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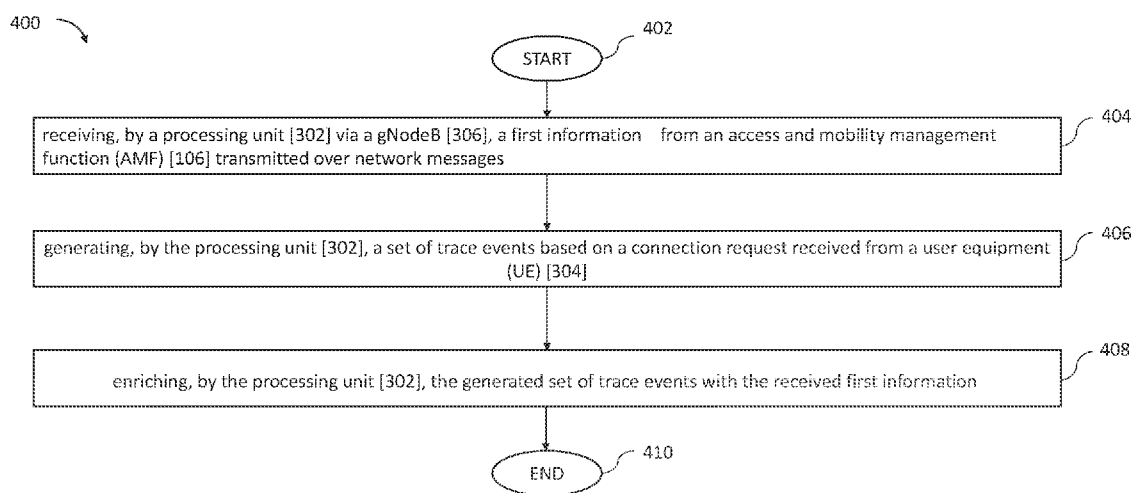


FIG. 4

(57) Abstract: The present disclosure relates to a method and a system for enriching 5G radio access network (RAN) session trace events. The method includes receiving, by a processing unit [302] via a gNodeB [306], a first information from an access and mobility management function (AMF) [106] transmitted over network messages. The method further includes generating, by the processing unit [302], a set of trace events based on a connection request received from a user equipment (UE) [304]. Furthermore, the method encompasses enriching, by the processing unit [302], the generated set of trace events with the received first information.

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METHOD AND SYSTEM FOR ENRICHING 5G RADIO ACCESS NETWORK (RAN) SESSION TRACE EVENTS

TECHNICAL FIELD

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[0001] Embodiments of the present disclosure generally relate to network performance management systems. More particularly, embodiments of the present disclosure relate to enriching 5G radio access network (RAN) session trace events.

10 BACKGROUND

[0002] The following description of the related art is intended to provide background information pertaining to the field of the disclosure. This section may include certain aspects of the art that may be related to various features of the present disclosure. However, it should
15 be appreciated that this section is used only to enhance the understanding of the reader with respect to the present disclosure, and not as admissions of the prior art.

[0003] Wireless communication technology has rapidly evolved over the past few decades, with each generation bringing significant improvements and advancements. The first generation
20 of wireless communication technology was based on analog technology and offered only voice services. However, with the advent of the second-generation (2G) technology, digital communication and data services became possible, and text messaging was introduced. 3G technology marked the introduction of high-speed internet access, mobile video calling, and location-based services. The fourth-generation (4G) technology revolutionized wireless
25 communication with faster data speeds, better network coverage, and improved security. Currently, the fifth-generation (5G) technology is being deployed, promising even faster data speeds, low latency, and the ability to connect multiple devices simultaneously. With each generation, wireless communication technology has become more advanced, sophisticated, and capable of delivering more services to its users.

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[0004] For existing solutions, the problem lies in the need for an effective methodology to collect subscriber information for enrichment of session traces for all users connected to a gNodeB from the Core network while minimizing complexity and the impact on the Access and Mobility Management Function (AMF). The existing methods lack efficiency in achieving
35 this goal, often resulting in increased complexity and a heavy processing load on the AMF.

Therefore, there is a need for an improved approach that addresses these issues. The existing solutions lack an effective methodology to collect subscriber information for enrichment of session traces for all users connected to a gNodeB from the Core network while minimizing complexity and the impact on the Access and Mobility Management Function (AMF). The existing methods fail to provide an efficient solution, resulting in increased complexity and a significant processing load on the AMF. This problem hinders the overall session level observability in the 5G Radio Access Network (RAN). The complexity introduced by the current approaches poses challenges in efficiently collecting subscriber information, which is essential for various network analytics and troubleshooting purposes. Moreover, the high processing load on the AMF affects its ability to handle other critical functions efficiently. The complexity and processing load imposed on the AMF not only hinder its performance but also impact the overall scalability of the network. This limitation inhibits the efficient analysis and troubleshooting of network issues, ultimately affecting the quality of service provided to subscribers. The existing methods fall short in providing an effective solution to this problem. The complexity and processing load imposed on the AMF not only hinder its performance but also impact the overall scalability of the network. This limitation inhibits the efficient analysis and troubleshooting of network issues, ultimately affecting the quality of service provided to subscribers.

[0005] To address these limitations, an improved methodology is required that ensures effective collection of subscriber information without imposing excessive complexity and processing load on the AMF. By developing a more streamlined and efficient approach, the invention aims to overcome the drawbacks of the prior art and enhance the session level observability in the 5G RAN without impacting AMF scalability.

[0006] Therefore, in light of the foregoing discussion, there exists a need to overcome the aforementioned drawbacks.

SUMMARY

[0007] This section is provided to introduce certain aspects of the present disclosure in a simplified form that are further described below in the detailed description. This summary is not intended to identify the key features or the scope of the claimed subject matter.

[0008] An aspect of the present disclosure may relate to a method for enriching 5G radio access network (RAN) session trace events. The method includes receiving, by a processing unit via a gNodeB, a first information from an access and mobility management function (AMF) transmitted over network messages. Further the method includes generating, by the processing unit, a set of trace events based on a connection request received from a user equipment (UE). Furthermore, the method encompasses enriching, by the processing unit, the generated set of trace events with the received first information.

[0009] In an exemplary aspect of the present disclosure, the first information comprises at least one of international mobile subscriber identity (IMSI) and international mobile equipment identity (IMEI).

[0010] In an exemplary aspect of the present disclosure, the method further comprises streaming, by the processing unit, the enriched set of trace events to a trace control entity (TCE) using a transmission control protocol/internet protocol (TCP/IP).

[0011] In an exemplary aspect of the present disclosure, the method comprises storing, by the processing unit, the enriched set of trace events within the TCE server for subsequent analysis and troubleshooting.

[0012] In an exemplary aspect of the present disclosure, the gNodeB receives the IMSI and IMEI during initial registration of the UE.

[0013] In an exemplary aspect of the present disclosure, the enrichment is performed using a predefined field in certain network messages over next generation application protocol (NGAP) protocol and XnAP protocol to obtain the IMSI and IMEI.

[0014] In an exemplary aspect of the present disclosure, the predefined field are implemented at both the AMF and the gNodeB ends, ensuring seamless communication and information transfer.

[0015] In an exemplary aspect of the present disclosure, the method further performs encoding at one of source gNodeB and source AMF, and decoding at a target gNodeB.

[0016] In an exemplary aspect of the present disclosure, the set of trace events are generated in real-time to track and record a sequence of interactions and communications between the UE and the gNodeB.

5 [0017] In an exemplary aspect of the present disclosure, the streaming of enriched set of trace events to the TCE is continuous, facilitating real-time monitoring of network activities.

[0018] In an exemplary aspect of the present disclosure, the enriched set of trace events stored in the TCE server are time-stamped, providing a chronological record of network
10 interactions for the UE.

[0019] In an exemplary aspect of the present disclosure, the gNodeB receives the IMSI and IMEI from the AMF during one of initial attach/registration, Xn handover, UE context retrieval in case of radio link failure (RLF), NG AP handover, and inter RAT handover.

15 [0020] Another aspect of the present disclosure may relate to a system for enriching 5G radio access network (RAN) session trace events. The system includes a processing unit. The processing unit is configured to receive, via a gNodeB, a first information from an AMF transmitted over network messages. Further, the system is configured to generate a set of trace
20 events based on a connection request received from a UE. Furthermore, the system is configured to enrich the generated set of trace events with the received first information.

[0021] Yet another aspect of the present disclosure may relate to a non-transitory computer readable storage medium storing instructions for enriching 5G radio access network (RAN)
25 session trace events, the instructions include executable code which, when executed by a one or more units of a system, causes: a processing unit of the system to receive via a gNodeB, a first information from an AMF transmitted over network messages; the processing unit of the system to further generate a set of trace events based on a connection request received from a UE; and the processing unit of the system to further enrich the generated set of trace events
30 with the received first information.

[0022] Yet another aspect of the present disclosure may relate to a User Equipment (UE) for enriching 5G radio access network (RAN) session trace events, the UE may include a processor configured to transmit, via a gNodeB, a first information from an access and mobility
35 management function (AMF) transmitted over network messages. The processor may be further

configured to generate, via a server, a set of trace events based on a connection request received from a user equipment (UE). Furthermore, the processor of the UE may be configured to enrich, via the server, the generated set of trace events with the first information.

5 OBJECTS OF THE INVENTION

[0023] Some of the objects of the present disclosure, which at least one embodiment disclosed herein satisfies are listed herein below.

10 [0024] It is an object of the present disclosure to provide a method and system for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information.

