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(71) Applicants *(for CN only)*: **NOKIA SHANGHAI BELL CO., LTD.** [CN/CN]; No. 388, Ningqiao Road, Pudong Jinqiao, Shanghai 201206 (CN). **NOKIA SOLUTIONS AND NETWORKS OY** [FI/FI]; Karaportti 3, Espoo, 02610 (FI).

(71) Applicant *(for all designated States except CN)*: **NOKIA TECHNOLOGIES OY** [FI/FI]; Karaportti 3, Espoo, 02610 (FI).

(72) Inventors: **GU, Junrong**; No. 388 Ningqiao Road, Pudong Jinqiao, Shanghai 201206 (CN). **LENG, Xiaobing**; No. 388 Ningqiao Road, Pudong Jinqiao, Shanghai 201206 (CN). **WANG, Dawei**; No. 388 Ningqiao Road, Pudong Jinqiao, Shanghai 201206 (CN). **SHEN, Gang**; No. 388 Ningqiao Road, Pudong Jinqiao, Shanghai 201206 (CN).

(74) Agent: **KING & WOOD MALLESONS**; 20th Floor, East Tower, World Financial Centre, No. 1 Dongsanhuan Zhonglu, Chaoyang District, Beijing 100020 (CN).

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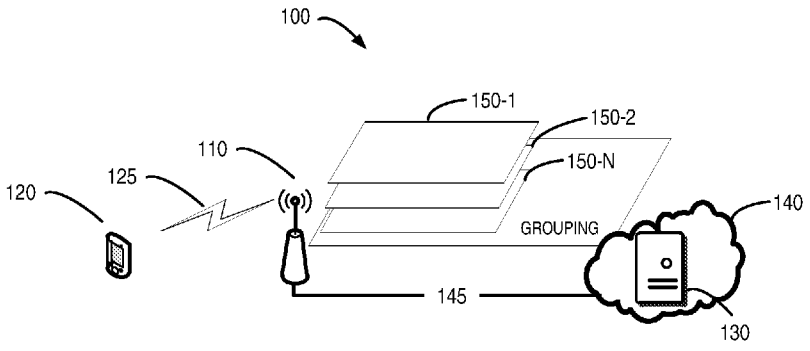

FIG. 1

(57) Abstract: Example embodiments of the present disclosure relate to a device, method, apparatus and computer readable storage medium of slice grouping for mobility of a terminal device. In example embodiments, a network device determines that a plurality of service loads for a plurality of groups of network slices are to be changed. The network device adjusts resources allocated to the plurality of groups at least in part based on the determining.

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SLICE GROUPING FOR MOBILITY OF TERMINAL DEVICE

FIELD

[0001] Example embodiments of the present disclosure generally relate to the field of communications, and in particular, to a device, method, apparatus and computer readable storage medium of slice grouping for mobility of a terminal device.

BACKGROUND

[0002] Services in the fifth generation (5G) are categorized into three key scenarios, including ultra-reliable low latency communication (URLLC), massive machine type communication (mMTC) and enhanced mobile broadband (eMBB). Network virtualization is introduced to decouple the services from network infrastructures, such that different services can share the same network infrastructure. When a collection of virtualized functions are connected together for a specific use case or a business model to provide certain type of services, a network slice, or "5G slice", is built up. One benefit of the network slicing is reducing the cost of deploying the 5G services with the legacy infrastructure. In another aspect, a network slice is easily reconfigurable. For example, the network slice could be readily configured and adjusted in a network controller without cumbersome lower level configuration in the individual devices one by one.

[0003] One base station (for example, a gNB) may support a huge number of network slices (for example, hundreds of slices) simultaneously or geographically in specified frequencies. Mostly, resources are unevenly distributed in a network. For example, base stations (or gNBs) of some operators are not universally or ubiquitously deployed. In this case, it is extremely difficult for a base station to support such a large number of network slices. In addition, these network slices are discontinuous in time, frequency and space (or geography) domains. The slice discontinuity may induce a tremendous impact to capacities of the network slices especially when many user equipment (UEs) are moving across a coverage area of the base station. Moreover, a big challenge may be posed to peak capacities of the services in the network slices as the UEs are moving across the discontinuous slices.

[0004] Currently, a UE is permitted to connect to 8 slices in parallel. The number of slices will become larger in the future. The management overhead increases as the

number of slices grows large.

SUMMARY

[0005] In general, example embodiments of the present disclosure provide a device, method, apparatus and computer readable storage medium of slice grouping for mobility of a terminal device.

[0006] In a first aspect, a device is provided which comprises at least one processor; and at least one memory including computer program code. The at least one memory and the computer program code are configured to, with the at least one processor, cause the device to determine, by a network device, that a plurality of service loads for a plurality of groups of network slices are to be changed. The device is further caused to adjust resources allocated to the plurality of groups at least in part based on the determining.

[0007] In a second aspect, a method is provided. In the method, a network device determines that a plurality of service loads for a plurality of groups of network slices are to be changed. The network device adjusts resources allocated to the plurality of groups at least in part based on the determining.

[0008] In a third aspect, there is provided an apparatus comprising means for performing the method according to the second aspect.

[0009] In a fourth aspect, there is provided a computer readable storage medium that stores a computer program thereon. The computer program, when executed by a processor of a device, causes the device to perform the method according to the second aspect.

[0010] It is to be understood that the summary section is not intended to identify key or essential features of example embodiments of the present disclosure, nor is it intended to be used to limit the scope of the present disclosure. Other features of the present disclosure will become easily comprehensible through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Some example embodiments will now be described with reference to the accompanying drawings, where:

[0012] FIG. 1 illustrates an example environment in which example embodiments of the

present disclosure can be implemented;

[0013] FIG. 2 illustrates an example scenario in which some example embodiments of the present disclosure can be implemented;

[0014] FIG. 3 illustrates example slice grouping in accordance with some example embodiments of the present disclosure;

[0015] FIG. 4 illustrates a flowchart of an example method for managing resources based on the slice grouping according to some example embodiments of the present disclosure;

[0016] FIG. 5 illustrates a signaling flow of a resource coordination process according to some example embodiments of the present disclosure;

[0017] FIG. 6 illustrates a signaling flow of an example process for reserving a group of network slices according to some example embodiments of the present disclosure;

[0018] FIG. 7 illustrates a flowchart of an example process for handover of a terminal device based on slice grouping according to some example embodiments of the present disclosure;

[0019] FIG. 8 illustrates a signaling flow of an example process of slice mapping and slice creating based on slice grouping according to some example embodiments of the present disclosure; and

[0020] FIG. 9 illustrates a simplified block diagram of a device that is suitable for implementing example embodiments of the present disclosure.

[0021] Throughout the drawings, the same or similar reference numerals represent the same or similar element.

DETAILED DESCRIPTION

[0022] Principle of the present disclosure will now be described with reference to some example embodiments. It is to be understood that these example embodiments are described only for the purpose of illustration and help those skilled in the art to understand and implement the present disclosure, without suggesting any limitation as to the scope of the disclosure. The disclosure described herein can be implemented in various manners other than the ones described below.

[0023] In the following description and claims, unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of

ordinary skills in the art to which this disclosure belongs.

[0024] As used herein, the term "network device" refers to a device via which services can be provided to a terminal device in a communication network. The network device may comprise an access network device and a core network device.

[0025] As used herein, the term "access network device" refers to a device via which a terminal device or UE can access a communication network. Examples of the BS include a relay, an access point (AP), a transmission point (TRP), a node B (NodeB or NB), an evolved NodeB (eNodeB or eNB), a New Radio (NR) NodeB (gNB), a Remote Radio Module (RRU), a radio header (RH), a remote radio head (RRH), a low power node such as a femto, a pico, and the like.

[0026] As used herein, the term "core network device" refers to a device capable of communicating with the access network device and providing services to the terminal device in a core network. Examples of the core network device may include Mobile Switching Centers (MSCs), MMEs, Operation and Management (O&M) nodes, Operation Support System (OSS) nodes, Self-Organization Network (SON) nodes, positioning nodes, such as Enhanced Serving Mobile Location Centers (E-SMLCs), Mobile Data Terminals (MDTs), Common Control Network Function (CCNF), Access and mobility Management Function (AMF), and/or Network Slice Selection Function (NSSF).

[0027] As used herein, the term "terminal device" or "user equipment" (UE) refers to any terminal device capable of wireless communications with each other or with the base station. The communications may involve transmitting and/or receiving wireless signals using electromagnetic signals, radio waves, infrared signals, and/or other types of signals suitable for conveying information over air. In some example embodiments, the UE may be configured to transmit and/or receive information without direct human interaction. For example, the UE may transmit information to the network device on predetermined schedules, when triggered by an internal or external event, or in response to requests from the network side.

[0028] Examples of the UE include, but are not limited to, user equipment (UE) such as smart phones, wireless-enabled tablet computers, laptop-embedded equipment (LEE), laptop-mounted equipment (LME), and/or wireless customer-premises equipment (CPE). For the purpose of discussion, some example embodiments will be described with reference to UEs as examples of the terminal devices, and the terms "terminal device" and "user

equipment" (UE) may be used interchangeably in the context of the present disclosure.

[0029] As used herein, the term "network slice" refers to a collection of virtualized functions that are deployed on infrastructure of one or more access network device and connected together for a specific use case or a business model to provide a certain type of services. One access network device may enable a plurality of network slices, and one network slice may involve one or more access network devices.

[0030] As used herein, the term "circuitry" may refer to one or more or all of the following:

(a) hardware-only circuit implementations (such as implementations in only analog and/or digital circuitry) and

(b) combinations of hardware circuits and software, such as (as applicable): (i) a combination of analog and/or digital hardware circuit(s) with software/firmware and (ii) any portions of hardware processor(s) with software (including digital signal processor(s)), software, and memory(ies) that work together to cause an apparatus, such as a mobile phone or server, to perform various functions) and

(c) hardware circuit(s) and or processor(s), such as a microprocessor(s) or a portion of a microprocessor(s), that requires software (e.g., firmware) for operation, but the software may not be present when it is not needed for operation.

[0031] This definition of circuitry applies to all uses of this term in this application, including in any claims. As a further example, as used in this application, the term circuitry also covers an implementation of merely a hardware circuit or processor (or multiple processors) or portion of a hardware circuit or processor and its (or their) accompanying software and/or firmware. The term circuitry also covers, for example and if applicable to the particular claim element, a baseband integrated circuit or processor integrated circuit for a mobile device or a similar integrated circuit in a server, a cellular network device, or other computing or network device.

[0032] As used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. The term "includes" and its variants are to be read as open terms that mean "includes, but is not limited to". The term "based on" is to be read as "based at least in part on". The term "one embodiment" and "an embodiment" are to be read as "at least one embodiment". The term "another embodiment" is to be read as "at least one other embodiment". Other

definitions, explicit and implicit, may be included below.

[0033] As used herein, the terms "first", "second" and the like may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be referred to as a second element, and similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term "and/or" includes any and all combinations of one or more of the listed terms.

[0034] As described above, a gNB may support a huge number of network slices simultaneously or geographically in specified frequencies. Slice identifications (IDs) may be generated to identify different network slices. The slice IDs may be linked with radio resource management (RRM) policies to meet a Service Level Agreement (SLA). These network slices of the gNB are generally discontinuous in time, frequency and space (or geography) domains. The slice discontinuity may induce a tremendous impact to capacities of the network slices and pose a big challenge to peak capacities of the services especially when UEs are moving across a coverage area of the gNB.

