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(54) **METHODS AND APPARATUSES FOR SMS DELIVERY**

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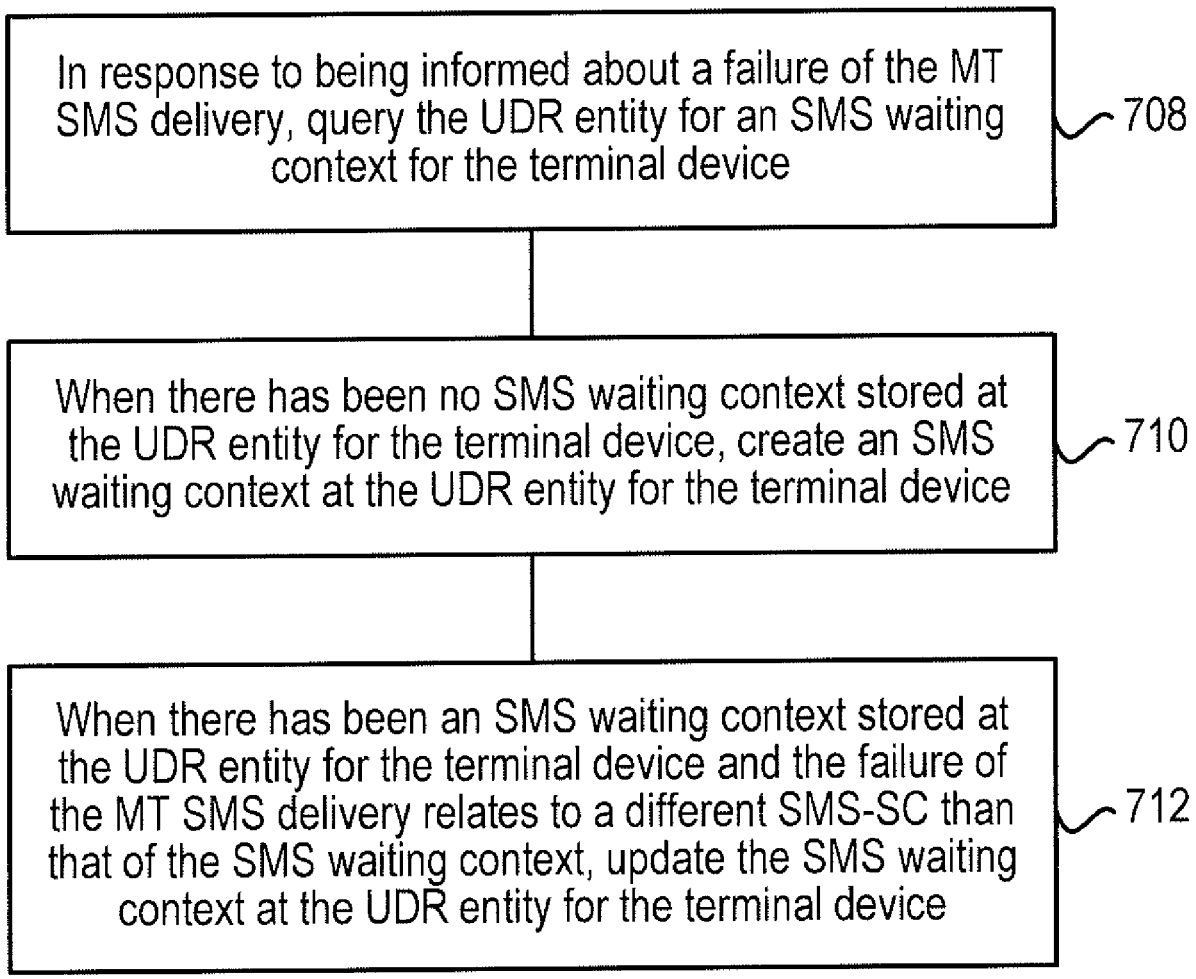
(57) **ABSTRACT**

Methods and apparatuses for short message service (SMS) delivery are disclosed. According to an embodiment, a unified data management (UDM) entity maintains a short message service (SMS) waiting context for a terminal device. The SMS waiting context is information related to a re-attempt of a mobile terminating (MT) SMS delivery from at least one SMS service center (SMS-SC) to the terminal device due to a failure of the MT SMS delivery.



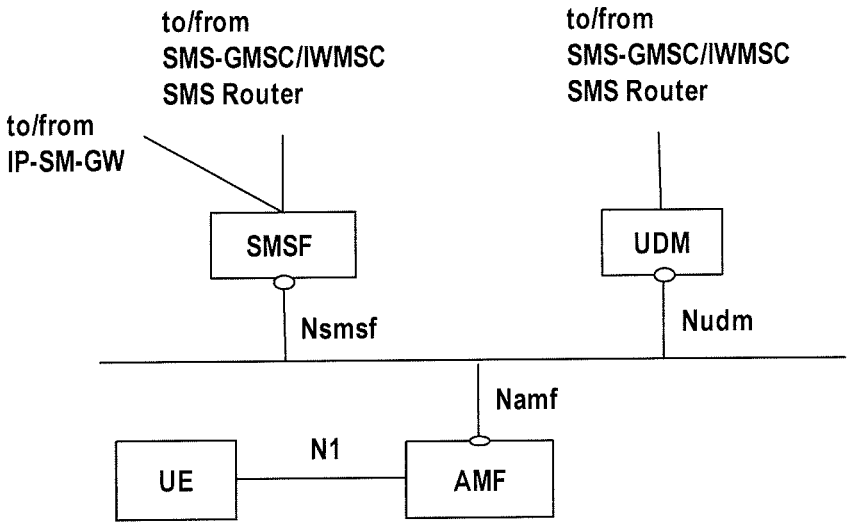

to/from
SMS-GMSC/IWMSC
SMS Router
to/from
SMS-GMSC/IWMSC
SMS Router
to/from
IP-SM-GW
SMSF
UDM
Nsmsf
Nudm
Namf
N1
UE
AMF

FIG. 1

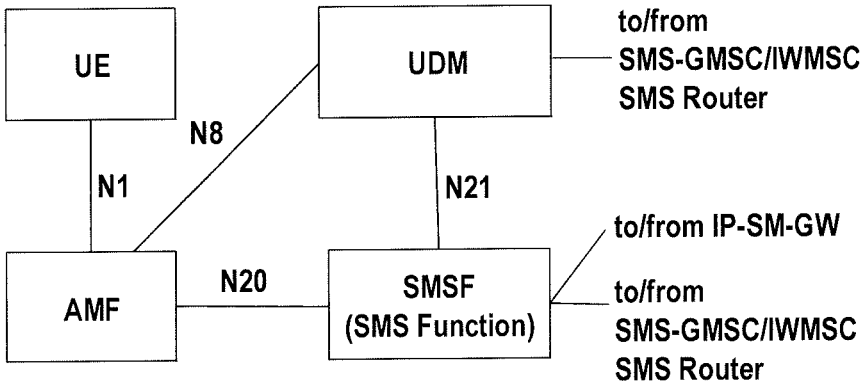

UE
UDM
to/from
SMS-GMSC/IWMSC
SMS Router
N8
N1
N21
to/from IP-SM-GW
AMF
N20
SMSF
(SMS Function)
to/from
SMS-GMSC/IWMSC
SMS Router

FIG. 2

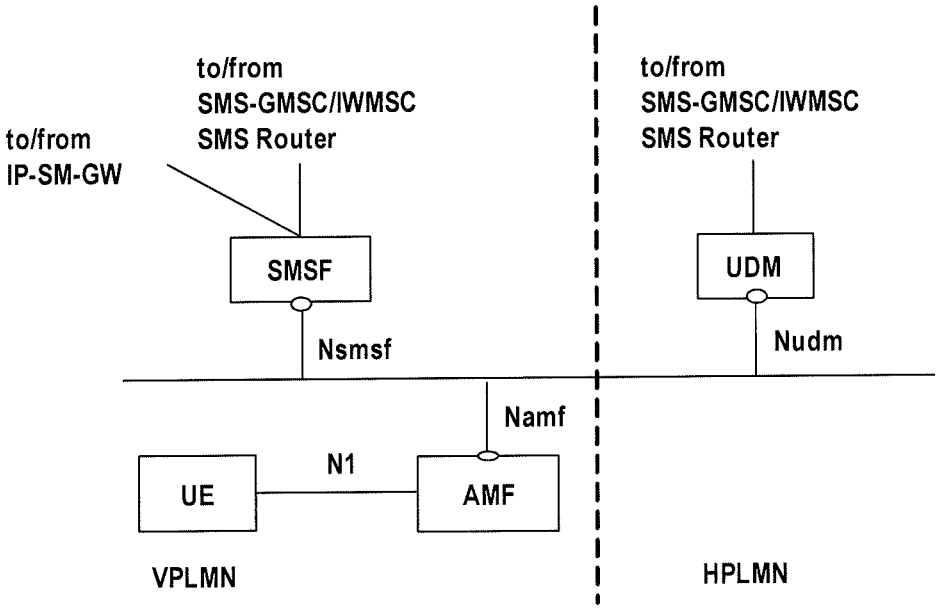

to/from
SMS-GMSC/IWMSC
SMS Router
to/from
IP-SM-GW
SMSF
Nsmsf
to/from
SMS-GMSC/IWMSC
SMS Router
UDM
Nudm
Namf
N1
UE
AMF
VPLMN
HPLMN

FIG. 3

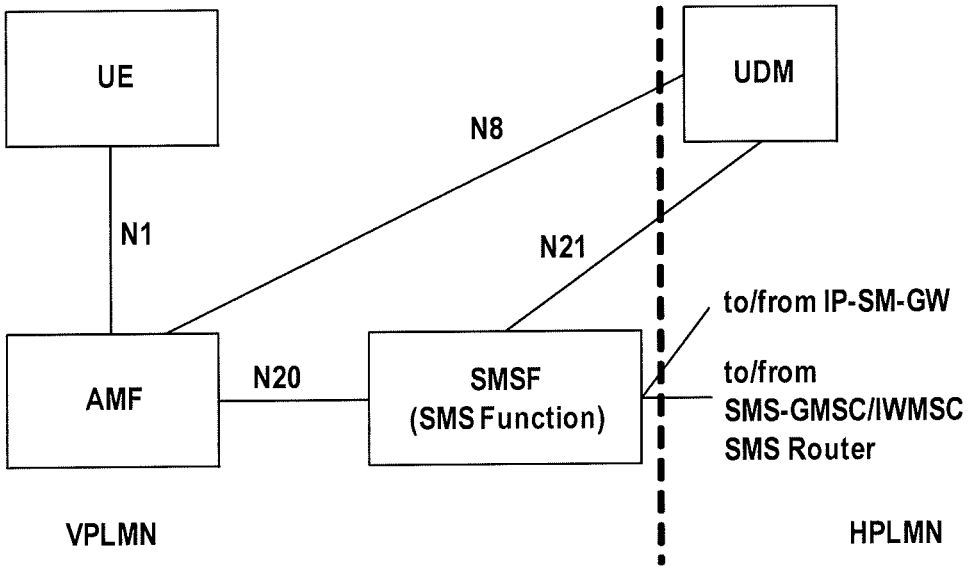

UE
N1
AMF
N8
N20
UDM
N21
SMSF
(SMS Function)
to/from IP-SM-GW
to/from
SMS-GMSC/IWMSC
SMS Router
VPLMN
HPLMN

