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(54) **METHOD AND ELECTRONIC DEVICE FOR SLICE ALLOCATION IN A TELECOMMUNICATION NETWORK**

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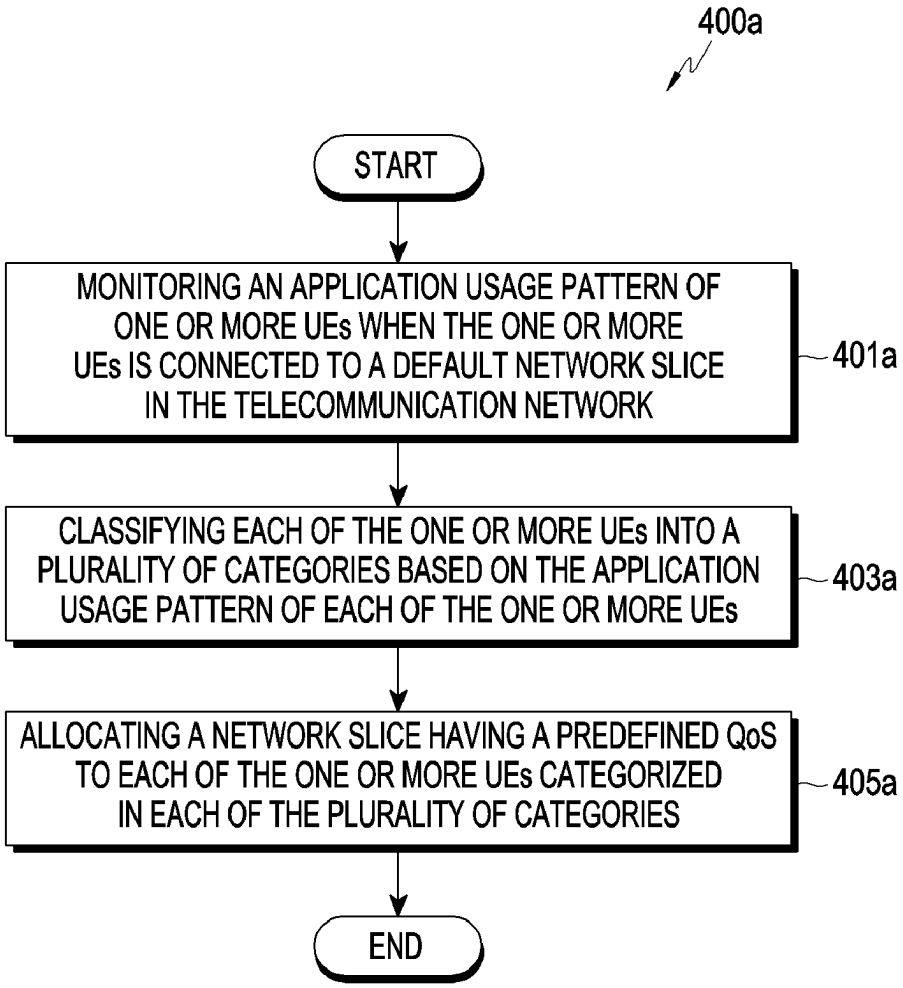
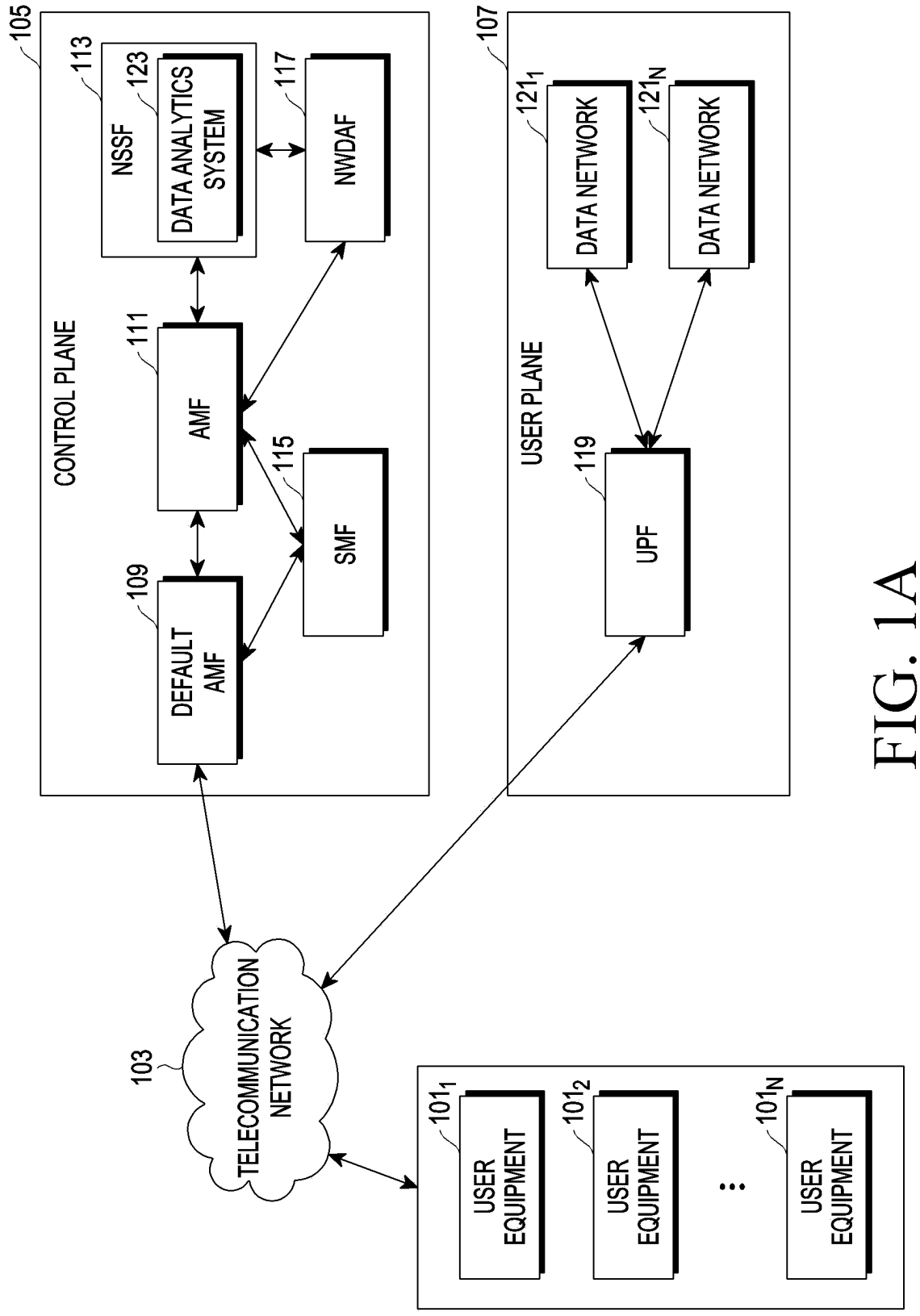
(52) **U.S. Cl.**

CPC ***H04W 36/26*** (2013.01); ***H04W 36/00833*** (2023.05); ***H04W 36/14*** (2013.01)

(57) **ABSTRACT**

A method for dynamic network slice allocation by an electronic device for a data analytics system in a telecommunication network, includes: monitoring one or more application usage patterns of one or more user equipments (UEs) which is connected to a default network slice in the telecommunication network; classifying the one or more UEs into one or more categories based on the one or more application usage patterns; and allocating one or more network slices having predefined qualities of service (QoS) to the one or more UEs based on the one or more categories.

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CONTROL PLANE
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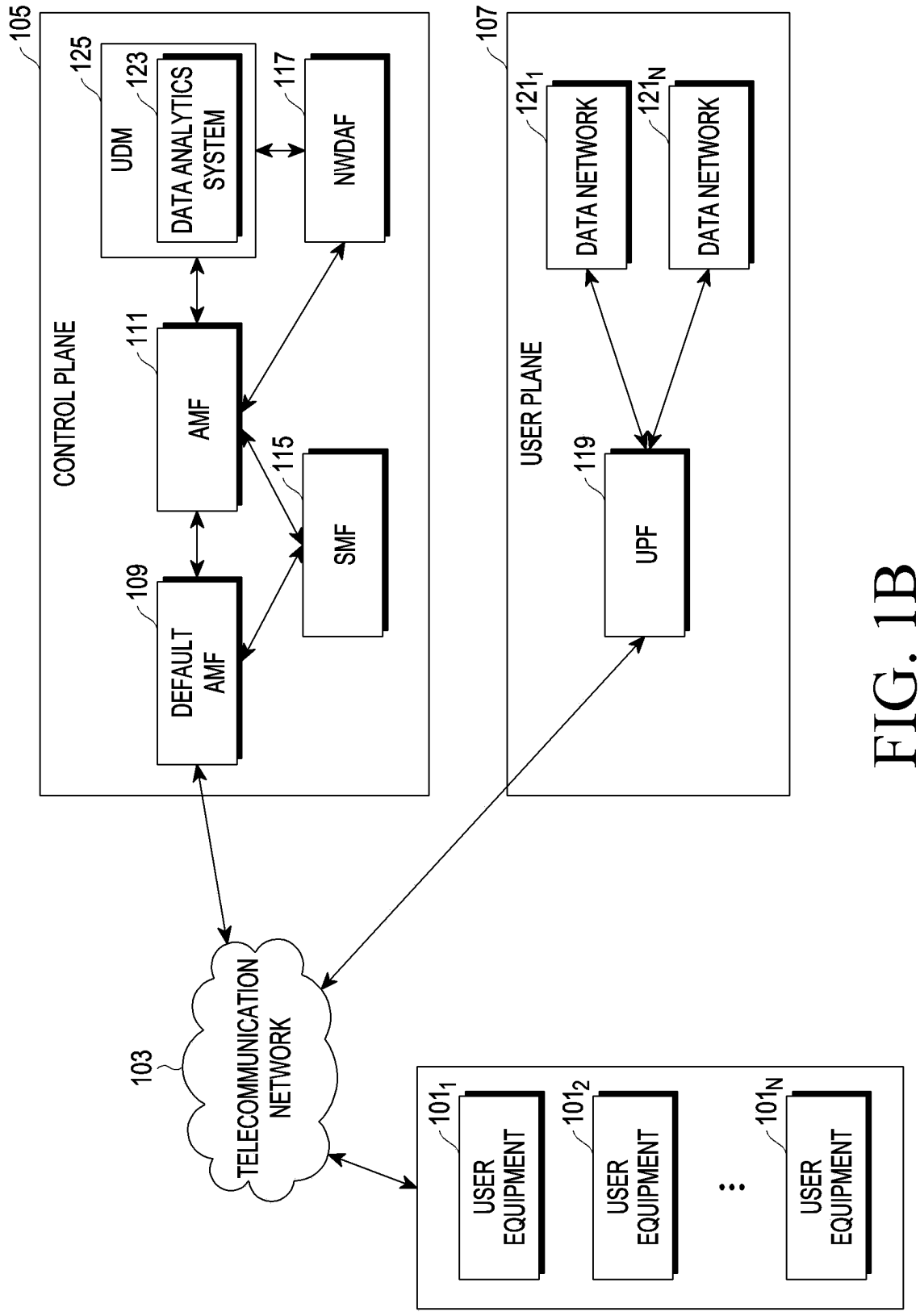
NSSF
123
DATA ANALYTICS SYSTEM
117
NWDAF
111
AMF
115
SMF
109
DEFAULT AMF
107
USER PLANE
121 1
DATA NETWORK
121 N
DATA NETWORK
119
UPF
103
TELECOMMUNICATION NETWORK
101 1
USER EQUIPMENT
101 2
USER EQUIPMENT
101 N
USER EQUIPMENT

FIG. 1A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UDM
123
DATA ANALYTICS SYSTEM
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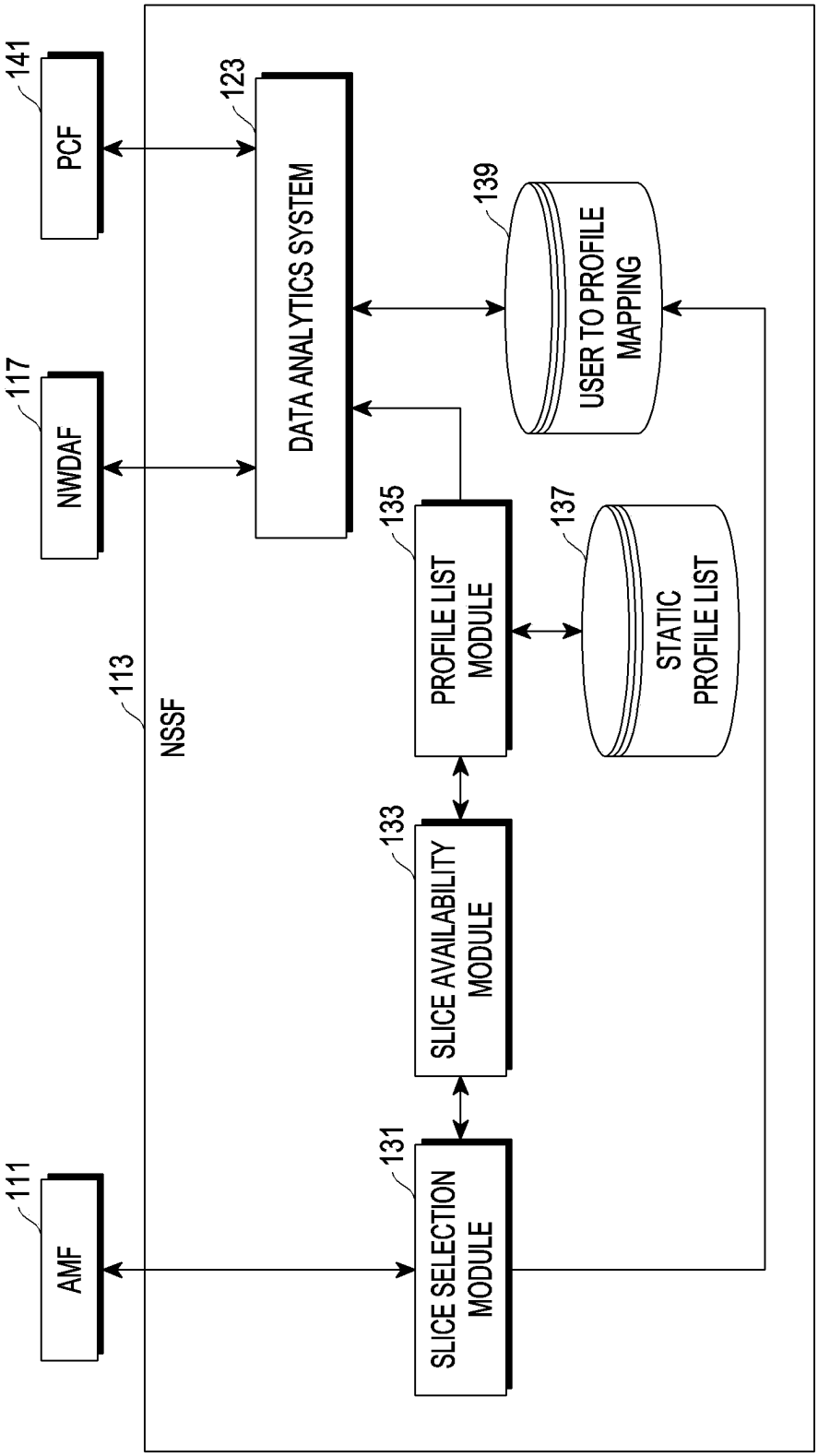
NWDAF
111
AMF
115
SMF
109
DEFAULT AMF
107
USER PLANE
121$_1$
DATA NETWORK
121$_N$
DATA NETWORK
119
UPF
103
TELECOMMUNICATION NETWORK
101$_1$
USER EQUIPMENT
101$_2$
USER EQUIPMENT
...
101$_N$
USER EQUIPMENT