15 [0025] It is another object of the present disclosure to provide a method and system for efficiently collecting subscriber information in 5G RAN that provide an efficient and streamlined methodology for collecting subscriber information in 5G Radio Access Network (RAN) from the Core network. The collection should occur for all users connected to a gNodeB (gNB), without creating undue complexity or negatively impacting the functionality of the Access and Mobility Management Function (AMF).

20 [0026] It is another object of the present disclosure to provide a method and system efficiently collecting subscriber information in 5G RAN that reduce the processing load on the AMF, thereby improving its overall performance, and allowing it to handle other crucial functions more effectively.

25 [0027] It is yet another object of the present disclosure to provide a method and system for subscriber information collection in 5G RAN that improves the scalability and performance of the 5G RAN by minimizing the complexity of subscriber information collection and reducing the processing burden on the AMF.

30 [0028] It is yet another object of the present disclosure to provide a method and system for subscriber information collection in 5G RAN that facilitates more efficient network analytics and troubleshooting by ensuring the timely and accurate collection of subscriber information.

[0029] It is yet another object of the present disclosure to provide a method and system for subscriber information collection in 5G RAN that improve the Quality of Service (QoS) provided to subscribers by enabling more effective network management, analytics, and troubleshooting, driven by reliable subscriber information.

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[0030] It is yet another object of the present disclosure to provide a method and system for subscriber information collection in 5G RAN that address the limitations of existing methods, which currently result in increased complexity and a significant processing load on the AMF, hindering network performance and scalability.

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[0031] It is yet another object of the present disclosure to provide a method and system for subscriber information collection in 5G RAN that eliminate the need for an entirely new message or process for transferring subscriber information, thereby simplifying the network communication and reducing the processing load.

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[0032] It is yet another object of the present disclosure to provide a method and system for subscriber information collection in 5G RAN that provide a system that can be efficiently utilized during various network scenarios such as initial registration, handovers, and other key processes, enhancing the flexibility and robustness of the system.

20

DESCRIPTION OF THE DRAWINGS

[0033] The accompanying drawings, which are incorporated herein, and constitute a part of this disclosure, illustrate exemplary embodiments of the disclosed methods and systems in which like reference numerals refer to the same parts throughout the different drawings. Components in the drawings are not necessarily to scale, emphasis instead being placed upon clearly illustrating the principles of the present disclosure. Also, the embodiments shown in the figures are not to be construed as limiting the disclosure, but the possible variants of the method and system according to the disclosure are illustrated herein to highlight the advantages of the disclosure. It will be appreciated by those skilled in the art that disclosure of such drawings includes disclosure of electrical components or circuitry commonly used to implement such components.

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[0034] FIG. 1 illustrates an exemplary block diagram representation of 5th generation core (5GC) network architecture.

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[0035] FIG. 2 illustrates an exemplary block diagram of a computing device upon which the features of the present disclosure may be implemented, in accordance with exemplary implementation of the present disclosure.

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[0036] FIG. 3 illustrates an exemplary block diagram of a system for enriching 5G radio access network (RAN) session trace events, in accordance with exemplary implementations of the present disclosure.

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[0037] FIG. 4 illustrates a method flow diagram for enriching 5G radio access network (RAN) session trace events, in accordance with exemplary implementations of the present disclosure.

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[0038] FIG. 5A illustrates an exemplary flow for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information during an Xn Handover, in accordance with exemplary embodiments of the present disclosure.

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[0039] FIG. 5B illustrates an exemplary method implemented during an Xn handover for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information, in accordance with exemplary embodiments of the present disclosure.

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[0040] FIG. 5C illustrates an exemplary method implemented during a UE context retrieval process for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information, in accordance with exemplary embodiments of the present disclosure.

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[0041] FIG. 5D illustrates an exemplary flow diagram indicating for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information, in accordance with exemplary embodiments of the present disclosure.

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[0042] The foregoing shall be more apparent from the following more detailed description of the disclosure.

DETAILED DESCRIPTION

5 [0043] In the following description, for the purposes of explanation, various specific details are set forth in order to provide a thorough understanding of embodiments of the present disclosure. It will be apparent, however, that embodiments of the present disclosure may be practiced without these specific details. Several features described hereafter may each be used independently of one another or with any combination of other features. An individual feature may not address any of the problems discussed above or might address only some of the
10 problems discussed above.

[0044] The ensuing description provides exemplary embodiments only, and is not intended to limit the scope, applicability, or configuration of the disclosure. Rather, the ensuing description of the exemplary embodiments will provide those skilled in the art with an enabling
15 description for implementing an exemplary embodiment. It should be understood that various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the disclosure as set forth.

[0045] Specific details are given in the following description to provide a thorough
20 understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that the embodiments may be practiced without these specific details. For example, circuits, systems, processes, and other components may be shown as components in block diagram form in order not to obscure the embodiments in unnecessary detail.

25 [0046] Also, it is noted that individual embodiments may be described as a process which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations may be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process is terminated when its operations are completed but
30 could have additional steps not included in a figure.

[0047] The word “exemplary” and/or “demonstrative” is used herein to mean serving as an example, instance, or illustration. For the avoidance of doubt, the subject matter disclosed herein is not limited by such examples. In addition, any aspect or design described herein as
35 “exemplary” and/or “demonstrative” is not necessarily to be construed as preferred or

advantageous over other aspects or designs, nor is it meant to preclude equivalent exemplary structures and techniques known to those of ordinary skill in the art. Furthermore, to the extent that the terms “includes,” “has,” “contains,” and other similar words are used in either the detailed description or the claims, such terms are intended to be inclusive—in a manner similar to the term “comprising” as an open transition word—without precluding any additional or other elements.

[0048] As used herein, a “processing unit” or “processor” or “operating processor” includes one or more processors, wherein processor refers to any logic circuitry for processing instructions. A processor may be a general-purpose processor, a special purpose processor, a conventional processor, a digital signal processor, a plurality of microprocessors, one or more microprocessors in association with a (Digital Signal Processing) DSP core, a controller, a microcontroller, Application Specific Integrated Circuits, Field Programmable Gate Array circuits, any other type of integrated circuits, etc. The processor may perform signal coding data processing, input/output processing, and/or any other functionality that enables the working of the system according to the present disclosure. More specifically, the processor or processing unit is a hardware processor.

[0049] As used herein, “a user equipment”, “a user device”, “a smart-user-device”, “a smart-device”, “an electronic device”, “a mobile device”, “a handheld device”, “a wireless communication device”, “a mobile communication device”, “a communication device” may be any electrical, electronic and/or computing device or equipment, capable of implementing the features of the present disclosure. The user equipment/device may include, but is not limited to, a mobile phone, smart phone, laptop, a general-purpose computer, desktop, personal digital assistant, tablet computer, wearable device or any other computing device which is capable of implementing the features of the present disclosure. Also, the user device may contain at least one input means configured to receive an input from at least one of a transceiver unit, a processing unit, a storage unit, a detection unit and any other such unit(s) which are required to implement the features of the present disclosure.

[0050] As used herein, “storage unit” or “memory unit” refers to a machine or computer-readable medium including any mechanism for storing information in a form readable by a computer or similar machine. For example, a computer-readable medium includes read-only memory (“ROM”), random access memory (“RAM”), magnetic disk storage media, optical storage media, flash memory devices or other types of machine-accessible storage media. The

storage unit stores at least the data that may be required by one or more units of the system to perform their respective functions.

5 [0051] As used herein “interface” or “user interface refers to a shared boundary across which two or more separate components of a system exchange information or data. The interface may also be referred to a set of rules or protocols that define communication or interaction of one or more modules or one or more units with each other, which also includes the methods, functions, or procedures that may be called.

10 [0052] All modules, units, components used herein, unless explicitly excluded herein, may be software modules or hardware processors, the processors being a general-purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASIC), Field
15 Programmable Gate Array circuits (FPGA), any other type of integrated circuits, etc.

[0053] As used herein the transceiver unit include at least one receiver and at least one transmitter configured respectively for receiving and transmitting data, signals, information or a combination thereof between units/components within the system and/or connected with the
20 system.

[0054] As discussed in the background section, the current known solutions have several shortcomings. The present disclosure aims to overcome the above-mentioned and other existing problems in this field of technology by providing a method and system of enriching 5G radio
25 access network (RAN) session trace events. An aspect of the present disclosure provides a system for efficiently collecting subscriber information in 5G RAN, said system executing the steps of receiving an International Mobile Subscriber Identity (IMSI) and an International Mobile Equipment Identity (IMEI) by gNodeB from an Access and Mobility Management Function (AMF) based on a connection request from a UE, wherein the IMSI and the IMEI are
30 transmitted on 3GPP standard messages; generating a set of trace events in the gNodeB based on a connection request from a user equipment (UE); enriching the set of trace events with the IMSI and the IMEI; streaming the generated trace events to a trace control entity (TCE) using a (transmission control protocol/internet protocol) TCP/IP, and storing the enriched trace events in the TCE server, wherein the stored enriched trace events facilitate in enhancing analysis and
35 troubleshooting network performance and issues.

[0055] The invention relates to efficient tracking and management of subscriber data in a 5G Radio Access Network (RAN), focusing on the use of Trace Events generated by gNodeB and sent to a Trace Control Entity (TCE). These Trace Events are used to monitor and diagnose call failure events and network issues. Traditionally, gNodeB lacks access to International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information as NAS-related messages are transparent to it. As a solution, the Third Generation Partnership Project (3GPP) has proposed a method of enrichment, but it is expected to add complexity and increase the processing load on the Access and Mobility Management Function (AMF). This invention proposes a different approach: using a predefined field in specific 3GPP standard messages over NGAP and XnAP protocols to enrich Trace Events with IMSI and IMEI information. This method is implemented in both gNodeB and AMF software and does not require the creation of new messages or processes. The enrichment is done during various operations: Initial Attach/Registration, Xn Handover, UE Context Retrieval Process (in case of RLF), NG AP Handover, and Inter RAT Handover. Each operation uses different 3GPP messages to acquire and transfer the required IMSI/IMEI information.