FIG. 4

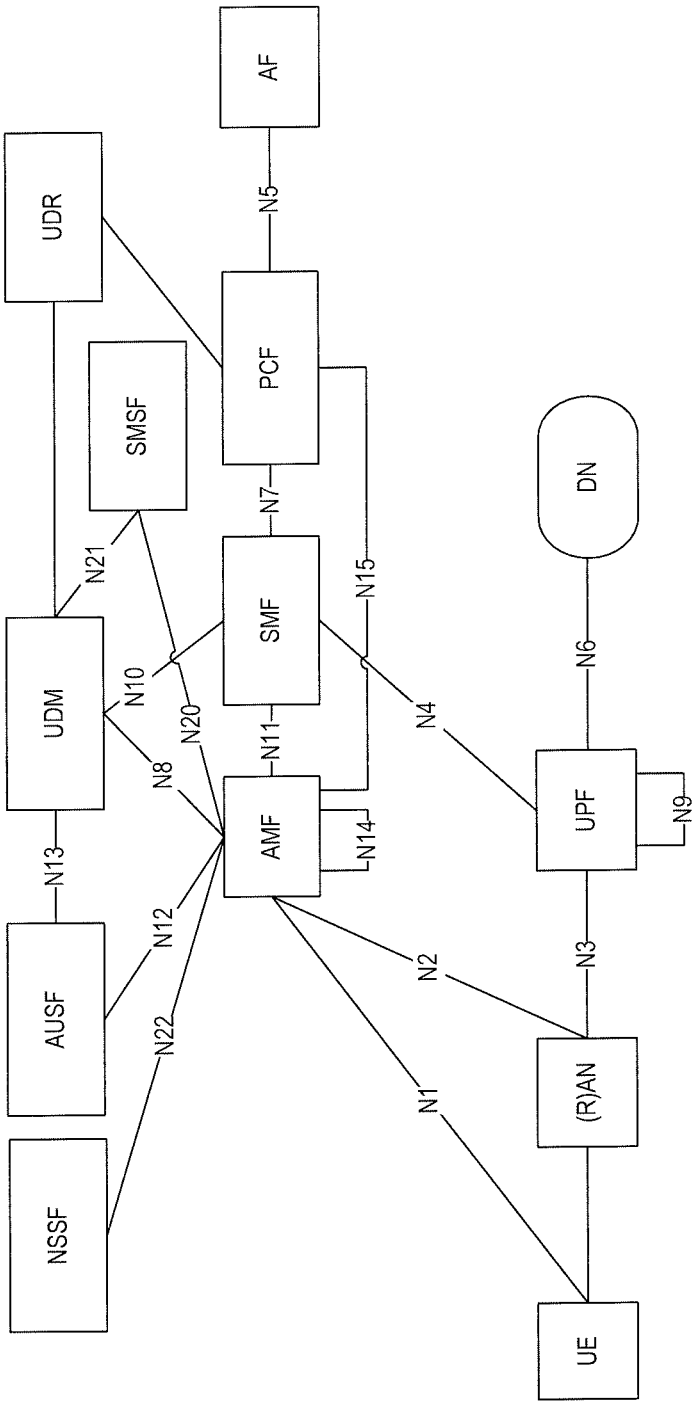

AF
N5
UDR
PCF
SMSF
N7
DN
N21
SMF
N15
N6
UDM
N10
N20
N11
N4
N8
AMF
UPF
N9
N14
N13
N12
N2
N3
AUSF
N22
(R)AN
N1
NSSF
UE

FIG. 5

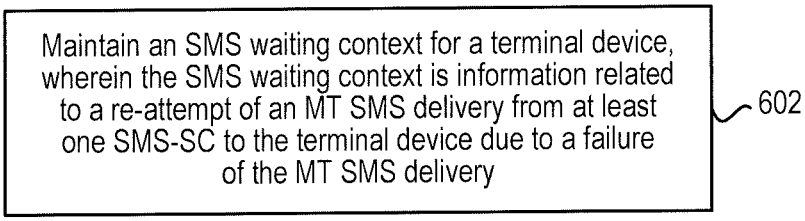


FIG. 6

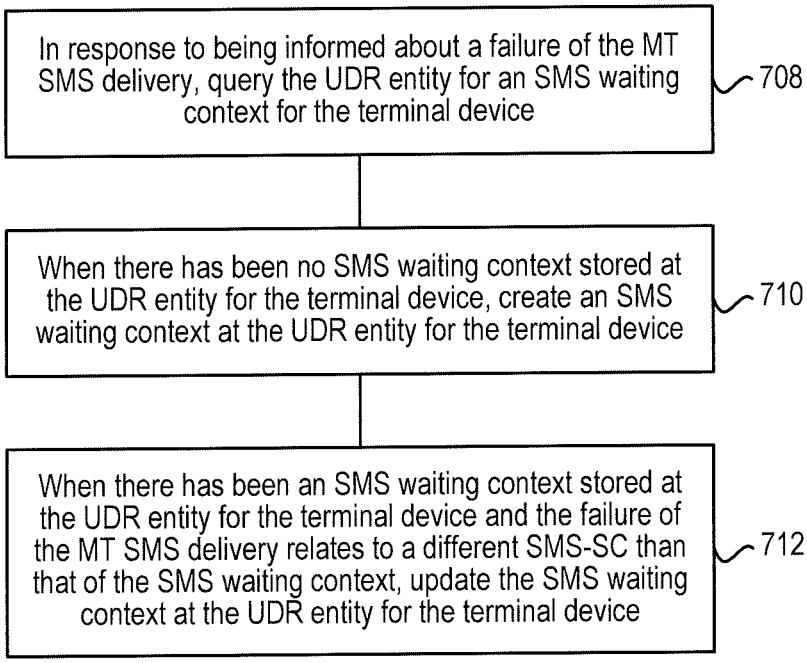


FIG. 7

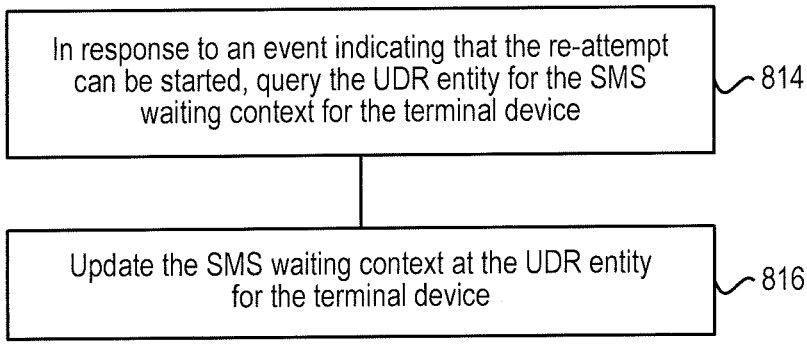


FIG. 8

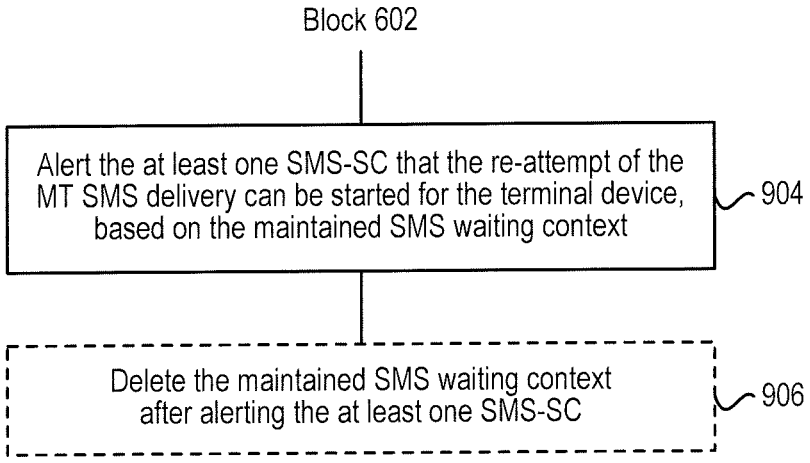


FIG. 9

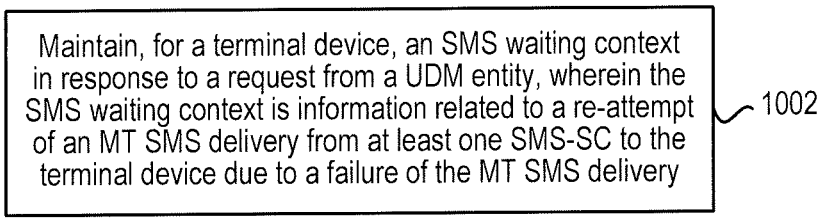


FIG. 10

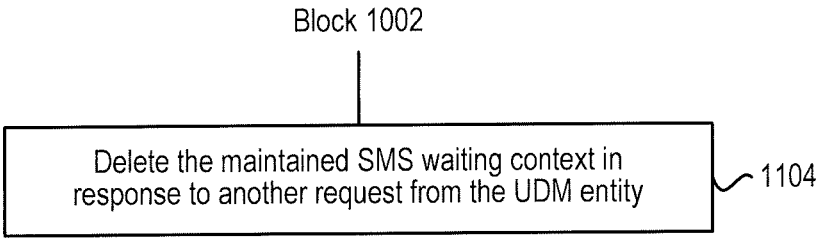


FIG. 11

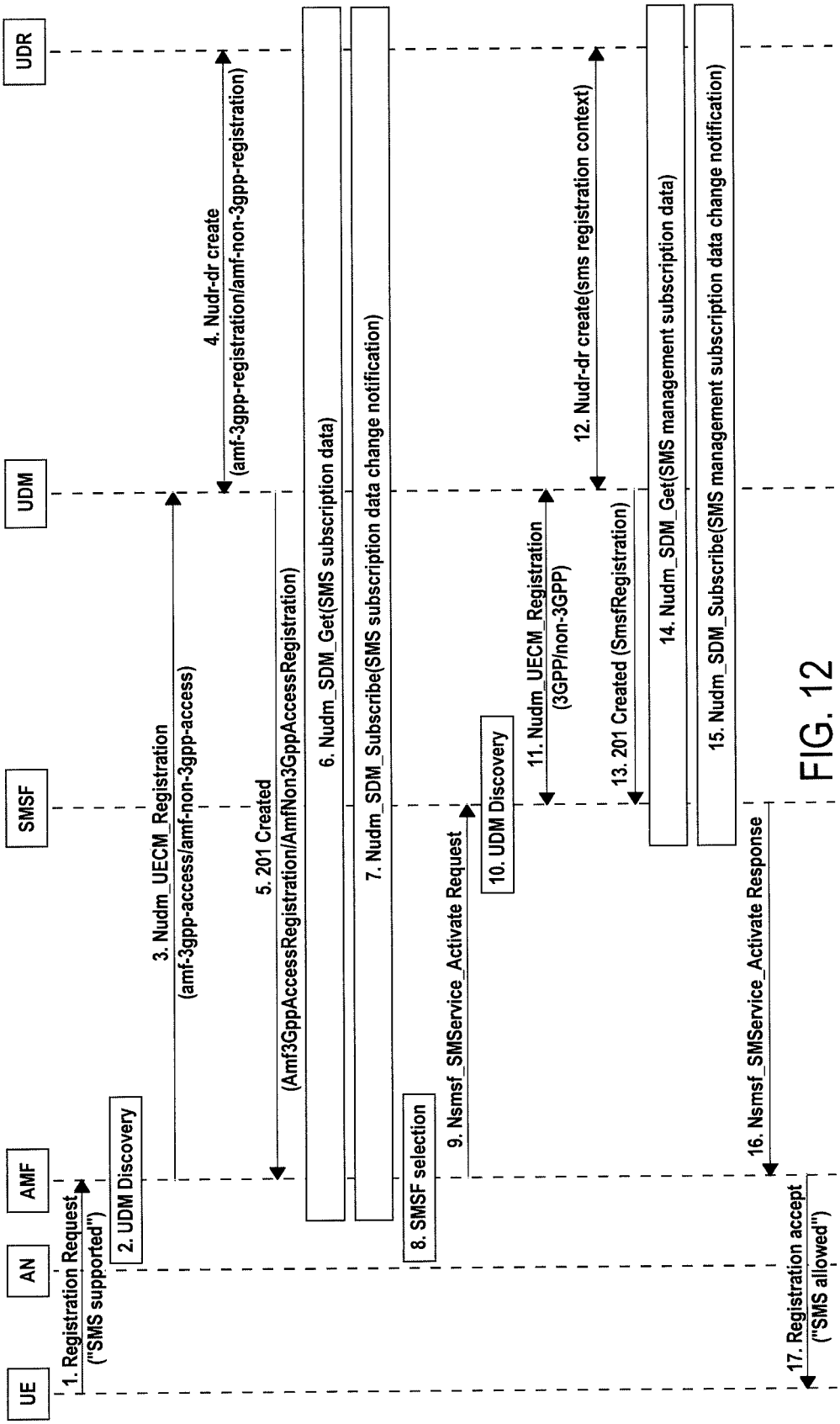

UE
AN
AMF
SMSF
UDM
UDR
1. Registration Request ("SMS supported")
2. UDM Discovery
3. Nudm_UECM_Registration (amf-3gpp-access/amf-non-3gpp-access)
4. Nudr-dr create (amf-3gpp-registration/amf-non-3gpp-registration)
5. 201 Created (Amf3GppAccessRegistration/AmfNon3GppAccessRegistration)
6. Nudm_SDM_Get(SMS subscription data)
7. Nudm_SDM_Subscribe(SMS subscription data change notification)
8. SMSF selection
9. Nsmsf_SMService_Activate Request
10. UDM Discovery
11. Nudm_UECM_Registration (3GPP/non-3GPP)
12. Nudr-dr create(sms registration context)
13. 201 Created (SmsfRegistration)
14. Nudm_SDM_Get(SMS management subscription data)
15. Nudm_SDM_Subscribe(SMS management subscription data change notification)
16. Nsmsf_SMService_Activate Response
17. Registration accept ("SMS allowed")