FIG. 1B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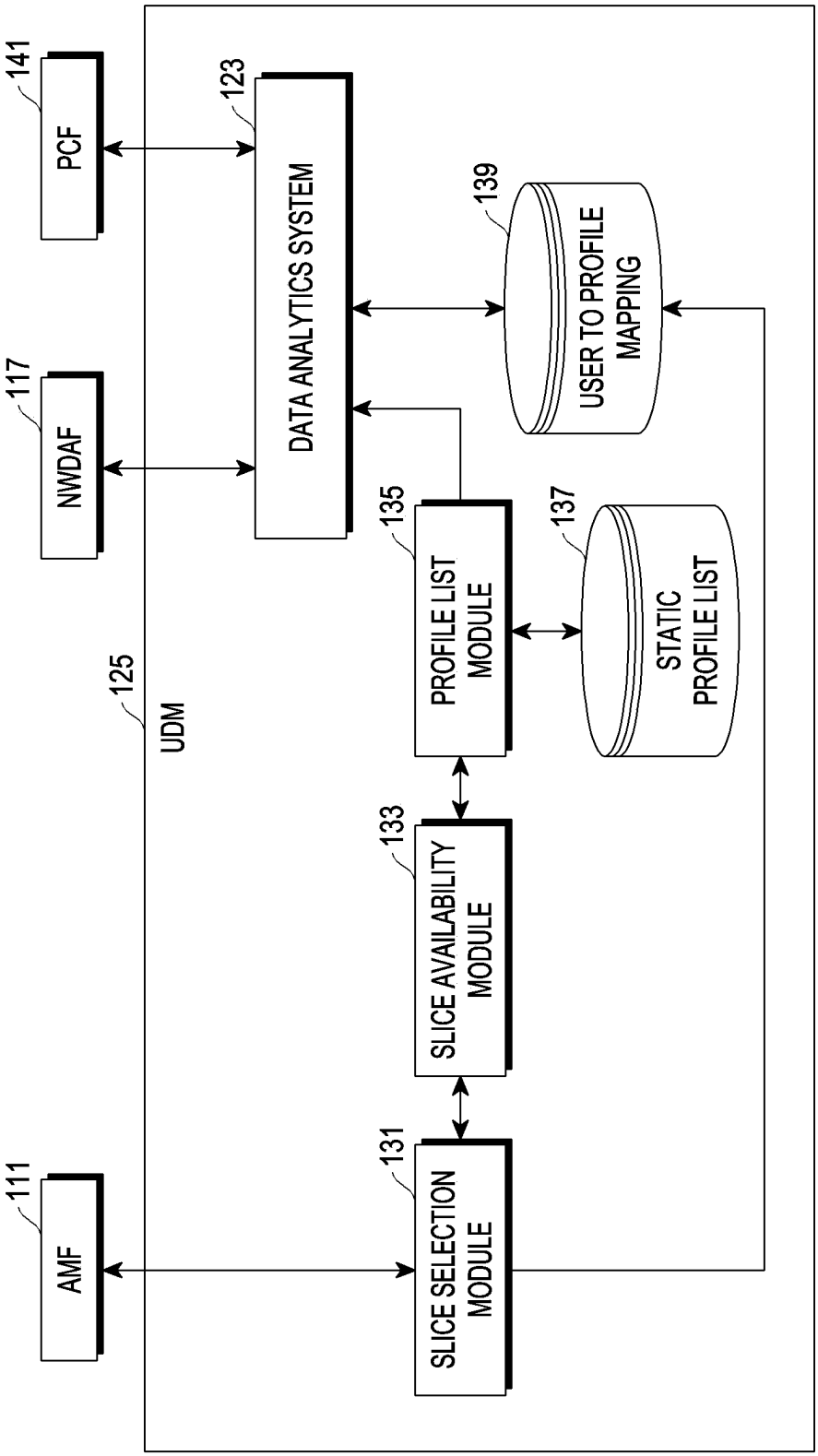
PCF
123
DATA ANALYTICS SYSTEM
139
USER TO PROFILE MAPPING
117
NWDAF
135
PROFILE LIST MODULE
137
STATIC PROFILE LIST
113
NSSF
133
SLICE AVAILABILITY MODULE
111
AMF
131
SLICE SELECTION MODULE

FIG. 1C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PCF
123
DATA ANALYTICS SYSTEM
139
USER TO PROFILE MAPPING
117
NWDAF
135
PROFILE LIST MODULE
137
STATIC PROFILE LIST
125
UDM
133
SLICE AVAILABILITY MODULE
111
AMF
131
SLICE SELECTION MODULE

FIG. 1D

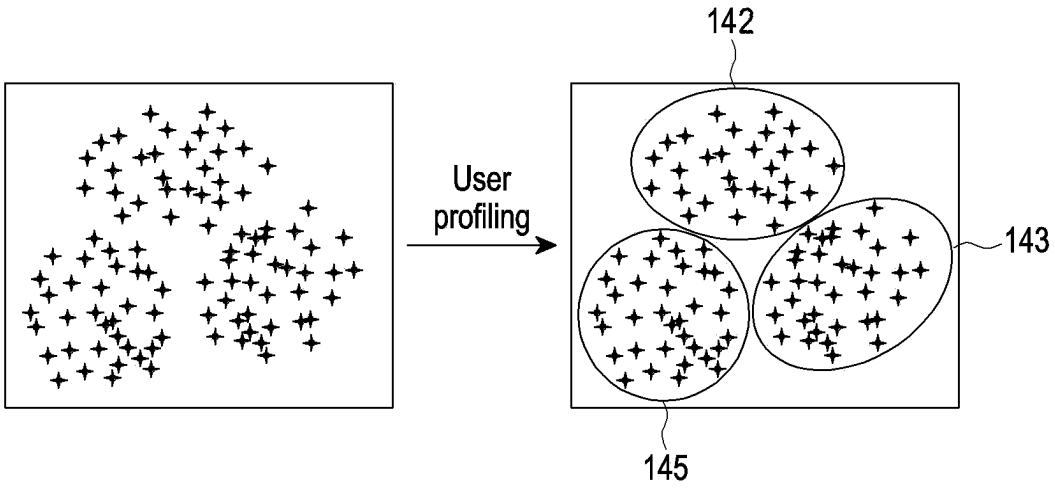


FIG. 1E

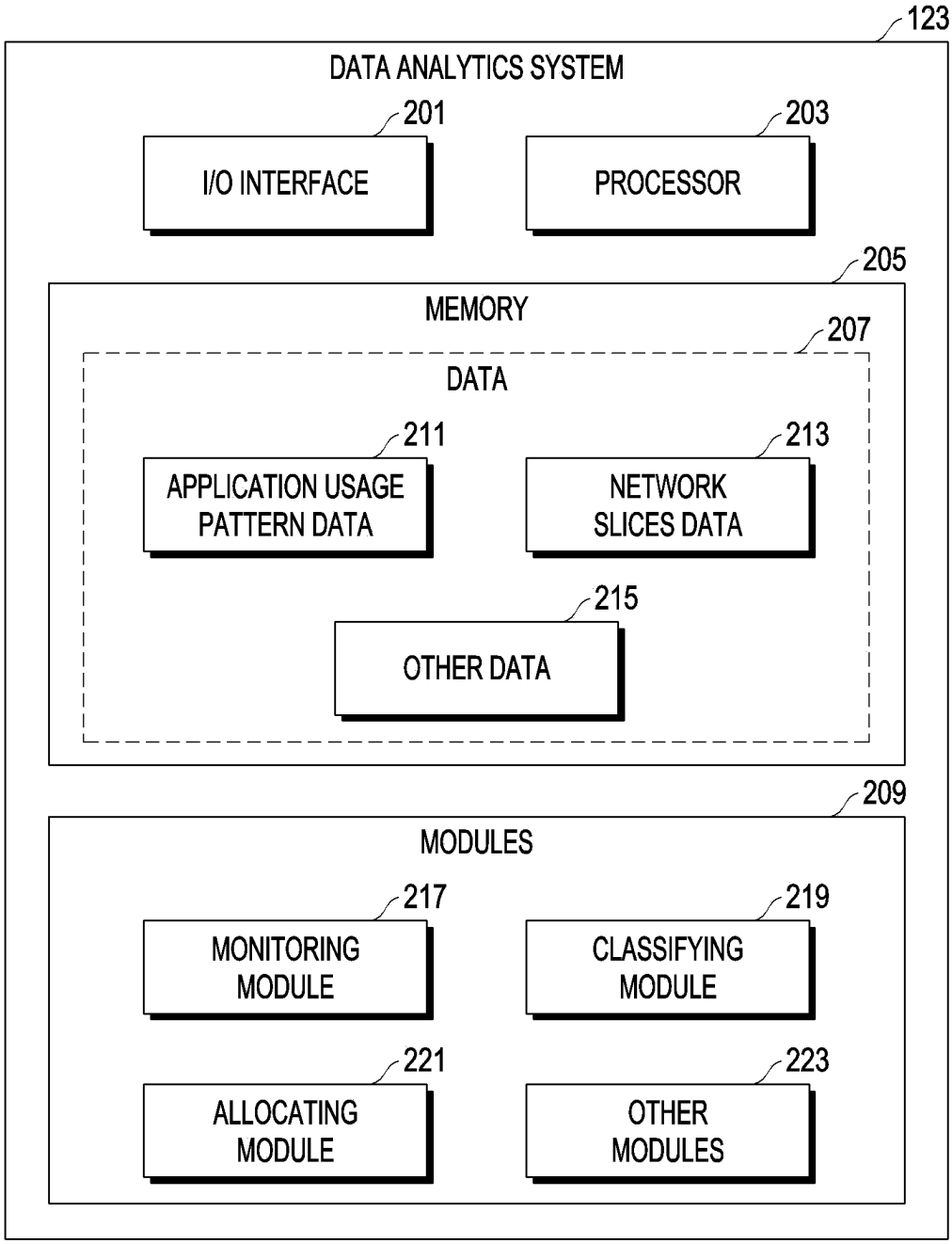
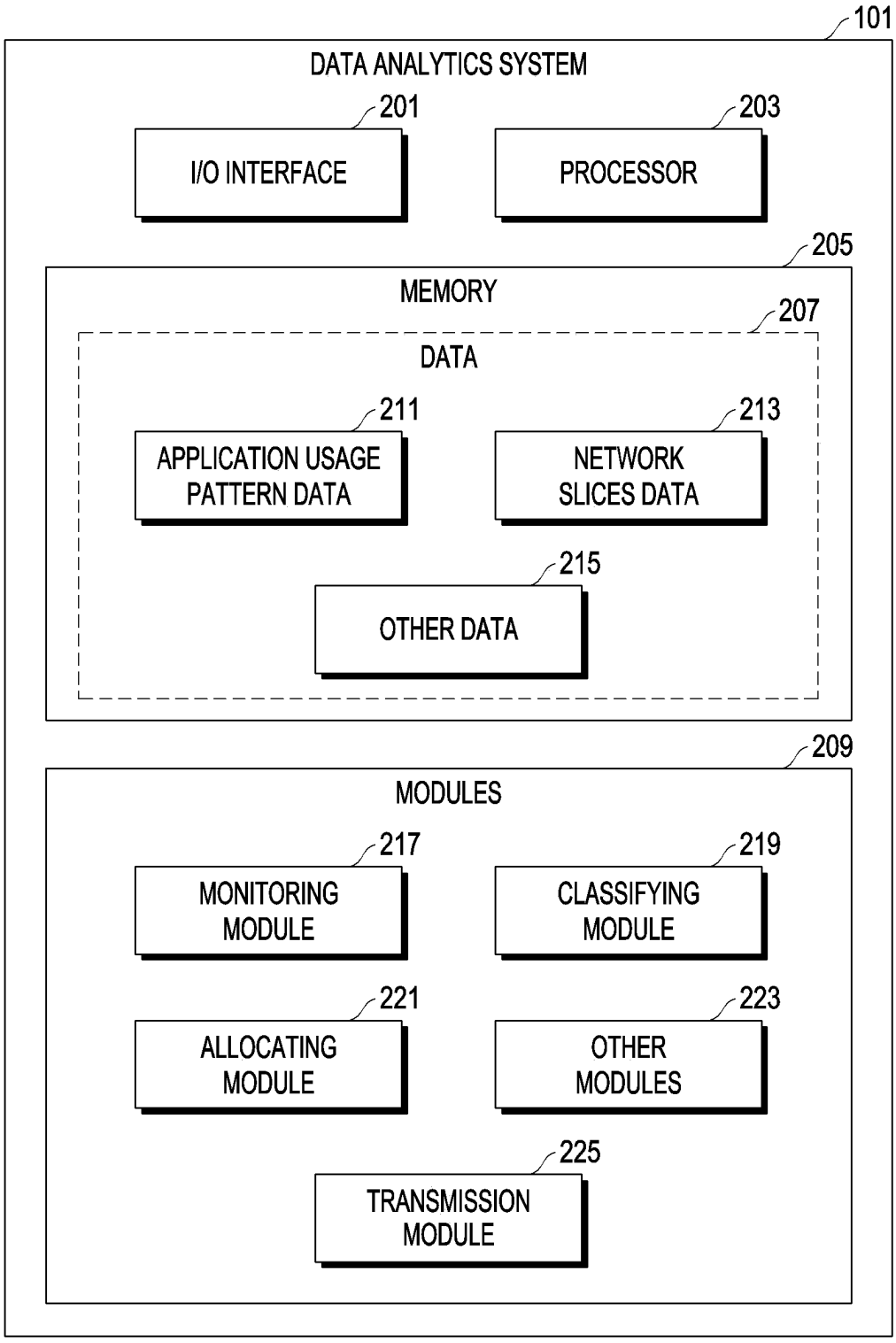

123
DATA ANALYTICS SYSTEM
201
I/O INTERFACE
203
PROCESSOR
205
MEMORY
207
DATA
211
APPLICATION USAGE PATTERN DATA
213
NETWORK SLICES DATA
215
OTHER DATA
209
MODULES
217
MONITORING MODULE
219
CLASSIFYING MODULE
221
ALLOCATING MODULE
223
OTHER MODULES

FIG. 2A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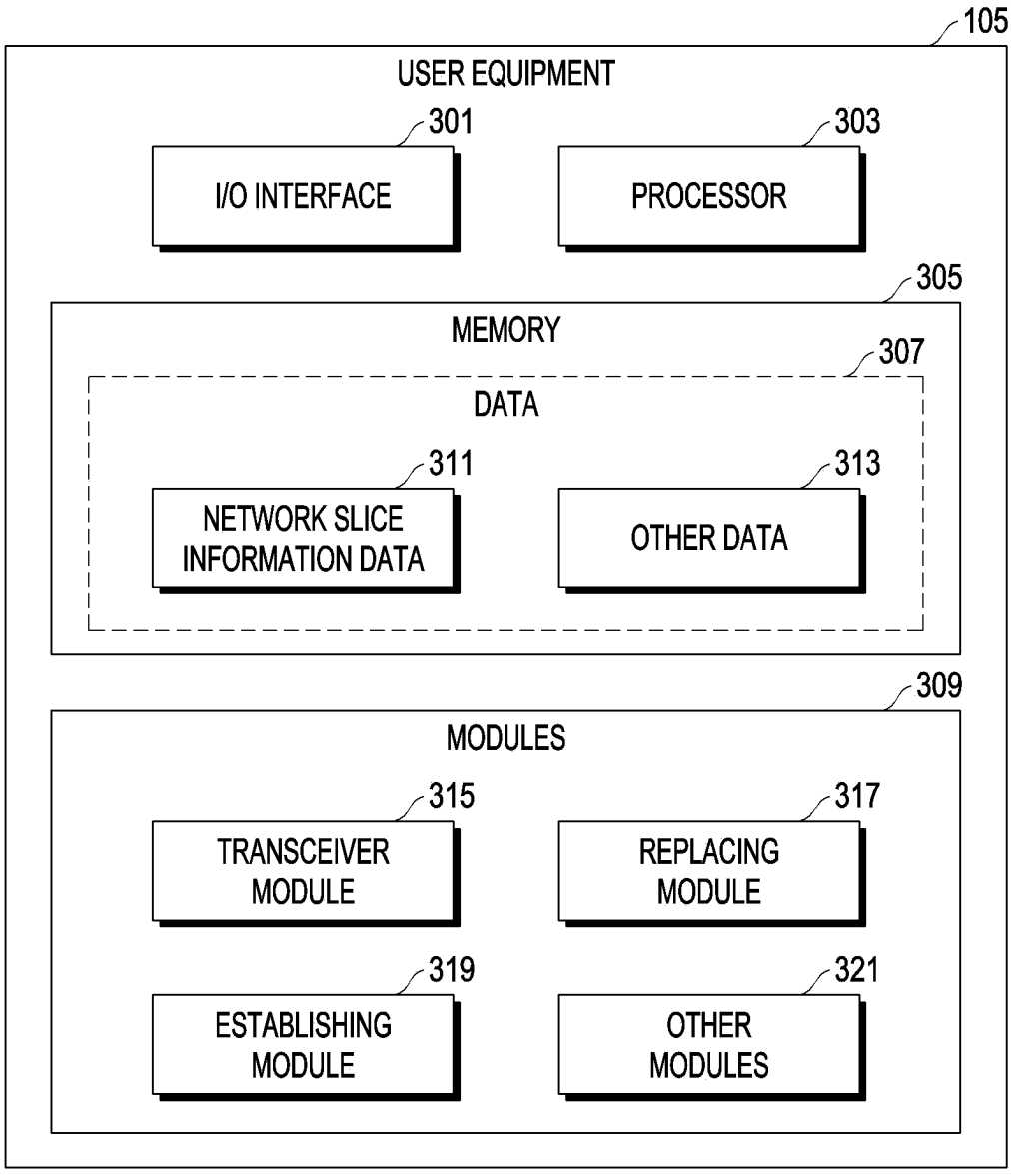
DATA ANALYTICS SYSTEM
201
I/O INTERFACE
203
PROCESSOR
205
MEMORY
207
DATA
211
APPLICATION USAGE PATTERN DATA
213
NETWORK SLICES DATA
215
OTHER DATA
209
MODULES
217
MONITORING MODULE
219
CLASSIFYING MODULE
221
ALLOCATING MODULE
223
OTHER MODULES
225
TRANSMISSION MODULE

FIG. 2B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USER EQUIPMENT
301
I/O INTERFACE
303
PROCESSOR
305
MEMORY
307
DATA
311
NETWORK SLICE INFORMATION DATA
313
OTHER DATA
309
MODULES
315
TRANSCEIVER MODULE
317
REPLACING MODULE
319
ESTABLISHING MODULE
321
OTHER MODULES

