户 IP 分组，该 SGW 充当当无线设备在 eNodeB 之间移动时用于数据承载的本地移动锚点。用于 eNodeB 间切换的本地移动锚点包括下行链路分组缓冲和网络触发服务请求的发起、合法的拦截、用户计费和 QCI 粒度以及每无线设备的 UL/DL 计费。SGW 还保留了关于当无线设备处于空闲状态的承载的信息（称为“EPS 连接管理 -IDLE”[ECM-IDLE]）并且当移动性管理实体 (MME) 发起无线设备的寻呼来重建承载时暂时缓冲下行链路数据。此外，SGW 在被拜访网络中执行一些管理功能如收集用于计费的信息（例如，向用户发送的 / 从用户接收的数据量）和合法的拦截。它还充当用于与如通用分组无线服务 (GPRS) 和 UMTS 的其他 3GPP 技术交互工作的移动锚点。

[0209] MME 是控制节点，其处理无线设备和 CN 之间的信令。在无线设备和 CN 之间运行的协议被称为非接入层 (NAS) 协议 (eMM，eSM) 和安全性、AS 安全性、跟踪区域列表管理、PDN GW 和 S-GW 选择、切换 (LTE 内和间）、认证、承载管理。MME 还包含用于避免和处理过载情况的机制。

[0210] eNodeB 执行无线资源管理功能，如无线承载控制、无线接纳控制、无线电移动性控制、上行链路和下行链路两者中的资源的调度和向无线设备的动态分配。eNodeB 可执行头压缩，这是指压缩可以其他方式表示显著的开销的 IP 分组头，尤其对于如 VoIP 的小分组来帮助保证无线电接口的高效使用。eNodeB 可通过保证加密在无线电接口上发送的所有数据来执行安全功能。

[0211] 在一个实施例中，虚拟最佳努力方法可使 DSA 通信系统能够通过使用不同的方法来管理资源分配。例如，主机网络的 PCRF 905 可控制接入主机网络并且跟踪资源的使用的次要用户的无线设备 101。可使用主机网络的计费系统来为次要用户计费。

[0212] 可替代地，主机网络的计费系统可控制 / 跟踪由次要用户进行的资源使用，并且次要用户的归属网络 PCRF 905 可提供优选的服务。在此类场景中，主机网络的 PCRF 905 可保留最终控制。

[0213] 可替代地，主机网络可提供接入并且次要用户的归属网络的 PCRF 905 可定义优选的服务。此外，作为使用虚拟最佳努力方法的分配过程的一部分，可向漫游到主机网络上的次要用户的无线设备指派不同的 TAI。这些 TAI 可为潜在的使用提供差别的服务区或定

义的地理区。在一个实施例中，可允许订户无线设备通过其在USIM中具有的或者预编程或者通过OTA供应提供的有效的PLMN的标识接入归属网络。由于不同的原因，归属网络可指令订户作为次要用户使用主机网络。此外，如果无线设备101能够同时接入两个网络，无线设备101可潜在地为一种类型的服务使用归属网络并且可被指令以使用用于其他服务的主机网络。

[0214] 在一个实施例中，可使用虚拟次要用户方法（例如系统内（即，频率出租者内(Intra freq-lessor)或频率主承租者内(Intra freq prime-lessee)））将可用的资源分配到次要用户。在虚拟次要用户方法中，主要主机网络可允许次要网络的次要用户使用主要网络的系统频谱资源操作，与主要用户相比具有不同的使用权限，如暂时租用但具有不同的SID。这可通过当主要网络系统和次要用户无线设备101之间存在技术兼容性时允许次要用户包括来自主要主机网络的频谱分配来实现。可将此分配应用到移动虚拟网络运营商，移动虚拟网络运营商提供移动电话服务但没有它自己的许可的无线电频谱的频谱分配，也没有提供移动电话服务所需的基础设施。

[0215] 在虚拟次要用户方法中，次要用户的优先化可遵循主机网络的PCRF 905和PGW 908规则。次要用户无线设备101可使用的PGW 908可或者由主机网络控制或者通过次要用户的归属网络可用。如果PGW 908通过次要用户的归属网络可用，可或者将它连接到适当的SGW 922或者例如通过由主机网络管理的中间PGW 908提供。在此类场景中，可将次要用户考虑成使用虚拟次要用户方法的DSA通信系统中的有效的漫游者，如图17中所示。

[0216] 在虚拟次要用户方法中，DSA通信系统可使用五个基础竞标规则集，这些规则集用于为次要用户无线设备101定义服务的类型、对待和持续时间。这些规则集可以包括以下信息，如：1)所请求的容量/边界；2)服务的对待，如何时要求它们以及QoS；3)基于所请求的服务的地理边界；4)请求资源的时间；以及5)次要用户将使用所请求的资源的持续时间，和可应用的其他规则集。设想到可取决于仲裁方案使用这些规则的所有或子集。

[0217] 在一个实施例中，当采用虚拟次要用户方法，主机网络可授权向次要用户无线设备101的接入，假使它满足预定的所要求的认证过程。使用虚拟次要用户方法的主机网络可使用不同的计费方案，其中无线设备101接入或使用全部由主机网络的规则和规范来管理，从而允许本地控制次要用户设备101。作为系统中的次要用户，可以取决于主机网络的条件来限制、减少或禁止无线设备的101向主机网络的接入。可在局部或系统范围的基础上取决于由竞标系统中的主机网络阐述的条件将限制、减少或禁止强加到呼叫上。可在动态基础上通过覆写竞标条件（例如在公共安全网络中）来进一步执行限制、减少或禁止。

[0218] 可遵循MAP/IS-41标准执行次要用户无线设备用户的认证或验证。使用MAP/IS-41，主机HSS 926和AAA可认证次要用户无线设备。

[0219] 在一个实施例中，当使用虚拟次要用户方法时，DSA通信系统可要求将主机网络和/或归属网络的不同组件用于资源分配。例如，主机网络计费系统和PCRF 905可控制次要用户向网络的接入并跟踪其使用。可替代地，主机网络计费系统可控制和/或跟踪使用并且次要用户的归属网络PCRF 905可提供优选的服务以及网络PCRF 905可执行最终控制。可替代地，主机网络可在归属网络中提供接入，并且PCRF 905可定义优选的服务。

[0220] 当使用虚拟次要用户方法分配的资源或者基于时间、使用或者其他标准接近耗尽时，DPC 902可通知主机网络中的归属网络运营商资源可能过期。如果允许的话，可使归属

网络运营商能够在主机网络处的额外资源上通过请求境外竞标来结束或补充可用于次要用户的资源或以其他方式提供额外的 RF 频谱资源。为向资源分配过程提供额外的灵活性，可向正漫游主机网络的次要用户的无线设备指派不同的 TAI。TAI 可为潜在的使用提供差异的服务区或不同的地理区域。

[0221] 在一个实施例中，次要用户的无线设备可能能够通过标识它可已经存储在它的通用订户身份模块（“USIM”）中的有效的公共陆地移动网络或 PLMN 来接入归属网络。可以或者预编程或者通过 OTA 供应来提供 USIM。当使用归属网络时，可重新指令次要用户的无线设备 101 来搜索它可以从其接收服务的主机网络。一旦标识了主机网络，次要用户无线设备 101 可为所有服务使用主机网络，或为一种类型的服务使用主机网络。可替代地，使用归属网络可以用于其他服务，如果无线设备 101 具有同时接入两个网络的能力。各种配置是可能的并且在本披露的范围内。

[0222] 图 18 根据一个实施例展示通信系统框图 1800，该框图展示在资源预留期间 DSA 通信系统中的两个网络的组件之间的通信。在一个实施例中，可由 OMC 912 控制主机网络（即，出租者）的配置。此外，归属网络（即，承租者）1802 可以与主机网络 1804 分离。

[0223] 在一个实施例中，使用虚拟次要用户方法的主机网络可通过使用不同的方法预留资源，包括 :1)eNodeB 的 X 分叉 ;2)SGW 和 PGW 链路带宽 ;3) 组合的资源分配 (PGW 和 eNodeB) ;以及 4)PCRF(主机) 控制。取决于主机网络要求和竞标过程，可以组合使用这些资源预留方法或这些资源预留方法可以是互斥的。

[0224] 通过对 eNodeB 进行 x 分叉，可为次要用户预留资源。在一个示例性实施例中，如图 19 中所示，可将 eNodeB 916b 分叉来为次要用户预留资源。eNodeb 916b 可从 PCRF 905、MME 914 和 SGW 922 接收分叉指令来划分百分比，如果它的资源可被用于另一 PLMN 网络。PGW 908 可位于主机网络或可位于远程。根据所接收的指令，eNodeB 916b 可为主要用户的使用而预留资源的 X% 并为由次要用户使用而预留资源的 Y%。eNodeB 916b 可传送增强的 PLMN(ePLMN)，该增强的 PLMN 可以是对于次要用户无线设备 101b 可识别的并且预占小区。

[0225] 在一个实施例中，还可通过控制次要用户无线设备被指派到其上的 SGW 922 和 PGW 908 之间的连接来预留资源。

[0226] 图 20 根据一个实施例展示一种用于控制 SGW 922 和 PGW 908a、908b 链路带宽分配方案的实施例方法。可通过控制主机 SGW 922 到各种 PGW 908a、908b 的连接来控制资源预留。可通过在动态基础上更改 SGW 922 和 PGW 908a、908b 之间的可用带宽来控制 SGW 922 到 PGW 908a、908b 的连接。相对于主机网络，PGW 908a、908b 可以是本地的和 / 或远程的。可通过可连接到 DSC 910 的 OMC/NMS 912 来更改 SGW 922 和 PGW 908 链路带宽。PGW 908a 可位于主机网络或远程。

[0227] 在一个实施例中，图 21 中所示，可通过将 eNodeB x 分叉和 SGW-PGW 链路带宽控制方法组合为分配目的而预留资源。

[0228] 在一个实施例中，主机 PCRF 905 可控制为向次要用户的分配的资源预留。主机 PCRF 905 可基于所请求的服务使用 QCI/ARQ 的组合来将次要用户无线设备 101 优先化，ARQ 可以是自动重传请求。在此场景中，PCRF 905 可向主要用户无线设备 101a 和次要用户无线设备 101b 指派 QCI/ARQ。

[0229] 在一个实施例中，可使用 RF 频谱分配方法来使资源可用于分配。在频谱分配方法

(例如系统间(频率出租者间、频率主要承租者间))中，主要网络可在地理区域中为由次要用户使用指派频谱资源。基于此，次要网络提供商可使主要网络资源可用作它们自己的正常操作网络的信道 / 频谱 (即，可以兼容或 IRAT)。还可将这应用到 MVNO。因此，次要用户可在他们的归属网络上接入主要网络资源而不必在主要网络上漫游。

[0230] 频谱分配方法可基于 a) 许可区 ;或 b) 局部区。在频谱分配的许可区和局部区方法中，可用来供主要网络提供商运营商 (即，出租者或网络 1) 使用的频谱可通过 OMC/NMS 912 编程。频谱分配方法可使主机网络能够基于期望的带宽、次要用户的地理边界、次要用户请求资源的时间和次要用户请求资源的持续时间来分配频谱。

[0231] 在一个实施例中，频谱分配方法可在动态的基础上使频谱资源对次要用户可用。用于频谱分配方法的计费过程可不涉及主机或拜访网络计费平台。而是，DPC 902 可协调用于此努力的计费。

[0232] 相比于虚拟最佳努力或虚拟次要用户方法，频谱分配方法可使归属网络运营商 (网络 2) 能够为次要用户无线设备 101 使用所分配的资源并且不与主要主机网络共享所分配的资源。因此，次要用户可在租用期间使用所分配的频谱资源。还可使次要用户归属网络能够在租用的持续期间通过使用它们的无线电接入网络节点 102 控制所分配的资源。

[0233] 图 23A 和图 23B 展示用于使用频谱分配方法向许可区 2300 分配频谱资源的实施例。当向许可区 2300 分配频谱资源时，主要主机网络可分配定义量的频谱资源来由次要用户归属网络使用。可授权次要归属网络的每个网络运营商在地理上定义的许可区上使用所分配的频谱。如图 23A 中所示，频谱许可块 2300 可属于特定许可区 2300。

[0234] 许可区频谱分配方法可涉及划分可在整个许可区上使用的频谱块 2302。可通过共享信道或通过其他方法在各种不同的信道中完成划分。如图 23B 中所示，频谱块 2302 可被划分以提供三个信道 2304a、2304b、2304c 供主要用户使用以及信道 2304d 供租用。

[0235] 图 24 展示用于使用频谱分配方法向局部区分配频谱资源的实施例。局部区频谱分配可涉及在主机网络的定义的许可区 2300 之内分配频谱。主要主机网络可分配某些定义的地理区。这些区包围可使用所分配的频谱资源的次要用户。因此，为所分配的资源的使用而指定的地理区可以是整个许可区 2300 的子区，其中运营商可以接入频谱。主机网络 (即，出租者) 可在时间基础上向其他次要运营商出租、售卖、选择或以其他方式转移资源，供它们的在地理上定义的子区中使用。这可允许主要主机运营商向它们的主要用户或为向其他次要网络出租而预留其他地理区的使用。

[0236] 可为可能的使用在运营商的许可区 2300 中定义单次资源分配。例如，可通过 DSA 通信系统将信道 (4)2302d 向针对区域 A 2402 的成功次要用户竞标者许可。还可将相同的信道 4 许可给针对区域 B 2404 的另一次要用户竞标者。在区域 A 2402 和 B2404 的外面，主要网络可使用全部频谱 (信道 1 至信道 4)2302。在区域 A 2402 和 B 2404 中，主要网络运营商只可使用信道 (1-3)2302a、2302b、2302c。在区域 A 2402 和 B 2404 中，主要用户可能不使用向次要网络提供商许可的信道 (4)2302d。例如，资源的竞标者可忙于许多不同的频谱合同关系，包括租用、购买、选择、交易、汇聚或以其他方式转移频谱。

[0237] 一旦分配了可用的资源，可基于不同的方法接入它们。频谱接入方法可取决于由正在提供资源的网络使用的分配的方法。一般来说，可将频谱接入方法分成漫游和非漫游方法两类。当基于漫游方法接入资源时，可要求次要用户无线设备 101 通过到主要网络上

的漫游使用可用资源。当基于非漫游方法接入资源时，可允许次要用户无线设备 101 仍然在它的归属网络上同时使用所分配的资源。

[0238] 图 25A 和图 25B 展示两个网络图，示出根据一个实施例使用漫游安排向资源的接入来允许无线设备 101 使用另一网络的资源。如图 25A 所示，无线设备 101 当前可使用网络 1 的频谱。网络 1 可将可能要求额外的频谱资源来继续对无线设备 101 的服务通信到 DPC 902。DPC 902 还可从可具有可分配供使用的额外或过剩频谱资源的网络 2 到来自其他网络的无线设备 101 接收信息。

[0239] 如图 25B 所示，一旦 DPC 902 证实网络 2 具有用于分配的频谱，基于所使用的服务、时间和 / 或地理位置，可指令无线设备 101 将运营商从网络 1 切换到网络 2。

[0240] 在一个实施例中，次要用户网络提供商可许可或租用使用由主要网络分配的频谱资源的权限。在此场景中，可不要求次要用户设备 101 漫游到主要网络上来使用所分配的频谱资源。次要用户设备 101 可仍然在可基于许可条款通过次要网络接入点使主要网络的资源可用的次要归属网络上。

[0241] 图 26A 和图 26B 展示根据一个实施例使用资源的短期租用的又一频谱分配方法。可通过采用 DSA 通信系统基于许可区、子许可区或通过各个节点、小区站点将可用的频谱租给其他网络。DSA 通信系统可使此类租用频谱通过遵循地理和空间边界确定的其他网络可用于次要使用。在一个实施例中，次要用户可通过它自己的次要网络接入主机网络的分配频谱并且不必切换到主机网络。

[0242] 图 26A 展示与网络 1 的无线接入节点 102a 通信的无线设备 101。网络 1 可具有与网络 2 的租用协定来使用网络 2 的指定频谱块。在此场景中，当网络 1 的频谱资源耗尽并且要求额外的资源时，网络 1 可使用许可的次要频谱资源来与订户无线设备 101 通信。图 26B 展示使用网络 2 的许可次要频谱资源与网络 1 通信的无线设备 101。

[0243] 频谱资源的租用可增强网络的容量，如图 27A 的图 27B 中所示。如图 27A 中所示，网络提供商 A 可取决于无线设备 101 的地理位置通过不同无线接入点 102a、102b、102c 为无线设备 101 服务。无线接入点 102a、102b、102c 可使用来自网络提供商 A 的频谱资源来为无线设备 101 服务。

[0244] 由于增加的流量，网络提供商 A 可要求额外的频谱资源来合适地服务它的订户。网络提供商 A 可许可或租用来自网络提供商 B 的频谱资源来增强并增大它的可用的频谱资源。如图 27B 中所示，提供商 A 的频谱容量增强可通过与提供商 B 共用无线电接入平台来实现。在此类场景中，无线接入点 102a、102b、102c 可广播从提供商 A 和 B 接收的频谱信号。

[0245] 初始小区选择

[0246] 小区或起呼可涉及为接入新网络上可用的额外的资源而将一个网络的无线设备 101 指向另一网络的情况。当前，为接收服务将无线设备 101 编程为建立与正确网络的连接。为找到正确的网络，一旦将无线设备 101 加电，它可搜索优选的公共陆地移动网络 (PLMN)、优选的漫游列表 (PRL) 和设备被授权使用的无线电运营商。可在无线设备上供应 PLMN/PRL 和无线电运营商的列表。PLMN/PRL 列表可包括授权网络的 PLMN 标识以及排序的运营商。

[0247] 由于 DSA 通信系统可提供对频谱资源的动态并且实时的接入，当使用 DSA 系统时，频谱资源可在无线设备的 PLMN/PRL 上未列出的网络处可用。

[0248] 作为DSA通信系统过程的一部分，可事先用适当的PLMN列表对无线设备101进行编程。而且，还可在次要归属网络上无线地供应无线设备101。无线供应可向一个或一组无线设备101提供指令来使用更新的PLMN列表重新发起小区选择过程。

[0249] 可替代地，无线设备101可配置有客户端应用，一收到WAP/SMS消息，该客户端应用便可使无线设备101能够搜索在DSA过程中已经可用的PLMN。

[0250] 可使用若干方法允许无线设备接入不同网络上的可用资源。在DSA通信系统中，存在至少两类网络或源系统：虚拟网络或现有网络。虚拟网络可包括利用主要网络的无线电接入网络(RAN)的网络。当要求无线设备101接入虚拟网络时，可能需要解决用于紧急呼叫(例如911呼叫)和其他监管规定的监管特征和要求。

[0251] 当连接到虚拟网络，主要网络的DPC 902可控制次要用户无线设备101的接入并且接入RF频谱资源和主要系统的订户记录以允许次要用户作为主要网络上的漫游者出现。次要用户无线设备101可使用优选的网络的列表来接入虚拟网络。

[0252] 可替代地，当使用现有网络起呼时，次要用户无线设备101可基于参与DSA通信系统的网络的优先级列表进行小区选择。一旦认证了次要用户无线设备101，主要主机网络的DPC 902可验证次要用户以接入主要网络上的资源。如果认证或验证不成功，主要用户的DPC 902可经由设备中的客户端向次要无线设备101发送请求来重新起呼到合适的系统上。

[0253] 无线设备101可包括通用订户身份模块或USIM。USIM可以是单个或双重USIM。可将选择正确的网络所需的关键信息(如数据)存储在USIM上。通过使用USIM，可使无线设备101不再使用PLMN。USIM可在其上存储信息，如归属国际移动订户身份或IMSI(HPLMN)、许可的VPLMN的优先化列表和禁止的PLMN列表。

[0254] 如果无线设备101使用双重USIM，可使它能够立即接入备选网络中可用的频谱资源。双重USIM可进一步使多频带、多模式无线设备101能够接入DSA中的各种网络以及使用标准漫游安排。

[0255] 图28展示用于通过无线设备101的在DSA通信系统中的网络和小区初始化的实施例方法2800。初始的网络和小区选择可以用无线设备101开始，当该无线设备或者上电或者试图重建连接(框2802)。无线设备101可初始地搜索存储在设备上的PLMN/PRL列表(框2804)，并且通过接收、读取和确定附近小区站点广播信道的强度来选择小区(框2806)。

[0256] 无线设备101可读取小区站点广播信道并且确定小区站点是否提供正确的系统(确定2808)。无线设备101可选择并且建立到最佳可用小区站点的连接。为标识最佳可用小区站点，无线设备101可基于接入技术来测量邻近的小区以确定最佳利用哪个小区。

[0257] 如果在一开始，合适的小区不可用(即，确定2808＝“否”)，无线设备101可使用任何小区选择过程/阶段并且通过选择下一PLMN/PRL列表单元继续搜索合适的小区站点直到它遵循适当的PLMN列表中的接入协议找到允许正常接入的站点(框2810)。

[0258] 如果正确的系统在所选择的小区站点中是可用的(即，确定2808＝“是”)，无线设备101可接收并读取由所选择的小区站点传送的系统信息块(SIB)/主信息块(MIB)(框2812)。SIB/MIB可包括关于小区站点正在为其提供服务的网络并且通过该网络可用的服务的信息。

[0259] 在一个实施例中，SIB/MIB 可包括很多信息，如 PLMN ID、小区 ID、流量分配标识符 (TAI)（路由区）、LTE 邻区列表、LTE 非系统站点、GSM cCell、UMTS 小区和 CDMA 小区。无线设备 101 可将此信息用于不同目的。例如，当无线设备 101 从 eNodeB 移动到 eNodeB 时，它可使用从新 eNodeB 发送的 SIB/MIB 信息来确定在服务 eNodeB 中已经发生改变。为检测 eNodeB 中的改变，无线设备 101 可标识 SIB/MIB 信息中的改变，SIB/MIB 信息可包括 PLMN 可用性和 TAI 参数中的改变中的改变。TAI 定义可以进一步用于限定在其中无线设备 101 可以使用可用资源的地理区域的特定的地理区。

[0260] 可通过网络将 SIB/MIB 传送到小区站点。小区站点可通过网络的 HSS 926 来接收网络信息。除了通过 SIB 传送的数据，网络的 HSS 926 还可提供关于无线设备 101 可使用哪个或哪些 PGW 908 来接入网络上的资源的信息。

[0261] 当读取 SIB/MIB 时，在确定框 2814 处，无线设备 101 可确定是否要求重选。如果不要求重选（即，确定框 2814 =“是”），在框 2816 中，无线设备 101 可预占小区信道。如果要求系统重选（即，确定框 2814 =“否”），可指令无线设备 101 基于小区选择 / 重选过程来重选新的小区或系统（框 2818）。

[0262] 当预占所选择的小区站点时，无线设备 101 可从如公共陆地移动网络或 PLMN/PRL 的更新的列表的选择的网络无线地接收额外的信息和指令。无线设备 101 还可为任何改变或额外的信息继续监控 SIB/MIB。

[0263] 在一个实施例中，SIB/MIB 可提供次要接入级别，该次要接入级别可使无线设备 101 能够基于 DSA 过程确定它可以通过重选过程使用哪些信道来接入。SIB/MIB 还可包括使预占的无线设备 101 能够重选另一无线电接入技术 (IRAT) 并且试图获取在新无线电接入终端 (RAT) 上的控制信道的数据。SIB/MIB 中的信息因此可被用于指令无线设备 101 重选另一 RAT，该另一 RAT 与可在另一频带上的相同或另一网络相关联的另一 RAT。

[0264] 可经由特定参数来控制可触发 PLMN 选择的小区重选。例如，DSA 通信系统可采用禁止的 PLMN-id 来阻止无线设备 101 使用来自一个网络的资源试图漫游到其他网络上。例如，DSA 通信系统可阻止次要用户无线设备 101 使用主要主机网络的资源来漫游回次要归属网络或建立与次要归属网络的连接。类似地，使用无线 (OTA)、客户端激活的或由双重 USIM 驱动的 PLMN id 优先化方案的 DSA 通信系统还可阻止无线设备 101 使用网络的资源来重建与其他网络的连接，除非 DSA 通信系统规则许可。

[0265] 在一个实施例中，在当前小区的容量达到预定等级时，可指令预占小区站点的无线设备 101 执行小区重选。在此类场景中，使用 OMC 912 的当前预占的网络的 DSC 910 可改变当前网络的 SIB/MIB 来包括指令预占的无线设备 101 执行小区重选和搜索另一 TAI 区或系统。执行小区重选的指令还可由 WAP/SMS 消息转发到无线设备 101。

[0266] 图 29 展示用于使用 TAI 中的改变的小区重选的实施例网络图。当使用网络时，取决于它们特定的用途和设备类型，不同的无线设备 101 可被指派不同的 TAI。例如，网络可向多个 DSA 通信系统用户指派一个 TAI。网络还可向并未使用 DSA 通信系统的多个设备指派另一个 TAI。使用多个并分层的 TAI 的优点可使指派 TAI 的网络能够选择性地定制使用流量。多个并且分层的 TAI 可进一步使指派 TAI 的网络阻止可具有正确的 PLMN-id 但不应该使用所选择的区的无线设备 101 选择小区但可被拒绝服务或可强制到小区重选中。

[0267] 在一个实施例中，可在兼容 DSA 通信系统的无线设备 101 上安装特殊客户端来使

无线设备 101 能够确定哪个系统和 RAT 应该在次要基础上使用。可通过接收经由文本消息或通过数据(IP)会话传送到手机的 WAP 或 SMS 来更新客户端应用的 PLMN/PRL 列表。该更新的客户端应用可指令无线设备 101 到用于接入主要网络的所分配的资源的合适的信道。

[0268] 使用客户端应用可促成实现可以或可以不拥有具有 SIB 中定义的次要接入信道的能力(例如,由于软件负载)的传统网络和系统中的 DSA 通信系统。

[0269] 在空闲模式中,可指令无线设备 101 执行小区重选过程中的频率内和频率间测量。使用 SIB/MIB 中的或来自客户端应用的信息,无线设备 101 可执行频率内搜索、频率间或无线电间接入技术(iRAT)。此过程可由 UTRAN 控制。频率内和频率间测量或无线电间接入技术可在区域或小区/扇区的基础上,取决于无线设备 101 的配置。

[0270] 次要用户无线设备的认证:

[0271] 无线设备 101 一旦选择了适当的小区站点并且在它进入空闲模式之前,无线设备可能需要它预占的系统的认证。所选择的网络要求验证和认证无线设备 101 来保证设备拥有接入网络所要求的许可。

[0272] DSA 通信系统可使用不同方法认证无线设备 101。用 DSA 认证无线设备可取决于不同提供商和 DSA 系统之间的业务安排。例如,认证可基于一般或优先化等级。可使用 DPC 902 HSS 904 作为锚来跟随认证过程并且可通过 LTE 或类似平台中的 PCRF 904 3G/2.5G 网络的 AAA/AuC 来对其进行接入。主机网络可通过使用标准 MAP/IS-41 信令来认证次要用户。

[0273] 一经认证,可为每个进入者指派:(a) 主机网络上允许的定义使用等级;系统上许可的持续时间;购买类型(例如,整售或 IMI 的范围);HSS 将允许呼入呼叫的重定向;当它们依靠可从后端接入的服务器时,应用将继续。

[0274] 所分配的资源的监控和跟踪:

[0275] DSA 通信系统可保证主要网络提供商一直具有足够的资源来管理在主要提供商网络(例如,网络 2)上的流量。因此,取决于流量,DSA 通信系统可动态地在实时和/或统计基础上更改可用于次要用户的频谱/容量。

[0276] 例如,在高峰时段,呼叫流量可在主要网络中增加。当主要网络中的呼叫流量增加时,DSA 通信系统可减少可用于向次要用户分配的频谱的量来保证主要用户具有足够的资源。

[0277] DSA 通信系统可基于包括用户的优先级等级、使用频谱的时间和用户的地理位置的不同因素来管理资源的分配和向资源的接入。在一个实施例中,当对主要网络的次要接入涉及某些事件,如灾难、紧急情况、第一响应者或公共安全,DSA 通信系统可通过使用不同的优先化来管理主要系统的次要使用。例如,当次要用户是使用主要网络资源的第一响应者时,DSA 通信系统可维持或增加由主要网络提供商向次要用户分配的资源来允许紧急呼叫成功接通,即使损害主要网络用户。

[0278] 在一个实施例中,可通过 DSA 通信系统的不同组件如 DPC 902 来管理和控制由次要用户进行的一个网络的频谱资源的使用。例如,主要网络的 DPC 902 可监控所分配的频谱资源的使用来保证当所分配的资源耗尽或不再可用于次要使用时采取适当的步骤。

[0279] 主要网络的 DSC 910 可以被配置成用于监控或接收关于与主要网络相关联的流量等级的数据,无线设备 101 可在主要网络上作为次要用户操作。如果达到主要网络容量阈值,DSC 910 可以被配置成用于通过将资源降级来分流次要用户、强制终止(即,分流)次

要用户的连接或将次要用户重定向到另一运营商或信道集。

[0280] 主要网络的 DSC 910 还可通知 DPC 902 何时可能要求分流次要用户。例如，主要呼叫者的不期望的激增可导致 DSC 910 请求分流次要用户来使资源可用于主要用户。当发起次要用户的分流时，可将技术接入参数发送到 (OTA) 无线设备 101。可替代地，系统可使用指令定义的无线设备 101 切换到新的 LTE 网络的 X2 链路经由 LTE 动态地指派资源。

[0281] 次要用户的分流可包括将次要用户的连接重定向回次要用户自己的网络、到另一提供商网络或信道或断开次要用户与主要提供商网络的连接。例如，当由于主要网络上的增加的需求要求导致主要主机网络终止次要用户时，DPC 可以被配置成用于确定其他网络是否可用于重定向次要用户的连接而不是终止。DPC 902 可查询来自其他网络的 DSC 910 的资源。如果资源可用于在其他网络中的使用，DPC 902 可使用规则集确定与满足资源请求要求的另一主机网络的最有成本效率的连接。一旦 DPC 902 已经标识了次要用户无线设备 101 可被重定向到其上的另一主机网络，DPC 902 可指令无线设备 101 过渡到用于通信会话的新的主机网络。次要用户的分流的过程可包括以下更详细解释的切换或退避过程。

[0282] 在又一示例性实施例中，主机网络的 DPC 902 还可以被配置成用于在主机网络资源用尽后指令主要主机网络将次要用户无线设备 101 释放回次要归属网络。DPC 902 可进一步被配置成用于如果 DPC 902 确定需要额外的容量供主要用户使用则强制终止次要用户与主要网络的连接。

[0283] 如果充足的容量可用，DPC 902 可强制次要用户继续使用主要主机网络的资源，直到主要主机网络上的业务量要求基于规则集的额外的动作。

[0284] 在各种实施例中，DSA 可进一步管理所分配和接入的频谱的使用。例如，DSA 通信系统可通过采用退避机制管理主机网络的 RF 频谱的使用。当高优先级用户接入主机频谱网络时，频谱可摆脱更低优先级用户以使频谱可用于更高优先级用户。

[0285] 图 30 展示用于根据一个实施例的频谱使用的监控和跟踪的网络架构图 3000。可使用不同方法执行频谱资源的使用的跟踪和监控。在使用资源分配的虚拟最佳努力方法的 DSA 通信系统中，DSC 910 可基于预安排的计费信息和与主要网络计费平台的通信来监控频谱资源的使用。

[0286] DSC 910 可监控用于群组的使用等级并且还与 PGW 908 一起跟踪使用等级。可将使用与预期或相当成功的竞标进行比较并且对其进行监控。一旦次要用户使用预定义量的分配资源，主要网络的 DSC 910 可以被配置成用于生成资源正接近非常低等级的通知并且将其通过 DPC 902 发送到次要网络提供商。次要用户可通过它自己的 DSC 910 接收该通知。一旦接收了该通知，次要用户提供商网络可为额外的资源重新竞标或仅让剩余的资源耗尽。

[0287] 在当所分配的资源完全消耗掉时次要用户活跃地使用主要网络的情况中，主要网络可指令次要用户无线设备 101 重新连接到归属网络 (次要用户网络提供商)、终止无线设备的连接或基于先前协商的合同向次要网络收取商品过剩或补充费用。一旦连接终止，次要用户无线设备可能不再能够接入主要网络资源，除非为次要用户分配额外的资源。

[0288] 在使用虚拟次要用户方法的 DSA 通信系统中，DSC 910 可基于预安排的计费信息来监控所分配的资源的使用以及与主机主要网络计费平台的通信。基于虚拟次要用户方法监控所分配的资源的使用的过程可涉及为群组指导使用等级并且还与 PGW 908 一起跟踪

使用等级。

[0289] 类似于使用虚拟最佳努力方法的DSA通信系统,使用虚拟次要用户方法的DSA通信系统可通过将使用与向次要用户网络提供商分配的资源的量进行比较来监控使用。一旦次要用户使用了预定义的量的所分配的资源,主要网络的DSC 910可以被配置成用于生成资源正接近非常低等级的通知并且通过DPC 902将其发送到次要网络提供商。次要用户可通过它自己的DSC 910接收该通知。一旦接收了该通知,次要用户提供商网络可为额外的资源重新竞标或仅让剩余的资源耗尽。

[0290] 在使用虚拟次要用户方法的DSA通信系统中,在所分配的资源耗尽后,可通过不同的方法来终止次要用户,例如通过如下讨论的1) 无优先化退避;或2) 优先化退避。

[0291] 在无优先化退避方法中,当消耗掉预定等级的所分配的频谱资源后,不再允许进一步使用。一旦所分配的频谱资源耗尽,主要网络DSC 910可指令次要用户无线设备连接到次要用户归属网络、终止次要用户无线设备与主要网络的连接或基于先前协商的合同收取商品过剩费。一旦从主要网络终止,次要用户无线设备可能不再能够接入主要网络资源,除非次要归属网络提供商获得额外的资源。

[0292] 在优先化退避方法中,当所分配的频谱资源处于非常低等级并且在资源彻底耗尽之前,主要网络可开始退避过程,期间主要网络可在另一合适的网络上拨打次要用户无线设备101。如果不,其他合适的网络可用于接受次要用户无线设备101,主要网络可将次要用户无线设备101切换回次要用户归属网络。主要网络可将次要用户未使用的任何所分配的资源结余至次要网络。

[0293] 当使用资源分配方法时,主要主机网络可取决于资源是否基于许可区或局部区方法分配不同地监控所分配的资源。

[0294] 如果基于许可区方法执行资源的分配,主要网络可监控由次要用户进行的资源的使用。当所分配的资源近乎耗尽时,DSC 910/DPC 902可通知次要用户网络资源的暂时租用将要过期并且向次要网络提供竞标并购买额外资源的机会。

[0295] 如果次要网络没能或拒绝获得额外的资源,主要网络可使用不同的方法从主要网络终止或退避次要用户,如,1) 无优先化退避;或2) 优先化方法。

[0296] 在无优先化退避方法中,当资源的租用过期时,频谱资源可能不再可用于次要用户。主要网络可指令次要用户无线设备101或者切换到它们的网络中的另一无线电接入系统或者终止它们的使用。

[0297] 在优先化退避方法中,主要网络的DSC 910/DPC 902可与关于受影响的站点的次要网络的DSC 910协调资源。次要网络可试图将次要用户无线网络切换到用于受影响的区的另一网络、基站、无线电接入信道或系统。主要网络可将来使用的所分配的资源结余至次要网络。

[0298] 如果基于局部区方法执行资源的分配,主要网络可监控由次要用户进行的资源的使用。当所分配的资源将要过期并且接近预定的耗尽等级时,主要主机网络的DSC 910/DPC 902可通知次要归属网络阻碍资源的终止。主要网络可向次要网络提供重新竞标额外资源的机会。

[0299] 如果次要网络未能或拒绝获得额外的资源,主要网络可使用不同的方法从主要网络终止或退避次要用户,如,1) 无优先化退避;或2) 优先化方法。

[0300] 在无优先化退避方法中，当所分配的资源的租用期过期时，次要用户可能不再能够接入主要网络的频谱资源。主要网络可或者将次要用户切换到他们的网络中的可以是主机网络或另一网络的另一无线电接入系统，或者终止次要用户向主要网络资源的接入。

[0301] 在优先化退避方法中，主要网络的 DSC 910 和 DPC 902 和次要网络的 DSC 910 可与受影响的站点协调资源并且在所分配的资源的租用过期之前开始退避过程。次要网络可试图将次要用户无线网络切换到用于受影响的区的另一网络、基站、无线电接入信道或系统。主要网络可将未使用的所分配的资源结余至次要网络。

[0302] 在分流期间次要用户的切换 ：

[0303] 在一个实施例中，DSA 通信系统可采用切换方法来阻止在无线设备 101、DSA 通信系统和 / 或网络提供商之间的通信会话期间的中断或维持该通信会话。例如，通信会话可包括无线设备 101 建立与网络的连接。当在一个通信会话时期期间无线设备 101 从归属网络迁移到主机网络并回到归属网络时，切换可发生。网络生成的 SIB/MIB 可包括可用于切换通信会话的小区和网络的列表。

[0304] 在 DSA 通信系统外面，移动辅助的切换可涉及无线设备 101 通知服务网络更好的服务器可用以及将连接从当前服务器改变到该更好的服务器。当无线设备正在主机网络上漫游时，可执行此类移动辅助的切换。然而，DSA 通信系统可能不允许此类移动辅助的切换，因为用于漫游目的最佳服务器可能不是用于容量减轻的最佳小区。与 DSA 通信系统进行的通信会话可涉及电路交换或分组交换服务。

[0305] 图 31 展示能够执行通信会话的切换的一个实施例网络的网络组件图。为实现通信会话的切换，主机网络和归属网络 (例如，网络 A 和网络 B) 的组件之间的某些连接性可存在。例如，可连接主机的 PGW908 和归属网络。主机的 PGW 908 和归属网络可通过互联网或私有数据网络通信。还可将主机的 PGW 908 连接到归属网络的 SGW 922。还可将主机的 ANDSF 918 和归属网络连接以允许向传统系统的切换并且当要求无线设备从主机向归属网络迁移时调用退避过程。

[0306] 将接入网络发现和选择功能 (ANDSF) 用于管理系统间移动性策略并且存储在支持此类来自 ANDSF 的信息的供应的无线设备中的接入网络发现信息。ANDSF 可发起从 ANDSF 到无线设备的信息的供应，如 3GPP TS 24.302[3AA] 中规定的。

[0307] 图 32 展示用于不依赖于介质的切换的实施例方法的网络图。贯穿 DSA 过程的 ANDSF 可通过向指令其进行空隙或非空隙切换的无线设备 101 发送 SMS/WAP 消息来发起切换。可在不同的环境下并且为不同的原因发起切换过程。例如，网络可基于在主机网络和归属网络之间的合同规范、基于在主机网络处的资源的等级以及资源是否已经达到预定的阈值、基于归属网络租用的资源耗尽或基于是否发起退避过程来开始切换过程。

[0308] 当主机资源不再可用于使用或发起退避过程时，DSA 通信系统可采取额外的组件或方案来切换通信会话。在此场景中，主机网络的 eNodeB 可基于 QCI 和 ARP 指定来执行退避过程。eNodeB 916 退避可涉及通过交换网络之间的 X2 链路的使用将当前通信会话从主机 eNodeB 916b 切换到另一 eNodeB。还可通过将 DSMPTA 过程与 ANDSF 一起使用来实现此过程。

[0309] 为发起并实现切换过程，主机网络可生成某些命令并将其发送到无线设备 101。例如，三个不同类型的切换包括 :1) 频间 ;2) 频内 ;和 3)IRAT。

[0310] 在频间切换中，当前为无线设备 101 服务的网络（即，当前网络）可发起无线设备 101 从当前网络到另一网络的切换。在频内切换中，当前网络可为能力分流发起无线设备从一个网络中的一个小区到相同网络中的另一小区的 101 的切换。在 IRAT 切换中，当前网络可发起无线设备 101 切换到另一 RAT。

[0311] 在当前网络向次要用户无线设备 101 发送指令以开始使用另一网络的资源时，可发起频间切换。例如，可为较大的文件的上载 / 下载而指令归属网络上的无线设备 101 使用主机网络。

[0312] 可使用频间切换来基于就位的策略决定从主机网络分流次要用户。当无线设备 101 不再需要作为次要用户使用主机网络的服务并且因此可被发送回它的归属网络时，可进一步使用频间切换。当无线设备 101 离开 DSA 通信系统集群或小区范围并且要求继续它的通信会话时，可进一步使用频间切换。在此类场景中，可将无线设备 101 或者转移到另一网络 / 集群或者发送回归属网络。频间切换可进一步用于通过允许一些主要用户作为次要用户使用另一网络的服务来缓解网络容量约束。

[0313] 可在当前网络中使用频内切换来缓解由从一个小区到另一个小区甩掉流量造成的小区拥塞。为避免可阻止解决容量问题的乒乓效应，频内切换命令可禁止无线设备 101 使用出现在 PLMN/PRL 列表上的相邻小区 / 扇区持续定义的时间段。

[0314] 可使用 IRAT 来将无线设备 101 重定向到另一 RAT。在从一个 IRAT 到另一个的切换期间，无线电接入技术和操作的频率两者都可改变。当 DSA 通信系统可用并且无线设备 101 首先在特定信道上活跃时，可使用此类型的切换。当前网络可指令无线设备 101 通过 IRAT 切换过程改变到另一 RAT。在一个实施例中，可从当前网络发起切换命令，或可替代地可以从不同的网络或实体发起切换命令。因此，如果在切换过程期间挂断无线设备 101 通信会话，无线设备 101 可能能够重建与目标 RAT 的通信会话并且不返回先前网络。

[0315] 在一个非限制性实施例中，在 INTERFREQ 和 / 或 INTRAFREQ 切换期间可挂断会话。在此实施例中，设备可通过返回到先前网络来重建连接。

[0316] 图 33 展示了作为 DSA 过程的一部分发起网络切换所需要的一种实施例系统的网络组件图。可通过 DSC 910 基于在竞标之前或在竞标过程期间建立的它的规则集而发起切换过程。考虑到最大的灵活性，ANDSF 918 的使用可使频内、频间和 IRAT 切换都能够发生。

[0317] 次要用户从主机网络的退避：

[0318] DPC 902 可连续监控主机网络资源来保证充足等级的资源可用于主机网络的主要用户的使用。当在主机网络处的可用资源的容量接近预定的阈值，主机网络可指令无线设备 101 开始次要用户的退避过程。可发起退避过程来释放在主机网络处的资源。

[0319] 当需要使资源可用于网络的主要用户或订户时，DSA 可发起次要用户的退避来释放额外的资源。退避过程可涉及取决于 DSA 配置的不同或组合的方法。然而，使用无线设备 101 类型和与设备相关联的任何特殊标志、用于重定向活跃和空闲流量的策略决定、将流量甩给谁及其顺序的策略决定以及重供应或者 OTA 或者经由激活客户端应用实现退避策略的共性。

[0320] 在一个实施例中，DSA 通信系统可以被配置成用于当发起退避过程时采用分层优先接入 (TPA) 规则（如以上参照图 1 至图 8 详细说明的）。例如，当资源等级到达可能是用户定义的预定的阈值等级时可发起退避过程。阈值检测过程可包括无线接入网 (RAN) 和核

心网资源的流量监控以及确定是否达到可触发 QoS 或要求甩掉次要用户来释放资源的预定的阈值等级。

[0321] 可基于次要用户可生成的流量使用来确定用于 RAN 和核心网资源的阈值等级。例如，当使用多于 RAN 资源的 85％时，可实现退避过程来或者减少次要用户的吞吐量或者从主机网络甩掉次要用户或两者。通过发起退避过程，主机网络保证可用 RAN 或核心网资源的量总是保持 15％以上。

[0322] 在一个实施例中，可允许主机网络维持某些量的资源总是自由的 DSA 的退避过程可以是前瞻性的并且与实际事件无关。在发生事件的情况中，如自然灾难，DSA 通信系统可具有使自由资源可用于第一响应者并且如果额外的资源是必要的则采用 TPA 过程的容量。

[0323] 在一个实施例中，在退避过程中，DSA 通信系统可监控流量并且开始为次要使用在用户定义的间隔释放 RAN 资源。

[0324] 在一个实施例中，每个主机网络可采用某些退避策略和资源标准决定是否发起退避过程。这些策略和资源标准可包括：频谱可用性（分开或共同存在）；容量／带宽可用性（RF 和核心）；开销标准（总可用容量 vs. 使用的容量的百分比）；退避条件（重选、切换－系统内和系统间）终止）；对待（如何对待／路由特定的服务／应用）；禁止对待（例如，禁止使用服务／应用）；分级（例如，如何分级服务，即，对于非高峰使用可能的特殊折扣）；地理边界（例如，定义要包含的区域或小区）；时间（例如，定义要包含的时间和日期）；持续时间（例如，基于时间和地理边界定义增量分配）；用户设备类型。

[0325] 可为不同的资源分配方法不同地实现退避过程。在一个实施例中，(EPC) 中阐述的 PCRF 905 策略规则集可管理用于虚拟最佳努力（纯漫游）分配方法的退避过程。eNodeB 还可以被配置成用于基于容量负载通过使用 X2 链路发起减少流量的动作。在此场景中，eNodeB 可使主机网络能够通过将流量切换到邻近的小区站点而甩掉次要用户。在一个实施例中，eNodeB 可向包括 UE 的一个或多个实体发送指令。在另一个实施例中，eNodeB 可发起该过程。

[0326] 此外，用于 DSA 的退避过程还可涉及一个或多个项目，该一个或多个项目将通过遵循协定的基于策略的规则集的 DSC 来管理或制定并且意在保证会话连续性或将 UE 重新分配到另一接入方法，试图在退避过程中保证用户体验。

[0327] 在一个实施例中，用于虚拟最佳努力的 (DSMPTA) 退避过程可超过并且超越是接入和 EPC 的一部分的典型规则集。当流量达到预定义的阈值时，DSA 通信系统可发起一个过程或一个过程组合来实现 DSMPTA 退避过程。PCRF 905 可动态地为次要用户无线设备 101 调整 QCI/ARQ 值。这可涉及限制带宽或将使用放置到最佳努力或更低优先级方案。经历容量约束的小区可被放置在禁止小区列表上以便无额外的次要用户可接入这些小区。可通过重供应发送到无线设备 101 的广播消息可将对禁止小区列表的更新通信到无线设备 101。可用关于禁止的小区和相邻的可用小区的信息来更新广播消息。

[0328] 为保证无线设备 101 接收和读取关于禁止的小区和可用的相邻小区的广播消息，DSA 通信系统可向所配置的无线设备 101 发送 WAP/SMS 消息来强制它们重选。当它们进入重选过程时，无线设备 101 将必须读取广播消息。

[0329] 在一个实施例中，DSA 可发起封闭服务组来将特定小区站点的使用限制到漫游的无线设备 101。可涉及容量问题的 CSG 和 TAI 的组合可限制次要用户无线设备 101 接入网

络。例如，CSG 和 TAI 可挂断呼叫者、可降低质量、可扩展网络或可提供处理容量问题的其他项目。

[0330] 在一个实施例中，在退避会话过程中，ANDSF 918 可促成次要用户切换到另一网络或切换回次要用户归属网络。ADDSF 918 可发起网络切换，如果与另一网络的连接可用。无线设备 101 可被切换到另一网络或另一接入网络 (RAT/IRAT)。

[0331] 在一个实施例中，EPC 和 DPC 902 中阐述的 PCRF 905 策略规则集可管理使用资源分配的虚拟次要用户方法的 DSA 中的退避过程。应用到次要用户的主要主机网络的 PCRF 905 策略规则可在由 DPC 902 强制的那些上取得优先级。然而，可基于由主要主机网络操作要求阐述的条件动态地改变或修改主要主机网络的 PCRF 905 策略规则。可替代地，DSA 通信系统中的退避过程可涉及额外的项目。可通过主要主机网络的 DSC 910 基于协定的策略和规则集来控制和管理这些额外项目的实现。DSC 910 策略和规则被设计成在退避过程期间保证通信会话连续性和良好的用户体验。

[0332] 在接入 EPC 中的现有的策略和规则集未能应用到退避过程的情况中，可实现用于次要用户的 DSA 退避过程。例如，当主要主机网络流量达到预定阈值等级，主机 DSC 910 可指令主机 eNodeB 使用 X2 链路并且基于次要用户无线设备 101QCI/ARQ 规则集将次要用户切换到主机网络之内的邻近小区站点。可替代地，当主机网络和归属网络连接用于完全移动性时，DSC 910 可指令主机 eNodeB 使用 X2 链路将次要用户切换到归属网络。

[0333] 基于从主机 DSC 910 接收的指令，主机 PCRF 905 可为次要用户无线设备 101 动态地调整 QCI/ARQ 值。例如，主机 PCRF 905 可限制带宽、将资源分配方法改变到虚拟最佳努力或将优先级方案改变到低优先级。

[0334] DSC 910 可指令主机网络更新或生成禁止小区列表并包括当前正在经历超过预定流量容量阈值的流量容量的小区。DSC 910 可进一步指令主机网络广播消息来用更新的禁止小区列表重供应次要用户无线设备 101。广播消息可进一步包括关于与受限小区或小区群组邻近的下一环或多个环的小区的信息。广播消息可包括改变的和有效的 PLMN-id、用于一个或多个小区的更改的 TAI 和用于次要用户无线设备 101 的使用的更改的邻区列表来执行切换过程或网络重选。为保证次要用户无线设备 101 检查重供应广播消息，主机网络可发送 WAP/SMS 消息到所配置的无线设备 101 来强制它们执行网络重选。

[0335] 主机 DSC 910 可进一步指令主机网络发起封闭服务组 (CGS) 来对漫游的次要用户无线设备 101 限制特定小区站点的使用。涉及网络容量的 CGS 和 TAI 的组合可限制漫游次要用户无线设备 101 到主机网络的接入。通过 CGS 和 TAI 的组合实现的接入限制可使主机网络只可接入指定的主要用户。

[0336] 在主要主机网络和另一网络（例如，次要归属网络）之间存在连接的情况中，主机 DSC 910 可指令主机 ANDSF 918 发起次要用户无线设备 101 到另一连接的网络或接入网络 (RAT/IRAT) 的网络切换。

[0337] 为当 eNodeB 是为资源分配和接入而进行 x 分叉时减少容量过载，主机 OMC 912（或被配置成用于管理容量的其他基于策略的控制）可指令 eNodeB 甩掉次要用户无线设备 101 可接入的资源。因此，可减少为次要用户指定的并与用于受影响的区的 eNodeB 相关联的资源。减少 eNodeB 的可用资源可以是强制切换到或重选具有资源的邻近小区。

[0338] 主机网络发起的切换可平衡 eNodeB 资源的重分配，以便强制次要用户无线设备

101 切换到另一网络，在该另一网络上，它们可以漫游并且被供以充足的资源。例如，切换可以是频间 RAT 或 IRAT 切换。

[0339] 还可将主机 PGW 908 用作退避过程的一部分。可基于主机 HSS 904 和 PCRF 905 的策略和规则将次要用户无线设备 101 的 SG 连接到适当的主机 PGW 908。主机 DSC 910 可控制主机 PGW 908 和无线设备的 101SG 之间的连接的带宽。在退避过程期间，主机 DSC 910 可发起主机网络来减少 PGW 908 和被移出主机网络的次要用户无线设备 101 的 SG 之间的带宽。预定的策略和规则可管理 DSC 910 可减少 PGW 908 和 SG 之间的带宽的过程。主机 DSC 910 可继续监控可由高流量造成负担过重的主机网络小区并且评估到主机 PGW 908 设备 SG 连接的额外的带宽减少来减少流量。

[0340] 并不是所有由 DSC 910 发起的作为 DSMPT 退避过程的一部分的过程都是必要的并且这些过程的实现和它们可能发生的顺序可取决于主机和归属网络之间的协定。

[0341] 在一个实施例中，可在 DSA 通信系统中使用资源分配的频谱分配方法来实现退避过程。该频谱分配方法可包用于资源分配的许可区和局部区方法。

[0342] 在一个实施例中，用于使用许可区方法的 DSA 的退避过程可涉及频谱资源从次要归属网络（即，承租者）到主要主机网络（即，出租者）的频谱资源的重分配。使用许可区方法的主机网络可发起退避过程来将所有现有的次要用户设备 101 从出租者的频谱切换到另一网络或切换回归属网络。将基于由出租者和承租者协定定义的规则集预先确定用于重新分配的时间帧。取决于规则集中定义的时间帧，可能不是将所有的次要用户及时迁出主机网络，并且结果是，可能挂断一些次要用户。

[0343] 基于出租者和承租者之间的预协商的协定，主机网络可确定是否将退避过程应用到部分或整个许可区。基于容量缓解涉及的地理区域，可不为整个许可区的每一小区要求频谱重分配。因此，可在许可区的子许可区中实现退避过程。

[0344] 在为整个许可区实现退避过程时，主机 DSC 910 可通知 DPC 902 主机网络已经达到流量容量的预定阈值。DPC 902 可将该消息通信到归属 DSC 910。归属 DSC 910 可以按逐步的方式减少可用于归属 eNodeB 的主机资源并且将次要用户流量切换到非租用的频谱。可在预定的时间间隔基础上执行减少可用于 eNodeB 的资源的步骤。如果未及时地迁移流量，归属 DPC 902 可发起网络切换来将次要用户从主机网络迁移到另一适当的信道。一旦资源被释放，归属 eNodeB 可从它的可用信道列表上移除该信道。

[0345] 在为子许可区（相对于整个许可区）实现退避过程时，可实现以上的过程，除了可使用定义的小区或 TAI 来代替整个许可区。

[0346] 一旦主要网络已经解决了容量限制，可将频谱重新分配到归属网络。为重新分配资源，主机 DSC 910 可通知 DPC 902 频谱资源再次可供归属网络使用。归属 DPC 902 可通知归属 DSC 910 资源再次可用。可基于预定的策略和规则集将资源重新分配到归属网络。

[0347] 对于不由接入和 EPC 中的规则和策略管理的退避过程，主机可发起 DSMPTA 退避过程。这基于规则集会是可能的。

[0348] 在一个实施例中，用于使用局部区方法的 DSA 通信系统的退避过程可取决于由出租者和承租者约定的策略和规则集。

[0349] 在使用资源分配的局部区方法的 DSA 中的退避过程可包括将使用局部区或子局部区中的主机频谱的所有现有的次要用户无线设务 101 切换回归属网络或另一网络。主

机DSC 910和DPC 902/DSC 910规则集可定义次要用户是否应被从局部区的整个或子集移出。

[0350] 可基于由出租者和承租者约定的策略和规则集来预先确定在退避过程期间的资源的重新分配的时间帧。如果未满足协定中阐述的时间线，在退避过程期间可能并不能将所有流量成功地迁移到归属网络或另一网络。在此场景中，预定的时间帧一过期就可挂断或丢失一些连接。