[0035] Slice availability has been discussed for a slice which would be in an available mode during intra-frequency and intra-frequency handover of a UE. To allow the availability, a lot of resources may be allocated for a slice to enhance the capacity of the slice and the peak capacity of the corresponding service. However, some resources may be redundant as the UEs are moving. The redundant resources will be a big waste and lower down utilization and efficiency of the resources.

[0036] In addition, a network slice may be typically configured in consistent with a Tracking Area (TA). UE mapping may be performed when a UE encounters network slice discontinuity, for instance, when the UE tries to cross an edge the connected network slice. One potential problem with the UE mapping would be compatibility with the new network slice. Slice creating may be performed to address the compatibility issue. For example, a new slice may be created to provide the corresponding services as the UE is moving. However, as the UE is permitted to connect to more and more network slices in parallel, very high signaling overhead will induced.

[0037] Embodiments of the present disclosure provide a mechanism of dynamic management of slice groups for UE mobility. In various embodiments of the present disclosure, the network slices are divided into groups. The grouping may be completed

by a network device such as an access network device (for example, a gNB), and the grouping criteria may be diverse. Services are requested by a terminal device to a group of network slices, instead of an individual network slice. The signaling overhead and processing complexity may be reduced, for example, to O(1/n) by grouping multiple network slices together, where n represents the number of network slices in a group. The simplified operation and signaling procedures are especially beneficial to URLLC services.

[0038] Operations and actions for the UE mobility are performed for a group of network slices instead of the individual network slices. In one aspect, resource management is implemented among different groups. If it is determined that service loads of a plurality of groups network slices are to be changed, a network device, such as an access network device and a core network device, adjusts resources allocated to the groups. The resource adjustment based on slice grouping improves the utilization and efficiency of the resources and meanwhile reduce the relevant signaling overhead, which is more efficient and effective. In addition to the service loads, other factors or rules related to the resource utilization and efficiency may be considered or used by a network controller or manager for the resource management based on the slice grouping.

[0039] In another aspect, handover of the terminal device is performed based on slice grouping. As the terminal device approaches an edge of the connected network slice, the terminal device may need the handover to another network slice for service continuity. The slice grouping allows several candidate slices in a group to be selectable for the handover and thereby ensures the service continuity in terms of quantity and quality of candidate slices. As such, the terminal device can make a purposeful choice and select the one network slice that fits most. Accordingly, the terminal device may be mapped to a reserved network slice that already exists in the same group as the connected network slice. Alternatively, the terminal device may move to a new network slice selected from a newly created group. The mapping or moving based on the slice grouping allows the service continuity to be more robust.

[0040] When the terminal device is to be handed over from an access network device to another access network device, slice mapping and slice creation are implemented based on the slice grouping. In response to the handover, the access network device determines two groups of network slices to be mapped and created, respectively. Accordingly, the mapping and creating are implemented per group. As such, the relevant signaling overhead may be reduced significantly.

[0041] In some example embodiments, the terminal device is provided with more freedom or options. The terminal device may change the grouped network slices by moving a network slice from the group for mapping to the group for creation, thereby allowing UE customization. For example, the terminal device may reserve the slices provided by the same operator and tenant, to reduce operations and costs across operators or tenants (or domains). The risk of slice discontinuity may be further mitigated by the slice reservation.

[0042] In this way, the unbalanced distribution of resources and even UEs may be mitigated, improving the slice continuity and the peak capacity of the services. There is no need of resource redundancy to ensure peak capacity, thereby increasing the utilization and efficiency of the resources. Moreover, signaling overheads induced by a larger number of network slices (currently maximum 8) in parallel may be significantly reduced, making the network slices more robust.

[0043] FIG. 1 shows an example environment 100 in which example embodiments of the present disclosure can be implemented. The environment 100, which may be a part of a communication network, comprises an access network device 110 and a terminal device 120. The access network device 110 and the terminal device 120 can communication via a radio link 125. The access network device 110 further communicates with a core network device 130 in a core network 140 via a backhaul link 145.

[0044] It is to be understood that one access network device, one terminal device and one core network device are shown in the environment 100 only for the purpose of illustration, without suggesting any limitation to the scope of the present disclosure. The environment 100 may include any suitable number of access network devices and terminal devices adapted for implementing example embodiments of the present disclosure.

[0045] The terminal device 120 can communicate with the access network device 110 or with another terminal device (not shown) directly or via the network device 110. The communication may follow any suitable communication standards or protocols such as Universal Mobile Telecommunications System (UMTS), long term evolution (LTE), LTE-Advanced (LTE-A), the fifth generation (5G) NR, Wireless Fidelity (Wi-Fi) and Worldwide Interoperability for Microwave Access (WiMAX) standards, and employs any suitable communication technologies, including, for example, Multiple-Input Multiple-Output (MIMO), Orthogonal Frequency Division Multiplexing (OFDM), time

division multiplexing (TDM), frequency division multiplexing (FDM), code division multiplexing (CDM), Bluetooth, ZigBee, and machine type communication (MTC), enhanced mobile broadband (eMBB), massive machine type communication (mMTC) and ultra-reliable low latency communication (URLLC) technologies.

[0046] The network device 110 enables a plurality of network slices, including a network slice 150-1, 150-2,..., 150-N where N represents any suitable integer more than 2. For the purpose of discussion, the network slices 150-1, 150-2,..., 150-N will be referred to as the network slices 150 collectively and individually. Each network slice 150 may have a slice ID, for example, Single Network Slice Selection Assistance Information (S-NSSAI), to make the network slice unique. The terminal device 120 is allowed to be connected to a number of network slices. In various embodiments of the present disclosure, the network slices 150 are divided into a plurality of groups (or classes). These network slices 150 can be managed per group.

[0047] In some example embodiments, the slice grouping may be transparent to the terminal device 120. In this case, the network slices 150 in a group are transparent to the terminal device 120. A member slice, as a part of a slice group, provides specific functions (services), as if the member slice acts as a sub-slice but with more complete functions. From the perspective of the terminal device 120, just one slice (group) is connected. The terminal device 120 sends a signal request for services, accordingly. The request may be mapped by the access network device 110 to a specific slice. As such, the signaling overhead may be reduced.

[0048] A group ID may be generated to identify a group. An example approaches for generating the group ID will be described below. This example is based on a mask managed by the access network device 110 and the slice ID. The slice ID is illustrated as follows, for example:

SST	SD			
0000001	xxxxxxxx	xxxxxxxx	xxxxxxxx	
A	*B*	*C*	*D*	*E*

where Slice/Service type (SST) with 8 bits indicates the type of a slice (or service), assuming SST = 1, and Slice Differentiator (SD) indicates a specific slice in the type of slices and contains up to 24 bits for an eMBB slice.

[0049] The slice ID is divided into four sets of bits, as shown. The set of bits "A"

represents the SST. The sets of bits "B", "C", "D" and "E" indicate various attributes of the slice. The attributes may comprise the service requirements, such as latency, bandwidth and data amount, the operators and the like.

[0050] The slice grouping can be performed based on a grouping function $f_{group}()$. The group ID, G_{ID}, may be generated using the following equation (1):

$$G_{ID} = f_{group}(A,B,C,D,M_{mask}) \qquad (1)$$

where M_{mask} represents a mask, which is related to the service requested by the terminal device 120. M_{mask} may be predefined at a network side, for example, by the operators, a network manager, or negotiated by the access network device 110 with the terminal device 120.

[0051] The function $f_{group}()$ may be defined in any suitable form. For example, the function $f_{group}()$ may be bit-wise exclusive OR (XOR) operation of the engaged bits with the mask M_{mask}, as shown in the following equation (2)

$$G_{ID} = [A\ B\ C\ D] \oplus M_{mask} \qquad (2)$$

where the sets A, B, C and D are concatenated by the operation $[\cdot]$.

[0052] The slices 150 with the same group ID, G_{ID}, are put into the same group. The grouping criteria may be diverse. Not all of the partitioned sets are necessarily contribute to the generation of G_{ID}. For example, the set E is not involved in the equation (1). The grouping may be further based on M_{mask}. Moreover, if the slices 150 are grouped by the operators, operation identifications may also be an operand in the function $f_{group}()$.

[0053] The slice grouping enables the flexibility of network slices. The slices 150 within a group will be scheduled and managed jointly, which is more effective and efficient. For example, the resource utilization is more feasible, and signaling overhead for slice management may be reduced.

[0054] In some other example embodiments, the slice grouping may be non-transparent to the terminal device. In this case, member slice information of a group may be indicated by the access network device 110 to the terminal device 120 in advance or by a label or mask together with the group ID. Using this member slice information, the terminal device 120 may have autonomy to select a specific group or slice. For example, in the stage of slice selection, the terminal device 120 may be intentionally connected to the group of network slices running on the infrastructures of the same provider or operator, for

better compatibility in lower layers.

[0055] As such, the UE mobility may be improved especially when the terminal device 120 encounters the slice discontinuity. For example, the terminal device 120 may be connected to 8 slices in parallel which do not necessarily fall into the same slice group. When moving between different network slices, the terminal device 120 may prefer the slices belonging to the cooperative operator groups for charge discount of the bills. The slice selection may be more desired for the terminal device 120 at this time.

[0056] As the number of network slices grows large, the slice grouping may enable the slice management to be easier and the processing complexity to be reduced significantly. Based on the grouping, the service continuity may be enabled in the case of resource unbalance in the time, frequency and space domains.

[0057] In one aspect, resource management is implemented based on the slice grouping. Example embodiments of the present disclosure in this aspect will be described below with reference to FIGS. 2-6.

[0058] FIG. 2 illustrates an example scenario 200 in which some example embodiments of the present disclosure can be implemented. The scenario 200 is an example implementation of the environment 100 as shown in FIG. 1. In this example, the scenario 200 is inside and around a stadium 205. A parking lot 210 and a road 215 are near the stadium 205. The scenario 200 may follow the urban planning to allow a large number of people gathering and leaving.

[0059] The scenario 200 provides grouped slices as shown in FIG. 3. The terminal device 120 can be connected to three network slices, including an eMBB slice 305 for a video service, an mMTC slice 310 for a parking service and a URLLC slice 315 for a driving service. These slices are labeled as slice 0, slice 1 and slice 2, respectively. Slice 0 and slice 1 form a group, and slice 2 forms another group.

[0060] It is to be understood that the specific slices and the grouping approach are shown only for the purpose of illustration, without suggesting any limitation to the scope of the present disclosure. The terminal device 120 may be connected to other slices for other services. Different slices may be grouped based on any suitable grouping criterion.

[0061] In the scenario 200, when an event, such as a match, occurs at a predetermined time in the stadium 205, many people may go there by cars. Because of the influx of a huge number of people into the stadium 205, the eMBB slice 305 (or slice 0) may require a

large number of extra resources to support the video streaming services. Meanwhile, the resources utilized by the URLLC slice 315 (or slice 2) will drop down since most of the people are inside the stadium 205 rather than inside the cars at that time. When the event ends, the people may leave the stadium 205 rapidly. The service transition may occur in a short time, which risks the smooth or continuity of the slices.