FIG. 12

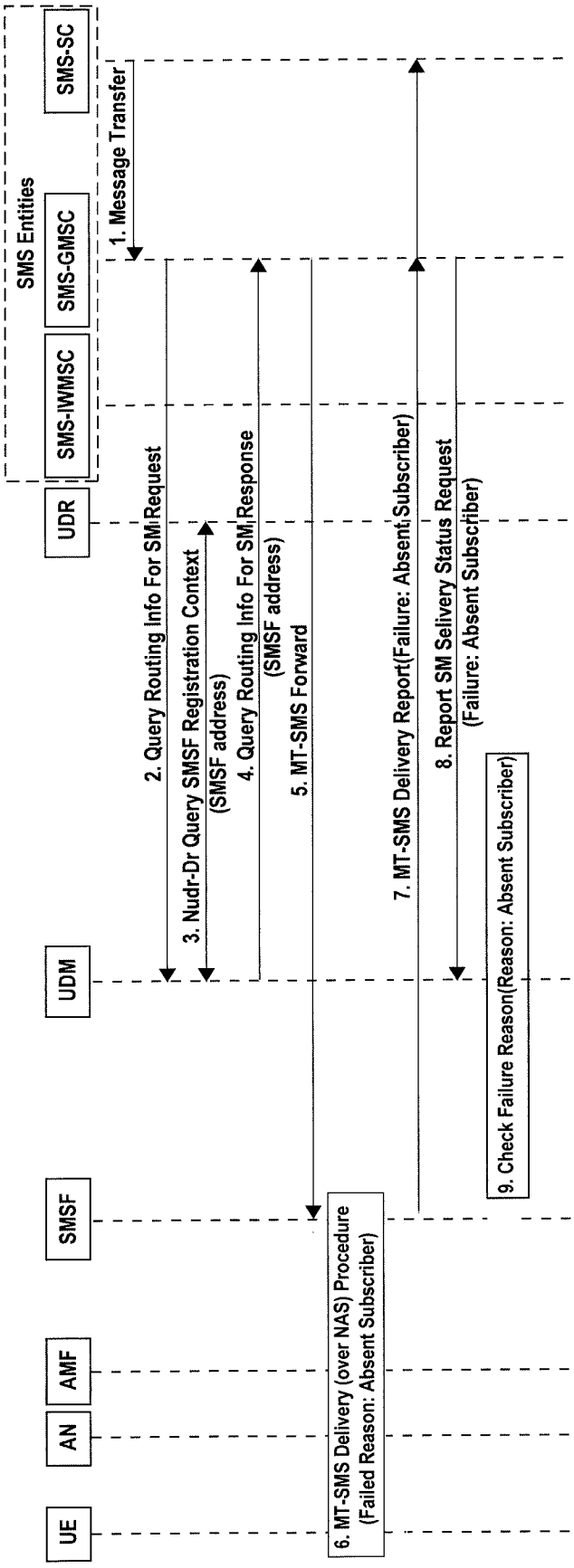

SMS Entities
SMS-SC
SMS-GMSC
SMS-IWMSC
UDR
UDM
SMSF
AMF
AN
UE
1. Message Transfer
2. Query Routing Info For SM Request
3. Nudr-Dr Query SMSF Registration Context
(SMSF address)
4. Query Routing Info For SM Response
(SMSF address)
5. MT-SMS Forward
6. MT-SMS Delivery (over NAS) Procedure
(Failed Reason: Absent Subscriber)
7. MT-SMS Delivery Report(Failure: Absent Subscriber)
8. Report SM Selivery Status Request
(Failure: Absent Subscriber)
9. Check Failure Reason(Reason: Absent Subscriber)

FIG. 13A

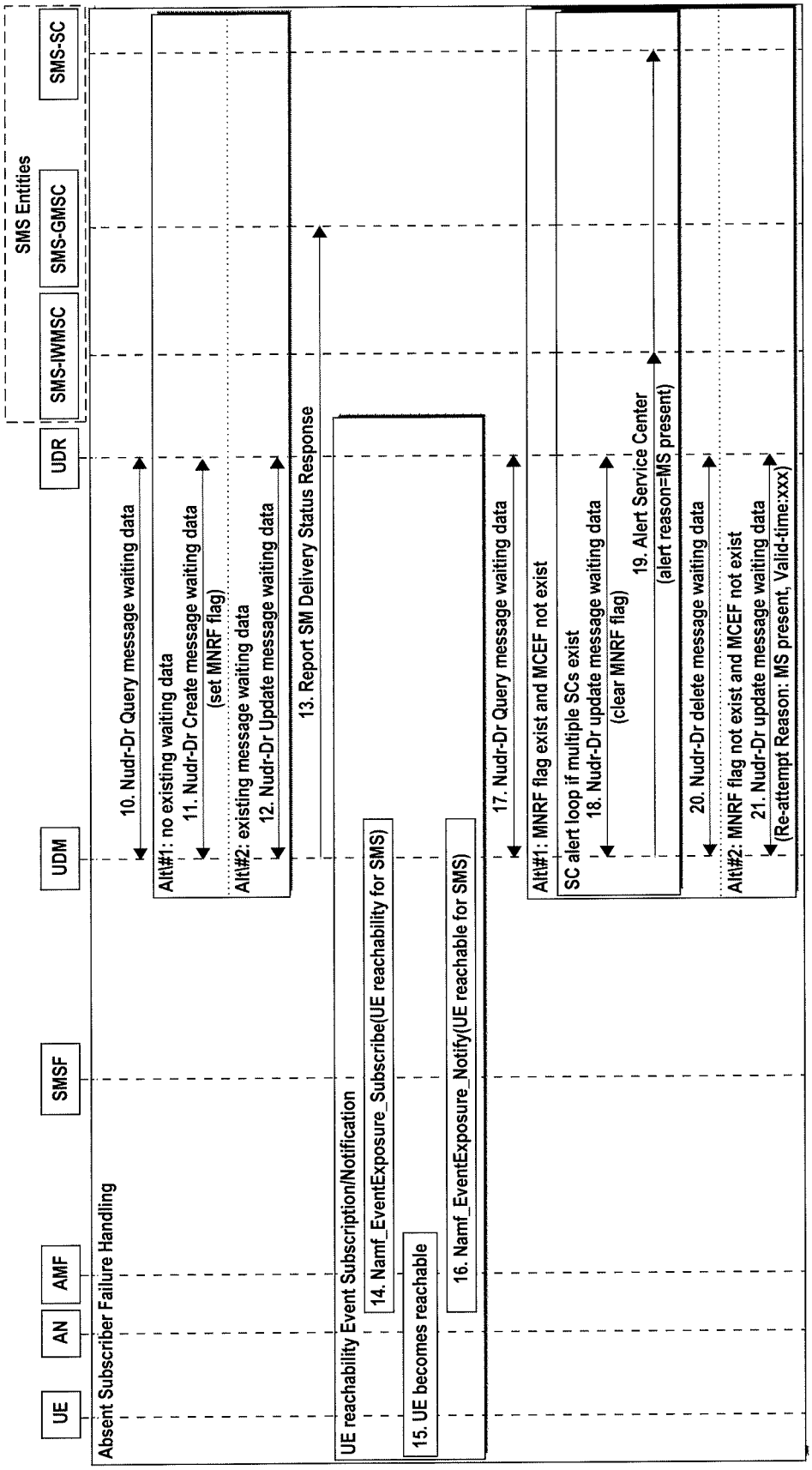

UE
AN
AMF
SMSF
UDM
UDR
SMS Entities
SMS-IWMSC
SMS-GMSC
SMS-SC
Absent Subscriber Failure Handling
10. Nudr-Dr Query message waiting data
Alt#1: no existing waiting data
11. Nudr-Dr Create message waiting data
(set MNRF flag)
Alt#2: existing message waiting data
12. Nudr-Dr Update message waiting data
13. Report SM Delivery Status Response
UE reachability Event Subscription/Notification
14. Namf_EventExposure_Subscribe(UE reachability for SMS)
15. UE becomes reachable
16. Namf_EventExposure_Notify(UE reachable for SMS)
17. Nudr-Dr Query message waiting data
Alt#1: MNRF flag exist and MCEF not exist
SC alert loop if multiple SCs exist
18. Nudr-Dr update message waiting data
(clear MNRF flag)
19. Alert Service Center
(alert reason=MS present)
20. Nudr-Dr delete message waiting data
Alt#2: MNRF flag not exist and MCEF not exist
21. Nudr-Dr update message waiting data
(Re-attempt Reason: MS present, Valid-time:xxx)

FIG. 13B

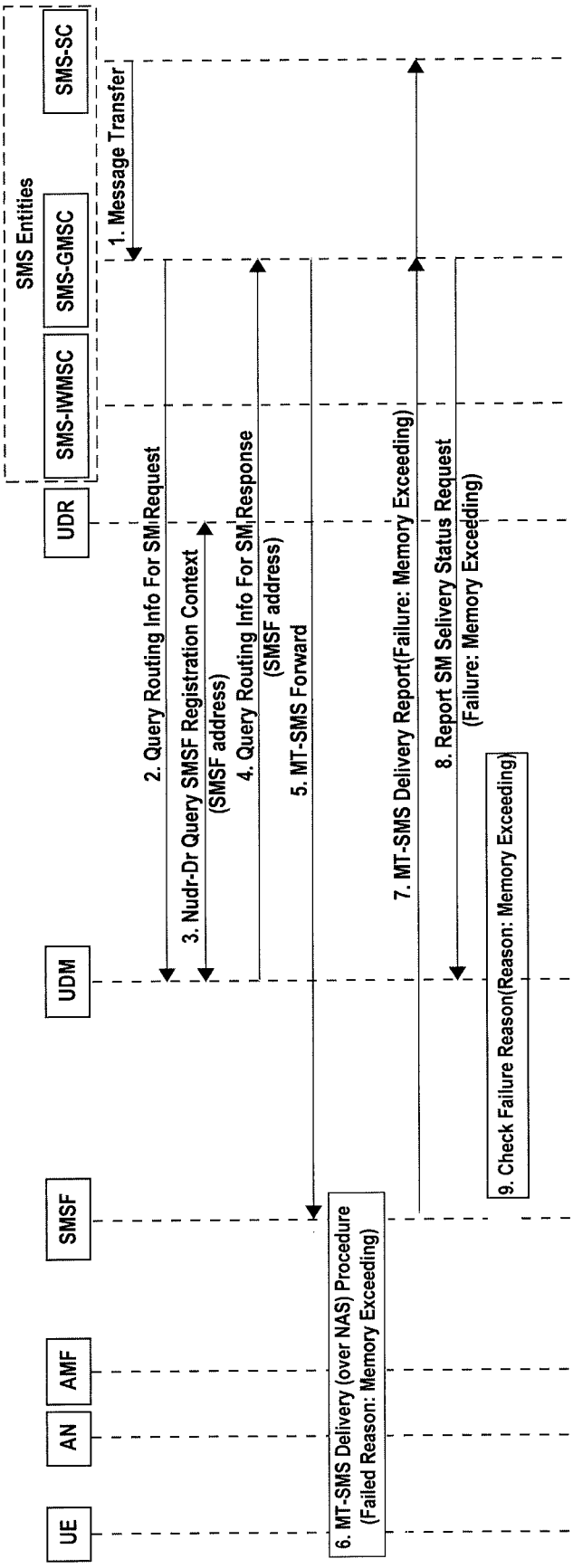

SMS Entities
SMS-SC
SMS-GMSC
SMS-IWMSC
UDR
UDM
SMSF
AMF
AN
UE
1. Message Transfer
2. Query Routing Info For SM Request
3. Nudr-Dr Query SMSF Registration Context
(SMSF address)
4. Query Routing Info For SM Response
(SMSF address)
5. MT-SMS Forward
6. MT-SMS Delivery (over NAS) Procedure
(Failed Reason: Memory Exceeding)
7. MT-SMS Delivery Report(Failure: Memory Exceeding)
8. Report SM Selivery Status Request
(Failure: Memory Exceeding)
9. Check Failure Reason(Reason: Memory Exceeding)