[0351] 当发起退避过程时，可以按逐步的方式减少与归属 eNodeB 相关联的承租者网络资源。归属 OMC 912 可发起由 eNodeB 减少资源。归属网络的其他基于策略的组件如 DPC 902 还可发起由 eNodeB 减少资源。归属网络可促成次要用户从主机网络频谱切换到归属网络频谱。如果归属网络并不具有处理业务量的容量或并未以及时的方式执行切换，它可或者将通信会话切换到另一网络或信道或者强制次要用户无线设备 101 执行重选过程。一旦 eNodeB 已经将所有次要用户从主机频谱切换，它可从次要用户可接入的信道的可用列表移除频谱信道。

[0352] 一旦主要网络已经解决了容量限制，可将频谱重新分配到归属网络。为重新分配资源，主机 DSC 910 可通知 DPC 902 频谱资源再次可供归属网络使用。归属 DPC 902 可通知归属 DSC 910 资源再次可用。可基于预定的策略和规则集将资源重新分配到归属网络。

[0353] 图 34 展示与连接到主要 3404 和次要 2306 的元件 3402 通信并且经由主要 RAT 和次要 RAT 与基站 102a 和 102b 通信的智能电话 101a、膝上型计算机 101b 和蜂窝电话 101c。基站 102a 与主要网络连接并且基站 102b 与次要网络 102b 连接。在一个实施例中，如图 34 中所示，DSA 通信系统可允许无线设备 101a-101c 同时接入若干无线电接入技术（即，主要和次要 RAT）。例如，DSA 可使使用主要网络的主要 RAT 的无线设备 101 能够接入次要网络上的次要 RAT，只针对某些类型的服务。例如，当主要网络的无线设备 101 使用引起高量或突发流量时，DSA 通信系统可使主要网络能够分流并向次要网络发送高量和突发流量。例如，主要和次要元件 2306 和 3404 可提供数据来使用数据头将流量路由到主要和次要无线网络和基站。切换可使用 DSA 发生从而在网络间切换。在另一个实施例中，切换可使用元件 3402、主要组件或次要组件 3404 或 3406 发生。在又一个实施例中，切换可由主要或次要 DSA 网络发起，或由观察网络的容量的另一实体发起。

[0354] 图 35 根据一个实施例展示了在 DSA 通信系统中的仲裁过程的消息流图 3500。在本实施例中，为简化起见，使用一个竞标者（即，网络 1），然而，可以考虑到，多个竞标者可以使用此过程。网络 1 3501 可以向 DPC 902 发送对于资源消息 3502 的请求。DPC 902 可以接收请求消息并且基于预定义的标准向网络 2 和网络 3 的参与 DSC 910a、910b 发送查询 3504、3506，该预定义的标准除了包括请求无线设备 101 的地理标准之外还可以包括用户无线设备 101 的类型和能力。地理标准可以包括用户无线设备 101 的地理位置、地理多边形或许可区。地理标准请求可以包括大于主机网络可能允许的那些参数的多个参数。DPC 902 可以从所接触的每一个 DSC 910a、910b 接收资源询问响应 3508、35010。

[0355] DPC 902 可发送资源可用性消息 3512 来通知网络 1 所请求的资源通过 DSC 910a 可用。网络 1 3501 可接收资源可用性消息 3510 并且作为响应向 DPC 902 发送资源请求消息 3514 来在 DSC 910a 处预留可用资源。DPC 902 可向 DSC 910a 发送资源预留请求 3516。当接收到资源预留请求 3516 时，DSC 910a 可预留所请求的频谱并将资源预留消息 3518 发

送回DPC 902。DPC 902可从网络1接收资源竞标消息3520,接受竞标(如果竞标服从DPC 902的策略和规则)并且向网络1 3501发送竞标接受消息3522。当接受来自竞标者的竞标时,DPC 902还可向DSC 910a发送指派资源请求3524来向网络1 3501分配所预留的资源。DSC 910a可接收指派资源请求3524、分配将由网络1 3501使用的资源并且向DPC 902发送资源分配消息3526。DPC 902可通过向网络1 3501发送资源分配消息3528来通知网络1 3501现在将所请求的资源分配供无线设备101订户网络1 3501使用。资源可供网络1 3501使用。一旦使用了这些资源,DSC 910a可向DPC 902发送资源消耗/释放消息3530。DPC 902可接收资源消耗/释放消息3530并向网络1 3501发送资源消耗/释放消息3532。网络1 3501可清偿用于它所使用的频谱的费用。

[0356] 图36至图40展示用于使用DSA通信系统来分配和接入资源的一个实施例方法的流程图。如图36中所示,网络1DSC 910a可监控相比于可用于网络1的总频谱资源的呼叫流量(框3602)。DSC 910a可记录网络1的资源状态并且将其报告到DPC 902。DPC 902可接收来自网络1的资源状态报告(框3702),并且存储它(框3704)。网络1的DSC 910a可基于资源状态报告确定是否可要求额外的资源来向网络1的现有的用户提供服务(确定3606)。如果不要求额外的资源(即,确定3606="否"),DSC 910a可通过回到框3602来继续监控可用资源vs.带宽流量。如果要求额外的资源(即,确定3606="是"),DSC 910a可向DPC 902发送对于额外的资源的请求(框3608)。

[0357] 网络2DSC 910b还可监控网络2中的可用资源vs.带宽流量(框3602),并且向DPC 902报告资源状态(框3804)。DPC 902可接收来自于DSC 910b的资源状态报告(框3702)并且存储所接收的数据(框3704)。DSC 910b可确定过剩量的资源是否可用在网络2中(确定3804)。如果过剩量的资源不可用在网络2中(即,确定3804="否"),DSC 910b可通过回到框3602继续监控可用资源vs.带宽流量。如果过剩量的资源可用(即,确定3804="是"),DSC 910b可分配过剩资源或过剩资源的子部分供次要使用(框3806),并且向DPC 902报告将资源分配供次要用户使用(框3808)。DPC 902可接收来自DSC 910b的资源分配报告(框3702),并且存储所接收的数据(框3704)。

[0358] DPC 902可接收来自许多不同网络的资源状态报告。然而,在此实施例中,为了容易说明,只示出了DPC 902与两个网络的交互。从网络接收的状态报告可进一步包括额外信息,如关于接入和使用所分配的资源的网络规则和策略。例如,来自网络2的状态报告可包括用于网络2的在无线设备101可以作为次要用户成功地接入网络2上的所分配的资源之前必须满足的系统要求。

[0359] DPC 902从网络1的DSC 910a接收对于额外资源的请求(框3706),并且在框3708中基于从其他网络接收的数据选择网络1可从其购买额外资源的最佳可用网络。在此示例中,DPC 902可选择网络2作为最适合的网络来向网络1提供资源。DPC 902可向网络2发送资源查询(框3710),来确定网络2的所分配的过剩资源的可用性和数量。

[0360] 网络2的DSC 910b可接收资源查询(框3810),并且确定资源可用性(框3812)。DSC 910b可向DPC 902发送资源查询响应。资源查询响应可包括关于可供次要用户使用的资源的数量和质量的信息。DPC 902可接收资源查询响应(框3712)。

[0361] 如图37中所示,DPC 902可基于从网络2的DSC 910b接收的数据来确定资源是否可用(框3714)。如果数据不可用(即,确定框3714="否"),DPC 902可向网络1发送

无可用资源消息（框 3722）。由于不同原因，资源可能不可供网络使用。例如，可在资源由网络预留之前由其他竞标者购买。网络 1 的 DSC 910a 可接收无可用资源消息（框 3614），并且搜索其他可用频谱资源或终止与用户的连接会话来释放网络 1 上的资源（框 3618）。

[0362] 如果数据可用（即，确定 3714 ＝“是”），DPC 902 可向 DSC 910a 发送资源可用消息来通知网络 1 关于可用于在网络 2 处的次要使用的资源的质量和数量（框 3716）。DSC 910a 可接收资源可用消息并且发送请求资源消息来为由网络 1 的订户使用预留网络 2 的所分配的资源（框 3612）。请求资源消息可包括如在此交易中网络 1 可要求的资源的数量的数据。

[0363] DPC 902 可接收资源请求消息（框 3718），并且向网络 2 发送预留资源请求消息（框 3720）。在网络 2 处的 DSC 910b 可接收预留资源请求（框 3816），并且为由网络 1 订户使用而预留所请求数量的所分配的资源（框 3818）。网络 2 的 DSC 910b 可通过发送资源预留消息证实所请求数量的所分配的资源为由网络 1 使用而预留（框 3820）。DPC 902 可接收来自网络 2 的资源预留消息并且为如图 38 中描述的竞标过程作准备。

[0364] 如图 38 中所示，网络 1 的 DSC 910a 可发送资源竞标来协商对网络 2 的所预留的资源的接入（框 3620）。DPC 902 可接收资源竞标并且对其进行处理（框 3726）。在确定框 3728 中，DPC 902 可确定是否接受从网络 1 接收的竞标。DPC 902 可基于除了由资源提供网络或由其他方法阐述的要求（如价格和分配或接入方法）以外的 DSA 通信系统的策略和规则集评估来自网络提供商的竞标。如果接受竞标（即，确定 3728 ＝“是”），DPC 902 可向网络 1 发送接受竞标消息（框 3730）。在框 3622 中，DSC 910a 可接收接受竞标消息并且等待资源接入指令。一旦接受了竞标，DPC 902 还可向网络 2 的 DSC 910b 发送指派资源消息（框 3732）。DSC 910b 可接收指派资源消息（框 3822），并且为由网络 1 使用而指派所预留的资源（框 3824）。DSC 910b 可发送资源接入消息来使网络 1 能够接入网络 2 的所指派的资源（框 3826），并且配置来建立与网络 1 的无线设备 101 的通信会话（框 3828）。

[0365] DPC 902 可向网络 1 转发资源接入消息（框 3734）。DSC 910a 可接收资源接入消息（框 3624）。资源接入消息可包括数据，如，次要用户无线设备 101 可用来接入网络 2 上的资源的接入参数。DSC 910a 可向具有与网络 1 的通信会话的无线设备 101 发送用于网络 2 的接入参数并且网络 1 已经指定迁移到网络 2（框 3626）。所指定的无线设备 101 可接收用于网络 2 的接入消息（框 3902），并且建立与网络 1 的无线设备 101 的通信会话，步骤 3904 和 3830。网络 2 可如以下参照图 40 更详细地描述的开始清偿过程。

[0366] 如果拒绝竞标（即，确定框 3728 ＝“否”），DPC 902 可向网络 1 发送拒绝竞标消息，（框 3736）（如图 39 所示）。如图 39 中所示，DSC 910a 可接收拒绝竞标消息（框 3736），并且确定是否重新竞标（确定 3640）。如果无重新竞标（即，确定 3640 ＝“否”），DSC 910a 可发送取消资源请求消息（框 3644）。DPC 902 可接收取消资源请求消息（框 3742），并且向网络 2 发送资源释放消息（框 3744）。网络 2 的 DSC 910b 可接收资源释放消息（框 3832），为由其他网络使用而释放所预留的资源（框 3834），并且如图 36 中所示通过返回框 3808 并且遵循以上关于图 36 描述的步骤向 DPC 902 报告所分配的资源状态。

[0367] 如果重新竞标（即，确定 3640 ＝“是”），DSC 910a 可发送对于相同资源的新竞标（框 3642）。DPC 902 可接收该新竞标（框 3738），并且确定是否接受新竞标（确定 3740）。如果再次拒绝新竞标（即，确定 3740 ＝“否”），DPC 902 可通过回到框 3736 发送拒绝竞标

消息。如果接受竞标(即,确定 3740 =“是”),如图 38 中所示并且遵循与以上参照图 38 所述相同的步骤,DPC 902 通过回到框 3730 发送接受竞标消息。

[0368] 图 40 展示在网络 2 提供对网络 1 的次要用户无线设备 101 的接入以后的清偿过程。网络 2 的 DSC 910b 可向 DPC 902 发送与由网络 1 使用所分配的资源有关的发票和支付指令(框 3836)。DPC 902 可将发票和支付指令从网络 2 转发到网络 1(框 3746)。DSC 910a 可接收发票和支付指令(框 3644),并且与网络 2 清偿收费(步骤 3648 和 3840)。

[0369] 可选地,网络 2 的 DSC 910b 可发送使用参数和支付指令到 DPC 902(框 3838)。DPC 902 可接收使用参数和支付指令(框 3748),创建发票(框 3750),和向网络 2 发送发票(框 3752)。DSC 910a 可接收发票和支付指令(框 3646),并且与网络 2 清偿收费(步骤 3648 和 3840)。

[0370] 图 41 展示向请求网络的其他资源分配可用资源的网络提供商的组件之间的消息通信的消息流图 4100。在网络 1 3501 处的 DSC 910a 可发送资源请求(消息 3502)。DPC 902 可接收对资源消息的请求并且向网络 2 发送资源查询(消息 3504)。在网络 2 处,可在 DSC 910b 处接收资源查询。DSC 910b 可向网络 2 中的 OMC 912 发送资源查询来确定资源是否可用于网络 1(消息 4106)。OMC 912 可接收来自 DSC 910b 的资源查询消息并且向接入资源 4102 发送资源查询消息(消息 4108)。OMC 912 还可向核心资源 4204 发送资源查询消息(消息 4110)。接入资源 4102 和核心资源 4204 各自接收来自 OMC 912 的资源查询消息并且分别向 OMC 912 发送资源响应(消息 4112、4114)。来自接入资源 4102 的资源可包括消息参数。来自接入资源 4102 的资源响应可包括其他消息参数。

[0371] OMC 912 可接收来自接入资源 4102 和核心资源 4104 的资源响应并向 DSC 910b 发送资源响应消息,该资源响应消息指示网络 2 中的资源可用性的状态(消息 4116)。DSC 910b 可接收来自 OMC 912 的资源响应消息并且向 DPC 902 发送资源查询响应(消息 3508)。DPC 902 可接收来自 DSC 910b 的资源查询响应,确定所请求的资源的类型是否在网络 2 处可用并且向网络 1 的 DSC 910a 发送资源可用消息(消息 3512)。DSC 910a 可接收资源可用消息并且发送资源请求消息来指引 DPC 902 请求来自网络 2 的可用资源(消息 3514)。DPC 902 可接收资源请求消息并且向 DSC 910b 发送资源预留请求消息来请求为由网络 1 使用而预留网络 2 中的可用资源(消息 3516)。DSC 910b 可接收资源预留请求消息并且经由 OMC 912 向接入资源 4102 发送资源预留请求(消息 4118),以及向核心资源 4104 发送资源预留请求(消息 4120)。

[0372] 接入资源 4102 可接收来自 OMC 912 的资源预留请求、预留可用资源并且经由 OMC 912 将资源预留消息发送回 DSC 910b(消息 4122)。类似地,核心资源 4104 可接收来自 OMC 912 的资源预留请求,预留可用资源并且经由 OMC 912 将资源预留消息发送回 DSC 910b(消息 4124)。DSC 910b 可接收来自接入资源 4102 和核心资源 4104 的资源预留消息并向 DPC 902 发送资源预留消息以通知 DPC 902 和网络 1 为由网络 1 使用而预留请求的资源(消息 3518)。DPC 902 可接收来自网络 1 的 DSC 910a 的资源竞标消息(消息 3520)。如果 DPC 902 接收的竞标满足网络 2 的价格和合同要求,DPC 902 可向 DSC 910a 发送竞标接受消息(消息 3522)。如果接受竞标,DPC 902 可向 DSC 910b 发送指派资源请求(消息 3524)。DSC 910b 可接收到接入资源 4102 的指派资源请求(消息 4126),以及接收到核心资源 4104 的指派资源请求(消息 4128)。DSC 910b 可进一步向可相对于 PCFF 相同或不同的策略控制

器 905 发送用于资源指派消息的策略（消息 4130）。DSC 910b 可进一步向 AAA/AuC 4106 发送用于所指派的资源的计量（消息 4132）。

[0373] 图 42 至图 44 展示用于通过将次要用户切换到他们的归属网络或终止他们与主机网络的通信会话来退避次要用户的实施例方法的过程流程图。来自网络 1 的无线设备 101 可经由 DSC 910b 建立与网络 2 的次要用户通信会话（步骤 3904、3830）。网络 2 的 DSC 910b 可连续地监控网络上的流量 vs. 可用资源（框 3602），并且向 DPC 902 发送报告（框 3604）。DPC 902 可从 DSC 910b 接收资源状态报告。DSC 910b 可基于网络的可用资源进一步确定网络量是否大于网络的容量（确定 4404）。如果网络量不大于网络的容量（即，确定 4404 =“否”），DSC 910b 可通过返回框 3602 继续监控网络流量 vs. 可用资源。如果网络量大于网络的容量（即，确定 4404 =“是”），DSC 910b 可标识网络上的用户（框 4406），并且确定该用户是否是次要用户（确定 4408）。

[0374] 如果该用户是次要用户（即，确定 4408 =“是”），DSC 910b 可发送在 t 处断开会话消息，t 是在网络 2 将终止次要用户通信会话之前剩下的时间的量（框 4410）。如图 43 中所示，DPC 902 可接收在 t 处断开会话消息（框 4306）。可选地，代替发送在 t 处断开会话消息，DSC 910b 可终止次要用户的通信会话来为主要用户或其他重要用户立即提供额外的资源（框 4412）。关于是否立即终止或在次要用户的终止之前传送警告可基于主要和次要网络提供商之间的合同条款以及 DSA 通信系统策略和规则集。

[0375] 如果该用户不是次要用户（即，确定 4408 =“否”），DSC 910b 可确定网络上是否存在任何其他次要用户（步骤 4414）。如果存在仍然连接到网络 1 的其他次要用户（即，确定 4414 =“是”），DSC 910b 可通过返回步骤 4410、4412 在主要用户之前首先发送尝试将他们的会话断开连接。如果主要网络上没有其他次要用户（即，确定 4414 =“否”），DSC 910b 可基于分层优先接入规则保持或挂断主要用户通信会话（框 4416）。例如，可最后挂断高端主要用户（即，具有更贵订阅计划的那些用户）。可替代地，在一个实施例（未示出）中，代替终止主要用户通信会话，DSC 910b 可尝试将用户切换到另一网络作为次要用户，因此，在减少网络 1 的量的同时保留通信会话连接。DSC 910b 可通过返回框 4404 返回监控网络量 vs. 容量来确定是否需要分流额外呼叫者。

[0376] 如图 43 中所示，DPC 902 可向 DSC 910a 转发在 t 处断开会话消息（框 4306）。DSC 910a 可接收在 t 处断开会话消息（框 4206），设置计时器从 t 倒计时（框 4208），并且监控它的可用资源（框 4210），以确定网络 1 上是否存在可用资源来从网络 2 接收次要用户通信会话（确定 4212）。如果资源在网络 1 上不可用（即，确定 4212 =“否”），DSC 910a 可向 DPC 902 发送对资源的请求（框 3808），以通过返回图 36 的框 3706 并且遵循如以上参照图 36 至图 40 描述的资源分配步骤来预留和购买来自网络提供商的可用资源。

[0377] 如果资源在网络 1 上可用（即，确定 4212 =“是”），DSC 910a 可向将被从网络 2 终止的次要用户分配资源（框 4212），并且向 DPC 902 发送对于无线设备 101 从网络 2 断开连接并且连接到网络 1 的指令，如图 44 中所示（框 4308）。DSC 910a 还可将网络 1 系统配置 / 准备成连接到次要用户无线设备 101（框 4218）。

[0378] 如图 44 中所示，DPC 902 可向网络 2 的 DSC 910b 转发用于无线设备 101 从网络 2 断开连接并且连接到网络 1 的指令（框 4308）。DSC 910b 可接收指令（框 4418），并且将它们发送到当前具有与网络 2 的通信会话的次要用户无线设备 101（框 4420）。无线设备 101

可接收指令以从网络 2 断开连接并且连接到网络 1（框 4220），并且结束与网络 2 的通信会话（框 4222），并且建立与网络 1 的通信会话（步骤 4224、4226）。

[0379] 公共安全网络：

[0380] 在一个实施例中，DSA 通信系统的主要网络提供商可以是公共安全网络。公共安全网络可以是公共安全频谱的持有者或拥有者。一般为由公共安全当局使用而预留公共安全频谱。所指派的公共安全带宽通常包括比公共安全当局基于平均情况的使用更多的频谱。预期将在如灾难的公共安全紧急情况中期间使用它，为公共安全使用指派过剩量的频谱。

[0381] 在一个实施例中，DSA 通信系统可允许当公共安全频谱可用并且未在使用中时公共安全网络将频谱资源租用给其他网络。在公共安全紧急情况期间，当可能需要所有网络资源以供公共安全当局使用时，DSA 通信系统可允许网络通过从公共安全网络分流流量来释放资源而从其他网络撤回它的全部的所分配的资源。

[0382] 此外，如果在紧急情况期间公共安全网络的所指派的频谱证明不足以处理公共安全当局的大量使用，DSA 通信系统可使公共安全网络能够租用或采用来自其他参与 DSA 通信系统的网络的资源。例如，DSA 通信系统可要求所有参与的网络连续地保持它们资源的一定百分比（例如，10％）未指派。公共安全网络在紧急情况期间可使用参与的网络的未指派的资源来增大它们用于公共安全通信的资源。DSA 通信系统可进一步分流主要网络的主要和 / 或次要用户来为由公共安全当局使用而释放资源。

[0383] 在一个实施例中，对公共安全频谱的接入可基于以上参照图 1 至图 8 描述的分层优先接入方法。例如，警察调度员可总是具有对频谱的接入。然而，可将公共安全资源的其他非政府用户的接入限制到采些时间段或日期，取决于用户和公共安全网络提供商之间的合同。

[0384] 在一个实施例中，可使用以上参照图 1 至图 8 描述的分层优先接入方法执行从公共安全网络或其他网络分流非公共安全用户。如，在公共安全网络中，当需要资源以供公共安全使用时，DSA 通信系统可使公共安全网络能够以优先顺序分流用户，如，首先分流次要非公共安全用户，第二，分流主要非公共安全用户，第三，分流低级别公共安全用户，以此类推。可使用类似的分层优先接入方法来分流另一网络的用户，公共安全网络可使用该网络的资源。

[0385] 在一个实施例中，在紧急情况期间，DSA 通信系统可限制对分配用于次要使用的任何公共安全网络的资源的接入。例如，一旦 DSA 通信系统确定存在公共安全紧急情况，DSA 通信系统可不再将来自涉及紧急情况的公共安全网络的所分配的资源考虑为可用于其他网络的使用的资源。

[0386] 在一个实施例中，DSA 通信系统策略和规则集可要求参与的网络分配它们资源的一定百分比用于公共安全使用以及灾难响应目的。在紧急情况期间，DSA 通信系统可使公共安全网络能够接入额外资源，每个非公共安全网络可将这些额外资源分配用于公共安全使用。在此场景中，如果所分配的资源在使用中，可使用分层优先接入方法来从所分配的资源分流用户。可不使用非公共安全网络的其他资源用于公共安全，除非合适地协商。

[0387] 图 45 至图 49 展示用于使用 DSA 通信系统分配和接入公共安全网络的资源的实施例方法的流程图。如图 45 中所示，DSC 910a 可监控网络 1 中的资源 vs. 带宽流量（框 3602）。DSC 910a 可记录网络 1 的资源状态并且将其报告到 DPC 902。DPC 902 可接收来自

网络 1 的资源状态报告 (框 3702),并且存储它 (框 3704)。网络 1 的 DSC 910a 可基于资源状态报告确定是否可要求额外资源以向网络 1 的现有的用户提供服务 (确定 3606)。如果不要求额外的资源 (即,确定 3606 =“否”),DSC 910a 可通过回到框 3602 继续监控可用资源 vs. 带宽流量。如果要求额外资源 (即,确定 3606 =“是”),DSC 910a 可向 DPC 902 发送对于额外资源的请求 (框 3608)。

[0388] 在框 4502 中,公共安全网络 DSC 910b 可预留预定量的未使用资源作为只用于由公共安全当局使用的备用。这可保证如果在如自然灾难的紧急情况期间需要资源资源可以容易地专用于公共安全使用直到通过从网络分流次要用户释放额外的资源。公共安全网络 DSC 910b 还可在公共安全网络中监控可用资源 vs. 带宽流量 (框 3602),并且向 DPC 902 报告资源状态 (框 3804)。DPC 902 可接收来自于 DSC 910b 的资源状态报告 (框 3702) 并且存储所接收的数据 (框 3704)。DSC 910b 可确定过剩量的资源是否可用在公共安全网络中 (确定 3804)。如果过剩量的资源不可用在公共安全网络中 (即,确定 3804 =“否”),DSC 910b 可通过回到框 3602 继续监控可用资源 vs. 带宽流量。如果过剩量的资源可用 (即,确定 3804 =“是”),DSC 910b 可分配过剩资源或过剩资源的子部分供次要使用 (框 3806),并且向 DPC 902 报告资源被分配供次要用户使用 (框 3808)。DPC 902 可接收来自 DSC 910b 的资源分配报告 (框 3702),并且存储所接收的数据 (框 3704)。

[0389] 从网络接收的状态报告可进一步包括信息,如关于对所分配的资源的接入和使用的网络规则和策略。例如,来自公共安全网络的状态报告可包括在无线设备 101 可以作为次要用户成功地接入公共安全网络上的所分配的资源之前必须满足的用于公共安全网络的系统要求。

[0390] DPC 902 从网络 1 的 DSC 910a 接收对于额外资源的请求 (框 3706),并且基于从其他网络接收的数据从最佳可用网络选择,网络 1 可从该最佳可用网络购买额外资源 (框 3708)。在此实施例中,DPC 902 可选择公共安全网络作为向网络 1 提供资源的最合适的网络。在框 3710 中,DPC 902 可向公共安全网络发送资源查询以确定公共安全网络的所分配的过剩资源的可用性和数量。

[0391] 公共安全网络的 DSC 910b 可接收资源查询 (框 3810),并且确定资源可用性 (框 3812)。DSC 910b 可向 DPC 902 发送资源查询响应。资源查询响应可包括关于可供次要用户使用的资源的数量和质量的信息。DPC 902 可接收资源查询响应 (框 3712)。

[0392] 如图 46 中所示,DPC 902 可基于从公共安全网络的 DSC 910b 接收的数据确定资源是否可用 (框 3714)。如果数据不可用 (即,确定 3714 =“否”),DPC 902 可向网络 1 发送无可用资源消息 (框 3722)。由于不同原因,资源可能不可供网络使用。例如,在由请求网络预留之前可将资源卖给其他竞标者。网络 1 的 DSC 910a 可接收无可用资源消息 (框 3614),并且搜索其他可用频谱资源或终止与用户的连接会话来释放网络 1 上的资源 (框 3618)。

[0393] 如果数据可用 (即,确定 3714 =“是”),DPC 902 可向 DSC 910a 发送资源可用消息来通知网络 1 在公共安全网络处可用于次要使用的资源的质量和数量 (框 3716)。DSC 910a 可接收资源可用消息并且发送请求资源消息来为由网络 1 的订户使用而预留公共安全网络的所分配的资源 (框 3612)。请求资源消息可包括如在此交易中网络 1 可要求的资源的数量的数据。DPC 902 可接收资源请求消息 (框 3718),并且向公共安全网络发送预留

资源请求消息(框 3720)。在公共安全网络处的 DSC 910b 可接收预留资源请求(框 3816),并且为由网络 1 订户的使用而预留所请求数量的所分配的资源(框 3818)。公共安全网络的 DSC 910b 可通过发送资源预留消息来证实为由网络 1 使用而预留所请求数量的所分配的资源(框 3820)。DPC 902 可接收来自公共安全网络的资源预留消息并为竞标过程做准备,如图 47 中所述。

[0394] 如图 47 中所示,网络 1 的 DSC 910a 可发送资源竞标来协商对公共安全网络的预留资源的接入(框 3620)。DPC 902 可接收资源竞标并且对其进行处理(框 3726)。在确定框 3728 中,DPC 902 可确定是否可接受从网络 1 接收的竞标。DPC 902 可基于 DSA 通信系统的策略和规则集以及由资源提供网络阐述的要求(如价格和分配或接入方法)评估来自网络提供商的竞标。

[0395] 如果接受竞标(即,确定 3728 =“是”),DPC 902 可向网络 1 发送接受竞标消息(框 3730)。DSC 910a 可接收接受竞标消息并且等待资源接入指令(框 3622)。一旦接受竞标,DPC 902 还可向公共安全网络的 DSC 910b 发送指派资源消息(框 3732)。DSC 910b 可接收指派资源消息(框 3822),并且为由网络 1 使用而指派所预留的资源(框 3824)。DSC 910b 可发送资源接入消息以使网络 1 能够接入公共安全网络的所指派的资源(框 3826),并且配置建立与网络 1 的无线设备 101 的通信会话(框 3828)。

[0396] DPC 902 可向网络 1 转发资源接入消息(框 3734)。DSC 910a 可接收资源接入消息(框 3624)。资源接入消息可包括数据,如可由次要用户无线设备 101 用来接入公共安全网络上的资源的接入参数。应认识到可将其他数据包括在资源接入消息中。DSC 910a 可向具有与网络 1 的通信会话的无线设备 101 发送用于公共安全网络的接入参数并且网络 1 已经指定迁移到公共安全网络(框 3626)。所指定的无线设备 101 可接收用于公共安全网络的接入参数(框 3902),并且建立与网络 1 的无线设备 101 的通信会话(步骤 3904 和 3830)。公共安全网络可开始如以下参照图 49 更加详细地描述的清偿过程。

[0397] 如果拒绝竞标(即,确定 3728 =“否”),DPC 902 可向网络 1 发送拒绝竞标消息(框 3736)(图 48 中所示)。如图 48 中所示,DSC 910a 可接收拒绝竞标消息(框 3736),并且确定是否重新竞标(确定 3640)。如果无重新竞标(即,确定 3640 =“否”),DSC 910a 可发送取消资源请求消息(框 3644)。DPC 902 可接收取消资源请求消息(框 3742),并且向公共安全网络发送资源释放消息(框 3744)。公共安全网络的 DSC 910b 可接收资源释放消息(框 3832),为由其他网络使用而释放所预留的资源(框 3834),并且通过回到框 3808 如图 45 中所示并且遵循以上参照图 45 描述的步骤向 DPC 902 报告所分配的资源状态。

[0398] 如果重新竞标(即,确定 3640 =“是”),DSC 910a 可发送对于相同资源的新竞标(框 3642)。DPC 902 可接收该新竞标(框 3738),并且确定是否接受新竞标(确定 3740)。如果再次拒绝新竞标(即,确定 3740 =“否”),DPC 902 可通过回到框 3736 发送拒绝竞标消息。如果接受竞标(即,确定 3740 =“是”),如图 47 中所示并且遵循与以上参照图 47 所述相同的步骤,DPC 902 通过回到框 3730 发送接受竞标消息。

[0399] 图 49 展示在公共安全网络提供商接入网络 1 的次要用户无线设备 101 以后的清偿过程。公共安全网络的 DSC 910b 可向 DPC 902 发送关于由网络 1 的所分配的资源的使用的发票和支付指令(框 3836)。DPC 902 可向网络 1 转发来自公共安全网络的发票和支付指令(框 3746)。DSC 910a 可接收发票和支付指令(框 3644),并且清偿对于公共安全网

络的计费(步骤 3648 和 3840)。

[0400] 可选地,公共安全网络的 DSC 910b 可向 DPC 902 发送使用参数和支付指令(框 3838)。DPC 902 可接收使用参数和支付指令(框 3748)、创建发票(框 3750)、并且向公共安全网络发送发票(框 3752)。DSC 910a 可接收发票和支付指令(框 3646),并且清偿对于公共安全网络的计费(步骤 3648 和 3840)。

[0401] 图 50 至图 53 展示用于通过将次要用户切换到他们的归属网络或终止他们与主机网络的通信会话来退避次要用户的实施例方法的过程流程图。来自网络 1 的无线设备 101 可经由 DSC 910b 建立与公共安全网络的次要用户通信会话(步骤 3904、3830)。公共安全网络的 DSC 910b 可继续监控网络上的流量 vs. 可用资源(框 3602),并且向 DPC 902 发送报告(框 3604)。DPC 902 可从 DSC 910b 接收资源状态报告。DSC 910b 可基于网络的可用资源进一步确定网络量是否大于网络的容量(确定 4404)。如果网络量不大于网络的容量(即,确定 4404 =“否”),DSC 910b 可通过返回框 3602 继续监控网络流量 vs. 可用资源。如果网络量大于网络的容量(即,确定 4404 =“是”),DSC 910b 可标识网络上的用户(框 4406),并且确定该用户是否是次要用户(确定 4408)。

[0402] 如果网络量超过网络的所分配的容量阈值(即,确定 4408 =“是”),存在可指示紧急情况正在展开的异常情况。在此场景中,DSC 910b 可遵循图 50 的过程流程图中展示的过程来为公共安全使用释放资源以及图 54 来基于分层优先接入制度增量地分配网络资源。

[0403] 如图 50 中所示,为给公共安全使用释放资源,公共安全网络可发送在 t 处断开会话消息,t 是在公共安全网络终止次要用户通信会话之前剩下的时间的量(框 4110)。如图 43 中所示,DPC 902 可接收在 t 处断开会话消息(框 4306)。可选地,代替发送在 t 处断开会话消息,DSC 910b 可终止次要用户的通信会话来为主要用户或其他重要用户立即提供额外的资源(框 4412)。关于是否立即终止或在次要用户的终止之前传送警告可基于主要和次要网络提供商之间的合同条款以及 DSA 通信系统策略和规则集。

[0404] 如果该用户不是次要用户(即,确定 4408 =“否”),DSC 910b 可确定网络上是否存在任何其他次要用户(框 4414)。如果存在仍然连接到网络 1 的其他次要用户(即,确定 4414 =“是”),DSC 910b 可通过返回步骤 4410、4412 在主要用户之前首先发送尝试将他们的会话断开连接。如果主要网络上没有其他次要用户(即,确定 4414 =“否”),DSC 910b 可基于分层优先接入规则保持或挂断主要用户通信会话(框 4416)。例如,可最后挂断高端主要用户(即,具有更贵订阅计划的那些用户)。可替代地,在一个实施例(未示出)中,代替终止主要用户通信会话,DSC 910b 可尝试将用户切换到另一网络作为次要用户,因此,在减少网络 1 的量的同时保留通信会话连接。DSC 910b 可通过返回框 4404 返回监控网络量 vs. 容量来确定是否需要分流额外呼叫者。

[0405] 如图 51 中所示,DPC 902 可向 DSC 910a 转发在 t 处断开会话消息(框 4306)。DSC 910a 可接收在 t 处断开会话消息(框 4206),设置计时器从 t 倒计时(框 4208),并且监控它的可用资源(框 4210),以确定是否存在在网络 1 上可用的资源来接收来自公共安全网络的次要用户通信会话(确定 4212)。如果资源在网络 1 上不可用(即,确定 4212 =“否”),DSC 910a 可向 DPC 902 发送对资源的请求(框 3808),以通过返回图 45 的框 3706 并且遵循如以上参照图 45 至图 49 描述的资源分配步骤来预留和购买来自网络提供商的可用资源。

[0406] 如果资源在网络 1 上可用(即,确定 4212 =“是”),DSC 910a 可向将被从公共安全网络终止的次要用户分配资源(框 4212),并且如图 52 中所示向 DPC 902 发送无线设备 101 从公共安全网络断开连接并且连接到网络 1 的指令(框 4308)。DSC 910a 还可将网络 1 系统配置 / 准备成连接到次要用户无线设备 101(框 4218)。

[0407] 如图 52 中所示,DPC 902 可将用于无线设备 101 从公共安全网络断开连接并且连接到网络 1 的指令转发到公共安全网络的 DSC 910b(框 4308)。DSC 910b 可接收指令(框 4418),并且将它们发送到当前具有与公共安全网络的通信会话的次要用户无线设备 101(框 4420)。无线设备 101 可接收从公共安全网络断开连接并且连接到网络 1 的指令(框 4220),并且结束与公共安全网络的通信会话(框 4222),并且建立与网络 1 的通信会话(步骤 4224、4226)。

[0408] 在又一个实施例中,公共安全网络可监控从 DPC 902 接收的所有新的预留资源请求和查询以保证只向那些由公共安全当局基于 TPA 发起的请求提供资源,至少直到资源容量回到低于阈值等级。公共安全网络可在 DSC 910b 处接收预留资源请求(框 3810),并且确定资源查询是否来自被授权 TPA 的设备(确定 312)。如果资源请求是来自被授权 TPA 的设备(即,确定 312 =“是”),DSC 910b 可将如次要用户通信会话的非 TPA 通信会话断开连接(框 314),并且连接 TPA 呼叫(框 315)。DSC 910b 可通过返回图 50 的框 3602 再次监控资源 vs. 可用带宽。如果资源预留消息是来自无线设备 101 而不是被授权的设备(即,确定 312 =“否”),公共安全网络可阻止呼叫直到过剩的资源再次可供次要用户使用(框 5302)。

[0409] 在一个实施例中,对于尝试使用订阅网络提供商而不是公共安全网络提供商的无线设备建立与公共安全网络的通信会话的被授权 TPA 的人员,可向公共安全当局提供可提醒接收网络提供商请求将通信会话转移到公共安全网络的前缀号码和接入 PIN。通过使用前缀号码和 PIN,公共安全用户可使用任何设备接入公共安全网络,即使设备被认为是公共安全网络上的次要用户无线设备 101。

[0410] 如图 54 到图 56 中所示,当被授权的公共安全官员要求建立与特定公共安全网络的连接时,他可使用网络 1 的任何未授权的无线设备 101 并拨特殊前缀号码如 *272 来拨打呼叫(框 5402)。DSC 910a 可接收并且处理该呼叫(框 5404),并且将前缀号码标识为请求将通信会话转移到公共安全网络(框 5406)。DSC 910a 可向无线设备 101 发送 PIN 请求(框 5408)。无线设备 101 可接收 PIN 请求(框 5410),使用图形用户接口 (GUI) 向用户显示 PIN 请求并且接收用户的 PIN 输入(框 5412)。无线设备 101 可向 DSC 910a 发送所输入的 PIN 用于处理(框 5414)。DSC 910a 可接收 PIN(框 5416),并且向 DPC 902 发送对于网络转移的请求连同 PIN(框 5418)。DPC 902 可接收对于网络转移的请求(框 5420),并且确定 PIN 是否匹配 PIN 数据库(确定 318)。如果 PIN 不匹配 PIN 数据库中的条目(即,确定 318 =“否”),DPC 902 可阻止该呼叫(框 5302)。如果 PIN 匹配 PIN 数据库中的条目(即,确定 318 =“否”),DPC 902 可基于所接收的 PIN 标识目标公共安全网络(框 5422)。

[0411] 如图 55 中所示,DPC 902 可确定网络 1 的无线设备 101 是否包括与目标公共安全网络兼容的技术(框 5424)。如果设备和公共安全网络在技术上不兼容(即,确定 5424 =“否”),DPC 902 可经由 DSC 910a 向设备发送网络不兼容消息(框 5426)。DSC 910a 可转发网络不兼容消息(框 5428),并且终止与无线设备 101 的连接(框 5432)。无线设备 101

可接收网络不兼容消息（框 5430），向用户显示该消息（框 5434），并且终止与网络 1 的连接（框 5436）。如果设备和公共安全网络技术兼容（即，确定 5424 ＝“是”），DPC 902 可向公共安全网络 DSC 910b 发送带有 PIN 预留资源请求（框 5438）。DSC 910b 可接收带有 PIN 预留资源请求（框 5440）。

[0412] 在一个实施例中，如图 56 中所示，被授权的公共安全当局对公共安全网络的接入可在优先级等级上。例如，公共安全组织的更高级别官员可具有相比于来自相同组织的更低级别官员对网络的优先级接入。在任何给定时间，取决于流量和可用资源的等级，公共安全网络可确定什么等级的当局可具有对网络的接入。可替代地，DSC 910b 可以被配置成允许具有所要求的优先级等级的那些而拒绝具有比所要求的更低的优先级等级的那些。DSC 910b 可连续地重新评估资源可用性并且基于资源的可用性改变官员的接入等级。DSC 910b 可基于 PIN 确定无线设备 101 的用户的优先级等级（框 5442）。DSC 910b 可确定当时是否允许该等级的优先级的设备 101 接入公共安全网络（确定 5444）。如果设备 101 优先级等级是被授权的（即，确定 5444 ＝“是”），DSC 910b 可将非 TPA 会话或更低优先级 TPA 会话断开连接来为对资源的新请求释放资源（框 5446），并且连接新的 TPA 会话（框 5448），并且返回监控网络的资源 vs. 带宽流量（图 45 的框 3602）。如果请求是来自于当时没有接入网络的优先级等级的被授权 TPA 的设备（即，确定 5444 ＝“否”），DSC 910b 可阻止呼叫（框 5302）。

[0413] 如上所述，各个实施例通过执行分层优先接入 (TPA) 操作克服了常规无线优先接入 (WPA) 系统的限制，分层优先接入操作可以包括监控无线网络的呼叫量、确定呼叫量是否超过阈值、当呼叫量超过阈值时划分网络资源以供紧急人员使用、为紧急人员预留一部分划分的资源、监控呼叫以确定是否正在进行向或来自与紧急人员相关联的移动设备的呼叫、以及当存在正在进行的向或来自与紧急人员相关联的移动设备的呼叫时限制对所预留的资源的一般访问。在各个实施例中，可以由处理器来执行这些或其他的 TPA 操作，该处理器耦接到基站组件（例如，基站收发器、NodeB、eNodeB 等）上并且在核心网的外面。

[0414] 在一个实施例中，分层优先接入 (TPA) 操作可以在演进的节点 B(eNodeB) 处或其上执行，如由 eNodeB 处理器、耦接到 eNodeB 组件上的处理器、或在与 eNodeB 组件进行通信的服务器或代理（例如，Diameter 代理、专用服务器、软件应用、进程、计算机系统等）执行。

[0415] 在各个实施例中，负责执行分层优先接入 (TPA) 操作的网络组件（例如，eNodeB、eNodeB 处理器或代理等）可以被配置为用于与负责执行动态频谱仲裁 (DSA) 操作的一个或多个组件进行交互。例如，eNodeB 可以被配置为用于将一个或多个资源的状态和／或 TPA 操作的结果通信至动态频谱控制器 (DSC) 和／或动态频谱策略控制器 (DPC)。在一个实施例中，DSA 服务器或系统可以被配置为用于使用在 TPA 网络组件（例如，eNodeB) 与控制器（例如，DSC、DPC 等）之间所通信的信息来作出更好并且更了解情况的频谱仲裁确定（例如，是否应该出租频谱、应该共享多少频谱等）。

[0416] 在各个实施例中，频谱仲裁确定（例如，是否以及多少频谱和／或无线电资源应该被租用或者被从一个网络共享到另一个网络）可以基本上在当网络正在正常流量状况下操作的同时发生。

[0417] 当网络经历资源使用的增长（如响应于公共安全事件而发生的流量突然增长）时，一个或多个 eNodeB 可以开始在本地对流量进行整形。这些 eNodeB 可以将资源使用的

增长（例如，流量超过某些阈值等）或本地流量整形（例如，切换、掉落的连接等）的结果报告给 DSC 服务器和 / 或 DPC 服务器。DPC 可以将这些报告记录或存储在存储器中以供将来频谱仲裁确定操作的使用。例如，DPC 可以被配置为用于向经历流量激增的网络授权频谱资源或无线电资源并且拒绝来自其他网络的对频谱的未来请求。类似地，DPC 可以被配置为用于撤销来自其他网络和 / 或经历流量激增的网络的对频谱资源或无线电资源的先前授权。

[0418] 在一个实施例中，可以将移动设备用户排序或组织为多个优先级组，并且系统可以被配置为用于基于这些移动设备用户所属的排序或优先级组来确定移动设备的优先级和 / 或接入权限。在一个实施例中，可以在网络服务器中确定这些排序 / 优先级组，其中，排序 / 优先级信息被发送至基站组件（例如，eNodeB 等）用于强制执行。在另一个实施例中，该基站组件可以被配置为用于在本地生成该基站组件中的排序 / 优先级。例如，在各个实施例中，排序或优先级信息可以基于所指派的 QoS 级别标识符 (QCI) 或分配和保留优先级 (ARP) 值。

[0419] 在各个实施例中，可以将流量整形（如动态 QoS 更改）跨一个或多个优先级组应用到一个或多个特定移动设备或应用到级别和设备的组合上。可以依次应用流量整形，如按步骤应用到第一集合一个或多个优先级组或设备，然后应用到第二集合，然后应用到第三集合，以此类推。实施例可以包括应用到任何数量集合的优先级组或移动设备的任何序列的流量整形。序列可以包括在对其他组的流量进行整形之前对一个或多个组的流量反复进行整形。

[0420] 图 57A 展示了在适用于实现各个实施例的示例长期演进 (LTE 或 4G LTE) 通信系统 5700 中的多个网络组件和信息流。典型的 LTE 通信系统 5700 包括耦接到移动性管理实体 (MME) 组件 5706 和服务网关 (SGW)5708 的多个 eNodeB 组件 5704。MME 5706 和 SGW 5708 可以是核心网 5716 的一部分，比如系统架构演进 (SAE) 或演进型分组核心 (EPC) 网络。eNodeB 5704 可以在核心网 5716 的外面。

[0421] eNodeB 5704 可以被配置为用于将语音信号、数据信号、和控制信号在移动设备 5702(例如，蜂窝电话）之间通信或通信至其他网络目的地。通过用作所有无线电协议朝向移动设备 5702 的终止点并且将语音信号（例如，VoIP 等）、数据信号和控制信号中继到核心网 5716 中的多个网络组件，eNodeB 5704 可以充当移动设备 5702 与核心网 5716 之间的桥（例如，第 2 层桥）。eNodeB 5704 可以被配置为用于执行各种无线电资源管理操作，比如控制无线电接口的使用、基于请求分配资源、根据各个服务质量 (QoS) 要求优化并调度流量、监控网络资源使用等。eNodeB 5704 还可以被配置为用于采集无线电信号电平测量结果、分析所采集的无线电信号电平测量结果、并且基于分析的结果而将移动设备 5702(或至移动设备的连接）切换至另一个基站（例如，第二 eNodeB)。

[0422] 一般而言，移动设备 5702 通过无线通信链路 5722 向 eNodeB 5704 发送语音信号、数据信号和 / 或控制信号并从 eNodeB 5704 接收语音信号、数据信号和 / 或控制信号。eNodeB 5704 可以将信令 / 控制信息（例如，与呼叫建立、安全、认证等有关的信息）通过 S1-MME 接口上的 S1-AP 协议发送至 MME 5706。MME 5706 可以通过 S6-a 接口从归属订户服务器 (HSS)5714 请求用户 / 订户信息，通过 S10 接口与其他 MME 组件进行通信，执行各种管理任务（例如，用户认证、漫游限制的强制执行等），选择 SGW 5708，并且将认授权和管理信

息发送至 eNodeB 5704 和 / 或 SGW 5708(例如,通过 S1-MME 和 S11 接口)。

[0423] 一旦从 MME 5706 接收到授权信息(例如,认证完成指示、所选择的 SGW 的标识符等),eNodeB 5704 可以通过 S1-U 接口上的 GTP-U 协议将从移动设备 5702 所接收的数据发送至所选择的 SGW 5708。SGW 5708 可以存储关于所接收的数据(例如,IP 承载服务的多个参数、网络内部路由信息等)的信息,并且通过 S11 接口将多个用户数据包转发至分组数据网络网关 (PGW) 和 / 或策略控制强制执行功能 (PCEF)5710。

[0424] PGW/PCEF 组件 5710 可以包括耦接到 PGW 组件上的 PCEF 组件、包括在 PGW 组件中的 PCEF 组件、或被配置为用于进行通常与 PGW 组件相关联的多个操作的 PCEF 组件。由于这些结构是众所周知的,为了集中说明最相关的特征,某些细节已经被省略。可以在"第 3 代合作伙伴项目技术规范组服务和系统方面、策略和收费控制体系结构 (3rd Generation Partnership Project Technical Specification Group Services and System Aspects, Policy and Charging Control Architecture)"TS 23.203(2011 年 6 月 12 日更新)中找到关于策略和收费执行功能操作的信息,其全部内容通过引用结合在此。

[0425] PCEF/PGW 5710 可以如在 Gx 接口上将信令信息(例如,控制面信息)发送到策略控制规则功能 (PCRF) 组件 5712。PCRF 组件 5712 可以负责针对给定的通信会话标识适当的策略规则。PCRF 组件 5712 可以通过 S9 接口与外部 PCRF 组件(未示出)进行通信、接入订户数据库、创建策略规则、和 / 或将策略规则发送到一个或多个 PCEF/PGW 组件 5710 进行强制执行。

[0426] PCEF/PGW 5710 可以从 PCRF 组件 5712 接收策略规则,并且强制执行所接收到的策略规则以控制带宽、服务质量 (QoS)、和 / 或有待在服务网络 5720 与移动设备 5702 之间通信的数据的其他特性。PCEF/PGW 5710 还可以基于所接收到的策略规则协调、分配、添加、移除和 / 或调整各个资源(例如,网络资源、订户资源等)。

[0427] 如上所述,网络活动 / 流量通常是由 PCEF/PGW 5710 组件从核心网 5716 中控制的。与现有的解决方案形成对照,各个实施例可以包括 eNodeB 组件 5704,该 eNodeB 组件被配置为用于进行 TPA 操作以从核心网 5716 的外部控制网络活动 / 流量。eNodeB 5704 可以被配置为用于监控网络活动(例如,呼叫量等)并基于当前网络状况对网络资源进行划分、分配和 / 或调整。eNodeB 5704 还可以被配置为用于基于网络状况动态地对移动设备 5702 的网络活动进行"整形"。对移动设备的网络活动进行整形可以包括减小带宽、降低 QoS、限制服务数量、甩掉连接、将连接的设备转移到另一个塔(例如,第二 eNodeB 等)、执行切换、和 / 或其他类似的业务管理活动或操作。

[0428] 在一个实施例中,核心网 5716 可以是动态服务仲裁通信系统的一部分(或可以包括动态服务仲裁通信系统),比如上述各个 DSA 系统中的任何 DSA 系统。例如,图 57A 展示了核心网 5716 可以包括适用于执行 DSA 操作的 DSC 组件 5722。在核心网 5716 中包括 DSC 组件 5722 可以使得一个或多个 eNodeB 5804a、5804b 能够将与网络活动和 / 或对网络活动进行整形所采取的各个步骤相关的信息发送至 DSC 5722,该 DSC 5722 可以使用此信息以做出更了解情况的频谱仲裁确定(例如,是否应该出租频谱、应该共享多少频谱等)。

[0429] 在图 57A 所展示的示例中,DSC 5722 直接连接至 PCRF 5712。在各个实施例中,DSC 5722 可以直接或间接地连接至 PCEF/PGW 5710 和 / 或核心网 5716 中的各个其他组件。在各个实施例中,DSC 5722 可以如通过直接通信链路 5730 直接或间接地与一个或多个 eNodeB

5704 相连接。

[0430] 在一个实施例中，DSC 5722可以连接至在核心网5716外面的DPC 5722。DSC 5722可配置有软件以使用容量策略标准向DPC 5724通信关于频谱资源的可用性的数据。通信到DPC 5724的数据可包括涉及网络或子网络的当前过剩容量和预期的未来容量的数据，如接收自一个或多个eNodeB 5804a、5804b的数据。

[0431] 在各个实施例中，DSC 5722和/或DPC 5724在动态频谱仲裁过程中可以依赖于来自一个或多个eNodeB的数据。例如，当网络具有活跃地对流量进行整形和/或报告高网络活动的一个或多个eNodeB 5804a、5804b时，DSC 5722和/或DPC 5724可以基于流量整形和/或网络活动信息对频谱资源进行再分配。

[0432] 在一个实施例中，eNodeB 5704可以被配置为用于将移动设备5702分类或组织为多个优先级组或级别，比如主要用户（例如，第一响应者或其他优先级用户）和次要用户（例如，非优先级用户）。

[0433] 在一个实施例中，eNodeB 5704可以被配置为用于基于这些优先级组/级别对移动设备的网络活动进行整形。在一个实施例中，eNodeB 5704可以对网络活动进行整形，从而使得随着网络活动增加属于较高优先级组的移动设备被分配较大百分比的可用网络资源（例如，带宽等）。

[0434] 图57B展示了LTE通信系统5750中的多个网络组件和信息流，该LTE通信系统包括被配置为用于执行TPA操作和/或基于优先级组/级别来对移动设备的网络活动进行整形的实施例eNodeB 5704a。在图57B中所展示的示例中，LTE通信系统5750包括MME 5706、SGW 5708、HSS 5714、PGW/PCEF 5710和PCRF 5712，所有这些都在逻辑上位于核心网5716的内部。LTE系统5750还可以是DSA通信系统的一部分或者包括DSA通信系统。

[0435] LTE系统5750可以包括DSC组件5722和/或DPC组件5724，这两个组件中的任何一个都可以在逻辑上位于核心网5716的内部或外部。LTE通信系统5750可以包括第一移动设备5702a、第二移动设备5702b、第一eNodeB 5704a和第二eNodeB 5704b，所有这些都在逻辑上位于核心网5716的外部。第一移动设备5702a可以被分类为主要用户的移动设备5702a，并且第二移动设备5702b可以被分类为次要用户的移动设备5702b。在图57B中所展示的示例中，主要用户的移动设备5702a通过第一无线通信链路5722a连接至第一eNodeB 5704a。次要用户的移动设备5702b通过第二无线通信链路5722b连接至第一eNodeB 5704a。

[0436] 第一eNodeB 5704a可以被配置为用于监控网络活动（例如，呼叫量、资源使用、拥塞、活跃连接的数量等）以确定网络活动是否超过两个或更多个阈值。当网络活动超过第一阈值时，第一eNodeB 5704a可以为主要用户的移动设备5702a预留通信信道。当网络活动超过第二（或后续）阈值时，第一eNodeB 5704a可以动态地对次要用户的移动设备5702b的网络活动进行“整形”。对移动设备的网络活动进行整形可以包括执行多个操作以控制无线网络链接5722b的一个或多个特性和/或正在被通信的数据，比如减小带宽、降低QoS、限制服务数量、甩掉连接（例如，无线通信链路5722b等）、将连接的设备转移到另一个eNodeB（例如，第二eNodeB 5704b等）、执行切换等。

[0437] 通过eNodeB 5704对移动设备的网络活动进行整形有多个优点，包括更快的检测和响应时间、改善的效率、以及更加集中的解决方案应用。例如，由于eNodeB 5704位于核

心网 5716 的外部,它可以比 PCEF/PGW 组件 5710 或位于核心网 5716 内部的其他组件更快地检测到网络活动的变化并作出响应。此外,eNodeB 5704 可以在逐小区或逐塔的基础上对网络活动和 / 或资源可用性的变化进行响应,而现有的解决方案通常要求将变化施加于整个地理区、更新网络范围的策略 / 控制、或将限制施加于特定订户或移动设备。

[0438] 进一步地,通过在 eNodeB 5704 上对网络活动进行整形,施加于移动设备 5702 的限制仅在移动设备 5702 试图通过特定 eNodeB 5704 进行通信时施加,并且在切换之后不跟随移动设备 5702。例如,当第一 eNodeB 5704a 对移动设备可用的带宽量进行限制然后将移动设备切换至第二 eNodeB 5704b 时,第二 eNodeB 5704b 将不会在移动设备上强制执行由第一 eNodeB 5704a 施加的带宽限制(如果限制由核心网 5716 之内的组件(如 PCEF/PGW 5710)集中地施加,其将会那样做)。这消除了需要以其他方式恢复移动设备的受限制的属性(例如,带宽、QoS 等)的附加消息或操作,并且从而提高了效率。