FIG. 3

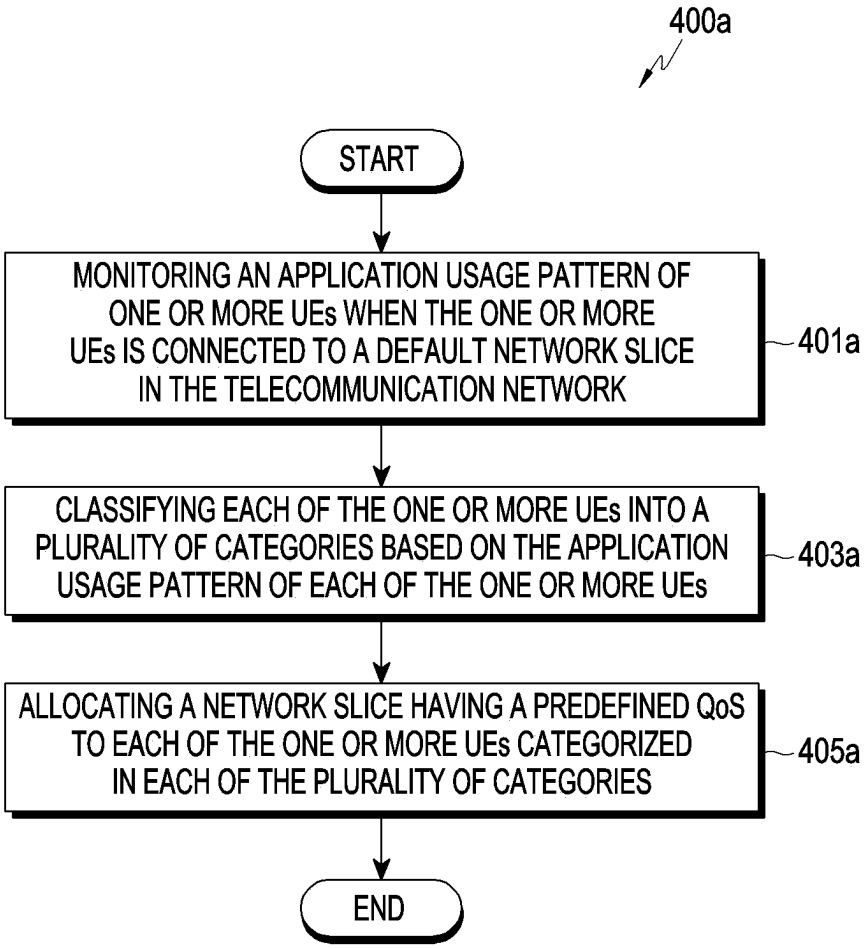
400a
START
MONITORING AN APPLICATION USAGE PATTERN OF ONE OR MORE UEs WHEN THE ONE OR MORE UEs IS CONNECTED TO A DEFAULT NETWORK SLICE IN THE TELECOMMUNICATION NETWORK
401a
CLASSIFYING EACH OF THE ONE OR MORE UEs INTO A PLURALITY OF CATEGORIES BASED ON THE APPLICATION USAGE PATTERN OF EACH OF THE ONE OR MORE UEs
403a
ALLOCATING A NETWORK SLICE HAVING A PREDEFINED QoS TO EACH OF THE ONE OR MORE UEs CATEGORIZED IN EACH OF THE PLURALITY OF CATEGORIES
405a
END

FIG. 4A

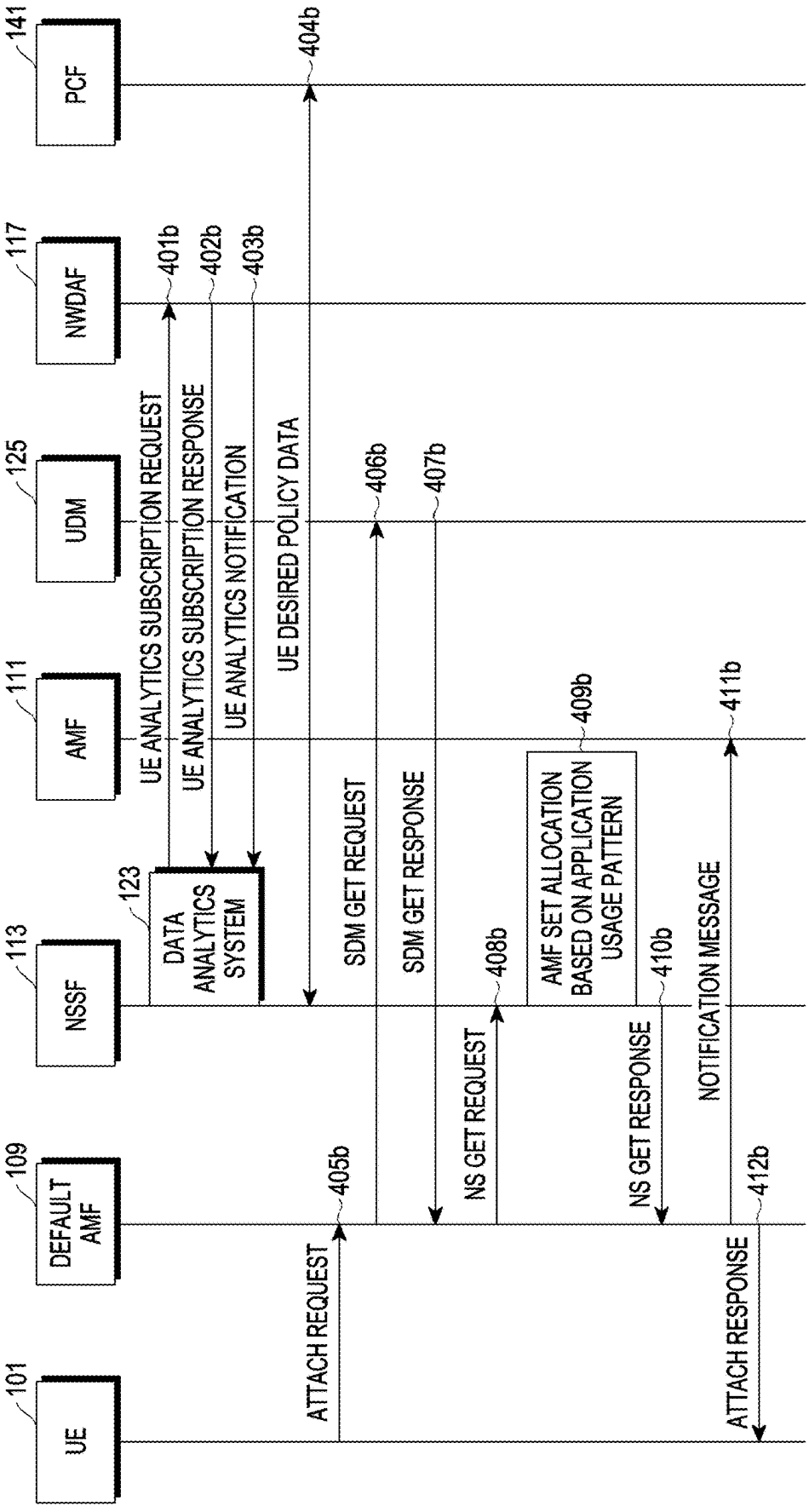
101
UE
109
DEFAULT AMF
113
NSSF
123
DATA ANALYTICS SYSTEM
111
AMF
125
UDM
117
NWDAF
141
PCF
401b
UE ANALYTICS SUBSCRIPTION REQUEST
402b
UE ANALYTICS SUBSCRIPTION RESPONSE
403b
UE ANALYTICS NOTIFICATION
404b
UE DESIRED POLICY DATA
405b
ATTACH REQUEST
406b
SDM GET REQUEST
407b
SDM GET RESPONSE
408b
NS GET REQUEST
409b
AMF SET ALLOCATION BASED ON APPLICATION USAGE PATTERN
410b
NS GET RESPONSE
411b
NOTIFICATION MESSAGE
412b
ATTACH RESPONSE

FIG. 4B

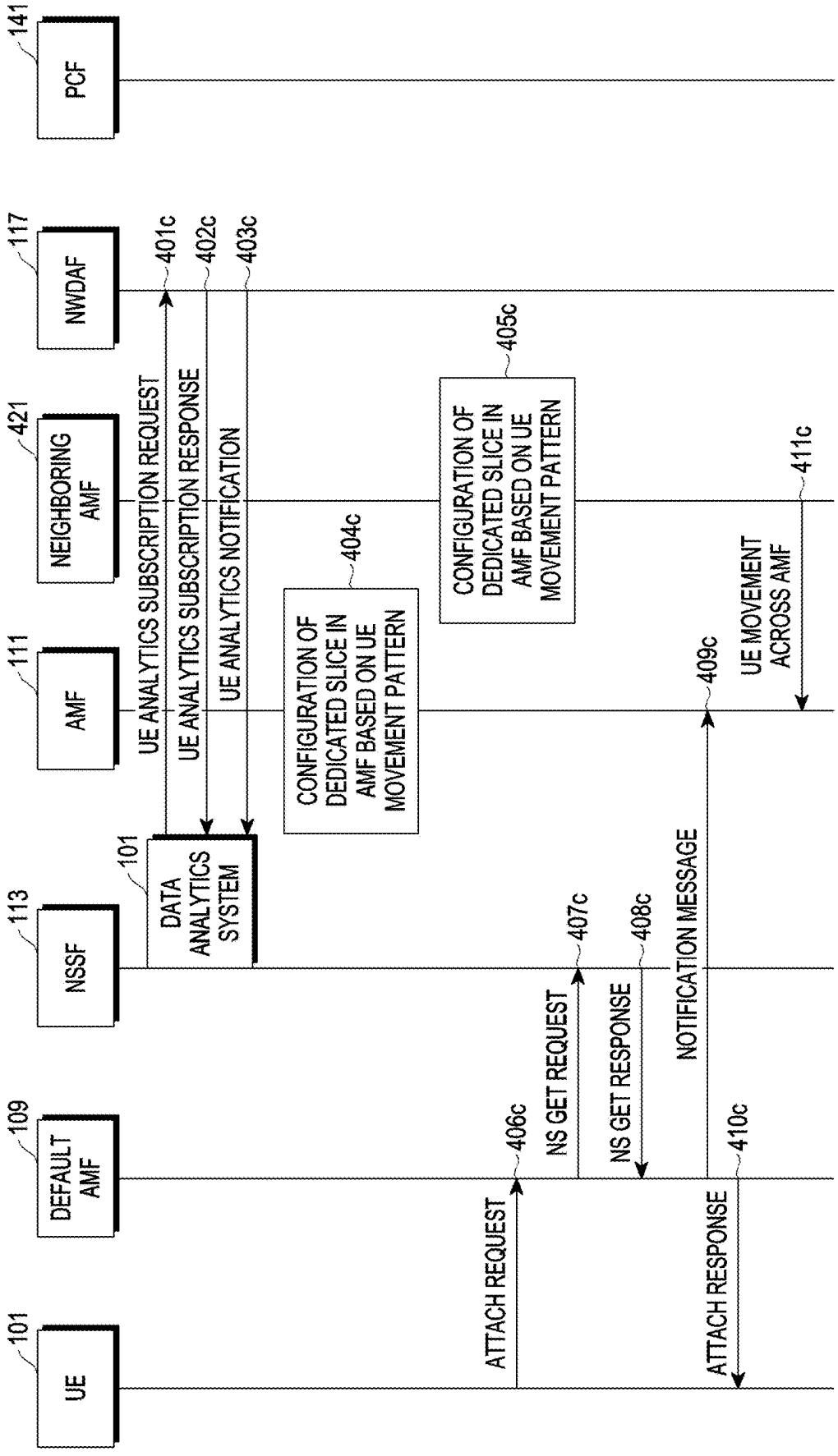
UE
101
DEFAULT AMF
109
NSSF
113
DATA ANALYTICS SYSTEM
101
AMF
111
NEIGHBORING AMF
421
NWDAF
117
PCF
141
ATTACH REQUEST
406c
NS GET REQUEST
407c
NS GET RESPONSE
408c
NOTIFICATION MESSAGE
409c
ATTACH RESPONSE
410c
UE ANALYTICS SUBSCRIPTION REQUEST
401c
UE ANALYTICS SUBSCRIPTION RESPONSE
402c
UE ANALYTICS NOTIFICATION
403c
CONFIGURATION OF DEDICATED SLICE IN AMF BASED ON UE MOVEMENT PATTERN
404c
CONFIGURATION OF DEDICATED SLICE IN AMF BASED ON UE MOVEMENT PATTERN
405c
UE MOVEMENT ACROSS AMF
411c

FIG. 4C

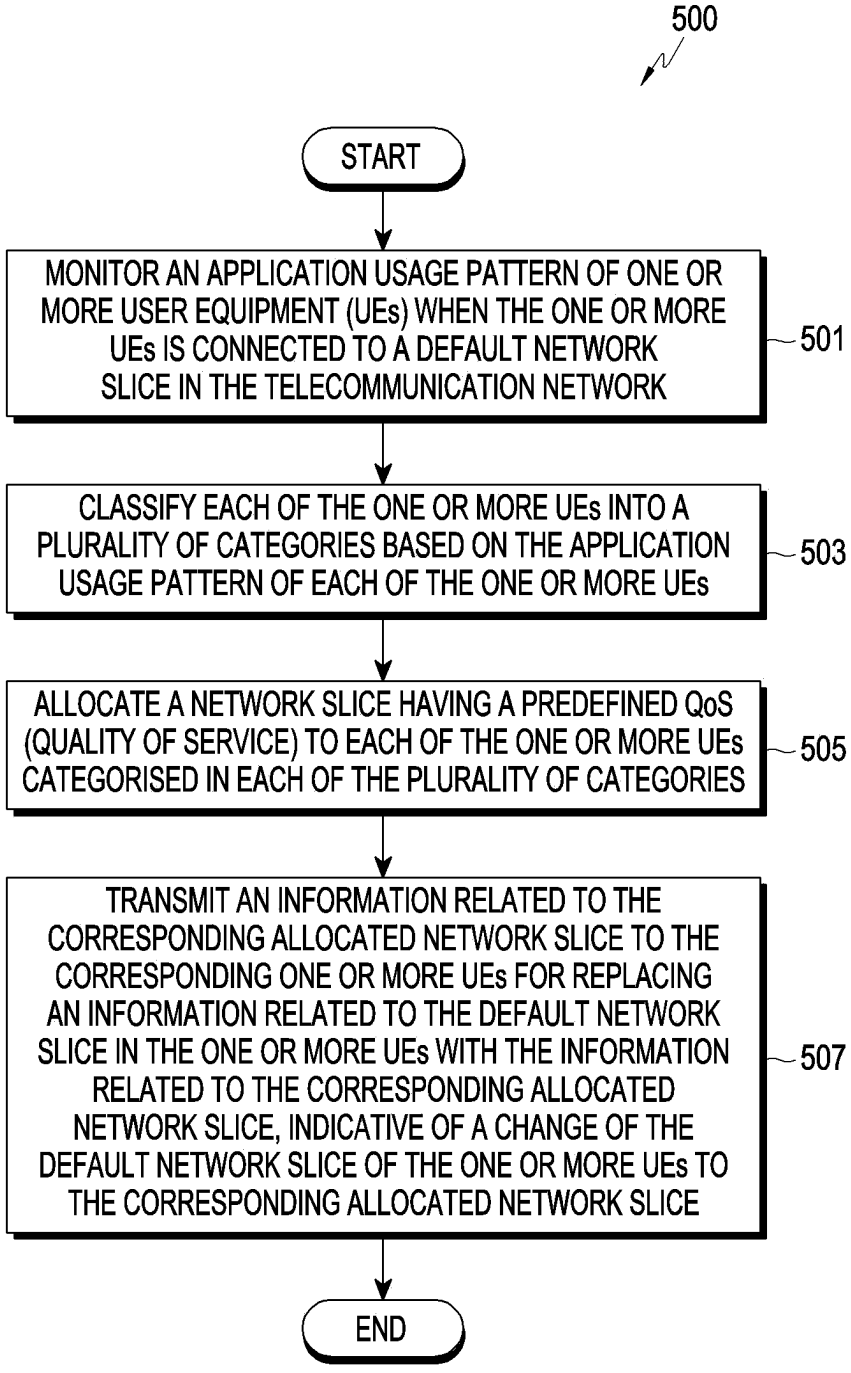
500
START
MONITOR AN APPLICATION USAGE PATTERN OF ONE OR MORE USER EQUIPMENT (UEs) WHEN THE ONE OR MORE UEs IS CONNECTED TO A DEFAULT NETWORK SLICE IN THE TELECOMMUNICATION NETWORK
501
CLASSIFY EACH OF THE ONE OR MORE UEs INTO A PLURALITY OF CATEGORIES BASED ON THE APPLICATION USAGE PATTERN OF EACH OF THE ONE OR MORE UEs
503
ALLOCATE A NETWORK SLICE HAVING A PREDEFINED QoS (QUALITY OF SERVICE) TO EACH OF THE ONE OR MORE UEs CATEGORISED IN EACH OF THE PLURALITY OF CATEGORIES
505
TRANSMIT AN INFORMATION RELATED TO THE CORRESPONDING ALLOCATED NETWORK SLICE TO THE CORRESPONDING ONE OR MORE UEs FOR REPLACING AN INFORMATION RELATED TO THE DEFAULT NETWORK SLICE IN THE ONE OR MORE UEs WITH THE INFORMATION RELATED TO THE CORRESPONDING ALLOCATED NETWORK SLICE, INDICATIVE OF A CHANGE OF THE DEFAULT NETWORK SLICE OF THE ONE OR MORE UEs TO THE CORRESPONDING ALLOCATED NETWORK SLICE
507
END