[0062] According to example embodiments of the present disclosure, resources may be managed and scheduled between different groups to improve the UE mobility especially when the resource requirements are unbalanced in the time domain. As such, the utilization and efficiency of the resources may be improved.

[0063] FIG. 4 shows a flowchart of an example method 400 for managing resources based on the slice grouping according to some example embodiments of the present disclosure. The process 400 can be implemented by the access network device 110 or the core network device 130 as shown in FIG. 1 in the scenario 200. For the purpose of discussion, the process 400 will be described with reference to FIGS. 1-3.

[0064] At block 405, a network device such as the access network device 110 or the core network device 130 determines that a plurality of service loads are to be changed for a plurality of groups of network slices. The determination may be based on the occurrence of an event causing the service loads to change. For example, in the scenario 200 as shown in FIG. 2, from the beginning of and during the event such as a match in the stadium 205, the service load of the URLLC slice (or slice 2) are gradually decreasing.

[0065] At block 410, resources allocated to the plurality of groups of network slices are adjusted at least in part based on the determining of the service loads for the groups of network slices. The transition of service loads will cause the transition of resource usage. Accordingly, resources for a group of network slices with the decreasing service load may be reallocated to other groups. In addition to the service loads, other factors or rules related to resource utilization and efficiency may be considered for use in the resource adjustment.

[0066] For example, if a service load (referred to as "a first service load") of the service loads for a group (referred to as "a first group") of the plurality of groups is determined to be decreased, a part of resources for the first group may be reallocated to a further group (referred to as "a second group") of the plurality of groups that is different from the first group. The resources to be allocated may be a part of spare resources for the first group.

[0067] The second group may be any suitable group from the plurality of groups which is different from the first group. In some example embodiments, the second group may be a group which is determined to have an increasing service load. If the second group comprises a plurality of network slices 150, the resource for the first group may be reallocated to the plurality of network slices.

[0068] In some example embodiments, the resources for the first group may be reallocated to the plurality of network slices in the second group in proportion and/or in sequence. Accordingly, at least one of proportions and time intervals may be determined for allocating the part of the resources to the plurality of network slices. Further, the resources may be reallocated to the plurality of network slices based on the at least one of the proportions and the time intervals.

[0069] By way of example, in the scenario 200, at the beginning of the event such as a match in the stadium 205, it is determined that the service load of the URLLC slice 315 (or slice 2) will decrease, and then a part of the resources may be released from slice 2 into a pool, for example, and then allocated to the mMTC slice 310 (or slice 1) for the parking service and the eMBB slice 305 (or slice 0) for the video service. Considering that a user may first get his car parked and then watch a video, the resource may be allocated to slice 1 and slice 0 in sequence and in proportion.

[0070] The proportion ρ_{re} and the time interval τ_{re} of the resource reallocation may be determined by a network device such as the access network device 110 and the core network device 130 according to statistics of the respective network slices in terms of resource usage such as a rate of the resource requests and the resource utilization. For example, the statistics may comprise historical usage of the resources for a slice. If the process 400 is implemented by the core network device 130, the statistic may be performed by the access network device 110 and reported to the core network device 130.

[0071] For example, in the scenario 200, the proportion ρ_{re} and the time interval τ_{re} for Slice 0 and Slice 1 may be determined as below:

$$[\rho_{re}\ \tau_{re}] = f_{\text{res\_all}}(G_{ID}, \omega_{01}) \qquad (3)$$

where G_{ID} represents the group ID, and ω_{01} represents the statistics for a group of slice 0 and slice 1. The determination approach of the proportion ρ_{re} and the time interval τ_{re} are implementation oriented. As an example, ρ_{re} and τ_{re} may be determined using machine learning based on historical data related to the resource usage.

[0072] In some example embodiments, if the process 400 is implemented by the core network device 130, an adjusting indication may be sent by the core network device 130 to the access network device 110 to adjust the resources allocated to the plurality of groups. For example, the adjustment indication may indicate that a part of resources for a selected group is to be released or increased. As another example, the adjustment indication may indicate that a part of resources for a group is allocated to the selected group. The adjustment indication may further indicate at least one of proportions and time intervals for allocating the part of the resources to the selected group. Accordingly, the access network device 110 makes the corresponding adjustment.

[0073] FIG. 5 shows a signaling flow of a resource coordination process 500 according to some example embodiments of the present disclosure. The process 500 is implemented in the scenario 200 where the eMBB slice 305 (or slice 0) and the mMTC slice 310 (or slice 1) are grouped together into a group 505.

[0074] As shown in FIG. 5, the schedule (for example, the beginning time and the duration) of the event such as a match in the stadium 205 is predetermined (510). The core network device 130 receives (515) from the URLLC slice 315 (or slice 2) a report of the statistics ω_2 and receives (520) from the group 505 of slice 0 and slice 1 a report of the statistics ω_{01}. The core network device 130 instructs (525) slice 2 to release the spare resources into a pool with a releasing rate. The core network device 130 decides (530) the proportions ρ_{re} and the time intervals τ_{re} by comprehensively considering the released resource from slice 2 and the conditions of slice 0 and slice 1. For example, the core network device 130 may make the decision based on the statistics of slice 0, slice 1 and slice 2. The core network device 130 sends (535) ρ_{re} and τ_{re} to the group 505 of slice 0 and slice 1. The resources released from slice 2 may be reallocated to slice 0 and slice 1 in sequence and in proportion.

[0075] In some example embodiments, if the first service load of the first group is increasing, a part of resources for the second group may be reallocated to the first group. The increase of the first service load may be determined in response to an end of the event causing the first service load of the first group to decrease.

[0076] For example, in the scenario 200, when the event ends and the people depart from the stadium 205, there will be a large amount of resource release in the eMBB slice 305 (or slice 0) and the mMTC slice 310 (or slice 1). The terminal device 120 may be handed

over from slice 0 and slice 1 to the URLLC slice 315 (or slice 2). Accordingly, the resources for slice 0 and slice 1 may be re-allocated to slice 2. Likewise, the resources may be released from slice 0 and slice 1 in portion and in sequence. The portions and time intervals may be determined by the statistics of slice 0 and slice 1 in a way similar to the determination of ρ_{re} and τ_{re}. For simplicity, the details will not be repeated.

[0077] In some example embodiments, the reallocation of the resources from the second group to the first group may be performed in response to reservation for the first group from the terminal device 120. For example, the terminal device 120 may reserve the services in the first group. Example operations and processing of the reservation at the terminal device 120 will be described below with reference to FIG. 6.

[0078] FIG. 6 shows a signaling flow of an example process 600 for reserving the first group of network slices according to some example embodiments of the present disclosure. The process 600 is implemented in the scenario 200 where the resources for the URLLC slice 315 (or slice 2) have been reallocated to a group of the eMBB slice 305 (or slice 0) and the mMTC slice 310 (or slice 1).

[0079] As pre-scheduled, the event such as a match is going to end (605) in the stadium 205, which is known to the terminal device 120, the access network device 110 and the core network device 130. Based on historical data, the terminal device 120 reserves (610) slice 2. For example, if the user drives a car to the stadium 205, he or she will probably leave with the car as well. According to historical data, the terminal device 120 reserves the connection to slice 2. It is also possible that the reservation of slice 2 is determined by the access network device 110 or the core network device 130 for the terminal device 120.

[0080] The access network device 110 sends (615) an activation request of slice 2 to the core network device 130. The core network device 130 processes (620) activation of slice 2. The resources of the slice group 505 (slice 0 and slice 1) are reallocated (625) to slice 2 in portion and in sequence. For example, the resources will first be released from slice 0 since the video service almost ends as the event ends. Then, the audience will get his car, and the parking service of this user will end. Further, the resources may be released from slice 1. After that, the spared resources are allocated to slice 2. The terminal device 120 is provided (630) with the services of slice 2.

[0081] In another aspect, handover of the terminal device 120 is performed based on slice grouping. When the terminal device 120 is to be handed over from the access network

device 110 to another access network device, slice mapping and slice creation are implemented based on the slice grouping.

[0082] For example, the network slices may be of a uniform configuration within TA. As the terminal device 120 moves across TAs, slice discontinuity will occur. In some embodiments, a new network slice may be created for the terminal device 120 when the terminal device moves across TAs. In parallel, slice mapping may also be performed. In some example embodiments, a group-based slice reservation mechanism may be provided to the terminal device 120. The group-based creation and mapping may reduce the operation complexity and the signaling overhead. Example embodiments of the present disclosure in this aspect will be described below with reference to FIGS. 7 and 8.

[0083] FIG. 7 shows a flowchart of an example process 700 for handover of the terminal device 120 based on the slice grouping according to some example embodiments of the present disclosure. The process 700 can be implemented by the access network device 110 as shown in FIG. 1. For the purpose of discussion, the process 700 will be described with reference to FIG. 1.

[0084] At block 705, in response to handover of the terminal device 110 to a further access network device, the access network device 110 determines two groups of network slices from a plurality of network slices connected with the terminal device 120. One group (referred to as "a third group") of network slices are to be mapped to the further access network device. The other group (referred to as "a fourth group") of network slices are to be created in the further access network device. For the purpose of discussion, the further access network device will be referred to as a target access network device hereinafter.

[0085] For example, in the case that the target access network device is a neighbor of the access network device 110, the access network device 110 may be aware of the status of the network slices supported by the target access network device. If the target access network device supports a network slice available for UE mapping, the mapping may be performed in this slice. When the terminal device 120 has several network slices to map to and join in, these network slices may be grouped together.

[0086] For some network slices connected with the terminal device 120, there may be no available network slices in the target access network device for the mapping. For example, there is no network slice in the target access network device falling into the same slice

group with the network slice in the access network device 110. In this case, a network slice may be created in the target access network device. The network slices to be created are also grouped together.

[0087] In some example embodiments, the terminal device 120 may decide whether to map a network slice in the access network device 110 to a new slice in the target access network device even if the new slice is available for the mapping. For example, the terminal device 120 may reserve a group of network slices to be created.

[0088] For example, the access network device 110 may first determine two candidate group of network slices, referred to as a first candidate group to be mapped and a second candidate group to be created. The access network device 110 sends the slice member information of the two candidate groups to the terminal device 120. The terminal device 120 may send a request to move a network slice from the first candidate group to the second candidate group. Then, the access network device 110 moves the network slice to determine the third group to be mapped and the fourth group to be created.

[0089] In this way, the terminal device 120 may maneuver and adjust the network slices in each group to enable user customization of the groups. For example, if the mapping of a network slice may cause some compatibility problems or undesirably high billing or poor peak-time services, the terminal device 120 may request the slice to be included in a group to be created.

[0090] After the third and fourth groups are determined, at block 710, the access network device causes the slice mapping for the third group and the slice creating for the fourth group. As such, the mapping and creating are both performed for a group of network slices instead of the individual network slices. In some example embodiments, temporary group IDs may be generated for the two groups for subsequent operations to further reduce the signaling overhead. Example operations and processing of the group based mapping and creation for the UE mobility will be discussed below with reference to FIG. 8.

[0091] FIG. 8 shows a signaling flow of an example process 800 of the slice mapping and creating based on the slice grouping according to some example embodiments of the present disclosure.