[0439] 如上文所讨论的,eNodeB 可以被配置为用于将这些移动设备分类或组织为多个级别。在一个实施例中,eNodeB 可以被配置为用于执行内部分层优先接入(ITPA)操作,这些内部分层优先接入操作可以包括将那些级别细分成多个层。eNodeB 5704 可以然后基于优先级级别 / 层对移动设备的网络活动进行整形以便更精确地控制对网络资源的分配。

[0440] 图 58 展示了示例 LTE 蜂窝通信网络 5800 中的多个网络组件和信息流,该 LTE 蜂窝通信网络包括被配置为用于根据各个实施例执行 ITPA 操作的 eNodeB 5804a。第一 eNodeB 5804a 可以被配置为用于将移动设备分类或组织为多个级别,然后将这些设备细分为多个层。在图 58 所展示的示例中,移动设备 5802a-c 被分类为主要移动设备,移动设备 5802d 被分类为次要移动设备,并且主要移动设备 5802a-c 被细分为第一层、第二层和第三层。虽然展示了两个级别和三个层,应当理解 eNodeB 5804a 可以将移动设备 5802 分类为任何数量的级别,并且每一个级别都可以被细分为任何数量的层。

[0441] 第一 eNodeB 5804a 可以被配置为用于监控网络活动(例如,呼叫量等)以确定网络活动是否超过多个阈值中的任何一个阈值。该多个阈值可以包括任何数量的阈值并且每一个阈值都可以存储与任何可测量网络活动或事件(拥塞、带宽、使用趋势、资源的可用性、QoS 等)相关的任何值。

[0442] 第一 eNodeB 5804a 可以被配置为用于响应于确定超过了阈值而预留通信信道和 / 或动态地对移动设备 5802a-d 中的一个或多个移动设备的网络活动进行整形。可以执行整形操作,从而使得较高优先级移动设备随着网络活动的增加或资源变得稀缺而被分配较大百分比的可用网络资源(例如,带宽等)。在一个实施例中,这可以通过渐进地减少较低优先级移动设备可用的网络资源的数量来实现。

[0443] 在一个实施例中,该多个阈值可以包括一系列渐进的阈值。例如,该多个阈值可以包括当 50%的网络资源在使用中时被超过的第一阈值、当 75%的网络资源在使用中时被超过的第二阈值、当 85%的网络资源在使用中时被超过的第三阈值和当 95%的网络资源在使用中时被超过的第四阈值等。

[0444] 当第一 eNodeB 5804a 确定所监控的网络活动超过第一阈值时,第一 eNodeB 5804a 可以为主要移动设备 5802a-c 预留带宽或无线电频率(RF)资源。

[0445] 当网络活动超过第二阈值时,第一 eNodeB 5804a 可以通过减少变得对次要用户的移动设备 5802d 可用的带宽或 RF 资源的量来动态地对次要移动设备 5802d 的网络活动

进行整形。

[0446] 当网络活动超过第三阈值时，eNodeB 5804a 可以进一步通过甩掉/终止无线通信链接 5822d 和/或将无线通信链接 5822d 转移至第二 eNodeB 5804b 来对次要移动设备 5802d 的网络活动进行整形。在一个实施例中，将无线通信链接 5822d 转移至第二 eNodeB 5804b 可以包括第一 eNodeB 5804a 通过 X2 接口与第二 eNodeB 5804b 进行通信，第二 eNodeB 5804b 建立与次要移动设备 5802d 的新的无线通信链接 5823d，并且第一 eNodeB 5804a 甩掉/终止无线通信链接 5822d。

[0447] 当网络活动超过第四阈值时，第一 eNodeB 5804a 可以通过例如减少变得对第三层主要移动设备 5802c 可用的带宽或无线电资源的量来开始对主要移动设备 5802a-c 的网络活动进行整形。此过程可以继续直至只有第一层主要移动设备 5802a 连接至第一 eNodeB 5804a，或直至没有移动设备连接至第一 eNodeB 5804a（即，为将来可能到来的额外的紧急人员等预留资源）。

[0448] 在一个实施例中，一个或多个 eNodeB 5804a、eNodeB 5804b 可以被配置为用于与 DSC 5722 和/或 DPC 5724 进行通信。例如，第一 eNodeB 5804a 可以被配置为用于每一次网络活动超过一个或多个阈值和/或当流量整形动作（例如，切换、QoS 调整、断开连接等）发生时都向 DSC 5722 和/或 DPC 5724 发送警告消息。

[0449] 虽然参照了特定的一组整形操作、特定数量的级别/层以及特定阈值对以上示例进行了描述，应当理解，可以基于级别/层的任何组合并且针对任何数量的阈值来执行整形操作的任何组合。

[0450] 图 59A 和 59B 展示了 eNodeB 可以将移动设备分类为任何数量的级别，并且每一个级别都可以被细分为任何数量的层。具体来说，图 59A 展示了 eNodeB 可以将移动设备分类为主要级别和次要级别，主要级别可以被细分为四个层（例如，铂、金、银、铜），并且次要级别可以被细分为多个层（例如，第 1-x 层）。图 59B 展示了具有三个级别的替代性安排，这些级别中的每一个级别都被细分为多个层。

[0451] 如上文所讨论的，整形操作可以包括对通信网络中可用的多个资源中的任何资源（无线电链路、带宽、资源块、CPU 时间等）进行调整、控制和/或分配。如上文还讨论的，eNodeB 可以基于一个或多个触发器或阈值来执行整形操作。触发器可以是指示网络活动已经发生变化和/或可以指示整形操作的任何事件，并且阈值可以存储与任何可测量的网络活动或事件（拥塞、带宽、使用趋势、资源可用性、QoS 等）相关的任何值。可以将一个或多个触发器或阈值分配给或者关联至在通信网络中任何或所有可用资源。类似地，可以将单个触发器/阈值关联至多个资源，并且可以将多个触发器/阈值关联至单个资源。例如，eNodeB 可以监控多个资源，生成代表资源的普遍可用性的复合值，将所生成的复合值与阈值进行比较从而确定是否将要执行整形操作，并且基于比较的结果对一个或多个移动设备的网络活动进行整形。

[0452] 图 60A 和图 60B 展示了适用于各个实施例中的示例阈值和触发器。图 60A 展示了第一触发器，该第一触发器可以例如在 eNodeB 确定可用资源（例如，无线电链接、资源块等）的使用超过 75％的阈值使用时被激活。第二阈值可以在例如确定可用资源的使用超过 90％的阈值使用时被激活。第一触发器的激活可以使 eNodeB 执行第一组操作（例如，QoS 降级、切换等）。第二触发器的激活可以使 eNodeB 执行第二组操作（例如，流量甩掉等）。

[0453] 图 60B 展示了触发器的替代性配置，该替代性配置具有在不同的资源使用百分比或水平上指派的四个触发器 (A、B、C 和 D)。替代性实施例可以包括任何数量的触发器，并且每一个触发器可以被指派表示任何资源使用百分比或水平的任何阈值。

[0454] 在一个实施例中，通信网络中的网络服务器可以确定阈值和 / 或触发器。在一个实施例中，eNodeB 可以被配置为用于基于网络状况（如资源的可用性、连接的数量、带宽可用性、服务数量、级别数量、层数量等）来动态地确定和设置阈值和 / 或触发器。以此方式，eNodeB 可以快速地调整到改变的网络状况以确保高效地分配资源。

[0455] 如上文所讨论的，可以在 eNodeB 或网络服务器中确定移动设备所属的级别和 / 或层。在一个实施例中，可以基于移动设备所属的归属 PLMN 来在 eNodeB 中确定移动设备所属的级别。在一个实施例中，移动设备所属的级别可以在它们各自的归属 PLMN 的网络服务器中进行确定并且通过 MME 组件变得对拜访网络的 eNodeB 可用。

[0456] 在一个实施例中，eNodeB 可以被配置为用于基于网络状况（如资源的可用性、连接的数量、带宽可用性、服务数量、级别数量、层数量等）来动态地确定和设置阈值和 / 或触发器。以此方式，eNodeB 可以快速地调整到改变的网络状况以确保高效地分配资源。

[0457] 一般而言，移动设备每次可以维持若干个可操作的承载信道。在一个实施例中，eNodeB 可以被配置为用于通过调整任何或全部可操作的承载信道的特性来对移动设备的网络活动进行整形。在一个实施例中，eNodeB 可以被配置为用于基于归属 PLMN 和 / 或独立于 PGW/PCEF 和 PCRF 设置或操作来在本地调整承载信道的特性。以此方式，eNodeB 可以快速地保证较高优先级的用户（例如，主要用户等）具有可用资源。

[0458] 图 61A 和图 61B 展示了一种基于触发器 / 阈值来整形网络资源的实施例 eNodeB 方法 6100。可以由 eNodeB 处理器、耦接到 eNodeB 组件上的处理器、或在与 eNodeB 组件进行通信的服务器或代理（例如，Diameter 代理、专用服务器、软件应用、进程、计算机系统等）来执行方法 6100 的操作。可以在本文所讨论的任何 DSA 系统或网络中执行网络资源的整形。

[0459] 在方法 6100 的操作 6102 中，eNodeB 可以监控资源使用。在一个实施例中，在调度器（例如，eNodeB 调度器等）分配一个或多个资源（例如，无线电链路、资源操作、带宽等）时，eNodeB 可以实时地监控该一个或多个资源。

[0460] 在确定操作 6104 中，eNodeB 可以确定正在被利用的资源（例如，无线电链路、资源操作、带宽等）的量是否超过第一阈值（例如，指示总可用资源的百分比的值等）。当 eNodeB 确定正在被利用的资源的量不超过第一阈值时（即，确定操作 6104 =“否”），eNodeB 可以在操作 6102 中继续监控资源。另一方面，当 eNodeB 确定正在被利用的资源的量确实超过第一阈值时（即，确定操作 6104 =“是”），在操作 6106 中，eNodeB 可以设置和启动第一计时器。

[0461] 在操作 6108 中，eNodeB 可以向 MME 发送触发器 1 警告消息以通知该 MME 限制移动设备到 eNodeB 的转移、起呼和切入。在一个实施例中，作为操作 6108 的一部分，eNodeB 还可以向 DSC（例如，DSC 5722) 发送触发器 1 警告消息，该警告消息也可以限制转移、起呼和切入。eNodeB 可以在直接通信链路（例如，连接 5730) 上发送消息或通过网络中的那些组件（例如，SGW 5708、PGW 5710 等）来直接通信消息。

[0462] 在一个实施例中，DSC 可以被配置为用于响应于从 eNodeB 接收到警告消息而与

DPC(例如，DPC 5724)进行通信。在一个实施例中，DSC 可以被配置为用于将从 eNodeB 所接收到的警告消息（例如，触发器 1 警告消息）中继到 DPC。在另一个实施例中，DSC 可以将对应于所接收到的触发器 1 警告消息的数据包括在资源状态报告消息中，该资源状态报告消息可以在不同的时间（如在报告资源状态时）被发送至 DPC(例如，图 36 中所展示的操作 3604 等)。在任何情况下，DPC 可以从 DSC 接收通信消息并且记录与包括在警告消息中的触发器 1 警告消息有关的信息（例如，网络资源状态等）以供稍后用于执行频谱仲裁确定操作。

[0463] 在操作 6110 中，eNodeB 可以限制起呼（例如，会话起呼、新通信链路的建立、对新的或额外服务的请求、对额外带宽的请求等）和 / 或切入。在操作 6108 和操作 6110 中，可以基于移动设备的优先级或排序对转移、切入、和 / 或起呼进行限制。例如，eNodeB 可以对在较低级别或层的移动设备的起呼或向或从移动设备的切入进行限制，同时允许对于较高级别 / 层的起呼和切入。作为一个进一步的示例，可以完全停止对于普通市民的起呼和切入，同时由第一响应者或其他紧急人员所操作的用于主要设备的起呼和切入可以保持不受限制。

[0464] 在各个实施例中，操作 6108 和操作 6110 的操作可以被执行多次。也就是说，虽然在图 61A 所展示的示例中仅施加了一次对于切入和 / 或起呼的限制，eNodeB 可以通过响应于任何数量的触发器 / 阈值向任何数量的不同级别或层施加任何数量的限制来逐渐地限制起呼和切入。

[0465] 在一个实施例中，作为操作 6108 和操作 6110 的一部分，eNodeB 可以在针对有待减轻或解决的网络拥塞对切入和 / 或起呼进行限制之后等待预定或可变时间量。

[0466] 在确定操作 6112 中，eNodeB 可以确定额外的资源是否已经变得可用和 / 或是否已经以其他方式减轻或解决网络拥塞（例如，资源使用已经下降回到触发器 1 或另一个可接受的水平之下）。当 eNodeB 确定已经解决了拥塞（即，确定操作 6112 =“是”)，在操作 6126 中，eNodeB 可以向 MME 发送触发器取消消息以通知 MME 停止对转移、起呼和切入进行限制。eNodeB 还可以通知 DSC 通知对转移、起呼和切入进行限制。eNodeB 还可以向 DSC 或 DPC 发送触发器取消消息以报告新的资源状态。在操作 6102 中，eNodeB 可以返回监控资源使用。

[0467] 当 eNodeB 确定尚未解决拥塞时（即，确定操作 6112 =“否”)，在操作 6114 中，eNodeB 可以使与一个或多个移动设备、无线通信链路、和 / 或会话相关联的本地服务质量(QoS)降级。在一个实施例中，可以由调度器（例如，eNodeB 调度器）来执行本地 QoS 的降级。在一个实施例中，可以基于优先级 / 排序（例如，级别、层等）来使本地 QoS 降级，从而使得与在最低层或级别中的移动设备相关联的无线通信链路首先被降级，随后是到在次低层 / 级别中的移动设备的无线通信链路等等。为确保主要用户或在最高层中的用户始终具有充足的 QoS，在一个实施例中，eNodeB 可以被配置为不对在较高级别和 / 或层中的移动设备的本地 QoS 进行降级。

[0468] 在确定操作 6116 中，eNodeB 可以确定拥塞是否已经解决（例如，由于低优先级移动设备的本地 QoS 的降级等）。当 eNodeB 确定已经解决网络拥塞时（即，确定操作 6116 =“是”)，在操作 6122 中，eNodeB 可以恢复被降级的无线通信链路或移动设备中的一个或多个的本地 QoS。在一个实施例中，eNodeB 可以以与本地 QoS 被降级的顺序相反的顺序和 /

或根据优先级 / 排序来恢复本地 QoS。

[0469] 在确定操作 6124 中，eNodeB 可以确定是否有足够的可用网络资源和 / 或网络拥塞是否保持被解决（例如，由于由较低优先级移动设备的本地 QoS 的恢复所利用的额外网络资源）。当 eNodeB 确定有足够的可用网络资源和 / 或网络拥塞保持被解决（即，确定操作 6124 =“是”），在操作 6126 中，eNodeB 可以发送触发器取消消息以基于触发器阈值来恢复 QoS 和 / 或起呼和切入。在一个实施例中，eNodeB 可以向 MME 发送通知 MME 停止限制切入、起呼和转移的触发器取消消息，并且在操作 6102 中返回监控资源。eNodeB 还可以向 DSC 发送通知 DSC 停止限制起呼、转移和切入的消息。eNodeB 还可以在操作 6126 中向 DSC 或 DPC 发送触发器取消消息以报告新的资源状态。

[0470] 当 eNodeB 确定网络被拥塞时（即，确定操作 6124 =“否”），在操作 6114 中，eNodeB 可以将额外无线通信链路 / 会话 / 移动设备的本地 QoS 降级或过度进行（或部分地过度进行）在操作 6122 中针对一个或多个无线通信链路 / 移动设备执行的恢复操作。

[0471] 在各个实施例中，所展示的操作 6114、6116、6122 和 6124 可以重复地执行（例如，当拥塞相对接近于被解决时）直至将最优水平的网络资源被分配给移动设备。重复操作 6114、6116、6122 和 6124 对于通过 QoS 调整来解决网络拥塞来说是令人期望的（与甩掉操作、终止操作、和 / 或切换操作相反）。

[0472] 在各个实施例中，eNodeB 可以被配置为用于避免通过例如标识贯穿这些操作的迭代的次数、增加本地 QoS 在操作 6114 中所降级的量、减少本地 QoS 在操作 6122 中所恢复的量、更新用于测量网络拥塞的多个参数等来重复执行操作 6114、6116、6122 和 6124。

[0473] 如上文所讨论的，在确定操作 6116 中，eNodeB 可以确定网络拥塞是否已经解决（例如，由于低优先级移动设备的本地 QoS 降级、额外资源的可用性等）。当 eNodeB 确定拥塞尚未解决时（即，确定操作 6116 =“否”），在确定操作 6118 中，eNodeB 可以确定第一计时器（即，计时器 1）是否已经过期。当 eNodeB 确定第一计时器（即，计时器 1）尚未过期时（即，确定操作 6118 =“否”），在确定操作 6120 中，eNodeB 可以确定正在被利用的资源的量是否超过第二触发器。当 eNodeB 确定网络资源的消耗未超过第二触发器时（即，确定操作 6120 =“否”），在操作 6114 中，eNodeB 可以使一个或多个移动设备、无线通信链路、会话等的本地 QoS 降级。

[0474] 当 eNodeB 确定第一计时器已经过期时（即，确定操作 6118 =“是”）或者资源超过第二触发器时（即，确定操作 6120 =“是”），在操作 6132 中（在图 61B 中所示的），eNodeB 可以启动第二计时器。

[0475] 参照图 61B，在操作 6134 中，eNodeB 可以向 MME 发送触发器 2 警告消息以指示 MME 开始协调转移或切换，转移或切换可以基于优先级和 / 或排序来执行。eNodeB 还可以向 DSC 发送触发器 2 警告消息以指示或者使 DSC 开始协调转移或切换，转移或切换可以基于优先级和 / 或排序来执行。当切换是到另一个网络时，DSC 可以对通过 DPC 到另一个网络中的可能目标 DSC 的切换请求进行协调。此外，eNodeB 还可以向 DSC 或 DPC 发送触发器 2 警告消息以报告新的资源状态。如上文所讨论的，DPC 可以依赖于稍后的频谱仲裁确定种的新资源状态报告。在操作 6136 中，eNodeB 可以将到在最低层或级别中的移动设备的无线通信链路切换或转移至第二 eNodeB。

[0476] 在一个实施例中，可以基于移动设备所切换至的目的地组件的属性来排序和 / 或

执行切换。例如，eNodeB 可以首先尝试将移动设备切换至由相同的运营商、服务提供商、出租者等所拥有或出租的第二 eNodeB。当属于相同的运营商、服务提供商、出租者等的第二 eNodeB 不可用时，eNodeB 可以将移动设备切换至附属于出租者、运营商、服务提供商的网络组件（例如，附属于运营商具有使用协议的另一个无线电接入系统）等。当附属于出租者、运营商、服务提供商的网络组件不可用时，eNodeB 可以将移动设备切换至由不同的承租者、运营商、服务提供商等所拥有 / 操作的网络组件。

[0477] 在确定操作 6138 中，eNodeB 可以确定拥塞是否已经解决。当 eNodeB 确定已经解决拥塞时（即，确定操作 6138 =“是”），在操作 6122 中，eNodeB 可以恢复尚未被切换的被降级的无线通信链路中的一个或多个的 QoS。当 eNodeB 确定拥塞尚未解决时（即，确定操作 6138 =“否”），在确定操作 6140 中，eNodeB 可以确定第二计时器是否已经过期。

[0478] 当 eNodeB 确定第二计时器尚未过期时（即，确定操作 6140 =“否”），在确定操作 6142 中，eNodeB 可以确定网络资源的消耗是否超过第三触发器或阈值。当 eNodeB 确定网络资源的消耗未超过第三触发器 / 阈值时（即，确定操作 6142 =“否”），在操作 6136 中，eNodeB 可以将额外移动设备（例如，在另一个层或级别中）切换或转移至另一个 eNodeB。

[0479] 当 eNodeB 确定第二计时器已经过期时（即，确定操作 6140 =“是”）或者网络资源的消耗超过第三触发器 / 阈值时（即，确定操作 6142 =“是”），在操作 6144 中，eNodeB 可以开始终止无线通信链路或会话。在一个实施例中，可以基于优先级或排序来终止无线通信链路 / 会话。

[0480] 如上文所讨论的，根据级别 / 层的连接 / 移动设备的优先级或排序可以由 eNodeB 用来确定有待首先终止的会话。例如，eNodeB 可以在终止与在较高级别 / 层中的移动设备相关联的会话之前终止与在最低级别 / 层中的移动设备相关联的会话。

[0481] 在操作 6150 中，eNodeB 可以向 DSC 或 DPC 发送触发器 3 警告消息以报告新的资源状态。如上文所讨论的，DPC 可以依赖于稍后的频谱仲裁确定种的新资源状态报告。

[0482] 在确定操作 6146 中，eNodeB 可以确定网络拥塞是否已经解决。当 eNodeB 确定拥塞来被解决时（即，确定操作 6146 =“否”），在操作 6144 中，eNodeB 可以终止额外无线通信链路或会话。当 eNodeB 确定已经解决拥塞时（即，确定操作 6146 =“是”），在操作 6122 中，eNodeB 可以恢复尚未被切换的被降级的无线通信链路或移动设备的会话中的一个或多个的 QoS。

[0483] 图 62 至图 65 展示了根据各个实施例的各种实施例 eNodeB 方法 6200、6300、6400、6500，这些 eNodeB 方法在 eNodeB 中执行 TPA 和 iTPA 操作并且将这些操作报告至 DSC 或 DPC 以供执行 DSA 操作中使用。在图 62 至图 65 所展示的示例中，移动设备 6252 可以维持与第一通信网络中的 PGW 组件 6260 或第二通信网络中的 PGW2 组件 6261 的活跃数据会话 6202。

[0484] 活跃数据会话 6202 的建立和 / 或维持可以通过 eNodeB(eNB) 组件 6254 和 / 或 MME 组件 6256 来实现，如上文参照图 57A 所描述的。除了建立和维持会话，eNodeB 6254 还可以调解移动设备 6252 与 PGW 6260 之间的活跃数据会话 6202，并且执行各个无线资源管理 (RRM) 操作（例如，监控网络资源的可用性等）。eNodeB 6254 还可以与 DSC 6262 和 / 或 DPC 6264 进行通信以报告资源状态。在各个实施例中，eNodeB 6254 可以直接地（例如，通过连接 5730 或其他直接通信链路）或比如通过各个组件（例如，MME 6256、PGW 6260 等）

间接地与 DSC 6262 和 / 或 DPC 6264 进行通信。DSC/DPC 组件 6262、6264 可以被配置为用于使用由 eNodeB 6254 所生成(并且包括在警告消息和 / 或资源状态报告中)的信息来作出更智能的频谱仲裁决策 / 确定。

[0485] 参照图 62,在方法 6200 的操作 6204 中,eNodeB 6254 可以通过例如确定正在被利用的资源的量是否超过第三阈值(例如,指示总可用资源的百分比的值等)来确定网络被拥塞。在操作 6206 中,eNodeB 6254 可以设置和启动拥塞计时器。在操作 6208 中,eNodeB 6254 可以向 MME 组件 6256 发送第一拥塞触发器警告消息以通知 MME 6256 限制额外移动设备到 eNodeB 6254 的转移和 / 或切换。作为操作 6208 的一部分,eNodeB 6254 还可以向 DSC 6262 或 DPC 6264 发送警告。在各个实施例中,可以直接地或间接地将这些警告发送至目的地。

[0486] 在操作 6210 中,eNodeB 6254 可以限制起呼(例如,会话起呼、新通信链路的建立、对新的或额外服务的请求、对额外带宽的请求等)和切入(即,停止接受来自其他基站的切换)。

[0487] 在操作 6212 中,eNodeB 6254 可以确定额外的资源已经变得可用和 / 或已经以其他方式减轻或解决了网络拥塞(例如,资源使用已经下降到一个可接受的水平等)。在操作 6214 中,eNodeB 6254 可以向 MME 6256 发送触发器取消消息以通知 MME 6256 停止限制转移切换,并且直接地或间接地向 DSC 6262 和 / 或 DPC 6264 发送警告。在操作 6216 中,eNodeB 6254 可以返回其正常稳定状态操作模式。

[0488] 图 63 展示了用于通过将一个或多个移动设备 6252 的本地 QoS 降级来解决网络拥塞的实施例 eNodeB 方法 6300。移动设备 6252 可能忙于与在另一个(即,第二)网络中的 PGW2 6261 之间的活跃数据会话 6302。

[0489] 在方法 6300 的操作 6304 中,eNodeB 6254 可以确定网络是拥塞的(例如,通过确定正在被利用的资源的质量是否超过阈值)。在操作 6306 中,eNodeB 6254 可以设置和 / 或启动拥塞计时器。

[0490] 在操作 6308 中,eNodeB 6254 可以向 MME 组件 6256 发送第一拥塞触发器警告消息以通知 MME 6256 限制额外移动设备到 eNodeB 6254 的转移和 / 或切换。作为操作 6308 的一部分,eNodeB 6254 还可以向 DSC 6262 和 / 或 DPC 6264 发送警告。

[0491] 在操作 6310 中,eNodeB 6254 可以限制起呼或切入。在确定操作 6312 中,eNodeB 6254 可以确定网络拥塞尚未被减轻或解决。在操作 6314 中,eNodeB 6254 可以选择一个或多个移动设备 6252 用于本地化的 QoS 降级,这可以根据优先级 / 排序(例如,级别、层等)来执行。在操作 6316 中,eNodeB 6254 可以将所选择的移动设备 6252 的 QoS 降级。

[0492] 在操作 6318 中,eNodeB 6254 可以确定额外的资源已经变得可用和 / 或已经以其他方式减轻或解决了网络拥塞(例如,资源使用已经下降到一个可接受的水平等)。在操作 6320 至操作 6322 中,eNodeB 6254 可以恢复所降级的移动设备 6252 中的一个或多个的本地 QoS。

[0493] 在操作 6324 中,eNodeB 6254 可以确定资源仍然是可用的和 / 或网络拥塞保持被解决。在操作 6326 中,eNodeB 6254 可以向 MME 6256 发送触发器取消消息以通知 MME 6256 停止限制转移和切换,并且向 DSC 6262 和 / 或 DPC 6264 发送警告消息。

[0494] 在操作 6328 中,eNodeB 6254 可以解除对起呼和切入的限制。在操作 6330 中,

eNodeB 6254 和系统可以返回正常操作状况（例如，稳定状态操作模式）。

[0495] 图 64 展示了用于通过执行切换操作以将移动设备转移至第二基站来解决网络拥塞的实施例方法 6400。在操作 6402 中，第一 eNodeB 6254a 可以检测网络拥塞。在操作 6404 中，eNodeB 6254a 可以启动拥塞计时器。在操作 6406 中，eNodeB 6254a 可以向 MME 组件 6256 发送第一拥塞触发器警告消息以通知 MME 6256 限制额外移动设备到 eNodeB 6254 的转移和 / 或切换。作为操作 6406 的一部分，eNodeB 6254 还可以向 DSC 6262 和 / 或 DPC 6264 发送警告。

[0496] 在操作 6408 中，eNodeB 6254a 可以限制起呼或切入。在操作 6412 中，eNodeB 6254a 可以选择一个或多个移动设备 6252 用于本地化的 QoS 降级，这可以根据优先级 / 排序（例如，级别、层等）来执行。在操作 6412 中，eNodeB 6254a 可以确定网络拥塞尚未被减轻或解决。在操作 6414 中，eNodeB 6254a 可以将所选择的移动设备 6252 的 QoS 降级。

[0497] 在操作 6416 中，eNodeB 6254a 可以确定网络拥塞尚未被减轻或解决（即，虽有对一个或多个移动设备的本地 QoS 的降级）。在操作 6418 中，eNodeB 6254a 可以向 MME 6256 发送第二触发器警告消息，并且向 DSC 6262 和 / 或 DPC 6264 发送警告消息。

[0498] 在操作 6420 中，eNodeB 6254a 可以选择一个或多个移动设备 6252 用于转移至另一个基站，该转移可以根据优先级 / 排序（例如，级别、层等）来执行。在各个实施例中，操作 6420 可以包括在 eNodeB 6254a 与 DSC 6262 之间交换备选移动设备的列表。

[0499] 在各个实施例中，MME 6256 和 / 或 DSC 6262 可以将不处于拥塞下或在用于操作 6440 中的切换的退避状况下的 eNodeB 作为目标。如果系统内 eNodeB 被作为目标，操作 6440 可以包括发送取消系统间切换过程的消息，比如在操作 6420 中所协调的系统间切换过程。可以通过任何连接直接地或间接地将取消消息发送至 DSC 6262、DPC 6264 或第二网络中的 DSC（例如，DSC2 6272）。

[0500] 在一个实施例中，选择移动设备用于切换可以与 MME 6256 相协作 / 协调地执行。例如，在操作 6420 中，MME 6256 可以基于移动设备有待切换至的目的地组件的属性来对所选择的移动设备可以被转移至的的第二 eNodeB(eNB-2)6254b 进行标识。优选应当给予由相同的运营商、服务提供商、或出租者所拥有或出租的第二 eNodeB，接着是附属于相同的运营商、服务提供商、或出租者的 eNodeB（例如，附属于运营商具有使用协议的另一个无线电接入系统等）。当 eNodeB 6254a 和 / 或 MME 6256 确定出租者（或运营商、服务提供商等）所拥有的或附属于出租者的网络组件不可用于转移移动设备 6252 时，eNodeB 6254a 和 / 或 MME 6256 可以选择由不同承租者（或运营商、服务提供商等）所拥有 / 操作的网络组件。

[0501] 在方法 6400 的操作 6422 中，第一 eNodeB 6254a 可以将一个或多个选择的移动设备 6252 切换至被作为目标的 / 所标识的第二 eNodeB 6254b。

[0502] 在操作 6424 中，eNodeB 6254a 可以确定网络拥塞尚未被减轻或解决（即，尽管将移动设备切换至第二 eNodeB 6254b）。在操作 6426 中，第一 eNodeB 6254a 可以将额外移动设备 6252 切换至被作为目标的 / 所标识的第二 eNodeB 6254b。

[0503] 在操作 6428 中，eNodeB 6254a 可以确定额外的资源已经变得可用和 / 或已经以其他方式减轻或解决了网络拥塞。在操作 6430 中，eNodeB 6254 可以向 MME 6256 发送触发器取消消息，并且向 DSC 6262 和 / 或 DPC 6264 发送警告消息。

[0504] 在操作 6432 中，eNodeB 6254 和系统可以返回正常操作状况（例如，稳定状态操

作模式)。

[0505] 在各个实施例中,DPC 6264可以通过消息6442与第二网络中的DSC(例如,DSC-2 6272)进行通信,该消息包括可以用于协调动态频谱仲裁操作的信息。消息6442包括在eNodeB 6254a中所生成的信息,如关于网络资源使用、拥塞(即,超过了各个阈值)、或流量整形(例如,QoS变化、切换、掉落的会话等)的信息。以此方式,DPC 6264可以作出更好地对现有网络状况负责的更智能的频谱仲裁决策。

[0506] 图65展示了一种用于通过执行流量甩掉操作来解决网络拥塞的实施例方法6500。在操作6502中,第一eNodeB 6254a可以检测网络拥塞。在操作6504中,eNodeB 6254a可以启动拥塞计时器。

[0507] 在操作6506中,eNodeB 6254a可以向MME组件6256和/或DSC组件6262发送第一拥塞触发器警告消息以通知MME 6256和/或DSC组件6262限制额外移动设备到eNodeB 6254a的转移和/或切换。eNodeB 6254还可以向DSC 6262和/或DPC 6264发送警告。与如在图62、图63和图64所示的单独的消息相反,操作6506被展示为消息链,但是任一种方法都可以用于各个实施例中。例如,eNodeB可以向MME 6256发送一个消息,而不是eNodeB向三个单独的目的地发送三个消息,MME可以向DSC 6262转发消息的副本,并且DSC可以向DPC 6264转发副本。

[0508] 在操作6508中,eNodeB 6254a可以限制起呼和切入。在操作6510中,eNodeB 6254a可以确定网络拥塞尚未被减轻或解决(即,虽有对切入的限制等)。在操作6512中,eNodeB 6254a可以选择一个或多个移动设备6252用于本地化的QoS降级,这可以根据优先级/排序(例如,级别、层等)来执行。在操作6514中,eNodeB 6254a可以将所选择的移动设备6252的QoS降级。

[0509] 在操作6516中,eNodeB 6254a可以确定网络拥塞尚未被减轻或解决(即,虽有对一个或多个移动设备的本地QoS的降级)。在操作6518中,eNodeB 6254a可以向MME 6256发送第二触发器警告消息,并且向DSC 6262和/或DPC 6264发送警告消息。

[0510] 在操作6520中,eNodeB 6254a可以选择一个或多个移动设备6252用于转移至另一个基站,该转移可以根据优先级/排序(例如,级别、层等)以及移动设备和/或移动设备有待切换至的目的地组件的各个属性来执行。

[0511] 在操作6550中,MME 6256可以在DSC 6262的辅助下将不处于拥塞中或在退避状况下的eNodeB作为目标。在各个实施例中,MME 6256可以通过借助于DSC 6262和次要系统中的DSC与第二网络中的MME(例如,MME-2 6580)进行通信来协调系统间切换。如上文所讨论的,第二eNodeB(即,eNB-2 6254)可以在第二网络(如与MME-2相同的网络)中,并且从MME-2接收切换指令。

[0512] 在操作6550中,DSC 6262可以将不处于拥塞中或在退避状况下的eNodeB作为目标。在各个实施例中,DSC 6262可以通过与第二网络中的MME(例如,MME-2 6580)进行通信来协调系统间切换。通信还可以通过DPC 6264发生在主要系统和次要系统中的DSC之间。第二eNodeB(即,eNB-2 6254)可以在第二网络中,并且从MME-2接收切换指令。

[0513] 在操作6522中,eNodeB 6254a可以将所选择的设备切换至第二eNodeB 6254b。可以从相同的网络或不同的网络中选择第二eNodeB 6254b。如果第二eNodeB 6254b来自第二网络,MME 6256可以与在第二网络中的MME进行协作,或者协作可以通过DSC来进

行。如上文所讨论的，优选应当给予由与第一 eNodeB 6254a 相同的运营商、服务提供商、或出租者所拥有或出租的第二 eNodeB，接着是附属于相同的运营商、服务提供商、或出租者的 eNodeB（例如，附属于运营商具有使用协议的另一个无线电接入系统等）。当通知 eNodeB 6254a 和 / 或 MME 6256 出租者（或运营商、服务提供商等）所拥有的或附属于出租者的网络组件不可用于转移移动设备 6252 时，eNodeB 6254a 和 / 或 MME 6256 和 / 或 DSC 6262 可以选择由不同承租者（或运营商、服务提供商等）所拥有 / 操作的网络组件。

[0514]　在操作 6524 中，eNodeB 6254a 可以确定拥塞计时器已经过期。在操作 6526 中，eNodeB 6254a 可以开始终止移动设备会话，这可以根据优先级 / 排序（例如，级别、层等）来执行。在操作 6528 中，可以终止一个或多个移动设备 6252 的一个或多个会话。在操作 6540 中，eNodeB 6254 可以向 MME 6256、DSC 6262 和 / 或 DPC 6264 发送警告。

[0515]　在操作 6530 至操作 6532 中，eNodeB 6254a 可以继续终止移动设备会话并且监控网络资源的可用性以确定是否已经解决了网络拥塞。在操作 6542 中，eNodeB 6254 可以向 MME 6256、DSC 6262 和 / 或 DPC 6264 发送警告。在操作 6534 中，eNodeB 6254a 可以确定网络拥塞已经被解决。在操作 6536 中，eNodeB 6254a 可以向 MME 6256 和 / 或 DSC 6262 发送触发器取消消息，并且向 DSC 6262 和 / 或 DPC 6264 发送警告。在操作 6538 中，eNodeB 6254 和系统可以返回正常操作状况（例如，稳定状态操作模式）。

[0516]　如上文参照图 64 所讨论的，DPC 6264 可以通过消息（图 65 中未示出）与第二网络中的 DSC 进行通信以基于从 eNodeB 直接地或间接地接收的关于网络资源使用（即，超过了各个阈值）或流量整形（例如，QoS 变化、切换、掉落的会话等）的消息来协调动态频谱仲裁操作。

[0517]　图 66 展示一种执行 DSA 操作的实施例方法 6600。在操作 6602 中，服务器（如 DPC）可以建立至第一通信网络的通信链路，该第一通信网络具有第一多个基塔、小区站点和 / 或 eNodeB。在操作 6604 中，服务器可以建立至第二通信网络的通信链路，该第二通信网络具有第二多个基塔、小区站点和 / 或 eNodeB。

[0518]　在操作 6606 中，服务器可以确定第一通信网络的 RF 频谱资源是否可用于分配（例如，服务器可以使用上文所讨论的 DSA 方法种的任一种 DSA 方法）。在操作 6608 中，服务器可以确定可用于分配的 RF 频谱资源的量或数量。在操作 6610 中，服务器可以发起分配过程以对确定可用于分配的 RF 资源的一部分资源进行分配。在操作 6612 中，服务器可以通知第二通信网络可以开始使用所分配的 RF 频谱资源。在操作 6614 中，服务器可以在交易数据库中记录交易，该交易对被分配以供第二通信网络使用的 RF 频谱资源的量进行标识。

[0519]　在操作 6616 中，系统组件（如 eNodeB）可以监控如上所述分组为多个层或优先级组的多个移动设备对网络资源使用。在一个实施例中，eNodeB 可以在第一通信网络中。在另一个实施例中，eNodeB 可以在第二通信网络中。

[0520]　在操作 6618 中，eNodeB 可以确定网络资源使用是否超过阈值。在操作 6620 中，eNodeB 可以如通过执行上文所讨论的实施例方法（例如，方法 6100 等）中的任何一种方法基于优先级组或排序来对流量进行整形。在操作 6622 中，服务器可以确定第一通信网络是否基于阈值是否被超过（即，基于操作 6618 中 eNodeB 的确定）来要求所分配的 RF 频谱资源。在操作 6624 中，服务器可以响应于确定操作中的第一通信网络要求所分配的 RF 频谱

资源中的至少一些资源而通知该第二通信网络应该终止使用所分配的 RF 频谱资源。在操作 6626 中，服务器可以更新交易数据库以包括对第二通信网络终止使用所分配的 RF 频谱资源的时间进行标识的信息。

[0521] 图 67 展示了从 eNodeB 的角度来看的实施例方法。在操作 6702 中，eNodeB（或与 eNodeB 进行通信的任何代理、处理器、硬件组件、或软件组件）可以监控网络资源使用。在一个实施例中，eNodeB 可以监控多个移动设备所使用的网络资源的量，这些移动设备可以被分组为多个层或优先级组。

[0522] 在操作 6704 中，eNodeB 可以确定网络资源使用是否超过阈值。在操作 6706 中，eNodeB 可以基于优先级组或排序来对流量进行整形（例如，通过实施例方法 6100 等）。

[0523] 在操作 6708 中，eNodeB 可以向通信服务器（例如，DPC）传送资源警告消息。通信服务器可以被配置为用于将可用 RF 频谱资源中的一部分资源分配在包括第一 eNodeB 的第一通信网络与第二通信网络之间。

[0524] 图 68 展示了从 DPC 的角度来看的实施例方法。在操作 6802 中，DPC 可以建立至第一通信网络中的通信链路。在操作 6804 中，DPC 可以建立至第二通信网络中的通信链路。在操作 6806 中，DPC 可以确定在操作中的第一通信网络之内可用于分配的射频 (RF) 频谱资源的量。

[0525] 在操作 6808 中，DPC 可以确定可用于分配的 RF 频谱资源的量。在操作 6810 中，可以分配可用的 RF 资源中的一部分资源。在操作 6812 中，DPC 可以通知第二通信网络可以开始使用在步骤 6810 中所分配的 RF 频谱资源。在操作 6814 中，DPC 可以在交易数据库中记录交易，该交易对被分配以供第二通信网络使用的 RF 频谱资源的量进行标识。

[0526] 在操作 6816 中，DPC 可以接收来自第一同通信网络上的 eNodeB 的资源警告消息。在操作 6818 中，DPC 可以确定第一通信网络是否基于资源警告消息来要求所分配的 RF 频谱资源。在操作 6820 中，DPC 可以响应于确定操作中的第一通信网络要求所分配的 RF 频谱资源中的至少一些资源而通知该第二通信网络应该终止使用所分配的 RF 频谱资源。在操作 6822 中，DPC 可以更新交易数据库以包括对第二通信网络终止使用所分配的 RF 频谱资源的时间进行标识的信息。

[0527] 各个方面可在各种移动计算设备上实现，其中的一个示例展示在图 69 中。具体来说，图 69 是形式为适用于与任何方面一起使用的智能电话 / 蜂窝电话 6900 的移动收发设备的系统框图。蜂窝电话 6900 可以包括处理器 6901，该处理器耦接到内部存储器 6902、显示器 6903、以及扬声器 6908。另外，蜂窝电话 6900 可包括用于发送和接收电磁辐射的天线 6904，该天线可连接至无线数据链路和 / 或耦合至处理器 6901 的蜂窝电话收发机 6905。蜂窝电话 6900 通常还包括用于接收用户输入的菜单选择按钮或拨动开关 6906。

[0528] 典型的蜂窝电话 6900 还包括声音编码 / 解码 (CODEC) 电路 6913，该声音编码 / 解码电路将接收自麦克风的声音数字化为适用于无线通信的数据包并且解码所接收的声音数据包以生成模拟信号，这些模拟信号被提供给扬声器 6908 以生成声音。同样，处理器 6901、无线收发机 6905 和 CODEC 6913 中的一个或多个可以包括数字信号处理器 (DSP) 电路（未单独示出）。蜂窝电话 6900 可以进一步包括用于无线设备之间的低功率短程通信的 ZigBee 接收机（即，IEEE 802.15.4 接收机）、或其他类似的通信电路（例如，实现蓝牙®或 WiFi 协议的电路等）。

[0529] 可在广播系统之内的多种可商购的服务器设备如图70中所示的服务器7000上实现包括频谱仲裁功能的上述实施例。此类服务器7000通常包括连接到易失性存储器7002和大容量非易性失存储器（如盘驱动器7003）的处理器7001。服务器7000还可包括耦接到处理器7001的软盘驱动器、致密盘（CD）或DVD盘驱动器7011。服务器7000还可包括耦接到处理器7001的用于与网络7005建立数据连接的网络接入端口7006，比如耦接到其他通信系统计算机和服务器的局域网。

[0530] 处理器6901、7001可以是可由软件指令（应用）配置成执行包括以下描述的各个方面的功能的多种功能的任何可编程微处理器、微处理器或多个处理器芯片。在一些移动设备中，可提供多个处理器7001，诸如专用于无线通信功能的一个处理器和专用于运行其他应用的一个处理器。通常，在软件应用被访问并被加载到处理器6901、7001中之前，这些软件应用可被存储在内部存储器6902、7002中。处理器6901、7001可包括足以存储应用软件指令的内部存储器。在一些服务器中，处理器5701可包括足以存储应用软件指令的内部存储器。在一些接收器设备中，安全存储器可以是耦接到处理器5701的分离的存储器芯片。内部存储器5702可以是易失性或非易失性存储器（如闪存），或两者的混合。为此描述的目的，对存储器的一般引用是指处理器5701可访问的所有存储器，包括内部存储器5702、插入到设备中的可移除存储器、以及处理器5701本身内的存储器。

[0531] 实施例包括用于如以上描述地管理、分配和仲裁RF带宽的方法。实施例还包括能够实现DPC方法的通信系统。实施例还包括为执行以上描述的方法而存储计算机可执行指令的非瞬态计算机可读存储介质。

[0532] 提供前述的方法描述和过程流程图作为说明性示例而不意在要求或暗示必须以呈现的顺序执行各种实施例的步骤。如本领域普通技术人员将认识到的，可以按照任何顺序执行前述实施例中的步骤的顺序。如“其后”、“然后”、“接下来”等词并不意在限制步骤的顺序；这些词仅用于贯穿方法的描述引导读者。而且，以单数形式声明元件的任何引用（例如使用冠词“一个”、“一种”或“该”）不应被解释为将该元件限制于单数。

[0533] 可将结合本文披露的实施例描述的各种说明性逻辑框、模块、电路和算法步骤实现为电子硬件、计算机软件或两者的组合。为了清楚地说明硬件和软件的此可互换性，已在以上一般地在它们的功能性方面描述了各种说明性的组件、块、模块、电路、和步骤。将这样的功能性实现为硬件还是软件取决于在整体系统上强加的具体应用和设计约束。熟练的业内人士可以针对每个具体应用以不同的方式实现所描述的功能性，但不应将这种实现方式决定解释为引起背离本发明的范围。

[0534] 可用设计成执行本文描述的功能的通用处理器、数字信号处理器（DPC）、专用集成电路（ASIC）、现场可编程门阵列（FPGA）或其他可编程逻辑器件、分立门或晶体管逻辑、分立硬件组件或其任何组合来实现或执行用于实现结合本文披露的实施例描述的各种说明性逻辑、逻辑框、模块和电路的硬件。通用处理器可以是微处理器，但可替代地，处理器可以是任何常规处理器、控制器、微处理器或状态机。还可将处理器实现为计算设备的组合，例如，DPC和微处理器、多个微处理器、一个或多个微处理器连同DPC核或任何其他此类配置的组合。可替代地，可通过专用于给定功能的电路来执行一些步骤或方法。

[0535] 在一个或多个示例性实施例中，可在硬件、软件、固件或其任何组合中实现所描述的功能。如果在软件中实现，可以在计算机可读介质上将功能作为一个或多个指令或代码

存储或传输。可在处理器可执行软件模块中实施本文披露的方法步骤或算法，该软件模块可存在于有形的、非瞬态计算机可读存储介质上。有形的、非瞬态计算机可读存储介质可以是计算机可访问的任何可用介质。通过示例，而非限制，如非瞬态计算机可读介质可包括RAM、ROM、EEPROM、CD-ROM、或其他光盘存储、磁盘存储或其他磁存储设备或可用来以指令或数据结构的形式存储期望的程序代码并且计算机可访问的任何其他介质。本文使用的盘和碟，包括致密碟 (CD)、激光碟、光碟、数字通用碟 (DVD)、软磁碟和蓝光碟，这里盘通常磁再生数据，而碟用激光光再生数据。以上的组合也应包括在非瞬态计算机可读介质之内。此外，方法或算法的操作可作为有形的、非瞬态的机器可读介质和 / 或计算机可读介质上的一个或任何组合或集合的代码和 / 或指令存在，其可结合在计算机程序产品中。

[0536] 提供披露的实施例的前述描述以使任何本领域普通技术人员能够进制造使用本发明。本领域技术人员将容易理解这些实施例的各种修改，并且在此所定义的一般原理可以在不背离本披露的范围的情况下应用到其他实施例。因此，本披露不旨在限于在此所描述的实施例，但符合与在此所披露的原理一致的最广泛范围。

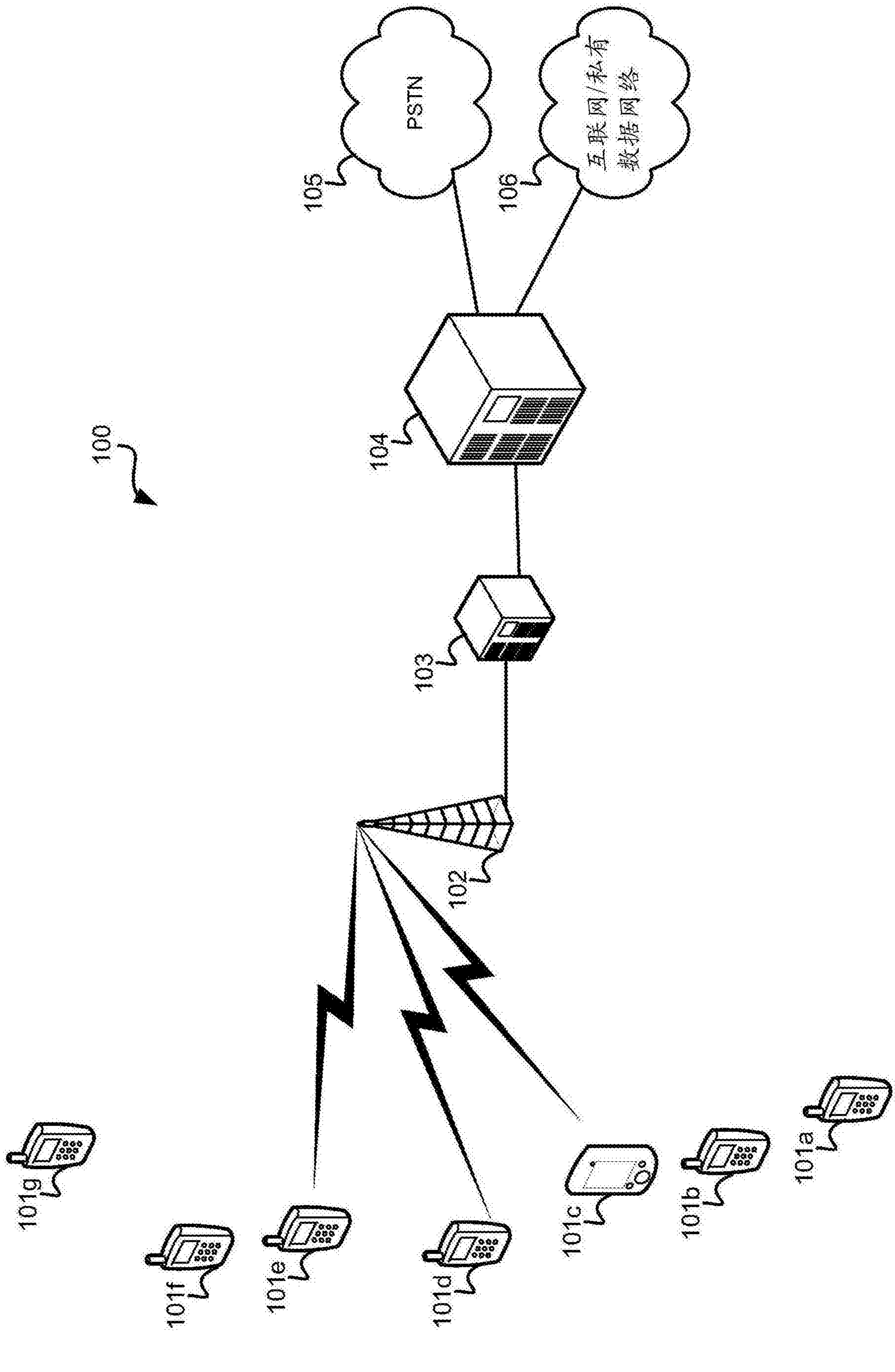

PSTN
互联网/私有数据网络
105
106
104
103
102
100
101a
101b
101c
101d
101e
101f
101g

图 1

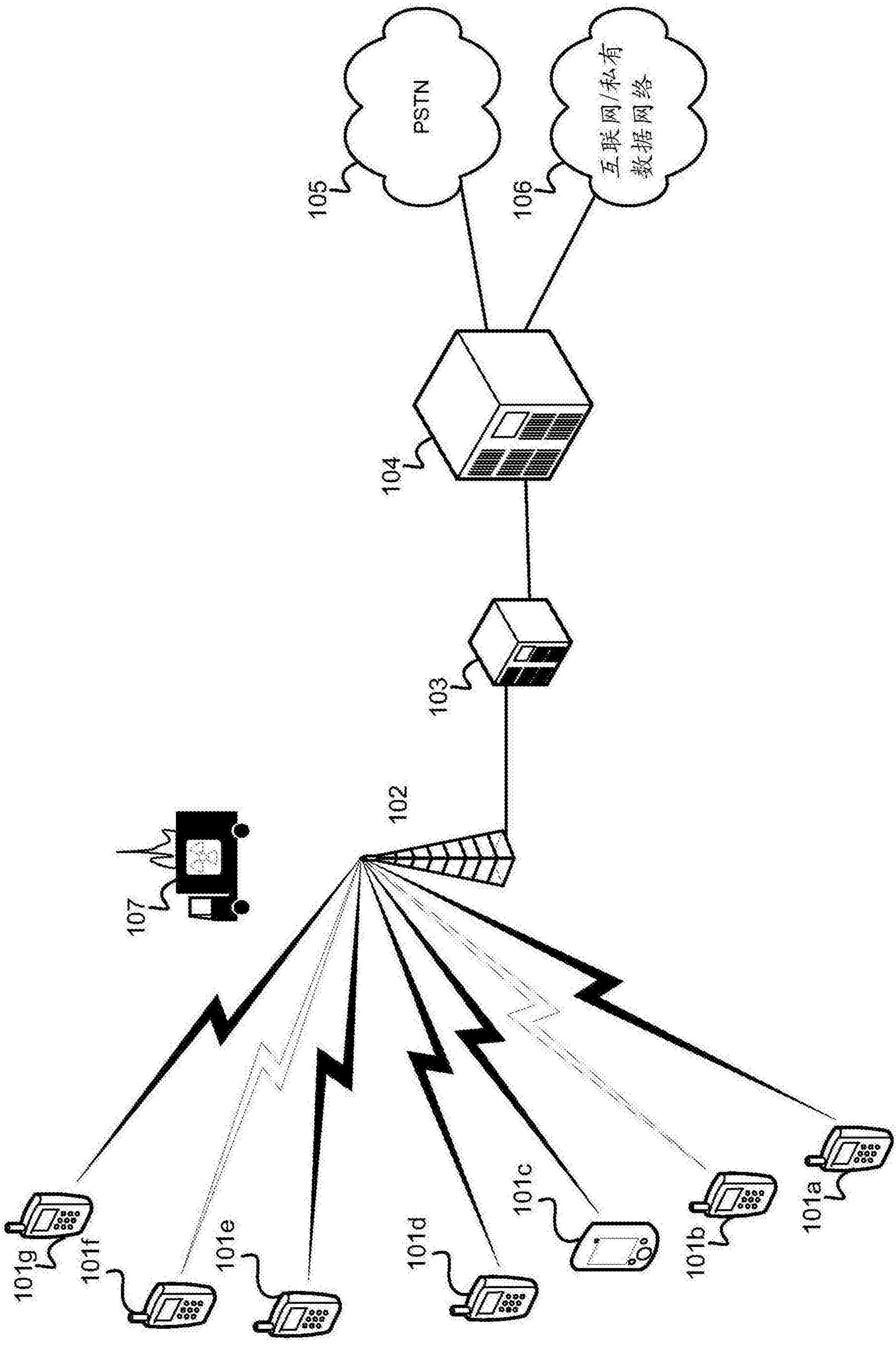

PSTN
互联网/私有数据网络
105
106
104
103
102
107
101a
101b
101c
101d
101e
101f
101g

图 2

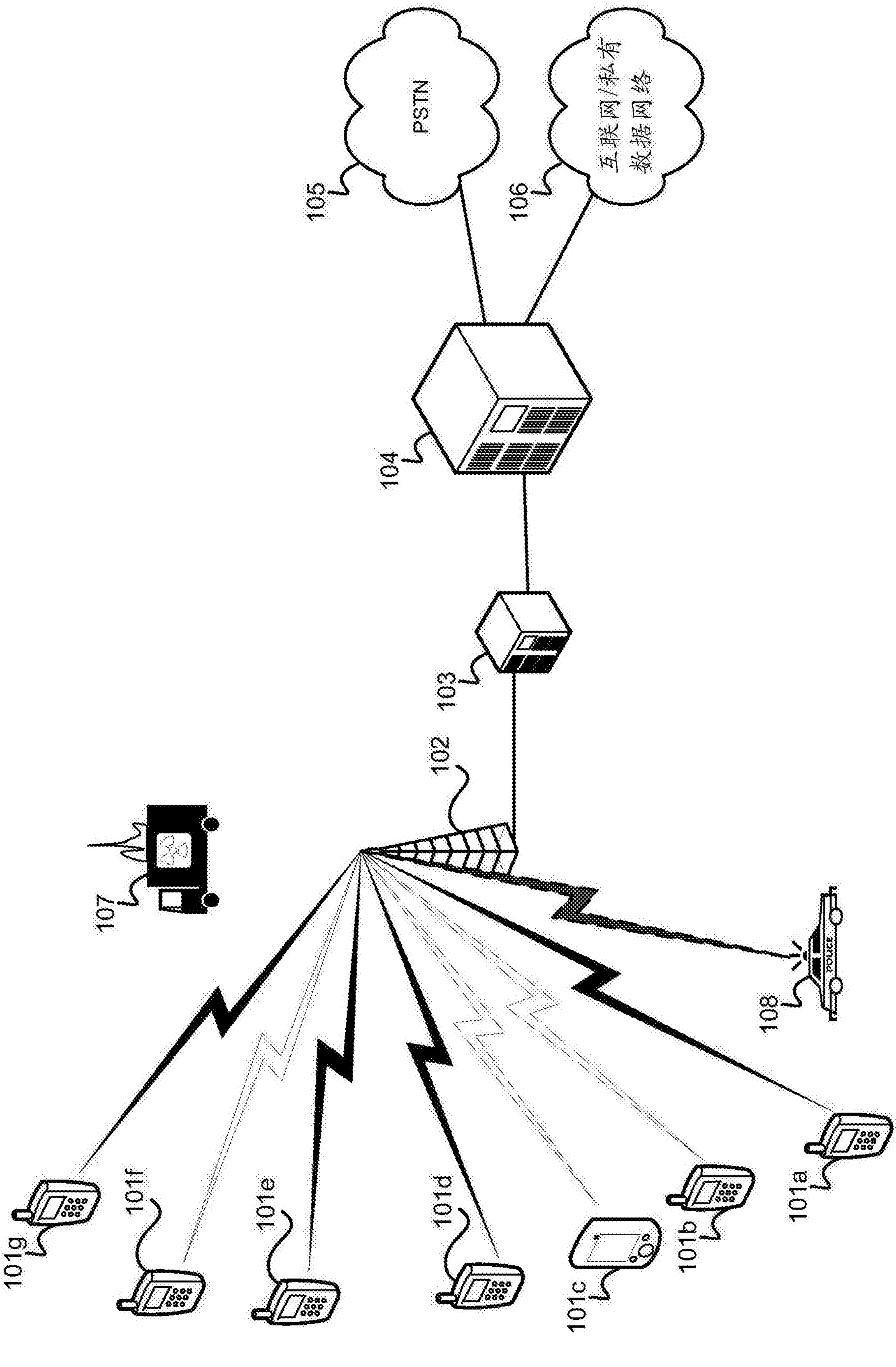

PSTN
互联网/私有
数据网络
105
106
104
103
102
107
108
POLICE
101a
101b
101c
101d
101e
101f
101g