FIG. 14A

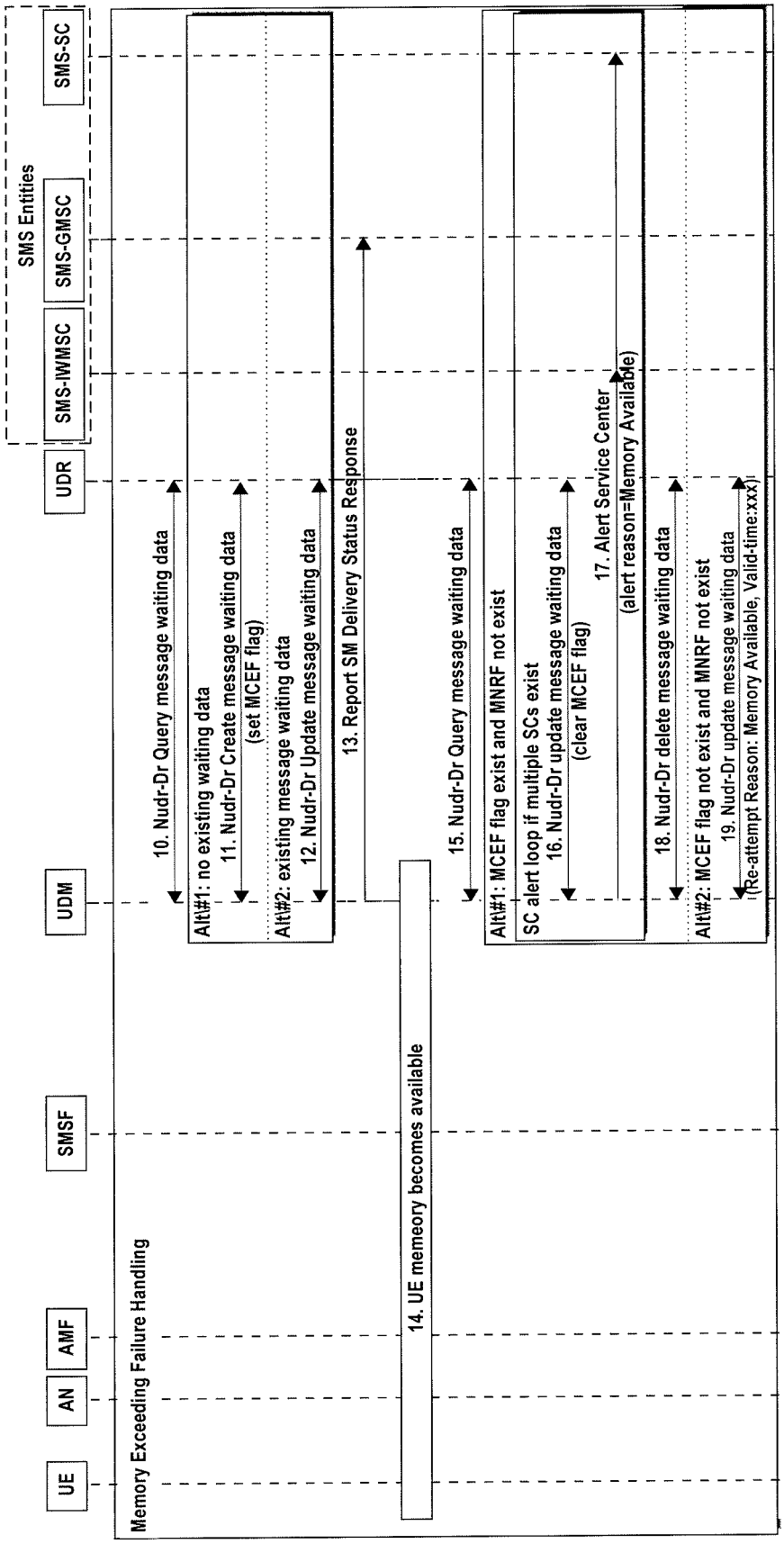

UE
AN
AMF
SMSF
UDM
UDR
SMS Entities
SMS-IWMSC
SMS-GMSC
SMS-SC
Memory Exceeding Failure Handling
10. Nudr-Dr Query message waiting data
Alt#1: no existing waiting data
11. Nudr-Dr Create message waiting data
(set MCEF flag)
Alt#2: existing message waiting data
12. Nudr-Dr Update message waiting data
13. Report SM Delivery Status Response
14. UE memeory becomes available
15. Nudr-Dr Query message waiting data
Alt#1: MCEF flag exist and MNRF not exist
SC alert loop if multiple SCs exist
16. Nudr-Dr update message waiting data
(clear MCEF flag)
17. Alert Service Center
(alert reason=Memory Available)
18. Nudr-Dr delete message waiting data
Alt#2: MCEF flag not exist and MNRF not exist
19. Nudr-Dr update message waiting data
(Re-attempt Reason: Memory Available, Valid-time:xxx)

FIG. 14B

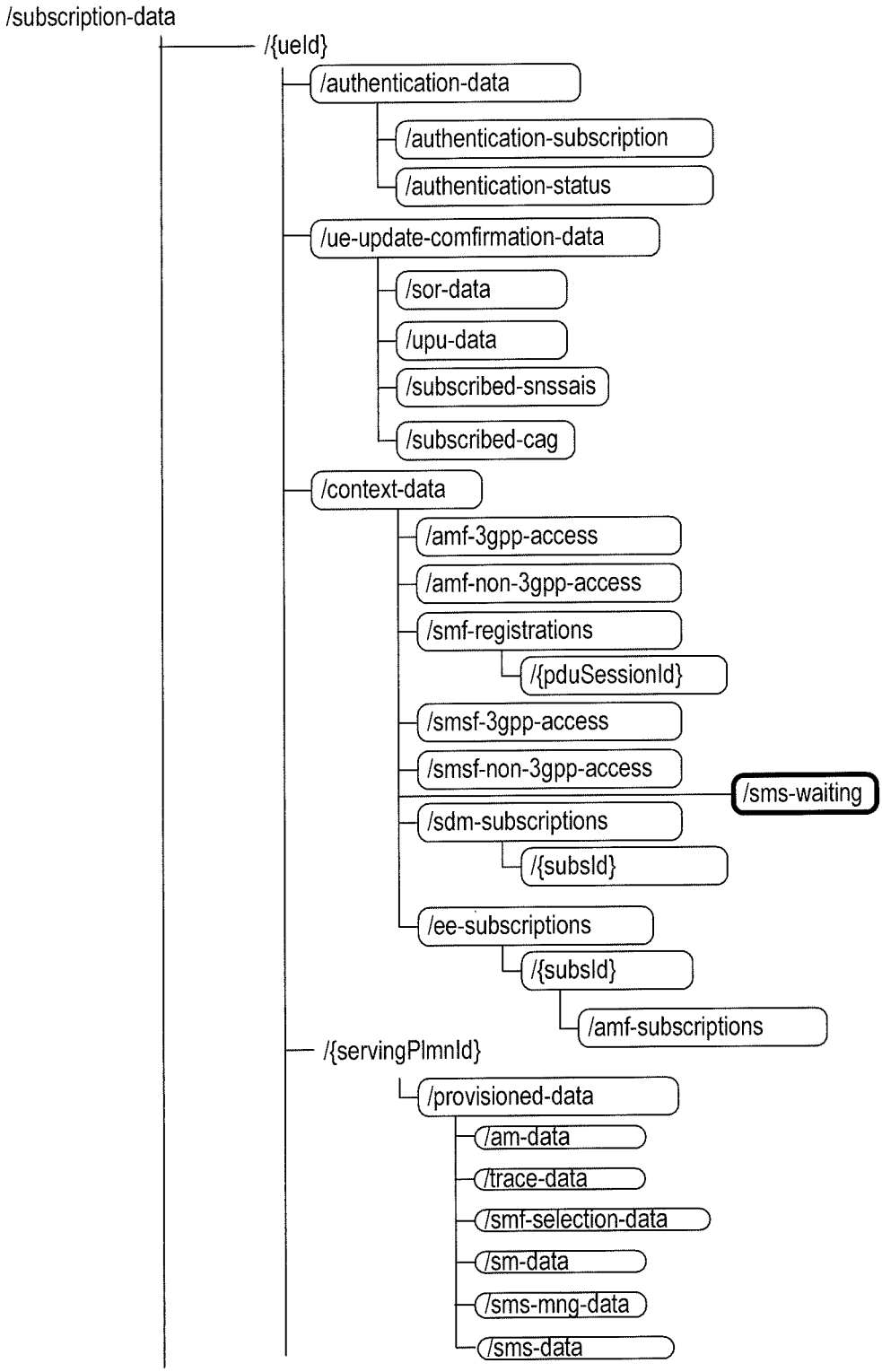

/subscription-data
/{ueId}
/authentication-data
/authentication-subscription
/authentication-status
/ue-update-comfirmation-data
/sor-data
/upu-data
/subscribed-snssais
/subscribed-cag
/context-data
/amf-3gpp-access
/amf-non-3gpp-access
/smf-registrations
/{pduSessionId}
/smsf-3gpp-access
/smsf-non-3gpp-access
/sms-waiting
/sdm-subscriptions
/{subsId}
/ee-subscriptions
/{subsId}
/amf-subscriptions
/{servingPlmnId}
/provisioned-data
/am-data
/trace-data
/smf-selection-data
/sm-data
/sms-mng-data
/sms-data

FIG. 15

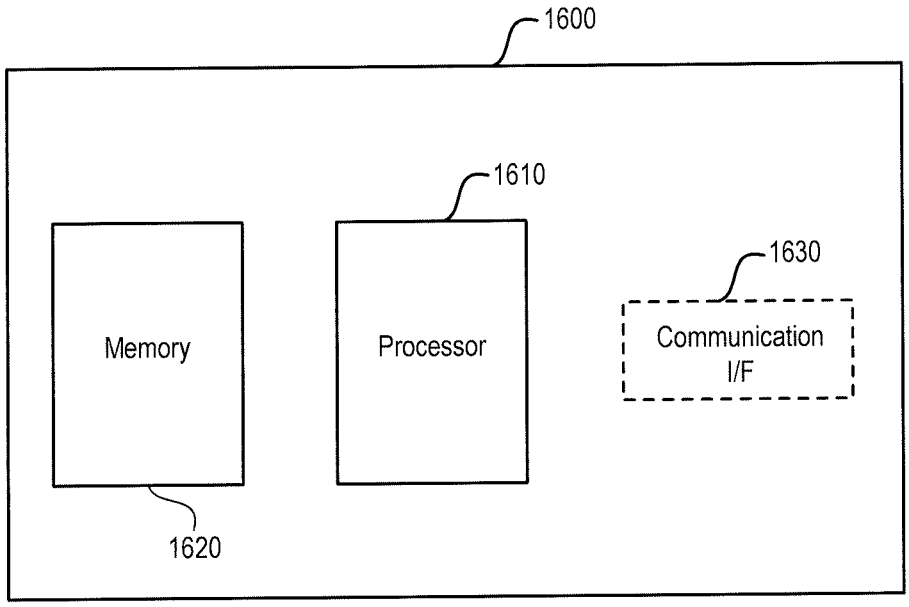


FIG. 16

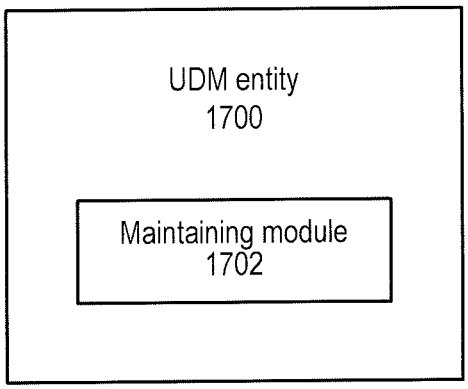


FIG. 17

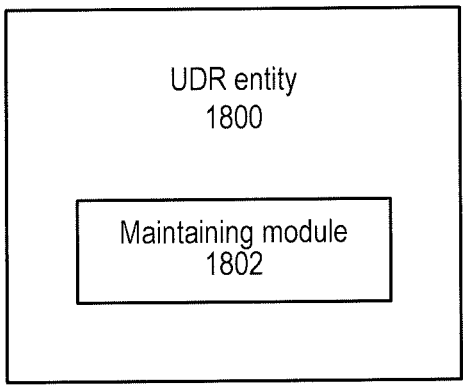


FIG. 18

METHODS AND APPARATUSES FOR SMS DELIVERY

TECHNICAL FIELD

[0001] Embodiments of the disclosure generally relate to communication, and, more particularly, to methods and apparatuses for SMS delivery.