[0092] In this example, the terminal device 120 is connected to eight network slices supported by the access network device 110 (for example, gNB1). All of the connections of the eight network slices need to be switched to a target access network device 805 (for

example, gNB2).

[0093] It is determined (810) that from the eight network slices, three network slices are available in the target access network device, three network slices can be mapped to three existing slices in the target access network device 805, and the remaining two network slices need to be newly created in the target access network device 805. The grouping information for the three types of network slices is exchanged between the access network device 110, the target access network device 805 and the terminal device 120.

[0094] Two temporary slice groups are generated (815) with group IDs G_{ID1} and G_{ID2} for the network slices to be mapped and the network slices to be created, respectively. One mapping slice in G_{ID1} is selected (820) by the terminal device 120 to be moved into G_{ID2} to create a new slice in the target access network device 805, for some customized considerations.

[0095] The process 800 proceeds (825) with UE mapping of the group G_{ID1} and the slice creation of the group G_{ID2}. As such, the mapping and creating may be implemented for a group, rather than each individual slice one by one. Thereby, the signaling overhead is significantly reduced. Then, TA update and the handover are performed (830).

[0096] It is to be understood that the operations and actions in the process 800 are not necessary for each terminal device. As an example, if a given network slice is available in the target access network device 805, the preceding operations (810, 815 and 820) may not be taken.

[0097] Typically, several UEs are connected to multiple network slices in a gNB. For UE mobility, some UEs connected with certain network slices may be mapped to the existing network slices in a target or new gNB, while some UEs may be handed over to real-time created network slices in the new gNB. The operation will be carried out in group manner to reduce the signalling overhead and bring beneficial to the handover management. The UE handover based on mapping or slice creation may be performed by the network manager or high level policy. Meanwhile, some freedom is provided for the UE to choose one of the mapping and creating for a network slice.

[0098] In some example embodiments, the method 400 and the process 700 described above with reference to FIGS. 1-8 may be performed by an apparatus comprising means for performing the respective steps of the method 200 and the process 600. The means may be implemented in any suitable form. For example, the means may be implemented in a

circuitry or software module.

[0099] FIG. 9 is a simplified block diagram of a device 900 that is suitable for implementing example embodiments of the present disclosure. The device 900 can be implemented at or as a part of the access network device 110 or the core network device 130 as shown in FIG. 1.

[00100] As shown, the device 900 includes a processor 910, a memory 920 coupled to the processor 910, a communication module 930 coupled to the processor 910, and a communication interface (not shown) coupled to the communication module 930. The memory 920 stores at least a program 940. The communication module 930 is for bidirectional communications, for example, via multiple antennas. The communication interface may represent any interface that is necessary for communication.

[00101] The program 940 is assumed to include program instructions that, when executed by the associated processor 910, enable the device 900 to operate in accordance with the example embodiments of the present disclosure, as discussed herein with reference to FIGS. 1-8. The example embodiments herein may be implemented by computer software executable by the processor 910 of the device 900, or by hardware, or by a combination of software and hardware. The processor 910 may be configured to implement various example embodiments of the present disclosure.

[00102] The memory 920 may be of any type suitable to the local technical network and may be implemented using any suitable data storage technology, such as a non-transitory computer readable storage medium, semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, fixed memory and removable memory, as non-limiting examples. While only one memory 920 is shown in the device 900, there may be several physically distinct memory modules in the device 900. The processor 910 may be of any type suitable to the local technical network, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multicore processor architecture, as non-limiting examples. The device 900 may have multiple processors, such as an application specific integrated circuit chip that is slaved in time to a clock which synchronizes the main processor.

[00103] When the device 900 acts as the access network device 110 or the core network device 130, or a part of the access network device 110 or the core network device 130, the

processor 910 and the communication module 930 may cooperate to implement the method 400 and the process 700 as described above with reference to FIGS. 1-8.

[00104] All operations and features as described above with reference to FIGS. 1-8 are likewise applicable to the device 900 and have similar effects. For the purpose of simplification, the details will be omitted.

[00105] Generally, various example embodiments of the present disclosure may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. Some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device. While various aspects of example embodiments of the present disclosure are illustrated and described as block diagrams, flowcharts, or using some other pictorial representations, it is to be understood that the block, apparatus, system, technique or method described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[00106] The present disclosure also provides at least one computer program product tangibly stored on a non-transitory computer readable storage medium. The computer program product includes computer-executable instructions, such as those included in program modules, being executed in a device on a target real or virtual processor, to carry out the method 400 or the process 700 as described above with reference to FIGS. 1-8. Generally, program modules include routines, programs, libraries, objects, classes, components, data structures, or the like that perform particular tasks or implement particular abstract data types. The functionality of the program modules may be combined or split between program modules as desired in various example embodiments. Machine-executable instructions for program modules may be executed within a local or distributed device. In a distributed device, program modules may be located in both local and remote storage media.

[00107] Program code for carrying out methods of the present disclosure may be written in any combination of one or more programming languages. These program codes may be provided to a processor or controller of a general purpose computer, special purpose computer, or other programmable data processing apparatus, such that the program codes,

when executed by the processor or controller, cause the functions/operations specified in the flowcharts and/or block diagrams to be implemented. The program code may execute entirely on a machine, partly on the machine, as a stand-alone software package, partly on the machine and partly on a remote machine or entirely on the remote machine or server.

[00108] In the context of the present disclosure, the computer program codes or related data may be carried by any suitable carrier to enable the device, apparatus or processor to perform various processes and operations as described above. Examples of the carrier include a signal, computer readable media.

[00109] The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable medium may include but not limited to an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples of the computer readable storage medium would include an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), Digital Versatile Disc (DVD), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing.

[00110] Further, while operations are depicted in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Likewise, while several specific implementation details are contained in the above discussions, these should not be construed as limitations on the scope of the present disclosure, but rather as descriptions of features that may be specific to particular example embodiments. Certain features that are described in the context of separate example embodiments may also be implemented in combination in a single embodiment. Conversely, various features that are described in the context of a single embodiment may also be implemented in multiple example embodiments separately or in any suitable sub-combination.

[00111] Although the present disclosure has been described in languages specific to structural features and/or methodological acts, it is to be understood that the present

disclosure defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

[00112] Various example embodiments of the techniques have been described. In addition to or as an alternative to the above, the following examples are described. The features described in any of the following examples may be utilized with any of the other examples described herein.

[00113] Example 1. a device comprising: at least one processor; and at least one memory including computer program code; the at least one memory and the computer program code configured to, with the at least one processor, cause the device to: determine, by a network device, that a plurality of service loads for a plurality of groups of network slices are to be changed; and adjust resources allocated to the plurality of groups at least in part based on the determining.

[00114] Example 2. the device of example 1, wherein the device is caused to determine that the plurality of service loads for the plurality of groups of network slices are to be changed by: in response to occurrence of an event causing the plurality of service loads to change, determining that the plurality of service loads are to be changed.

[00115] Example 3. the device of example 1 or 2, wherein the device is caused to determine that the plurality of service loads for the plurality of groups of network slices are to be changed by determining that a first service load of the plurality of service loads for a first group of the plurality of groups is to be decreased, and wherein the device is caused to adjust the resources by reallocating a part of resources for the first group to a second group of the plurality of groups different from the first group.

[00116] Example 4. the device of example 3, wherein the part of the resources for the first group comprises a part of spare resources of the first group.

[00117] Example 5. the device of example 3 or 4, wherein a second service load of the plurality of service loads for the second group is determined to increase.

[00118] Example 6. the device of any of examples 3-5, wherein the second group comprises a plurality of network slices, and the device is caused to reallocate the part of the resources to the second group by: determining at least one of proportions and time intervals for allocating the part of the resources to the plurality of network slices; and reallocating the part of the resources to the plurality of network slices based on the at least one of the

proportions and the time intervals.

[00119] Example 7. the device of example 6, wherein the at least one of the proportions and the time intervals are determined based on historic resource usage of the plurality of network slices.

[00120] Example 8. the device of example 3, wherein the device is caused to adjust the resources further by: determining that the first service load is to be increased; and reallocating a part of resources for the second group to the first group.

[00121] Example 9. the device of example 8, wherein the device is caused to determine that the first service load is to be increased by: in response to an end of an event causing the first service load to decrease, determining that the first service load is increased.

[00122] Example 10. the device of example 9, wherein the device is caused to reallocate the part of resources for the second group to the first group by: in response to reservation of the first group from a terminal device, reallocating the part of resources for the second group to the first group.

[00123] Example 11. the device of any of examples 8-10, wherein the second group comprises a plurality of network slices, and wherein the device is caused to reallocate the part of the resources for the second group to the first group by: determining at least one of proportions and time intervals for allocating resources for the plurality of network slices to the first group; and reallocating the resources for the plurality of network slices to the first group based on the at least one of the proportions and the time intervals.

[00124] Example 12. the device of example 1, wherein the network device is a core network device.

[00125] Example 13. the device of example 12, wherein the device is caused to adjust the resources by: sending an adjusting indication to an access network device to adjust the resources allocated to the plurality of groups.

[00126] Example 14. the device of example 1, wherein the network device is an access network device.

[00127] Example 15. the device of example 14, wherein the device is caused to adjust the resources by: receiving an adjusting indication from a core network device to adjust resources for a selected group of the plurality of groups; and adjusting the resources for the

selected group based on the adjusting indication.

[00128] Example 16. the device of example 15, wherein the adjusting indication indicates that a part of the resources for the selected group is to be released.

[00129] Example 17. the device of example 15, wherein the adjusting indication indicates that a part of resources for a further group of the plurality of groups is allocated to the selected group.

[00130] Example 18. the device of example 17, wherein the adjusting indication indicates at least one of proportions and time intervals for allocating the part of the resources to the selected group.

[00131] Example 19. the device of example 15, wherein the device is further caused to: determine historical usage of the resources for the selected group.

[00132] Example 20. the device of example 14, wherein the device is further caused to: divide a plurality of network slices into the plurality of groups based on at least one of service types, service requirements and operators of the plurality of network slices.

[00133] Example 21. the device of example 14, wherein the device is further caused to: transmit an identification of a selected group of the plurality of groups to a terminal device.

[00134] Example 22. the device of example 21, wherein the device is further caused to: receive, from the terminal device, a request for the selected group; and map the request to a network slice in the selected group.

[00135] Example 23. the device of example 21, wherein the device is further caused to: transmit slice member information of the selected group to the terminal device.

[00136] Example 24. the device of example 14, wherein the device is further caused to: in response to handover of a terminal device to a further access network device, determine, from a plurality of network slices connected with the terminal device, a third group of network slices to be mapped to the further access network device and a fourth group of network slices to be created in the further access network device; and cause the third group to be mapped to the further access network device and the fourth group to be created in the further access network device.

[00137] Example 25. the device of example 24, wherein the device is caused to determine the third and fourth groups by: in response to the handover of the terminal device, determining, from the plurality of network slices, a first candidate group of network slices

to be mapped to the further access network device and a second candidate group of the two groups to be created in the further access network device; sending slice member information of the first and second candidate groups to the terminal device; receiving a request from the terminal device to move a network slice from the first candidate group to the second candidate group; and determining the third and fourth groups by moving the network slice from the first candidate group to the second candidate group.

[00138] Example 26. a method comprising: determining, by a network device, that a plurality of service loads for a plurality of groups of network slices are to be changed; and adjusting resources allocated to the plurality of groups at least in part based on the determining.