[0056] FIG. 1 illustrates an exemplary block diagram representation of 5th generation core (5GC) network architecture [100], in accordance with exemplary implementation of the present disclosure. As shown in FIG. 1, the 5GC network architecture [100] includes a user equipment (UE) [102], a radio access network (RAN) [104], an access and mobility management function (AMF) [106], a Session Management Function (SMF) [108], a Service Communication Proxy (SCP) [110], an Authentication Server Function (AUSF) [112], a Network Slice Specific Authentication and Authorization Function (NSSAAF) [114], a Network Slice Selection Function (NSSF) [116], a Network Exposure Function (NEF) [118], a Network Repository Function (NRF) [120], a Policy Control Function (PCF) [122], a Unified Data Management (UDM) [124], an application function (AF) [126], a User Plane Function (UPF) [128], and a data network (DN) [130], wherein all the components are assumed to be connected to each other in a manner as obvious to the person skilled in the art for implementing features of the present disclosure.

[0057] The Radio Access Network (RAN) [104] is the part of a mobile telecommunications system that connects user equipment (UE) [102] to the core network (CN) and provides access to different types of networks (e.g., 5G network). It consists of radio base stations and the radio access technologies that enable wireless communication.

5 [0058] The Access and Mobility Management Function (AMF) [106] is a 5G core network function responsible for managing access and mobility aspects, such as UE registration, connection, and reachability. It also handles mobility management procedures like handovers and paging.

10 [0059] The Session Management Function (SMF) [108] is a 5G core network function responsible for managing session-related aspects, such as establishing, modifying, and releasing sessions. It coordinates with the User Plane Function (UPF) for data forwarding and handles IP address allocation and QoS enforcement.

15 [0060] The Service Communication Proxy (SCP) [110] is a network function in the 5G core network that facilitates communication between other network functions by providing a secure and efficient messaging service. It acts as a mediator for service-based interfaces.

[0061] The Authentication Server Function (AUSF) [112] is a network function in the 5G core responsible for authenticating UEs during registration and providing security services. It generates and verifies authentication vectors and tokens.

20 [0062] The Network Slice Specific Authentication and Authorization Function (NSSAAF) [114] is a network function that provides authentication and authorization services specific to network slices. It ensures that UEs can access only the slices for which they are authorized.

25 [0063] The Network Slice Selection Function (NSSF) [116] is a network function responsible for selecting the appropriate network slice for a UE based on factors such as subscription, requested services, and network policies.

30 [0064] The Network Exposure Function (NEF) [118] is a network function that exposes capabilities and services of the 5G network to external applications, enabling integration with third-party services and applications.

[0065] The Network Repository Function (NRF) [120] is a network function that acts as a central repository for information about available network functions and services. It facilitates the discovery and dynamic registration of network functions.

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[0066] The Policy Control Function (PCF) [122] is a network function responsible for policy control decisions, such as QoS, charging, and access control, based on subscriber information and network policies.

5 [0067] The Unified Data Management (UDM) [124] is a network function that centralizes the management of subscriber data, including authentication, authorization, and subscription information.

10 [0068] The Application Function (AF) [126] is a network function that represents external applications interfacing with the 5G core network to access network capabilities and services.

[0069] The User Plane Function (UPF) [128] is a network function responsible for handling user data traffic, including packet routing, forwarding, and QoS enforcement.

15 [0070] The Data Network (DN) [130] refers to a network that provides data services to user equipment (UE) in a telecommunications system. The data services may include but are not limited to Internet services, private data network related services.

20 [0071] Fig. 2 illustrates an exemplary block diagram of a computing device [1000] upon which the features of the present disclosure may be implemented in accordance with exemplary implementation of the present disclosure. In an implementation, the computing device [1000] may also implement a method for enriching 5G radio access network (RAN) session trace events utilising the system. In another implementation, the computing device [1000] itself implements the method for enriching 5G radio access network (RAN) session trace events using
25 one or more units configured within the computing device [1000], wherein said one or more units are capable of implementing the features as disclosed in the present disclosure.

[0072] The computing device [1000] may include a bus [1002] or other communication mechanism for communicating information, and a hardware processor [1004] coupled with bus
30 [1002] for processing information. The hardware processor [1004] may be, for example, a general-purpose microprocessor. The computing device [1000] may also include a main memory [1006], such as a random-access memory (RAM), or other dynamic storage device, coupled to the bus [1002] for storing information and instructions to be executed by the processor [1004]. The main memory [1006] also may be used for storing temporary variables
35 or other intermediate information during execution of the instructions to be executed by the

processor [1004]. Such instructions, when stored in non-transitory storage media accessible to the processor [1004], render the computing device [1000] into a special-purpose machine that is customized to perform the operations specified in the instructions. The computing device [1000] further includes a read only memory (ROM) [1008] or other static storage device
5 coupled to the bus [1002] for storing static information and instructions for the processor [1004].

[0073] A storage device [1010], such as a magnetic disk, optical disk, or solid-state drive is provided and coupled to the bus [1002] for storing information and instructions. The
10 computing device [1000] may be coupled via the bus [1002] to a display [1012], such as a cathode ray tube (CRT), Liquid crystal Display (LCD), Light Emitting Diode (LED) display, Organic LED (OLED) display, etc. for displaying information to a computer user. An input device [1014], including alphanumeric and other keys, touch screen input means, etc. may be coupled to the bus [1002] for communicating information and command selections to the
15 processor [1004]. Another type of user input device may be a cursor controller [1016], such as a mouse, a trackball, or cursor direction keys, for communicating direction information and command selections to the processor [1004], and for controlling cursor movement on the display [1012]. This input device typically has two degrees of freedom in two axes, a first axis (e.g., x) and a second axis (e.g., y), that allow the device to specify positions in a plane.

[0074] The computing device [1000] may implement the techniques described herein using customized hard-wired logic, one or more ASICs or FPGAs, firmware and/or program logic which in combination with the computing device [1000] causes or programs the
20 computing device [1000] to be a special-purpose machine. According to one implementation, the techniques herein are performed by the computing device [1000] in response to the processor [1004] executing one or more sequences of one or more instructions contained in the main memory [1006]. Such instructions may be read into the main memory [1006] from another storage medium, such as the storage device [1010]. Execution of the sequences of instructions contained in the main memory [1006] causes the processor [1004] to perform the process steps
25 described herein. In alternative implementations of the present disclosure, hard-wired circuitry may be used in place of or in combination with software instructions.

[0075] The computing device [1000] also may include a communication interface [1018] coupled to the bus [1002]. The communication interface [1018] provides a two-way data
35 communication coupling to a network link [1020] that is connected to a local network [1022].

For example, the communication interface [1018] may be an integrated services digital network (ISDN) card, cable modem, satellite modem, or a modem to provide a data communication connection to a corresponding type of telephone line. As another example, the communication interface [1018] may be a local area network (LAN) card to provide a data communication connection to a compatible LAN. Wireless links may also be implemented. In any such implementation, the communication interface [1018] sends and receives electrical, electromagnetic or optical signals that carry digital data streams representing various types of information.

[0076] The computing device [1000] can send messages and receive data, including program code, through the network(s), the network link [1020] and the communication interface [1018]. In the Internet example, a server [1030] might transmit a requested code for an application program through the Internet [1028], the ISP [1026], the host [1024], the local network [1022] and the communication interface [1018]. The received code may be executed by the processor [1004] as it is received, and/or stored in the storage device [1010], or other non-volatile storage for later execution.

[0077] Referring to FIG. 3, an exemplary block diagram of a system [300] for enriching 5G radio access network (RAN) session trace events, is shown, in accordance with the exemplary implementations of the present disclosure. The system [300] comprises at least one processing unit [302]. Also, all of the components/ units of the system [300] are assumed to be connected to each other unless otherwise indicated below. As shown in the figures all units shown within the system should also be assumed to be connected to each other. Also, in FIG. 3 only a few units are shown, however, the system [300] may comprise multiple such units or the system [300] may comprise any such numbers of said units, as required to implement the features of the present disclosure. Further, in an implementation, the system [300] may be present in a user device to implement the features of the present disclosure. The system [300] may be a part of the user device / or may be independent of but in communication with the user device (may also referred herein as a UE). In another implementation, the system [300] may reside in a server or a network entity. In yet another implementation, the system [300] may reside partly in the server/ network entity and partly in the user device.

[0078] The system [300] is configured for enriching 5G radio access network (RAN) session trace events, with the help of the interconnection between the components/units of the system [300].

[0079] The system [300] includes a processing unit [302]. The processing unit [302] is configured to receive, via a gNodeB [306], a first information from an AMF [106] transmitted over network messages. The first information comprises International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI). IMSI refers to International Mobile Subscriber Identity, which is a unique identification number stored on the SIM card for every user equipment and IMEI refers to International mobile Equipment Identity, which is stored in a database of a user equipment (UE) [102] to identify a device.

[0080] The gNodeB [306] receives the IMSI and IMEI during initial registration of the UE [304]. The gNodeB [306] receives the IMSI and IMEI from the AMF [106] during one of initial attach/registration, Xn handover, UE context retrieval in case of a Radio Link Failure (RLF), Next Generation Application Protocol (NG AP) handover and inter- Radio Access technology (RAT) handover. The Radio Link Failure (RLF) refers to a scenario where the gNodeB [306] loses a radio link with the UE [304]. The RLF may be due to interference, handover failures, or the like. The Next Generation Application Handover Protocol (NG AP) is responsible for establishing communication between the gNodeB [306] and the AMF [106]. NGAP handover refers to when a source gNodeB may decide to handover to a target gNodeB. The inter-RAT handover refers to a scenario where the handover takes place between the same RAT coverage area. For instance, when a UE [304] handovers within different generations of a communication network.