FIG. 5A

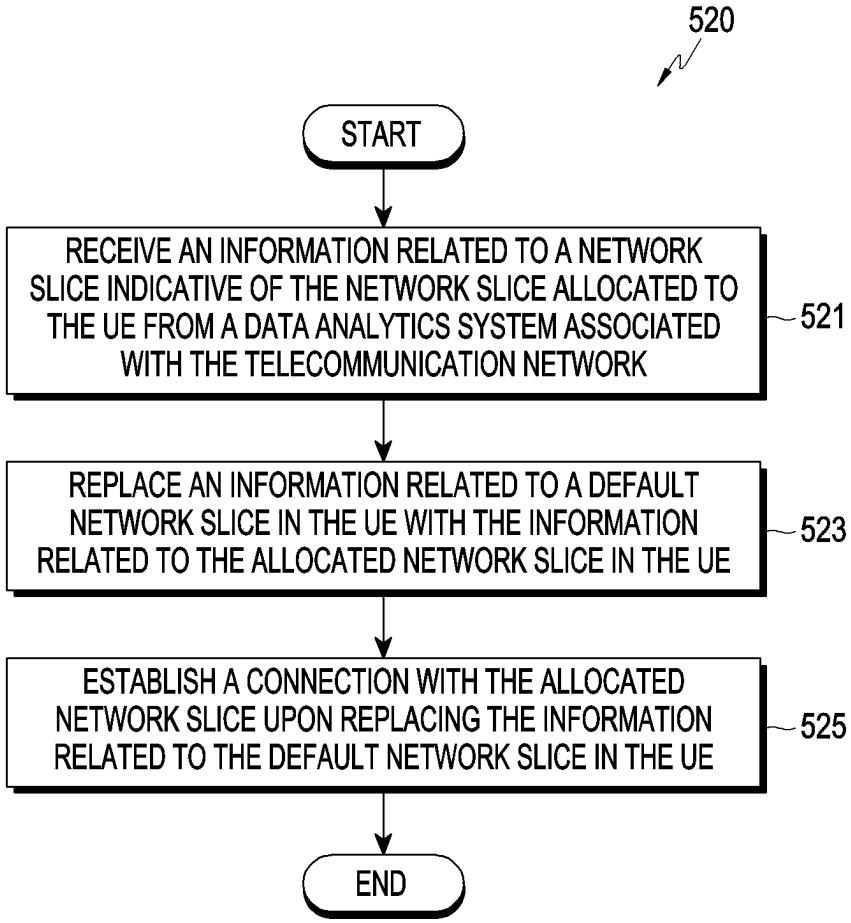
520
START
RECEIVE AN INFORMATION RELATED TO A NETWORK SLICE INDICATIVE OF THE NETWORK SLICE ALLOCATED TO THE UE FROM A DATA ANALYTICS SYSTEM ASSOCIATED WITH THE TELECOMMUNICATION NETWORK
521
REPLACE AN INFORMATION RELATED TO A DEFAULT NETWORK SLICE IN THE UE WITH THE INFORMATION RELATED TO THE ALLOCATED NETWORK SLICE IN THE UE
523
ESTABLISH A CONNECTION WITH THE ALLOCATED NETWORK SLICE UPON REPLACING THE INFORMATION RELATED TO THE DEFAULT NETWORK SLICE IN THE UE
525
END

FIG. 5B

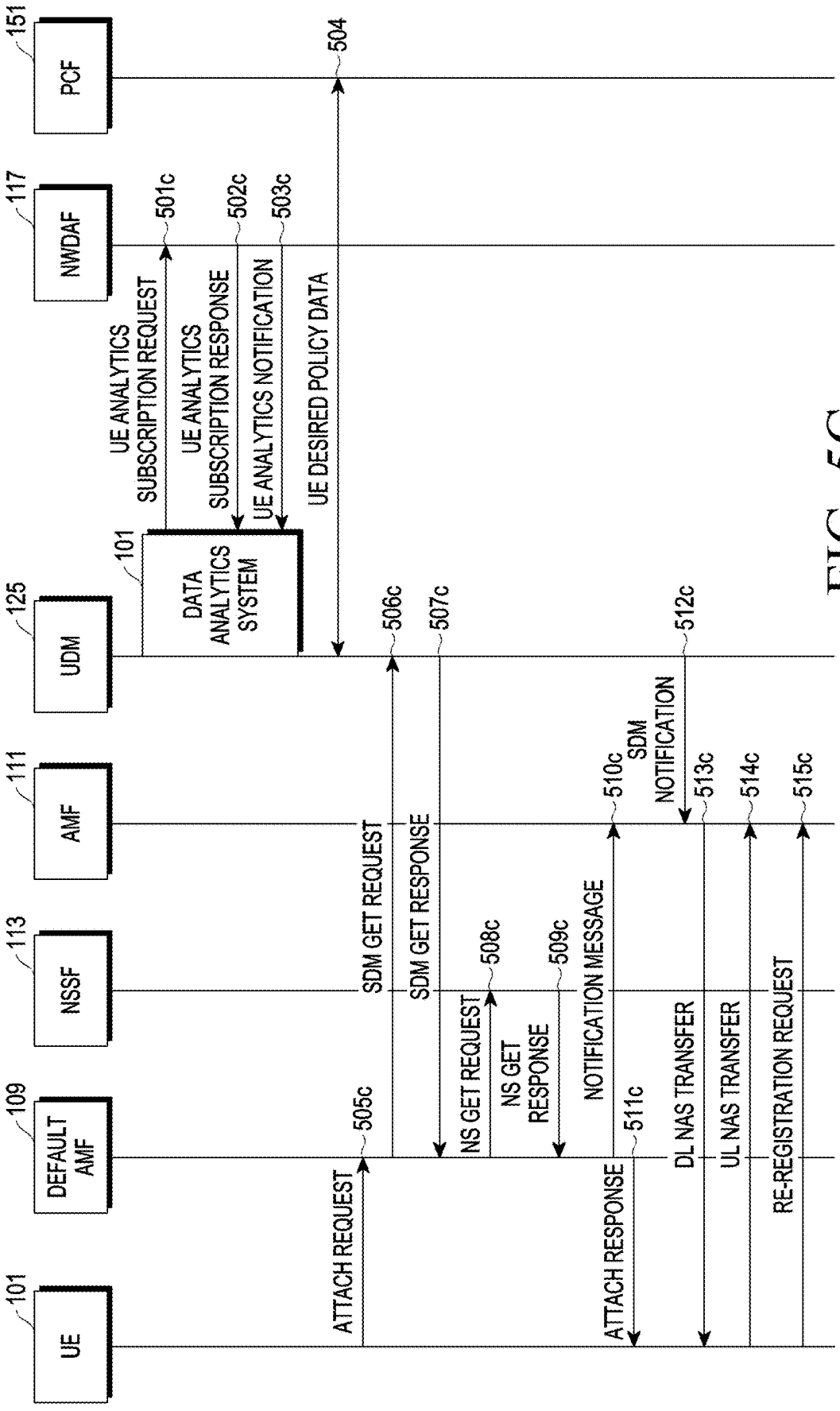
151
PCF
504
117
NWDAF
501c
502c
503c
UE ANALYTICS SUBSCRIPTION REQUEST
UE ANALYTICS SUBSCRIPTION RESPONSE
UE ANALYTICS NOTIFICATION
UE DESIRED POLICY DATA
101
DATA ANALYTICS SYSTEM
125
UDM
506c
507c
512c
111
AMF
SDM GET REQUEST
SDM GET RESPONSE
510c
SDM NOTIFICATION
513c
514c
515c
113
NSSF
508c
509c
NS GET REQUEST
NS GET RESPONSE
NOTIFICATION MESSAGE
109
DEFAULT AMF
505c
511c
ATTACH REQUEST
ATTACH RESPONSE
DL NAS TRANSFER
UL NAS TRANSFER
RE-REGISTRATION REQUEST
101
UE

FIG. 5C

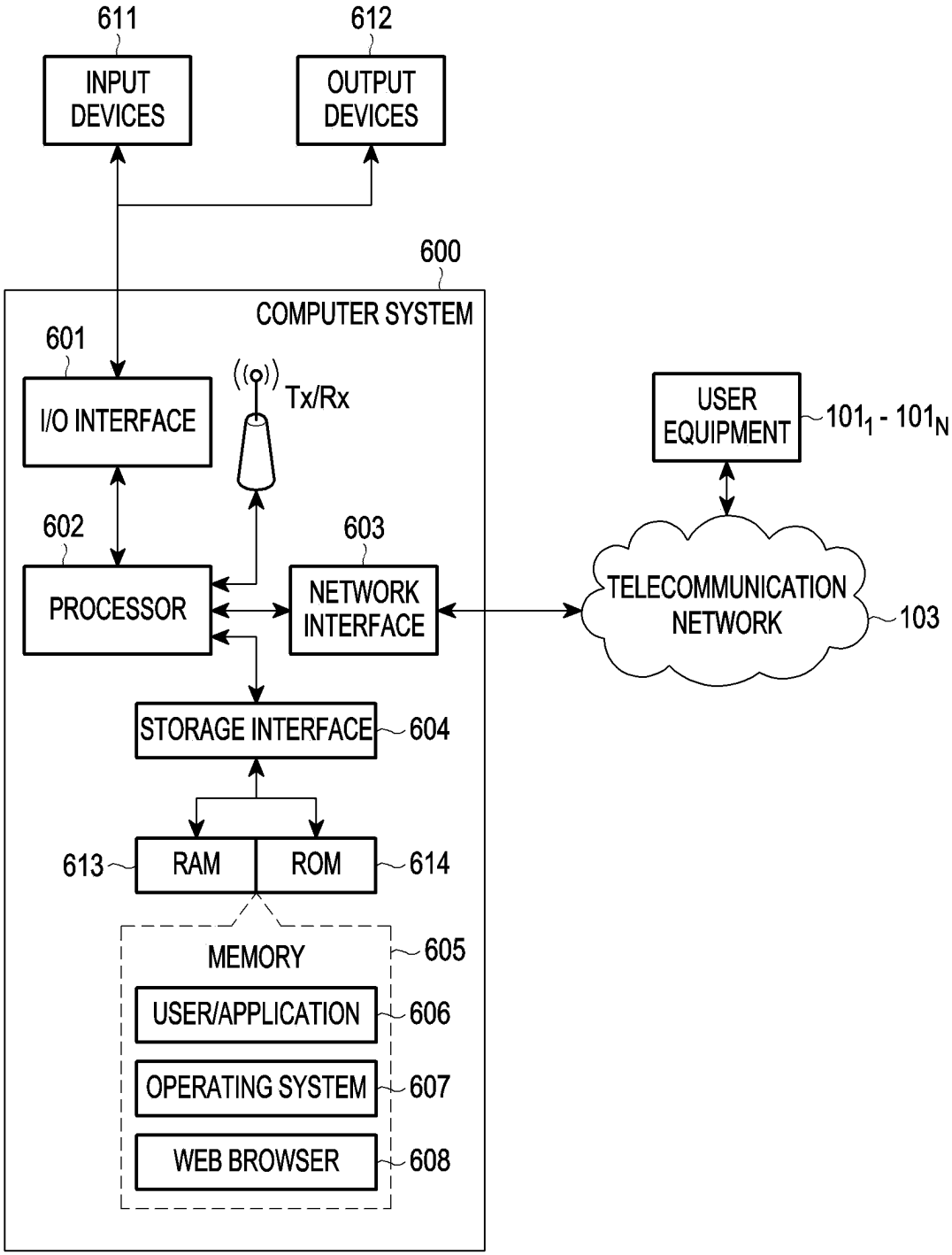
611
INPUT DEVICES
612
OUTPUT DEVICES
600
COMPUTER SYSTEM
601
I/O INTERFACE
Tx/Rx
602
PROCESSOR
603
NETWORK INTERFACE
STORAGE INTERFACE
604
613
RAM
ROM
614
MEMORY
605
USER/APPLICATION
606
OPERATING SYSTEM
607
WEB BROWSER
608
USER EQUIPMENT
101_1 - 101_N
TELECOMMUNICATION NETWORK
103

FIG. 6

METHOD AND ELECTRONIC DEVICE FOR SLICE ALLOCATION IN A TELECOMMUNICATION NETWORK

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a by-pass continuation application of International Application No. PCT/KR2024/017999, filed on Nov. 14, 2024, which is based on and claims priority to Indian Patent Application No. 202441010255, filed on Feb. 14, 2024, the disclosures of which are incorporated by reference herein in their entireties.

BACKGROUND

1. Field

[0002] The disclosure relates to the field of telecommunication networks, and in particular, to a method and system for dynamic slice allocation in a telecommunication network.

2. Description of Related Art

[0003] A network slice in 5^{th} Generation telecommunication network is a logical block used for targeting different services with different requirements on speed, latency, and reliability. Various types of smart devices or User Equipment (UE) which communicate using the telecommunication network are allocated with a default network slice each. In 5G solutions, slicing may be based on a Single Network Slice Selection Assistance Information (S-NSSAI) which may constitute of Slice/Service Type (SST) and Slice Differentiator (SD) values provisioned in the UE. A default slice may be allocated for the lifetime of the UE. The network slices may be allocated by default and may remain the same for lifetime. Conventional systems may not provide a mechanism to change the default network slice. Such default network slice may be pre-allocated without considering application usage pattern of the UE. As the default slice allocated to the user may only provide a specific Quality of Service (QoS), it may not fulfill the network requirements of the UE for each application. This may impact the user experience and may degrade the QoS for the user equipment. By enabling only a default network slice for each UE, available network resources and their capabilities that may increase QoS may be under-utilized Therefore, there is a need for a solution capable of allocating the network slice to the UE based on usage pattern of the UE.

[0004] The information in this background section is only for understanding and should not be taken as prior art already known to a person skilled in the art.

SUMMARY

[0005] According to an aspect of the disclosure, a method for network slice allocation in a telecommunication network, is provided. The method may comprise: monitoring one or more application usage patterns of one or more user equipment (UEs) which are connected to a default network slice in the telecommunication network; classifying the one or more UEs into one or more categories based on the one or more application usage patterns; and allocating, by the data analytics system, one or more network slices having predefined qualities of service (QoS) to the one or more UEs based on the one or more categories.

[0006] The one or more application usage patterns may be monitored based on UE communication service data received from a first network function of the telecommunication network.

[0007] A first network slice allocated to one or more first UEs classified according to a first category may be different from other network slices allocated to other UEs classified according to other categories.

[0008] The method may further include: monitoring a mean opinion score (MOS) value indicating a service experience of one or more applications being used by the one or more first UEs based on allocating the first network slice; and replacing the first network slice with a second network slice based on the MOS value being below a predefined threshold value.

[0009] The method may further include redirecting connection of the one or more first UEs from the default network slice to the first network slice without changing a single network slice selection assistance information (S-NSSAI) value in the one or more first UEs, wherein the S-NSSAI value indicates the default network slice.

[0010] The method may further include transmitting first information indicating the first network slice to the one or more first UEs, wherein the first information is for replacing second information indicating the default network slice in the one or more first UEs. The first information may indicate a change of the default network slice of the one or more first UEs to the first network slice.

[0011] The method may further include: determining a movement pattern of the one or more first UEs based on one or more previous handovers in the telecommunication network of the one or more first UEs, wherein the one or more previous handovers are determined based on UE communication service data received from a first network function of the telecommunication network; and pre-defining a second network slice to be allocated to the one or more first UEs based on the movement pattern and a stored list of one or more second network slices allocated to the one or more first UEs in the one or more previous handovers.

[0012] According to an aspect of the disclosure, a method of dynamic network slice allocation in a telecommunication network, includes: monitoring, by a data analytics system associated with the telecommunication network, one or more application usage patterns of one or more User Equipment (UEs) based on the one or more UEs is connected to a default network slice in the telecommunication network; classifying, by the data analytics system, the one or more UEs into one or more categories based on the one or more application usage patterns; allocating, by the data analytics system, one or more network slices having predefined Qualities of Service (QoS) to the one or more UEs, wherein a first network slice allocated to one or more first UEs classified according to a first category is different from other network slices allocated to other UEs in other categories; and transmitting, by the data analytics system, first information indicating the first network slice to the one or more first UEs, wherein the first information is for replacing second information indicating the default network slice in the one or more first UEs, wherein the first information indicates a change of the default network slice of the one or more first UEs to the first network slice.

[0013] The one or more application usage patterns may be monitored based on UE communication service data received from a first network function of the telecommunication network.

[0014] The method may further include: monitoring, by the data analytics system, a Mean Opinion Score (MOS) value indicating a service experience of one or more applications being used by the one or more first UEs based on allocating the first network slice; and replacing, by the data analytics system, the first network slice with a second network slice based on the MOS being below a predefined threshold value.

[0015] According to an aspect of the disclosure, a method performed at User Equipment (UE) for dynamic network slice allocation in a telecommunication network, includes: receiving, by the UE, first information indicating a first network slice allocated to the UE from a data analytics system associated with the telecommunication network; replacing, by the UE, second information indicating a default network slice in the UE with the first information; and establishing, by the UE, a connection with the first network slice based on replacing the second information with the first information.

[0016] The establishing the connection with the first network slice may include transmitting, by the UE, a registration request to a second network element that facilitates allocation of the first network slice.

[0017] According to an aspect of the disclosure, an electronic device for a data analytics system for network slice allocation in a telecommunication network, may comprise: one or more processors; and memory storing instructions, which, when executed by the one or more processors, cause the electronic device to: monitor one or more application usage patterns of one or more user equipment (UEs) which areconnected to a default network slice in the telecommunication network; classify the one or more UEs into one or more categories based on the one or more application usage patterns; and allocate one or more network slices having predefined qualities of service (QoS) to the one or more UEs based on the one or more categories.

[0018] According to an aspect of the disclosure, a data analytics system for dynamic network slice allocation in a telecommunication network, includes: one or more processors; and a memory, storing instructions, which, when executed by the one or more processors, cause the data analytics system to: monitor one or more application usage patterns of one or more User Equipment (UEs) based on the one or more UEs being connected to a default network slice in the telecommunication network; classify the one or more UEs into one or more categories based on the one or more application usage patterns; allocate one or more network slices having predefined Qualities of Service (QoS) to the one or more UEs, wherein a first network slice allocated to one or more first UEs classified according to a first category is different from other network slices allocated to other UEs classified according to other categories; and transmit first information indicating the first network slice to the one or more first UEs, wherein the first information is for replacing second information indicating the default network slice in the one or more first UEs, wherein the first information indicates a change of the default network slice of the one or more first UEs to the first network slice.