[00139] Example 27. the method of example 26, wherein the determining comprises: in response to occurrence of an event causing the plurality of service loads to change, determining that the plurality of service loads are to be changed.

[00140] Example 28. the method of example 26 or 27, wherein the determining comprises determining that a first service load of the plurality of service loads for a first group of the plurality of groups is to be decreased, and wherein the adjusting comprises reallocating a part of resources for the first group to a second group of the plurality of groups different from the first group.

[00141] Example 29. the method of example 28, wherein the part of the resources for the first group comprises a part of spare resources of the first group.

[00142] Example 30. the method of example 28 or 29, wherein a second service load of the plurality of service loads for the second group is determined to increase.

[00143] Example 31. the method of any of examples 28-30, wherein the second group comprises a plurality of network slices, and reallocating the part of the resources to the second group comprises: determining at least one of proportions and time intervals for allocating the part of the resources to the plurality of network slices; and reallocating the part of the resources to the plurality of network slices based on the at least one of the proportions and the time intervals.

[00144] Example 32. the method of example 31, wherein the at least one of the proportions and the time intervals are determined based on historic resource usage of the plurality of network slices.

[00145] Example 33. the method of example 28, wherein the adjusting further comprises: determining that the first service load is to be increased; and reallocating a part of resources for the second group to the first group.

[00146] Example 34. the method of example 33, wherein determining that the first service load is to be increased comprises: in response to an end of an event causing the first service load to decrease, determining that the first service load is increased.

[00147] Example 35. the method of example 34, wherein reallocating the part of resources for the second group to the first group comprises: in response to reservation of the first group from a terminal device, reallocating the part of resources for the second group to the first group.

[00148] Example 36. the method of any of examples 33-35, wherein the second group comprises a plurality of network slices, and reallocating the part of the resources for the second group to the first group comprises: determining at least one of proportions and time intervals for allocating resources for the plurality of network slices to the first group; and reallocating the resources for the plurality of network slices to the first group based on the at least one of the proportions and the time intervals.

[00149] Example 37. the method of example 26, wherein the network device is a core network device.

[00150] Example 38. the method of example 37, wherein adjusting the resources comprises: sending an adjusting indication to an access network device to adjust the resources allocated to the plurality of groups.

[00151] Example 39. the method of example 26, wherein the network device is an access network device.

[00152] Example 40. the method of example 39, wherein adjusting resources allocated to the plurality of groups comprises: receiving an adjusting indication from a core network device to adjust resources for a selected group of the plurality of groups; and adjusting the resources for the selected group based on the adjusting indication.

[00153] Example 41. the method of example 40, wherein the adjusting indication indicates that a part of the resources for the selected group is to be released.

[00154] Example 42. the method of example 40, wherein the adjusting indication indicates that a part of resources for a further group of the plurality of groups is allocated to

the selected group.

[00155] Example 43. the method of example 42, wherein the adjusting indication indicates at least one of proportions and time intervals for allocating the part of the resources to the selected group.

[00156] Example 44. the method of example 40, further comprising: determining historical usage of the resources for the selected group.

[00157] Example 45. the method of example 39, further comprising: dividing a plurality of network slices into the plurality of groups based on at least one of service types, service requirements and operators of the plurality of network slices.

[00158] Example 46. the method of example 39, further comprising: transmitting an identification of a selected group of the plurality of groups to a terminal device.

[00159] Example 47. the method of example 45, further comprising: receiving, from the terminal device, a request for the selected group; and mapping the request to a network slice in the selected group.

[00160] Example 48. the method of example 45, further comprising: transmitting slice member information of the selected group to the terminal device.

[00161] Example 49. the method of example 39, further comprising: in response to handover of a terminal device to a further access network device, determining, from a plurality of network slices connected with the terminal device, a third group of network slices to be mapped to the further access network device and a fourth group of network slices to be created in the further access network device; and causing the third group to be mapped to the further access network device and the fourth group to be created in the further access network device.

[00162] Example 50. the method of example 49, wherein determining the third and fourth groups comprises: in response to the handover of the terminal device, determining, from the plurality of network slices, a first candidate group of network slices to be mapped to the further access network device and a second candidate group of the two groups to be created in the further access network device; sending slice member information of the first and second candidate groups to the terminal device; receiving a request from the terminal device to move a network slice from the first candidate group to the second candidate group; and determining the third and fourth groups by moving the network slice from the

first candidate group to the second candidate group.

[00163] Example 51. an apparatus comprising: means for determining, by a network device, that a plurality of service loads for a plurality of groups of network slices are to be changed; and means for adjusting resources allocated to the plurality of groups at least in part based on the determining.

[00164] Example 52. the apparatus of example 51, wherein the means for determining comprises: means for in response to occurrence of an event causing the plurality of service loads to change, determining that the plurality of service loads are to be changed.

[00165] Example 53. the apparatus of example 51 or 52, wherein the means for determining comprises means for determining that a first service load of the plurality of service loads for a first group of the plurality of groups is to be decreased, and wherein the means for adjusting comprises means for reallocating a part of resources for the first group to a second group of the plurality of groups different from the first group.

[00166] Example 54. the apparatus of example 53, wherein the part of the resources for the first group comprises a part of spare resources of the first group.

[00167] Example 55. the apparatus of example 53 or 54, wherein a second service load of the plurality of service loads for the second group is determined to increase.

[00168] Example 56. the apparatus of any of examples 53-55, wherein the second group comprises a plurality of network slices, and the means for reallocating the part of the resources to the second group comprises: means for determining at least one of proportions and time intervals for allocating the part of the resources to the plurality of network slices; and means for reallocating the part of the resources to the plurality of network slices based on the at least one of the proportions and the time intervals.

[00169] Example 57. the apparatus of example 56, wherein the at least one of the proportions and the time intervals are determined based on historic resource usage of the plurality of network slices.

[00170] Example 58. the apparatus of example 53, wherein the means for adjusting further comprises: means for determining that the first service load is to be increased; and means for reallocating a part of resources for the second group to the first group.

[00171] Example 59. the apparatus of example 58, wherein the means for determining that the first service load is to be increased comprises: in response to an end of an event

causing the first service load to decrease, determining that the first service load is increased.

[00172] Example 60. the apparatus of example 59, wherein the means for reallocating the part of resources for the second group to the first group comprises: in response to reservation of the first group from a terminal device, reallocating the part of resources for the second group to the first group.

[00173] Example 61. the apparatus of any of examples 58-60, wherein the second group comprises a plurality of network slices, and the means for reallocating the part of the resources for the second group to the first group comprises: means for determining at least one of proportions and time intervals for allocating resources for the plurality of network slices to the first group; and means for reallocating the resources for the plurality of network slices to the first group based on the at least one of the proportions and the time intervals.

[00174] Example 62. the apparatus of example 51, wherein the network device is a core network device.

[00175] Example 63. the apparatus of example 62, wherein the means for adjusting the resources comprises: sending an adjusting indication to an access network device to adjust the resources allocated to the plurality of groups.

[00176] Example 64. the apparatus of example 51, wherein the network device is an access network device.

[00177] Example 65. the apparatus of example 64, wherein the means for adjusting resources allocated to the plurality of groups comprises: means for receiving an adjusting indication from a core network device to adjust resources for a selected group of the plurality of groups; and means for adjusting the resources for the selected group based on the adjusting indication.

[00178] Example 66. the apparatus of example 65, wherein the adjusting indication indicates that a part of the resources for the selected group is to be released.

[00179] Example 67. the apparatus of example 65, wherein the adjusting indication indicates that a part of resources for a further group of the plurality of groups is allocated to the selected group.

[00180] Example 68. the apparatus of example 67, wherein the adjusting indication

indicates at least one of proportions and time intervals for allocating the part of the resources to the selected group.

[00181] Example 69. the apparatus of example 65, further comprising: means for determining historical usage of the resources for the selected group.

[00182] Example 70. the apparatus of example 64, further comprising: means for dividing a plurality of network slices into the plurality of groups based on at least one of service types, service requirements and operators of the plurality of network slices.

[00183] Example 71. the apparatus of example 64, further comprising: means for transmitting an identification of a selected group of the plurality of groups to a terminal device.

[00184] Example 72. the apparatus of example 70, further comprising: means for receiving, from the terminal device, a request for the selected group; and means for mapping the request to a network slice in the selected group.

[00185] Example 73. the apparatus of example 70, further comprising: means for transmitting slice member information of the selected group to the terminal device.

[00186] Example 74. the apparatus of example 64, further comprising: means for in response to handover of a terminal device to a further access network device, determining, from a plurality of network slices connected with the terminal device, a third group of network slices to be mapped to the further access network device and a fourth group of network slices to be created in the further access network device; and means for causing the third group to be mapped to the further access network device and the fourth group to be created in the further access network device.

[00187] Example 75. the apparatus of example 49, wherein the means for determining the third and fourth groups comprises: means for in response to the handover of the terminal device, determining, from the plurality of network slices, a first candidate group of network slices to be mapped to the further access network device and a second candidate group of the two groups to be created in the further access network device; means for sending slice member information of the first and second candidate groups to the terminal device; means for receiving a request from the terminal device to move a network slice from the first candidate group to the second candidate group; and means for determining the third and fourth groups by moving the network slice from the first candidate group to the second candidate group.

[00188] Example 76. a computer readable storage medium comprising program instructions stored thereon, the instructions, when executed by a processor of a device, causing the device to perform the method of any of examples 26-50.

WHAT IS CLAIMED IS:

1. A device comprising:

at least one processor; and

at least one memory including computer program code;

the at least one memory and the computer program code configured to, with the at least one processor, cause the device to:

determine, by a network device, that a plurality of service loads for a plurality of groups of network slices are to be changed; and

adjust resources allocated to the plurality of groups at least in part based on the determining.

2. The device of claim 1, wherein the device is caused to determine that the plurality of service loads for the plurality of groups of network slices are to be changed by:

in response to occurrence of an event causing the plurality of service loads to change, determining that the plurality of service loads are to be changed.

3. The device of claim 1 or 2, wherein the device is caused to determine that the plurality of service loads for the plurality of groups of network slices are to be changed by determining that a first service load of the plurality of service loads for a first group of the plurality of groups is to be decreased, and

wherein the device is caused to adjust the resources by reallocating a part of resources for the first group to a second group of the plurality of groups different from the first group.

4. The device of claim 3, wherein the part of the resources for the first group comprises a part of spare resources of the first group.

5. The device of claim 3 or 4, wherein a second service load of the plurality of service loads for the second group is determined to increase.

6. The device of any of claims 3-5, wherein the second group comprises a plurality of network slices, and the device is caused to reallocate the part of the resources to the second group by:

determining at least one of proportions and time intervals for allocating the part of the resources to the plurality of network slices; and

reallocating the part of the resources to the plurality of network slices based on the at least one of the proportions and the time intervals.

7. The device of claim 6, wherein the at least one of the proportions and the time intervals are determined based on historic resource usage of the plurality of network slices.

8. The device of claim 3, wherein the device is caused to adjust the resources further by:

determining that the first service load is to be increased; and

reallocating a part of resources for the second group to the first group.

9. The device of claim 8, wherein the device is caused to determine that the first service load is to be increased by:

in response to an end of an event causing the first service load to decrease, determining that the first service load is increased.