[0081] In an implementation of the present disclosure, in the 5th Generation Core Network, the processing unit [302] may obtain through a gNodeB the IMSI and IMEI information fields in 3GPP standard messages over NGAP Protocol and XnAP protocol during multiple scenarios from Core Network. The multiple scenarios may include but are not limited to initial attachment process or registration process, during Xn Handover, during UE context retrieval in case of RLF, during Next Generation Application Protocol (NG AP) handover, during Inter RAT Handover, and the like. The gNodeB [306] may use “Initial context setup request” process to get the required information during Initial Attach/Registration process.

[0082] NG AP: NG AP supports both UE and non-UE associated services including configuration updates, UE context transfer, PDU session resource management, convey uplink and downlink NAS (Non-Access Stratum) messages as a payload, as well as support CM (Connected Mode) idle and CM connected operations such as paging and UE context release.

[0083] The 5th generation Core Network may use extended Information Element (IE) in “UE Security Capabilities” to send SUPI/IMEI details toward GNodeB. Extended IE refers to extended or additional information element that extend the parameters beyond the basic information. In addition to the basic information contained in the set of trace events (like a timestamp, a type of request, a gNodeB response), the gNodeB [306] also adds these trace events with the UE's IMSI and IMEI. As a result, each enriched trace event may not only tell that a connection request was made at a specific time, but also provides IMSI information (indicating which subscriber made the request) and IMEI information (indicating what device was used to make the request).

[0084] The processing unit [302] is further configured to generate a set of trace events based on a connection request received from the UE [304]. The set of trace events are generated in real-time to track and record a sequence of interactions and communications between the UE [304] and the gNodeB [306].

[0085] In an implementation of the present disclosure, when a connection request is initiated by the UE [304] in the 5th generation core network, activities during the attachment process may be recorded to ensure that the network can be monitored and troubleshooted effectively when required. The set of trace events may include the timestamp, the type of request, the gNodeB response, and the like.

[0086] The processing unit [302] is further configured to enrich the generated set of trace events with the received first information. The processing unit [302] is configured to stream the enriched set of trace events to a TCE using a TCP/IP. The stream of enriched set of trace events to the TCE is continuous, facilitating real-time monitoring of network activities. The enriched set of trace events stored in the TCE server are time-stamped, providing a chronological record of network interactions for the UE [304]. The processing unit [302] is further configured to store the enriched set of trace events within the TCE server for subsequent analysis and troubleshooting. The enrichment is performed using a predefined field(s) in certain network messages over next generation application protocol (NGAP) protocol and XnAP protocol to obtain the IMSI and IMEI. The predefined fields are implemented at both the AMF and the gNodeB ends, ensuring seamless communication and information transfer. In an embodiment of the present disclosure, the predefined field may be a ‘Protocol Extension’. The ‘Protocol Extension’ enrich the set of trace events with IMSI (subscriber) and IMEI information to carry

out analytics and debugging of call failure events in the 5th Generation core network at user level.

5 [0087] The processing unit [302] is further configured to perform encoding at one of source gNodeB [306] and source AMF [106], and decoding at a target gNodeB [306].

[0088] In an implementation, the system [300] may be incorporated in the server [308]. The system [300] may be configured to efficiently collect subscriber information, such as International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI), in a 5G Radio Access Network (RAN) through several specific steps:

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[0089] Upon a connection request from the UE [304], the gNodeB [306] starts generating a set of trace events. These events are logs or records of significant or noteworthy activities that occur as the UE [304] attempts to establish a connection with the network.

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[0090] The gNodeB [306] enhances the collected trace events by adding the IMSI and IMEI to them. This process of adding information to the trace events is known as 'enriching'. The enriched trace events now contain valuable data about the subscriber and the mobile device, which can help in more granular and efficient network management. The enriched trace events are then sent over to a Trace Control Entity (TCE) using the Transmission Control Protocol/Internet Protocol (TCP/IP). The TCE is a centralized system that collects and manages the trace events from various network elements like the gNodeB [306]. Once received by the TCE, the set of trace events are stored on the TCE server. This central repository of trace events allows for easy access and management of this data.

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25 [0091] As an example, the UE [304] (like a smartphone) tries to connect to the 5G network. During the initial registration process, the smartphone communicates with the network and sends information including the IMSI and IMEI to the AMF. The AMF verifies the UE's authenticity and its access rights to the network based on this information.

30 [0092] As part of the ongoing network procedures, the AMF might need to share this IMSI and IMEI information with the gNodeB [306] (which is responsible for communication between the UE [304] and the core network). This transfer of information is done via 3GPP standard messages. The gNodeB [306] can then use this information to perform various tasks, like setting up the connection, maintaining the session, and troubleshooting if necessary. The

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specific protocol and the type of 3GPP message used for this information transfer can vary based on different factors like network configuration, stage of communication, etc.

5 [0093] In an exemplary implementation of the present disclosure, the system [300] may reside independent of the gnodeB [306], AMF [106], and the UE [304]. It is further noted that the system [300] may be in interaction with the gnodeB [306], AMF [106], and the UE [304], lying as standalone entity.

10 [0094] It would be appreciated by the person skilled in the art that to enhance the analysis and troubleshooting of network performance and issues. By enriching the trace events with the IMSI and IMEI, network operators can gain a deeper understanding of network activities at the subscriber level. This may help in identifying issues, improving network performance, and optimizing resource allocation in the 5G RAN.

15 [0095] Referring to FIG. 4, an exemplary method flow diagram [400] for enriching 5G radio access network (RAN) session trace events, in accordance with exemplary implementations of the present disclosure is shown. In an implementation the method [400] is performed by the system [300]. Further, in an implementation, the system [300] may be present in a server device to implement the features of the present disclosure. Also, as shown in Figure
20 4, the method [400] starts at step [402].

[0096] At step [404], the method comprises receiving, by the processing unit [302] via the gNodeB [306], a first information from the access and mobility management function (AMF) [106] transmitted over network messages. The first information comprises at least one of
25 international mobile subscriber identity (IMSI) and international mobile equipment identity (IMEI). The gNodeB [306] receives the IMSI and IMEI during initial registration of the UE [304]. The gNodeB [306] receives the IMSI and IMEI from the AMF [106] during one of initial attach/registration, Xn handover, UE context retrieval in case of a Radio Link Failure (RLF), Next Generation Application Protocol (NG AP) handover and inter- Radio Access technology
30 (RAT) handover. The Radio Link Failure (RFL) refers to a scenario where the gNodeB [306] loses a radio link with the UE [304]. The RFL may be due to interference, handover failures, or the like. The Next Generation Application Handover Protocol (NG AP) is responsible for establishing communication between the gNodeB [306] and the AMF [106]. NGAP handover refers to when a source gNodeB may decide to handover to a target gNodeB. The inter-RAT
35 handover refers to a scenario where the handover takes place between the same RAT coverage

area. For instance, when a UE [304] handovers within different generations of a communication network.

5 [0097] In an implementation of the present disclosure, the process begins when the gNodeB [306] (Next Generation NodeB), a part of the 5G base station in a RAN, receives an IMSI and IMEI from the Access and Mobility Management Function (AMF) in the 5th Generation Core Network. The AMF [106] is an entity that manages the access and mobility for the user equipment (UE) [304] in a 5G core network. The IMSI and IMEI are specific identifiers for the subscriber and the mobile device respectively. These identifiers are
10 transmitted via 3GPP (3rd Generation Partnership Project) standard messages, a set of protocols used in 5G networks.

[0098] In an implementation of the present disclosure, the 5th generation Core Network may use extended Information Element (IE) in “UE Security Capabilities” to send SUPI/IMEI
15 details toward gNodeB [306]. Extended IE refers to extended or additional information element that extend the parameters beyond the basic information. In addition to the basic information contained in the set of trace events (like a timestamp, a type of request, a gNodeB response), the gNodeB [306] also adds these trace events with the UE's IMSI and IMEI. As a result, each enriched trace event may not only tell that a connection request was made at a specific time,
20 but also provides IMSI information (indicating which subscriber made the request) and IMEI information (indicating what device was used to make the request).

[0099] Next at step [406], the method comprises generating, by the processing unit [302], a set of trace events based on a connection request received from the user equipment (UE)
25 [304]. The set of trace events are generated in real-time to track and record a sequence of interactions and communications between the UE [304] and the gNodeB [306].

[0100] In an implementation of the present disclosure, in a 5G network, the User Equipment (UE) [304], such as a smartphone or a tablet, communicates with the network via
30 base stations known as gNodeBs (next-generation NodeB). The process of generating a set of trace events involves tracking and recording the sequence of interactions and communications between the UE [304] and the gNodeB [306].

[0101] These trace events are often system-level or application-level logs generated as a
35 part of network activity. They help network operators to understand the UE's [304] journey

from the initial connection request to the final connection establishment (or connection failure). These trace events could include information like the timestamp of the connection request, the identity of the UE [304], the type of request, the gNodeB [306] response, and so forth.

5 [0102] In the context of network troubleshooting and performance analysis, these identifiers (IMSI and IMEI) can provide valuable insights when included, or "enriched", with trace events generated in the gNodeB [306]. Enrichment of trace events involves the addition of supplementary information (in this case, the IMSI and IMEI) to the existing trace events that are generated based on network activity.