图 3

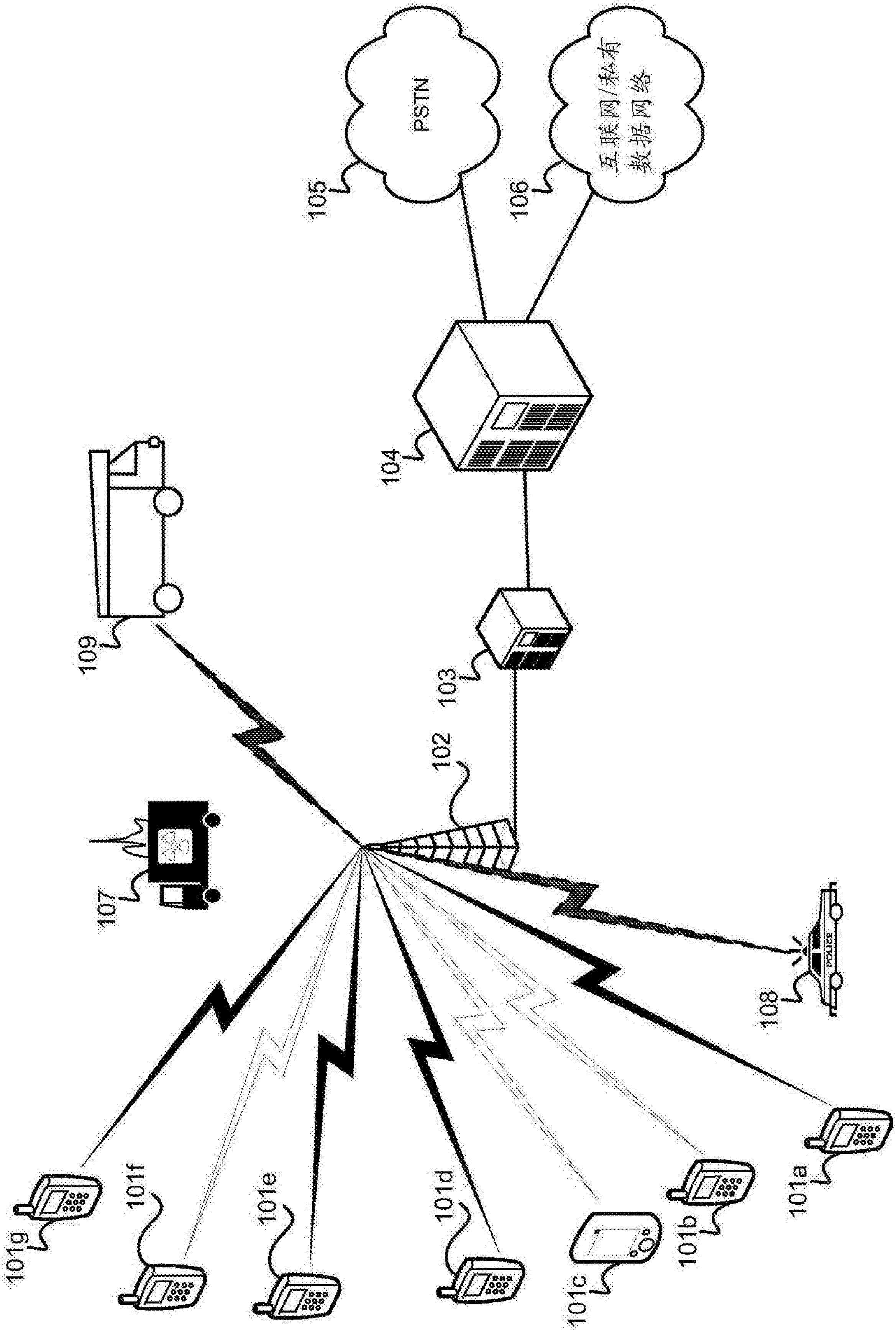

PSTN
互联网/私有
数据网络
105
106
104
103
102
109
107
108
101a
101b
101c
101d
101e
101f
101g
POLICE

图 4

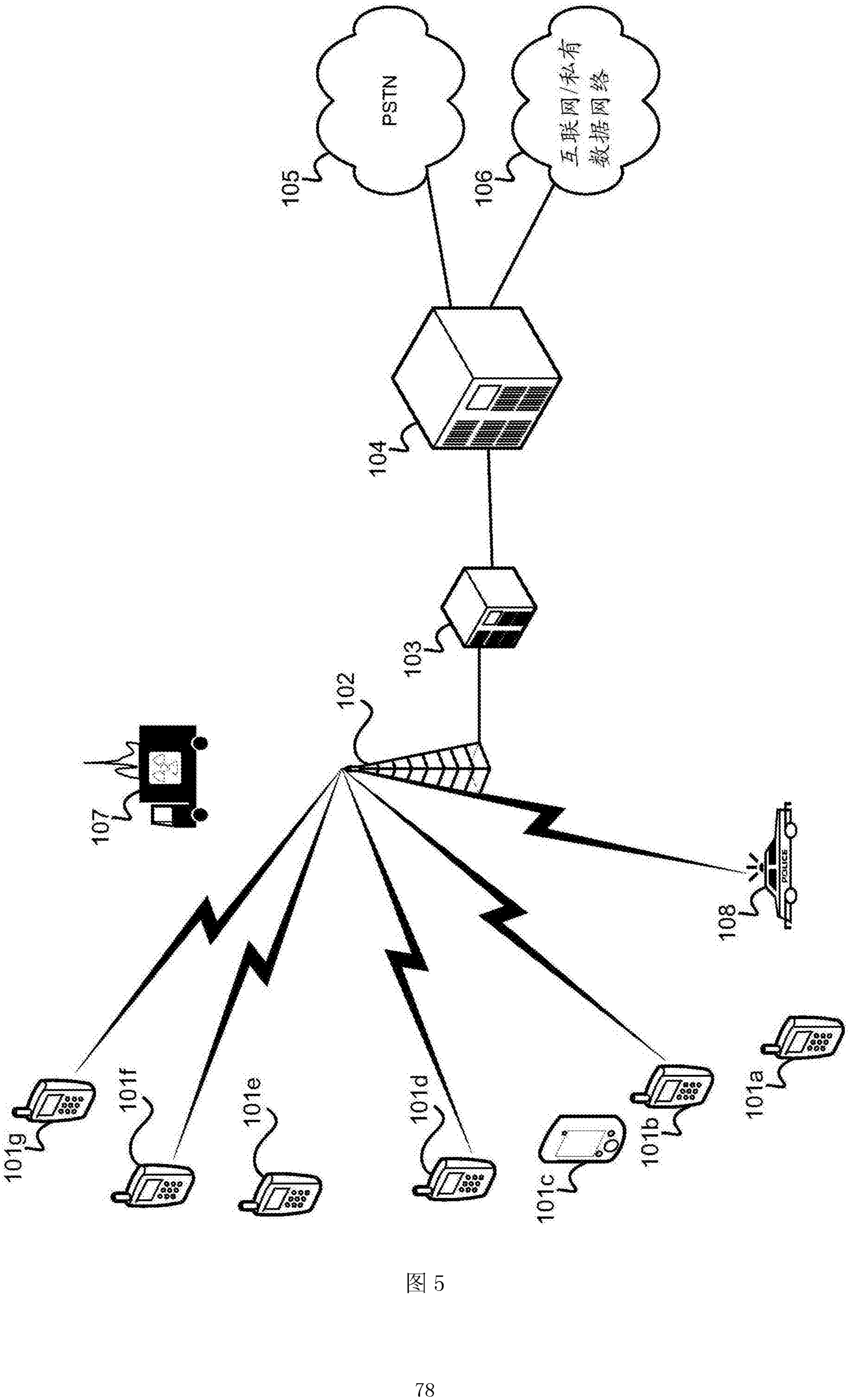

105
PSTN
106
互联网/私有数据网络
104
103
102
107
108
101a
101b
101c
101d
101e
101f
101g

图 5

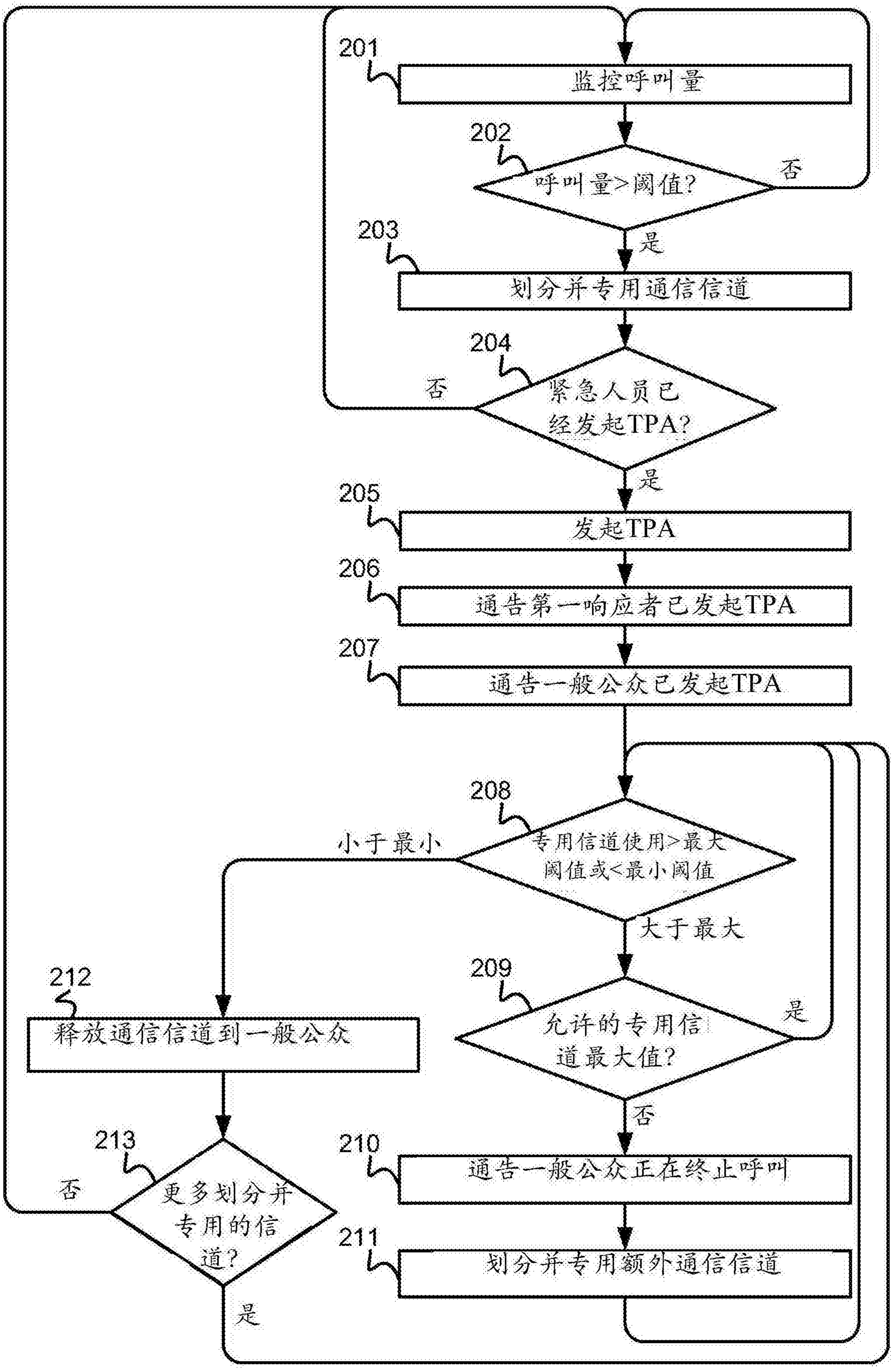

201
监控呼叫量
202
呼叫量>阈值?
否
是
203
划分并专用通信信道
204
紧急人员已经发起TPA?
否
是
205
发起TPA
206
通告第一响应者已发起TPA
207
通告一般公众已发起TPA
208
专用信道使用>最大阈值或<最小阈值
小于最小
大于最大
209
允许的专用信道最大值?
是
否
210
通告一般公众正在终止呼叫
211
划分并专用额外通信信道
212
释放通信信道到一般公众
213
更多划分并专用的信道?
否
是

图 6

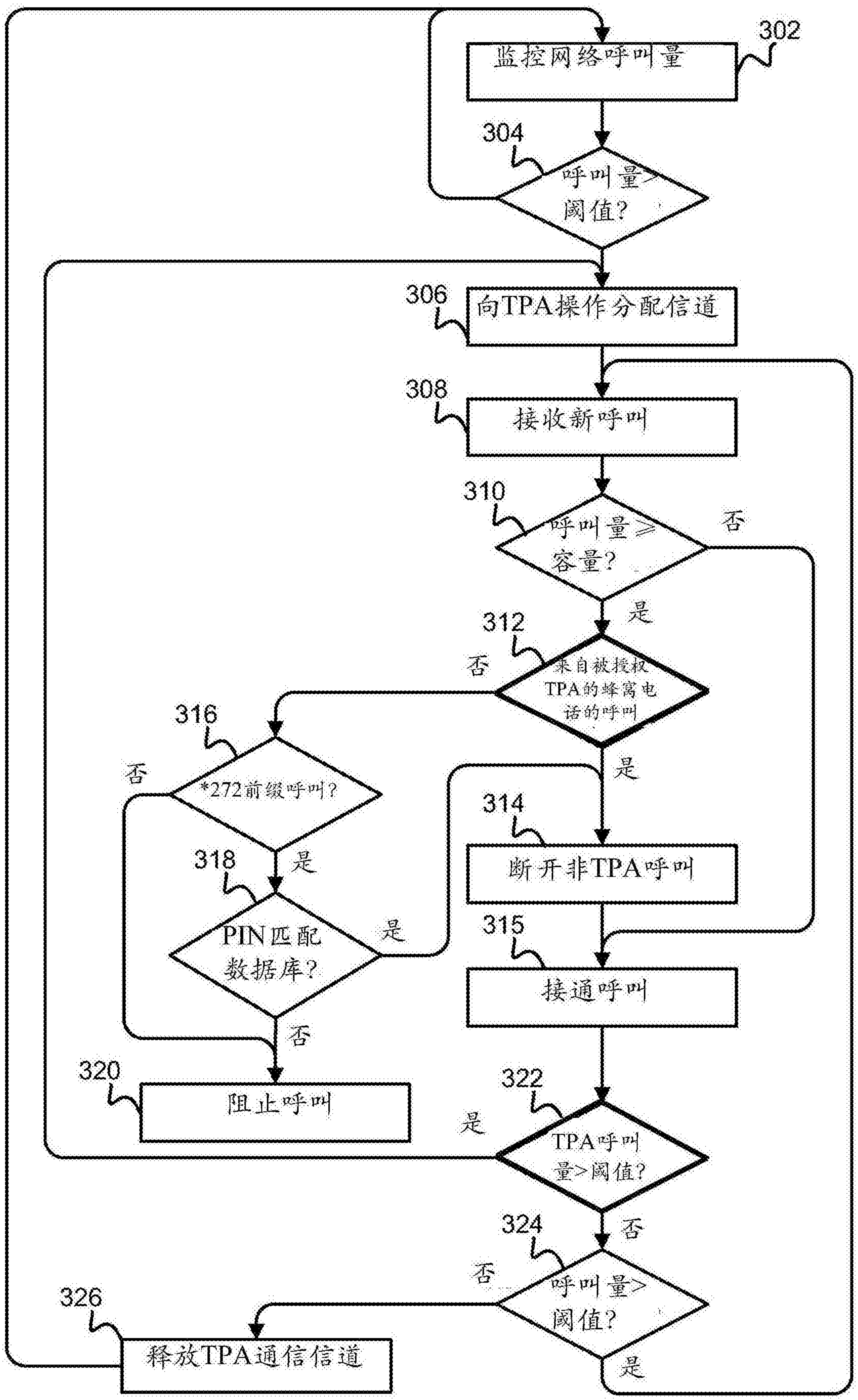

302
监控网络呼叫量
304
呼叫量>阈值?
306
向TPA操作分配信道
308
接收新呼叫
310
呼叫量≥容量?
否
是
312
来自被授权TPA的蜂窝电话的呼叫
否
是
316
*272前缀呼叫?
否
是
318
PIN匹配数据库?
是
否
314
断开非TPA呼叫
315
接通呼叫
320
阻止呼叫
322
TPA呼叫量>阈值?
是
否
324
呼叫量>阈值?
否
是
326
释放TPA通信信道

图 7

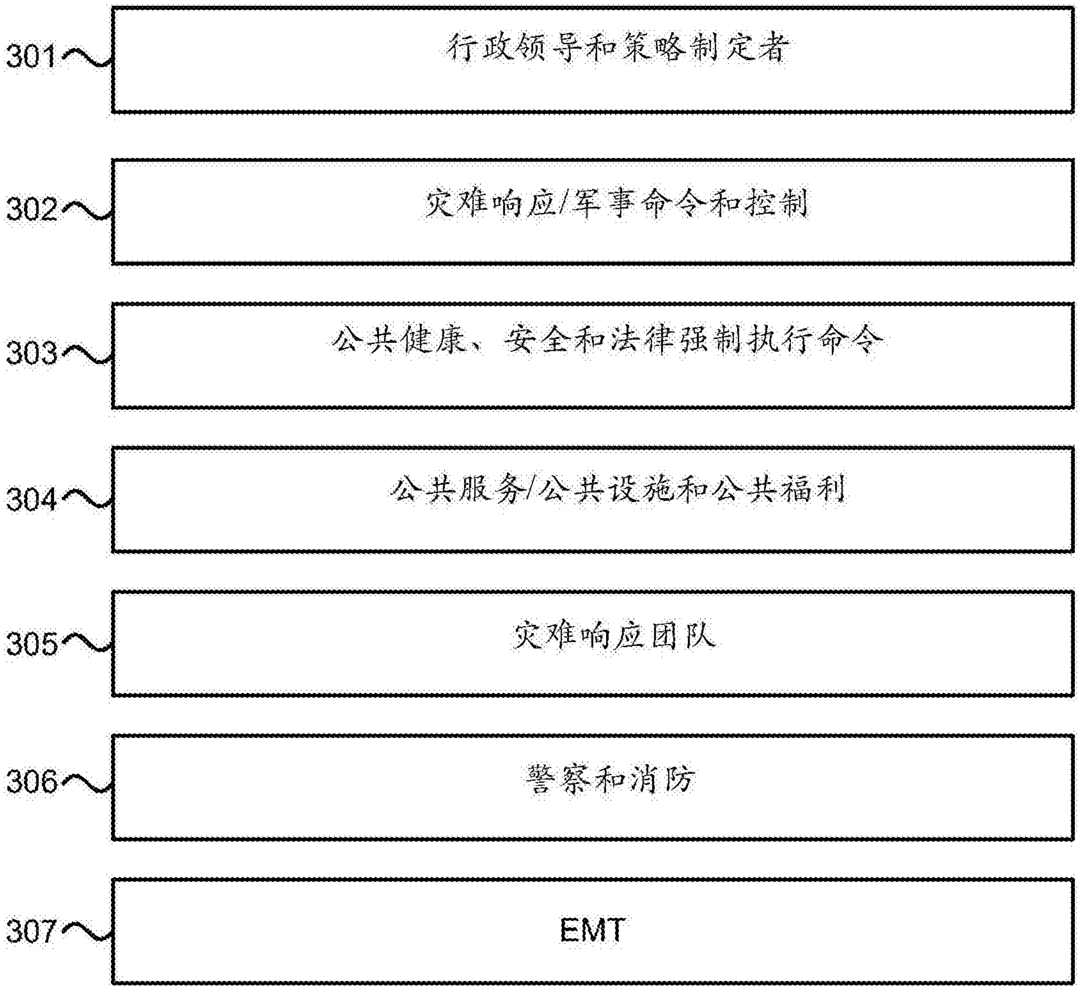

301
行政领导和策略制定者
302
灾难响应/军事命令和控制
303
公共健康、安全和法律强制执行命令
304
公共服务/公共设施和公共福利
305
灾难响应团队
306
警察和消防
307
EMT

图 8

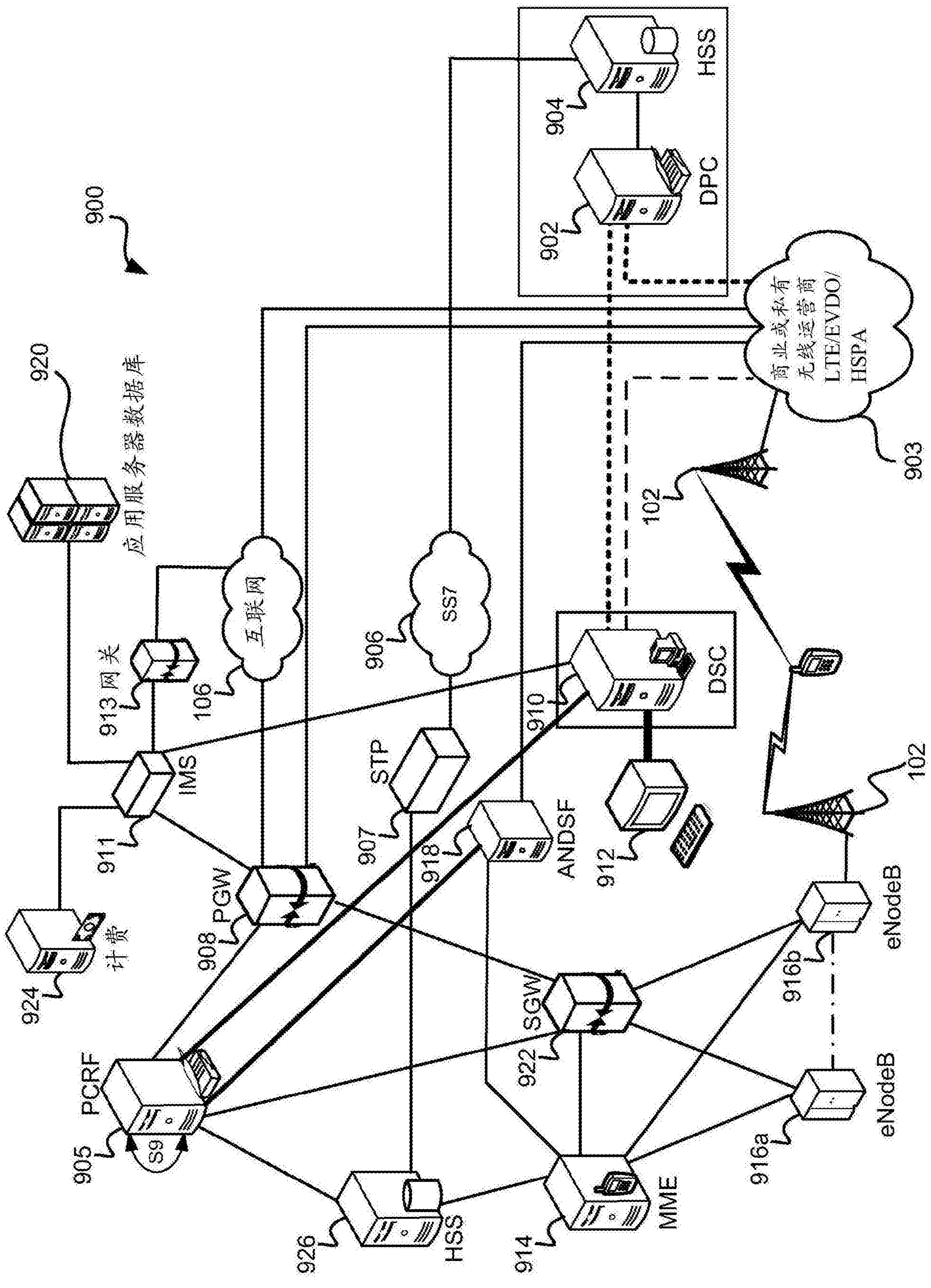

900
920
应用服务器数据库
HSS
DPC
904
902
商业或私有无线运营商
LTE/EVDO/
HSPA
903
102
互联网
106
913 网关
SS7
906
DSC
910
STP
907
IMS
911
ANDSF
918
912
PGW
908
计费
924
SGW
922
eNodeB
916b
eNodeB
916a
PCRF
905
S9
HSS
926
MME
914

图 9

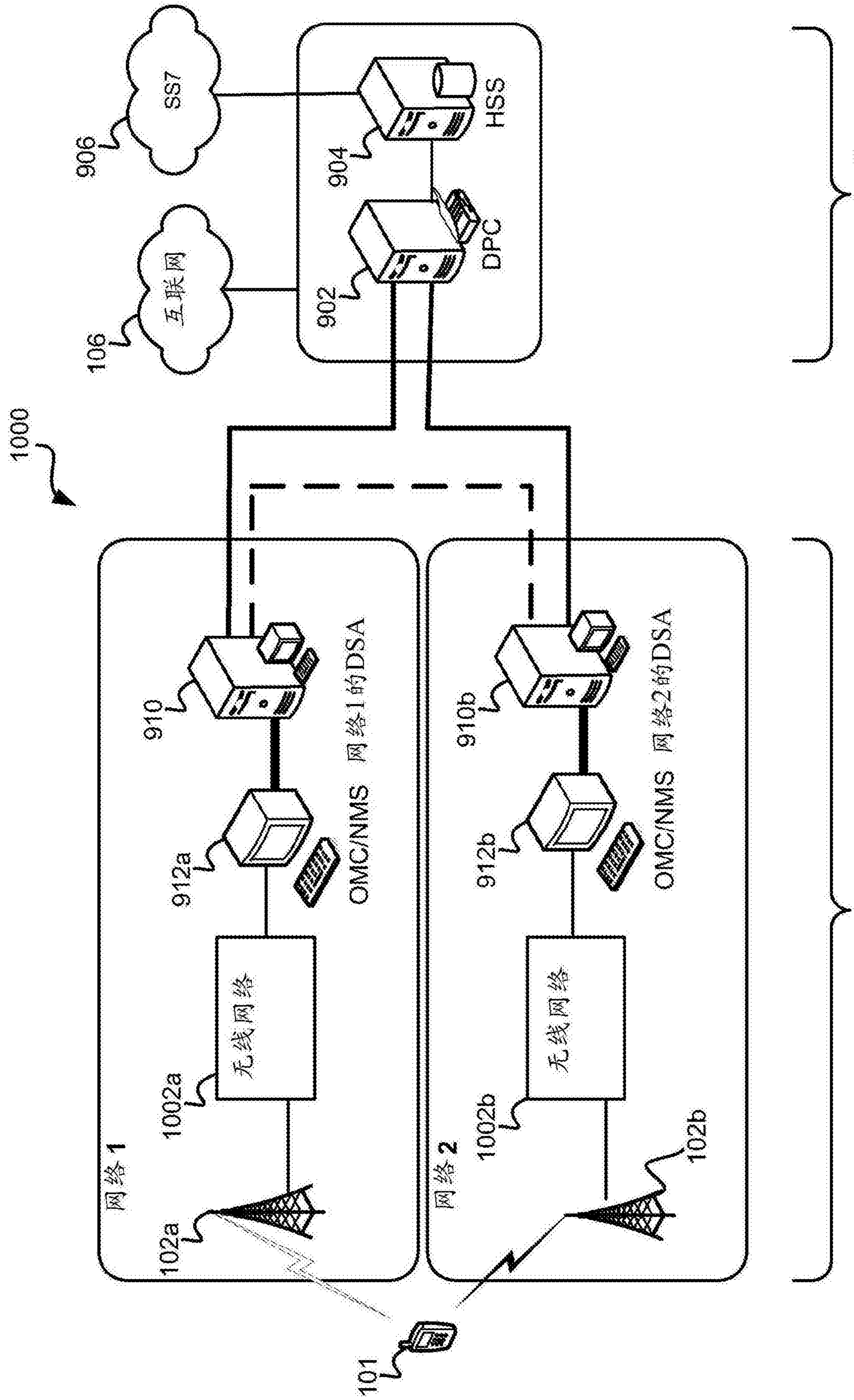

SS7
906
HSS
904
DPC
902
互联网
106
网络外
1000
910
网络1的DSA
OMC/NMS
912a
无线网络
1002a
网络1
102a
910b
网络2的DSA
OMC/NMS
912b
无线网络
1002b
网络2
102b
网络内
101

图 10

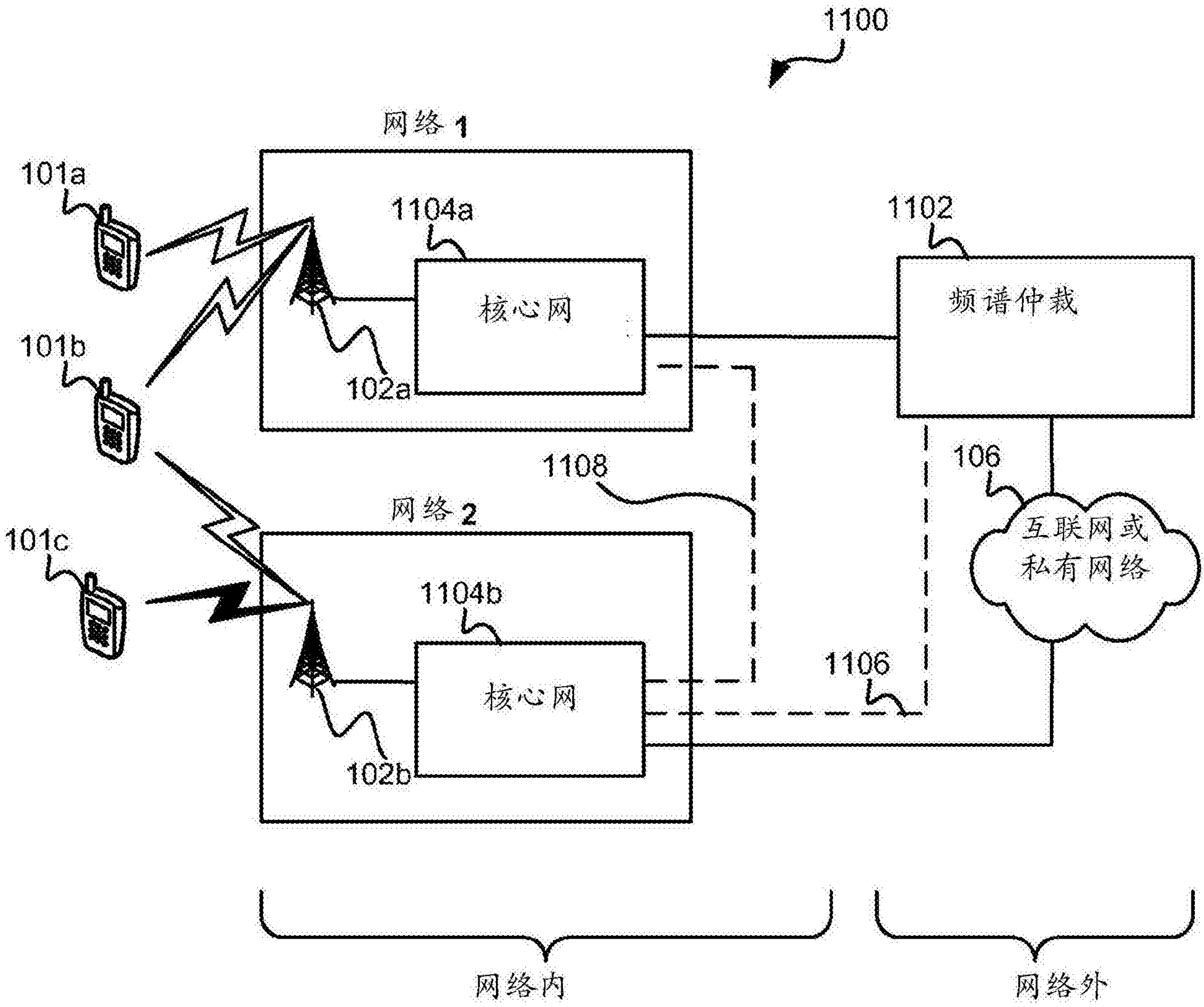

1100
网络 1
101a
1104a
1102
核心网
频谱仲裁
101b
102a
1108
106
网络 2
101c
互联网或
私有网络
1104b
1106
核心网
102b
网络内
网络外

图 11

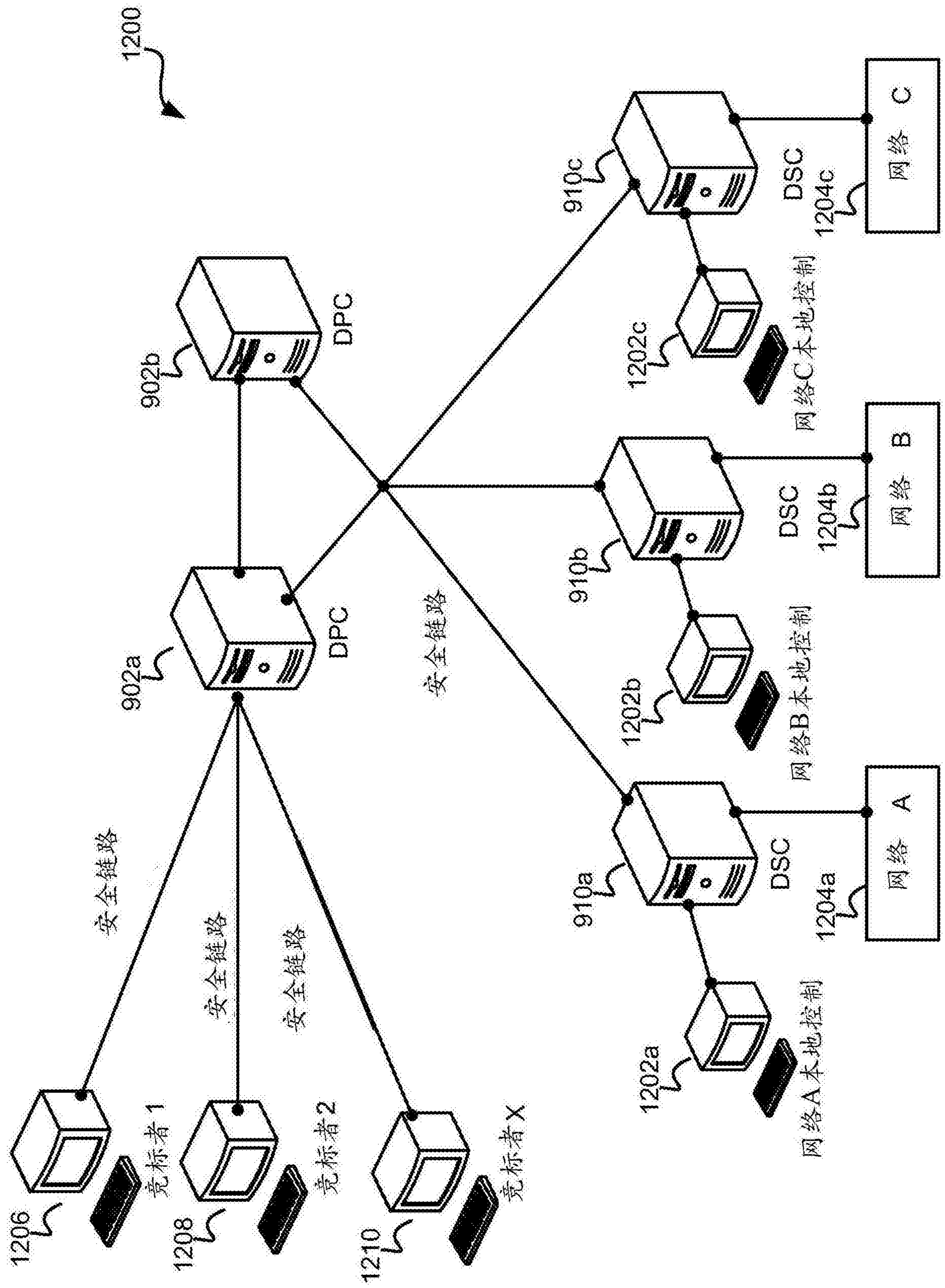

1200
902a
DPC
902b
DPC
安全链路
安全链路
安全链路
安全链路
910a
DSC
910b
DSC
910c
DSC
1202a
网络A本地控制
1202b
网络B本地控制
1202c
网络C本地控制
1204a
网络 A
1204b
网络 B
1204c
网络 C
1206
竞标者 1
1208
竞标者 2
1210
竞标者 X

图 12

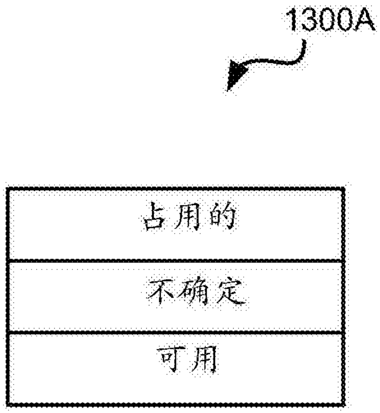

1300A
占用的
不确定
可用

图 13A

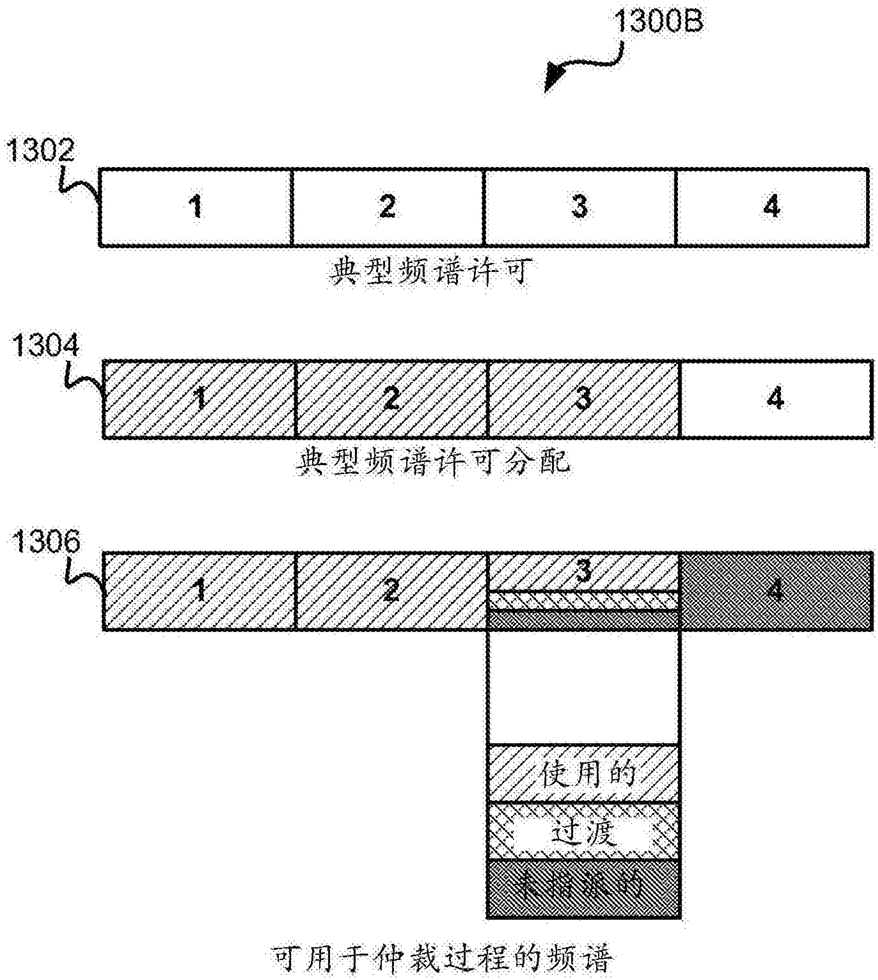

1300B
1302
1
2
3
4
典型频谱许可
1304
1
2
3
4
典型频谱许可分配
1306
1
2
3
4
使用的
过渡
可用于仲裁过程的频谱

图 13B

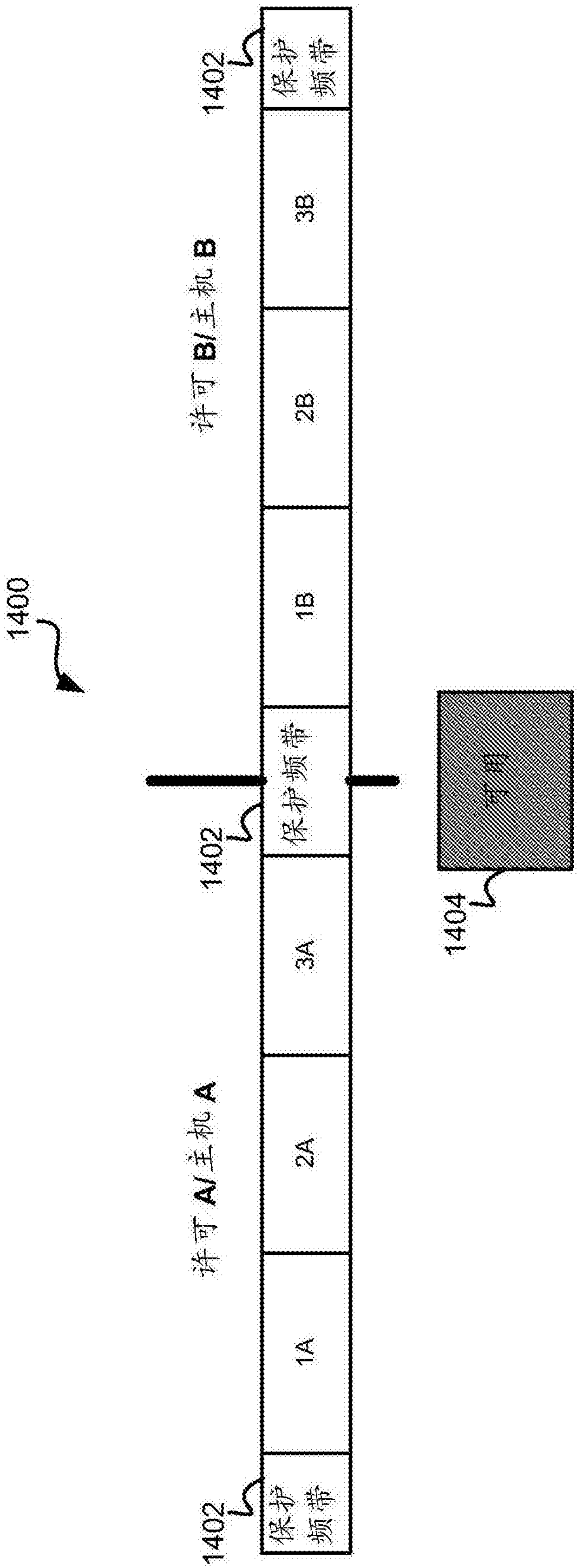

1400
许可 B/ 主机 B
1402
保护频带
3B
2B
1B
保护频带
1402
3A
2A
1A
许可 A/ 主机 A
保护频带
1402
可用
1404

图 14

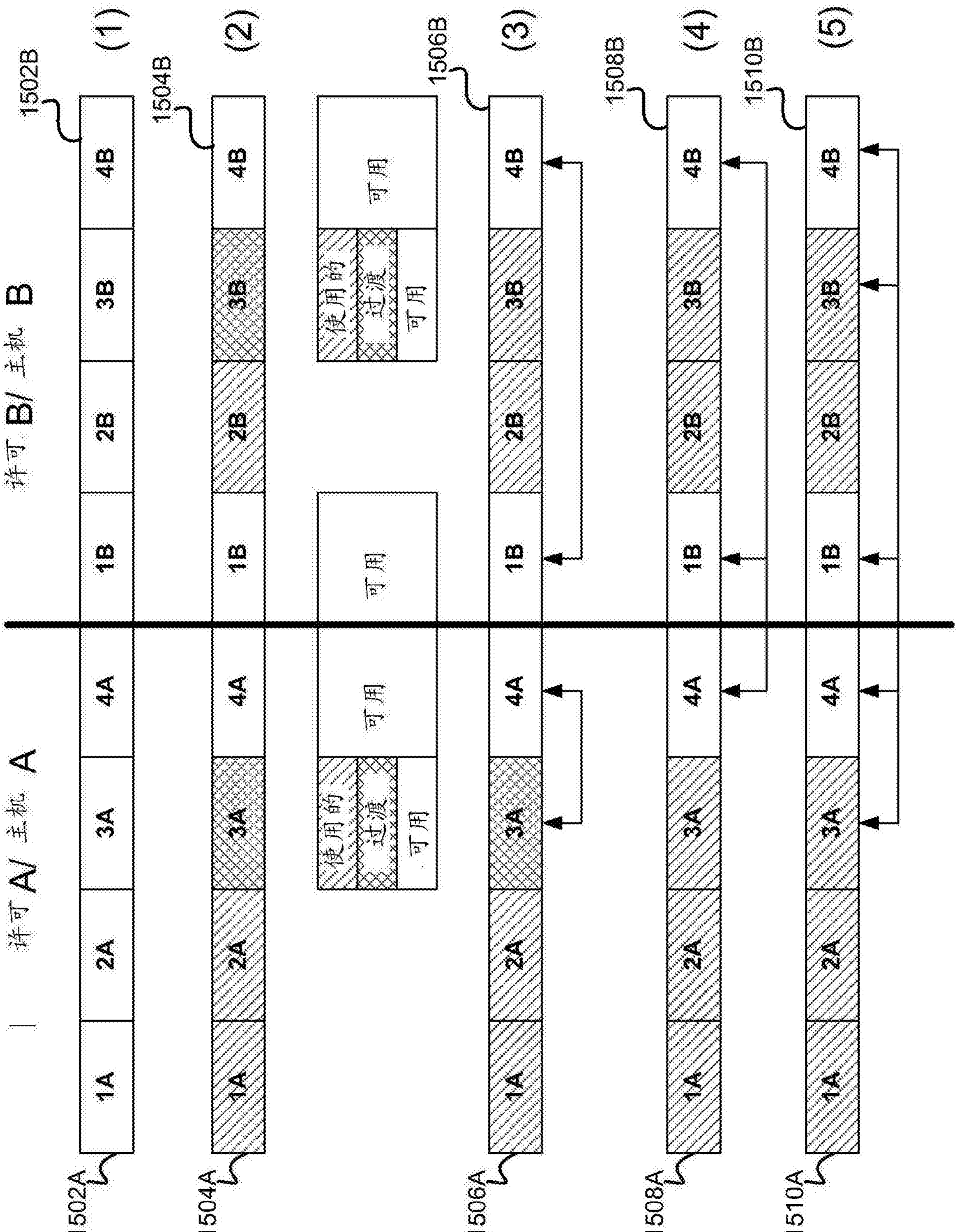

许可 A/ 主机 A
许可 B/ 主机 B
1A
2A
3A
4A
1B
2B
3B
4B
(1)
(2)
(3)
(4)
(5)
1502A
1502B
1504A
1504B
1506A
1506B
1508A
1508B
1510A
1510B
使用的
过渡
可用

图 15

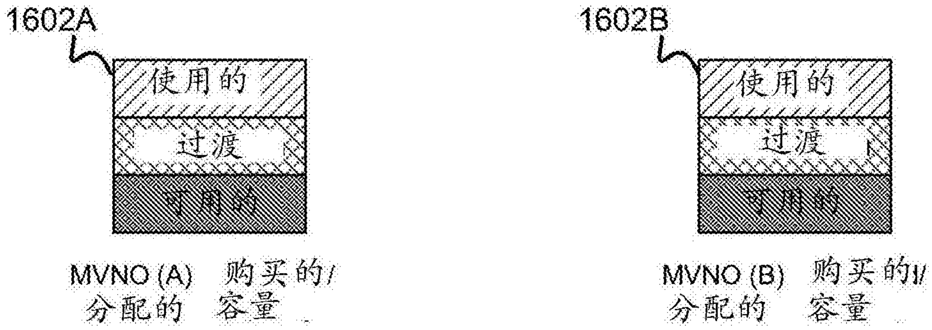


图 16A

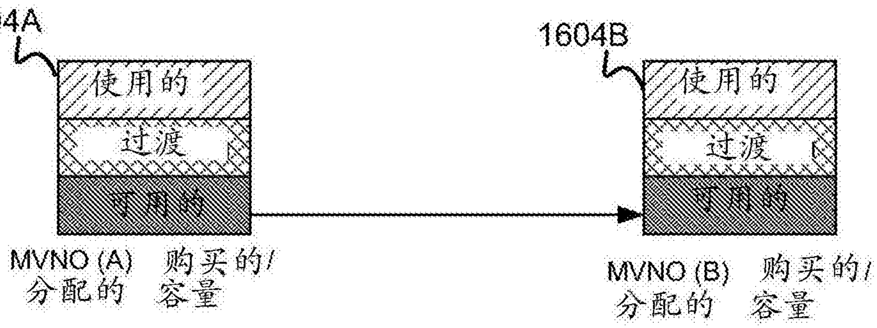


图 16B

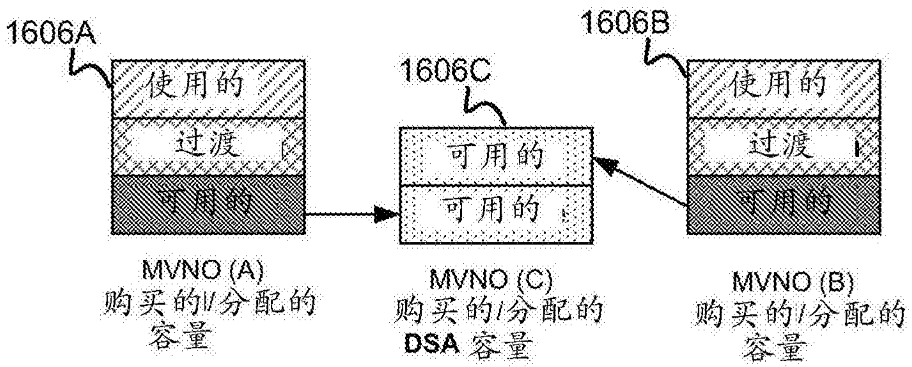


图 16C

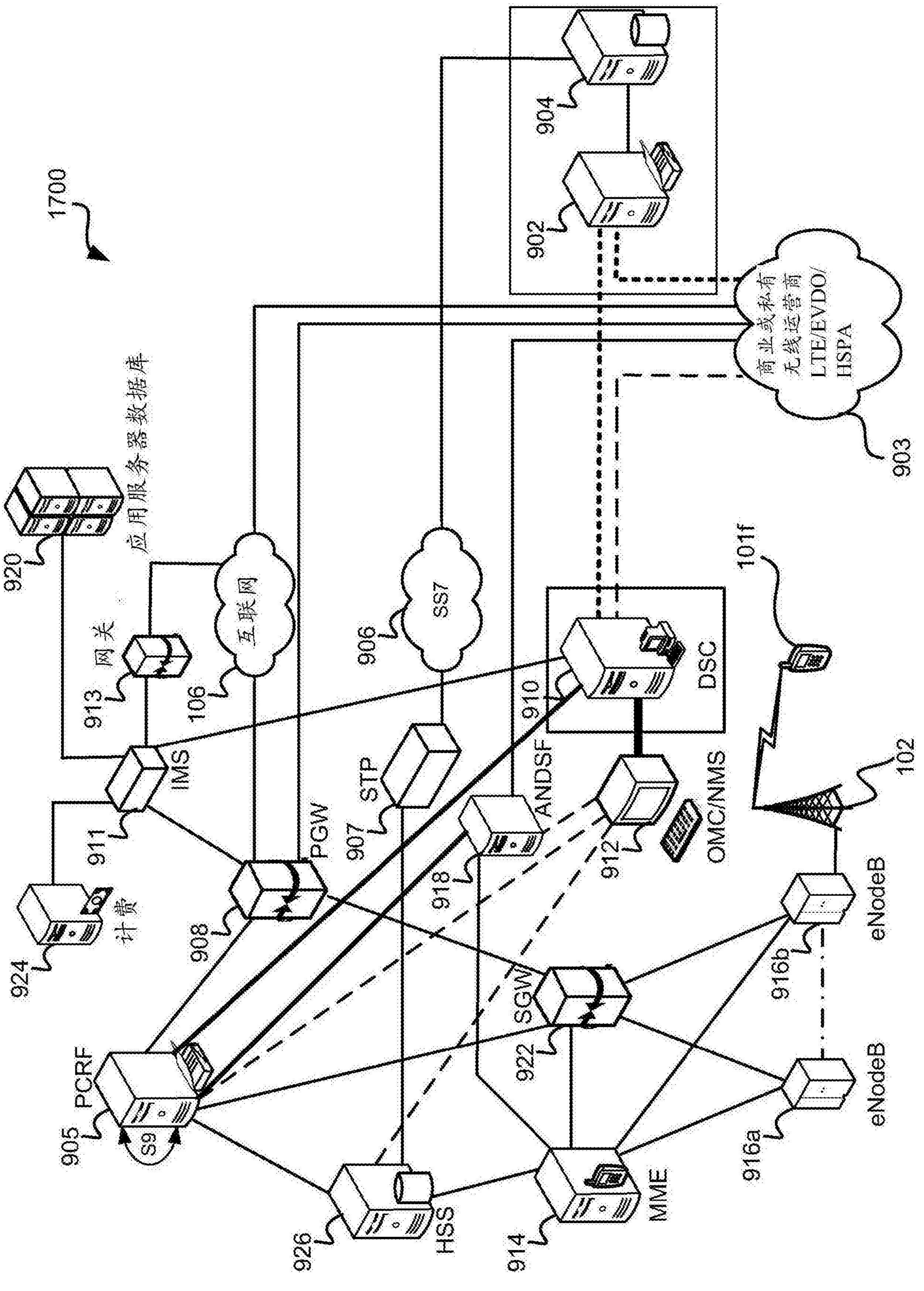

1700
902
904
商业或私有无线运营商LTE/EVDO/HSPA
903
920
应用服务器数据库
913
网关
106
互联网
906
SS7
910
DSC
101f
924
计费
911
IMS
908
PGW
907
STP
918
ANDSF
912
OMC/NMS
102
905
PCRF
S9
922
SGW
916b
eNodeB
926
HSS
914
MME
916a
eNodeB