10. The device of claim 9, wherein the device is caused to reallocate the part of resources for the second group to the first group by:

in response to reservation of the first group from a terminal device, reallocating the part of resources for the second group to the first group.

11. The device of any of claims 8-10, wherein the second group comprises a plurality of network slices, and

wherein the device is caused to reallocate the part of the resources for the second group to the first group by:

determining at least one of proportions and time intervals for allocating resources for the plurality of network slices to the first group; and

reallocating the resources for the plurality of network slices to the first group based on the at least one of the proportions and the time intervals.

12. The device of claim 1, wherein the network device is a core network

device.

13. The device of claim 12, wherein the device is caused to adjust the resources by:

sending an adjusting indication to an access network device to adjust the resources allocated to the plurality of groups.

14. The device of claim 1, wherein the network device is an access network device.

15. The device of claim 14, wherein the device is caused to adjust the resources by:

receiving an adjusting indication from a core network device to adjust resources for a selected group of the plurality of groups; and

adjusting the resources for the selected group based on the adjusting indication.

16. The device of claim 15, wherein the adjusting indication indicates that a part of the resources for the selected group is to be released.

17. The device of claim 15, wherein the adjusting indication indicates that a part of resources for a further group of the plurality of groups is allocated to the selected group.

18. The device of claim 17, wherein the adjusting indication indicates at least one of proportions and time intervals for allocating the part of the resources to the selected group.

19. The device of claim 15, wherein the device is further caused to:

determine historical usage of the resources for the selected group.

20. The device of claim 14, wherein the device is further caused to:

divide a plurality of network slices into the plurality of groups based on at least one of service types, service requirements and operators of the plurality of network slices.

21. The device of claim 14, wherein the device is further caused to:

transmit an identification of a selected group of the plurality of groups to a terminal device.

22. The device of claim 21, wherein the device is further caused to:

receive, from the terminal device, a request for the selected group; and

map the request to a network slice in the selected group.

23. The device of claim 21, wherein the device is further caused to:

transmit slice member information of the selected group to the terminal device.

24. The device of claim 14, wherein the device is further caused to:

in response to handover of a terminal device to a further access network device, determine, from a plurality of network slices connected with the terminal device, a third group of network slices to be mapped to the further access network device and a fourth group of network slices to be created in the further access network device; and

cause the third group to be mapped to the further access network device and the fourth group to be created in the further access network device.

25. The device of claim 24, wherein the device is caused to determine the third and fourth groups by:

in response to the handover of the terminal device, determining, from the plurality of network slices, a first candidate group of network slices to be mapped to the further access network device and a second candidate group of the two groups to be created in the further access network device;

sending slice member information of the first and second candidate groups to the terminal device;

receiving a request from the terminal device to move a network slice from the first candidate group to the second candidate group; and

determining the third and fourth groups by moving the network slice from the first candidate group to the second candidate group.

26. A method comprising:

determining, by a network device, that a plurality of service loads for a plurality of

groups of network slices are to be changed; and

adjusting resources allocated to the plurality of groups at least in part based on the determining.

27. The method of claim 26, wherein the determining comprises:

in response to occurrence of an event causing the plurality of service loads to change, determining that the plurality of service loads are to be changed.

28. The method of claim 26 or 27, wherein the determining comprises determining that a first service load of the plurality of service loads for a first group of the plurality of groups is to be decreased, and

wherein the adjusting comprises reallocating a part of resources for the first group to a second group of the plurality of groups different from the first group.

29. The method of claim 28, wherein the part of the resources for the first group comprises a part of spare resources of the first group.

30. The method of claim 28 or 29, wherein a second service load of the plurality of service loads for the second group is determined to increase.

31. The method of any of claims 28-30, wherein the second group comprises a plurality of network slices, and reallocating the part of the resources to the second group comprises:

determining at least one of proportions and time intervals for allocating the part of the resources to the plurality of network slices; and

reallocating the part of the resources to the plurality of network slices based on the at least one of the proportions and the time intervals.

32. The method of claim 31, wherein the at least one of the proportions and the time intervals are determined based on historic resource usage of the plurality of network slices.

33. The method of claim 28, wherein the adjusting further comprises:

determining that the first service load is to be increased; and

reallocating a part of resources for the second group to the first group.

34. The method of claim 33, wherein determining that the first service load is to be increased comprises:

in response to an end of an event causing the first service load to decrease, determining that the first service load is increased.

35. The method of claim 34, wherein reallocating the part of resources for the second group to the first group comprises:

in response to reservation of the first group from a terminal device, reallocating the part of resources for the second group to the first group.

36. The method of any of claims 33-35, wherein the second group comprises a plurality of network slices, and reallocating the part of the resources for the second group to the first group comprises:

determining at least one of proportions and time intervals for allocating resources for the plurality of network slices to the first group; and

reallocating the resources for the plurality of network slices to the first group based on the at least one of the proportions and the time intervals.

37. The method of claim 26, wherein the network device is a core network device.

38. The method of claim 37, wherein adjusting the resources comprises:

sending an adjusting indication to an access network device to adjust the resources allocated to the plurality of groups.

39. The method of claim 26, wherein the network device is an access network device.

40. The method of claim 39, wherein adjusting resources allocated to the plurality of groups comprises:

receiving an adjusting indication from a core network device to adjust resources for a selected group of the plurality of groups; and

adjusting the resources for the selected group based on the adjusting indication.

41. The method of claim 40, wherein the adjusting indication indicates that a part of the resources for the selected group is to be released.

42. The method of claim 40, wherein the adjusting indication indicates that a part of resources for a further group of the plurality of groups is allocated to the selected group.

43. The method of claim 42, wherein the adjusting indication indicates at least one of proportions and time intervals for allocating the part of the resources to the selected group.

44. The method of claim 40, further comprising:
determining historical usage of the resources for the selected group.

45. The method of claim 39, further comprising:
dividing a plurality of network slices into the plurality of groups based on at least one of service types, service requirements and operators of the plurality of network slices.

46. The method of claim 39, further comprising:
transmitting an identification of a selected group of the plurality of groups to a terminal device.

47. The method of claim 45, further comprising:
receiving, from the terminal device, a request for the selected group; and
mapping the request to a network slice in the selected group.

48. The method of claim 45, further comprising:
transmitting slice member information of the selected group to the terminal device.

49. The method of claim 39, further comprising:
in response to handover of a terminal device to a further access network device, determining, from a plurality of network slices connected with the terminal device, a third

group of network slices to be mapped to the further access network device and a fourth group of network slices to be created in the further access network device; and

causing the third group to be mapped to the further access network device and the fourth group to be created in the further access network device.

50. The method of claim 49, wherein determining the third and fourth groups comprises:

in response to the handover of the terminal device, determining, from the plurality of network slices, a first candidate group of network slices to be mapped to the further access network device and a second candidate group of the two groups to be created in the further access network device;

sending slice member information of the first and second candidate groups to the terminal device;

receiving a request from the terminal device to move a network slice from the first candidate group to the second candidate group; and

determining the third and fourth groups by moving the network slice from the first candidate group to the second candidate group.

51. An apparatus comprising:

means for determining, by a network device, that a plurality of service loads for a plurality of groups of network slices are to be changed; and

means for adjusting resources allocated to the plurality of groups at least in part based on the determining.

52. A computer readable storage medium comprising program instructions stored thereon, the instructions, when executed by a processor of a device, causing the device to perform the method of any of claims 26-50.

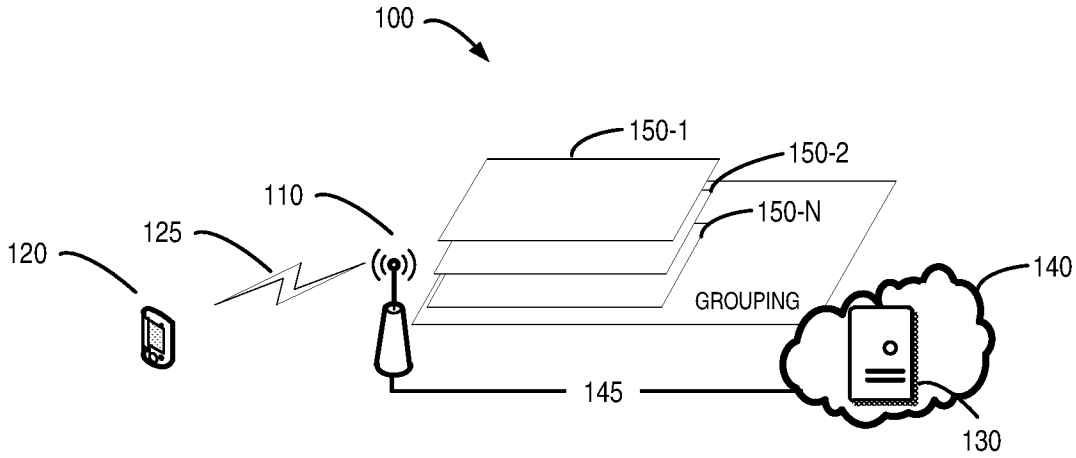
100
150-1
150-2
150-N
110
125
120
GROUPING
140
145
130

FIG. 1

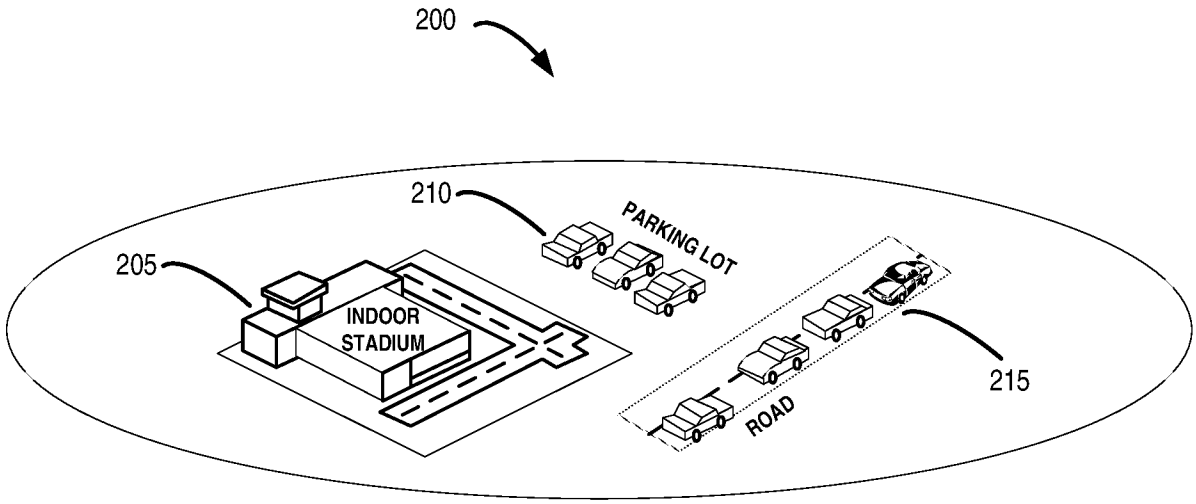
200
210
PARKING LOT
205
INDOOR
STADIUM
215
ROAD

FIG. 2

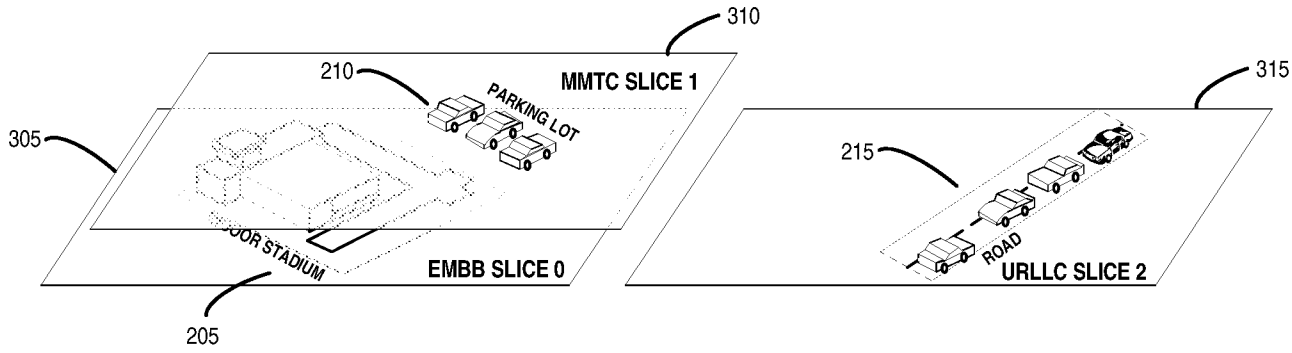
310
210
MMTC SLICE 1
PARKING LOT
305
315
215
ROAD
URLLC SLICE 2
EMBB SLICE 0
205