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[0103] In an example, the user equipment (UE) [304] sends a connection request to the gNodeB [306]. The gNodeB [306] responds and in the process generates trace events that record this interaction. Now, in addition to the basic information contained in these trace events (like timestamps, type of request, gNodeB response), the gNodeB [306] also adds (or "enriches")
15 these trace events with the UE's IMSI and IMEI. As a result, each enriched trace event may not only tell that a connection request was made at a specific time, but also provides IMSI information (indicating which subscriber made the request) and IMEI information (indicating what device was used to make the request). This enriched data allows network operators to analyze network issues or performance metrics at a much finer granularity. For example, they
20 can analyze network behavior for specific subscribers (using IMSI) or for specific models of devices (using IMEI), which can be crucial in identifying and resolving network issues, enhancing the quality of service, and improving user experience.

[0104] Next at step [408], the method comprises enriching, by the processing unit [302],
25 the generated set of trace events with the received first information. The enrichment is performed using the predefined field in certain network messages over next generation application protocol (NGAP) protocol and XnAP protocol to obtain the IMSI and IMEI. The predefined fields are implemented at both the AMF [106] and the gNodeB [306] ends, ensuring seamless communication and information transfer. In an embodiment of the present disclosure,
30 the predefined field may be a 'Protocol Extension'. The 'Protocol Extension' enriches the set of trace events with IMSI (subscriber) and IMEI information to carry out analytics and debugging of call failure events in the 5th Generation core network at user level.

[0105] The enriched set of trace events stored in the TCE server are time-stamped,
35 providing a chronological record of network interactions for the UE [304]. The method

comprises streaming, by the processing unit [302], the enriched set of trace events to a trace control entity (TCE) using a transmission control protocol/internet protocol (TCP/IP). The streaming of enriched set of trace events to the TCE is continuous, facilitating real-time monitoring of network activities. The method comprises storing, by the processing unit, the enriched set of trace events within the TCE server for subsequent analysis and troubleshooting. The enriched set of trace events stored in the TCE server are time-stamped, providing a chronological record of network interactions for the UE [304].

[0106] In an implementation of the present disclosure, the storing of the enriched trace events in the TCE server, wherein the stored enriched trace events facilitate in enhancing analysis and troubleshooting network performance and issues. After the trace events are enriched with IMSI and IMEI information, they are then sent to the Trace Control Entity (TCE) server for storage. In detail, a trace event refers to a record of activity within a system, such as the gNodeB [306].

[0107] In an embodiment, each trace event becomes "enriched" when it is associated with the unique identifiers of a mobile subscriber (IMSI) and their device (IMEI). This enrichment process adds meaningful context to the trace events, making them more valuable for later analysis. The transmission control protocol (TCP) is used to stream these enriched trace events from the gNodeB [306] to the TCE server, which then stores these events. This storage process is not just a matter of holding the data; it is an integral part of preserving the valuable enriched trace events for future analysis and troubleshooting of network performance and issues. The stored enriched trace events can later be accessed by network engineers or software programs to conduct in-depth analysis, investigate any network issues, or optimize network performance.

[0108] Generally, streaming the generated trace events to a Trace Control Entity (TCE) using Transmission Control Protocol/Internet Protocol (TCP/IP) is part of the process of network monitoring and troubleshooting. Trace events are essentially data logs that contain specific information about activities or events happening within the network nodes, in this case, the gNodeB [306]. These events are logged as they occur in real-time and can be enriched with additional data, such as IMSI and IMEI in this scenario, to provide a more detailed context of network activities. Streaming these trace events refers to the continuous, real-time transfer of this data to a separate system or entity, the TCE, that is designed to collect, store, analyze, and/or display these events for network monitoring and troubleshooting purposes. TCP/IP is a suite of communication protocols used to interconnect network devices on the internet. TCP/IP

can also be used as a communications protocol in a private network (an intranet or an extranet). In the context of this example, TCP/IP is the protocol being used to facilitate the transfer of trace event data from the gNodeB [306] to the TCE.

5 [0109] In an example, the user equipment (UE) [304] establishes a connection with the gNodeB [306], which triggers the generation of trace events within the gNodeB [306]. The trace events, which are enriched with the UE's IMSI and IMEI, are packaged for transfer and sent over the network to the TCE. The transfer is facilitated by TCP/IP, which handles the packaging of the data into packets, ensures reliable transmission of the data from the gNodeB [306] to the TCE, and handles the reassembly of the packets into the original data on the TCE's end. The TCE, upon receiving the trace event data, can then store it for later analysis, display it in real-time for immediate monitoring, or perform other functions as per its design and the needs of the network operator.

15 [0110] Therefore, streaming the generated trace events to the TCE using TCP/IP is a crucial part of the overall process of network monitoring, troubleshooting, and performance analysis. It ensures that relevant network activity data is efficiently and reliably transferred from the gNodeB [306], where it is generated, to the TCE, where it can be used for valuable insights.

20 [0111] The method terminates at step [410].

[0112] As an example, the UE [304] is attempting to connect to the network. The steps involved includes:

- 25 • Connection Request: The UE [304] sends a connection request to the gNodeB [306], intending to establish a network connection.
- Trace Event Generated: Upon receiving the request, the gNodeB [306] generates a trace event indicating that a connection request has been received from the UE [304]. This trace event would include details like the timestamp of the request and the identity of the UE [304].
- 30 • Connection Response: The gNodeB [306] responds to the connection request, either by accepting the connection or denying it based on the network's capacity and the UE's [304] access privileges.
- 35

- Trace Event Generated: The gNodeB [306] generates another trace event documenting its response to the UE's [304] connection request. If the connection was accepted, the trace event would detail the resources allocated to the UE [304]. If the connection was denied, the trace event might provide a reason for the denial.

[0113] These trace events, when collectively analyzed, provide a rich source of information for network engineers to study the connection procedures, diagnose issues, and optimize network performance.

[0114] For example, the user equipment (UE) [304] experiences a call drop while communicating through the gNodeB [306]. The series of enriched trace events associated with that UE's IMSI and IMEI is stored in the TCE server. A network engineer could then retrieve these stored events from the TCE server to help them understand what happened in the lead-up to the call drop, thereby facilitating troubleshooting and potentially identifying solutions to prevent such incidents from reoccurring in the future. The enriched trace events would provide valuable insights into the state of the UE [304] and the network at the time of the incident, greatly aiding in the analysis and resolution of the issue. The method [400] will be more clear from the exemplary embodiments as mentioned in FIG. 5A-5D below.

[0115] Referring to FIG. 5A-5D, they illustrate an exemplary flow diagram for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information during an Xn Handover, during UE context retrieval process, during NG handover process and during IRAT handover process respectively. In an implementation the method is performed by the server [308].

[0116] Referring to FIG. 5A, it illustrates an exemplary method implemented during an initial attachment and registration process for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information.

[0117] The gNodeB [306] and the AMF [106] perform authentication to confirm if both the target and the source gNodeB [306] are connected to the same AMF [106].

[0118] Once the confirmation is received, at step 2, the AMF [106] may request the gNodeB [306] for initial context setup to obtain the International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI).

5 [0119] At step 3, the gNodeB [306] generates a series of Trace Events along with session summary which is streamed and stored in a Trace Collection Entity (TCE) server. The traces are enriched with IMSI and IMEI information. The core network may use extended IE in "UE Security Capabilities" to send SUPI/IMEI details toward the gNodeB [306]. Extended
10 Information Element (IE) in "User Equipment (UE) Security Capabilities" includes additional Information Elements that have been added to extend the functionality or the information content of the original set of Information Elements. The IE extension may be used to support additional features, capabilities, or standards. Extended IE refers to extended or additional information element that extend the parameters beyond the basic information. In addition to the
15 basic information contained in the set of trace events (like a timestamp, a type of request, a gNodeB response), the gNodeB [306] also adds these trace events with the UE's IMSI and IMEI. As a result, each enriched trace event may not only tell that a connection request was made at a specific time, but also provides IMSI information (indicating which subscriber made the request) and IMEI information (indicating what device was used to make the request).

20 [0120] The enrichment may help in ease of analytics and debugging of call failure events in 5G RAN to be performed at subscriber level and also for different phone models. The IMSI and IMEI enrichment is performed by using proprietary the predefined field in a specific 3GPP standard message over XnAP protocol which may be exchanged during the initial attachment or registration process. In an embodiment of the present disclosure, the predefined field may be
25 a 'Protocol Extension'. The 'Protocol Extension' enriches the set of trace events with IMSI (subscriber) and IMEI information to carry out analytics and debugging of call failure events in the 5th Generation core network at user level. Encoding at source gNodeB or AMF end as well as for decoding at target gNodeB end is performed by the ProtocolExtension. Since existing 3GPP messages are being used to transfer the information, the need of an entirely new
30 message has been eliminated, which may be required to exclusively transfer subscriber information in an alternate solution.

[0121] At step 4, once the AMF [106] receives the set of trace events which includes the enriched IMSI and IMEI, registration of the gNodeB at the AMF [106] is complete. Now,

analytics and debugging of call failure events in 5G RAN may be carried out at subscriber level and may also be done for different user equipment.

5 [0122] FIG. 5B illustrates an exemplary method implemented during an Xn handover for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information.

10 [0123] When the source gNodeB [450] and the target gNodeB [452] are connected to the same AMF, Xn handover will be applicable. Xn handover cannot be used if Source and Target gNodeB are connected to different AMF. But the source may or may not be connected to Source and Target gNB can be connected to different UPFs.

15 [0124] At step 1, the UE [304] reports a measurement report with a neighbor cell PCI and signal strength to source gNodeB [450]. Further, the source gNodeB [450] may take the decision to start handover procedure to best target gNodeB [452].