[0019] The one or more application usage patterns may be monitored based on UE communication service data received from a first network function of the telecommunication network.

[0020] The one or more processors may be further configured to execute the instructions to cause the data analytics system to: monitor a Mean Opinion Score (MOS) value indicating a service experience of one or more applications being used by the one or more first UEs based on allocating the first network slice; and replace the first network slice with a second network slice based on the MOS value obeing below a predefined threshold value.

[0021] According to an aspect of the disclosure, a User Equipment (UE) for dynamic network slice allocation in a telecommunication network, includes: one or more processors; and a memory, storing instructions, which, when executed by the one or more processors, causes the UE to: receive first information indicating a first network slice allocated to the UE from a data analytics system associated with the telecommunication network; replace second information indicating a default network slice in the UE with the first information; and establish a connection with the first network slice based on replacing the second information with the first information.

[0022] According to an aspect of the disclosure, a non-transitory computer readable storage medium storing instructions which, when executed by one or more processors of an electronic device, cause the electronic device to perform operations is provided. The operations may comprise monitoring one or more application usage patterns of one or more user equipment (UEs) which are connected to a default network slice in the telecommunication network; classifying the one or more UEs into one or more categories based on the one or more application usage patterns; and allocating, by the data analytics system, one or more network slices having predefined qualities of service (QoS) to the one or more UEs based on the one or more categories.

[0023] To establish the connection with the first network slice, the one or more processors may be configured to execute the instructions to cause the UE to transmit a registration request to a second network element that facilitates allocation of the first network slice.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The accompanying drawings illustrate exemplary embodiments and, together with the description, explain one or more embodiments. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The same numbers are used throughout the figures to reference like features and components. Some embodiments of system and/or methods in accordance with embodiments of the present subject matter are now described, by way of example only, and regarding the accompanying figures, in which:

[0025] FIG. **1**A and **1**B show an exemplary architecture for dynamic network slice allocation in a telecommunication network using a data analytics system, in accordance with one or more embodiments;

[0026] FIG. **1**C shows an exemplary architecture of Network Slice Selection Function (NSSF), in accordance with one or more embodiments;

[0027] FIG. **1**D shows an exemplary architecture for Unified Data Management (UDM), in accordance with one or more embodiments;

[0028] FIG. **1**E shows an exemplary clustering of one or more User Equipment (UE), in accordance with one or more embodiments;

[0029] FIG. **2**A and FIG. **2**B show detailed block diagrams of a data analytics system, in accordance with one or more embodiments;

[0030] FIG. **3** shows a detailed block diagram of a User Equipment (UE), in accordance with one or more embodiments;

[0031] FIG. **4**A shows a flowchart illustrating an exemplary method of dynamic network slice allocation in a telecommunication network, in accordance with one or more embodiments;

[0032] FIG. **4**B shows an exemplary call flow diagram for dynamic network slice allocation in a telecommunication network, in accordance with one or more embodiments;

[0033] FIG. **4**C shows an exemplary call flow diagram for dynamic network slice allocation in a telecommunication network during handover of a User Equipment (UE), in accordance with one or more embodiments;

[0034] FIG. **5**A shows a flowchart illustrating an exemplary method of dynamic network slice allocation in a telecommunication network involving a User Equipment (UE), in accordance with one or more embodiments;

[0035] FIG. **5**B shows a flowchart illustrating an exemplary method performed at User Equipment (UE) for dynamic network slice allocation in a telecommunication network, in accordance with one or more embodiments;

[0036] FIG. **5**C shows an exemplary sequence diagram for dynamic network slice allocation in a telecommunication network involving a User Equipment (UE), in accordance with one or more embodiments, in accordance with one or more embodiments; and

[0037] FIG. **6** illustrates a block diagram of an exemplary computer system for implementing one or more embodiments.

[0038] It should be appreciated by those skilled in the art that any block diagrams herein represent conceptual views of illustrative systems embodying the principles of the present subject matter. Similarly, it will be appreciated that any flow charts, flow diagrams, state transition diagrams, pseudo code, and the like represent various processes which may be substantially represented in computer readable medium and executed by a computer or processor, whether such computer or processor is explicitly shown.

DETAILED DESCRIPTION

[0039] The embodiments described in the disclosure, and the configurations shown in the drawings, are only examples of embodiments, and various modifications may be made without departing from the scope and spirit of the disclosure.

[0040] In the present document, the word "exemplary" is used herein to mean "serving as an example, instance, or illustration." Any embodiment or implementation of the present subject matter described herein as "exemplary" is not to be construed as preferred or advantageous over other embodiments.

[0041] While one or more embodiments may have modified forms, description thereof is provided by way of example in the drawings and in detail below. It should be understood, however that such descriptions are not intended to limit the disclosure to a specific form, but on the contrary, the disclosure includes all modifications, equivalents, and alternatives falling within the spirit of the disclosure.

[0042] The terms "comprises", "comprising", "includes", or any other variations thereof, are intended to cover a non-exclusive inclusion, such that a setup, device, or method that comprises a list of components, steps, or operations does not include only those components or steps but may include other components, steps, or operations. One or more elements in a system or apparatus proceeded by "comprises . . . a" does not, without more constrain, preclude the existence of other elements or additional elements in the system or method.

[0043] Provided are one or more embodiments capable of facilitating dynamic allocation. One or more embodiments may be referred as a network only method as the method of dynamically allocating the network slice based on application usage pattern of the UE may not make changes at the UE end. The changes to adapt to the dynamically allocated network slice may be performed at the network end. One or more embodiments may dynamically allocate the network slice based on application usage pattern of the UE may include interference of the UE along with the actions taken at the network end. In one or more embodiments, a data analytics system monitors an application usage pattern of one or more UEs. The data analytics system may be configured in Network Slice Selection Function (NSSF) of the telecommunication network. A default network slice may be allocated to the UE based on the UE being powered ON. To monitor the UE application usage pattern, the data analytics system may monitor communication service data of each of the one or more UEs available at a first network function of the telecommunication network. As an example, the first network function may be, without limitation, a Network Data Analytics Function (NWDAF) in 5G network. The application usage pattern may facilitate understanding of the usage pattern of user of the UE which indicates the current application used in the UE, uplink traffic of the UE, downlink traffic of the UE and like. Using the application usage pattern, the data analytics system may classify each of the one or more UEs into a plurality of categories based on the application usage pattern of each of the one or more UEs. As an example, the plurality of categories may include, without limitation, audio streaming users, video streaming users, message application using users, browsing application using users and gaming users. Upon classifying each of the one or more UEs, the data analytics system may allocate a network slice having a predefined QoS (Quality of Service) to each of the one or more UEs categorized in each of the plurality of categories, wherein the network slice allocated to each of the one or more UEs in one category is different from the network slice allocated to each of the one or more UEs in other categories of the plurality of categories. The data analytics system may be further configured to redirect connection of the one or more UEs from the default network slice to the allocated network slice without changing a Single Network Slice Selection Assistance Information (S-NSSAI) value indicative of the default network slice in the one or more UEs. Further, the data analytics system may monitor a Mean Opinion Score (MOS) value of the one or more UEs indicative of service experience of one or more applications being used in each of the one or more UEs. If the MOS value is below a predefined threshold value, the data analytics may update the network slice allocated to the UE. In the second method which involves combination of the network and the UE for dynamic slice allocation, the data analytics system transmits information related to the

corresponding allocated network slice to the corresponding one or more UEs for replacing information related to a default network slice in the one or more UEs with the information related to the corresponding allocated network slice, indicative of a change of the default network slice of the one or more UEs to the corresponding allocated network slice. In this scenario, S-NSSAI value in the UE is updated. The connection of the UE is interrupted and the UE establishes connection using allocated network slice. Also, the UE is configured to receive the information related to the network slice indicative of the network slice allocated to the UE from the data analytics system and replace the information related to the default network slice in the UE with the information related to the allocated network slice in the UE. Finally, the UE establishes a connection with the allocated network slice upon replacing the information related to the default network slice in the UE.

[0044] One or more embodiments may dynamically allocate a network slice based on the application usage pattern of the UE. This may enhance the user experience and may provide increased QoS to the UE as the allocated slice fulfills the network requirements of the UE. One or more embodiments may be performed at a network end, this helps in updating the network slice of the UE without interrupting the connection of the UE with the network. One or more embodiments may classify each of the one or more UEs into a plurality of categories based on the application usage pattern. Each category have different QoS. This helps in classifying the user in the correct category which fulfills the network requirement. One or more embodiments may monitor the user experience upon allocating the network slice and updates the network slice if there is a change in user experience. This helps in dynamically updating the network slice which enhances the user experience and the QoS. One or more embodiment may determine a movement pattern of the UE based on one or more previous handovers of the UE. Using the movement pattern, the network slice to be allocated is pre-defined for the UE during handover of the UE. As the movement pattern of the UE is determined, the network slice to be allocated is predefined in the new location of the UE which helps in dynamically allocating the network slice without monitoring the application usage pattern again in the new location of the UE. The new location here refers to different location from the present location of the UE. This in turn eliminates additional processing for monitoring the application usage pattern and reduces time taken to dynamically allocating a network slice to the UE.

[0045] In the following detailed description of one or more embodiments, reference is made to the accompanying drawings that form a part hereof, and in which are shown by way of illustration. These embodiments are described in sufficient detail to enable those skilled in the art to practice the disclosure, and it is to be understood that other embodiments may be utilized and that changes may be made without departing from the scope of the present disclosure. The following description is, therefore, not to be taken in a limiting sense.

[0046] For convenience of explanation, terms and names defined in the 3rd Generation Partnership Project Radio Access Network (3GPP RAN) standards are used herein. The terms 'Control plane', 'User plane', 'Core Network', Access and Mobility Function (AMF), Network Slice Selection Function (NSSF), Subscriber Data Management (SDM) function, a Network Data Analytics Function (NWDAF), Operations Administration and Maintenance (OAM), Data Network Name (DNN) and Policy Control Function (PCF) are to be interpreted as including such entities from the 3GPP RAN standards.

[0047] FIG. **1**A shows an exemplary architecture for dynamic network slice allocation in a telecommunication network using a data analytics system, in accordance with one or more embodiments.

[0048] Exemplary architecture illustrates network components and User Equipment (UE) $\mathbf{101}_1$ to UE $\mathbf{101}_N$ (also collectively referred as one or more UEs **101**). The one or more UEs **101** are connected with the network components of a telecommunication network **103**. As an example, the telecommunication network **103** may be 5^{th} Generation (5G) network. The network components may include control plane **105** and user plane **107**. The control plane **105** and user plane **107** includes a plurality of interconnected Network Functions (NFs) which are defined by the 3GPP for delivering the control plane **105** functionality and user plane **107** functionality of a communication system. The plurality of interconnected NFs may be interconnected NFs with each NF authorized to access the services of other NFs. The NFs in the control plane **105** may include, without limitation, one or more Access and Mobility Function (AMF **111**), Network Slice Selection Function (NSSF) **113**, Session Management Function (SMF) **115** function and a Network Data Analytics Function (NWDAF) **117**. In an embodiment, one or more AMFs **111** may include, without limitation, a default AMF **109**, and an allocated AMF **111** (as shown in FIG. **1**A and **1**B). The default AMF **109** may be allocated to the UE $\mathbf{101}_N$ when the UE $\mathbf{101}_N$ is powered ON and the allocated AMF **111** may refer to the AMF **111** among the one or more AMFs **111** that is allocated based on application usage pattern of the UE $\mathbf{101}_N$. The NFs in the user plane **107** may include, without limitation, User Plane Function (UPF) **119** and one or more data networks ($\mathbf{121}_1$-$\mathbf{121}_N$). In an embodiment, the NSSF **113** may include a data analytics system **123** which may be configured to perform the method according to one or more embodiments. In some embodiments, the data analytics system **123** may be configured in Unified Data Management (UDM) **125** of the control plane **105** (as shown in FIG. **1**B). In some embodiments, the data analytics system **123** may be external and associated with the NSSF **113** through a communication network. In some embodiments, the data analytics system **123** may be external and associated with the UDM **125** through the communication network. As an example, the communication network may be a wired communication network, a wireless communication network or a combination of both.

[0049] FIG. **1**C illustrates an exemplary NSSF **113** which includes the data analytics system **123**. In an embodiment, an existing NSSF **113** may include slice selection module **131** and slice availability module **133**. The slice selection module **131** and slice availability module **133** perform slice selection based on conventional 3GPP procedure. The profile list module **135** maintains configurable static user profiles which can be allocated to users with default list. During initial registration, UE $\mathbf{101}_N$ receives the SNSSAI which is allowed by NSSF in response to the registration request by the UE $\mathbf{101}_N$. The profile list module **135** may store a static profile which stores a default profile which may be allocated to the UE $\mathbf{101}_N$ when UE $\mathbf{101}_N$ is connected initially. Upon monitoring application usage pattern of the UE $\mathbf{101}_N$, the

SNSSAI value may be updated, which is also updated in the profile list module **135**. The profile list module **135** may be configured using NSSF **113** Operations Administration and Maintenance (OAM). The slice selection module **131** communicates with the AMF **111** when there is a change in network slice allocated to the UE $\mathbf{101}_N$. The data analytics system **123** communicates with NWDAF **117** to receive UE $\mathbf{101}_N$ communication service data and service experience data of the UE $\mathbf{101}_N$. Also, the data analytics system **123** communicates with Policy Control Function (PCF) **141** for efficient rule generation. The functionality of the components illustrated in FIG. **1**C will be explained in further part of the description. Although the FIG. **1**C shows the components of the NSSF **113**, it is to be understood that other embodiments are not limited thereon. In other embodiments, the NSSF **113** may include less or a greater number of components. Further, the labels or names of the components are used only for illustrative purpose and does not limit the scope. One or more components can be combined together to perform same or substantially similar technical feature for the dynamic network slice allocation in a telecommunication network **103**.

[0050] In an embodiment, when the UE $\mathbf{101}_N$ is powered ON, a default network slice is allocated to the UE $\mathbf{101}_N$. As an example, the default network slice may be allocated based on type of the UE $\mathbf{101}_N$. As an example, the UE $\mathbf{101}_N$ may include, without limitation, any device used by a user to at least one of communicate and access content such as, but not limited to, mobile phones, smartphones, laptops, wearables, and Internet of Things (IoTs). Each network slice may be identified using a Single Network Slice Selection Assistance Information (S-NSSAI) value. Further, the S-NSSAI value may include, without limitation, Slice/Service Type (SST) and Slice Differentiator (SD). The SST may identify the type of network slice, such as a network slice for mobile broadband, Internet of Things (IoT) and the like. The SD may be a field that may further differentiate network slices of the same type.

[0051] In an embodiment, the data analytics system **123** may be configured to monitor an application usage pattern of one or more UEs **101** when the one or more UEs **101** are connected to the default network slice in the telecommunication network **103**. The application usage pattern of the one or more UEs **101** may be monitored based on the UE $\mathbf{101}_N$ communication service data available at a first network function of the telecommunication network **103**. As an example, the first network function may be, without limitation, a Network Data Analytics Function (NWDAF) **117** in 5G network. In an embodiment, the UE $\mathbf{101}_N$ communication service data may include, without limitation, an application Identity (ID) of an application used by the UE $\mathbf{101}_N$, a Data Network Name (DNN), uplink traffic volume, downlink traffic volume, interval time of periodic communication of the UE $\mathbf{101}_N$ and duration of communication of the UE $\mathbf{101}_N$.

[0052] In an embodiment, upon monitoring the application usage pattern, the data analytics system **123** may be configured to classify each of the one or more UEs **101** into a plurality of categories based on the application usage pattern of each of the one or more UEs **101**. As an example, the plurality of categories may include, without limitation, audio streaming users, video streaming users, message application using users, browsing application using users and gaming users. As shown in FIG. **1**E, each of the one or more UEs **101** into a plurality of categories based on the application usage pattern of each of the one or more UEs **101**. Referring to FIG. **1**E, the cluster **142** may be video streaming users, the cluster **143** may be message application using users and the cluster **145** may be browsing application using users. As an example, when a user is using the video streaming application on the UE $\mathbf{101}_N$ for a predefined duration, the UE $\mathbf{101}_N$ will be classified into video streaming application category. After a duration, if the user switches to messaging application, the UE $\mathbf{101}_N$ will be classified into messaging application category. In an embodiment, the data analytics system **123** may be configured for classifying the UE $\mathbf{101}_N$ into a category in the plurality of categories based on the application usage pattern of the UE $\mathbf{101}_N$ continuously and/or at predefined time intervals.

[0053] In an embodiment, upon classifying each of the one or more UEs **101**, the data analytics system **123** may be configured to allocate a network slice having a predefined QoS (Quality of Service) to each of the one or more UEs **101** categorized in each of the plurality of categories. The network slice allocated to each of the one or more UEs **101** in one category may be different from the network slice allocated to each of the one or more UEs **101** in other categories of the plurality of categories. In an embodiment, the data analytics system **123** may redirect connection of the one or more UEs **101** from the default network slice to the allocated network slice without changing a S-NSSAI value indicative of the default network slice in the one or more UEs **101**. In an embodiment, the default configured rules for static profiles is present in the data analytics system **123**. The data analytics system **123** communicates the rules associated with the allocated network slice with the PCF **141** for efficient rule generation.