FIG. 3

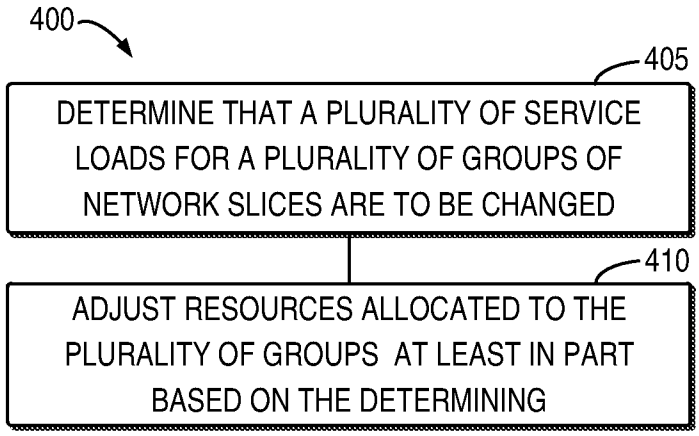
400
405
DETERMINE THAT A PLURALITY OF SERVICE LOADS FOR A PLURALITY OF GROUPS OF NETWORK SLICES ARE TO BE CHANGED
410
ADJUST RESOURCES ALLOCATED TO THE PLURALITY OF GROUPS AT LEAST IN PART BASED ON THE DETERMINING

FIG. 4

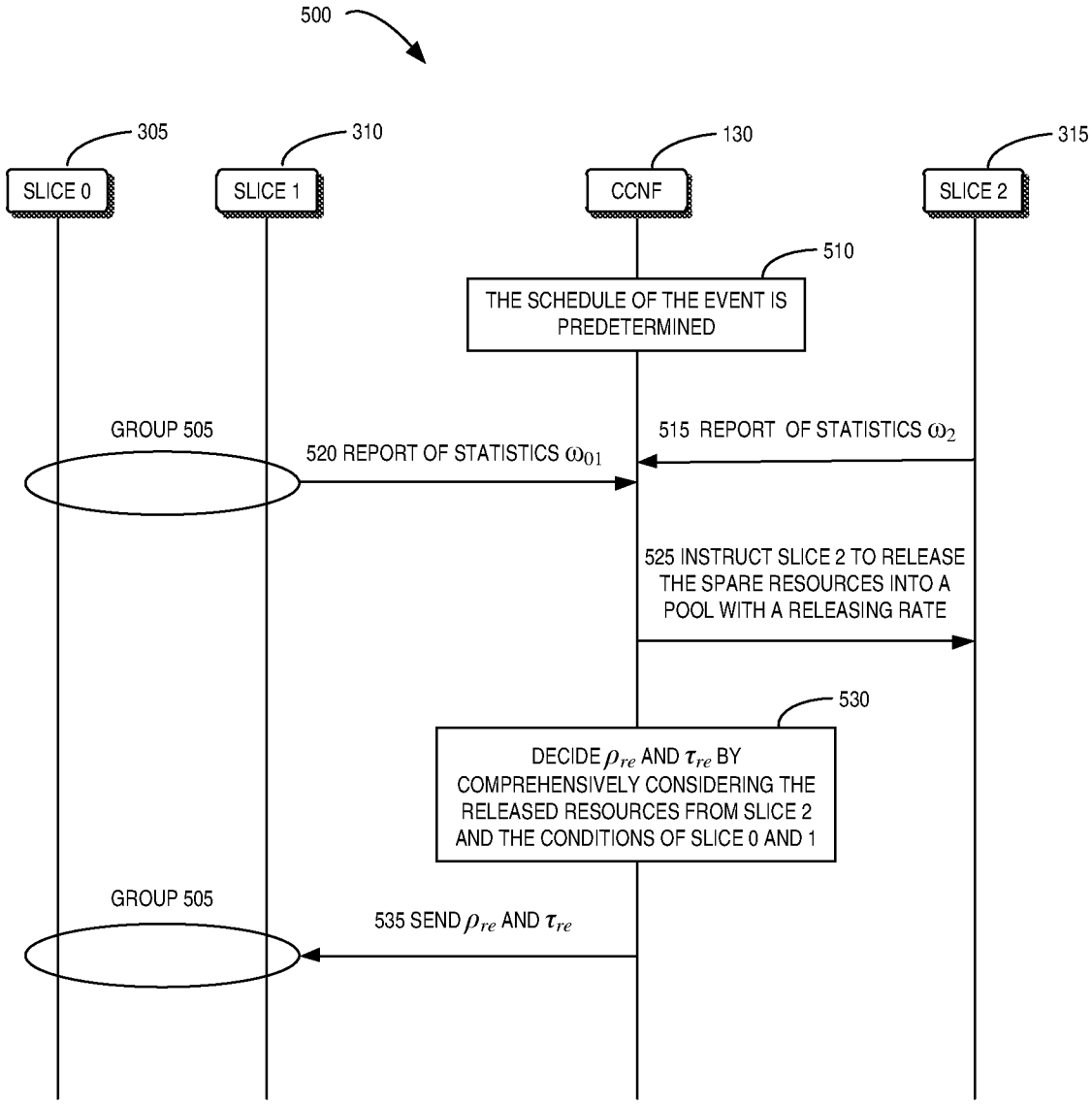
500
305
SLICE 0
310
SLICE 1
130
CCNF
315
SLICE 2
510
THE SCHEDULE OF THE EVENT IS PREDETERMINED
GROUP 505
520 REPORT OF STATISTICS ω_{01}
515 REPORT OF STATISTICS ω_2
525 INSTRUCT SLICE 2 TO RELEASE THE SPARE RESOURCES INTO A POOL WITH A RELEASING RATE
530
DECIDE ρ_{re} AND τ_{re} BY COMPREHENSIVELY CONSIDERING THE RELEASED RESOURCES FROM SLICE 2 AND THE CONDITIONS OF SLICE 0 AND 1
GROUP 505
535 SEND ρ_{re} AND τ_{re}

FIG. 5

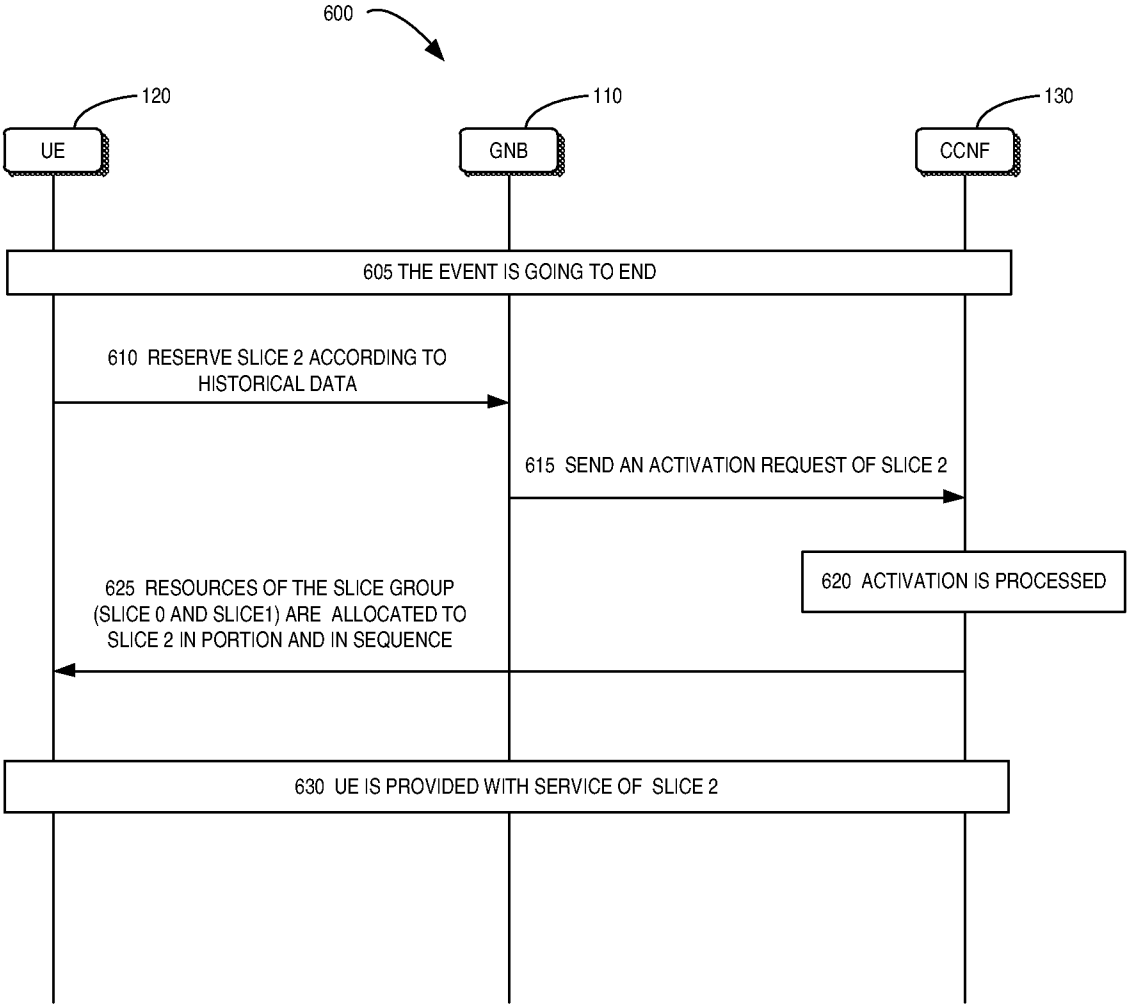
600
120
UE
110
GNB
130
CCNF
605 THE EVENT IS GOING TO END
610 RESERVE SLICE 2 ACCORDING TO HISTORICAL DATA
615 SEND AN ACTIVATION REQUEST OF SLICE 2
620 ACTIVATION IS PROCESSED
625 RESOURCES OF THE SLICE GROUP (SLICE 0 AND SLICE1) ARE ALLOCATED TO SLICE 2 IN PORTION AND IN SEQUENCE
630 UE IS PROVIDED WITH SERVICE OF SLICE 2