20 [0125] At step 2, the source gNodeB [450] sends a request for handover to the target gNodeB [452]. The source gNodeB [450] will use "Handover request" message to transfer the enriched IMEI/IMSI information to Target gNodeNB [452]. Source gNodeB [450] will send SUPI/IMEI details toward Target gNodeB [452] using extended IE in UE Context Information IE. Extended IE refers to extended or additional information element that extends the parameters beyond the basic information. The enrichment may help in ease of analytics and debugging of call failure events in 5G RAN to be performed at subscriber level and also for different phone models. The IMSI and IMEI enrichment is performed by using proprietary the predefined field in a specific 3GPP standard message over XnAP protocol which may be exchanged during the Xn handover. Encoding at source gNodeB or AMF end as well as for decoding at target gNodeB end is performed by the ProtocolExtension. Since existing 3GPP messages are being used to transfer the information, the need of an entirely new message has been eliminated, which may be required to exclusively transfer subscriber information in an alternate solution. The source gNodeB [450] will receive the UE context and IMEI/IMSI info from "Initial registration", before sending it to the target gNodeB [452] in the handover request.

35 [0126] At step 3, the target gNodeB [452] acknowledges the handover request from the source gNodeB [450] and sends the acknowledgment. Further at step 4, the handover request is completed and the target gNodeB [452] receives the IMEI/IMSI

[0127] Referring to FIG. 5C, it illustrates an exemplary method implemented during a UE context retrieval process for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information.

[0128] For UE context retrieval, the UE Context Release procedure is initiated by the source gNodeB [450] to indicate to the target gNodeB [452] that radio and control plane resources for the associated UE context are allowed to be released to the target gNodeB [452].

[0129] At step 1, a Radio Link Failure (RFL) occurs at the source gNodeB [450]. RFL refers to a situation where the communication link between a User Equipment and the source gNodeB [450] is either lost or is not reliable for communication further.

[0130] At step 2, the target gNodeB [452] sends a request to retrieve a UE context. The source gNodeB [450] will use "Retrieve UE Context response" message to transfer the enriched IMEI/IMSI information to Target gNodeB [452]. Before "Retrieve UE Context response" message Source gNodeB will have UE context and IMEI/IMSI info from "Initial registration". The enrichment may help in ease of analytics and debugging of call failure events in 5G RAN to be performed at subscriber level and also for different phone models. The IMSI and IMEI enrichment is performed using proprietary the predefined field in a specific 3GPP standard message over XnAP or NGAP protocol which may be exchanged during the UE context retrieval. In an embodiment of the present disclosure, the predefined field may be a 'Protocol Extension'. The 'Protocol Extension' enrich the set of trace events with IMSI (subscriber) and IMEI information to carry out analytics and debugging of call failure events in the 5th Generation core network at user level. Encoding at source gNodeB or AMF end as well as for decoding at target gNodeB end is performed by the ProtocolExtension. Since existing 3GPP messages are being used to transferring the information, the need of an entirely new message has been eliminated, which may be required to exclusively transfer subscriber information in an alternate solution.

[0131] At step 3, the target gNodeB [452] receives the retrieve UE context response from the source gNodeB [450] which includes the enriched IMEI/IMSI information to allow analytics and debugging of call failure events in 5G RAN to be carried out at subscriber level and may also be done for different user equipment.

[0132] Referring to FIG. 5D, it illustrates an exemplary flow diagram for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information during an NG Handover process or during an Inter Radio Access Technology (IRAT). In an implementation the method is performed by the server [308].

[0133] At step 1, the source NG-RAN decides to initiate an N2-based handover to the target NG-RAN. This can be triggered due to conditions including but not limited to new radio conditions or load balancing, an error indication from the target NG-RAN after an unsuccessful Xn-based handover, and the like.

[0134] At step 2, the AMF [106] sends a handover request to the target gNodeB [452]. The target gNodeB [452] may use “HANDOVER REQUEST” message to get the required information. The enriched IMSI/IMEI details may be transferred using extended IE in “UE Security Capabilities”. The enrichment may help in ease of analytics and debugging of call failure events in 5G RAN to be performed at subscriber level and also for different phone models. The IMSI and IMEI enrichment is performed using proprietary the predefined field in a specific 3GPP standard message over XnAP or NGAP protocol which may be exchanged during the UE context retrieval. Encoding at the source gNodeB [450] or AMF end as well as for decoding at the target gNodeB [452] end is performed by the ProtocolExtension. Since existing 3GPP messages are being used to transferring the information, the need of an entirely new message has been eliminated, which may be required to exclusively transfer subscriber information in an alternate solution.

[0135] At step 3, the target gNodeB [452] acknowledges the receipt of the request.

[0136] At step 4, the Handover process is completed between the target gNodeB [452] and the AMF [106]. The enriched IMSI/IMEI information received during the handover process may allow analytics and debugging of call failure events in 5G RAN to be carried out at subscriber level and may also be done for different user equipment.

[0137] In 5G network communications, the gNodeB (Next Generation NodeB) [306], a component of a 5G base station, receives critical information about the user equipment (UE) [304], specifically the International Mobile Subscriber Identity (IMSI) and the International Mobile Equipment Identity (IMEI), from the Access and Mobility Management Function

(AMF) [106]. The IMSI is a unique number assigned to each mobile subscriber in the GSM, UMTS, and LTE networks. It is stored in the SIM card and used to identify the subscriber to the network. The IMEI is a unique number given to every single mobile phone, typically found behind the battery. It can be used by a network to identify valid devices, and therefore can be used for stopping a stolen phone from accessing the network in that country. The AMF [106] is a critical component of the 5G core network. It's responsible for managing the UE mobility, registration to the network, connection and reachability, and several other functions. The IMSI and IMEI are transmitted from the AMF [106] to the gNodeB [306] using 3GPP (3rd Generation Partnership Project) standard messages. 3GPP is a collaboration between groups of telecommunications standards associations, and it's responsible for the development and maintenance of protocols for mobile telephony, including 5G.

[0138] It would be appreciated by the person skilled in the art that the method allows for more effective data collection with less impact on interoperability and without the need for additional complexity or processing load at the Radio and Core network end.

[0139] The present disclosure further discloses a non-transitory computer readable storage medium storing instructions for enriching 5G radio access network (RAN) session trace events, the instructions include executable code which, when executed by a one or more units of a system, causes: a processing unit [302] of the system to receive, via a gNodeB [306], a first information from an AMF [106] transmitted over network messages; the processing unit [302] of the system to further generate a set of trace events based on a connection request received from a UE [304]; and the processing unit [302] of the system to further enrich the generated set of trace events with the received first information.

[0140] Yet another aspect of the present disclosure may relate to a User Equipment (UE) for enriching 5G radio access network (RAN) session trace events, the UE may include a processor [1004] configured to transmit, via a gNodeB [306], a first information from an access and mobility management function (AMF) [106] transmitted over network messages. The processor may be further configured to generate, via a server [308], a set of trace events based on a connection request received from a user equipment (UE) [304]. Furthermore, the processor of the UE [304] may be configured to enrich, via the server [308], the generated set of trace events with the first information.

[0141] As is evident from the above, the present disclosure provides a technically advanced solution for enriching 5G radio access network (RAN) session trace events. The present solution provides a method and system for enriching 5G RAN session trace events with International Mobile Subscriber Identity (IMSI) and International Mobile Equipment Identity (IMEI) information. It further provides a method and system for efficiently collecting subscriber information in 5G RAN that provides an efficient and streamlined methodology for collecting subscriber information in 5G Radio Access Network (RAN) from the Core network. This collection should occur for all users connected to the gNodeB (gNB), without creating undue complexity or negatively impacting the functionality of the Access and Mobility Management Function (AMF). The present disclosure further reduces the processing load on the AMF, thereby improving its overall performance, and allowing it to handle other crucial functions more effectively. The present disclosure further provides a system that can be efficiently utilized during various network scenarios such as initial registration, handovers, and other key processes, enhancing the flexibility and robustness of the system. The present disclosure further provides a method and system for subscriber information collection in 5G RAN that improve the scalability and performance of the 5G RAN by minimizing the complexity of subscriber information collection and reducing the processing burden on the AMF.

[0142] While considerable emphasis has been placed herein on the disclosed implementations, it will be appreciated that many implementations can be made and that many changes can be made to the implementations without departing from the principles of the present disclosure. These and other changes in the implementations of the present disclosure will be apparent to those skilled in the art, whereby it is to be understood that the foregoing descriptive matter to be implemented is illustrative and non-limiting.

We Claim:

1. A method for enriching 5G radio access network (RAN) session trace events, the method
5 comprising the steps of:
receiving, by a processing unit [302] via a gNodeB [306], a first information from an
access and mobility management function (AMF) [106] transmitted over network messages;
generating, by the processing unit [302], a set of trace events based on a connection
request received from a user equipment (UE) [304]; and
10 enriching, by the processing unit [302], the generated set of trace events with the
received first information.
2. The method as claimed in claim 1, wherein the first information comprises at least one of
international mobile subscriber identity (IMSI) and international mobile equipment identity
15 (IMEI).
3. The method as claimed in claim 1, wherein the method comprises streaming, by the
processing unit [302], the enriched set of trace events to a trace control entity (TCE) server
using a transmission control protocol/internet protocol (TCP/IP).
20
4. The method as claimed in claim 3, wherein the method comprises storing, by the processing
unit [302], the enriched set of trace events within the TCE server for subsequent analysis
and troubleshooting.
- 25 5. The method as claimed in claim 2, wherein the gNodeB [306] receives the IMSI and IMEI
during initial registration of the UE [304].
6. The method as claimed in claim 2, wherein the enrichment is performed using a predefined
field in certain network messages over next generation application protocol (NGAP)
30 protocol and XnAP protocol to obtain the IMSI and IMEI.