[0054] Upon allocating the network slice, the data analytics system **123** may be configured to monitor a Mean Opinion Score (MOS) value of the one or more UEs **101** indicative of service experience of one or more applications being used in each of the one or more UEs **101**. In an embodiment, the data analytics may also identify, without limitation, network area of the UE $\mathbf{101}_N$ where the service experience is monitored, application ID of the application used in the UE $\mathbf{101}_N$ and Data Network Name (DNN) with network identifier and operator identifier. Further, the data analytics system **123** may be configured to update the network slice allocated for the one or more UEs **101** with a new network slice when the MOS value of the one or more UEs **101** in the one of the plurality of categories is below a predefined threshold value. As an example, consider the user is using the video streaming application or a messaging application or a gaming application on the UE $\mathbf{101}_N$ simultaneously. The data analytics system **123** may be configured for allocating the network slice having the predefined QoS which may fulfill the QoS requirements for video streaming application, a messaging application and a gaming application, all of them combined. In the above example, when the network slice is updated, the S-NSSAI value in the UE $\mathbf{101}_N$ is not changed. In an embodiment, the QoS for the UE $\mathbf{101}_N$ is updated as per the application usage pattern and the UE $\mathbf{101}_N$ is currently connected with the default network slice. However, the connection from the default AMF **109** with the default network slice is updated to the AMF **111** with the allocated network slice. The connection of the UE **101** is redirected from the default AMF **109** to the AMF **111** with

the allocated network slice. The default network slice of the UE $\mathbf{101}_N$ remains the same as the S-NSSAI value in the UE $\mathbf{101}_N$ is not changed.

[0055] In some embodiment, during the mobility of the UE $\mathbf{101}_N$, handover procedure may take place to continuously provide services to the UE $\mathbf{101}_N$ without interruptions. To allocate the network slice to the UE $\mathbf{101}_N$ when the UE $\mathbf{101}_N$ moves to a different location, the data analytics system **123** may determine a movement pattern of the one or more UEs **101** based on one or more previous handovers of the one or more UEs **101** in the telecommunication network **103** using a UE communication service data available at a first network function of the telecommunication network **103**. As an example, the first network function may be, without limitation, NWDAF **117** in the 5G network. Consider an exemplary scenario in which the UE $\mathbf{101}_N$ moves between location A and location B frequently, the data analytics system **123** may determine a movement pattern of the UE $\mathbf{101}_N$ between location A and location B using the information related to the one or more previous handovers. Further, the data analytics system **123** may pre-allocate a corresponding subsequent network slice to be allocated to the one or more UEs **101** based on the movement pattern of the one or more UEs **101** and a corresponding stored list of network slices allocated to the one or more UEs **101** in the one or more previous handovers. Considering the example discussed above, the data analytics system **123** may pre-define the corresponding subsequent network slice to be allocated in the location B when the UE $\mathbf{101}_N$ moves from location A to location B without again monitoring the application usage pattern of the UE $\mathbf{101}_N$. However, if the application usage pattern of the UE $\mathbf{101}_N$ changes in the location B, the data analytics system **123** may allocate the network slice based on the application usage pattern.

[0056] In some embodiments, as shown in FIG. **1**D, the data analytics system **123** may be configured in the UDM **125**. The components in the UDM **125** may be same as the components in NSSF **113**. Although the FIG. **1**D shows the components of the UDM **125**, it is to be understood that other embodiments are not limited thereon. In other embodiments, the UDM **125** may include less or a greater number of components. Further, the labels or names of the components are used only for illustrative purpose and does not limit the scope. One or more components can be combined together to perform same or substantially similar technical feature for the dynamic network slice allocation in a telecommunication network **103**.

[0057] In an embodiment, when the data analytics is configured in the UDM **125**, the data analytics system **123** may be configured to transmit information related to the corresponding allocated network slice to the corresponding one or more UEs **101** for replacing information related to a default network slice in the one or more UEs **101** with the information related to the corresponding allocated network slice, indicative of a change of the default network slice of the one or more UEs **101** to the corresponding allocated network slice. Upon receiving the information, the UE $\mathbf{101}_N$ may be configured to replace information related to a default network slice in the UE $\mathbf{101}_N$ with the information related to the allocated network slice in the UE $\mathbf{101}_N$. As an example, to update the information in the UE $\mathbf{101}_N$, the UE $\mathbf{101}_N$ may update/change the S-NSSAI information of the default network slice in the UE $\mathbf{101}_N$ with the S-NSSAI information of the allocated network slice. After updating, the UE $\mathbf{101}_N$ may establish a connection with the allocated network slice upon replacing the information related to the default network slice in the UE $\mathbf{101}_N$. To establish the connection, the UE $\mathbf{101}_N$ may transmit a registration request to a second network element that facilitates the allocated network slice. As an example, the second network element may be AMF **111** supporting the allocated network slice. Upon allocating the network slice, the data analytics system **123** may be configured to monitor the MOS value of the one or more UEs **101** indicative of service experience of one or more applications being used in each of the one or more UEs **101**. In an embodiment, the data analytics may also identify, without limitation, network area of the UE $\mathbf{101}_N$ where the service experience is monitored, application ID of the application used in the UE $\mathbf{101}_N$ and DNN with network identifier and operator identifier. Further, the data analytics system **123** may be configured to update the network slice allocated for the one or more UEs **101** with a new network slice when the MOS value of the one or more UEs **101** in the one of the plurality of categories is below a predefined threshold value. As an example, consider the user is using the video streaming application or a messaging application or a gaming application on the UE $\mathbf{101}_N$ simultaneously. The data analytics system **123** may be configured for allocating the network slice having the predefined QoS which may fulfill the QoS requirements for video streaming application, a messaging application and a gaming application, all of them combined. The UE $\mathbf{101}_N$ may receive information related to the allocated network slice and update the default network slice with the allocated network slice. During establishing the connection with the allocated network slice, the connection of the UE $\mathbf{101}_N$ with the telecommunication network **103** may be interrupted. In the above example, when the network slice is updated, the S-NSSAI value in the UE $\mathbf{101}_N$ is also updated.

[0058] FIG. **2**A and FIG. **2**B show detailed block diagrams of data analytics system **123**, in accordance with one or more embodiments.

[0059] In some embodiments, the data analytics system **123** may be implemented in an electronic device. The electronic device may be a part of a network entity (e.g. the NSSF **113** or the UDM**125**) or may also implement the network entity. The data analytics system **123** may include an I/O interface **201**, a processor **203** and a memory **205**. In an embodiment, the memory **205** may be communicatively coupled to the processor **203**. The processor **203** may be configured to perform one or more functions of the data analytics system **123** for dynamic network slice allocation in a telecommunication network **103**, using the data **207** and the one or more modules **209** of the data analytics system **123**. In an embodiment, the memory **205** may store data **207**.

[0060] In an embodiment, the data **207** stored in the memory **205** may include, without limitation, application usage pattern data **211**, network slices data **213**, and other data **215**. In some embodiments, the data **207** may be stored within the memory **205** in the form of various data structures. Additionally, the data **207** may be organized using data models, such as relational or hierarchical data models. The other data **215** may include various temporary data and files generated by the one or more modules **209**.

[0061] In an embodiment, the application usage pattern data **211** may store application usage pattern of each of one or more User Equipment (UEs) **101** which is monitored based on a UE communication service data available at a

first network function of the telecommunication network **103**. In an embodiment, the UE communication service data may include, without limitation, an application Identity (ID) of an application used by the UE $\mathbf{101}_N$, a Data Network Name (DNN), uplink traffic volume, downlink traffic volume, interval time of periodic communication of the UE $\mathbf{101}_N$ and duration of communication of the UE $\mathbf{101}_N$. The application ID may indicate the application being used in each of the one or more UEs **101**. As an example, the application may be, without limitation, video streaming application, web browsing application and gaming application. Each application may be identified using a unique ID. The DNN may be used to identify data networks. The DNN may be used in 5^{th} Generation (5G) network, which may be similar to Access Point Name (APN) in 4^{th} Generation (5G) network. The uplink traffic volume may indicate amount of data transmitted from each of the one or more UEs **101** to the telecommunication network **103**. The downlink traffic volume may indicate amount of data transmitted from the telecommunication network **103** to each of the one or more UEs **101**. The interval time of periodic communication of the UE $\mathbf{101}_N$ may be time duration between two consecutive transmissions between each of the one or more UEs **101** and the telecommunication network **103**. The duration of communication of the UE $\mathbf{101}_N$ may indicate the total time consumed during the communication of the UE $\mathbf{101}_N$.

[0062] In an embodiment, the network slices data **213** may store information related to network slices allocated to each of the one or more UEs **101**. In an embodiment, each of the one or more UEs **101** may be connected to a default network slice in the telecommunication network **103**. Each of the one or more UEs **101** may be classified into a plurality of categories based on the application usage pattern data **211** of each of the one or more UEs **101**. Upon classification, a network slice having a predefined QoS (Quality of Service) may be allocated to each of the one or more UEs **101** categorized in each of the plurality of categories. The network slices data **213** may be updated when the network slice is allocated to the each of the one or more UEs **101**. In an embodiment, the network slices data **213** may also store Single Network Slice Selection Assistance Information (S-NSSAI) of each network slice. Further, the S-NSSAI value may include, without limitation, Slice/Service Type (SST) and Slice Differentiator (SD). The SST may identify the type of network slice, such as a network slice for mobile broadband, Internet of Things (IoT) and the like. The SD may be a field that may be used to further differentiate network slices of the same type. In some embodiments, the network slices data **213** which may include information related to the allocated network slice may also be transmitted to the UE $\mathbf{101}_N$ for updating the network slice information in the UE $\mathbf{101}_N$ with the information related to the allocated network slice.

[0063] In an embodiment, the data **207** may be processed by one or more modules **209** of the data analytics system **123**. In some embodiments, the one or more modules **209** may be communicatively coupled to the processor **203** for performing one or more functions of the data analytics system **123**. In an embodiment, the one or more modules **209** may include, without limiting to, a monitoring module **217**, a classifying module **219**, an allocating module **221** and other modules **223**. In some embodiments, the data analytics system **123** may also include a transmission module **225** (as shown in FIG. **2**B).

[0064] As used herein, the term module may refer to an Application Specific Integrated Circuit (ASIC), an electronic circuit, a hardware processor **203** (shared, dedicated, or group) and memory that execute one or more software or firmware programs, a combinational logic circuit, and/or other components that provide the described functionality. In an embodiment, each of the one or more modules **209** may be configured as stand-alone hardware computing units. In an embodiment, the other modules **223** may be used to perform various miscellaneous functionalities on the data analytics system **123**. It will be appreciated that such one or more modules **209** may be represented as a single module or a combination of different modules.

[0065] In an embodiment, the monitoring module **217** may be configured for monitoring an application usage pattern of one or more User Equipment (UEs) **101** when the one or more UEs **101** is connected to a default network slice in the telecommunication network **103**. Further, the monitoring module **217** may be configured to monitor the application usage pattern of the one or more UEs **101** based on a UE communication service data available at a first network function of the telecommunication network **103**. As an example, the first network function may be, without limitation, a network data analytics function (NWDAF) **117** in 5G network. In an embodiment, the UE communication service data may include, without limitation, an application Identity (ID) of an application used by the UE $\mathbf{101}_N$, a Data Network Name (DNN), uplink traffic volume, downlink traffic volume, interval time of periodic communication of the UE $\mathbf{101}_N$ and duration of communication of the UE $\mathbf{101}_N$. In an embodiment, the monitoring module **217** may be configured for monitoring the application usage pattern of one or more UEs **101** in at least one of predefined intervals and continuously.

[0066] In an embodiment, the classifying module **219** may be configured for classifying each of the one or more UEs **101** into a plurality of categories based on the application usage pattern of each of the one or more UEs **101**. As an example, the plurality of categories may be, without limitation, audio streaming users, video streaming users, message application using users, browsing application using users and gaming users. As an example, when a user is using the video streaming application on the UE $\mathbf{101}_N$ for a predefined duration, the UE $\mathbf{101}_N$ will be classified into video streaming application category. After a duration, if the user switches to messaging application, the UE $\mathbf{101}_N$ will be classified into messaging application category. The classifying module **219** may be configured for continuously classifying the UE $\mathbf{101}_N$ into a category in the plurality of categories based on the application usage pattern of the UE $\mathbf{101}_N$.

[0067] In an embodiment, the allocating module **221** may be configured for allocating a network slice having a predefined QoS (Quality of Service) to each of the one or more UEs **101** based on the corresponding category of the plurality of categories that each of the one or more UEs **101** are categorized into. The network slice allocated to each of the one or more UEs **101** in one category is different from the network slice allocated to each of the one or more UEs **101** in other categories of the plurality of categories. Upon allocating, the allocating module **221** may be configured for redirecting the connection of the one or more UEs **101** from the default network slice to the corresponding allocated network slice without changing a Single Network Slice

Selection Assistance Information (S-NSSAI) value indicative of the default network slice in each of the one or more UEs **101**. The S-NSSAI value is not changed in the UE $\mathbf{101}_N$ and the connection of the UE $\mathbf{101}_N$ with the telecommunication network **103** may not be interrupted. As an example, when the user is using the video streaming application on the UE $\mathbf{101}_N$ for a predefined duration, the UE $\mathbf{101}_N$ will be classified into video streaming application category. The allocating module **221** may be configured for allocating the network slice having the predefined QoS for the video streaming application. After a duration, if the user switches to messaging application, the UE $\mathbf{101}_N$ will be classified into messaging application category and the allocating module **221** may be configured for allocating the network slice having the predefined QoS for the messaging application. In the above example, when the network slice is updated, the S-NSSAI value in the UE $\mathbf{101}_N$ is not changed. However, the QoS provided to the UE $\mathbf{101}_N$ is updated based on the application usage pattern due to redirection of the connection of the UE $\mathbf{101}_N$ to the allocated network slice from the default network slice.

[0068] In an embodiment, upon allocating the network slice, the monitoring module **217** may be configured for monitoring a Mean Opinion Score (MOS) value of the one or more UEs **101** indicative of service experience of one or more applications being used in each of the one or more UEs **101**. Further, the updating module may be configured for updating the network slice allocated for the one or more UEs **101** with a new network slice when the MOS value of the one or more UEs **101** in the one of the plurality of categories is below a predefined threshold value. Table 1 below shows exemplary value of the service experience in the UE $\mathbf{101}_N$ in which three applications are currently used.

TABLE 1

NWDAF Data	Details	Value
Application ID	Determine application ID	x_1
Bandwidth request	Required Bandwidth	x_2
DNN	Identifies DNN, a full DNN with both the Network Identifier and Operator Identifier	x_3
Uplink volume	Identifies the uplink traffic volume	x_4
Downlink volume	Identifies the downlink traffic volume	x_5
Time period	Identifies interval time of periodic communication	x_6
Communication duration	Identifies the duration of the communication	x_7

[0069] The above values may be transmitted as an input to a trained machine learning model which will result into corresponding score (Rn) of the application ID. Rn score serves as weights for applications where higher score represents higher usage of application by user. Final MOS will be calculated as weighted average of observed service MOS of applications.

[0070] In an embodiment, the allocating module **221** may also be configured to determine a movement pattern of the one or more UEs **101** based on one or more previous handovers of the one or more UEs **101** in the telecommunication network **103** using a UE communication service data available at a first network function of the telecommunication network **103**. Further, the allocating module **221** may also be configured to pre-define a corresponding subsequent network slice to be allocated to the one or more UEs **101** based on the movement pattern of the one or more UEs **101** and a corresponding stored list of network slices allocated to the one or more UEs **101** in the one or more previous handovers.

[0071] In one or more embodiments, when the change of network slice includes interference of the UE $\mathbf{101}_N$, the data analytics system **123** may include an additional module such as a transmission module **225** as shown in FIG. **2**B. The functionality of the modules such as monitoring module **217**, classifying module **219** and allocating module **221** shall remain same as discussed above in the description of FIG. **2**A. In an embodiment, the transmission module **225** may be configured to transmit information related to the corresponding allocated network slice to the corresponding one or more UEs **101** for replacing information related to a default network slice in the one or more UEs **101** with the information related to the corresponding allocated network slice, indicative of a change of the default network slice of the one or more UEs **101** to the corresponding allocated network slice. As an example, the transmitting module may transmit the information comprising S-NSSAI value to the UE $\mathbf{101}_N$. Upon receiving the information related to the allocated network slice, the UE $\mathbf{101}_N$ may update the information related to the default network slice with the information related to the allocated network slice that causes the UE $\mathbf{101}_N$ to establish a connection with allocated network slice thereafter, which provides QoS based on the application usage pattern.

[0072] FIG. **3** shows a detailed block diagram of a User Equipment (UE) $\mathbf{101}_N$, in accordance with one or more embodiments.

[0073] In some embodiments, the UE $\mathbf{101}_N$ may include an I/O interface **301**, a processor **303** and a memory **305**. In an embodiment, the memory **305** may be communicatively coupled to the processor **303**. The processor **303** of the UE $\mathbf{101}_N$ may be configured to perform one or more functions of the UE $\mathbf{101}_N$ for dynamic network slice allocation in a telecommunication network **103**, using the data **307** and the one or more modules **309** of the data analytics system **123** UE **101**. In an embodiment, the memory **305** of the UE $\mathbf{101}_N$ may store data **307**.

[0074] In an embodiment, the data **307** stored in the memory **305** may include, without limitation, network slice information data **311** and other data **313**. In some embodiments, the data **307** may be stored within the memory **305** of the UE $\mathbf{101}_N$ in the form of various data structures. Additionally, the data **307** may be organized using data models, such as relational or hierarchical data models. The other data **313** may include various temporary data and files generated by the one or more modules **309**.