FIG. 6

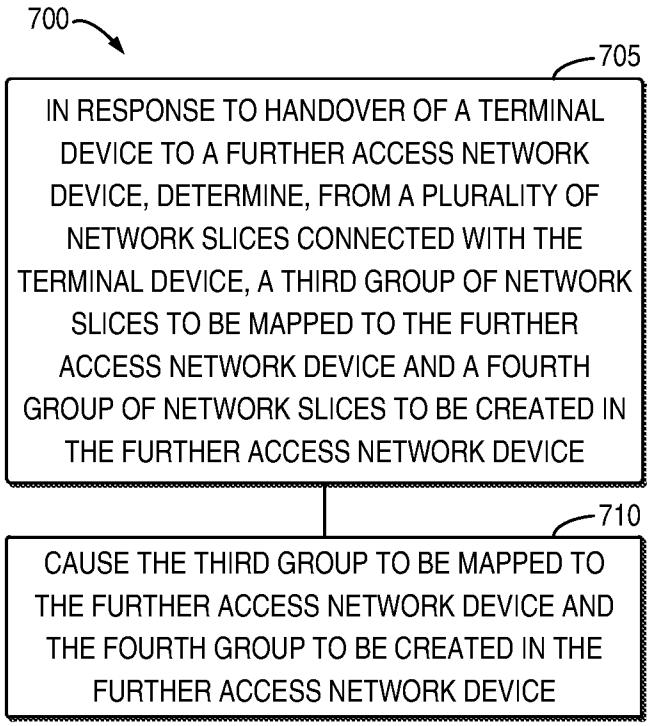
700
705
IN RESPONSE TO HANDOVER OF A TERMINAL DEVICE TO A FURTHER ACCESS NETWORK DEVICE, DETERMINE, FROM A PLURALITY OF NETWORK SLICES CONNECTED WITH THE TERMINAL DEVICE, A THIRD GROUP OF NETWORK SLICES TO BE MAPPED TO THE FURTHER ACCESS NETWORK DEVICE AND A FOURTH GROUP OF NETWORK SLICES TO BE CREATED IN THE FURTHER ACCESS NETWORK DEVICE
710
CAUSE THE THIRD GROUP TO BE MAPPED TO THE FURTHER ACCESS NETWORK DEVICE AND THE FOURTH GROUP TO BE CREATED IN THE FURTHER ACCESS NETWORK DEVICE

FIG. 7

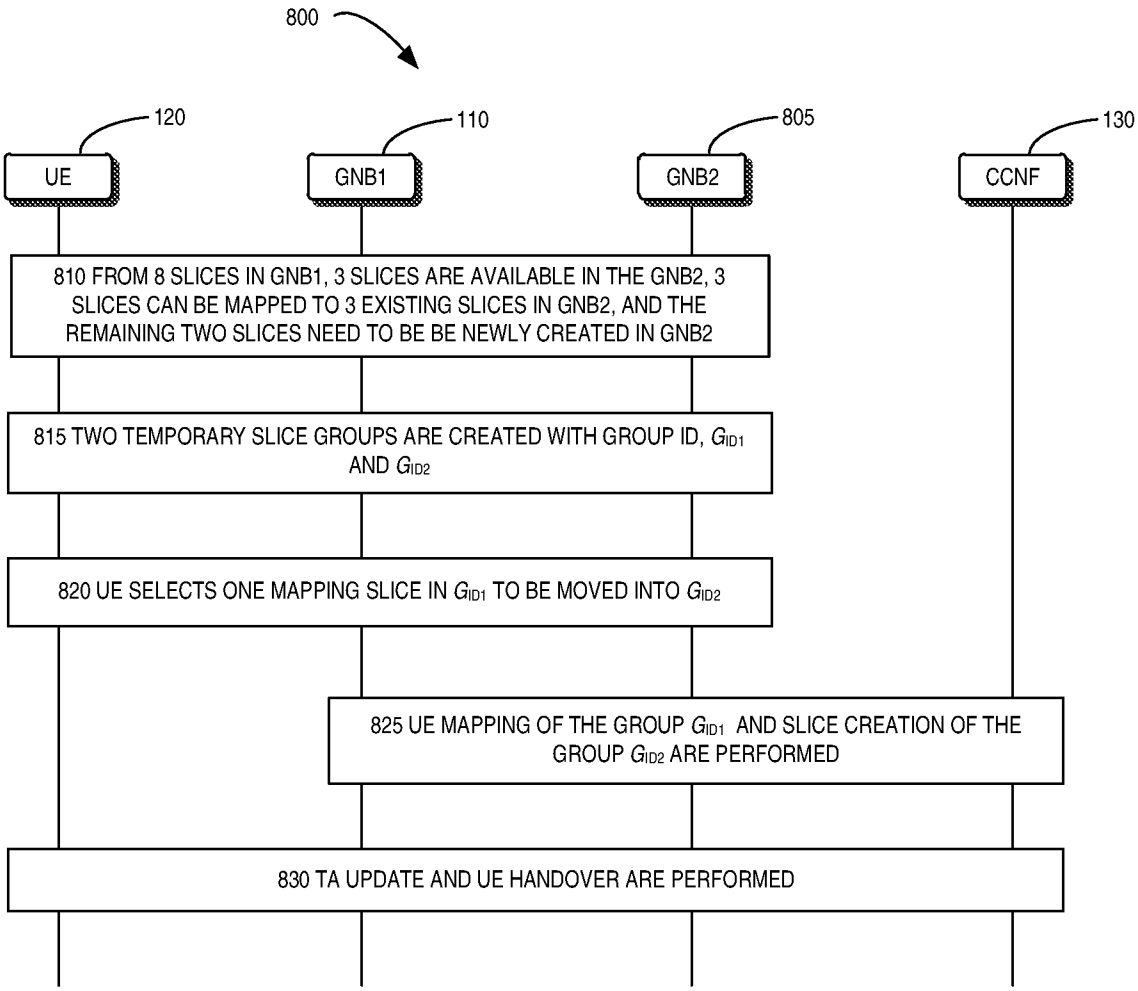
800
120
110
805
130
UE
GNB1
GNB2
CCNF
810 FROM 8 SLICES IN GNB1, 3 SLICES ARE AVAILABLE IN THE GNB2, 3 SLICES CAN BE MAPPED TO 3 EXISTING SLICES IN GNB2, AND THE REMAINING TWO SLICES NEED TO BE BE NEWLY CREATED IN GNB2
815 TWO TEMPORARY SLICE GROUPS ARE CREATED WITH GROUP ID, G_{ID1} AND G_{ID2}
820 UE SELECTS ONE MAPPING SLICE IN G_{ID1} TO BE MOVED INTO G_{ID2}
825 UE MAPPING OF THE GROUP G_{ID1} AND SLICE CREATION OF THE GROUP G_{ID2} ARE PERFORMED
830 TA UPDATE AND UE HANDOVER ARE PERFORMED

FIG. 8

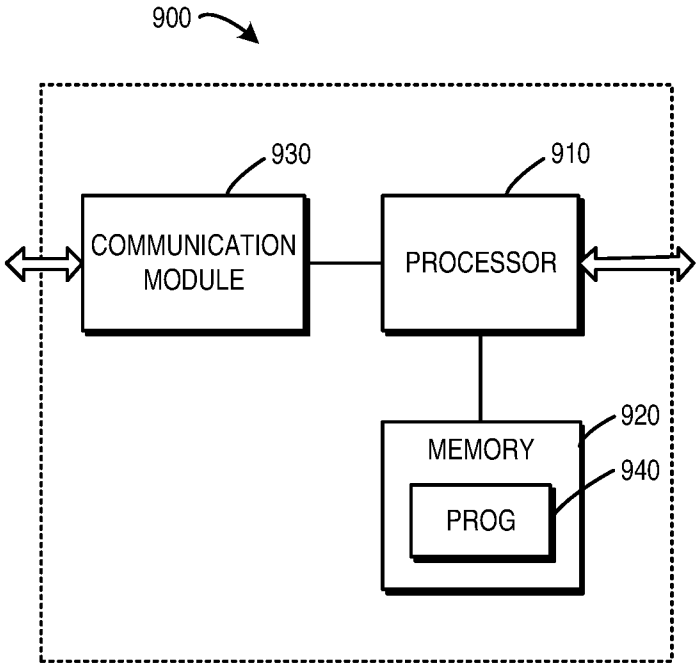
900
930
910
COMMUNICATION MODULE
PROCESSOR
920
MEMORY
940
PROG

FIG. 9

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/072298

A. CLASSIFICATION OF SUBJECT MATTER

H04W 28/00(2009.01)i; H04W 36/28(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, H04L

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

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

CNABS, CNTXT, CNKI, VEN, USTXT, EPTXT, WOTXT, IEEE, 3GPP: network, slice, group, plurality, service, load, management, NSM, change, adjust, reallocate, decrease, reduce, increase

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2019000284 A1 (HUAWEI TECH CO LTD) 03 January 2019 (2019-01-03) description, paragraphs 0035-0080, and figures 1-6	1, 12-16, 19-23, 26, 37-41, 44-48, 51, 52
A	CN 108111931 A (TATE GRID LIAONING ELECTRIC POWER SUPPLY CO LTD ET AL.) 01 June 2018 (2018-06-01) the whole document	1-52
A	CN 107087255 A (ZTE CORP) 22 August 2017 (2017-08-22) the whole document	1-52
A	CN 108476406 A (TELEFONAKTIEBOLAGET ERICSSON L M) 31 August 2018 (2018-08-31) the whole document	1-52
A	CN 108282352 A (HUAWEI TECH CO LTD) 13 July 2018 (2018-07-13) the whole document	1-52
A	CN 106412905 A (CHINA UNICOM GROUP CO LTD) 15 February 2017 (2017-02-15) the whole document	1-52

☑ 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
30 September 2019	**22 October 2019**
Name and mailing address of the ISA/CN **National Intellectual Property Administration, PRC** **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer **MA,Jing** Telephone No. **86-(010)-62412156**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018278466 A1 (MCCORMICK WILLIAM CARSON ET AL.) 27 September 2018 (2018-09-27) the whole document	1-52
A	WO 2018114009 A1 (HUAWEI TECH CO LTD) 28 June 2018 (2018-06-28) the whole document	1-52

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/072298

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2019000284 A1	03 January 2019	None	
CN 108111931 A	01 June 2018	None	
CN 107087255 A	22 August 2017	WO 2017140204 A1	24 August 2017
CN 108476406 A	31 August 2018	EP 3400731 A1	14 November 2018
		WO 2017119844 A1	13 July 2017
		US 2018376407 A1	27 December 2018
CN 108282352 A	13 July 2018	WO 2018127144 A1	12 July 2018
CN 106412905 A	15 February 2017	None	
US 2018278466 A1	27 September 2018	WO 2018171458 A1	27 September 2018
WO 2018114009 A1	28 June 2018	CN 110115055 A	09 August 2019