7. The method as claimed in claim 6, wherein the predefined fields are implemented at both the AMF [106] and the gNodeB [306] ends, ensuring seamless communication and information transfer.
- 5 8. The method as claimed in claim 7, wherein the method is being further used to perform encoding at one of source gNodeB [306] and source AMF [106], and decoding at a target gNodeB [306].
- 10 9. The method as claimed in claim 1, wherein the set of trace events are generated in real-time to track and record a sequence of interactions and communications between the UE [304] and the gNodeB [306].
10. The method as claimed in claim 3, wherein the streaming of enriched set of trace events to the TCE is continuous, facilitating real-time monitoring of network activities.
- 15 11. The method as claimed in claim 4, wherein the enriched set of trace events stored in the TCE server are time-stamped, providing a chronological record of network interactions for the UE [304].
- 20 12. The method as claimed in claim 2, wherein the gNodeB [306] receives the IMSI and IMEI from the AMF [106] during one of initial attach/registration, Xn handover, UE context retrieval in case of radio link failure (RLF), NG AP handover, and inter RAT handover.
13. A system [300] for enriching 5G RAN session trace events, the system comprises:
- 25 a processing unit [302], wherein the processing unit [302] is configured to:
- receive, via a gNodeB [306], a first information from an AMF [106] transmitted over network messages;
- generate a set of trace events based on a connection request received from a UE [304]; and
- 30 enrich the generated set of trace events with the received first information.

14. The system [300] as claimed in claim 13, wherein the first information comprises IMSI and IMEI.
- 5 15. The system [300] as claimed in claim 13, wherein the processing unit [302] is configured to stream the enriched set of trace events to a TCE server using a TCP/IP.
16. The system [300] as claimed in claim 15, wherein the processing unit [302] is further configured to store the enriched set of trace events within the TCE server for subsequent analysis and troubleshooting.
- 10 17. The system [300] as claimed in claim 14, wherein the gNodeB [306] receives the IMSI and IMEI during initial registration of the UE [304].
- 15 18. The system [300] as claimed in claim 14, wherein the enrichment is performed using a predefined field in certain network messages over next generation application protocol (NGAP) protocol and XnAP protocol to obtain the IMSI and IMEI.
- 20 19. The system [300] as claimed in claim 18, wherein the predefined field are implemented at both the AMF and the gNodeB [306], ensuring seamless communication and information transfer.
- 25 20. The system [300] as claimed in claim 19, wherein the processing unit [302] is further configured to perform encoding at one of source gNodeB [306] and source AMF [106], and decoding at a target gNodeB [306].
- 30 21. The system [300] as claimed in claim 13, wherein the set of trace events are generated in real-time to track and record a sequence of interactions and communications between the UE [304] and the gNodeB [306].
22. The system [300] as claimed in claim 15, wherein the stream of enriched set of trace events to the TCE is continuous, facilitating real-time monitoring of network activities.

23. The system [300] as claimed in claim 16, wherein the enriched set of trace events stored in the TCE server are time-stamped, providing a chronological record of network interactions for the UE [304].
- 5 24. The system [300] as claimed in claim 14, wherein the gNodeB [306] receives the IMSI and IMEI from the AMF [106] during one of initial attach/registration, Xn handover, UE context retrieval in case of RLF, NG AP handover, and inter RAT handover.
- 10 25. A user equipment (UE) [304] for enriching 5G radio access network (RAN) session trace events, the UE [304] comprising:
- a processor [1004] configured to:
- transmit, via a gNodeB [306], a first information from an access and mobility management function (AMF) [106] transmitted over network messages;
- generate, via a server [308], a set of trace events based on a connection request;
- 15 and
- enrich, via the server [308], the generated set of trace events with the first information.
- 20 26. The UE [304] as claimed in claim 25, wherein the first information comprises at least one of international mobile subscriber identity (IMSI) and international mobile equipment identity (IMEI).
- 25 27. A non-transitory computer-readable storage medium storing for performing real-time analysis of Key Performance Indicators (KPIs) for enriching 5G radio access network (RAN) session trace events, the storage medium comprising executable code which, when executed by one or more units of a system, causes:
- a processing unit [302] to:
- receive, via a gNodeB [306], a first information from an AMF [106] transmitted over network messages;
- 30 • generate a set of trace events based on a connection request received from a UE [304]; and;
- enrich the generated set of trace events with the received first information.