[0075] In an embodiment, the network slice information data **311** may store information related to network slice allocated to the UE $\mathbf{101}_N$. In an embodiment, the network slice information data **313** may also store Single Network Slice Selection Assistance Information (S-NSSAI) of each network slice. Further, the S-NSSAI value may include, without limitation, Slice/Service Type (SST) and Slice Differentiator (SD). The SST may identify the type of network slice, such as a network slice for mobile broadband, Internet of Things (IoT) and the like. The SD may be a field that may further differentiate network slices of the same type. In an embodiment, when the UE $\mathbf{101}_N$ connects with the telecommunication network **103**, a default network slice is allocated.

The information related to the default network slice may be stored in network slice information data **311**. In an embodiment, when a network slice is allocated to the UE $\mathbf{101}_N$ based on the application usage pattern, the UE $\mathbf{101}_N$ may receive information related to a network slice indicative of the network slice allocated to the UE $\mathbf{101}_N$ from a data analytics system **123** associated with the telecommunication network **103**. Further, the UE $\mathbf{101}_N$ may replace information related to a default network slice in the network slice information data **311** of the UE $\mathbf{101}_N$ with the information related to the allocated network slice in the UE $\mathbf{101}_N$.

[0076] In an embodiment, the data **307** may be processed by one or more modules **309** of the UE **101**. In some embodiments, the one or more modules **309** may be communicatively coupled to the processor **303** of the UE $\mathbf{101}_N$ for performing one or more functions of the data analytics system **123**. In an embodiment, the one or more modules **309** may include, without limiting to, a transceiver module **315**, a replacing module **317**, an establishing module **319** and other modules **321**.

[0077] As used herein, the term module may refer to an Application Specific Integrated Circuit (ASIC), an electronic circuit, a hardware processor **303** (shared, dedicated, or group) and memory that execute one or more software or firmware programs, a combinational logic circuit, and/or other components that provide the described functionality. In an embodiment, each of the one or more modules **309** may be configured as stand-alone hardware computing units. In an embodiment, the other modules **321** may be used to perform various miscellaneous functionalities on the data analytics system **123**. It will be appreciated that such one or more modules **309** may be represented as a single module or a combination of different modules.

[0078] In an embodiment, the transceiver module **315** may be configured for receiving information related to a network slice indicative of the network slice allocated to the UE $\mathbf{101}_N$ from a data analytics system **123** associated with the telecommunication network **103**. As an example, the information related to the network slice may include a Single Network Slice Selection Assistance Information (S-NSSAI) value of the network slice. In an embodiment, the network slice may be allocated to the UE $\mathbf{101}_N$ based on the application usage pattern of the UE $\mathbf{101}_N$ as discussed in detail in the FIGS. **2**A and **2**B.

[0079] In an embodiment, the replacing module **317** may be configured for replacing information related to a default network slice in the UE $\mathbf{101}_N$ with the information related to the allocated network slice in the UE $\mathbf{101}_N$. In an embodiment, when the UE $\mathbf{101}_N$ connects with the telecommunication network **103**, a default network slice is allocated. The information related to the default network slice may be replaced with the information related to the allocated network slice. As an example, the S-NSSAI value associated with the default network slice may be replaced with the S-NSSAI value of the allocated network slice.

[0080] In an embodiment, the establishing module **319** may be configured for establishing a connection with the allocated network slice upon replacing the information related to the default network slice in the UE $\mathbf{101}_N$. In an embodiment, when the S-NSSAI value is updated in the UE $\mathbf{101}_N$, the connection of the UE $\mathbf{101}_N$ with the telecommunication network **103** may be interrupted, to establish connection with the telecommunication network **103** and resume the services utilized by the UE $\mathbf{101}_N$, the establishing module **319** may be configured for establishing the connection with the allocated network slice. In an embodiment, for establishing the connection, the transceiver module **315** may transmit a registration request to a second network element that facilitates the allocated network slice. As an example, the second network element may be Access and Mobility Function (AMF) **111** which facilitates the allocated network slice.

[0081] FIG. **4**A shows a flowchart illustrating an exemplary method of dynamic network slice allocation in a telecommunication network **103**, in accordance with one or more embodiments.

[0082] As illustrated in FIG. **4**A, the method **400** may include one or more blocks illustrating a method of dynamic network slice allocation in a telecommunication network **103** using the data analytics system **123** illustrated in FIG. **2**A. The method **400** may be described in the context of computer executable instructions. Computer executable instructions may include routines, programs, objects, components, data structures, procedures, modules, or functions, which perform functions or implement data types.

[0083] The order in which the method **400** is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method may be implemented in a variety of hardware, software, firmware, or combination thereof.

[0084] At block **401**, the method **400** includes monitoring, by a processor **203** of the data analytics system **123**, an application usage pattern of one or more User Equipment (UEs) **101** when the one or more UEs **101** is connected to a default network slice in the telecommunication network **103**. The application usage pattern of the one or more UEs **101** is monitored based on a UE communication service data available at a first network function of the telecommunication network **103**.

[0085] At block **403**, the method **400** includes classifying, by the processor **203**, each of the one or more UEs **101** into a plurality of categories based on the application usage pattern of each of the one or more UEs **101**.

[0086] At block **405**, the method **400** includes allocating, by the processor **203**, a network slice having a predefined Quality of Service (QoS) to each of the one or more UEs **101** categorized in each of the plurality of categories. The network slice allocated to each of the one or more UEs **101** in one category is different from the network slice allocated to each of the one or more UEs **101** in other categories of the plurality of categories. The processor may redirect connection of the one or more UEs **101** from the default network slice to the allocated network slice without changing a Single Network Slice Selection Assistance Information (S-NSSAI) value indicative of the default network slice in the one or more UEs **101**. Upon allocating the network slice, the processor **203** may monitor a Mean Opinion Score (MOS) value of the one or more UEs **101** indicative of service experience of one or more applications being used in each of the one or more UEs **101** upon allocating the network slice having the predefined QoS. Further, the processor **203** may update the network slice allocated for the one or more UEs **101** with a new network slice when the MOS value of the one or more UEs **101** in the one of the plurality of categories is below a predefined threshold value. Additionally, the processor **203** may determine a movement pattern of the one or more UEs **101** based on one or more

previous handovers of the one or more UEs **101** in the telecommunication network **103** using a UE communication service data available at a first network function of the telecommunication network **103**. Upon determining the movement pattern, the processor **203** may pre-define a corresponding subsequent network slice to be allocated to the one or more UEs **101** based on the movement pattern of the one or more UEs **101** and a corresponding stored list of network slices allocated to the one or more UEs **101** in the one or more previous handovers.

[0087] FIG. **4**B shows an exemplary call flow diagram for dynamic network slice allocation in a telecommunication network **103**, in accordance with one or more embodiments.

[0088] In an embodiment, the data analytics system **123** may be configured in Network Slice Selection Function (NSSF) **113**. When a User Equipment (UE) **101** is powered ON, a default network slice is allocated to the UE $\mathbf{101}_N$. As an example, the default network slice may be allocated based on type of the UE $\mathbf{101}_N$. As an example, the UE $\mathbf{101}_N$ may include, without limitation, any device used by a user to at least one of communicate and access content such as, but not limited to, mobile phones, smartphones, laptops, wearables, and Internet of Things (IoTs). At operation 1, the data analytics system **123** may transmit UE analytics subscription request to Network Data Analytics Function (NWDAF) **117**. At operation 2, the data analytics system **123** receives UE analytics subscription response. At operation 3, the data analytics system **123** receives UE analytics notification which may comprise an application usage pattern. The data analytics system **123** may monitor an application usage pattern of the UE $\mathbf{101}_N$ when the one or more UEs **101** is connected to the default network slice in the telecommunication network **103**. The application usage pattern of the one or more UEs **101**UE **101** may be monitored based on the UE communication service data available at NWDAF **117**. At operation 4, there is an occurrence of NSSF **113** interaction which may be used to decide the policies for the UE $\mathbf{101}_N$. At operation 5, the UE $\mathbf{101}_N$ transmits an attach request. During attach request processing when Subscriber Data Management (SDM) GET is sent to Unified Data Management (UDM) **125**, the UDM **125** function allocates the default slice information (operations 6 and 7). At operation 8, default AMF **109** which facilitates the default network slice forwards the Network Slice (NS) selection GET request to NSSF **113**, the NSSF **113** allocates an AMF **111** set which facilitates a network slice allocated based on the application usage pattern of the UE $\mathbf{101}_N$, which may be assigned for the UE $\mathbf{101}_N$ for slice allocation (operation 8, 9 and 10). Finally, the default AMF **109** notifies the allocated AMF **111** and the connection of the UE $\mathbf{101}_N$ is redirected to the AMF **111** with the allocated network slice without changing the S-NSSAI value in the UE $\mathbf{101}_N$ (operation 11 and 12). The connection of the UE $\mathbf{101}_N$ was not interrupted as the allocation of the network slice was performed without the involvement of the UE $\mathbf{101}_N$ by redirecting the connection of the UE $\mathbf{101}_N$ from the default AMF **109** to the AMF **111** with the allocated network slice. The UE $\mathbf{101}_N$ is unaware of the changes in the network slice and the allocation is internally managed within the network functions of the telecommunication network **103**.

[0089] FIG. **4**C shows an exemplary call flow diagram for dynamic network slice allocation in a telecommunication network **103** during handover of a User Equipment (UE) **101**, in accordance with one or more embodiments.

[0090] In an embodiment, the data analytics system **123** may be configured in Network Slice Selection Function (NSSF) **113**. When a User Equipment (UE) **101** is powered ON, a default network slice is allocated to the UE $\mathbf{101}_N$. As an example, the default network slice may be allocated based on type of the UE $\mathbf{101}_N$. At operation 1, the data analytics system **123** may transmit UE analytics subscription request to Network Data Analytics Function (NWDAF) **117**. At operation 2, the data analytics system **123** receives UE analytics subscription response. At operation 3, the data analytics system **123** receives UE analytics notification which may comprise an application usage pattern. The data analytics system **123** may monitor an application usage pattern of one or more UEs **101** when the one or more UEs **101** is connected to the default network slice in the telecommunication network **103**. The application usage pattern of the one or more UEs **101** may be monitored based on the UE communication service data available at NWDAF **117**. At operation 4, using the UE communication service data, the data analytics system **123** determines regular movement pattern of the UE $\mathbf{101}_N$ across AMF **111** and configures a network slice in neighboring AMF **421** based on the one or more previous handovers of the UE $\mathbf{101}_N$. Similarly, the data analytics system **123** may configure the network slice in neighboring AMF **421**. At operation 6, the UE $\mathbf{101}_N$ transmits an attach request. During attach request processing when Subscriber Data Management (SDM) GET is sent to Unified Data Management (UDM) **125**, the UDM **125** function allocates the default slice information (operations 7 and 8). Default AMF **111** which facilitates the default network slice forwards the Network Slice (NS) selection GET request to NSSF **113**, the NSSF **113** allocates an AMF **111** set which facilitates a network slice allocated based on the application usage pattern of the UE $\mathbf{101}_N$, which may be assigned for the UE $\mathbf{101}_N$ for slice allocation. Operation 9, the default AMF **109** notifies the allocated AMF **111** and the connection of the UE $\mathbf{101}_N$ is redirected to the AMF **111** with the allocated network slice without changing the S-NSSAI value in the UE $\mathbf{101}_N$. During the UE $\mathbf{101}_N$ movement across AMF **111**, the allocated network slice may be directly allocated to UE **101** upon detecting handover of the UE $\mathbf{101}_N$ to the neighbouring AMF **421** which has already configured the allocated network slice (operation 11). If the allocated slice is not available in the neighbouring AMF **421**, the default network slice may be allocated to the UE $\mathbf{101}_N$. The connection of the UE $\mathbf{101}_N$ was not interrupted as the allocation of the network slice was performed without the involvement of the UE $\mathbf{101}_N$. The UE $\mathbf{101}_N$ is unaware of the changes in the network slice and the allocation is internally managed within the network functions of the telecommunication network **103**.

[0091] FIG. **5**A shows a flowchart illustrating an exemplary method of dynamic network slice allocation in a telecommunication network **103** involving a User Equipment (UE) **101**, in accordance with one or more embodiments.

[0092] As illustrated in FIG. **5**A, the method **500** may include one or more blocks illustrating a method of dynamic network slice allocation with User Equipment involvement (UE) **101** in a telecommunication network **103** using the data analytics system **123** illustrated in FIG. **2**B. The method **500** may be described in the context of computer executable instructions. Computer executable instructions may include

routines, programs, objects, components, data structures, procedures, modules, or functions, which perform functions or implement data types.

[0093] The order in which the method **500** is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method may be implemented in a variety of hardware, software, firmware, or combination thereof.

[0094] At block **501**, the method **500** includes monitoring, by a processor **203** of the data analytics system **123**, an application usage pattern of one or more User Equipment (UEs) **101** when the one or more UEs **101** are connected to a default network slice in the telecommunication network **103**. The application usage pattern of the one or more UEs **101** is monitored based on a UE communication service data available at a first network function of the telecommunication network **103**.

[0095] At block **503**, the method **500** includes classifying, by the processor **203**, each of the one or more UEs **101** into a plurality of categories based on the application usage pattern of each of the one or more UEs **101**.

[0096] At block **505**, the method **500** includes allocating, by the processor **203**, a network slice having a predefined Quality of Service (QoS) to each of the one or more UEs **101** categorized in each of the plurality of categories. The network slice allocated to each of the one or more UEs **101** in one category is different from the network slice allocated to each of the one or more UEs **101** in other categories of the plurality of categories.

[0097] At block **507**, the method **500** includes transmitting, by the processor **203**, information related to the corresponding allocated network slice to the corresponding one or more UEs **101** for replacing information related to a default network slice in the one or more UEs **101** with the information related to the corresponding allocated network slice, indicative of a change of the default network slice of the one or more UEs **101** to the corresponding allocated network slice. Upon transmitting the information related to the corresponding allocated network slice, the processor **203** may monitor a Mean Opinion Score (MOS) value of the one or more UEs **101** indicative of service experience of one or more applications being used in each of the one or more UEs **101** upon allocating the network slice having the predefined QoS. Further, the processor **203** may update the network slice allocated for the one or more UEs **101** with a new network slice when the MOS value of the one or more UEs **101** in the one of the plurality of categories is below a predefined threshold value.

[0098] FIG. **5**B shows a flowchart illustrating an exemplary method performed at User Equipment (UE) **101** for dynamic network slice allocation in a telecommunication network **103**, in accordance with one or more embodiments.

[0099] As illustrated in FIG. **5**B, the method **520** may include one or more blocks illustrating a method performed at User Equipment (UE) **101** for dynamic network slice allocation in a telecommunication network **103** using the data analytics system **123** illustrated in FIG. **3**. The method **500** may be described in the context of computer executable instructions. Computer executable instructions may include routines, programs, objects, components, data structures, procedures, modules, or functions, which perform functions or implement data types.

[0100] The order in which the method **520** is described is not intended to be construed as a limitation, and any number of the described method blocks can be combined in any order to implement the method. Furthermore, the method may be implemented in a variety of hardware, software, firmware, or combination thereof.

[0101] At block **521**, the method **520** includes receiving, by a processor **303** of the UE $\mathbf{101}_N$, information related to a network slice indicative of the network slice allocated to the UE $\mathbf{101}_N$ from a data analytics system **123** associated with the telecommunication network **103**.

[0102] At block **523**, the method **520** includes replacing, by the processor **303**, information related to a default network slice in the UE $\mathbf{101}_N$ with the information related to the allocated network slice in the UE $\mathbf{101}_N$.

[0103] At block **525**, the method **520** includes establishing, by the processor **303**, a connection with the allocated network slice upon replacing the information related to the default network slice in the UE $\mathbf{101}_N$. The processor **303** is further configured to transmit a registration request to a second network element that facilitates the allocated network slice.

[0104] FIG. **5**C shows an exemplary call flow diagram for dynamic network slice allocation in a telecommunication network **103** involving a User Equipment (UE) **101**, in accordance with one or more embodiments.

[0105] In an embodiment, the data analytics system **123** may be configured in Unified Data Management (UDM) **125**. When a User Equipment (UE) $\mathbf{101}_N$ is powered ON, a default network slice is allocated to the UE $\mathbf{101}_N$. As an example, the default network slice may be allocated based on type of the UE $\mathbf{101}_N$. At operation 1, the data analytics system **123** may transmit UE analytics subscription request to Network Data Analytics Function (NWDAF) **117**. At operation 2, the data analytics system **123** receives UE analytics subscription response. At operation 3, the data analytics system **123** receives UE analytics notification which may comprise an application usage pattern. The data analytics system **123** may monitor an application usage pattern of one or more UEs **101** when the one or more UEs **101** is connected to the default network slice in the telecommunication network **103**. The application usage pattern of the one or more UEs **101** may be monitored based on the UE communication service data available at NWDAF **117**. At operation 4, the UDM **125** interacts with the PCF **141** to decide the policies for the UE $\mathbf{101}_N$. At operation 5, the UE $\mathbf{101}_N$ transmits an attach request. During attach request processing when Subscriber Data Management (SDM) GET is sent to the UDM **125** function, the UDM **125** function allocates the default slice information (operations 6 and 7). At operation 8, default AMF **109** which facilitates the default network slice forwards the Network Slice (NS) selection GET request to NSSF **113**, the NSSF **113** allocates an AMF **111** set which facilitates a network slice allocated based on the application usage pattern of the UE $\mathbf{101}_N$, which may be assigned for the UE $\mathbf{101}_N$ for slice allocation (operation 8 and 9). At operation 10, the default AMF **109** notifies the allocated AMF **111**, and the UE $\mathbf{101}_N$ will be attached with the allocated AMF **111**. At operation 12, the UDM **125** transmits the SDM notification to the allocated AMF **111**. At operation 13, the allocated AMF **111** may perform downlink Non-Access Stratum (NAS) transfer. In response to DL NAS transfer, the UE $\mathbf{101}_N$ performs uplink DAS transfer (operation 14). The connection of the UE $\mathbf{101}_N$

is interrupted, and the UE $\mathbf{101}_N$ transmits a re-registration request to establish connection with the allocated AMF **111** (operation 15).