图 17

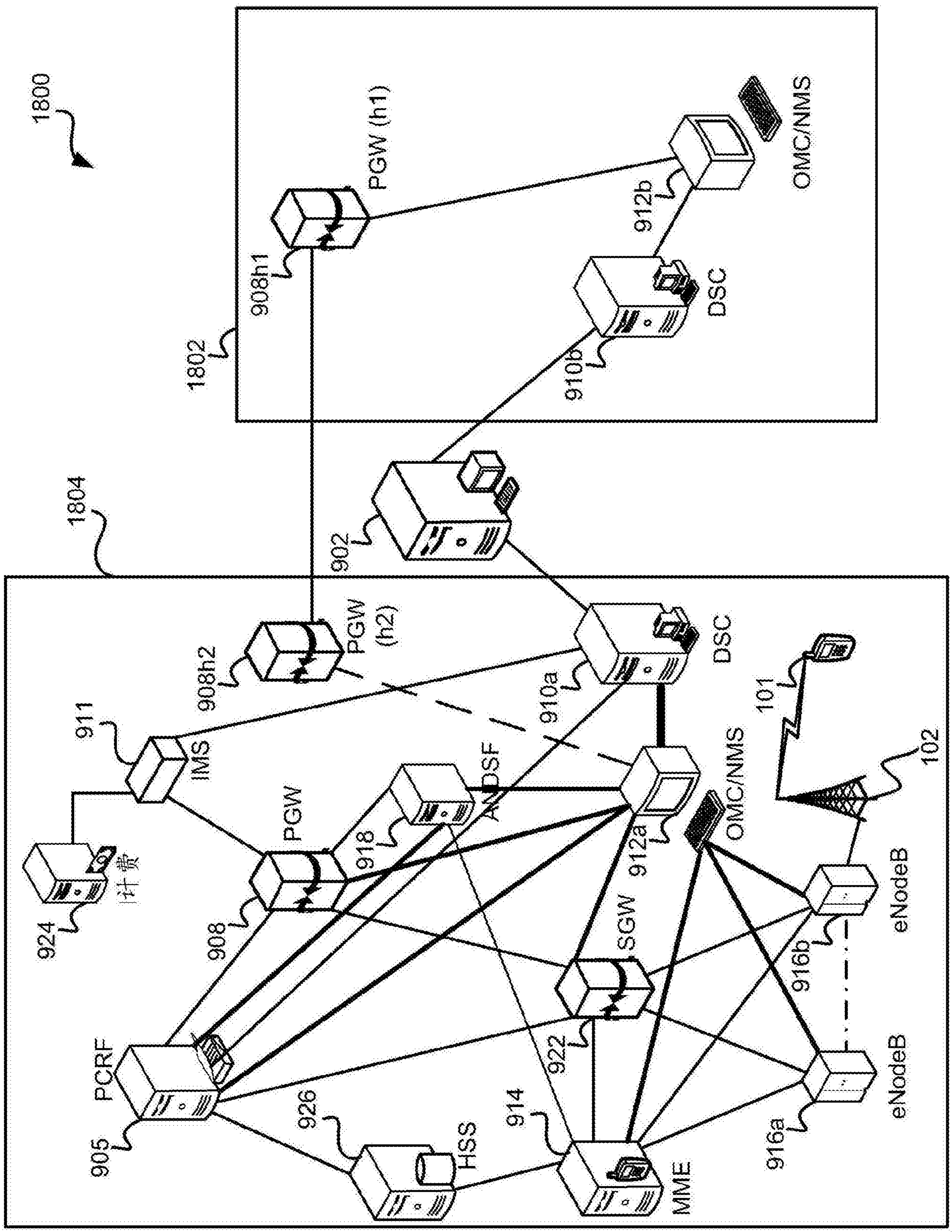

1800
1802
1804
PGW (h1)
908h1
OMC/NMS
912b
DSC
910b
902
PGW
(h2)
908h2
DSC
910a
101
911
IMS
ANDSF
918
OMC/NMS
912a
102
924
计费
PGW
908
SGW
eNodeB
916b
PCRF
905
922
926
HSS
914
MME
eNodeB
916a

图 18

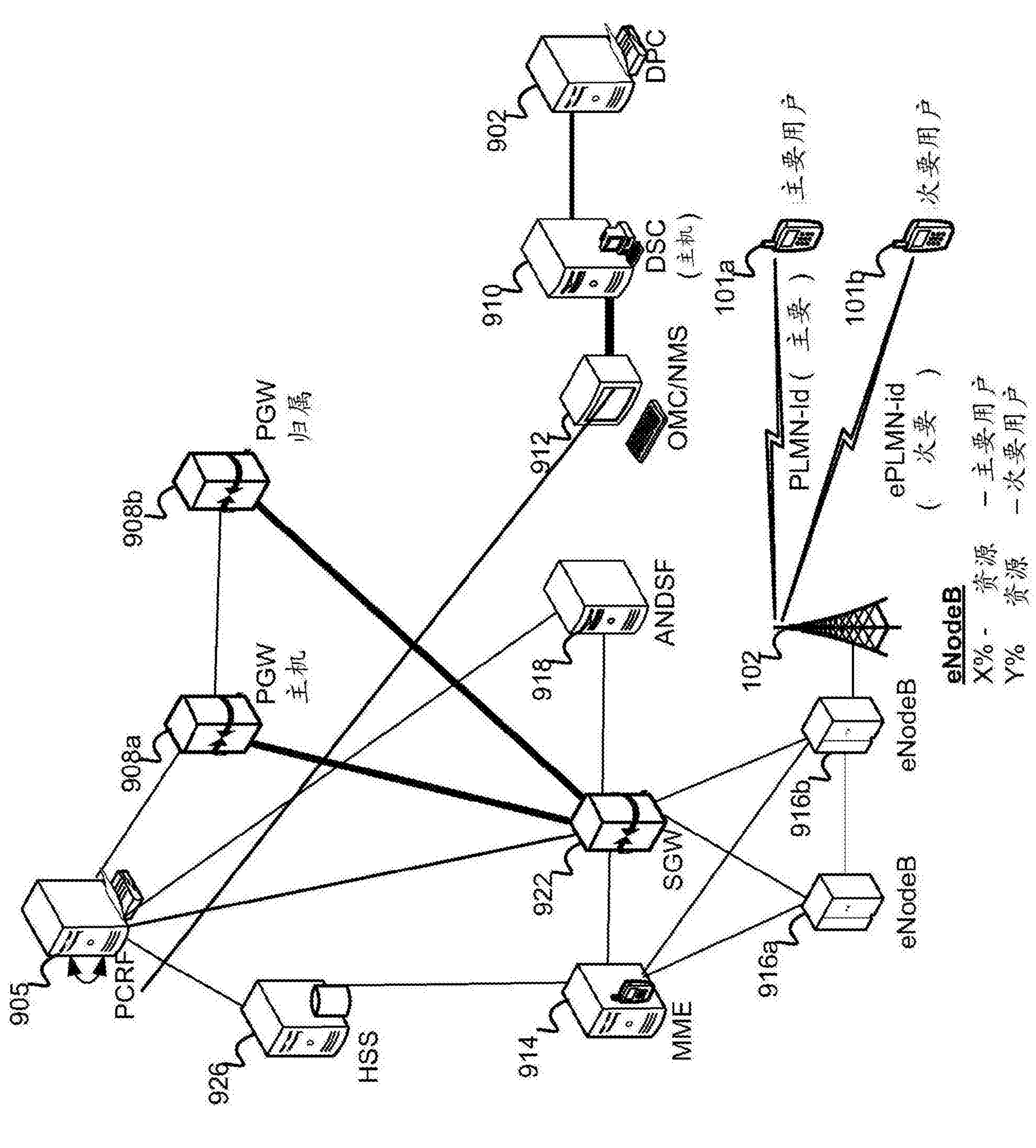
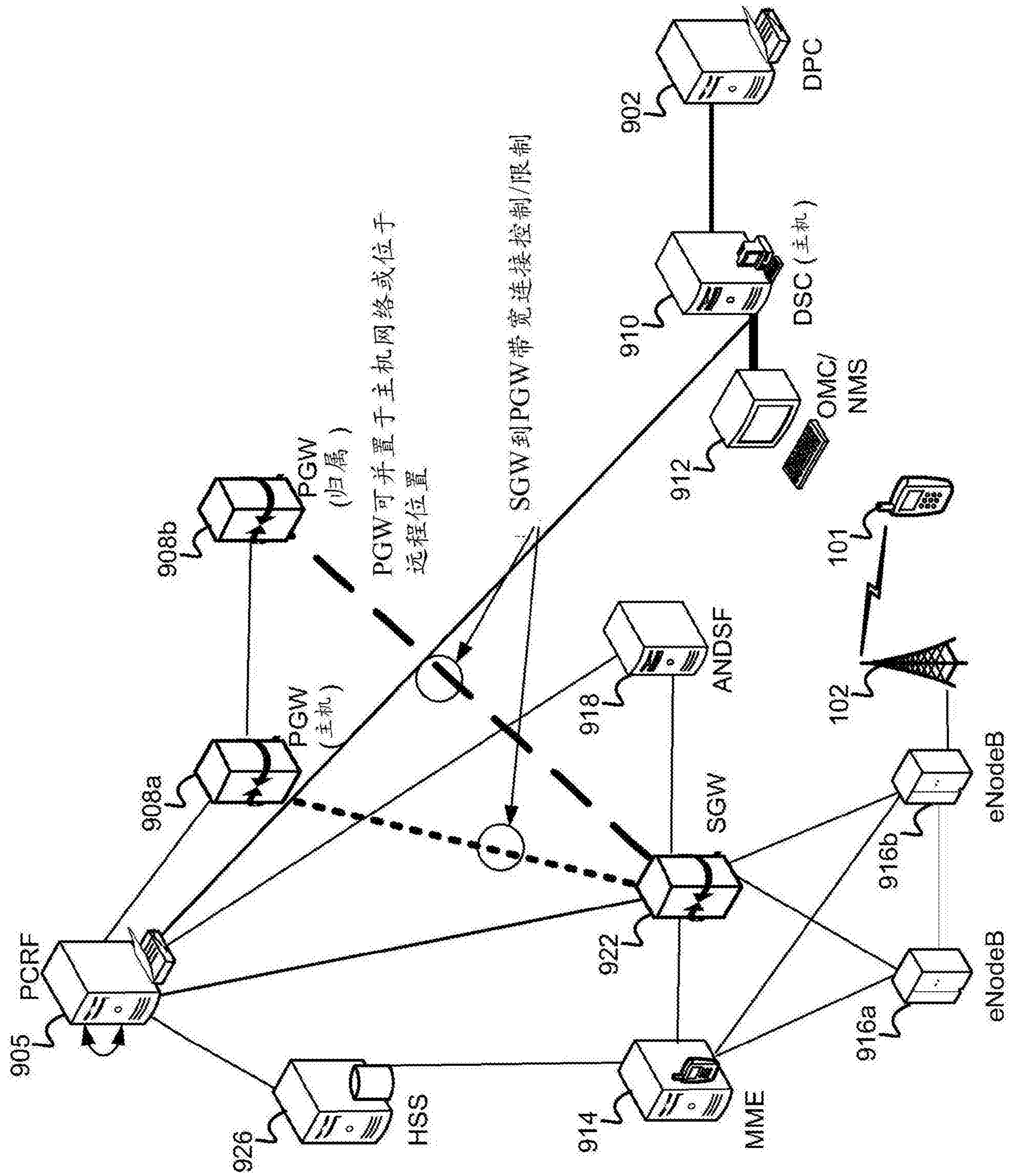
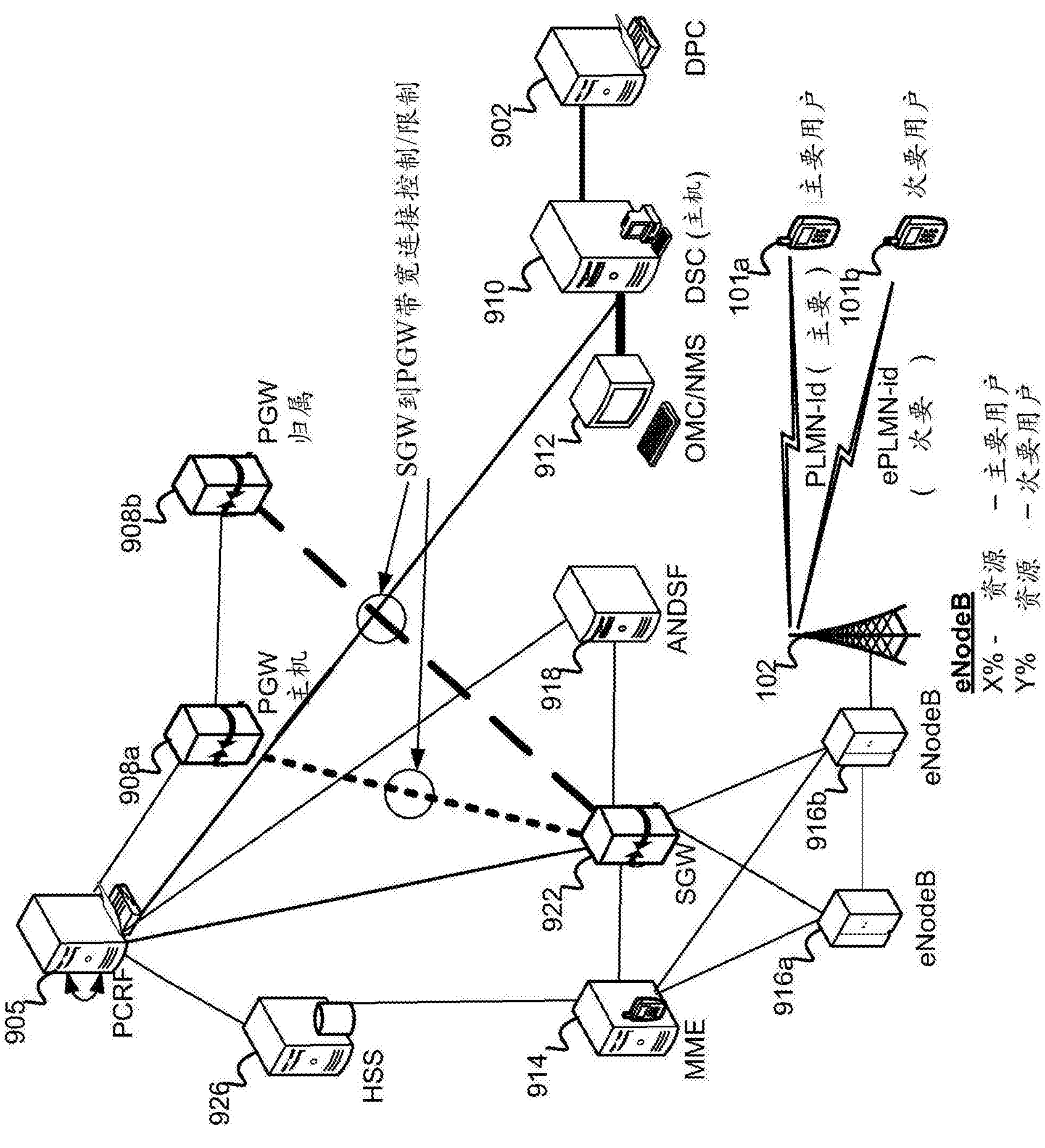

DPC
902
910
DSC
（主机）
101a
主要用户
101b
次要用户
OMC/NMS
912
PGW
归属
908b
PLMN-id（主要）
ePLMN-id（次要）
ANDSF
918
PGW
主机
908a
102
eNodeB
X%- 资源 – 主要用户
Y% 资源 –次要用户
eNodeB
eNodeB
916b
SGW
922
eNodeB
916a
PCRF
905
HSS
926
MME
914

图 19



902
DPC
910
DSC（主机）
912
OMC/
NMS
908b
PGW
（归属）
PGW可并置于主机网络或位于远程位置
SGW到PGW带宽连接控制/限制
908a
PGW
（主机）
918
ANDSF
101
102
905
PCRF
922
SGW
916b
eNodeB
916a
eNodeB
926
HSS
914
MME

图 20



902
DPC
910
DSC(主机)
912
OMC/NMS
SGW到PGW带宽连接控制/限制
908b
PGW
归属
908a
PGW
主机
918
ANDSF
905
PCRF
922
SGW
926
HSS
914
MME
916a
eNodeB
916b
eNodeB
102
101a
101b
主要用户
次要用户
PLMN-Id(主要)
ePLMN-Id(次要)
eNodeB
X% - 资源 — 主要用户
Y% 资源 — 次要用户

图 21

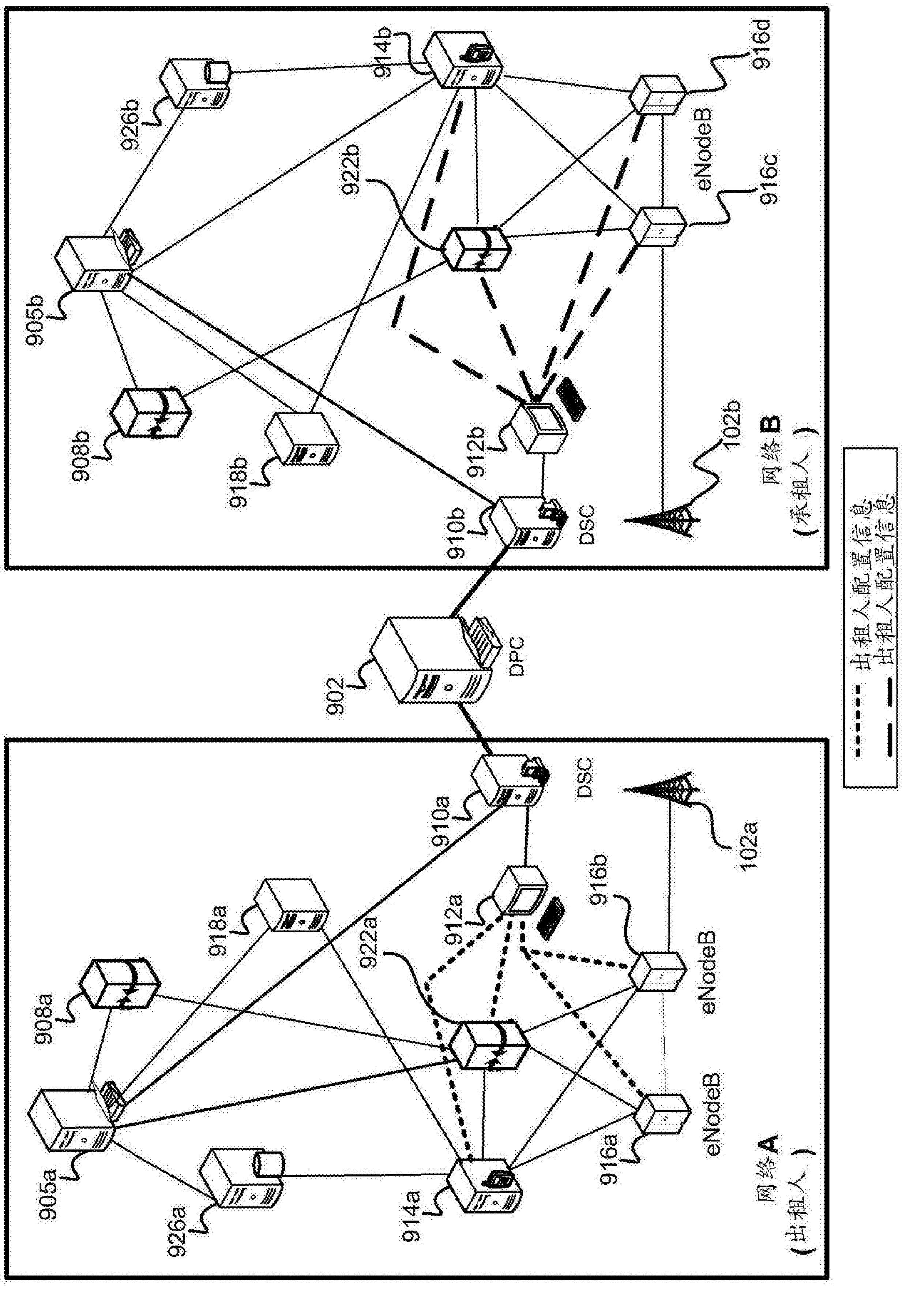

902
DPC
DSC
910a
DSC
910b
912a
912b
914a
914b
916a
916b
eNodeB
eNodeB
916c
916d
eNodeB
eNodeB
918a
918b
922a
922b
926a
926b
905a
905b
908a
908b
102a
102b
网络A
（出租人）
网络B
（承租人）
出租人配置信息
出租人配置信息

图 22

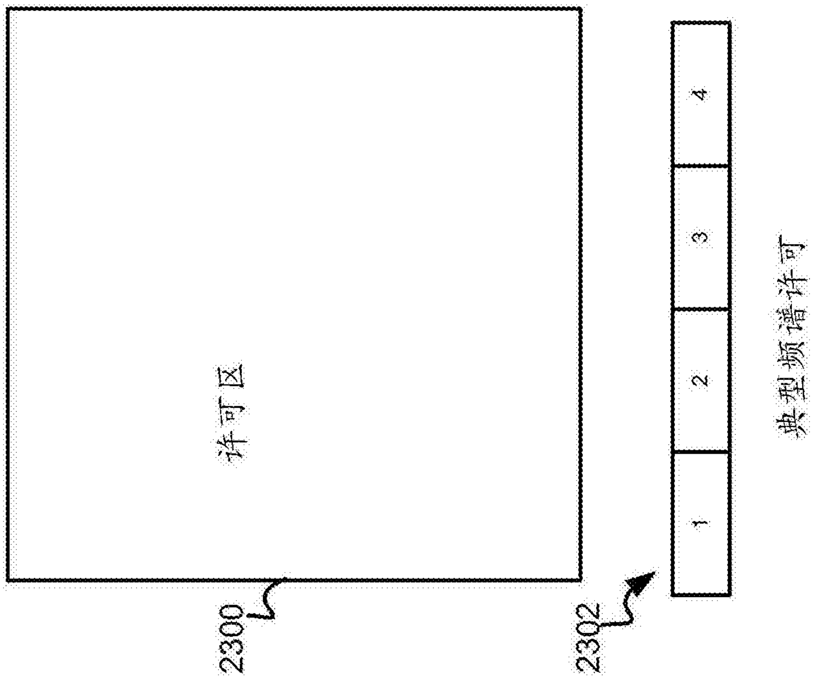

许可区
1
2
3
4
典型频谱许可
2300
2302

图 23A

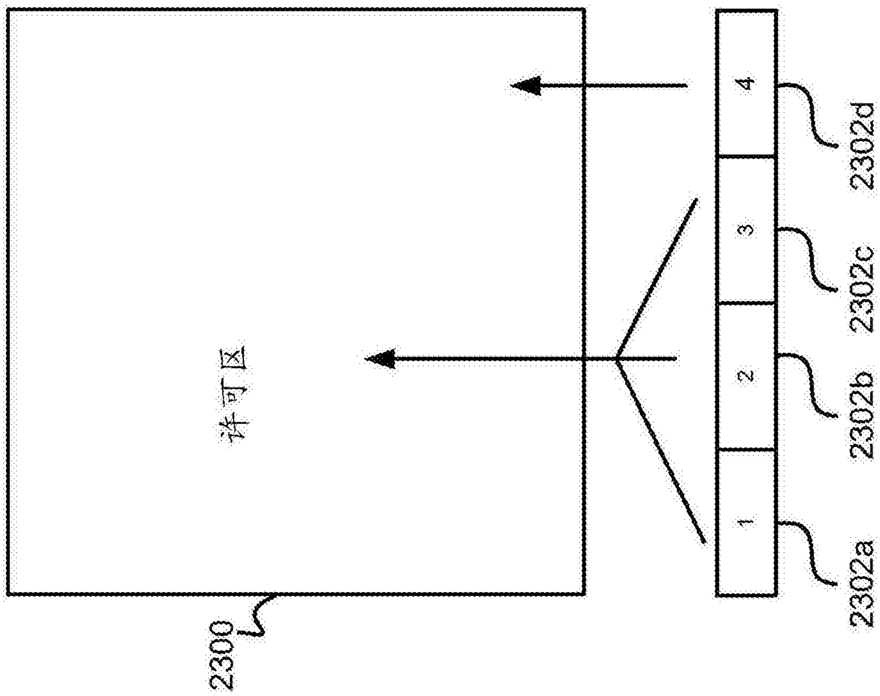

许可区
1
2
3
4
2302a
2302b
2302c
2302d
2300

图 23B

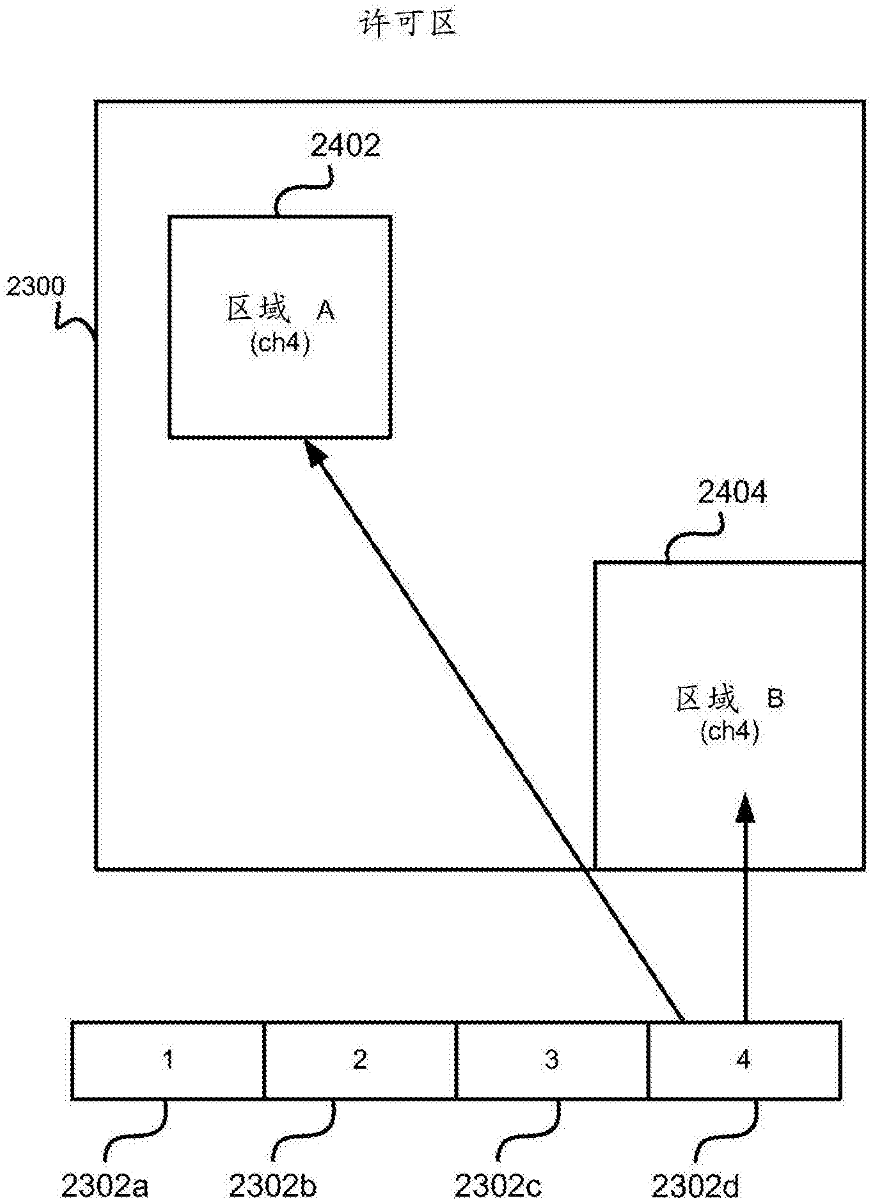

许可区
2402
2300
区域 A
(ch4)
2404
区域 B
(ch4)
1
2
3
4
2302a
2302b
2302c
2302d

图 24

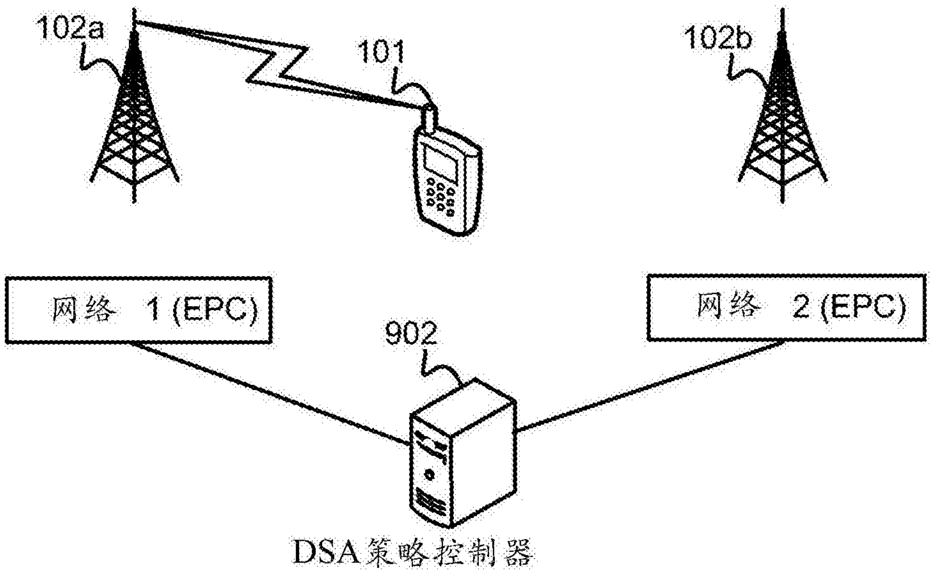

102a
101
102b
网络 1 (EPC)
网络 2 (EPC)
902
DSA策略控制器

图 25A

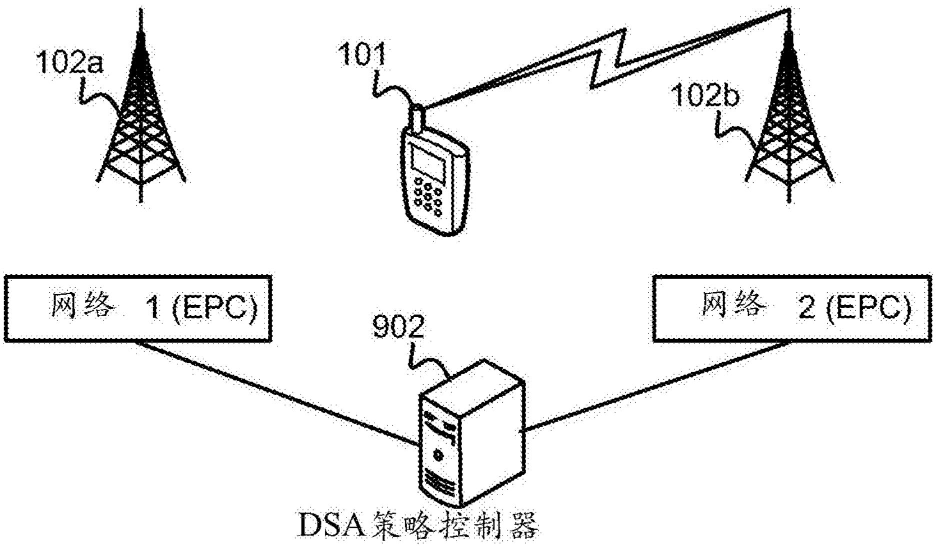

102a
101
102b
网络 1 (EPC)
网络 2 (EPC)
902
DSA策略控制器

图 25B

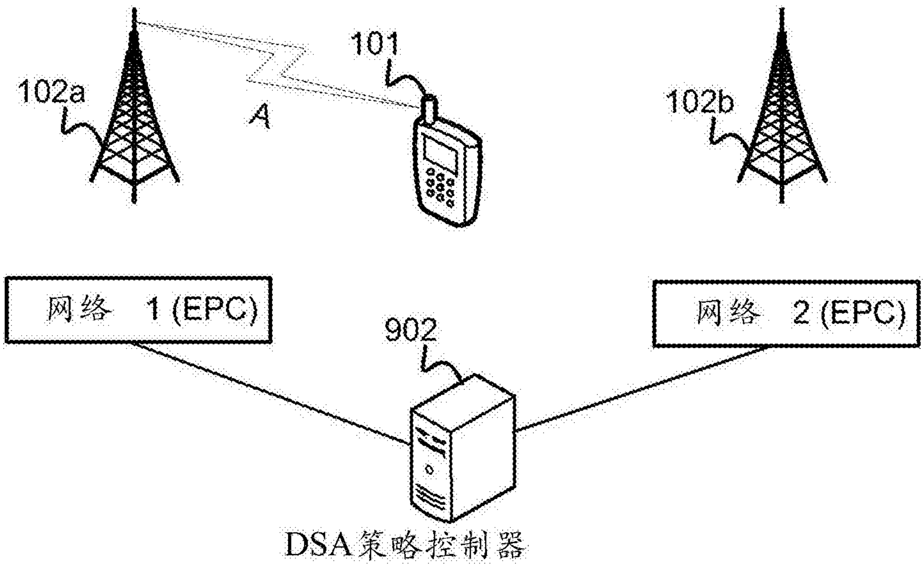

102a
A
101
102b
网络 1 (EPC)
902
网络 2 (EPC)
DSA策略控制器

图 26A

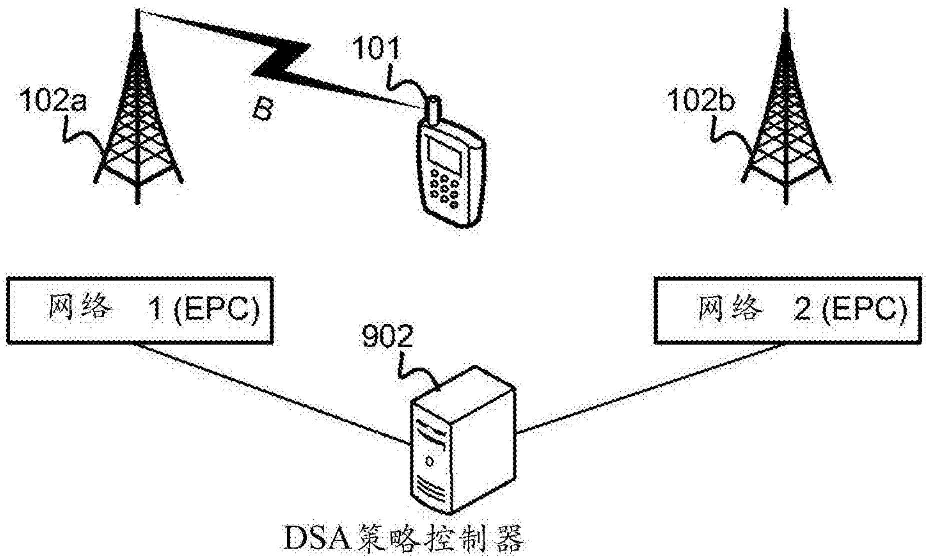

102a
B
101
102b
网络 1 (EPC)
902
网络 2 (EPC)
DSA策略控制器

图 26B

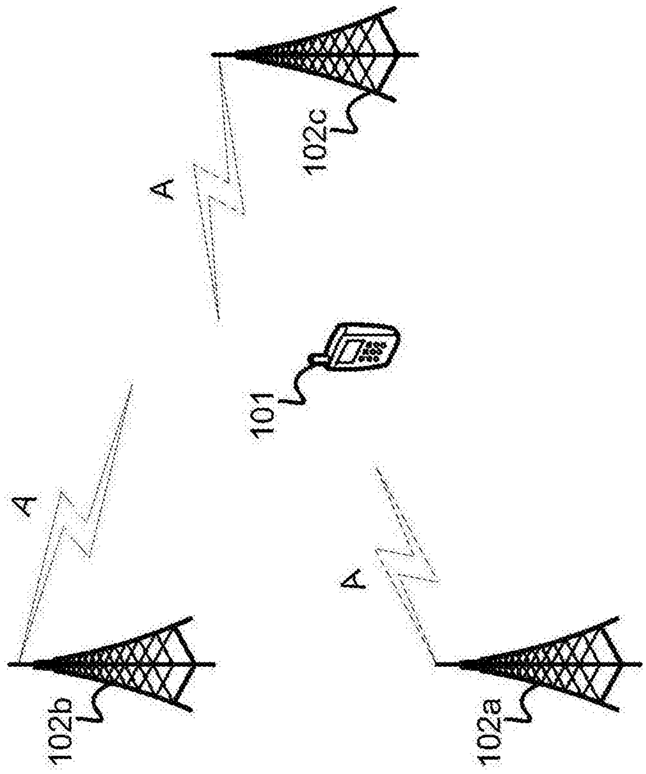


图 27A

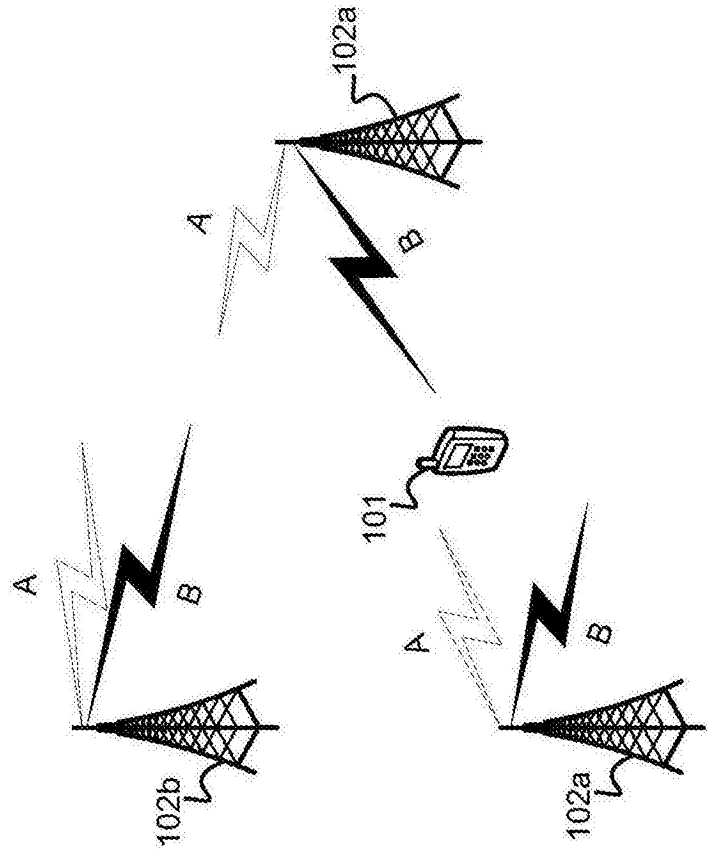


图 27B

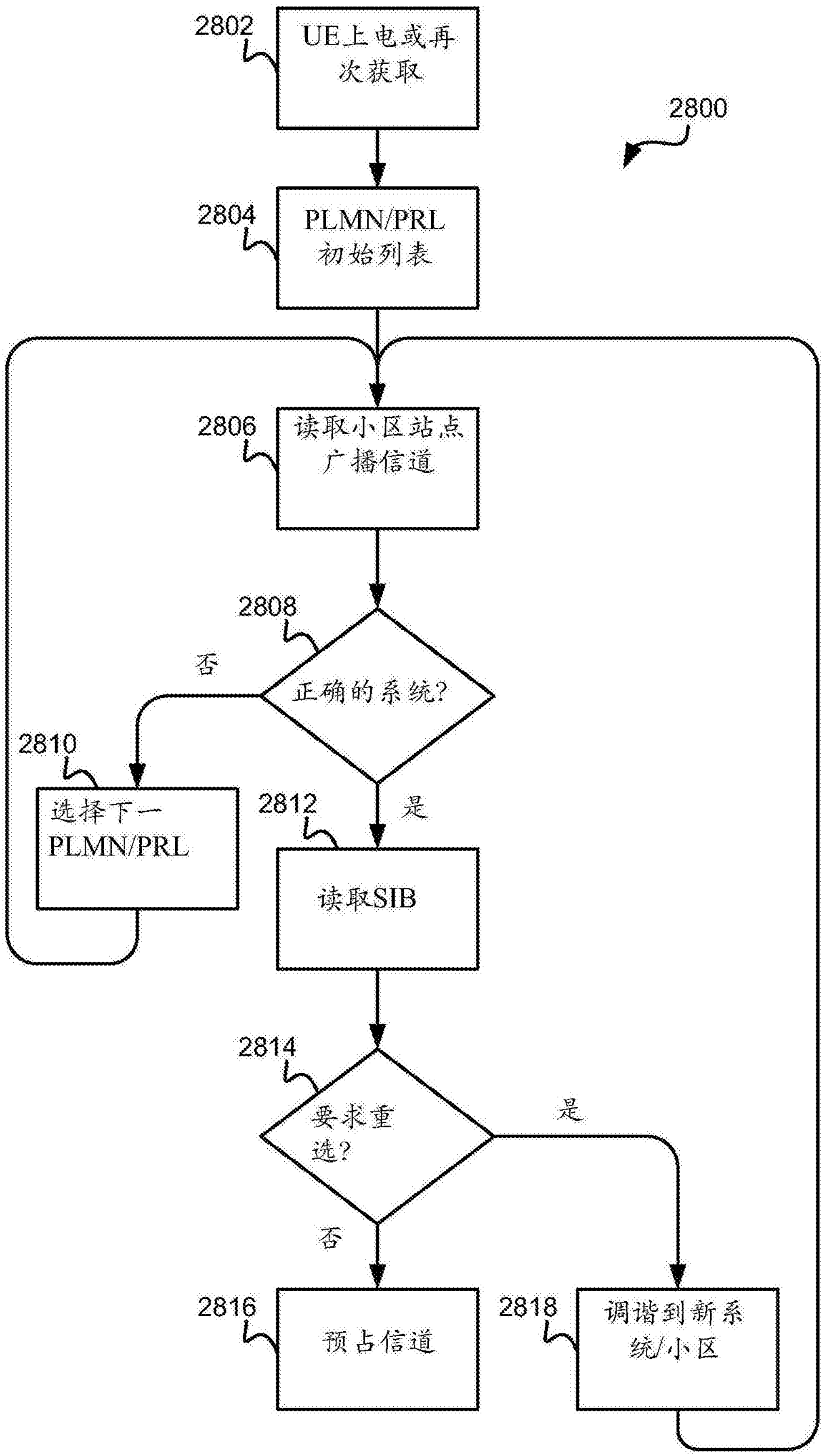

2802
UE上电或再次获取
2800
2804
PLMN/PRL初始列表
2806
读取小区站点广播信道
2808
正确的系统?
否
2810
选择下一PLMN/PRL
2812
是
读取SIB
2814
要求重选?
是
否
2816
预占信道
2818
调谐到新系统/小区

图 28

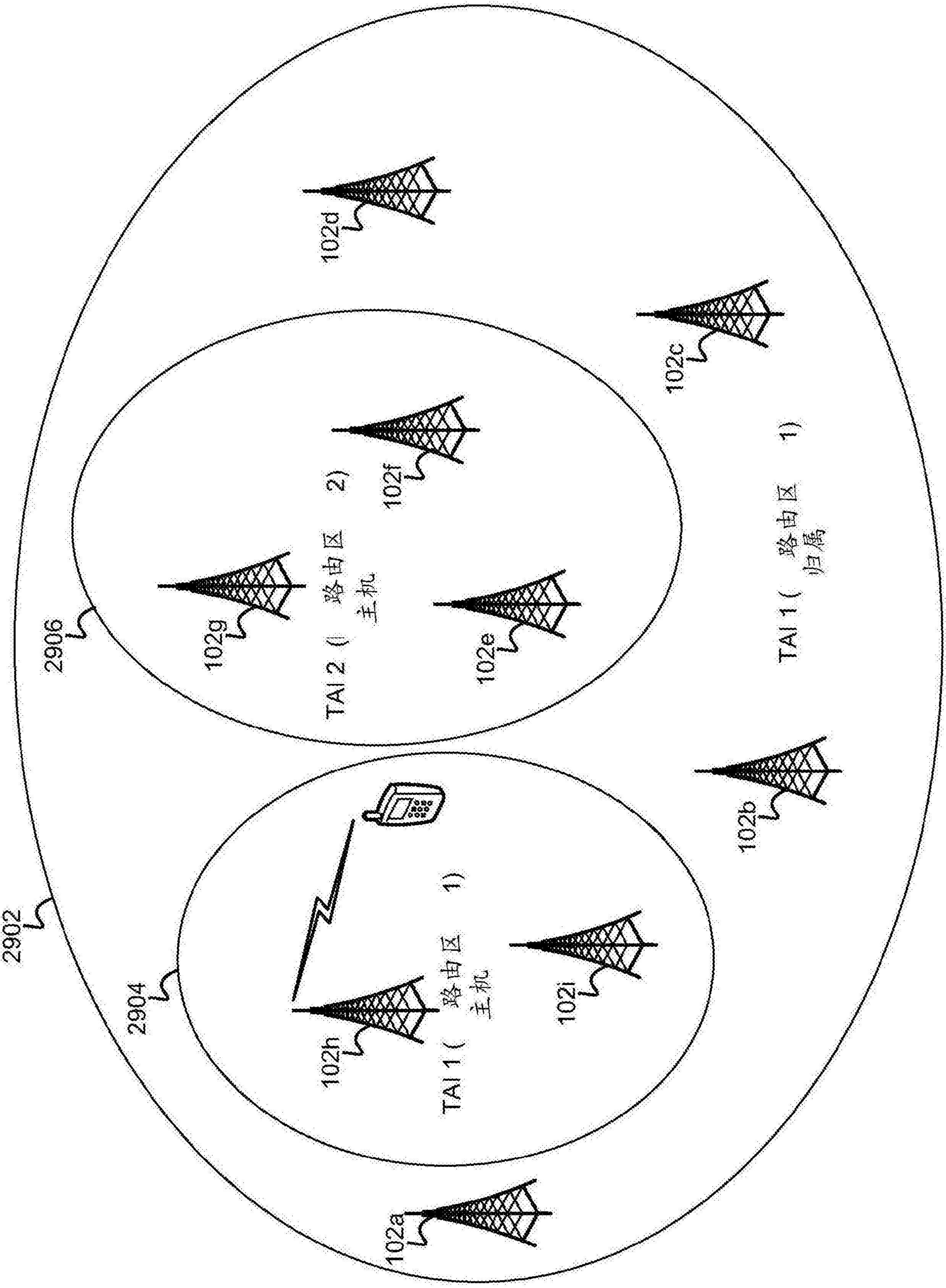

2902
2904
2906
102a
102b
102c
102d
102e
102f
102g
102h
102i
TAI 1 (路由区 1)
归属
TAI 2 (路由区 2)
主机
TAI 1 (路由区 1)
主机

图 29

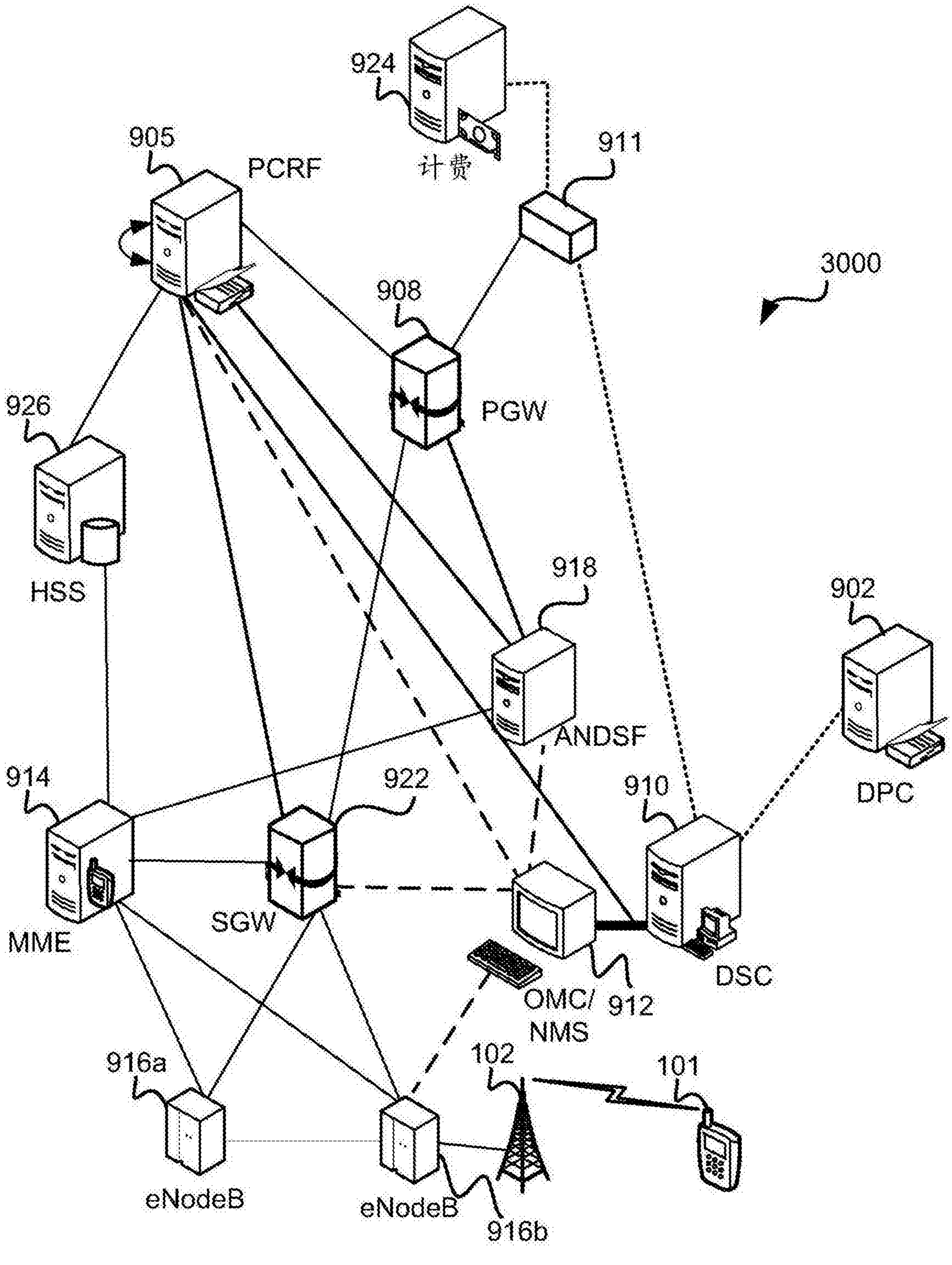

924
计费
911
905
PCRF
3000
908
PGW
926
HSS
918
902
ANDSF
DPC
914
922
910
MME
SGW
DSC
OMC/
NMS
912
102
101
916a
eNodeB
eNodeB
916b