100

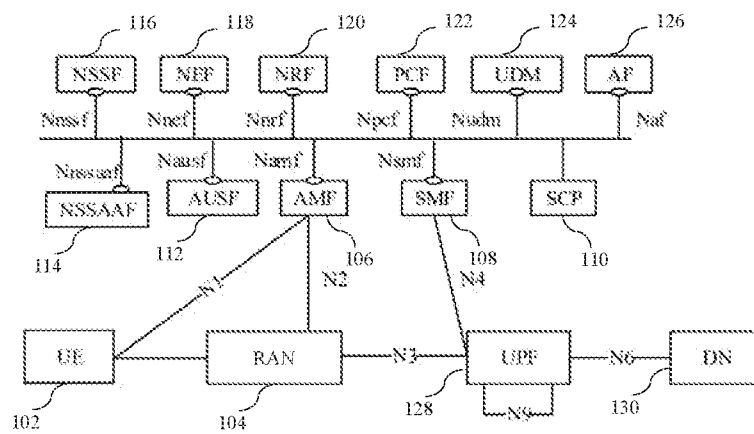


FIG. 1

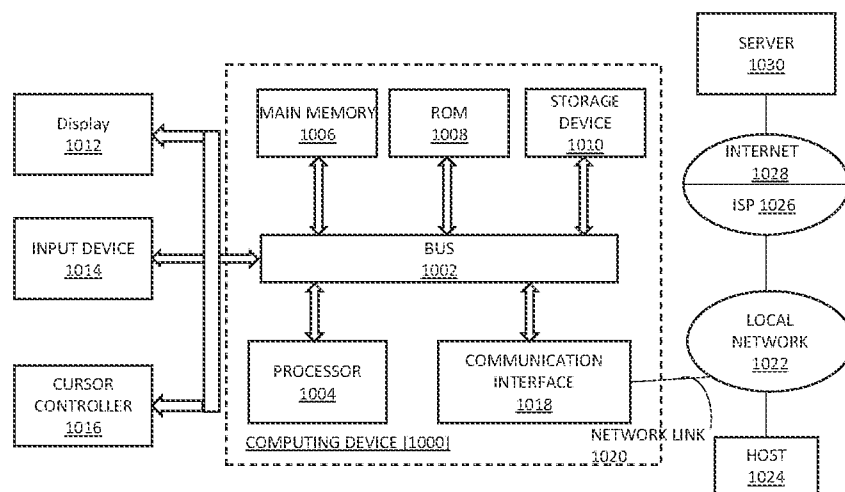


FIG. 2

300

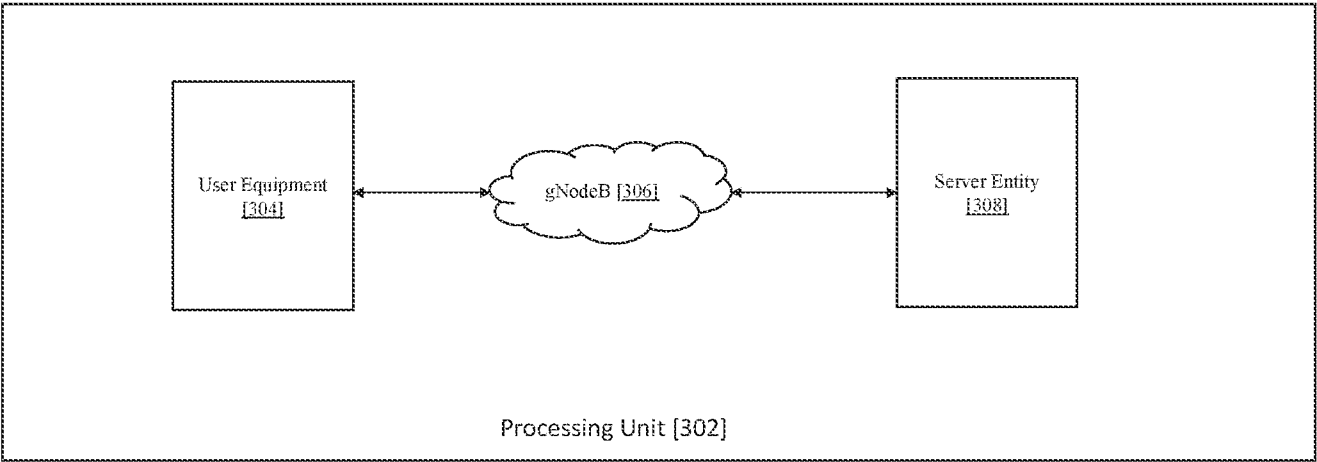


FIG. 3

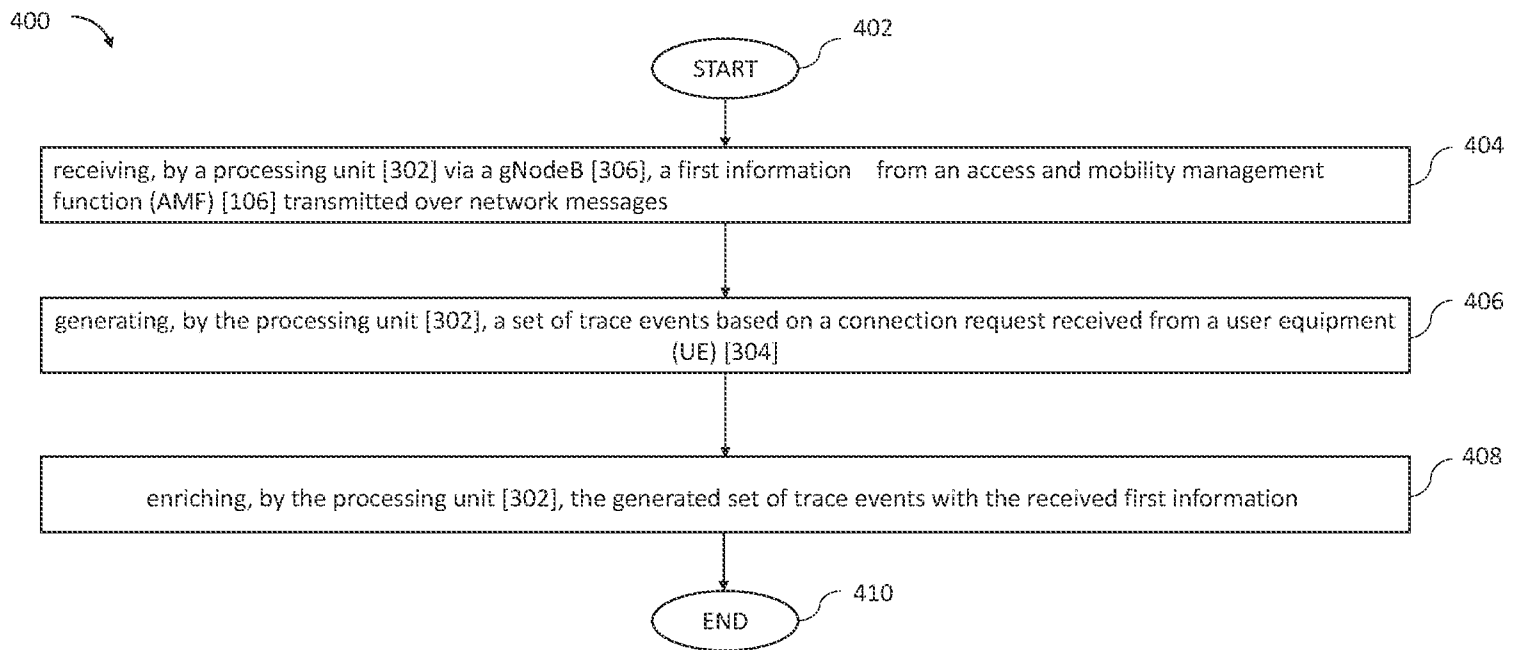


FIG. 4

500A

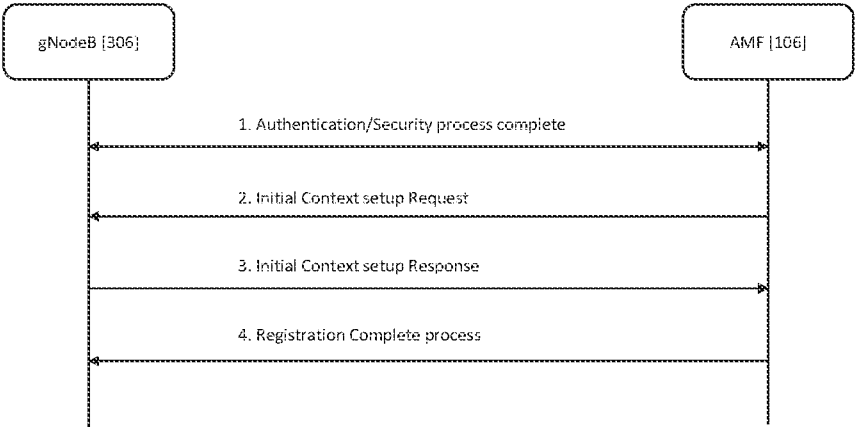


FIG. 5A

500B

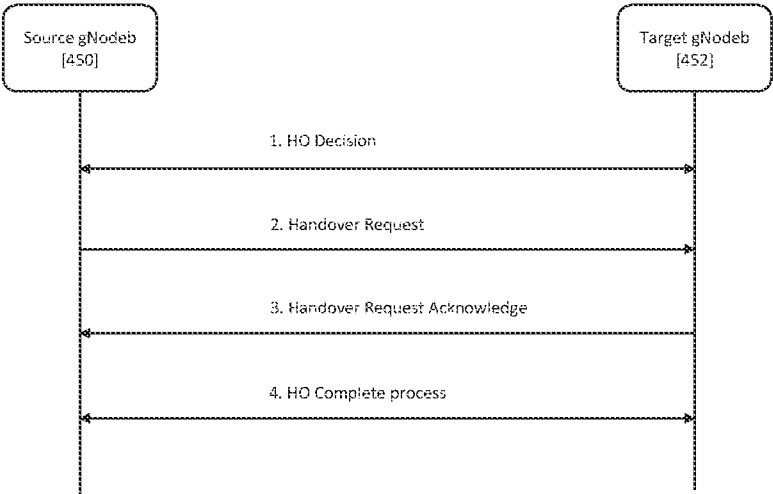


FIG. 5B

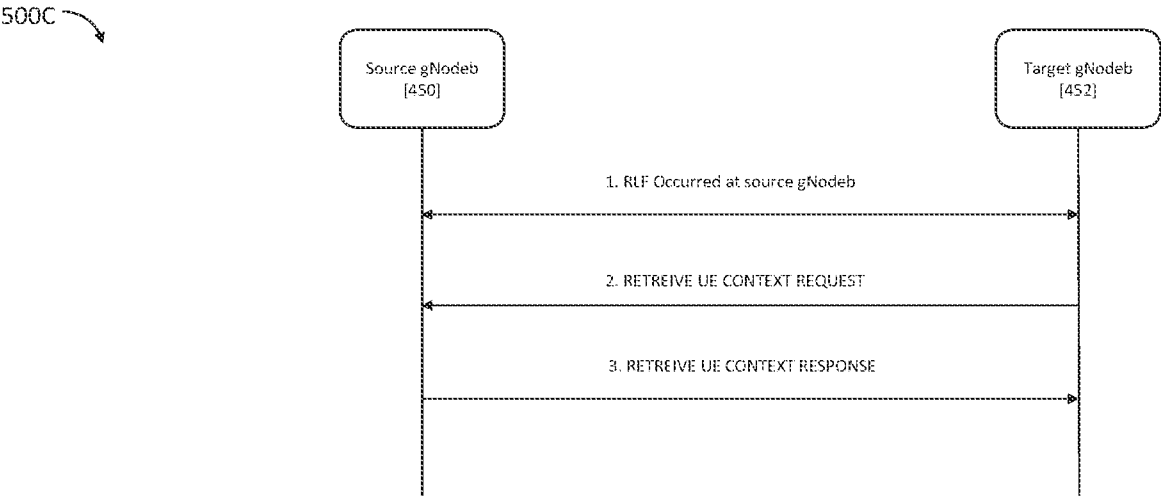


FIG. 5C

500D

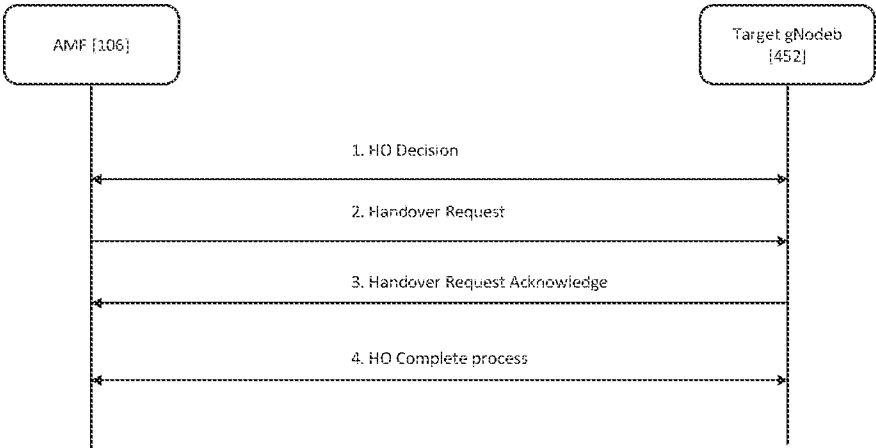


FIG. 5D

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IN2024/050834

A. CLASSIFICATION OF SUBJECT MATTER

H04W60/04, H04W48/18, H04W76/10, H04W8/08 Version=2024.01

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

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

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

PatSeer, IPO Internal Database

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	(US20150163688A1) (TELEFONAKTIEBOLAGET LM ERICSSON AB) (11 JUNE 2015) (11-06-2015) CLAIM 1, PARAGRAPHS [0028], [0045]	1-27
Y	(3RD GENERATION PARTNERSHIP PROJECT; TECHNICAL SPECIFICATION GROUP SERVICES AND SYSTEM ASPECTS; SYSTEM ARCHITECTURE FOR THE 5G SYSTEM (5GS); STAGE 2 (RELEASE 18)) (3GPP TS 23.501 V18.2.1 (2023-06)) (29 JUNE 2023) (29-06-2023) PAGE 226	1-27
Y	(3RD GENERATION PARTNERSHIP PROJECT; TECHNICAL SPECIFICATION GROUP SERVICES AND SYSTEM ASPECTS; TELECOMMUNICATION MANAGEMENT; SUBSCRIBER AND EQUIPMENT TRACE; TRACE CONTROL AND CONFIGURATION MANAGEMENT (RELEASE 17)) (3GPP TS 32.422 V17.10.0 (2023-03)) (31 MARCH 2023) (31-03-2023) PAGES 36, FIGURE 4.1.1.9.3.1	1-27



Further documents are listed in the continuation of Box C.



See patent family annex.

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

"&" document member of the same patent family

Date of the actual completion of the international search

08-10-2024

Date of mailing of the international search report

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