BACKGROUND

[0002] This section introduces aspects that may facilitate better understanding of the present disclosure. Accordingly, the statements of this section are to be read in this light and are not to be understood as admissions about what is in the prior art or what is not in the prior art.

[0003] According to section 4.4.2 of 3rd generation partnership project (3GPP) technical specification (TS) 23.501 V16.3.0, short message service (SMS) can be implemented over non-access stratum (NAS). FIG. **1** shows the non-roaming architecture to support SMS over NAS using service-based interfaces within the control plane. As shown, the architecture comprises a user equipment (UE), an access and mobility management function (AMF), an SMS function (SMSF), a unified data management (UDM), an Internet protocol (IP) short message gateway (IP-SM-GW), and an SMS gateway mobile switching center (SMS-GMSC)/interworking mobile switching center (IWMSC)/SMS router. The term Nsmsf refers to a service-based interface exhibited by the SMSF.

[0004] FIG. **2** shows the non-roaming architecture to support SMS over NAS using reference point representation. N1 is the reference point for SMS transfer between UE and AMF via NAS. The following reference points are realized by service based interfaces: N8 which is the reference point for SMS subscription data retrieval between AMF and UDM; N20 which is the reference point for SMS transfer between AMF and SMSF; and N21 which is the reference point for SMSF address registration management and SMS management subscription data retrieval between SMSF and UDM. FIG. **3** shows the roaming architecture to support SMS over NAS using service-based interfaces within the control plane. The term HPLMN refers to home public land mobile network (PLMN) and VPLMN refers to visited PLMN. FIG. **4** shows the roaming architecture to support SMS over NAS using reference point representation. Note that unified data repository (UDR) is not shown in FIGS. **1-4** for brevity.

SUMMARY

[0005] This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter.

[0006] One of the objects of the disclosure is to provide an improved solution for SMS delivery.

[0007] According to a first aspect of the disclosure, there is provided a method performed by a unified data management (UDM) entity. The method may comprise transmitting an HTTP request to a unified data repository, UDR, entity to maintain a short message service (SMS) waiting context for a terminal device, at the UDR entity. The SMS waiting context may be information related to a re-attempt of a mobile terminating (MT) SMS delivery from at least one SMS service center (SMS-SC) to the terminal device due to a failure of the MT SMS delivery.

[0008] In this way, when the re-attempt of the MT SMS delivery can be started, it can be triggered by the UDM entity since the SMS waiting context is maintained.

[0009] In an embodiment of the disclosure, the SMS waiting context may be maintained by at least one of the following steps: querying the UDR entity for an SMS waiting context for the terminal device; creating an SMS waiting context for the terminal device; and updating the SMS waiting context for the terminal device.

[0010] In an embodiment of the disclosure, the querying may be performed by sending a hypertext transfer protocol (HTTP) GET request to the UDR entity. The creating may be performed by sending an HTTP PUT request to the UDR entity. The updating may be performed by sending an HTTP PUT or PATCH request to the UDR entity.

[0011] In an embodiment of the disclosure, the HTTP PUT request may comprise the SMS waiting context for the terminal device. Alternatively or additionally, the HTTP PATCH request may comprise an indication indicating at least one of the SMS waiting context for the terminal device.

[0012] In an embodiment of the disclosure, the method may further comprise receiving an HTTP GET response in response to HTTP GET request, wherein the HTTP GET response may comprise the SMS waiting context for the terminal device.

[0013] In an embodiment of the disclosure, the method may further comprise alerting the at least one SMS-SC that the re-attempt of the MT SMS delivery can be started for the terminal device, based on the maintained SMS waiting context.

[0014] In an embodiment of the disclosure, the method may further comprise deleting the maintained SMS waiting context after alerting the at least one SMS-SC.

[0015] In an embodiment of the disclosure, the maintained SMS waiting context may be deleted from a UDR entity.

[0016] In an embodiment of the disclosure, the deleting may be performed by sending an HTTP DELETE request to the UDR entity.

[0017] In an embodiment of the disclosure, the SMS waiting context for the terminal device may contain at least one of: a list of an address of the at least one SMS-SC; a list of an expiry time of the at least one SMS-SC until which the re-attempt of the MT SMS delivery by the at least one SMS-SC is valid; a first indicator indicating that a reason for the failure of the MT SMS delivery is the terminal device being not reachable; a second indicator indicating that the reason for the failure of the MT SMS delivery is a memory capacity of the terminal device being exceeded; a third indicator indicating a reason for the re-attempt of the MT SMS delivery; a first time point until which the re-attempt of the MT SMS delivery is valid; and a second time point until which the second indicator is valid.

[0018] In an embodiment of the disclosure, the third indicator may have a first value indicating that the terminal device is reachable for the re-attempt, and/or a second value indicating that the terminal device has available memory for the re-attempt.

[0019] In an embodiment of the disclosure, maintaining the SMS waiting context at the UDR entity for the terminal device may comprise at least one of the following steps: in response to being informed about a failure of the MT SMS

delivery, querying the UDR entity for an SMS waiting context for the terminal device; when there has been no SMS waiting context stored at the UDR entity for the terminal device, creating an SMS waiting context at the UDR entity for the terminal device; and when there has been an SMS waiting context stored at the UDR entity for the terminal device and the failure of the MT SMS delivery relates to a different SMS-SC than that of the SMS waiting context, updating the SMS waiting context at the UDR entity for the terminal device.

[0020] In an embodiment of the disclosure, the UDM entity may be informed that the reason for the failure of the MT SMS delivery is the terminal device being not reachable. The created or updated SMS waiting context may contain the first indicator.

[0021] In an embodiment of the disclosure, the UDM entity may be informed that the reason for the failure of the MT SMS delivery is the memory capacity of the terminal device being exceeded. The created or updated SMS waiting context may contain the second indicator.

[0022] In an embodiment of the disclosure, maintaining the SMS waiting context at the UDR entity for the terminal device may comprise, in response to an event indicating that the re-attempt can be started, querying the UDR entity for the SMS waiting context for the terminal device. Maintaining the SMS waiting context at the UDR entity for the terminal device may further comprise updating the SMS waiting context at the UDR entity for the terminal device.

[0023] In an embodiment of the disclosure, the event may be the UDM entity being informed that the terminal device is reachable. The queried SMS waiting context contains the first indicator and does not contain the second indicator. The SMS waiting context may be updated at the UDR entity by deleting the first indicator from the SMS waiting context.

[0024] In an embodiment of the disclosure, the event may be the UDM entity being informed that the terminal device has available memory for the re-attempt. The queried SMS waiting context contains the second indicator and does not contain the first indicator. The SMS waiting context may be updated at the UDR entity by deleting the second indicator from the SMS waiting context.

[0025] In an embodiment of the disclosure, the event may be the UDM entity being informed that the terminal device is reachable or has available memory for the re-attempt. The queried SMS waiting context does not contain the first indicator and the second indicator. The SMS waiting context may be updated at the UDR entity by adding the third indicator and the first time point into the SMS waiting context.

[0026] According to a second aspect of the disclosure, there is provided a method performed by a UDR entity. The method may comprise maintaining, for a terminal device, an SMS waiting context in response to an HTTP request from a UDM entity. The SMS waiting context may be information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery.

[0027] In an embodiment of the disclosure, the SMS waiting context may be maintained by at least one of the following steps: responding to a query from the UDM entity for an SMS waiting context for the terminal device; creating an SMS waiting context for the terminal device; and updating the SMS waiting context for the terminal device.

[0028] In an embodiment of the disclosure, the query may be an HTTP GET request. The creating may be performed by receiving an HTTP PUT request from the UDM entity. The updating may be performed by receiving an HTTP PUT or PATCH request from the UDM entity.

[0029] In an embodiment of the disclosure, the method may further comprise deleting the maintained SMS waiting context in response to another request from the UDM entity.

[0030] In an embodiment of the disclosure, the deleting may be performed by receiving an HTTP DELETE request from the UDM entity.

[0031] In an embodiment of the disclosure, the SMS waiting context for the terminal device may contain at least one of: a list of an address of the at least one SMS-SC; a list of an expiry time of the at least one SMS-SC until which the re-attempt of the MT SMS delivery by the at least one SMS-SC is valid; a first indicator indicating that a reason for the failure of the MT SMS delivery is the terminal device being not reachable; a second indicator indicating that the reason for the failure of the MT SMS delivery is a memory capacity of the terminal device being exceeded; a third indicator indicating a reason for the re-attempt of the MT SMS delivery; a first time point until which the re-attempt of the MT SMS delivery is valid; and a second time point until which the second indicator is valid.

[0032] In an embodiment of the disclosure, the third indicator may have a first value indicating that the terminal device is reachable for the re-attempt, and/or a second value indicating that the terminal device has available memory for the re-attempt.

[0033] According to a third aspect of the disclosure, there is provided a method implemented in a communication system including a UDM entity and a UDR entity. The method may comprise transmitting an HTTP request to the UDR entity to maintain, by the UDM entity, an SMS waiting context at the UDR entity for a terminal device. The SMS waiting context may be information related to a re-attempt of a MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery. The UDR entity may maintain, for the terminal device, the SMS waiting context in response to an HTTP request from the UDM entity.

[0034] According to a fourth aspect of the disclosure, there is provided a UDM entity. The UDM entity may comprise at least one processor and at least one memory. The at least one memory may contain instructions executable by the at least one processor, whereby the UDM entity may be operative to transmit an HTTP request to the UDM entity to maintain an SMS waiting context for a terminal device, at the UDM entity. The SMS waiting context may be information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery.

[0035] In an embodiment of the disclosure, the UDM entity may be operative to perform the method according to the above first aspect.

[0036] According to a fifth aspect of the disclosure, there is provided a UDR entity. The UDR entity may comprise at least one processor and at least one memory. The at least one memory may contain instructions executable by the at least one processor, whereby the UDR entity may be operative to maintain, for a terminal device, an SMS waiting context in response to an HTTP request from a UDM entity. The SMS waiting context may be information related to a re-attempt

of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery.

[0037] In an embodiment of the disclosure, the UDR entity may be operative to perform the method according to the above second aspect.

[0038] According to a sixth aspect of the disclosure, there is provided a computer program product. The computer program product may comprise instructions which when executed by at least one processor, cause the at least one processor to perform the method according to any of the above first and second aspects.

[0039] According to a seventh aspect of the disclosure, there is provided a computer readable storage medium. The computer readable storage medium may comprise instructions which when executed by at least one processor, cause the at least one processor to perform the method according to any of the above first and second aspects.

[0040] According to an eighth aspect of the disclosure, there is provided a UDM entity. The UDM entity may comprise a transmitting module for transmitting an HTTP request to the UDR entity to maintain an SMS waiting context for a terminal device, at the UDR entity. The SMS waiting context may be information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery.

[0041] According to a ninth aspect of the disclosure, there is provided a UDR entity. The UDR entity may comprise a maintaining module for maintaining, for a terminal device, an SMS waiting context in response to an HTTP request from a UDM entity. The SMS waiting context may be information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery.

[0042] According to a tenth aspect of the disclosure, there is provided a communication system. The communication system may comprise a UDM entity and a UDR entity. The UDM entity may be configured to transmit an HTTP request to the UDR entity to maintain an SMS waiting context at the UDR entity for a terminal device. The SMS waiting context may be information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery. The UDR entity may be configured to maintain, for the terminal device, the SMS waiting context in response to the HTTP request from the UDM entity.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] These and other objects, features and advantages of the disclosure will become apparent from the following detailed description of illustrative embodiments thereof, which are to be read in connection with the accompanying drawings.