图 30

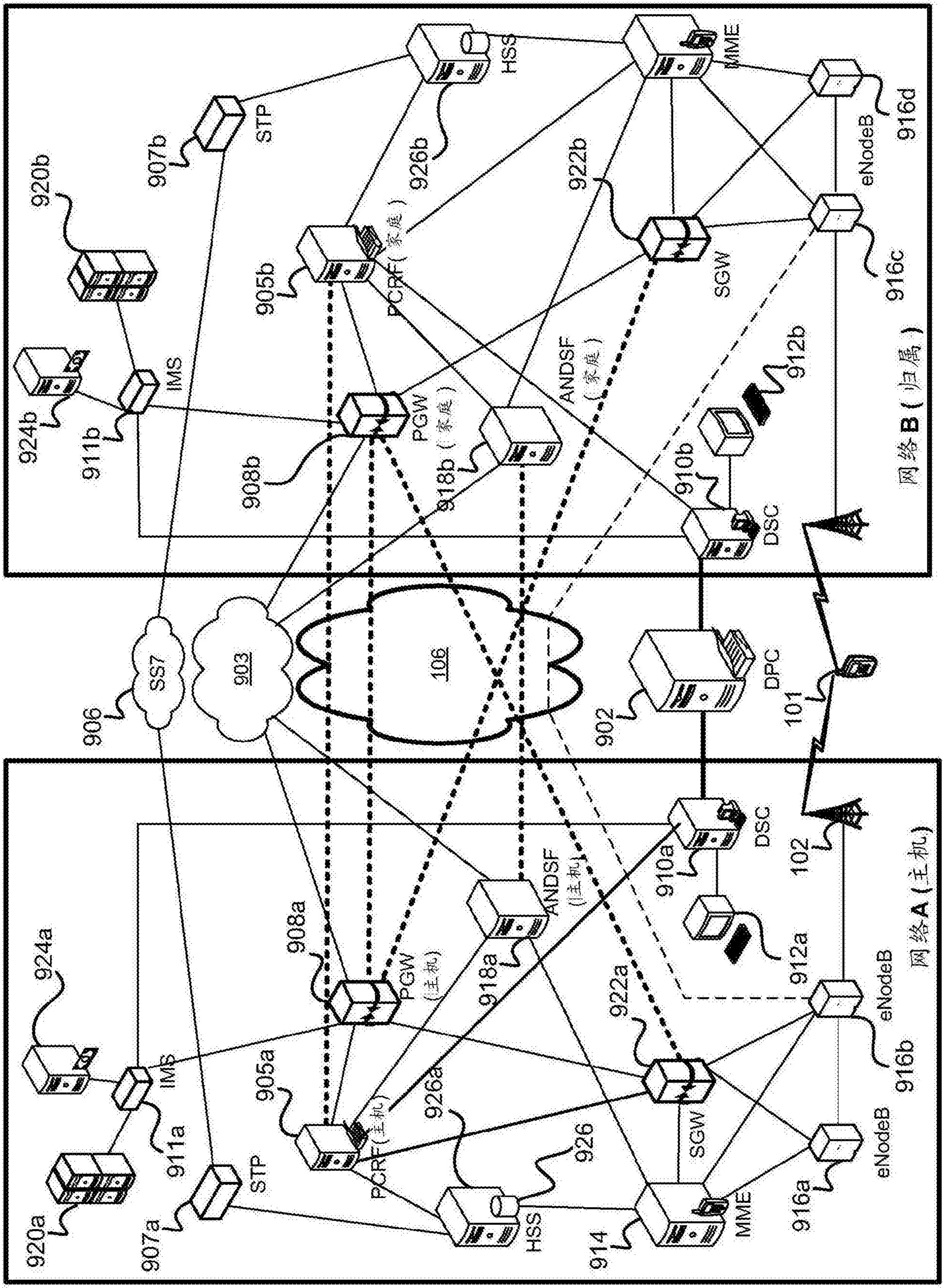

网络B(归属)
920b
907b
STP
HSS
926b
MME
924b
911b
IMS
905b
PCRF(家庭)
922b
916d
eNodeB
908b
PGW(家庭)
918b
ANDSF(家庭)
SGW
916c
912b
910b
DSC
906
SS7
903
106
902
DPC
101
网络A(主机)
924a
920a
911a
IMS
907a
STP
905a
PCRF(主机)
908a
PGW(主机)
926a
926
HSS
918a
ANDSF(主机)
914
MME
SGW
922a
910a
DSC
912a
102
916a
eNodeB
916b
eNodeB

图 31

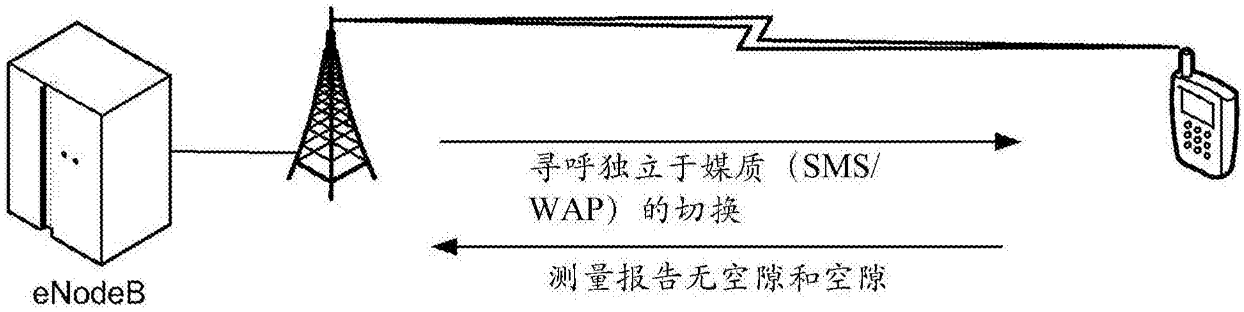


图 32

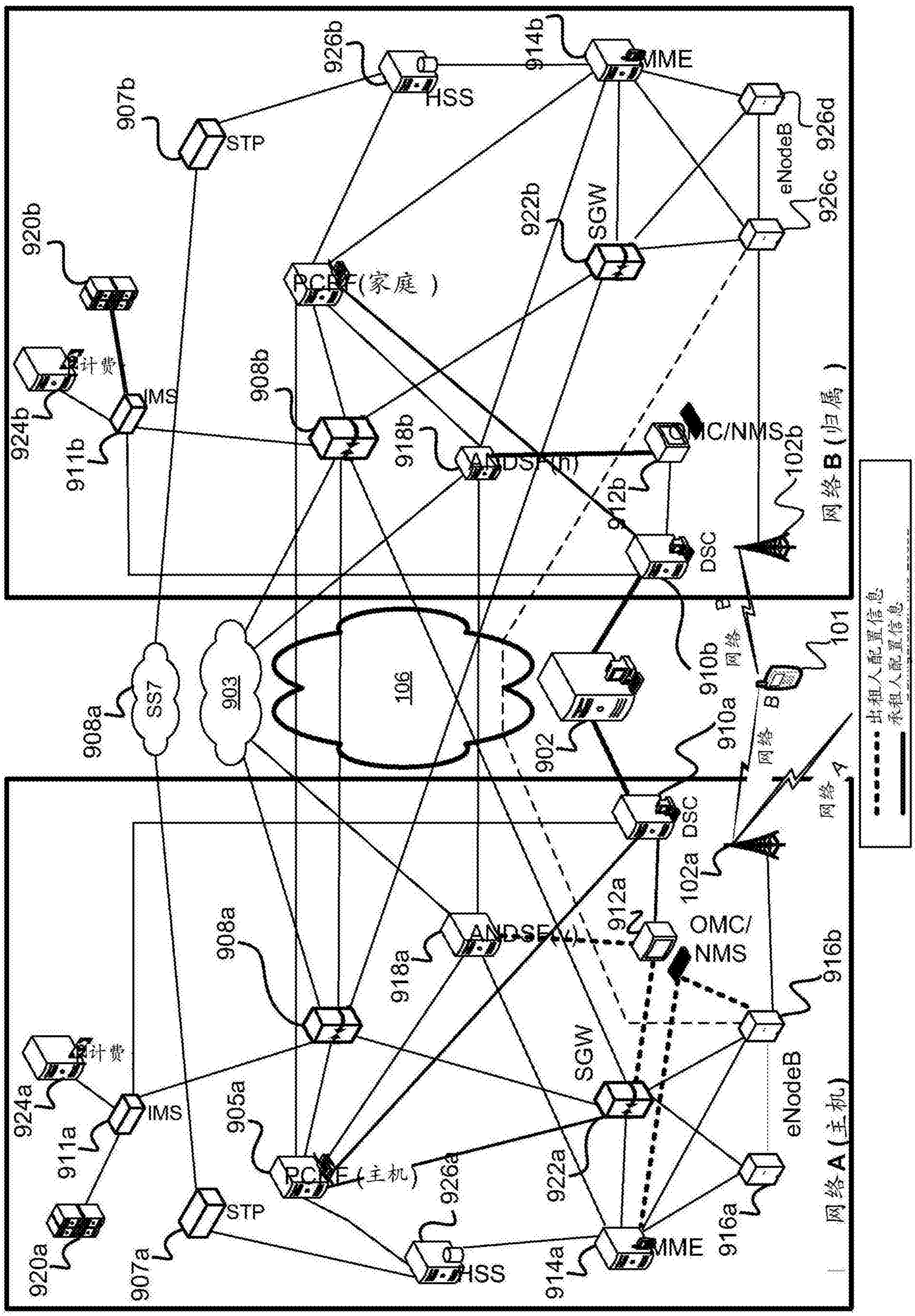

网络 A (主机)
网络 B (归属)
出租人配置信息
承租人配置信息
MME
HSS
STP
IMS
计费
PCRF (主机)
PCRF (家庭)
SGW
eNodeB
ANDSF(v)
ANDSF(h)
OMC/NMS
DSC
SS7
903
106
网络 A
网络 B
914a
916a
926a
922a
905a
907a
920a
911a
924a
908a
918a
912a
916b
102a
910a
902
908a
101
910b
102b
912b
918b
908b
911b
924b
920b
907b
926b
914b
922b
926c
926d

图 33

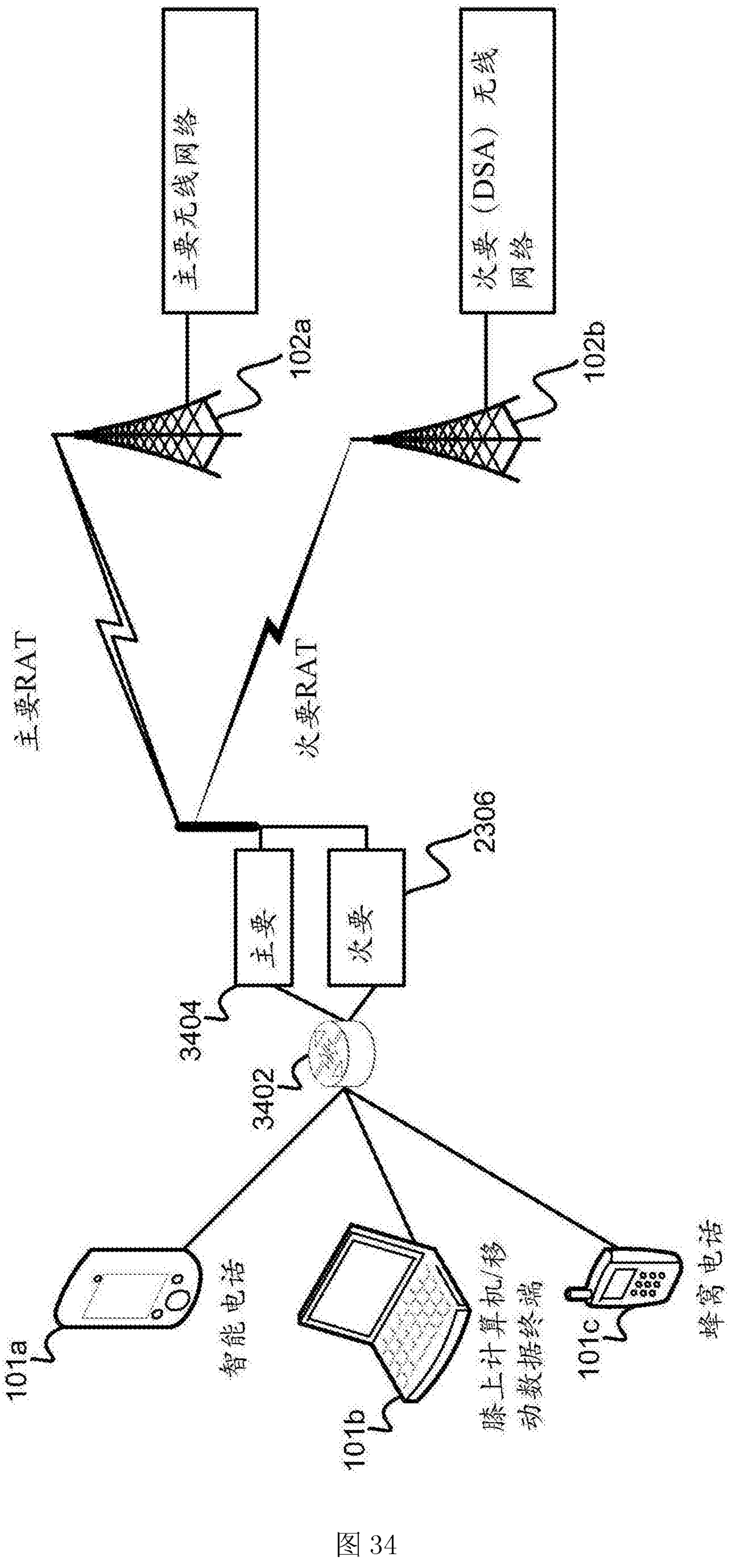

主要无线网络
次要（DSA）无线网络
102a
102b
主要RAT
次要RAT
2306
主要
次要
3404
3402
101a
智能电话
101b
膝上计算机/移动数据终端
101c
蜂窝电话

图 34

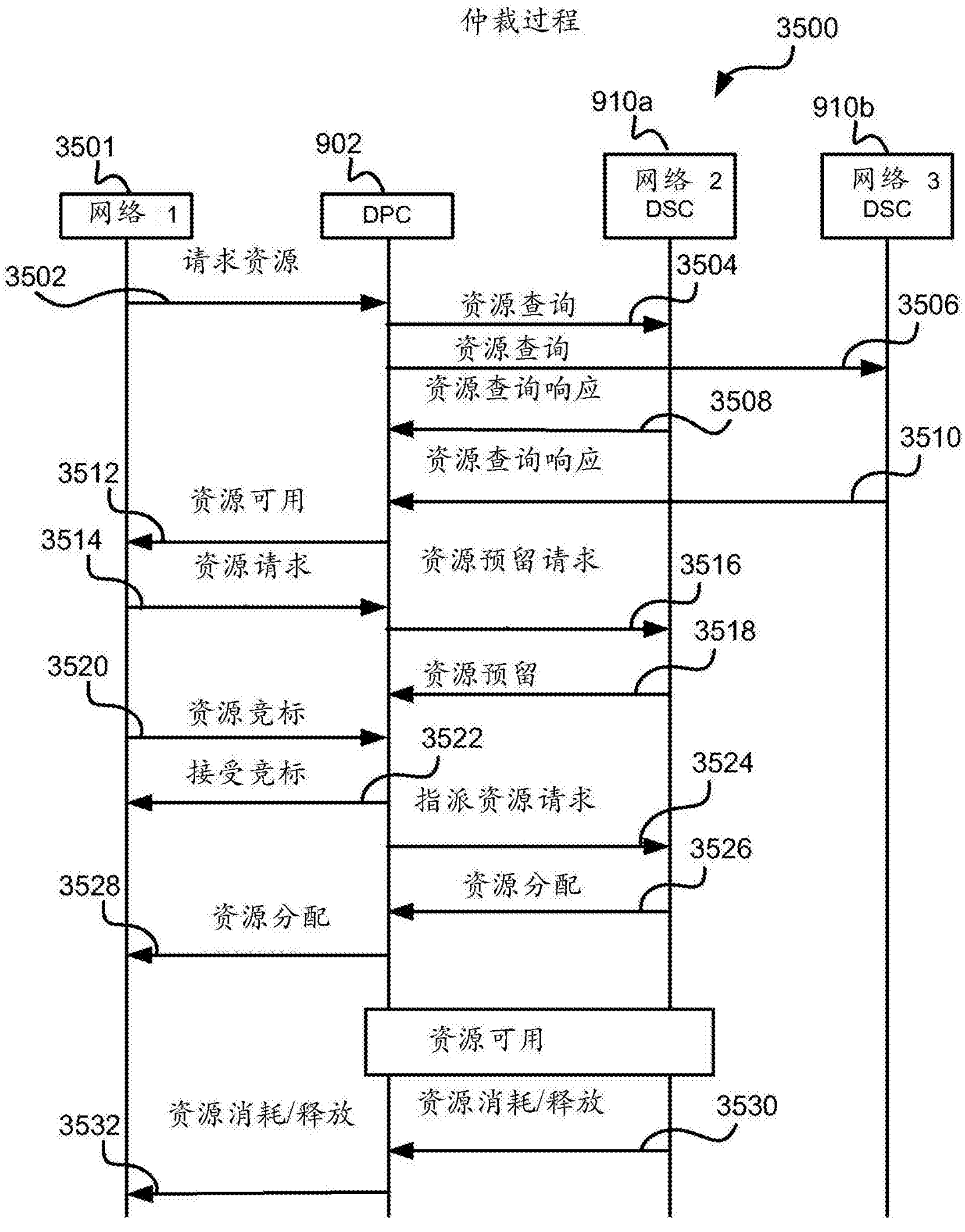

仲裁过程
3500
910a
910b
3501
902
网络 1
DPC
网络 2
DSC
网络 3
DSC
请求资源
3502
3504
资源查询
3506
资源查询
资源查询响应
3508
资源查询响应
3510
3512
资源可用
3514
资源请求
资源预留请求
3516
3518
3520
资源预留
资源竞标
3522
接受竞标
3524
指派资源请求
3526
3528
资源分配
资源分配
资源可用
资源消耗/释放
资源消耗/释放
3530
3532

图 35

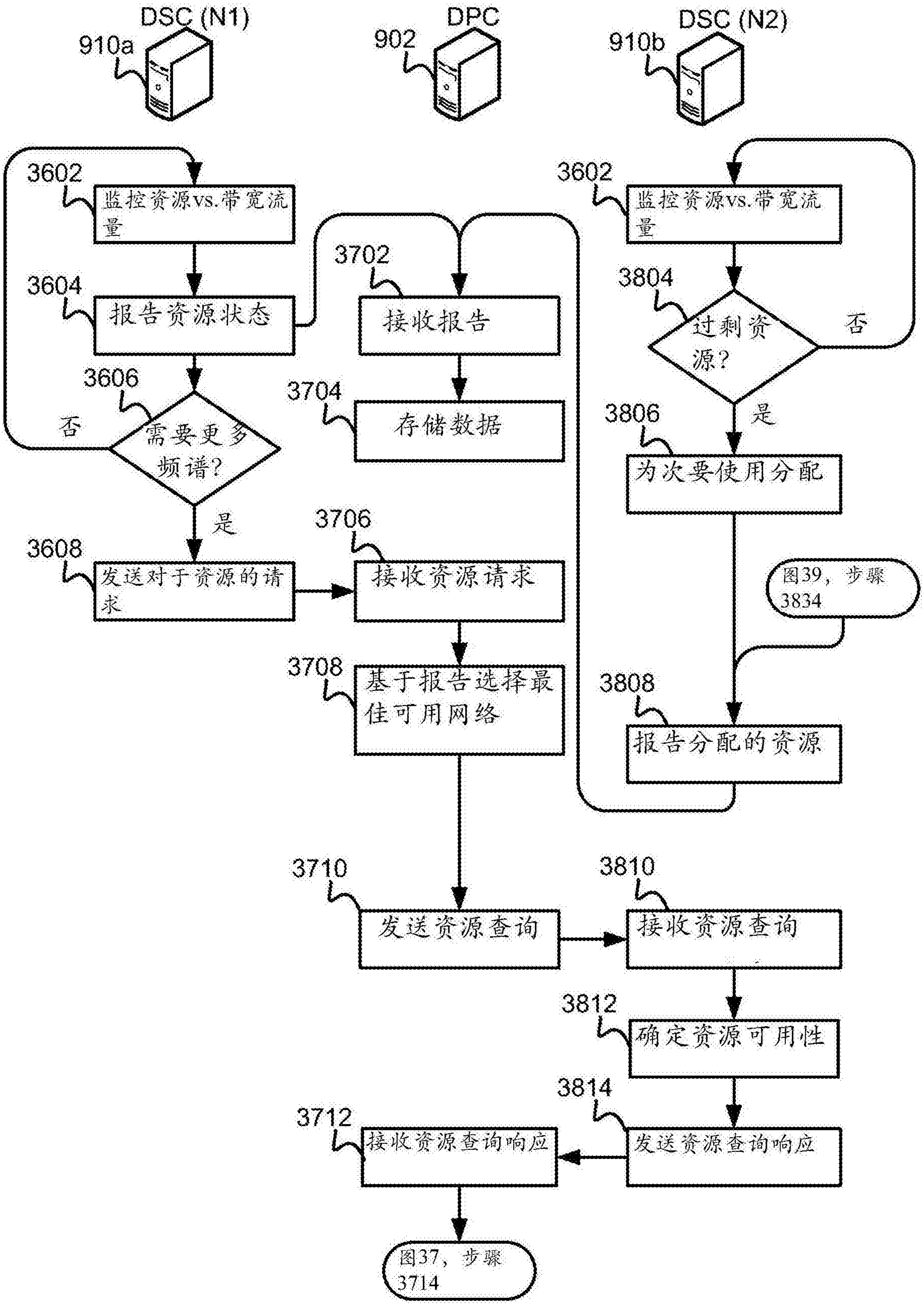

DSC (N1)
910a
DPC
902
DSC (N2)
910b
3602
监控资源vs.带宽流量
3604
报告资源状态
3606
需要更多频谱?
否
是
3608
发送对于资源的请求
3702
接收报告
3704
存储数据
3706
接收资源请求
3708
基于报告选择最佳可用网络
3602
监控资源vs.带宽流量
3804
过剩资源?
否
是
3806
为次要使用分配
图39，步骤3834
3808
报告分配的资源
3710
发送资源查询
3810
接收资源查询
3812
确定资源可用性
3814
发送资源查询响应
3712
接收资源查询响应
图37，步骤3714

图 36

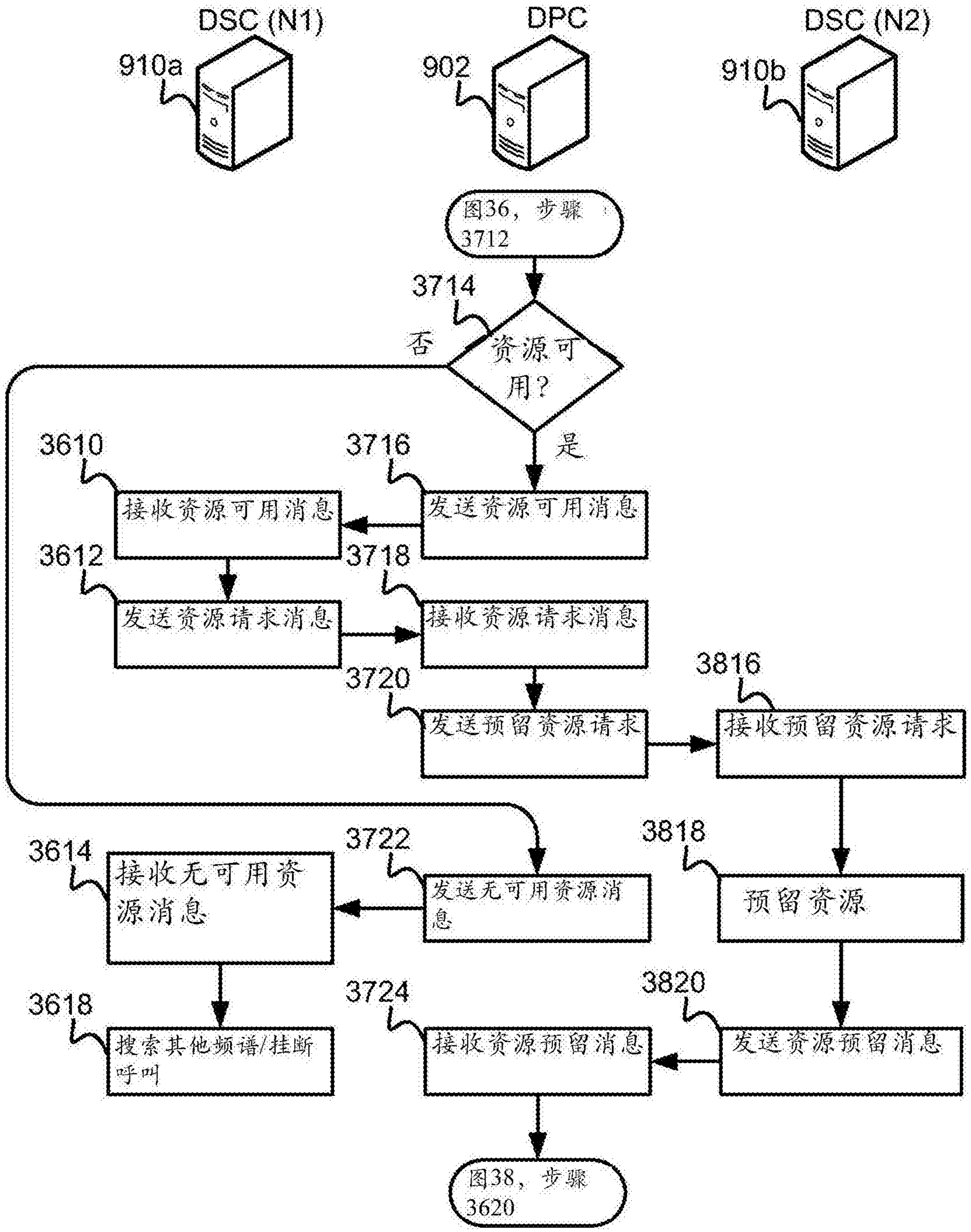

DSC (N1)
910a
DPC
902
DSC (N2)
910b
图36，步骤3712
3714
资源可用？
否
是
3610
接收资源可用消息
3716
发送资源可用消息
3612
发送资源请求消息
3718
接收资源请求消息
3720
发送预留资源请求
3816
接收预留资源请求
3614
接收无可用资源消息
3722
发送无可用资源消息
3818
预留资源
3618
搜索其他频谱/挂断呼叫
3724
接收资源预留消息
3820
发送资源预留消息
图38，步骤3620

图 37

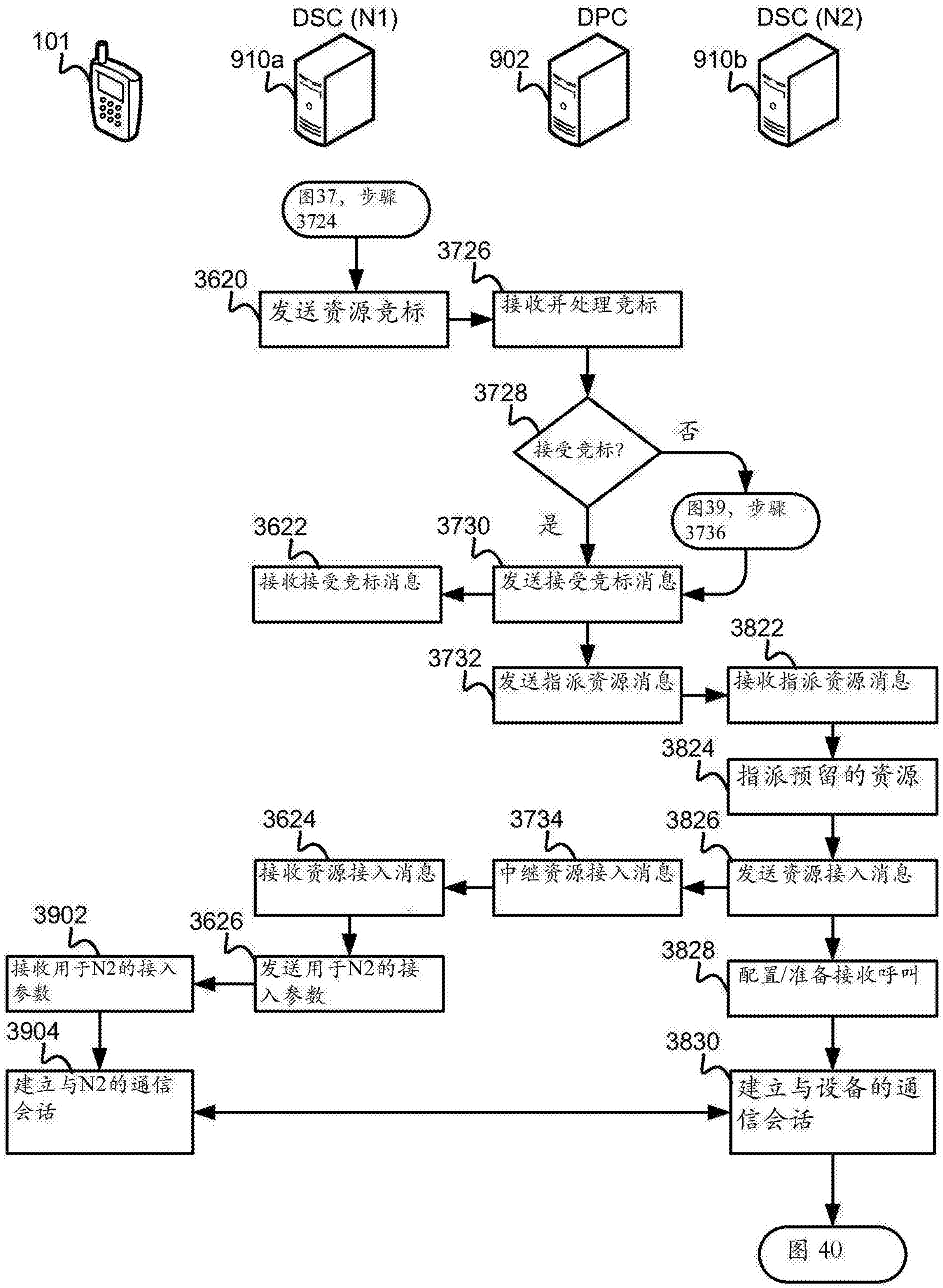

DSC (N1)
DPC
DSC (N2)
101
910a
902
910b
图37，步骤3724
3620
发送资源竞标
3726
接收并处理竞标
3728
接受竞标?
否
图39，步骤3736
是
3622
接收接受竞标消息
3730
发送接受竞标消息
3732
发送指派资源消息
3822
接收指派资源消息
3824
指派预留的资源
3624
接收资源接入消息
3734
中继资源接入消息
3826
发送资源接入消息
3902
接收用于N2的接入参数
3626
发送用于N2的接入参数
3828
配置/准备接收呼叫
3904
建立与N2的通信会话
3830
建立与设备的通信会话
图 40

图 38

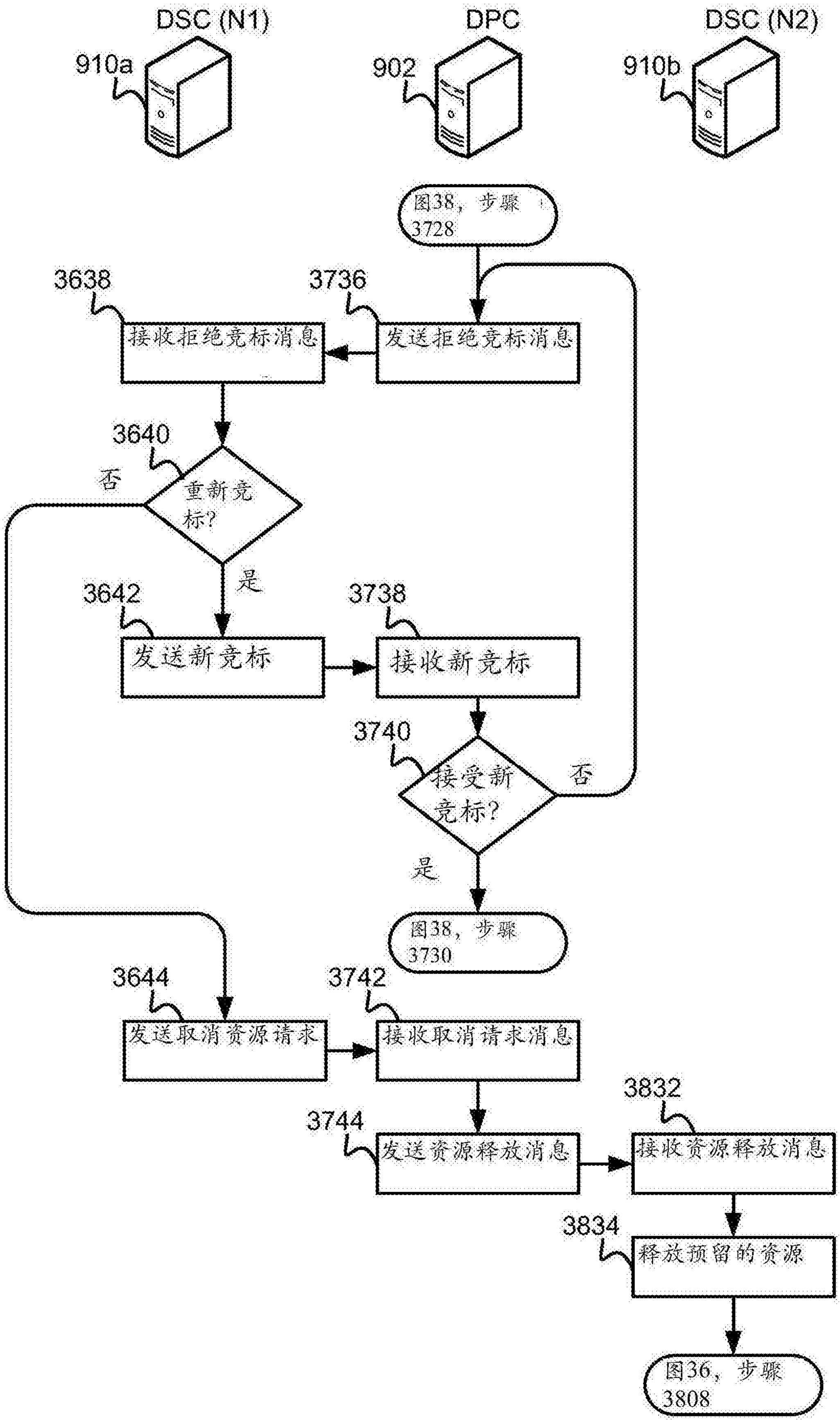

DSC (N1)
910a
DPC
902
DSC (N2)
910b
图38，步骤 3728
3638
3736
接收拒绝竞标消息
发送拒绝竞标消息
3640
否
重新竞标?
是
3642
3738
发送新竞标
接收新竞标
3740
接受新竞标?
否
是
图38，步骤 3730
3644
3742
发送取消资源请求
接收取消请求消息
3832
3744
发送资源释放消息
接收资源释放消息
3834
释放预留的资源
图36，步骤 3808

图 39

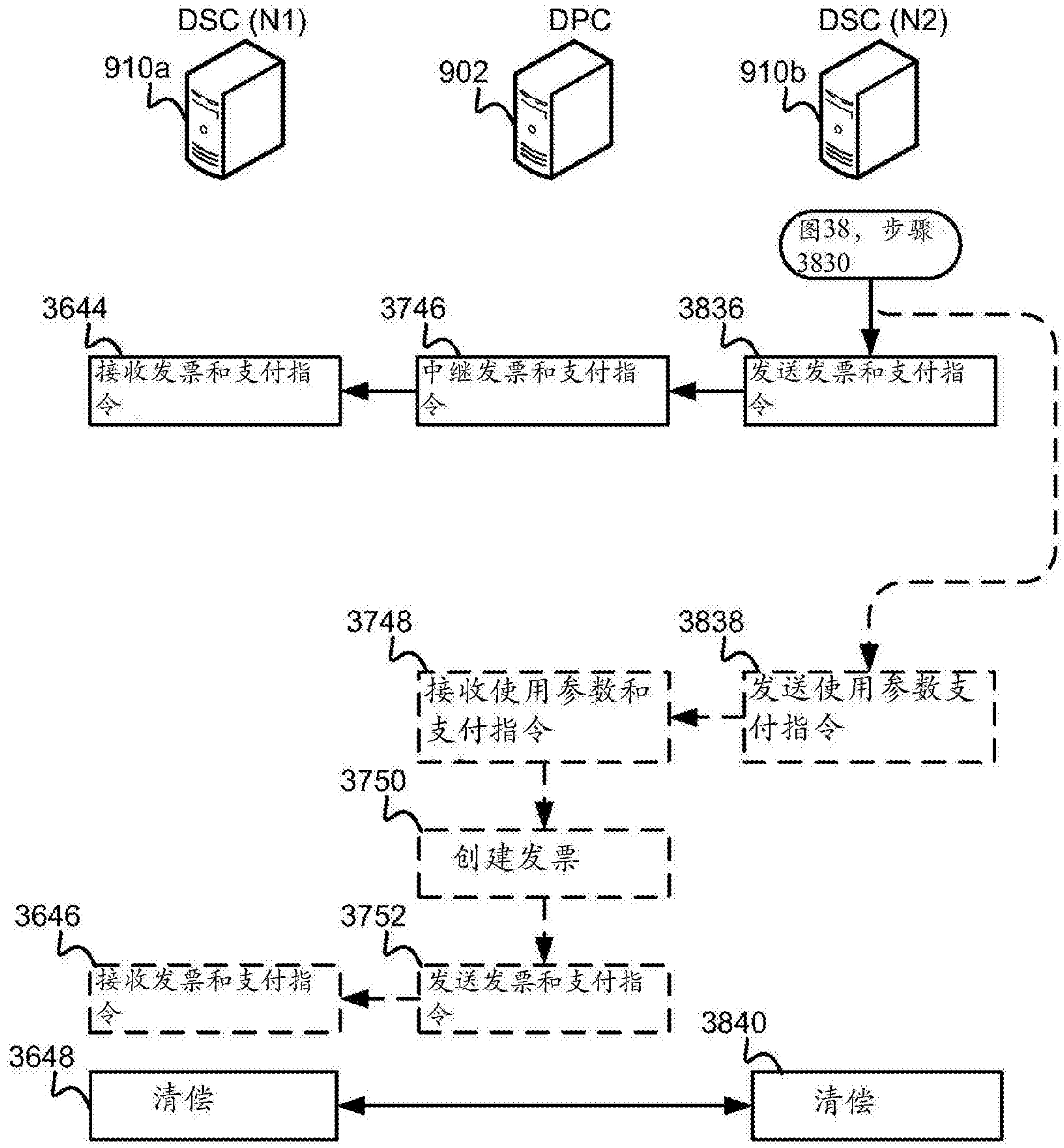

DSC (N1)
910a
DPC
902
DSC (N2)
910b
图38，步骤3830
3644
接收发票和支付指令
3746
中继发票和支付指令
3836
发送发票和支付指令
3748
接收使用参数和支付指令
3838
发送使用参数支付指令
3750
创建发票
3646
接收发票和支付指令
3752
发送发票和支付指令
3648
清偿
3840
清偿

图 40

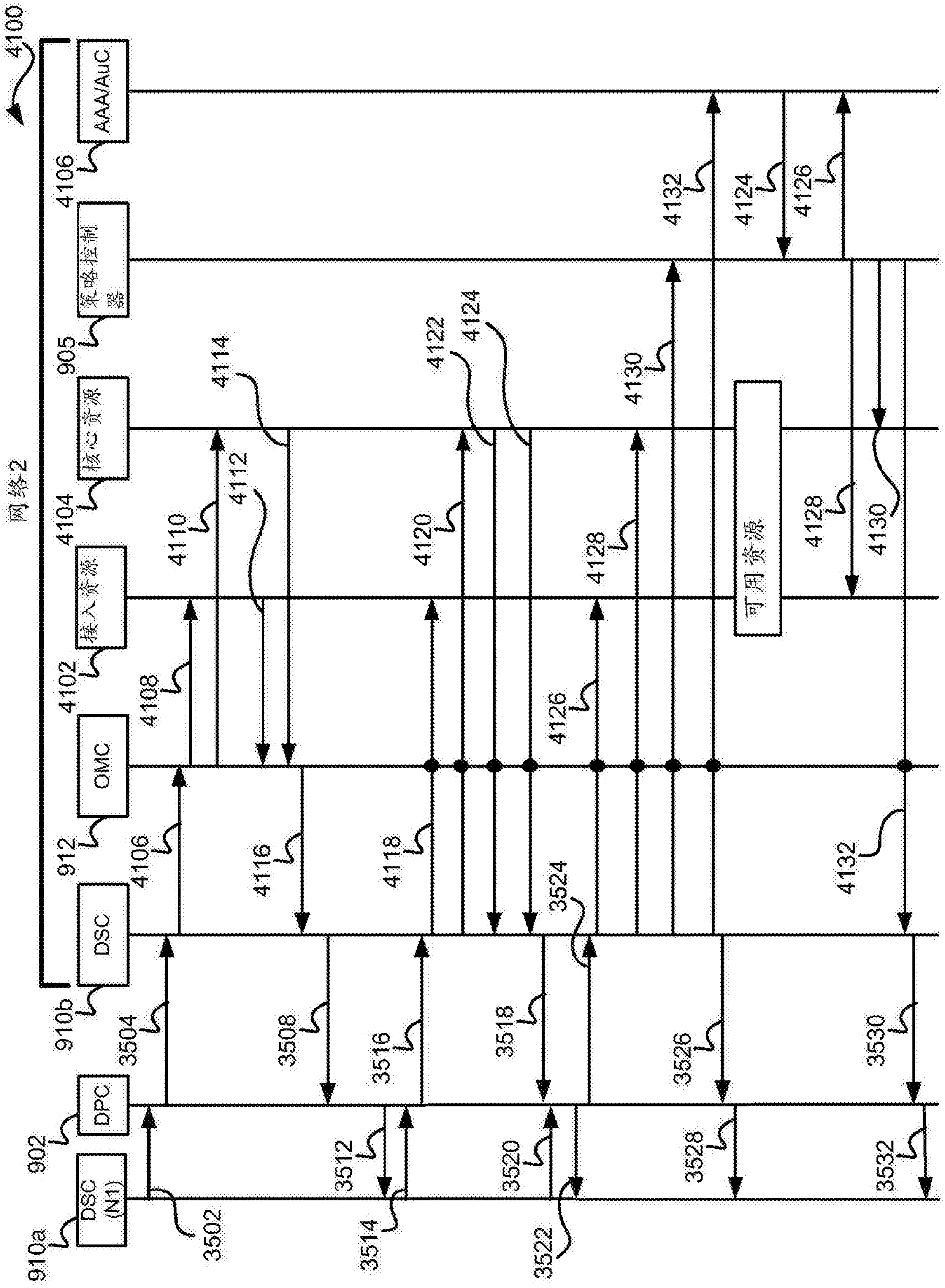

4100
网络2
DSC (N1)
DPC
DSC
OMC
接入资源
核心资源
策略控制器
AAA/AuC
可用资源
910a
902
910b
912
4102
4104
905
4106
3502
3504
3508
3512
3514
3516
3518
3520
3522
3524
3526
3528
3530
3532
4106
4108
4110
4112
4114
4116
4118
4120
4122
4124
4126
4128
4130
4132

图 41

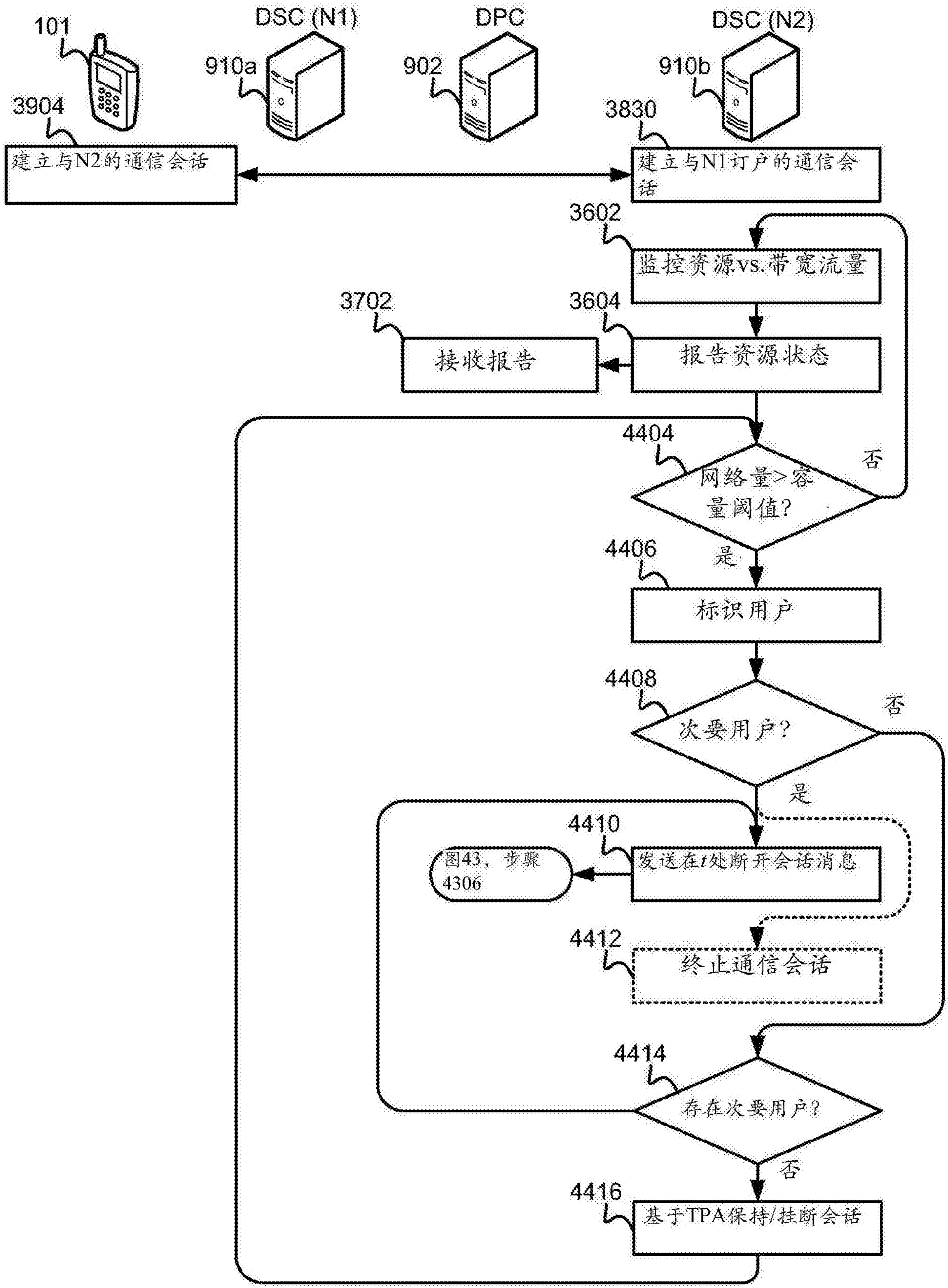

101
DSC (N1)
DPC
DSC (N2)
910a
902
910b
3904
3830
建立与N2的通信会话
建立与N1订户的通信会话
3602
监控资源vs.带宽流量
3702
3604
接收报告
报告资源状态
4404
网络量>容量阈值?
否
4406
是
标识用户
4408
次要用户?
否
是
4410
图43，步骤4306
发送在t处断开会话消息
4412
终止通信会话
4414
存在次要用户?
否
4416
基于TPA保持/挂断会话

图 42

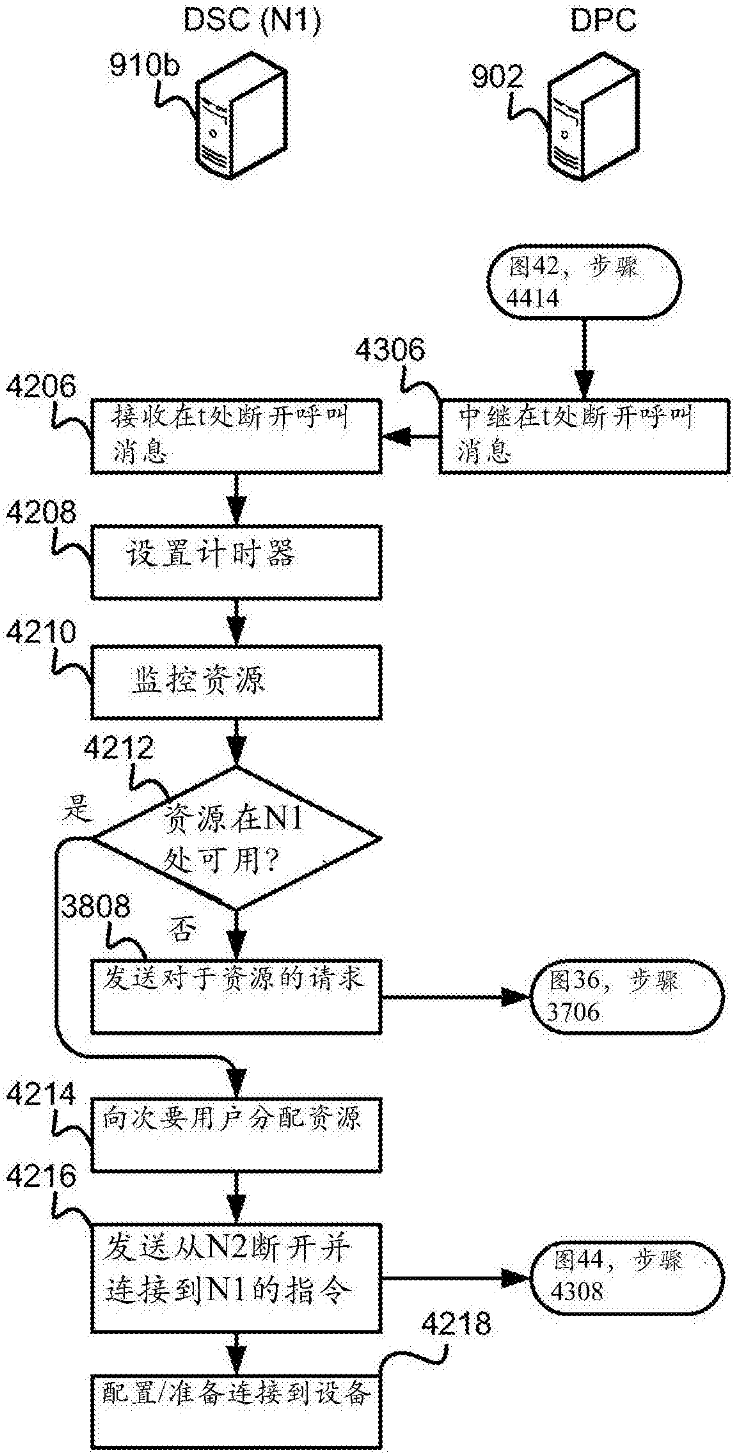

DSC (N1)
910b
DPC
902
图42，步骤 4414
4306
中继在t处断开呼叫消息
4206
接收在t处断开呼叫消息
4208
设置计时器
4210
监控资源
4212
资源在N1处可用?
是
否
3808
发送对于资源的请求
图36，步骤 3706
4214
向次要用户分配资源
4216
发送从N2断开并连接到N1的指令
图44，步骤 4308
4218
配置/准备连接到设备

图 43

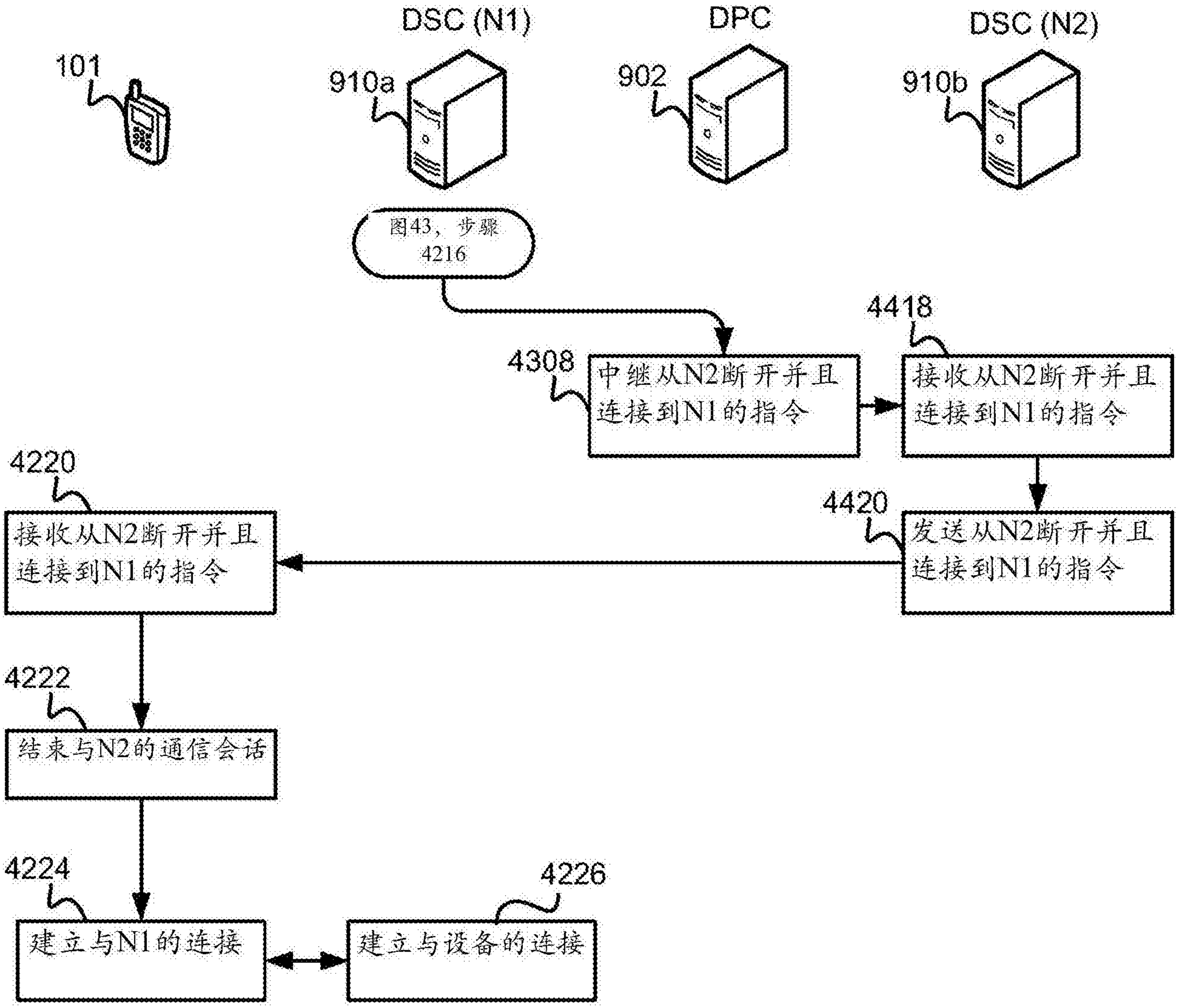

DSC (N1)
DPC
DSC (N2)
101
910a
902
910b
图43，步骤
4216
4418
4308
中继从N2断开并且连接到N1的指令
接收从N2断开并且连接到N1的指令
4220
4420
接收从N2断开并且连接到N1的指令
发送从N2断开并且连接到N1的指令
4222
结束与N2的通信会话
4224
4226
建立与N1的连接
建立与设备的连接