Computer System

[0106] FIG. **6** illustrates a block diagram of an exemplary computer system **600** for implementing one or more embodiments. In an embodiment, the computer system **600** may be the data analytics system illustrated in FIG. **2**A and **2**B. The computer system **600** may include a central processing unit ("CPU" or "processor" or "memory controller") **602**. The processor **602** may comprise at least one data processor for executing program components for executing user-or system-generated business processes. A user may include a network manager, an application developer, a programmer, an organization, or any system/sub-system being operated parallelly to the computer system **600**. The processor **602** may include processing units such as integrated system (bus) controllers, memory controllers/memory management control units, floating point units, graphics processing units, or digital signal processing units, for example.

[0107] The processor **602** may be disposed in communication with one or more Input/Output (I/O) devices (**611** and **612**) via I/O interface **601**. The I/O interface **601** may employ communication protocols/methods such as, without limitation, audio, analog, digital, stereo, IEEE®-1394, serial bus, Universal Serial Bus (USB), infrared, PS/2, BNC, coaxial, component, composite, Digital Visual Interface (DVI), high-definition multimedia interface (HDMI), Radio Frequency (RF) antennas, S-Video, Video Graphics Array (VGA), IEEE® 802.n/b/g/n/x, Bluetooth, or cellular (for example, Code-Division Multiple Access (CDMA), High-Speed Packet Access (HSPA+), Global System For Mobile Communications (GSM), Long-Term Evolution (LTE) or the like), for example. Using the I/O interface **601**, the computer system **600** may communicate with one or more I/O devices **611** and **612**.

[0108] In some embodiments, the processor **602** may be disposed in communication with a network **609** via a network interface **603**. The network interface **603** may communicate with the network **609**. The network interface **603** may employ connection protocols including, without limitation, direct connect, Ethernet (for example, twisted pair 10/100/1000 Base T), Transmission Control Protocol/Internet Protocol (TCP/IP), token ring, or IEEE® 802.11a/b/g/n/x, for example.

[0109] In an embodiment, the network **609** may be implemented as one of the several types of networks, such as intranet or Local Area Network (LAN) and such within the organization. The network **609** may either be a dedicated network or a shared network, which represents an association of several types of networks that use a variety of protocols, for example, Hypertext Transfer Protocol (HTTP), Transmission Control Protocol/Internet Protocol (TCP/IP), or Wireless Application Protocol (WAP) for example, to communicate with each other. Further, the network **609** may include a variety of network devices, including routers, bridges, servers, computing devices, or storage devices, for example. Using the network interface **603** and the network **609**, the computer system **600** may communicate with one or more User Equipment (UEs).

[0110] In some embodiments, the processor **602** may be disposed in communication with a memory **605** (for example, RAM **613**, or ROM **614**, as shown in FIG. **6**) via a storage interface **604**. The storage interface **604** may connect to memory **605** including, without limitation, memory drives, or removable disc drives, for example, employing connection protocols such as Serial Advanced Technology Attachment (SATA), Integrated Drive Electronics (IDE), IEEE-1394, Universal Serial Bus (USB), fiber channel, or Small Computer Systems Interface (SCSI), for example. The memory drives may further include a drum, magnetic disc drive, magneto-optical drive, optical drive, Redundant Array of Independent Discs (RAID), solid-state memory devices, or solid-state drives, for example.

[0111] The memory **605** may store a collection of program or database components, including, without limitation, user/application interface **606**, an operating system **607**, a web browser **608**, and the like. In some embodiments, computer system **600** may store user/application data **606**, such as the data, variables, or records, for example. Such databases may be implemented as fault-tolerant, relational, scalable, secure databases such as Oracle® or Sybase®.

[0112] The operating system **607** may facilitate resource management and operation of the computer system **600**. Examples of operating systems include, without limitation, APPLE® MACINTOSH® OS X®, UNIX®, UNIX-like system distributions (for example., BERKELEY SOFTWARE DISTRIBUTION® (BSD), FREEBSD®, NETBSD®, or OPENBSD), LINUX® DISTRIBUTIONS (for example, RED HAT®, UBUNTU®, or KUBUNTU®), IBM® OS/2®, MICROSOFT® WINDOWS® (XP®, VISTA®/7/8, or 10, for example), APPLE® IOS®, GOOGLE™ ANDROID™, BLACKBERRY® OS, or the like.

[0113] The user interface **606** may facilitate display, execution, interaction, manipulation, or operation of program components through textual or graphical facilities. For example, the user interface **606** may provide computer interaction interface elements on a display system operatively connected to the computer system **600**, such as cursors, icons, check boxes, menus, scrollers, windows, widgets, and the like. Further, Graphical User Interfaces (GUIs) may be employed, including, without limitation, APPLE® MACINTOSH® operating systems' Aqua®, IBM® OS/2®, MICROSOFT® WINDOWS® (for example, Aero, or Metro), web interface libraries (for example, ActiveX®, JAVA®, JAVASCRIPT®, AJAX, HTML, or ADOBE® FLASH®), or the like.

[0114] The web browser **608** may be a hypertext viewing application. Secure web browsing may be provided using Secure Hypertext Transport Protocol (HTTPS), Secure Sockets Layer (SSL), Transport Layer Security (TLS), and the like. The web browsers **608** may utilize facilities such as AJAX, DHTML, ADOBE® FLASH®, JAVASCRIPT®, JAVA®, Application Programming Interfaces (APIs), and the like. Further, the computer system **600** may implement a mail server stored program component. The mail server may utilize facilities such as ASP, ACTIVEX®, ANSI® C++/C #, MICROSOFT®, .NET, CGI SCRIPTS, JAVA®, JAVASCRIPT®, PERL®, PHP, PYTHON®, or WEBOBJECTS®, for example. The mail server may utilize communication protocols such as Internet Message Access Protocol (IMAP), Messaging Application Programming Interface (MAPI), MICROSOFT® exchange, Post Office Protocol (POP), Simple Mail Transfer Protocol (SMTP), or the like. In some embodiments, the computer system **600** may imple-

ment a mail client stored program component. The mail client may be a mail viewing application, such as APPLE® MAIL, MICROSOFT® ENTOURAGE®, MICROSOFT® OUTLOOK®, MOZILLA® THUNDERBIRD®, and the like.

[0115] Furthermore, one or more computer-readable storage media may be utilized in implementing one or more embodiments. A computer-readable storage medium refers to any type of physical memory on which information or data readable by a processor may be stored. Thus, a computer-readable storage medium may store instructions for execution by one or more processors, including instructions for causing the processor(s) to perform steps, operations, or stages consistent with the embodiments described herein. The term "computer-readable medium" should be understood to include tangible items and exclude carrier waves and transient signals, for example, non-transitory. Examples include Random Access Memory (RAM), Read-Only Memory (ROM), volatile memory, nonvolatile memory, hard drives, Compact Disc (CD) ROMs, Digital Video Disc (DVDs), flash drives, disks, and any other known physical storage media.

[0116] Advantages of one or more embodiments are apparent from the descriptions provided herein.

[0117] One or more embodiments dynamically allocates network slice based on the application usage pattern of the UE. This may enhance the user experience and may increase QoS to the UE as the allocated slice fulfills the network requirements of the UE. One or more embodiments may be performed at network end, this helps in updating the network slice of the UE without interrupting the connection of the UE with the network.

[0118] One or more embodiments may classify each of the one or more UEs into a plurality of categories based on the application usage pattern. Each category have different QoS. This helps in classifying the user in the correct category which fulfills the network requirement. One or more embodiments may monitor the user experience upon allocating the network slice and updates the network slice if there is a change in user experience. This helps in dynamically updating the network slice which enhances the user experience and the QoS.

[0119] One or more embodiments may determine a movement pattern of the UE based on one or more previous handovers of the UE. Using the movement pattern, the network slice to be allocated is pre-defined for the UE during handover of the UE. As the movement pattern of the UE is determined, the network slice to be allocated is predefined in the new location of the UE which helps in dynamically allocating the network slice without monitoring the application usage pattern again in the new location of the UE. The new location here refers to different location from the present location of the UE. This in turn eliminates additional processing for monitoring the application usage pattern and reduces time taken to dynamically allocating a network slice to the UE.

[0120] As stated above, it shall be noted that one or more embodiments may be used to address various technical problems related to network slice allocation in a telecommunication network. One or more embodiments have a practical application and may provide a solution to the technical problems associated with the existing approach into network slice allocation in the telecommunication network.

[0121] The disclosed operations, according to one or more embodiments, are not routine, conventional, or well-known aspects in the art, and the operations may provide solutions to existing technical problems, and the operations may provide an improvement in the functioning of the system itself.

[0122] The terms "an embodiment", "embodiment", "embodiments", "the embodiment", "the embodiments", "one or more embodiments", "some embodiments", and "one embodiment" mean "one or more (but not all) embodiments" unless expressly specified otherwise.

[0123] The terms "including", "comprising", "having" and variations thereof mean "including but not limited to", unless expressly specified otherwise.

[0124] The enumerated listing of items does not imply that any or all the items are mutually exclusive, unless expressly specified otherwise. The terms "a", "an" and "the" mean "one or more", unless expressly specified otherwise.

[0125] A description of one or more embodiments with several components in communication with each other does not imply that all embodiments include such components. On the contrary, a variety of components are described to illustrate one or more embodiments.

[0126] When a single device or article is described herein, it will be clear that more than one device/article (whether they cooperate) may be used in place of a single device/article. Similarly, where more than one device/article is described herein (whether they cooperate), it will be clear that a single device/article may be used in place of the more than one device/article or a different number of devices/articles may be used instead of the shown number of devices or programs. The functionality and/or features of a device may be included in one or more additional devices.

[0127] Finally, the language used in herein has been selected for readability and instructional purposes, and is not intended to limit the disclosure thereto. Accordingly, the embodiments described herein are intended to be illustrative of, but not limiting to, the scope of the disclosure.

[0128] While various aspects and embodiments have been disclosed herein, other aspects and embodiments may be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting.

Referral Numerals:

Reference Number	Description
1011-101N	One or more User Equipment (UEs)
103	Telecommunication network
105	Control plane
107	User plane
109	Default Access and Mobility Function (AMF)
111	Access and Mobility Function (AMF)
113	Network Slice Selection Function (NSSF)
115	Session Management Function (SMF)
117	Network Data Analytics Function (NWDAF)
119	User Plane Function (UPF)
121_1-121_N	One or more data networks
123	Data analytics system
125	Unified Data Management (UDM)
131	Slice selection module
133	Slice availability module
135	Profile list module
137	Static profile list
139	User to profile mapping
141	Policy Control Function (PCF)

-continued

Referral Numerals:	
Reference Number	Description
201	I/O Interface
203	Processor
205	Memory
207	Data
209	Modules
211	Application usage pattern data
213	Network slices data
215	Other data
217	Monitoring module
219	Classifying module
221	Allocating module
223	Other modules
225	Transmission module
301	I/O Interface of the UE
303	Processor of the UE
305	Memory of the UE
307	Data of the UE
309	Modules of the UE
311	Network slice information data
313	Other data
315	Transceiver module
317	Determining module
319	Establishing module
321	Other modules
421	Neighboring AMF
600	Computer system
601	I/O Interface of the exemplary computer system
602	Processor of the exemplary computer system
603	Network interface
604	Storage interface
605	Memory of the exemplary computer system
606	User/Application
607	Operating system
608	Web browser
611	Input devices
612	Output devices
613	RAM
614	ROM

What is claimed is:

1. A method for network slice allocation by an electronic device for a data analytics system in a telecommunication network, comprising:

monitoring, one or more application usage patterns of one or more user equipment (UEs) which are connected to a default network slice in the telecommunication network;

classifying the one or more UEs into one or more categories based on the one or more application usage patterns; and

allocating, by the data analytics system, one or more network slices having predefined qualities of service (QoS) to the one or more UEs based on the one or more categories.

2. The method of claim **1**, wherein the one or more application usage patterns are monitored based on UE communication service data received from a first network function of the telecommunication network.

3. The method of claim **1**, wherein a first network slice allocated to one or more first UEs classified according to a first category is different from other network slices allocated to other UEs classified according to other categories.

4. The method of claim **3**, further comprising:

monitoring a mean opinion score (MOS) value indicating a service experience of one or more applications being used by the one or more first UEs based on allocating the first network slice; and

replacing the first network slice with a second network slice based on the MOS value being below a predefined threshold value.

5. The method of claim **3**, further comprising:

redirecting connection of the one or more first UEs from the default network slice to the first network slice without changing a single network slice selection assistance information (S-NSSAI) value in the one or more first UEs,

wherein the S-NSSAI value indicates the default network slice.

6. The method of claim **3**, further comprising:

transmitting first information indicating the first network slice to the one or more first UEs, wherein the first information is for replacing second information indicating the default network slice in the one or more first UEs,

wherein the first information indicates a change of the default network slice of the one or more first UEs to the first network slice.

7. The method of claim **1**, further comprising:

determining a movement pattern of the one or more first UEs based on one or more previous handovers in the telecommunication network of the one or more first UEs, wherein the one or more previous handovers are determined based on UE communication service data received from a first network function of the telecommunication network; and

pre-defining a second network slice to be allocated to the one or more first UEs based on the movement pattern and a stored list of one or more second network slices allocated to the one or more first UEs in the one or more previous handovers.

8. An electronic device for a data analytics system for network slice allocation in a telecommunication network, comprising:

one or more processors; and

memory storing instructions, which, when executed by the one or more processors, cause the electronic device to:

monitor one or more application usage patterns of one or more user equipment (UEs) which are connected to a default network slice in the telecommunication network;

classify the one or more UEs into one or more categories based on the one or more application usage patterns; and

allocate one or more network slices having predefined qualities of service (QoS) to the one or more UEs based on the one or more categories.

9. The electronic device of claim **8**, wherein the instructions, when executed by the one or more processors, cause the electronic device to monitor the one or more application usage patterns based on UE communication service data received from a first network function of the telecommunication network.

10. The electronic device of claim **8**, wherein a first network slice allocated to one or more first UEs classified

according to a first category is different from other network slices allocated to other UEs classified according to other categories.

11. The electronic device of claim **10**, wherein the instructions, when executed by the one or more processors, cause the electronic device further to:

monitor a mean opinion score (MOS) value indicating a service experience of one or more applications being used by the one or more first UEs based on allocating the first network slice; and

replace the first network slice with a second network slice based on the MOS value being below a predefined threshold value.

12. The electronic device of claim **10**, wherein the instructions, when executed by the one or more processors, cause the electronic device further to:

redirect connection of the one or more first UEs from the default network slice to the first network slice without changing a single network slice selection assistance information (S-NSSAI) value in the one or more first UEs,

wherein the S-NSSAI value indicates the default network slice.

13. The electronic device of claim **10**, wherein the instructions, when executed by the one or more processors, cause the electronic device to:

transmit first information indicating the first network slice to the one or more first UEs, wherein the first information is for replacing second information indicating the default network slice in the one or more first UEs,

wherein the first information indicates a change of the default network slice of the one or more first UEs to the first network slice.

14. The electronic device of claim **8**, wherein the instructions, when executed by the one or more processors, cause the electronic device further to:

determine a movement pattern of the one or more first UEs based on one or more previous handovers in the telecommunication network of the one or more first UEs, wherein the one or more previous handovers are determined based on UE communication service data received from a first network function of the telecommunication network; and

pre-define a second network slice to be allocated to the one or more first UEs based on the movement pattern and a stored list of one or more second network slices allocated to the one or more first UEs in the one or more previous handovers.

15. A non-transitory computer readable storage medium storing instructions which, when executed by one or more processors of an electronic device, cause the electronic device to perform operations, the operations comprising:

monitoring, one or more application usage patterns of one or more user equipment (UEs) which are connected to a default network slice in the telecommunication network;

classifying the one or more UEs into one or more categories based on the one or more application usage patterns; and

allocating, by the data analytics system, one or more network slices having predefined qualities of service (QoS) to the one or more UEs based on the one or more categories.

16. The non-transitory computer readable storage medium of claim **15**, wherein the one or more application usage patterns are monitored based on UE communication service data received from a first network function of the telecommunication network.

17. The non-transitory computer readable storage medium of claim **15**, wherein a first network slice allocated to one or more first UEs classified according to a first category is different from other network slices allocated to other UEs classified according to other categories.

18. The non-transitory computer readable storage medium of claim **17**, wherein the operations further comprises:

monitoring a mean opinion score (MOS) value indicating a service experience of one or more applications being used by the one or more first UEs based on allocating the first network slice; and

replacing the first network slice with a second network slice based on the MOS value being below a predefined threshold value.

19. The non-transitory computer readable storage medium of claim **17**, wherein the operations further comprises:

redirecting connection of the one or more first UEs from the default network slice to the first network slice without changing a single network slice selection assistance information (S-NSSAI) value in the one or more first UEs,

wherein the S-NSSAI value indicates the default network slice.

20. The non-transitory computer readable storage medium of claim **17**, wherein the operations further comprises:

transmitting first information indicating the first network slice to the one or more first UEs, wherein the first information is for replacing second information indicating the default network slice in the one or more first UEs,

wherein the first information indicates a change of the default network slice of the one or more first UEs to the first network slice.

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