[0044] FIG. **1** is a diagram illustrating the non-roaming architecture for SMS over NAS;

[0045] FIG. **2** is a diagram illustrating the non-roaming architecture for SMS over NAS in reference point representation;

[0046] FIG. **3** is a diagram illustrating the roaming architecture for SMS over NAS;

[0047] FIG. **4** is a diagram illustrating the roaming architecture for SMS over NAS in reference point representation;

[0048] FIG. **5** is a diagram illustrating an exemplary communication system into which an embodiment of the disclosure is applicable;

[0049] FIG. **6** is a flowchart illustrating a method implemented at a UDM entity according to an embodiment of the disclosure;

[0050] FIG. **7** is a flowchart for explaining the method of FIG. **6**;

[0051] FIG. **8** is a flowchart for explaining the method of FIG. **6**;

[0052] FIG. **9** is a flowchart illustrating a method implemented at a UDM entity according to an embodiment of the disclosure;

[0053] FIG. **10** is a flowchart illustrating a method implemented at a UDR entity according to an embodiment of the disclosure;

[0054] FIG. **11** is a flowchart illustrating a method implemented at a UDR entity according to an embodiment of the disclosure;

[0055] FIG. **12** is a flowchart illustrating an exemplary process of UE registration with SMS service supported;

[0056] FIGS. **13**A-**13**B are flowcharts illustrating an exemplary process according to an embodiment of the disclosure;

[0057] FIGS. **14**A-**14**B are flowcharts illustrating an exemplary process according to an embodiment of the disclosure;

[0058] FIG. **15** is a diagram illustrating the structure for subscription data according to an embodiment of the disclosure;

[0059] FIG. **16** is a block diagram showing an apparatus suitable for use in practicing some embodiments of the disclosure;

[0060] FIG. **17** is a block diagram showing a UDM entity according to an embodiment of the disclosure; and

[0061] FIG. **18** is a block diagram showing a UDR entity according to an embodiment of the disclosure.

DETAILED DESCRIPTION

[0062] For the purpose of explanation, details are set forth in the following description in order to provide a thorough understanding of the embodiments disclosed. It is apparent, however, to those skilled in the art that the embodiments may be implemented without these specific details or with an equivalent arrangement.

[0063] According to section 4.13.3.9 of 3GPP TS 23.502 V16.3.0, the procedure of unsuccessful mobile terminating SMS delivery re-attempt is defined as follows. If the UE is registered over both 3GPP access and non-3GPP access in the same AMF (i.e. the UE is registered in the same PLMN for both access types): if the MT-SMS delivery over one Access Type has failed, the AMF, based on operator local policy, may re-attempt the MT-SMS delivery over the other Access Type before indicating failure to SMSF; and if the MT-SMS delivery on both Access Types has failed, the AMF shall inform the SMSF immediately.

[0064] If the AMF informs the SMSF that it cannot deliver the MT-SMS to the UE, the SMSF sends a failure report to the first SMS-GMSC (which can be co-located with IP-SM-GW or SMS Router) as defined in TS 23.040. If the SMS-GMSC has more than one entity for SMS transport towards the UE, then upon receiving MT-SMS failure report, the SMS-GMSC, based on operator local policy, may re-attempt the MT-SMS delivery via the other entity.

[0065] After the first SMS-GMSC informs the UDM/home subscriber server (HSS) that the UE is not able to receive MT-SMS, the UDM shall set its internal URRP-

AMF flag. If the UE is registered in an AMF and the UDM has not subscribed to UE Reachability Notification in the AMF yet, the UDM immediately initiates a subscription procedure as specified in clause 4.2.5.2. When the AMF detects UE activities, it notifies UDM with UE Activity Notification as described in clause 4.2.5.3. The UDM clears its URRP-AMF flag and alerts related SCs to retry MT-SMS delivery.

[0066] When the SMS-GMSC requests routing information from UDM for a UE not registered in the 5th generation core (5GC), or for a registered UE which has not been yet registered for SMS service, the UDM responds to the SMS-GMSC that the UE is absent, stores the SC address in the MWD list (if not yet stored) and indicates that to the SC as defined in TS 23.040. The UDM also sets an internal SMSF registration notification flag to notify the SC upon subsequent SMSF registration for the UE. When the UDM receives an Nudm_UECM_Registration Request from an SMSF for a UE for which the SMSF registration notification flag is set, the UDM clears the flag and alerts the related SCs to retry the MT-SMS delivery. Note that this scenario assumes that the UE is not in 2G/3G/4G coverage.

[0067] With the introduction of the 5G service-based architecture (SBA) in the packet-based core network and UDR as a common back-end repository, network functions (NFs) could be implemented as stateless front-end and its needed states and context across sessions are stored in the UDR. The UDR Resource Model for Nudr application programming interface (API) is described in section 5.2.1 of 3GPP TS 29.505 V16.1.0. FIG. 5.2.1-1 and FIG. 5.2.1-2 of this technical specification show the resource uniform resource identifier (URI) sub-level structure for subscription data. Table 5.2.1-1 of this technical specification provides an overview of the resources and applicable HTTP methods.

[0068] To support unsuccessful mobile terminating SMS (MT-SMS) delivery re-attempt, UDM at one side needs to support the UE reachability event monitoring if the failure reason is UE not present or to be ready for notification if the failure reason is memory exceeding at client side. At the other side, when get notification of UE reachable event and memory available event, UDM needs to alert the SMS-SC to re-attempt the MT-SMS delivery which has failed before. Since there exists a certain period of time between the time point when the UDM knows the failure of the SMS delivery and the time point when the UDM knows the re-attempt can be started, the MT-SMS waiting context should be stored somewhere for stateless UDM to access. However, from the latest Nudr API depicted in FIG. 5.2.1-1 and FIG. 5.2.1-2 of 3GPP TS 29.505 V16.1.0, SMS waiting context data for 5G SMS service is not supported by UDR. So the unsuccessful MT-SMS delivery re-attempt does not really work in a 5GC deployment. It is even worse when it is for vertical customers who do not have legacy generation of mobile networks deployed yet.

[0069] The present disclosure proposes an improved solution for SMS delivery. Hereinafter, the solution will be described in detail with reference to FIGS. **5-18**.

[0070] FIG. **5** is a diagram showing an exemplary communication system into which an embodiment of the disclosure is applicable. As shown, the communication system comprises a UE, a (radio) access network ((R)AN), a user plane function (UPF), a data network (DN), an access and mobility management function (AMF), a session management function (SMF), a policy control function (PCF), an application function (AF), a short message service function (SMSF), a network slice selection function (NSSF), an authentication server function (AUSF), a unified data management (UDM) and a unified data repository (UDR). The functional description of the above entities is specified in clause 6 of 3GPP TS 23.501 V16.3.0, which is incorporated herein by reference in its entirety.

[0071] Note that the term UE used herein may also be referred to as, for example, terminal device, access terminal, mobile station, mobile unit, subscriber station, or the like. It may refer to any end device that can access a wireless communication network and receive services therefrom. By way of example and not limitation, the UE may include a portable computer, an image capture terminal device such as a digital camera, a gaming terminal device, a music storage and playback appliance, a mobile phone, a cellular phone, a smart phone, a tablet, a wearable device, a personal digital assistant (PDA), or the like.

[0072] In an Internet of things (IoT) scenario, a UE may represent a machine or other device that performs monitoring and/or measurements, and transmits the results of such monitoring and/or measurements to another UE and/or a network equipment. In this case, the UE may be a machine-to-machine (M2M) device, which may, in a 3GPP context, be referred to as a machine-type communication (MTC) device. Particular examples of such machines or devices may include sensors, metering devices such as power meters, industrial machineries, bikes, vehicles, or home or personal appliances, e.g. refrigerators, televisions, personal wearables such as watches, and so on.

[0073] As used herein, the term "communication system" refers to a system following any suitable communication standards, such as the first generation (1G), 2G, 2.5G, 2.75G, 3G, 4G, 4.5G, 5G communication protocols, and/or any other protocols either currently known or to be developed in the future. Furthermore, the communications between a terminal device and a network node in the communication system may be performed according to any suitable generation communication protocols, including, but not limited to, 1G, 2G, 2.5G, 2.75G, 3G, 4G, 4.5G, 5G communication protocols, and/or any other protocols either currently known or to be developed in the future. In addition, the specific terms used herein do not limit the present disclosure only to the communication system related to the specific terms, which however can be more generally applied to other communication systems.

[0074] FIG. **6** is a flowchart illustrating a method implemented at a UDM entity according to an embodiment of the disclosure. At block **602**, the UDM entity maintains an SMS waiting context for a terminal device. The SMS waiting context is information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery. In this way, when the re-attempt of the MT SMS delivery can be started, it can be triggered by the UDM entity since the SMS waiting context is maintained.

[0075] For example, the SMS waiting context for the terminal device may contain, but not limited to, at least one of: a list of an address of the at least one SMS-SC; a list of an expiry time of the at least one SMS-SC until which the re-attempt of the MT SMS delivery by the at least one SMS-SC is valid; a first indicator indicating that a reason for the failure of the MT SMS delivery is the terminal device being not reachable; a second indicator indicating that the

reason for the failure of the MT SMS delivery is a memory capacity of the terminal device being exceeded; a third indicator indicating a reason for the re-attempt of the MT SMS delivery; a first time point until which the re-attempt of the MT SMS delivery is valid; and a second time point until which the second indicator is valid. The third indicator may have a first value indicating that the terminal device is reachable for the re-attempt, and/or a second value indicating that the terminal device has available memory for the re-attempt.

[0076] As an option, the SMS waiting context may be maintained at a UDR entity in response to a request from the UDM entity. For example, the SMS waiting context may be maintained by interacting with the UDR entity through at least one of: querying the UDR entity for an SMS waiting context for the terminal device; creating an SMS waiting context for the terminal device; and updating the SMS waiting context for the terminal device. As an exemplary example, the querying may be performed by sending an HTTP GET request to the UDR entity. The creating may be performed by sending an HTTP PUT request to the UDR entity. The updating may be performed by sending an HTTP PUT or PATCH request to the UDR entity. As another option, it is also possible that the UDM entity has a storage component with a function similar to the UDR entity such that the SMS waiting context is maintained within the UDM entity itself.

[0077] For example, the maintaining at block **602** may be performed in response to the UDM entity being informed about a failure of the MT SMS delivery, or in response to an event indicating that the re-attempt can be started. Depending on different conditions, block **602** may be implemented as blocks **708** and **710**, or blocks **708** and **712**, or blocks **814** and **816**. At block **708**, in response to being informed about a failure of the MT SMS delivery, the UDM entity queries the UDR entity for an SMS waiting context for the terminal device. As a first example, the UDM entity may be informed that the reason for the failure of the MT SMS delivery is the terminal device being not reachable. As a second example, the UDM entity may be informed that the reason for the failure of the MT SMS delivery is the memory capacity of the terminal device being exceeded.

[0078] If there has been no SMS waiting context stored at the UDR entity for the terminal device, the UDM entity creates an SMS waiting context at the UDR entity for the terminal device at block **710**. On the other hand, if there has been an SMS waiting context stored at the UDR entity for the terminal device and the failure of the MT SMS delivery relates to a different SMS-SC than that of the SMS waiting context, the UDM entity updates the SMS waiting context at the UDR entity for the terminal device at block **712**. For the above first example, the created or updated SMS waiting context may contain the first indicator. For the above second example, the created or updated SMS waiting context may contain the second indicator.

[0079] At block **814**, in response to an event indicating that the re-attempt can be started, the UDM entity queries the UDR entity for the SMS waiting context for the terminal device. As a third example, the event may be the UDM entity being informed that the terminal device is reachable. As a fourth example, the event may be the UDM entity being informed that the terminal device has available memory for the re-attempt. At block **816**, the UDM entity updates the SMS waiting context at the UDR entity for the terminal device. For the above third example, it is possible that the queried SMS waiting context contains the first indicator and does not contain the second indicator. In this case, the SMS waiting context may be updated at the UDR entity by deleting the first indicator from the SMS waiting context. Note that the term "deleting" may refer to the first indicator being set to an opposite value when the first indicator can have two opposite values (e.g. TRUE and FALSE) to indicate opposite conditions.