图 44

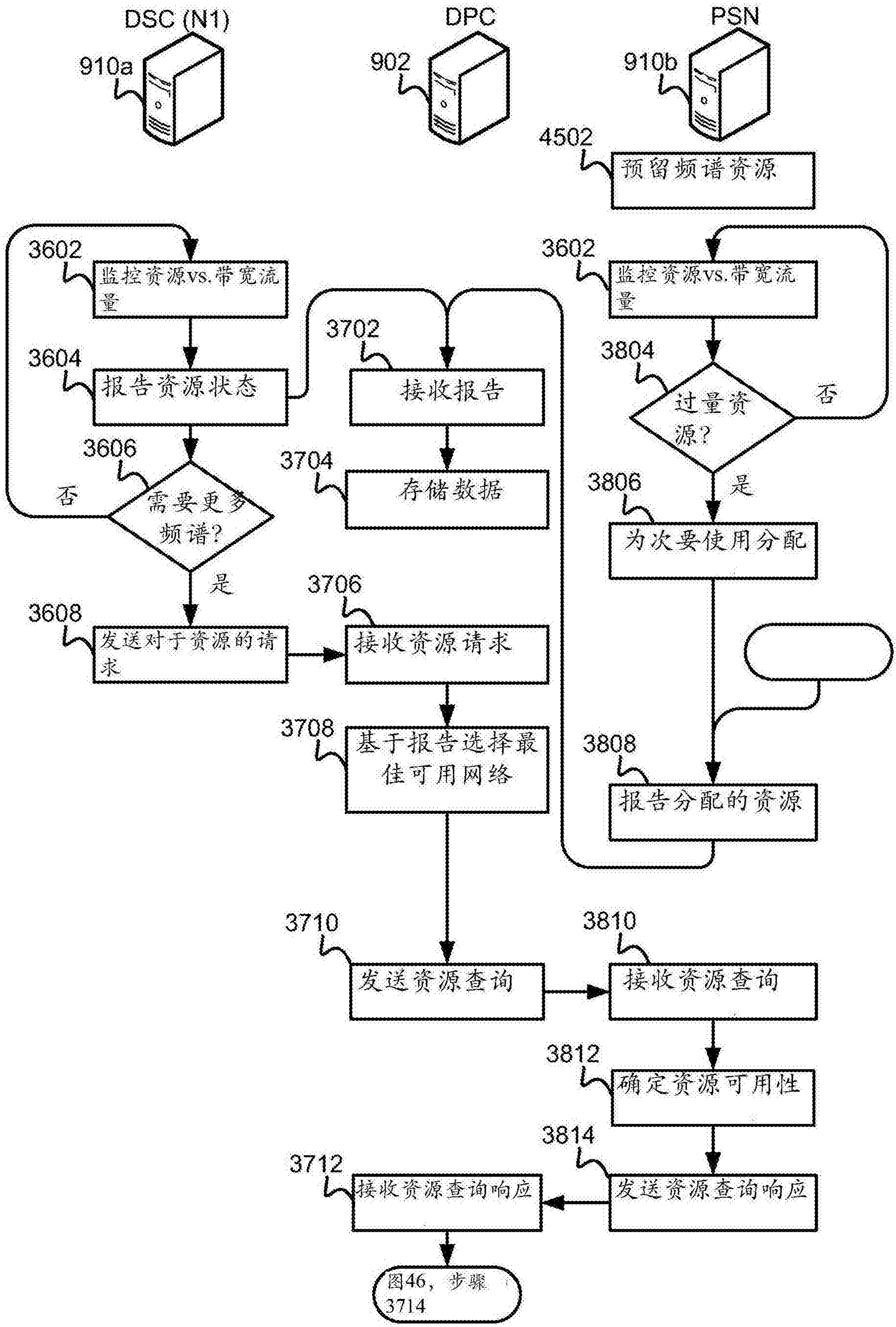

DSC (N1)
910a
DPC
902
PSN
910b
4502
预留频谱资源
3602
监控资源vs.带宽流量
3604
报告资源状态
3606
需要更多频谱?
否
是
3608
发送对于资源的请求
3702
接收报告
3704
存储数据
3706
接收资源请求
3708
基于报告选择最佳可用网络
3602
监控资源vs.带宽流量
3804
过量资源?
否
是
3806
为次要使用分配
3808
报告分配的资源
3710
发送资源查询
3810
接收资源查询
3812
确定资源可用性
3814
发送资源查询响应
3712
接收资源查询响应
图46，步骤3714

图 45

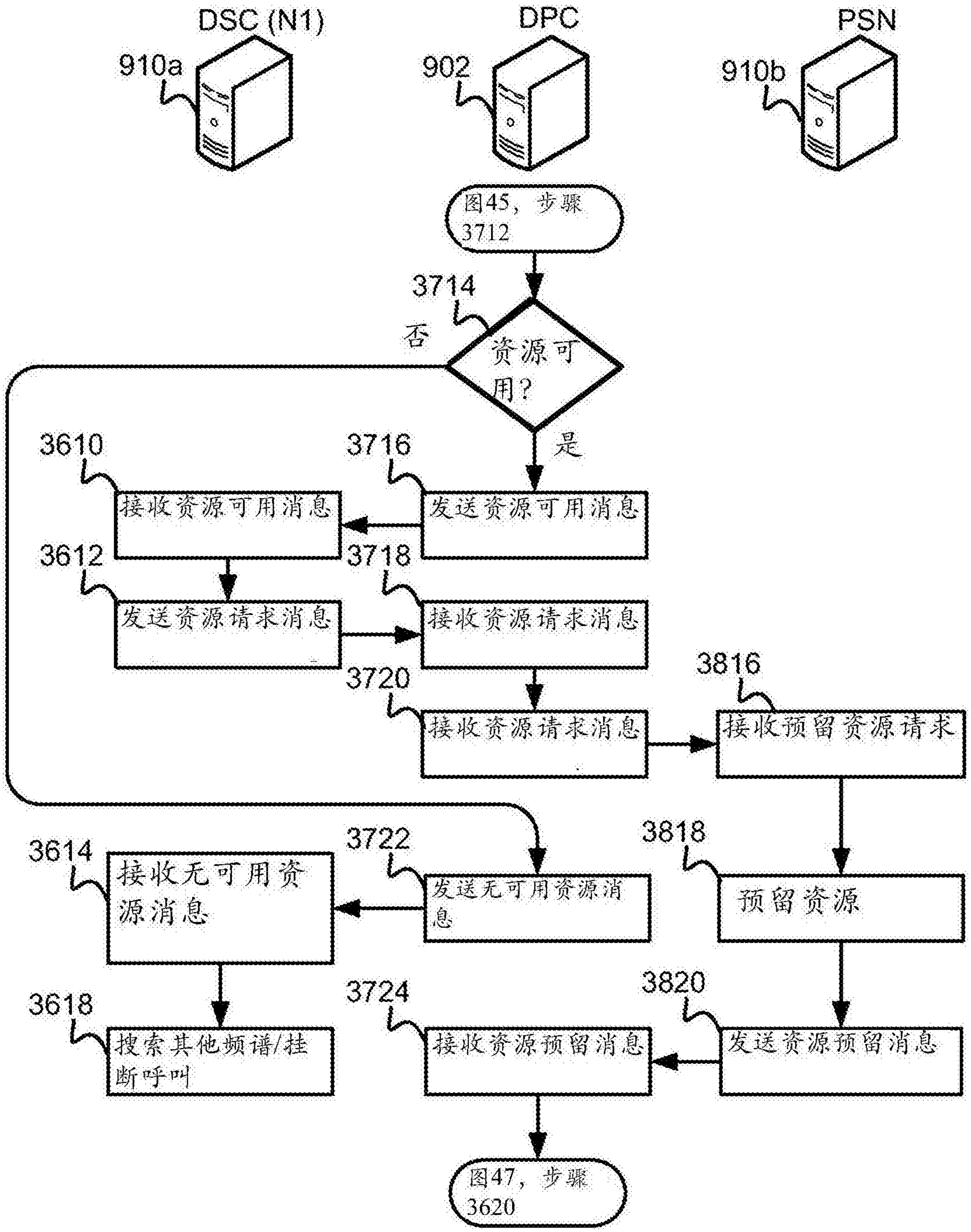
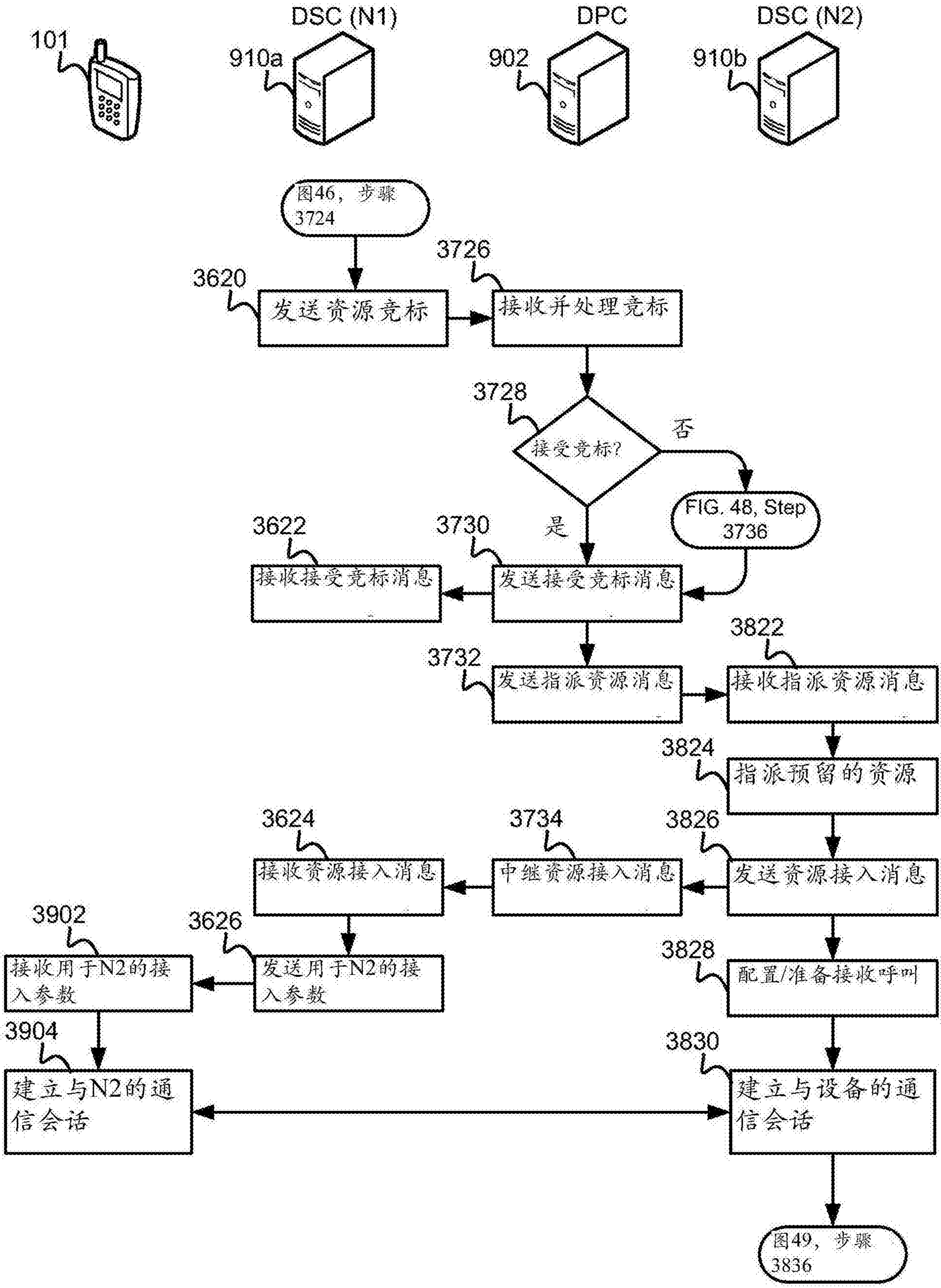

DSC (N1)
DPC
PSN
910a
902
910b
图45，步骤3712
3714
资源可用?
否
是
3610
接收资源可用消息
3716
发送资源可用消息
3612
发送资源请求消息
3718
接收资源请求消息
3720
接收资源请求消息
3816
接收预留资源请求
3614
接收无可用资源消息
3722
发送无可用资源消息
3818
预留资源
3618
搜索其他频谱/挂断呼叫
3724
接收资源预留消息
3820
发送资源预留消息
图47，步骤3620

图 46



101
DSC (N1)
910a
DPC
902
DSC (N2)
910b
图46，步骤 3724
3620
发送资源竞标
3726
接收并处理竞标
3728
接受竞标?
否
是
FIG. 48, Step 3736
3622
接收接受竞标消息
3730
发送接受竞标消息
3732
发送指派资源消息
3822
接收指派资源消息
3824
指派预留的资源
3624
接收资源接入消息
3734
中继资源接入消息
3826
发送资源接入消息
3902
接收用于N2的接入参数
3626
发送用于N2的接入参数
3828
配置/准备接收呼叫
3904
建立与N2的通信会话
3830
建立与设备的通信会话
图49，步骤 3836

图 47

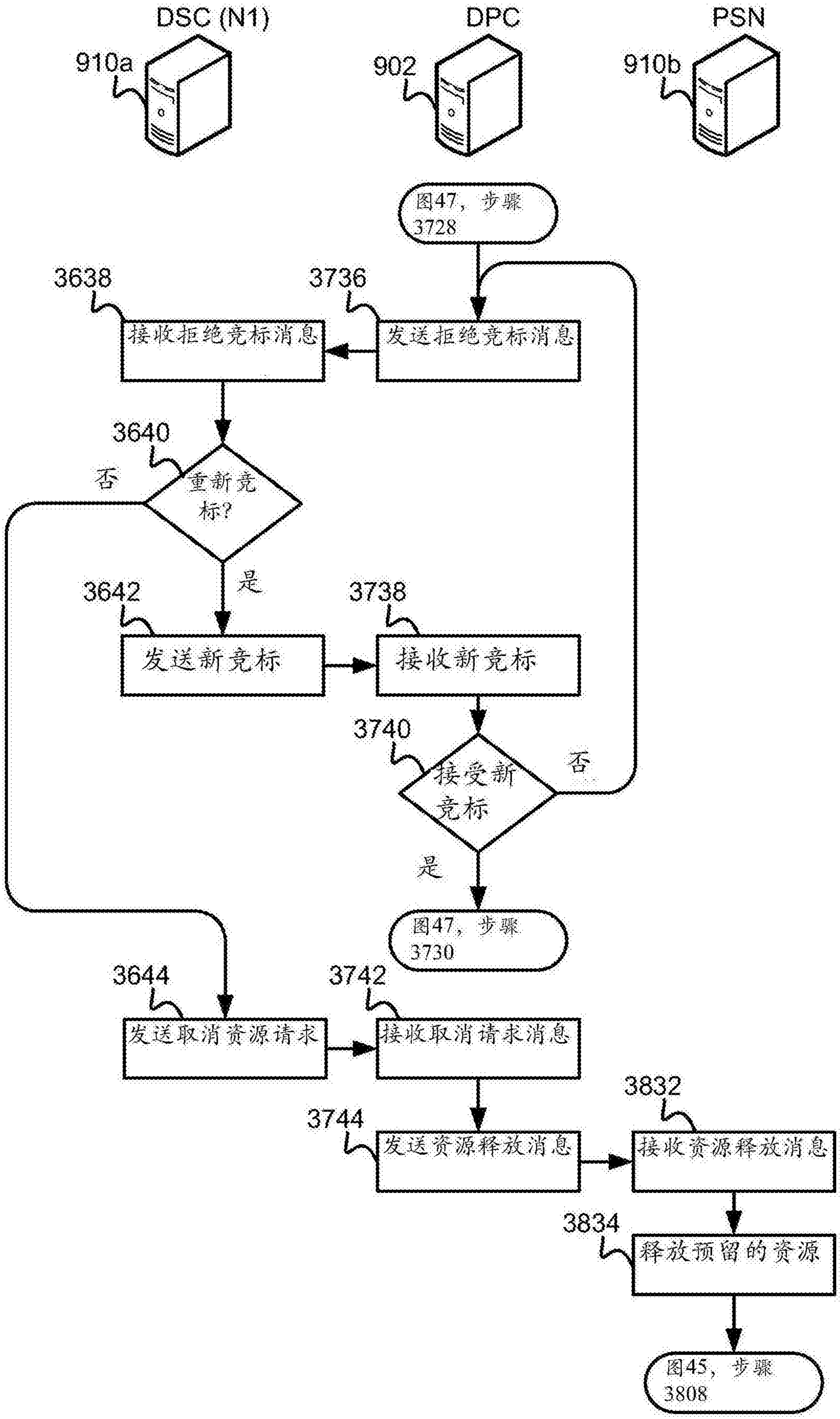

DSC (N1)
DPC
PSN
910a
902
910b
图47，步骤 3728
3638
3736
接收拒绝竞标消息
发送拒绝竞标消息
3640
否
重新竞标?
是
3642
3738
发送新竞标
接收新竞标
3740
接受新竞标
否
是
图47，步骤 3730
3644
3742
发送取消资源请求
接收取消请求消息
3832
3744
发送资源释放消息
接收资源释放消息
3834
释放预留的资源
图45，步骤 3808

图 48

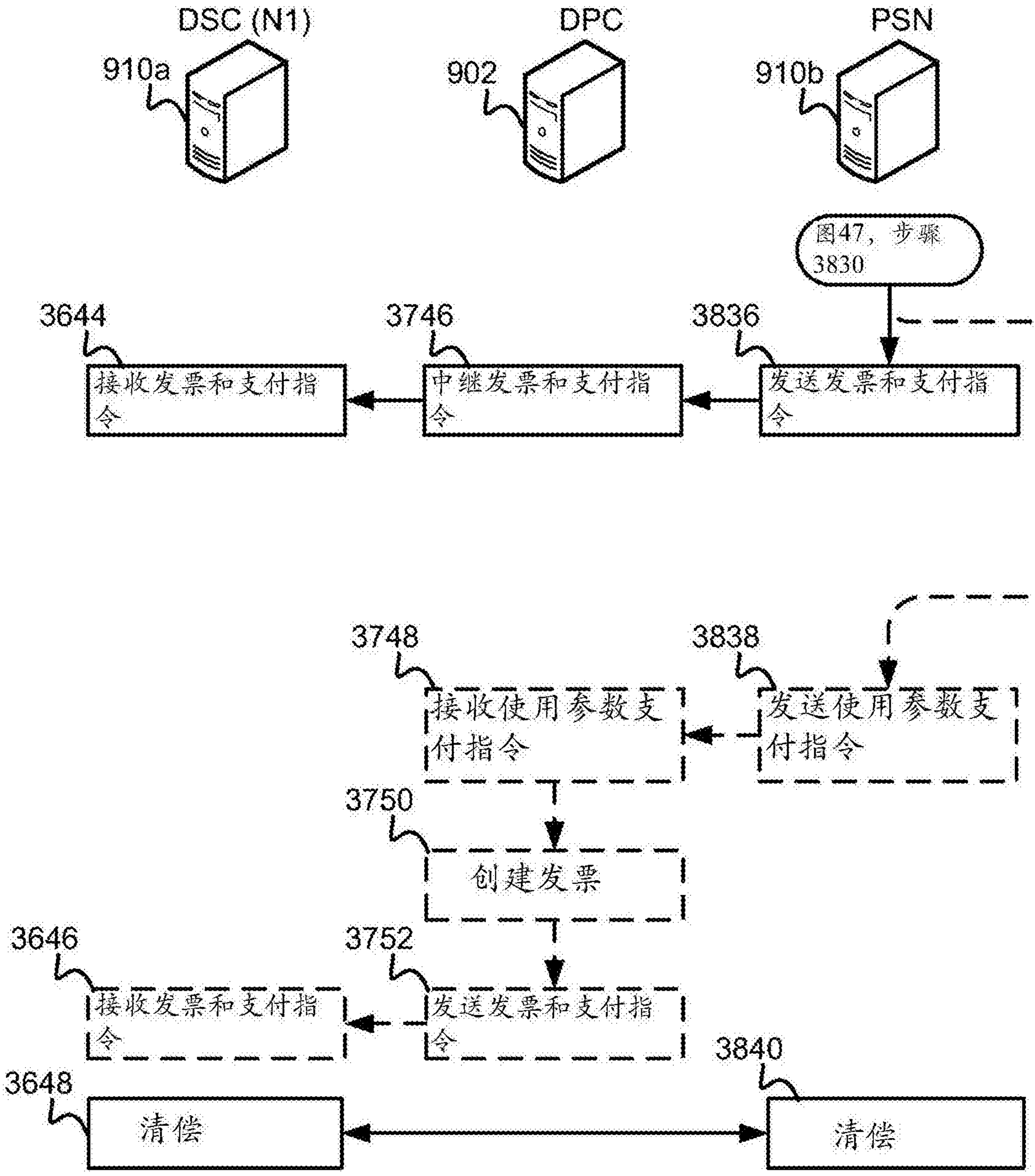
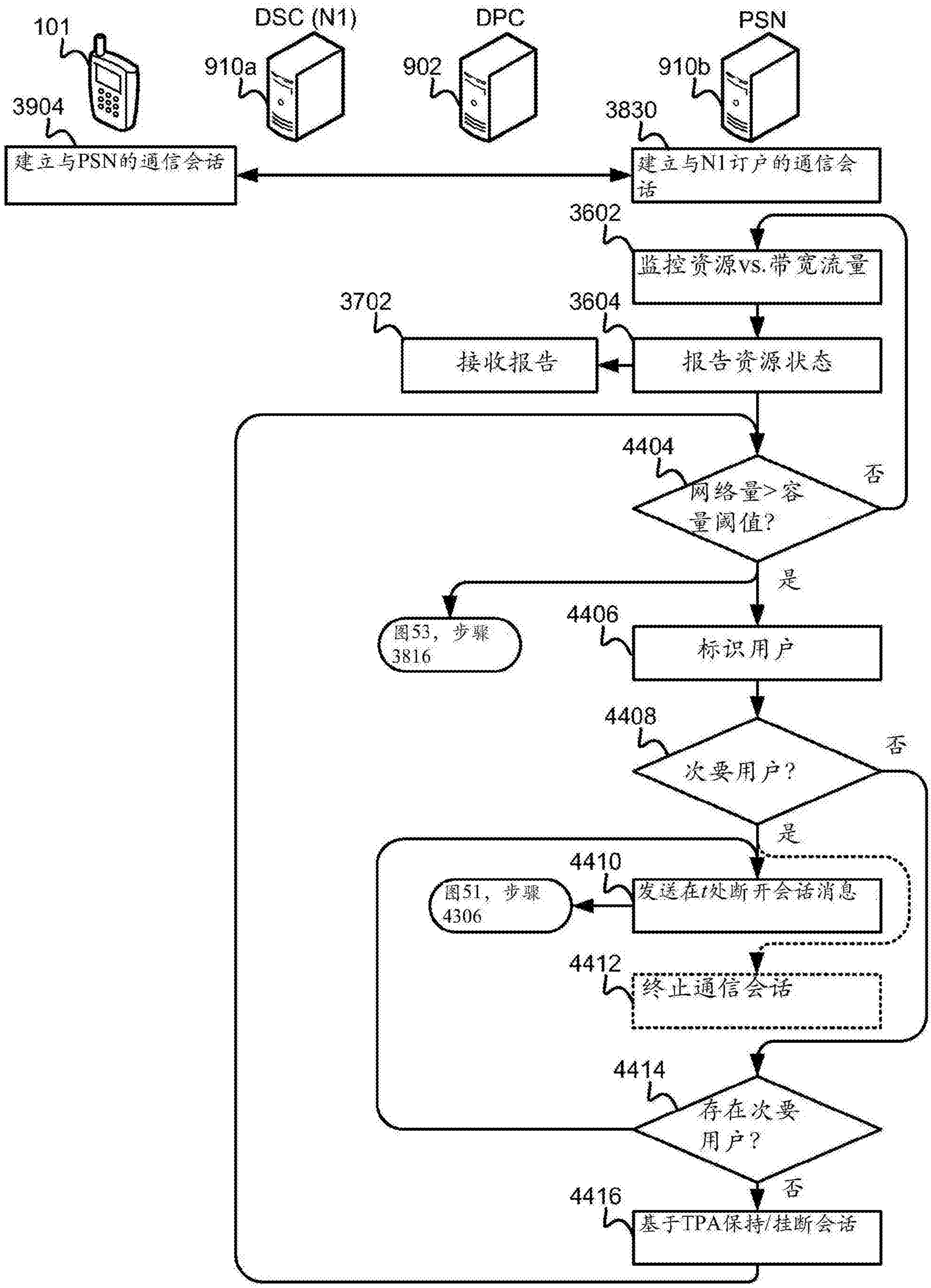

DSC (N1)
910a
DPC
902
PSN
910b
图47，步骤3830
3644
接收发票和支付指令
3746
中继发票和支付指令
3836
发送发票和支付指令
3748
接收使用参数支付指令
3838
发送使用参数支付指令
3750
创建发票
3646
接收发票和支付指令
3752
发送发票和支付指令
3840
3648
清偿
清偿

图 49



101
DSC (N1)
DPC
PSN
910a
902
910b
3904
3830
建立与PSN的通信会话
建立与N1订户的通信会话
3602
监控资源vs.带宽流量
3702
3604
接收报告
报告资源状态
4404
网络量>容量阈值?
否
是
图53，步骤3816
4406
标识用户
4408
次要用户?
否
是
4410
图51，步骤4306
发送在t处断开会话消息
4412
终止通信会话
4414
存在次要用户?
否
4416
基于TPA保持/挂断会话

图 50

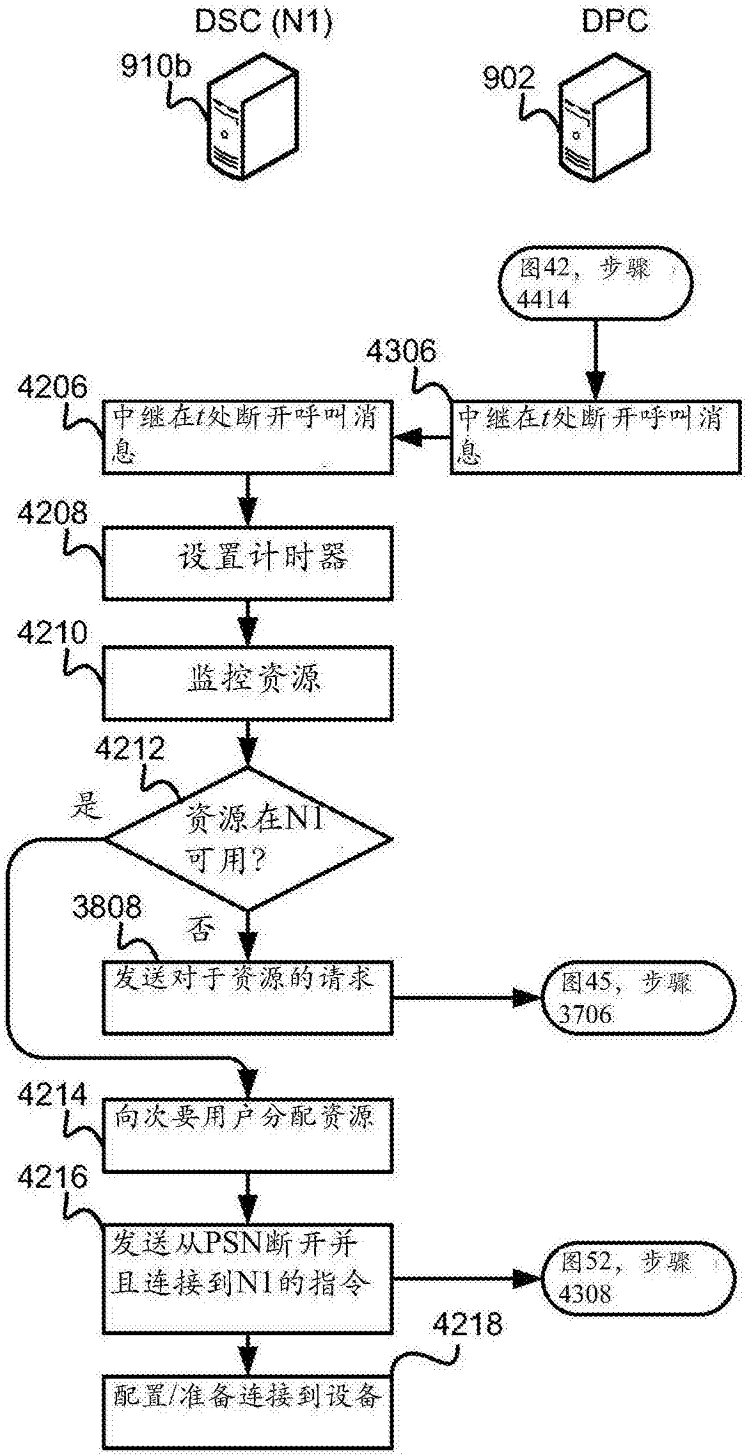

DSC (N1)
DPC
910b
902
图42，步骤
4414
4306
中继在t处断开呼叫消息
4206
中继在t处断开呼叫消息
4208
设置计时器
4210
监控资源
4212
是
资源在N1
可用?
3808
否
发送对于资源的请求
图45，步骤
3706
4214
向次要用户分配资源
4216
发送从PSN断开并且连接到N1的指令
图52，步骤
4308
4218
配置/准备连接到设备

图 51

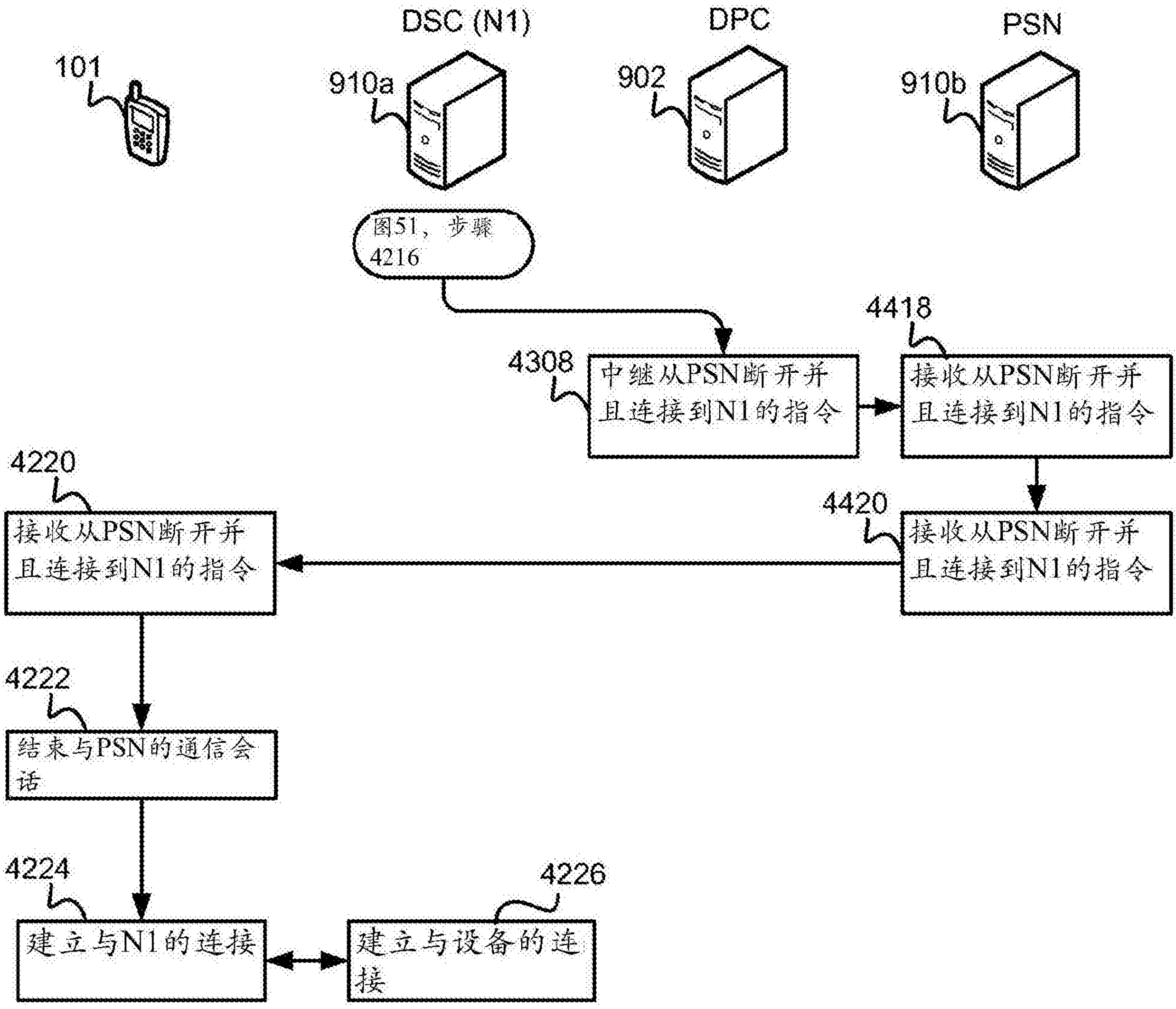

DSC (N1)
DPC
PSN
101
910a
902
910b
图51，步骤4216
4308
中继从PSN断开并且连接到N1的指令
4418
接收从PSN断开并且连接到N1的指令
4220
接收从PSN断开并且连接到N1的指令
4420
接收从PSN断开并且连接到N1的指令
4222
结束与PSN的通信会话
4224
建立与N1的连接
4226
建立与设备的连接

图 52

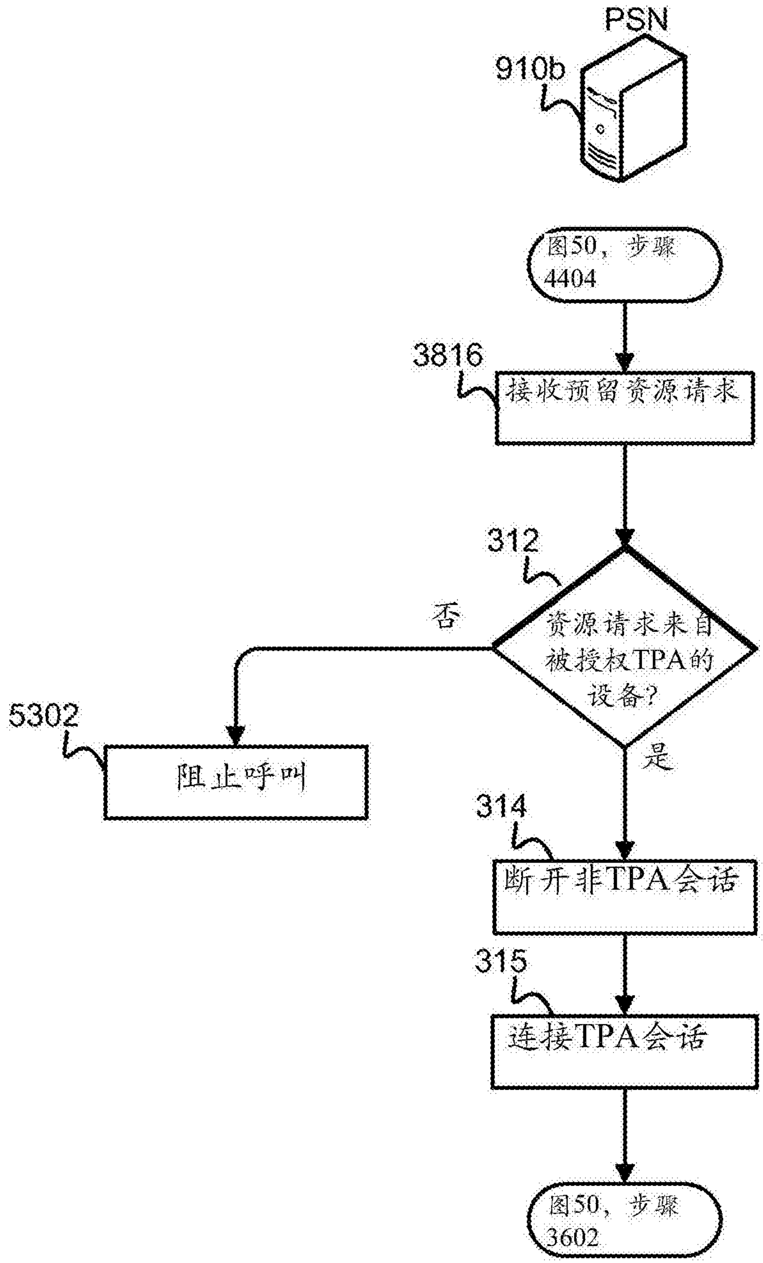

PSN
910b
图50，步骤
4404
3816
接收预留资源请求
312
资源请求来自
被授权TPA的
设备?
否
是
5302
阻止呼叫
314
断开非TPA会话
315
连接TPA会话
图50，步骤
3602

图 53

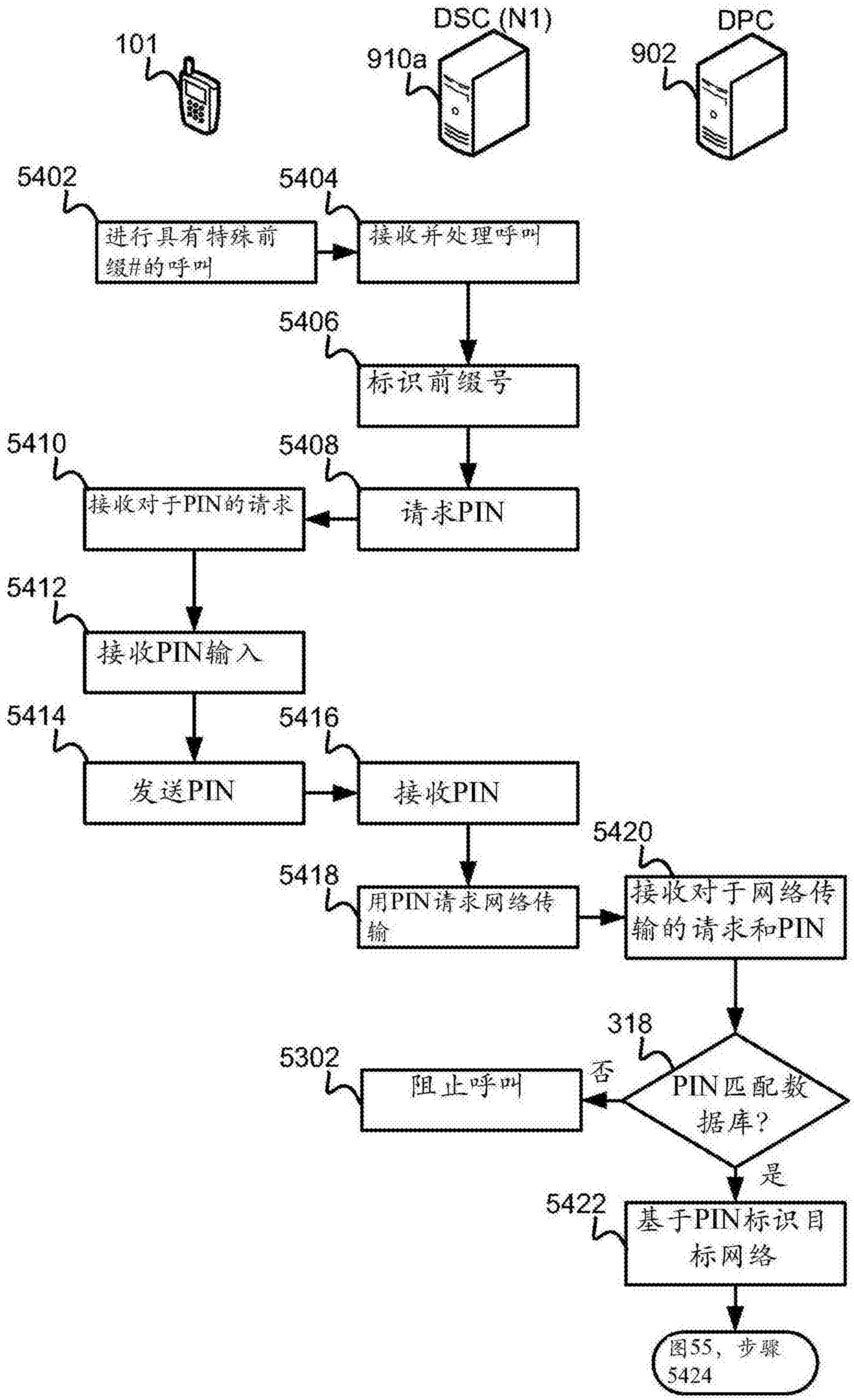

101
DSC (N1)
910a
DPC
902
5402
进行具有特殊前缀#的呼叫
5404
接收并处理呼叫
5406
标识前缀号
5408
请求PIN
5410
接收对于PIN的请求
5412
接收PIN输入
5414
发送PIN
5416
接收PIN
5418
用PIN请求网络传输
5420
接收对于网络传输的请求和PIN
318
PIN匹配数据库?
否
5302
阻止呼叫
是
5422
基于PIN标识目标网络
图55，步骤5424

图 54

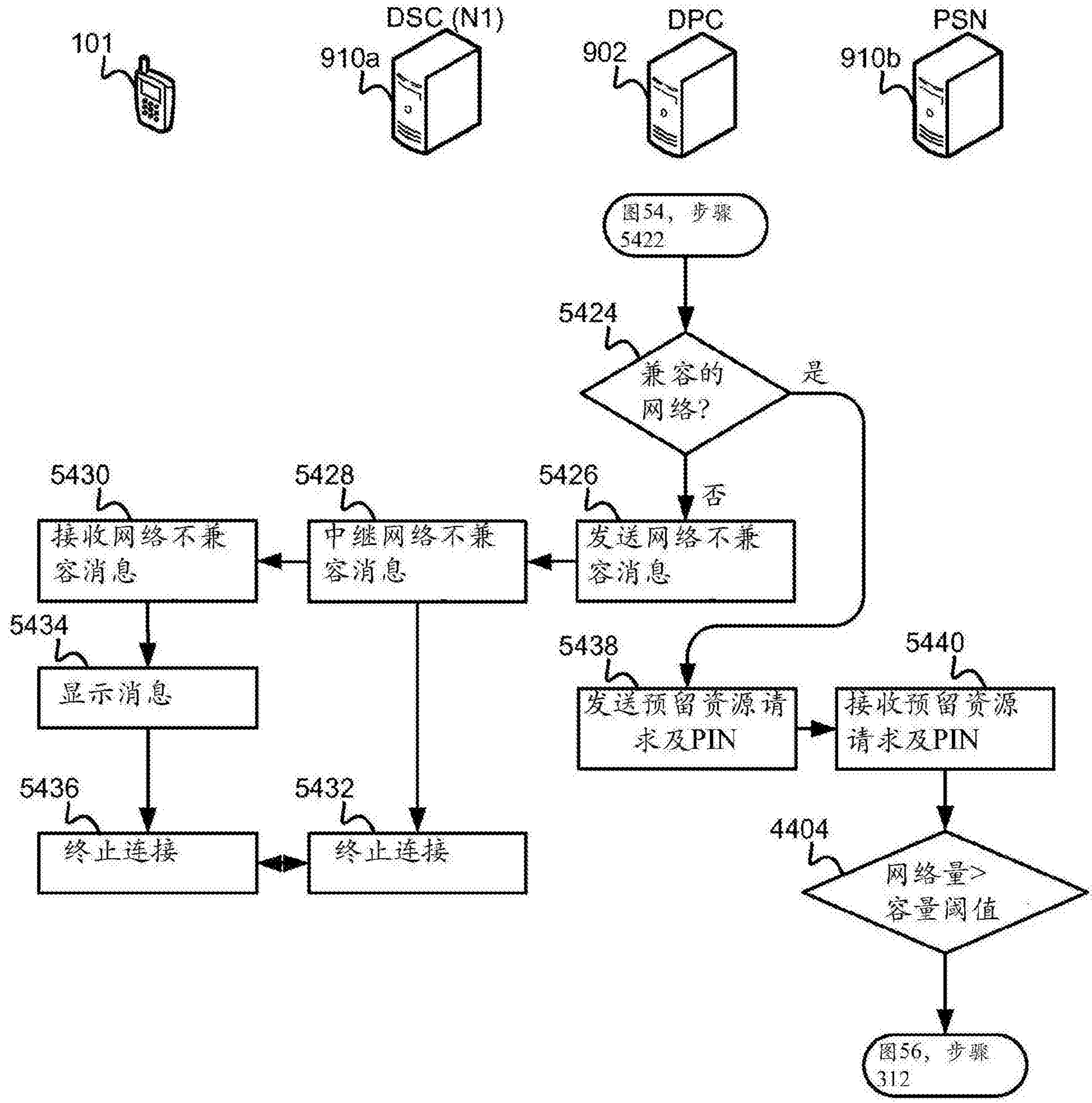

101
DSC (N1)
910a
DPC
902
PSN
910b
图54，步骤5422
5424
兼容的网络?
是
否
5426
发送网络不兼容消息
5428
中继网络不兼容消息
5430
接收网络不兼容消息
5434
显示消息
5436
终止连接
5432
终止连接
5438
发送预留资源请求及PIN
5440
接收预留资源请求及PIN
4404
网络量>容量阈值
图56，步骤312

图 55

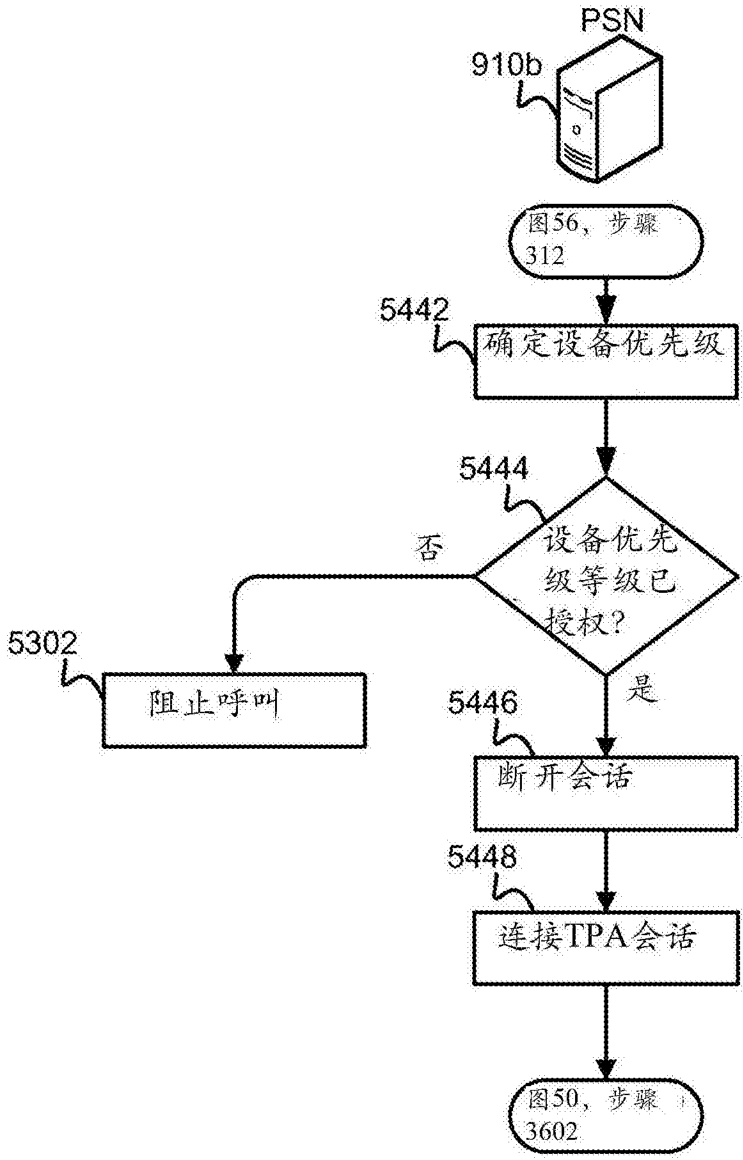

PSN
910b
图56，步骤312
5442
确定设备优先级
5444
设备优先级等级已授权？
否
是
5302
阻止呼叫
5446
断开会话
5448
连接TPA会话
图50，步骤3602

图 56

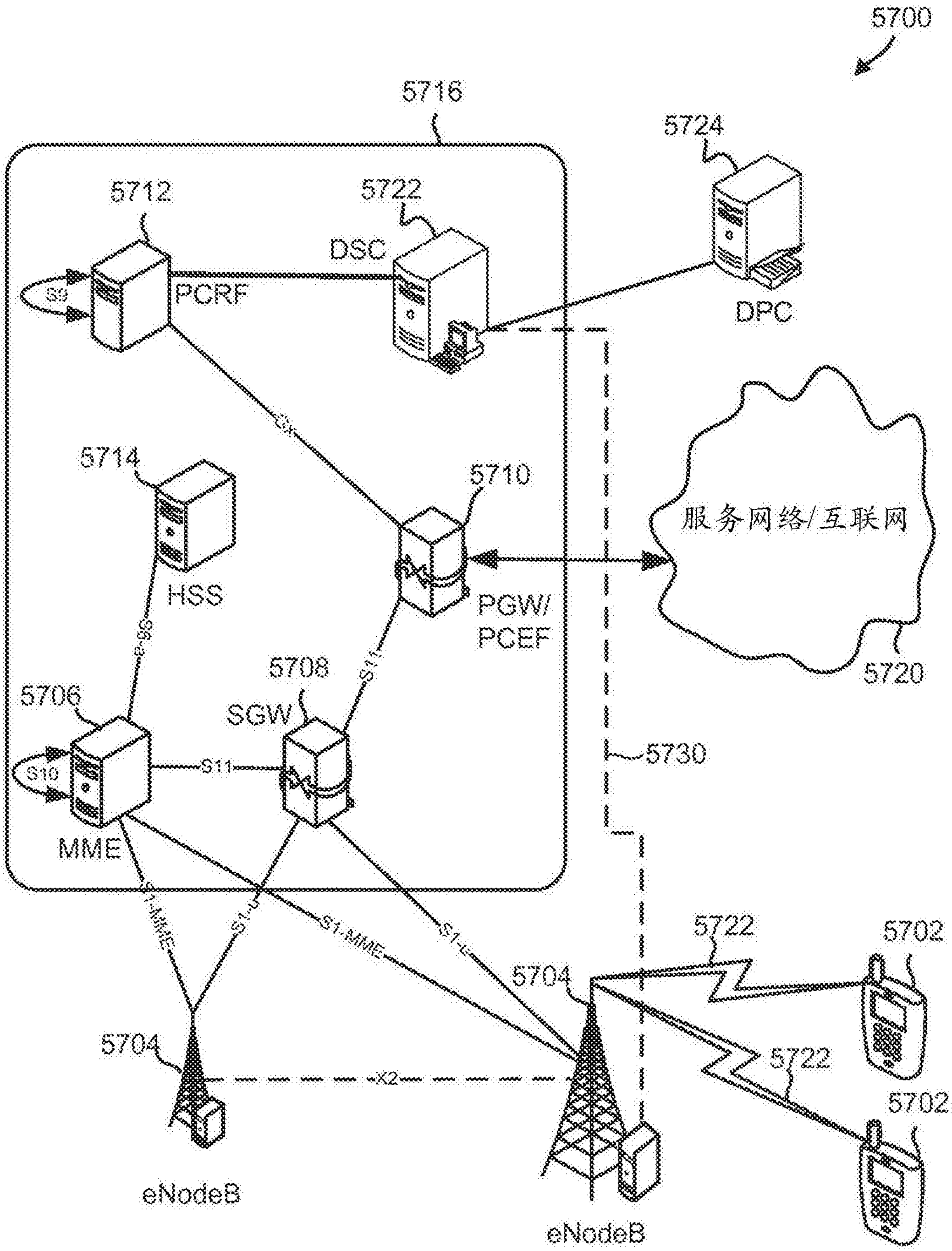

5700
5716
5724
5712
5722
DSC
S9
PCRF
DPC
Gx
5714
5710
服务网络/互联网
HSS
PGW/
PCEF
S6a
S11
5720
5708
5706
SGW
S10
S11
5730
MME
S1-MME
S1-U
S1-MME
S1-U
5722
5702
5704
5722
5704
X2
5702
eNodeB
eNodeB

图 57A

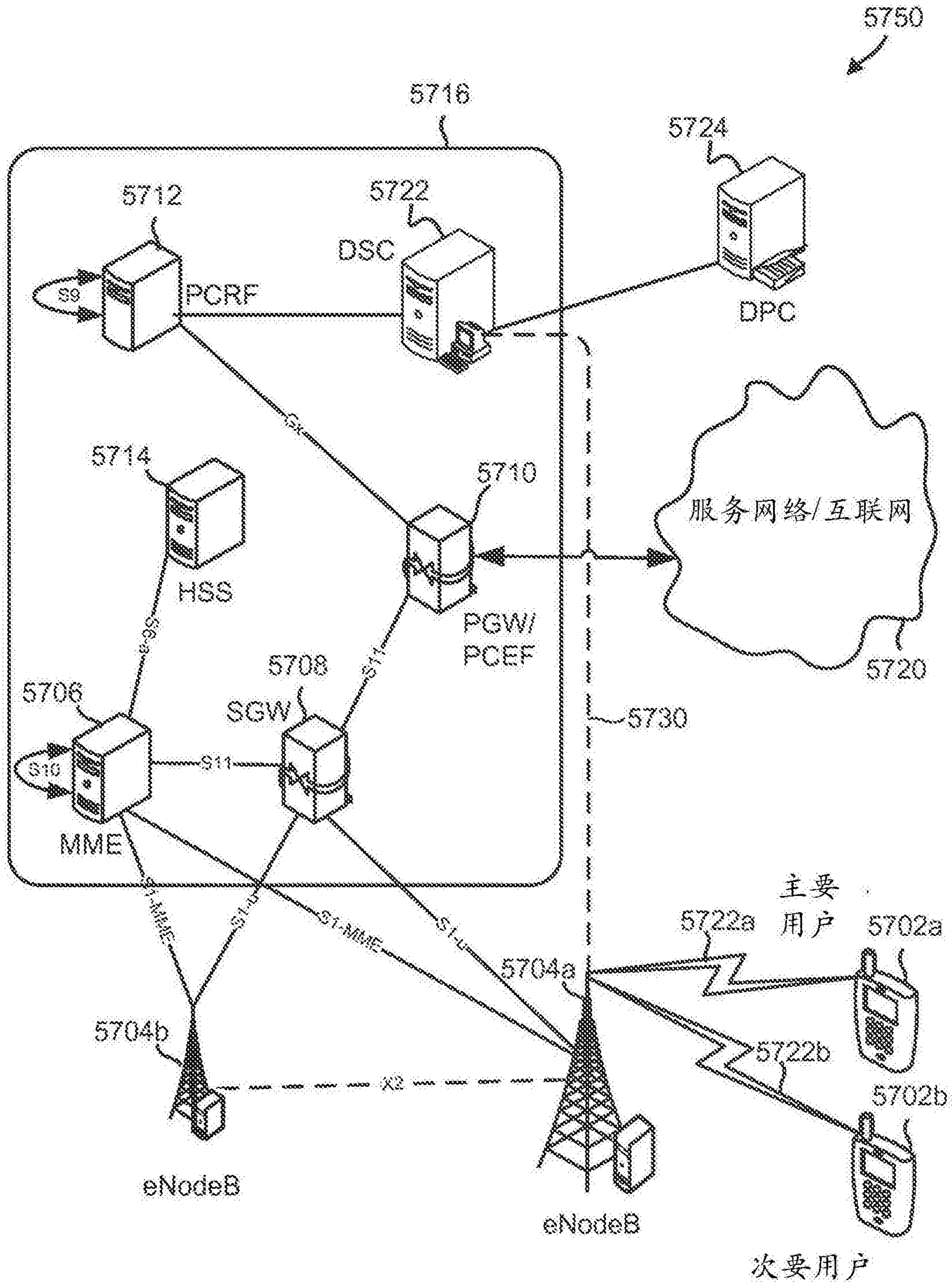

5750
5716
5724
5712
5722
DSC
S9
PCRF
DPC
Gx
5714
5710
服务网络/互联网
HSS
S6a
PGW/
PCEF
5708
S11
5720
5706
SGW
5730
S10
S11
MME
S1-MME
S1-U
S1-MME
S1-U
主要
用户
5722a
5702a
5704a
5704b
5722b
X2
5702b
eNodeB
eNodeB
次要用户