[0080] For the above fourth example, it is possible that the queried SMS waiting context contains the second indicator and does not contain the first indicator. In this case, the SMS waiting context may be updated at the UDR entity by deleting the second indicator from the SMS waiting context. For the above third and fourth examples, it is also possible that the queried SMS waiting context does not contain the first indicator and the second indicator. In this case, the SMS waiting context may be updated at the UDR entity by adding the third indicator and the first time point into the SMS waiting context. The third indicator may have the first value (indicating that the terminal device is reachable for the re-attempt) for the third example, and the second value (indicating that the terminal device has available memory for the re-attempt) for the fourth example.

[0081] FIG. **9** is a flowchart illustrating a method implemented at a UDM entity according to an embodiment of the disclosure. As shown, the method comprises block **602**, **904** and **906**. Note that the dotted block may be an optional block. Block **602** has been described above and its details are omitted here. At block **904**, the UDM entity alerts the at least one SMS-SC that the re-attempt of the MT SMS delivery can be started for the terminal device, based on the maintained SMS waiting context. For example, block **904** may be performed in response to the UDM entity being informed that the terminal device is reachable or the terminal device has available memory for the re-attempt. At least the list of the address of the at least one SMS-SC may be used for alerting the at least one SMS-SC. With the method comprising blocks **602** and **904**, the re-attempt of the SMS delivery can be supported by the UDM entity.

[0082] Optionally, at block **906**, the UDM entity deletes the maintained SMS waiting context after alerting the at least one SMS-SC. In the case where the SMS waiting context is maintained at the UDR entity, the maintained SMS waiting context may be deleted from the UDR entity. As an exemplary example, the deleting may be performed by sending an HTTP DELETE request to the UDR entity. In the case where the SMS waiting context is maintained within the UDM entity itself, the SMS waiting context may be simply deleted by the UDM entity.

[0083] FIG. **10** is a flowchart illustrating a method implemented at a UDR entity according to an embodiment of the disclosure. At block **1002**, the UDR entity maintains, for a terminal device, an SMS waiting context in response to a request from a UDM entity. The SMS waiting context is information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery. With the method of FIG. **10**, it is possible for the UDM entity to trigger the re-attempt of the MT SMS delivery since the SMS waiting context is maintained.

[0084] The details of the SMS waiting context have been described above and thus are omitted here. The SMS waiting context may be maintained by at least one of: responding to

a query from the UDM entity for an SMS waiting context for the terminal device; creating an SMS waiting context for the terminal device; and updating the SMS waiting context for the terminal device. As an exemplary example, the query may be an HTTP GET request. The creating may be performed by receiving an HTTP PUT request from the UDM entity. The updating may be performed by receiving an HTTP PUT or PATCH request from the UDM entity.

[0085] FIG. **11** is a flowchart illustrating a method implemented at a UDR entity according to an embodiment of the disclosure. As shown, the method comprises blocks **1002** and **1104**. At block **1104**, the UDR entity deletes the maintained SMS waiting context in response to another request from the UDM entity. As an exemplary example, the deleting may be performed by receiving an HTTP DELETE request from the UDM entity.

[0086] Based on the above, at least one aspect of the disclosure provides a method implemented in a communication system including a UDM entity and a UDR entity. The method comprises maintaining, by the UDM entity, an SMS waiting context at the UDR entity for a terminal device. The SMS waiting context is information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery. The UDR entity maintains, for the terminal device, the SMS waiting context in response to a request from the UDM entity.

[0087] Correspondingly, at least one aspect of the disclosure provides a communication system comprising a UDM entity and a UDR entity. The UDM entity is configured to maintain an SMS waiting context at the UDR entity for a terminal device. The SMS waiting context is information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery. The UDR entity is configured to maintain, for the terminal device, the SMS waiting context in response to a request from the UDM entity.

[0088] For better understanding of the disclosure, a process of UE registration in 5G core network with SMS service supported will be described with reference to FIG. **12**. As shown, this process involves a UE, an access network (AN), an AMF, an SMSF, a UDM and a UDR. Once the UE registration succeeds, then there is a registration context stored in the UDR which could be queried if there is pending MT-SMS for delivering to the UE, as depicted in step **3** of FIG. **13**A and FIG. **14**A.

[0089] At step **1**, during 5G UE registration procedure, to enable SMS over NAS transporting, the UE includes an "SMS supported" indication in Registration Request indicating the UE's capability for SMS over NAS transporting. The "SMS supported" indication indicates whether the UE supports SMS delivery over NAS. At step **2**, the AMF discovers a UDM for AMF registration. At steps **3-5**, the AMF registers into the UDM either for 3GPP access or for non-3GPP access. The registration context is also stored into the UDR. At step **6**, if the "SMS supported" indication is included in the Registration Request, the AMF checks SMS subscription data from the UDM for the UE on whether the SMS service is subscribed by the UE. At step **7**, the AMF subscribes to data change notification for SMS subscription data.

[0090] At step **8**, if SMS service is subscribed and the UE context does not include an available SMSF of the serving PLMN, the AMF discovers and selects an SMSF to serve the UE. At step **9**, the AMF invokes Nsmsf_SMService_Activate service operation from the SMSF. The invocation includes AMF address, Access Type, radio access technology (RAT) type, Trace requirements, generic public subscription identifier (GPSI) (if available) and subscription permanent identifier (SUPI). The AMF uses the SMSF address derived from step **8**.

[0091] At step **10**, the SMSF discovers a UDM for SMSF registration. If the UE context already exists in the SMSF, the SMSF shall replace the old AMF address with the new AMF address. Otherwise, at step **11**, the SMSF registers with the UDM using Nudm_UECM_Registration with Access Type (3GPP/non-3GPP). At step **12**, the UDM stores the SMSF registration context into the UDR. At step **13**, the UDM answers the SMSF for the SMSF registration request. At step **14**, the SMSF retrieves SMS management subscription data using Nudm_SDM_Get (the UDM may get this information from the UDR by Nudr_DR_Query) and the SMSF also creates a UE context to store the SMS management subscription information and the AMF address that is serving this UE. At step **15**, the SMSF subscribes to be notified when the SMS management subscription data is modified (the UDM may subscribe to notifications from the UDR by Nudr_DR_Subscribe).

[0092] At step **16**, the SMSF responds back to the AMF with Nsmsf_SMService_Activate service operation response message. The AMF stores the SMSF address received as part of the UE context. At step **17**, the AMF includes the "SMS allowed" indication to the UE in the Registration Accept message if the AMF has received a positive indication from the selected SMSF. The "SMS allowed" indication in the Registration Accept message indicates to the UE whether the network allows the SMS message delivery over NAS.

[0093] FIGS. **13A-13B** illustrate an exemplary process according to an embodiment of the disclosure. It corresponds to a use case for MT-SMS re-attempt after a failure of absent subscriber. As shown, the process involves a UE, an AN, an AMF, an SMSF, a UDM, a UDR, an SMS-IWMSC, an SMS-GMSC and an SMS-SC. At step **1**, the SMS-SC has pending SMS to be sent to a target UE, so it sends the message to an SMS entity SMS-GMSC. At step **2**, the SMS-GMSC queries the current SMS serving node for the target UE (the identity thereof could be MSISDN or IMSI) from the UDM. In 5G domain, the serving SMS node is an SMSF. The UE registration procedure in 5G has been described above with reference to FIG. **12**. At step **3**, the UDM queries the current SMS serving node for the target UE from the UDR. Suppose the UE has registered before into 5G domain. Then, an SMSF address is returned by the UDR. At step **4**, the UDM answers the SMS entity SMS-GMSC of the serving SMSF address for the target UE. At step **5**, the SMS-GMSC forwards the MT-SMS to the SMSF address get in step **4**.

[0094] At step **6**, the SMSF executes the MT-SMS over NAS delivery procedure, which may further trigger UE paging if the UE is not in connected state. The delivery may succeed or fail depends on the UE connectivity state in the network or the memory state on the UE. In this process, suppose the SMS delivery fails because the UE is absent in the network. Then, at step **7**, the SMSF forwards an MT-SMS delivery report to the SMS-GSMC and the SMS-SC. The failure indicator indicates a failure reason of Absent Subscriber. At step **8**, the SMS-GMSC reports the MT-SMS

delivery status to the UDM. The failure reason included in the message is Absent Subscriber. At step **9**, the UDM checks the failure reason, then based on the failure of Absent Subscriber, starts the Absent Subscriber Failure Handling.

[0095] At step **10**, the UDM queries the UDR whether there is an existing SMS waiting context for the target UE. Because this is not supported by the UDR in the prior art, this message is based on our proposed new GET method. If there is not any SMS waiting context existed before, the UDM creates and stores the SMS waiting context for the UE in the UDR at step **11**. Because this is not supported by the UDR in the prior art, this message is based on our proposed new PUT method. In the message body, a mobile not reachable flag (MNRF) is set to true to indicate the failure reason of Absent Subscriber. On the other hand, if there is an existing SMS waiting context before for the same failure reason, the UDM checks whether this is for a new SMS-SC address. If this is a failure for a new SMS-SC address, then the UDM updates the SMS waiting context for the target UE at step **12** by adding the new SMS-SC address. Because this is not supported by the UDR in the prior art, this message is based on our proposed new PATCH method for delta update or based on our proposed new PUT method for full update. At step **13**, the UDM answers the SMS-GMSC for the report SM delivery status request at step **8**.

[0096] If UE reachability for SMS event has not been subscribed before, the UDM subscribes the UE reachability for SMS event from the AMF based on its exposed interfaces Namf_EventExposure_Subscribe at step **14**. Sometime later, the UE becomes reachable again for SMS at step **15**, for example within a good coverage area. At step **16**, once detecting that the UE is reachable for SMS, the AMF notifies the UDM this reachable for SMS event by Namf_EventExposure_Notify.

[0097] At step **17**, the UDM queries the UDR for the SMS waiting context of the target UE. Because this is not supported by the UDR in the prior art, this message is based on our proposed new GET method. If the MNRF is true and memory capacity exceeding flag (MCEF) is false, then the UDM updates the SMS waiting context stored in the UDR to set the MNRF flag to false at step **18**. Because this is not supported by the UDR in the prior art, this message is based on our proposed new PATCH method for delta update or based on our proposed new PUT method for full update. For each SMS-SC address stored in the SMS waiting context, the UDM sends the alert service center message to the SMS-SC through the SMS-IWMSC at step **19**, with an alert reason to indicate a desired SMS delivery re-attempt because of MS present. Once receiving the alert message, the SMS-SC could trigger the SMS redelivery procedure. If all alert service center messages have been sent, then the UDM deletes the message waiting context for the target UE from the UDR at step **20**. Because this is not supported by the UDR in the prior art, this message is based on our proposed new DELETE method.

[0098] If the MNRF is false and MCEF is false, then the UDM updates the SMS waiting context stored in the UDR at step **21**. The update is on the re-attempt reason as MS present and the valid time for the re-attempt. Because this is not supported by the UDR in the prior art, this message is based on our proposed new PATCH method for delta update or based on our proposed new PUT method for full update.

[0099] FIGS. **14**A-**14**B illustrate an exemplary process according to an embodiment of the disclosure. It corresponds to a use case for MT-SMS re-attempt after a failure of memory exceeding. Similar to FIGS. **13**A-**13**B, the process involves a UE, an AN, an AMF, an SMSF, a UDM, a UDR, an SMS-IWMSC, an SMS-GMSC and an SMS-SC. At step **1**, the SMS-SC has pending SMS to be sent to a target UE, so it sends the message to an SMS entity SMS-GMSC. At step **2**, the SMS-GMSC queries the current SMS serving node for the target UE (the identity thereof could be MSISDN or IMSI) from the UDM. In 5G domain, the serving SMS node is an SMSF. The UE registration procedure in 5G has been described above with reference to FIG. **12**. At step **3**, the UDM queries the current SMS serving node for the target UE from the UDR. Suppose the UE has registered before into 5G domain. Then, an SMSF address is returned by the UDR. At step **4**, the UDM answers the SMS entity SMS-GMSC of the serving SMSF address for the target UE. At step **5**, the SMS-GMSC forwards the MT-SMS to the SMSF address get in step **4**.

[0100] At step **6**, the SMSF executes the MT-SMS over NAS delivery procedure, which may further trigger UE paging if the UE is not in connected state. The delivery may succeed or fail depends on the UE connectivity state in the network or the memory state on the UE. In this process, suppose the SMS delivery fails because the UE's memory capacity is exceeded. Then, at step **7**, the SMSF forwards an MT-SMS delivery report to the SMS-GSMC and the SMS-SC. The failure indicator indicates a failure reason of Memory Exceeding. At step **8**, the SMS-GMSC reports the MT-SMS delivery status to the UDM. The failure reason included in the message is Memory Exceeding. At step **9**, the UDM checks the failure reason, then based on the failure of Memory Exceeding, starts the Memory Exceeding Failure Handling.