图 57B

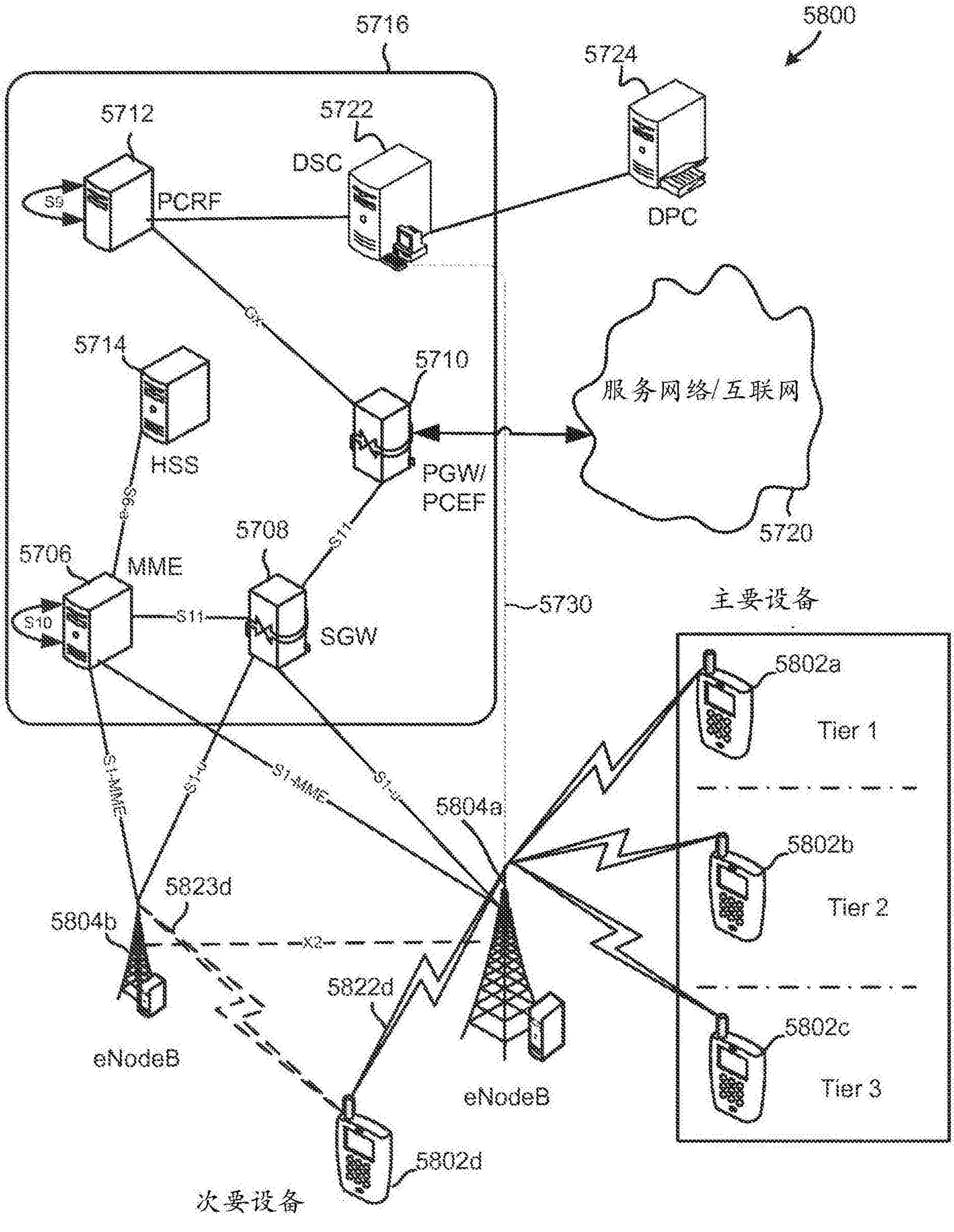

5800
5716
5724
5712
5722
DSC
S9
PCRF
DPC
Gx
5714
5710
服务网络/互联网
HSS
S6a
PGW/
PCEF
5708
S11
5720
5706
MME
5730
主要设备
S10
S11
SGW
5802a
Tier 1
S1-MME
S1-U
S1-MME
S1-U
5804a
5802b
5823d
Tier 2
5804b
X2
5822d
5802c
eNodeB
Tier 3
eNodeB
5802d
次要设备

图 58

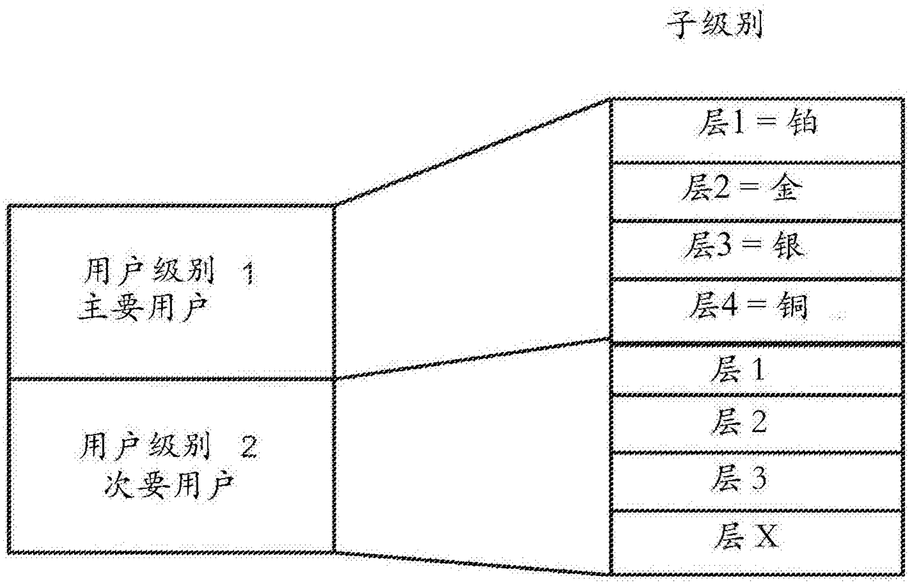

子级别
层1 = 铂
层2 = 金
层3 = 银
层4 = 铜
层 1
层 2
层 3
层 X
用户级别 1
主要用户
用户级别 2
次要用户

图 59A

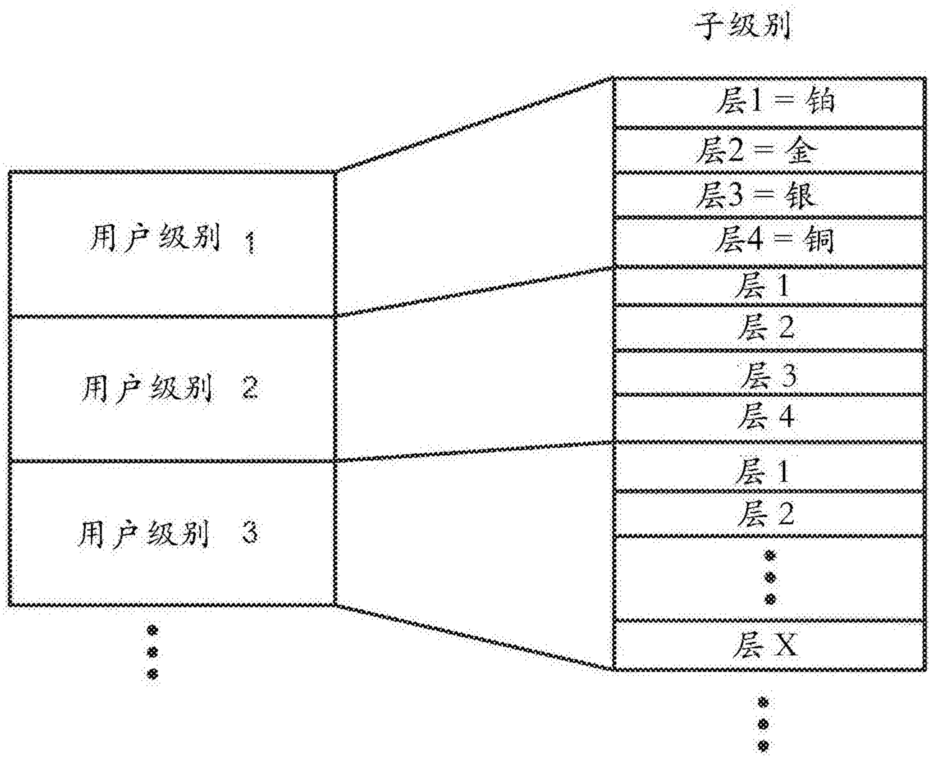

子级别
层1 = 铂
层2 = 金
层3 = 银
层4 = 铜
层 1
层 2
层 3
层 4
层 1
层 2
层 X
用户级别 1
用户级别 2
用户级别 3

图 59B

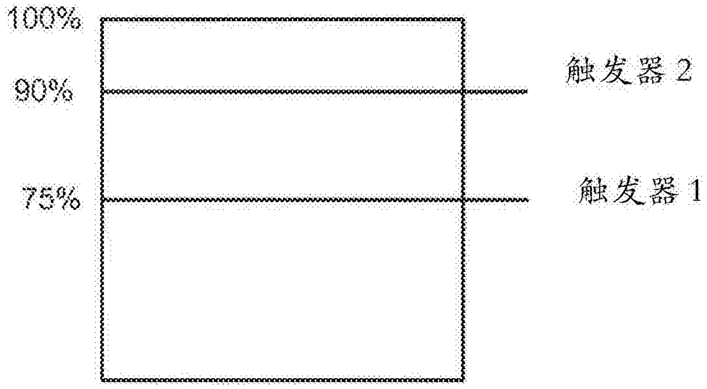


图 60A

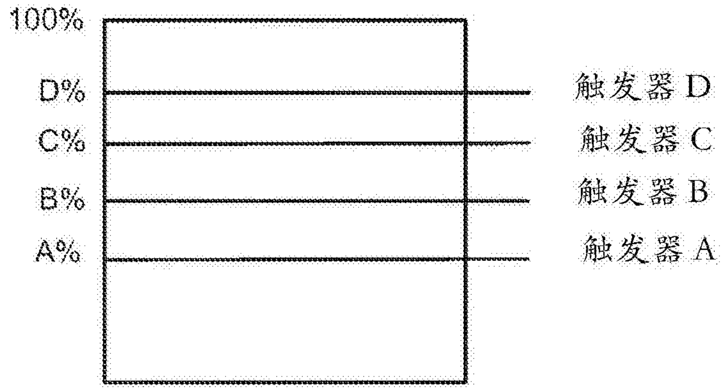


图 60B

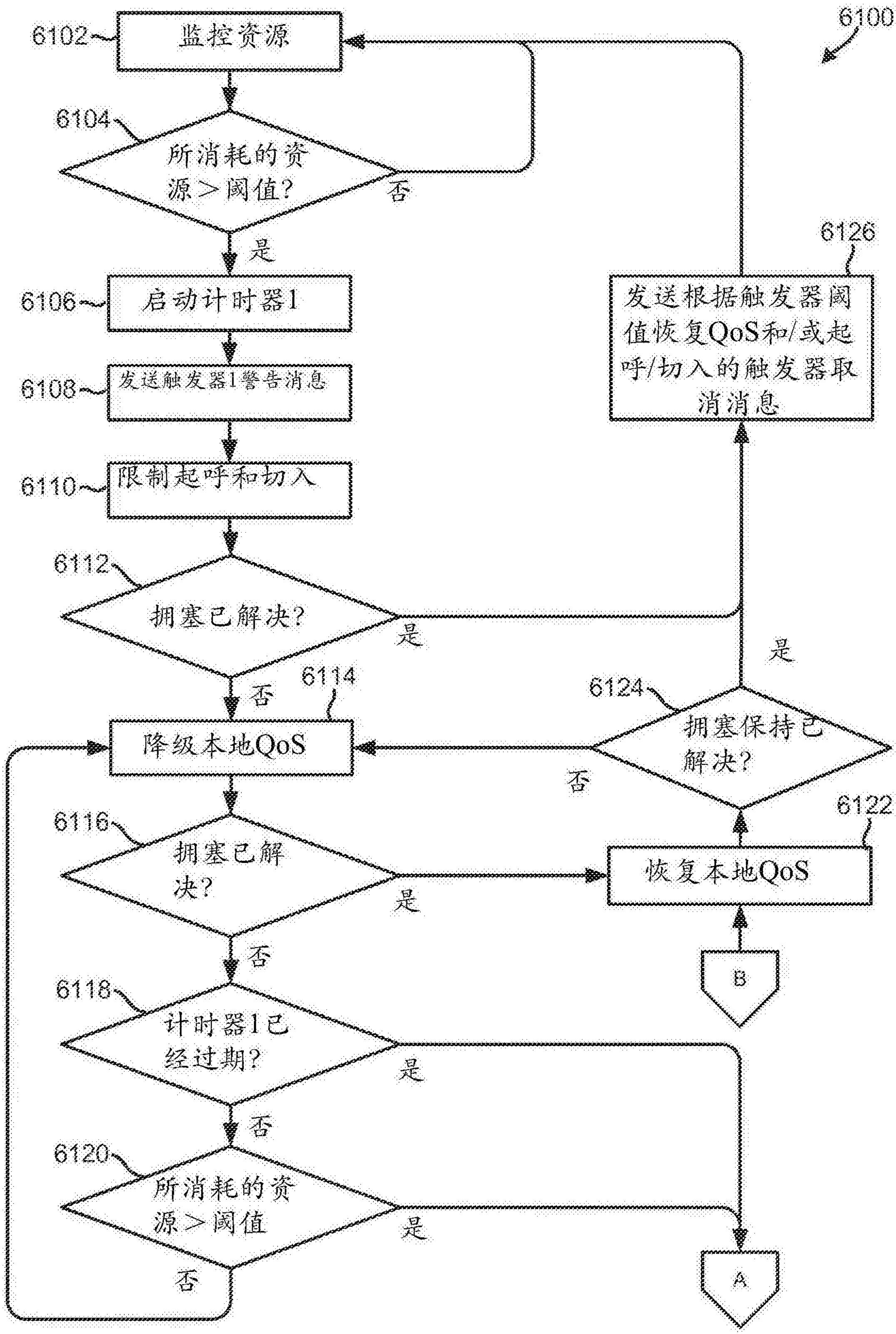

6100
6102
监控资源
6104
所消耗的资源>阈值?
否
是
6106
启动计时器1
6108
发送触发器1警告消息
6110
限制起呼和切入
6112
拥塞已解决?
是
否
6114
降级本地QoS
6116
拥塞已解决?
是
否
6118
计时器1已经过期?
是
否
6120
所消耗的资源>阈值
是
否
6126
发送根据触发器阈值恢复QoS和/或起呼/切入的触发器取消消息
是
6124
拥塞保持已解决?
否
6122
恢复本地QoS
B
A

图 61A

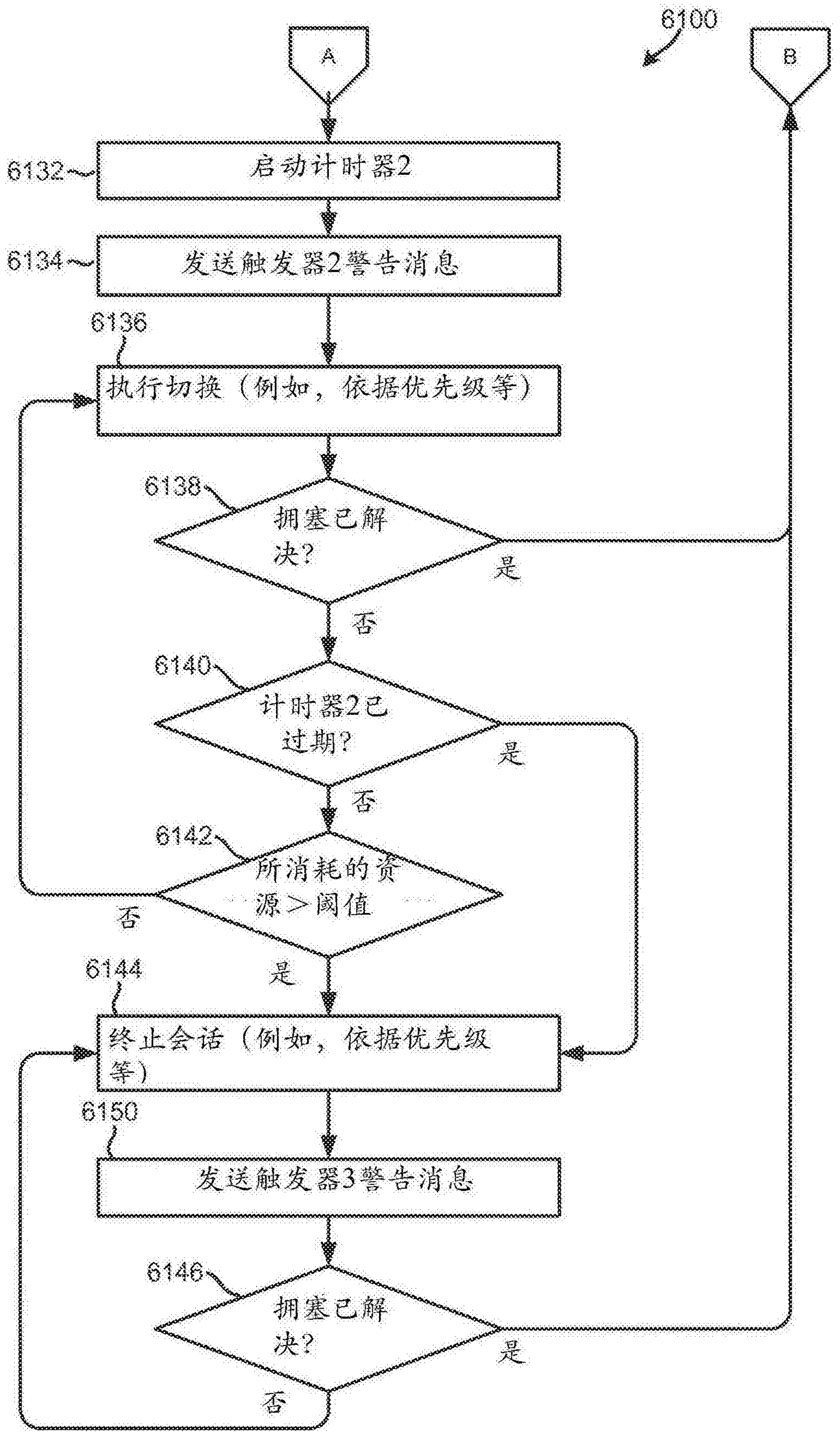

6100
A
B
6132
启动计时器2
6134
发送触发器2警告消息
6136
执行切换（例如，依据优先级等）
6138
拥塞已解决?
是
否
6140
计时器2已过期?
是
否
6142
所消耗的资源＞阈值
否
是
6144
终止会话（例如，依据优先级等）
6150
发送触发器3警告消息
6146
拥塞已解决?
是
否

图 61B

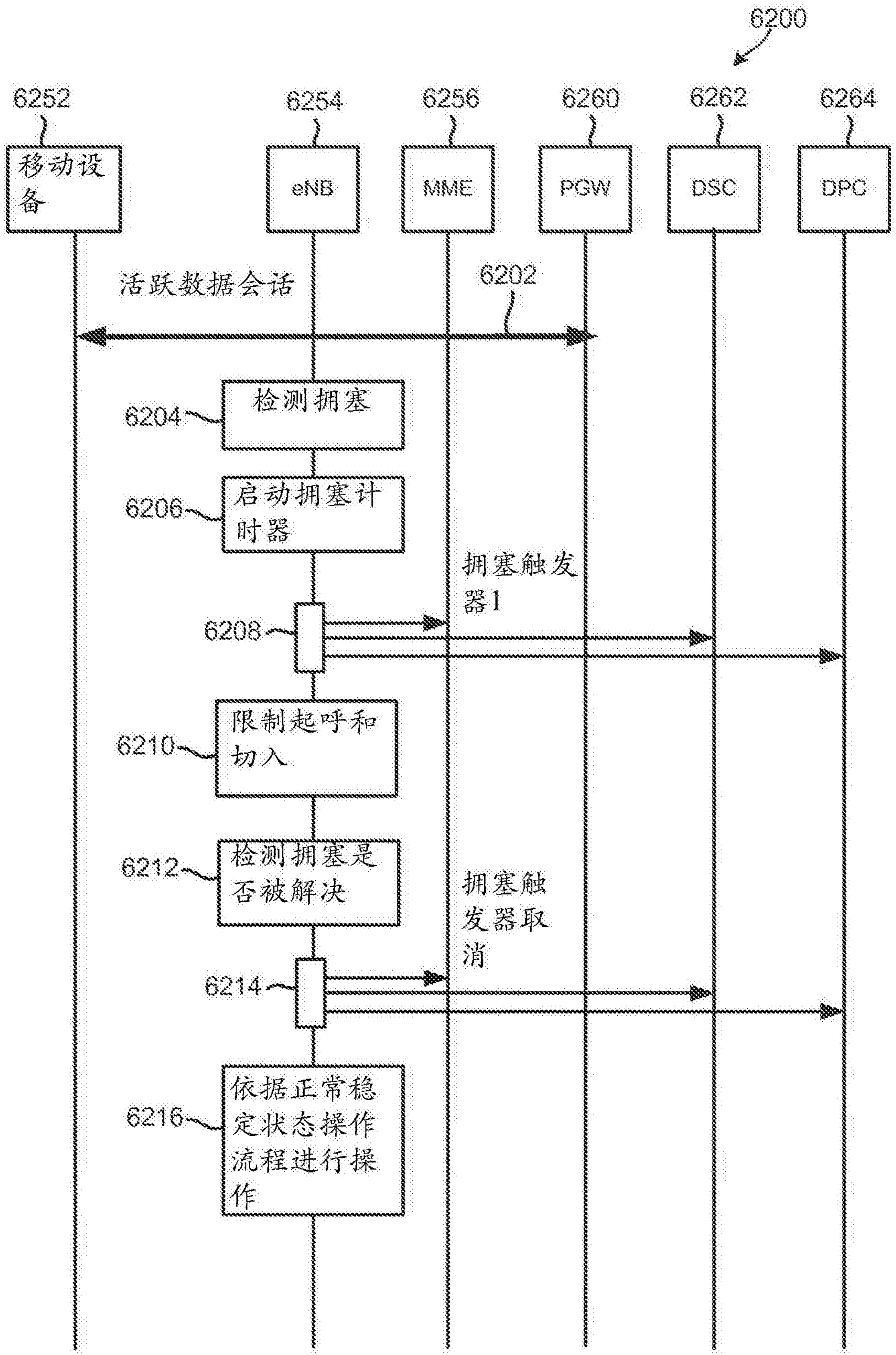

6200
6252
6254
6256
6260
6262
6264
移动设备
eNB
MME
PGW
DSC
DPC
活跃数据会话
6202
6204
检测拥塞
6206
启动拥塞计时器
拥塞触发器1
6208
6210
限制起呼和切入
6212
检测拥塞是否被解决
拥塞触发器取消
6214
6216
依据正常稳定状态操作流程进行操作

图 62

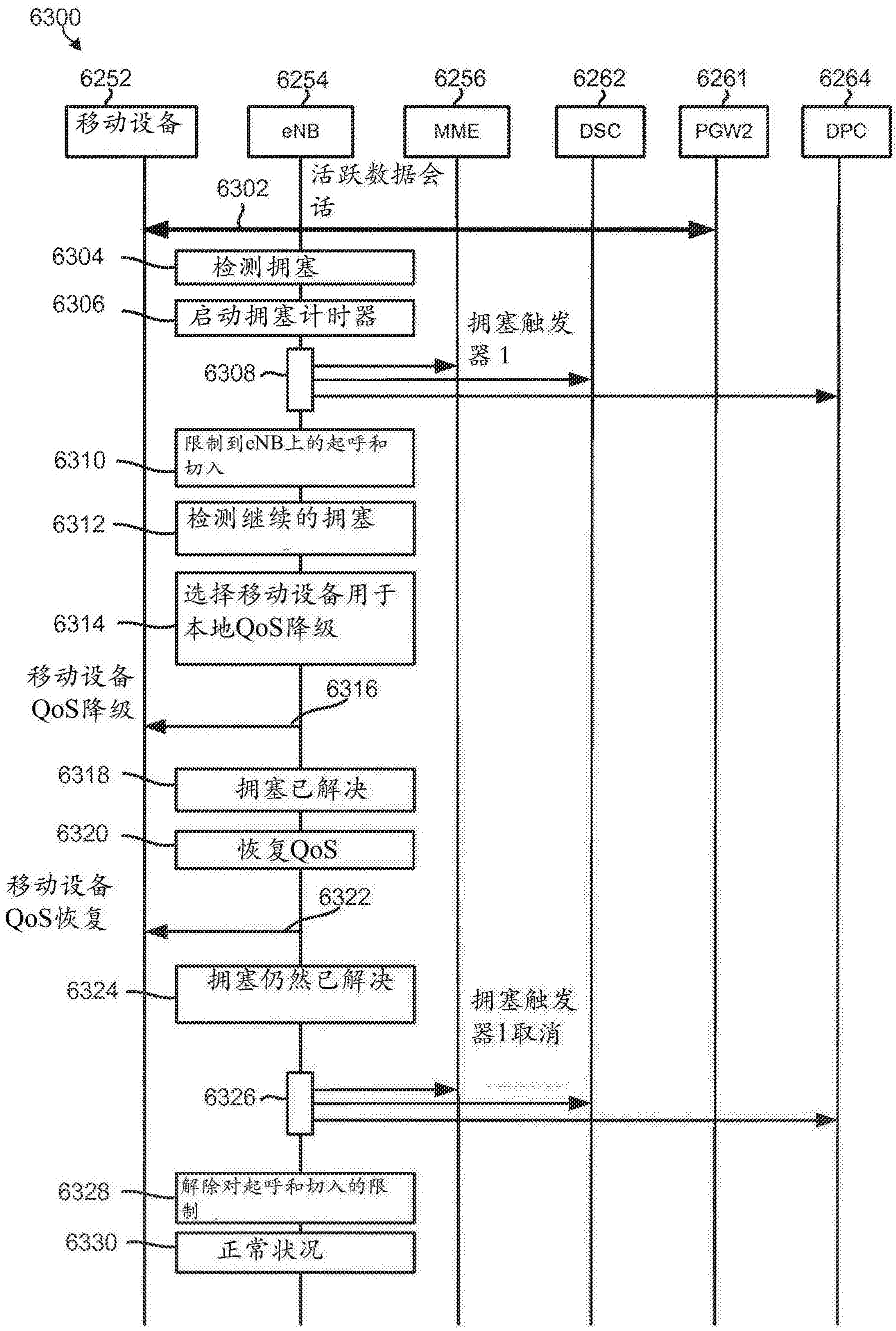

6300
6252
移动设备
6254
eNB
6256
MME
6262
DSC
6261
PGW2
6264
DPC
6302
活跃数据会话
6304
检测拥塞
6306
启动拥塞计时器
拥塞触发器 1
6308
6310
限制到eNB上的起呼和切入
6312
检测继续的拥塞
6314
选择移动设备用于本地QoS降级
移动设备QoS降级
6316
6318
拥塞已解决
6320
恢复QoS
移动设备QoS恢复
6322
6324
拥塞仍然已解决
拥塞触发器1取消
6326
6328
解除对起呼和切入的限制
6330
正常状况

图 63

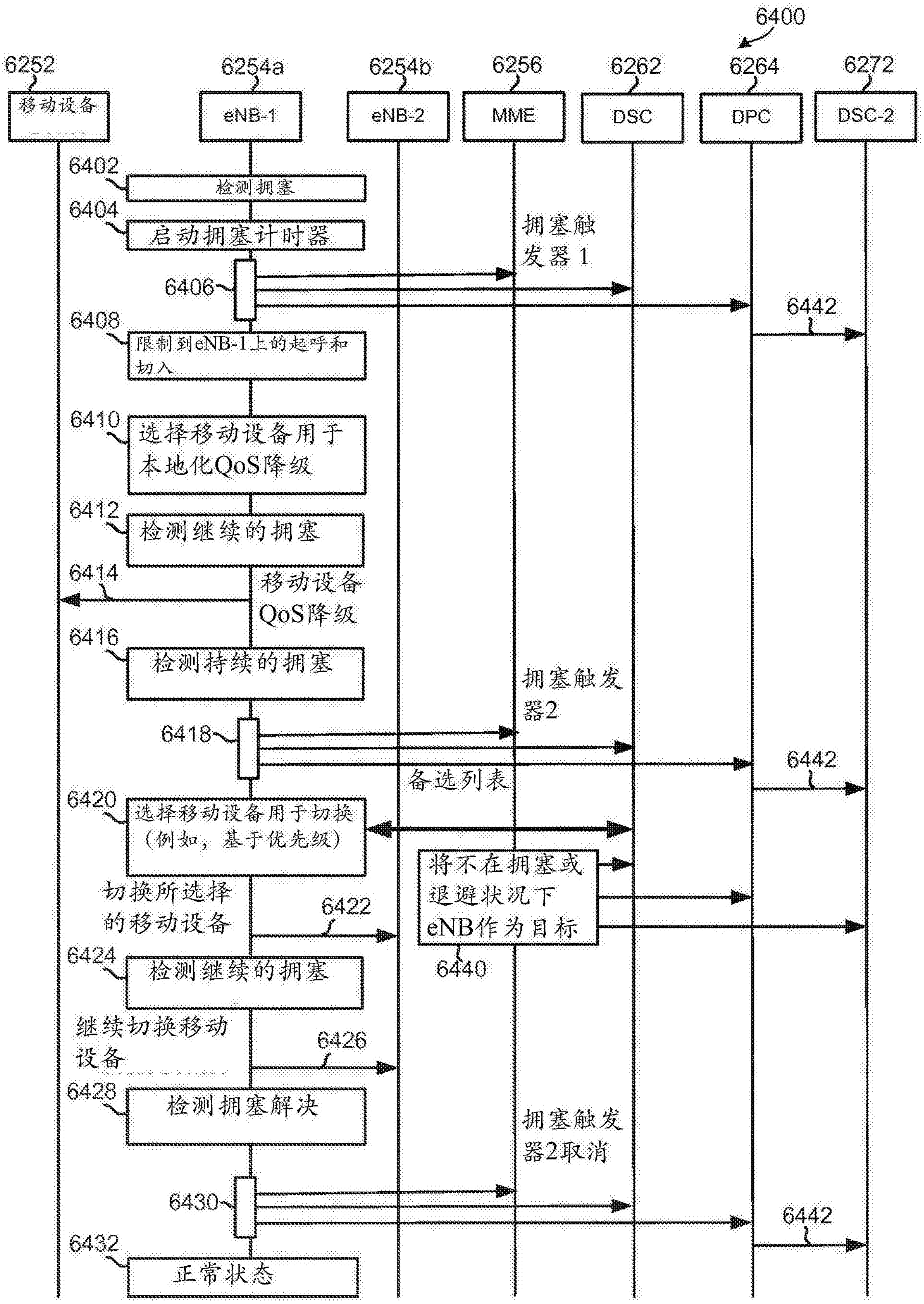

6400
6252
6254a
6254b
6256
6262
6264
6272
移动设备
eNB-1
eNB-2
MME
DSC
DPC
DSC-2
6402
检测拥塞
6404
启动拥塞计时器
拥塞触发器 1
6406
6442
6408
限制到eNB-1上的起呼和切入
6410
选择移动设备用于本地化QoS降级
6412
检测继续的拥塞
6414
移动设备QoS降级
6416
检测持续的拥塞
拥塞触发器2
6418
6442
备选列表
6420
选择移动设备用于切换(例如，基于优先级)
将不在拥塞或退避状况下eNB作为目标
切换所选择的移动设备
6422
6440
6424
检测继续的拥塞
继续切换移动设备
6426
6428
检测拥塞解决
拥塞触发器2取消
6430
6442
6432
正常状态

图 64

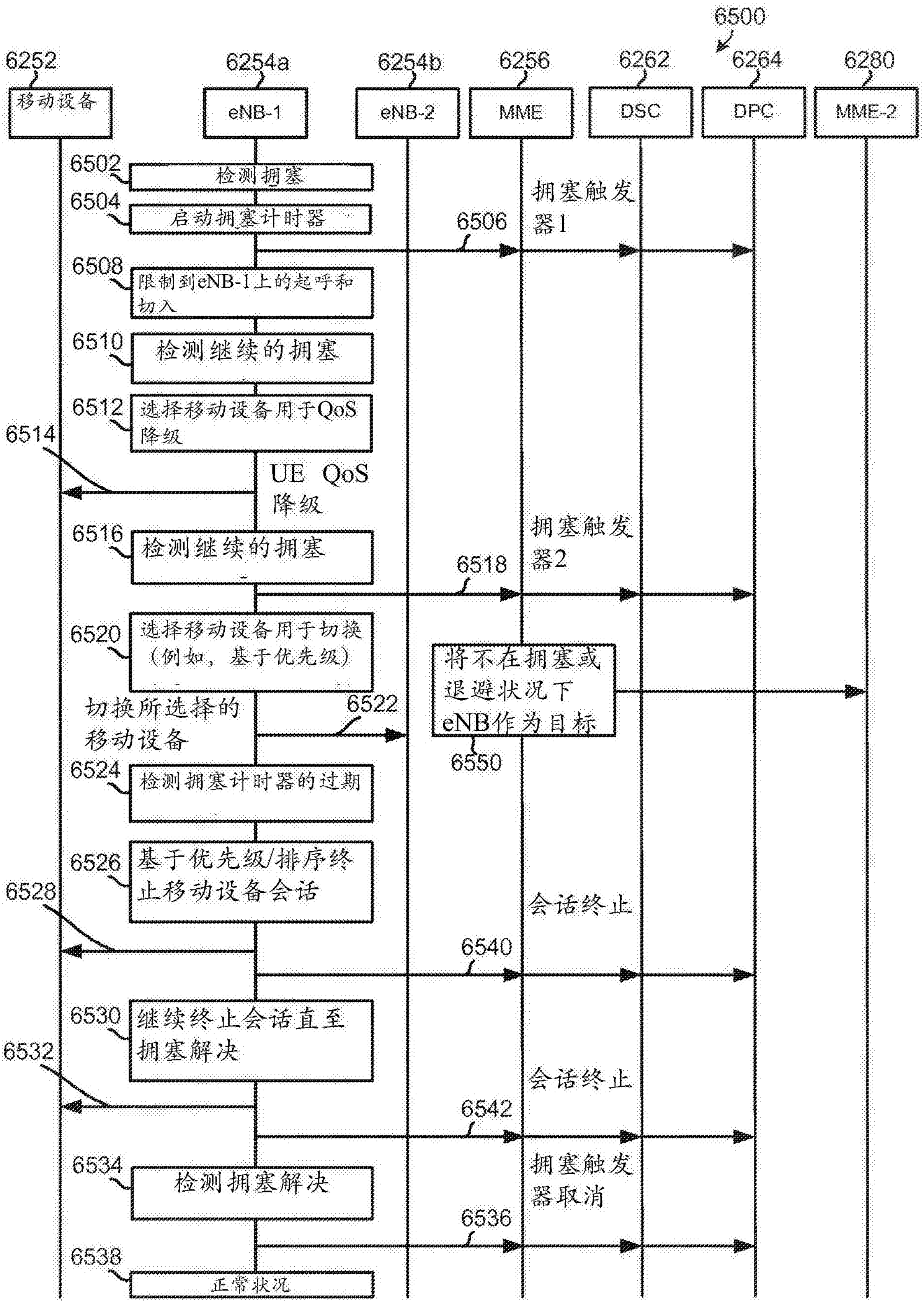

6500
6252
6254a
6254b
6256
6262
6264
6280
移动设备
eNB-1
eNB-2
MME
DSC
DPC
MME-2
6502
检测拥塞
6504
启动拥塞计时器
拥塞触发器1
6506
6508
限制到eNB-1上的起呼和切入
6510
检测继续的拥塞
6512
选择移动设备用于QoS降级
6514
UE QoS降级
6516
检测继续的拥塞
拥塞触发器2
6518
6520
选择移动设备用于切换（例如，基于优先级）
将不在拥塞或退避状况下eNB作为目标
切换所选择的移动设备
6522
6550
6524
检测拥塞计时器的过期
6526
基于优先级/排序终止移动设备会话
6528
会话终止
6540
6530
继续终止会话直至拥塞解决
6532
会话终止
6542
6534
检测拥塞解决
拥塞触发器取消
6536
6538
正常状况

图 65

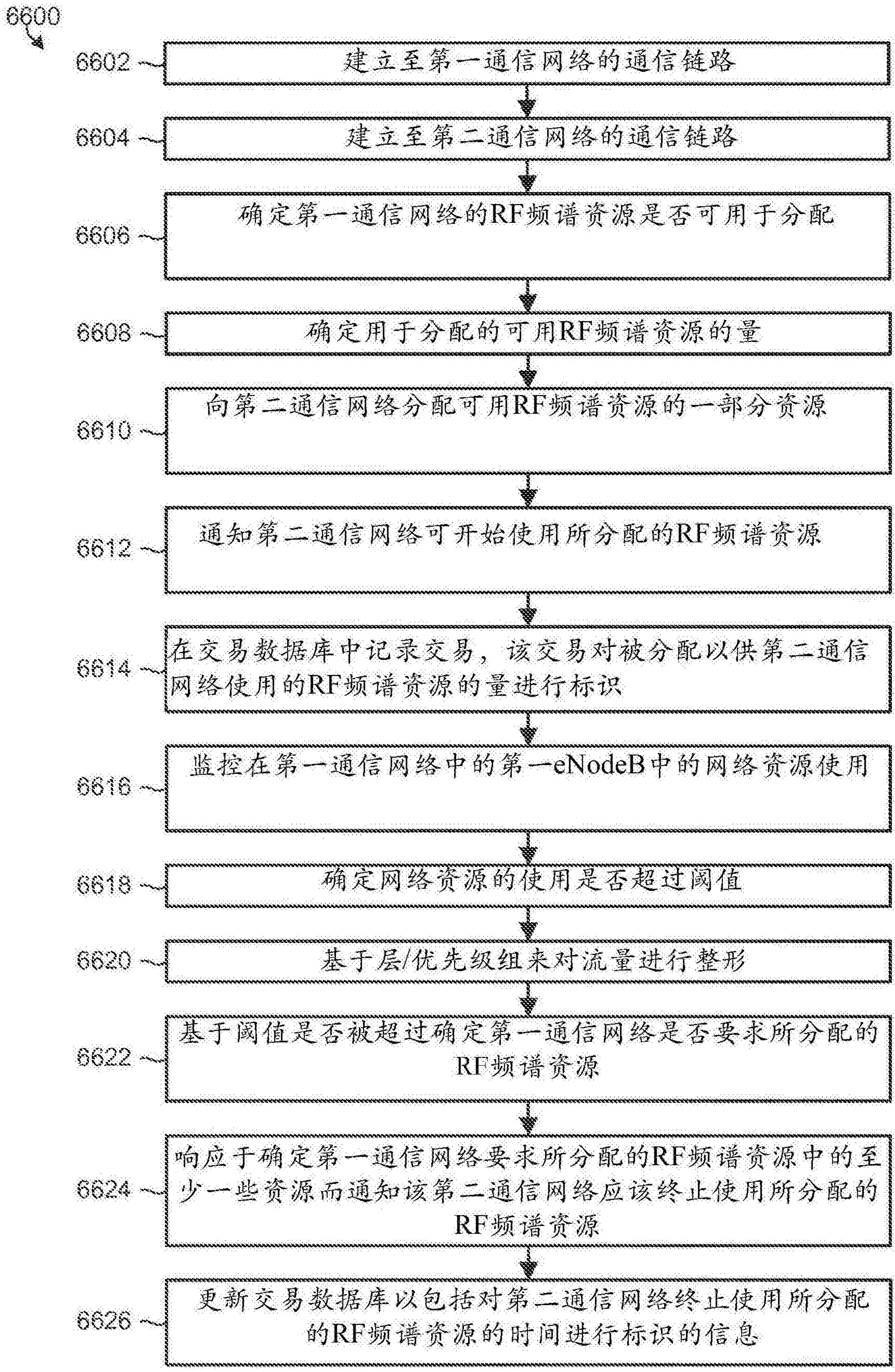

6600
6602
建立至第一通信网络的通信链路
6604
建立至第二通信网络的通信链路
6606
确定第一通信网络的RF频谱资源是否可用于分配
6608
确定用于分配的可用RF频谱资源的量
6610
向第二通信网络分配可用RF频谱资源的一部分资源
6612
通知第二通信网络可开始使用所分配的RF频谱资源
6614
在交易数据库中记录交易，该交易对被分配以供第二通信网络使用的RF频谱资源的量进行标识
6616
监控在第一通信网络中的第一eNodeB中的网络资源使用
6618
确定网络资源的使用是否超过阈值
6620
基于层/优先级组来对流量进行整形
6622
基于阈值是否被超过确定第一通信网络是否要求所分配的RF频谱资源
6624
响应于确定第一通信网络要求所分配的RF频谱资源中的至少一些资源而通知该第二通信网络应该终止使用所分配的RF频谱资源
6626
更新交易数据库以包括对第二通信网络终止使用所分配的RF频谱资源的时间进行标识的信息

图 66

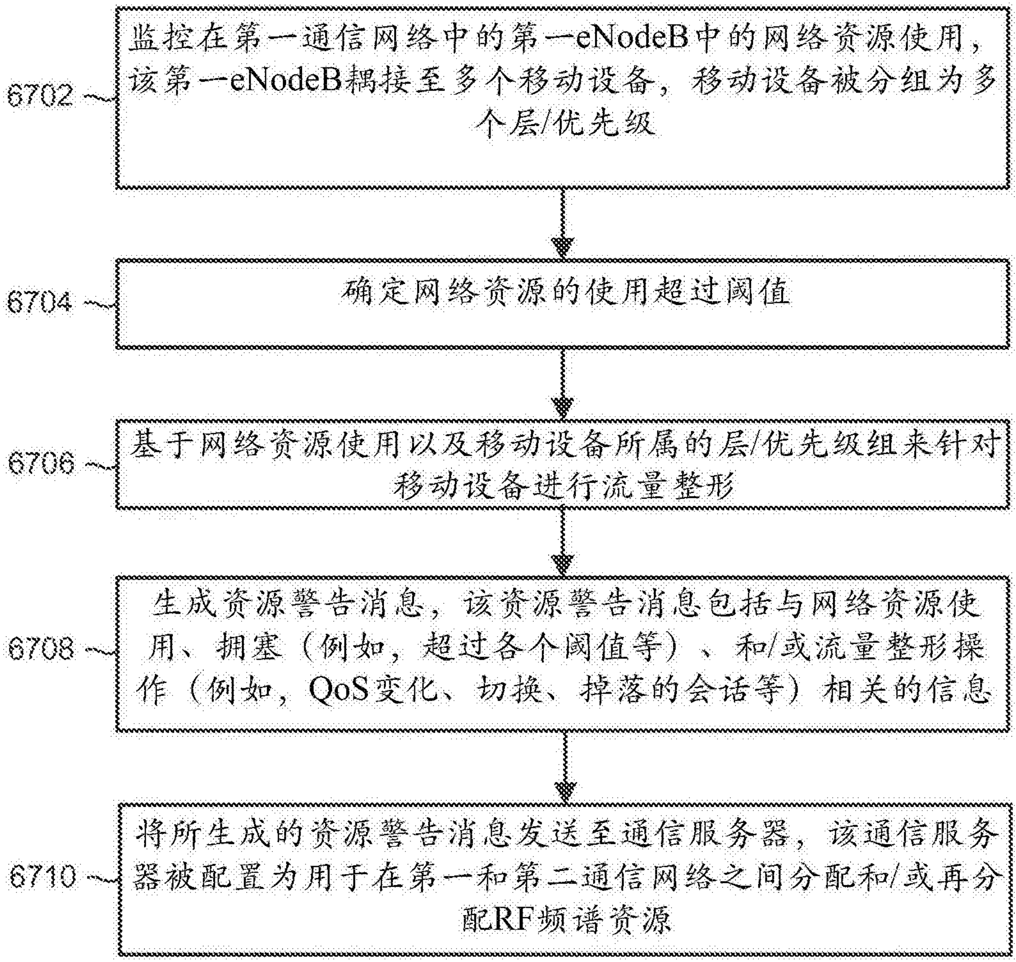

6702
监控在第一通信网络中的第一eNodeB中的网络资源使用，该第一eNodeB耦接至多个移动设备，移动设备被分组为多个层/优先级
6704
确定网络资源的使用超过阈值
6706
基于网络资源使用以及移动设备所属的层/优先级组来针对移动设备进行流量整形
6708
生成资源警告消息，该资源警告消息包括与网络资源使用、拥塞（例如，超过各个阈值等）、和/或流量整形操作（例如，QoS变化、切换、掉落的会话等）相关的信息
6710
将所生成的资源警告消息发送至通信服务器，该通信服务器被配置为用于在第一和第二通信网络之间分配和/或再分配RF频谱资源

图67

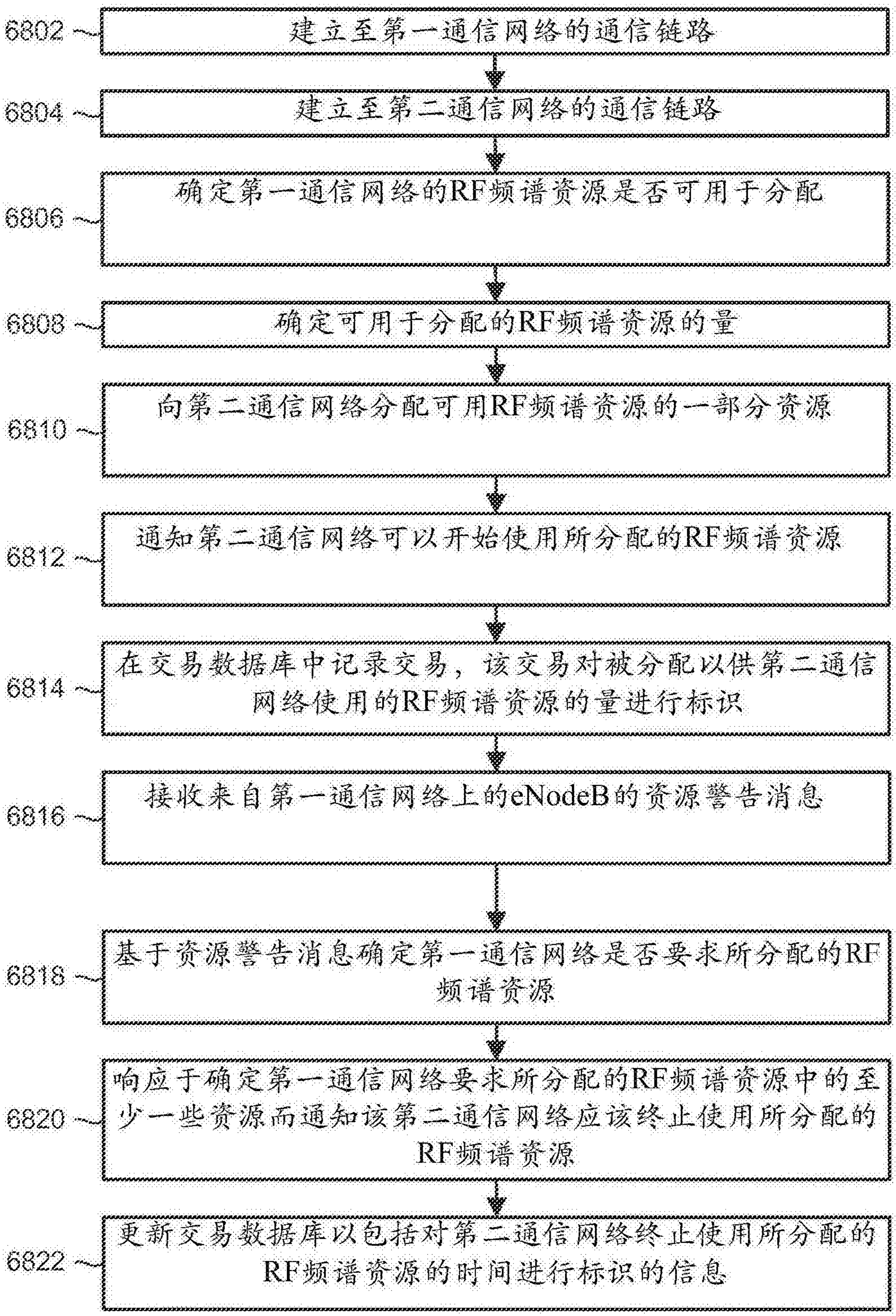

6802
建立至第一通信网络的通信链路
6804
建立至第二通信网络的通信链路
6806
确定第一通信网络的RF频谱资源是否可用于分配
6808
确定可用于分配的RF频谱资源的量
6810
向第二通信网络分配可用RF频谱资源的一部分资源
6812
通知第二通信网络可以开始使用所分配的RF频谱资源
6814
在交易数据库中记录交易，该交易对被分配以供第二通信网络使用的RF频谱资源的量进行标识
6816
接收来自第一通信网络上的eNodeB的资源警告消息
6818
基于资源警告消息确定第一通信网络是否要求所分配的RF频谱资源
6820
响应于确定第一通信网络要求所分配的RF频谱资源中的至少一些资源而通知该第二通信网络应该终止使用所分配的RF频谱资源
6822
更新交易数据库以包括对第二通信网络终止使用所分配的RF频谱资源的时间进行标识的信息

图 68

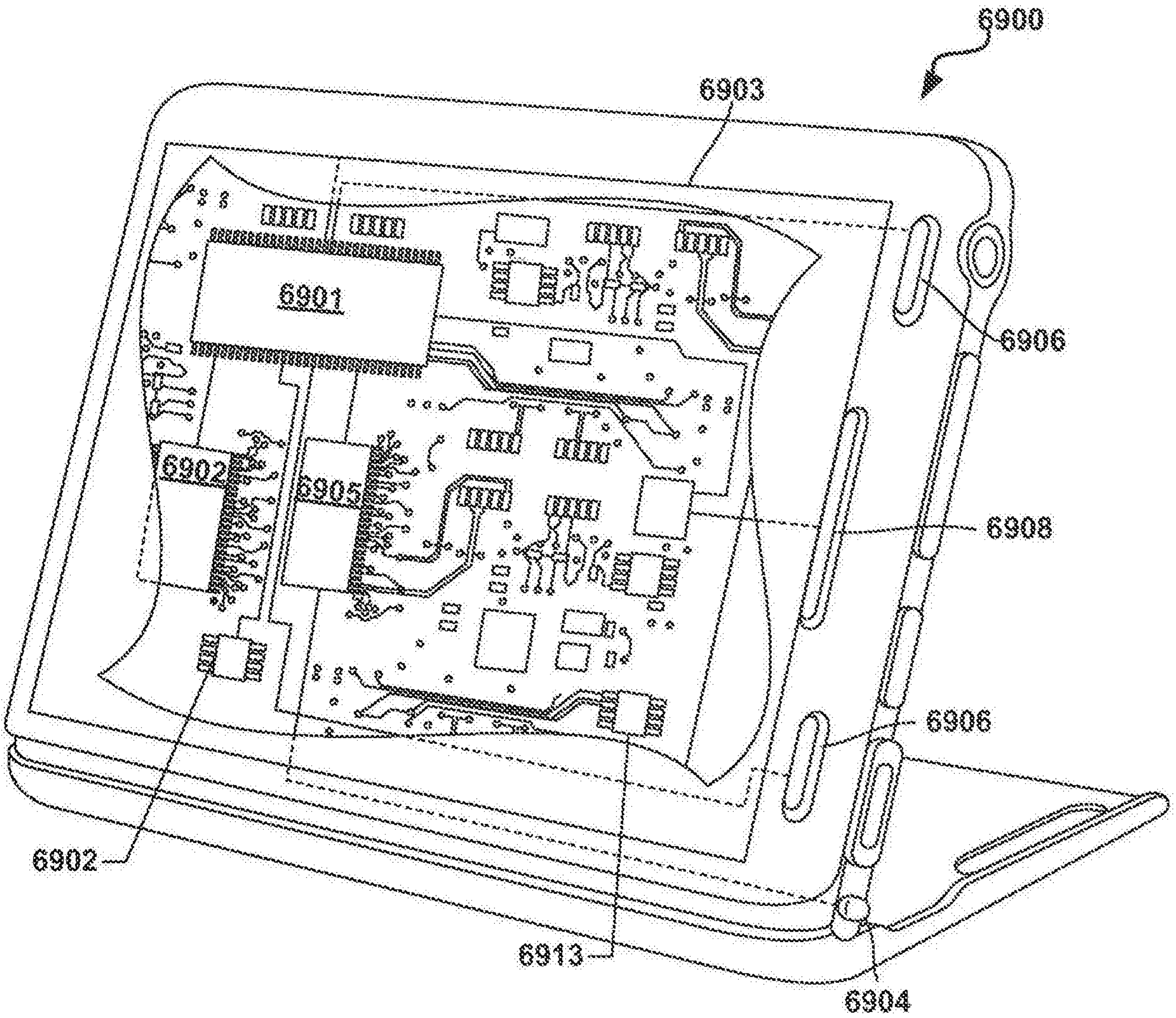


图 69

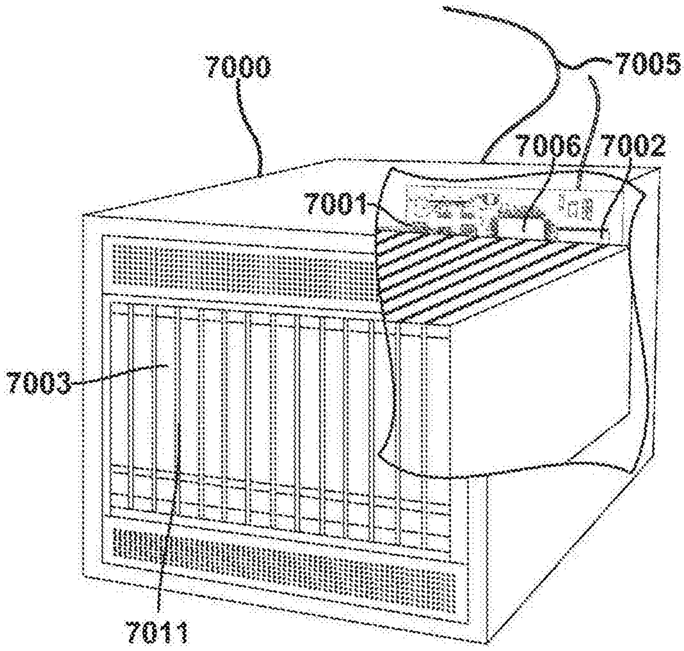


图 70