[0101] At step **10**, the UDM queries the UDR whether there is an existing SMS waiting context for the target UE. Because this is not supported by the UDR in the prior art, this message is based on our proposed new GET method. If there is not any SMS waiting context existed before, the UDM creates and stores the SMS waiting context for the UE in the UDR at step **11**. Because this is not supported by the UDR in the prior art, this message is based on our proposed new PUT method. In the message body, a mobile memory exceeding flag (MCEF) is set to true to indicate the failure reason of Memory Exceeding. On the other hand, if there is an existing SMS waiting context before for the same failure reason, the UDM checks whether this is for a new SMS-SC address. If this is a failure for a new SMS-SC address, then the UDM updates the SMS waiting context for the target UE at step **12** by adding the new SMS-SC address. Because this is not supported by the UDR in the prior art, this message is based on our proposed new PATCH method for delta update or based on our proposed new PUT method for full update. At step **13**, the UDM answers the SMS-GMSC for the report SM delivery status request at step **8**.

[0102] Sometime later, the UE memory becomes available again for SMS at step **14**, for example more memory is freed on the UE, and this state is reported to the network by the UE. At step **15**, the UDM queries the UDR for the SMS waiting context of the target UE. Because this is not supported by the UDR in the prior art, this message is based on our proposed new GET method. If the MCEF is true and MNRF is false, then the UDM updates the SMS waiting context stored in the UDR to set the MCEF flag to false at step **16**. Because this is not supported by the UDR in the

prior art, this message is based on our proposed new PATCH method for delta update or based on our proposed new PUT method for full update. For each SMS-SC address stored in the SMS waiting context, the UDM sends the alert service center message to the SMS-SC through the SMS-IWMSC, with an alert reason to indicate a desired re-attempt because of UE memory available. Once receiving the alert message, the SMS-SC could trigger the SMS redelivery procedure. If all alert service center messages have been sent, then the UDM deletes the message waiting data for the target UE from the UDR at step **18**. Because this is not supported by the UDR in the prior art, this message is based on our proposed new DELETE method.

[0103] If the MCEF is false and MNRF is false, then the UDM updates the SMS waiting context stored in the UDR at step **19**. The update is on the re-attempt reason as memory available and the valid time for the re-attempt. Because this is not supported by the UDR in the prior art, this message is based on our proposed new PATCH method for delta update or based on our proposed new PUT method for full update.

[0104] According to the above exemplary processes, to solve the problem in the prior art that SMS waiting context data for 5G SMS service re-attempt use cases is not supported by UDR, a novel method is introduced between UDM and UDR to manage the SMS waiting context for re-attempt. Thereby, with the help of the new method, the unsuccessful MT-SMS delivery re-attempt could be really supported in a 5GC deployment.

[0105] Based on the above description, the following changes are proposed to be made to the current technical specifications. Firstly, a new UDR interface and corresponding resources are proposed for management of the MT-SMS waiting context for re-attempt. FIG. **15** shows this proposal for the new UDR interface for MT-SMS waiting context. As shown, the resource URI sub-level structure for subscription data is updated with "/sms-waiting" under "/context-data", compared to FIG. 5.2.1-1 of 3GPP TS 29.505 V16.1.0. This update is highlighted by a box drawn with thick lines.

[0106] The following Table 1 shows the proposal for UDR Resources and methods overview. The updates are underlined compared to Table 5.2.1-1 of 3GPP TS 29.505 V16.1.0.

TABLE 1

Resources and methods overview (added with SmsWaitingContext resource compared to Table 5.2.1-1 of 3GPP TS 29.505 V16.1.0)

Resource name	Resource URI	HTTP method	Description
AuthenticationSubscription	/subscription-data/{ueId}/authentication-data/authentication-subscription	GET	Retrieve a UE's authentication subscription data
		PATCH	Update a UE's authentication subscription data Updates shall be limited to the sequenceNumber attribute. Attempts to patch any other attribute shall be rejected by the UDR.
AuthenticationSoR	/subscription-data/{ueId}/ue-update-confirmation-data/sor-data	PUT	Store UE's SOR acknowledgement information (SoR-XMAC-IUE)
		GET	Retrieve UE's SoR acknowledgement information
AuthenticationUPU	/subscription-data/{ueId}/ue-update-confirmation-data/upu-data	PUT	Store UE Parameter Update acknowledgement information (UPU-XMAC-IUE)
		GET	Retrieve UE Parameter Update acknowledgement information
SubscribedSNSSAIs	/subscription-data/{ueId}/ue-update-confirmation-data/subscribed-snssais	PUT	Store UE-acknowledgement info for change of subscribed S-NSSAIs
		GET	Retrieve UE-acknowledgement info for change of subscribed S-NSSAIs
SubscribedCAG	/subscription-data/{ueId}/ue-update-confirmation-data/subscribed-cag	PUT	Store UE-acknowledgement info for change of subscribed CAG

TABLE 1-continued

Resources and methods overview (added with SmsWaitingContext resource compared to Table 5.2.1-1 of 3GPP TS 29.505 V16.1.0)

Resource name	Resource URI	HTTP method	Description
		GET	Retrieve UE-acknowledgement info for change of subscribed CAG
AuthenticationStatus	/subscription-data/{ueId}/authentication-data/authentication-status	PUT	Store a UE's authentication status
		GET	Retrieve a UE's authentication status
ProvisionedData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data	GET	Retrieve the UE's subscribed Provisioned Data
AccessAndMobility-SubscriptionData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/am-data	GET	Retrieve the UE's subscribed Access and Mobility Data
SmfSelection-SubscriptionData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/smf-selection-subscription-data	GET	Retrieve the UE's subscribed SMF Selection Data
SessionManagement-SubscriptionData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/sm-data	GET	Retrieve the UE's subscribed SM Subscription Data
ContextData	/subscription-data/{ueId}/context-data	GET	Retrieve the UE's context Data
Amf3GppAccess-Registration	/subscription-data/{ueId}/context-data/amf-3gpp-access	PUT	Create and Update the AMF registration for 3GPP access
		PATCH	Modify the AMF registration for 3GPP access
		GET	Retrieve the AMF registration information for 3GPP access
AmfNon3GppAccess-Registration	/subscription-data/{ueId}/context-data/amf-non-3gpp-access	PUT	Update the AMF registration for non 3GPP access
		PATCH	Modify the AMF registration for non 3GPP access
		GET	Retrieve the AMF registration information for non 3GPP access
SmfRegistrations	/subscription-data/{ueId}/context-data/smf-registrations	GET	Retrieve the list of the SMF registrations
IndividualSmfRegistration	/subscription-data/{ueId}/context-data/smf-registrations/{pduSessionId}	PUT	Store an individual SMF registration identified by PDU Session Id
		DELETE	Delete an individual SMF registration
		GET	Retrieve individual SMF registration
OperatorSpecificData	/subscription-data/{ueId}/operator-specific-data	GET	retrieve the operator specific subscription data of a UE
		PATCH	modify the operator specific subscription data of a UE
OperatorDetermined-BarringData	/subscription-data/{ueId}/operator-determined-barring-data	GET	Retrieve the UE's Operator Determined Barring
SMSManagement-SubscriptionData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/sms-mng-data	GET	Retrieve the UE's subscribed SMS management subscription data.
Smsf3GppAccess-Registration	/subscription-data/{ueId}/context-data/smsf-3gpp-access	PUT	Create or Update the SMSF registration
		DELETE	Delete the SMSF registration for 3GPP access

TABLE 1-continued

Resources and methods overview (added with SmsWaitingContext resource compared to Table 5.2.1-1 of 3GPP TS 29.505 V16.1.0)

Resource name	Resource URI	HTTP method	Description
		GET	Retrieve the SMSF registration information
SmsfNon3GppAccess-Registration	/subscription-data/{ueId}/context-data/smsf-non-3gpp-access	PUT	Create or Update the SMSF registration for non 3GPP access
		DELETE	Delete the SMSF registration for non 3GPP access
		GET	Retrieve the SMSF registration information for non 3GPP access
SmsWaitingContext	/subscription-data/{ueId}/context-data/sms-waiting	PUT	Create/Update an individual MT-SMS waiting context for re-attempt
		DELETE	Delete an individual MT-SMS waiting context for re-attempt
		PATCH	Update an individual MT-SMS waiting context for re-attempt
		GET	Retrieve an individual MT-SMS waiting context for re-attempt
SdmSubscriptions	/subscription-data/{ueId}/context-data/sdm-subscriptions	GET	Retrieve SDM subscriptions
		POST	Create an individual SDM subscription
IndividualSdmSubscription	/subscription-data/{ueId}/context-data/sdm-subscriptions/{subsId}	PUT	Update an individual SDM subscription
		DELETE	Delete an individual SDM subscription
		PATCH	Update an individual SDM Subscription
EeSubscriptions	/subscription-data/{ueId}/context-data/ee-subscriptions	GET	Retrieve EE subscriptions
		POST	Create an EE subscription
IndividualEeSubscription	/subscription-data/{ueId}/context-data/ee-subscriptions/{subsId}	PUT	Update an individual EE subscription
		DELETE	Delete an individual EE subscription
		PATCH	Update an individual EE subscription
AmfSubscriptionInfo	/subscription-data/{ueId}/context-data/ee-subscriptions/{subsId}/amf-subscriptions	PUT	Store information related the a received Amf-EE-Subscription response
		DELETE	Delete the Amf-EE-subscriptions
		GET	Retrieve AMF-subscriptions
		PATCH	Update AMF-subscriptions
EeProfileData	/subscription-data/{ueId}/ee-profile-data	GET	Retrieve the UE's subscribed EE profile data.
ProvisionedParamenterData	/subscription-data/{ueId}/pp-data	PATCH	Update of provisioned parameters.
		GET	Retrieves the UE's provisioned parameters.
SMSSubscriptionData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/sms-data	GET	Retrieve the UE's subscribed SMS subscription data.

TABLE 1-continued

Resources and methods overview (added with SmsWaitingContext resource compared to Table 5.2.1-1 of 3GPP TS 29.505 V16.1.0)

Resource name	Resource URI	HTTP method	Description
SubscriptionData-Subscriptions	/subscription-data/subs-to-notify	GET	Retrieve existing subscriptions
		POST	Create a subscription, i.e. subscribe a node to receive notification for change of data
		DELETE	Deletes multiple subscriptions for a given UE.
IndividualSubscription-DataSubscription	/subscription-data/subs-to-notify/{subsId}	DELETE	Delete the subscription identified by {subsId}, i.e. unsubscribe a node to receive notification for change of data
		PATCH	Update an individual Subscription to notification
EeGroupSubscriptions	/subscription-data/group-data/{ueGroupId}/ee-subscriptions	GET	Retrieve EE subscriptions for groups of UEs
		POST	Create an EE subscription for groups of UEs
IndividualEeGroup-Subscription	/subscription-data/group-data/{ueGroupId}/ee-subscriptions/{subsId}	PUT	Update an individual EE subscription for a group of UEs
		DELETE	Delete an individual EE subscription for a group of UEs
		PATCH	Update an individual EE subscription for a group of UEs
TraceData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/trace-data	GET	Retrieve the UE's trace configuration data
IdentityData	/subscription-data/{ueId}/identity-data	GET	Retrieve identity data that corresponds to the provided ueId
SharedData (Collection)	/subscription-data/shared-data	GET	Retrieve shared data
GroupIdentifiers	/subscription-data/group-data/group-identifiers	GET	Retrieve group identifiers
5GVnGroups	/subscription-data/group-data/5g-vn-groups	GET	Retrieve 5G VN Groups
Individual5GVnGroup	/subscription-data/group-data/5g-vn-groups/{externalGroupId}	PUT	Create a 5G VN Group
		PATCH	Update a 5G VN Group
		DELETE	Delete a 5G VN Group
		GET	Retrieve a 5G VN Group
LcsPrivacySubscriptionData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/lcs-privacy-data	GET	Retrieve the UE's subscribed LCS privacy Subscription Data
LcsMobileOriginated-SubscriptionData	/subscription-data/{ueId}/{servingPlmnId}/provisioned-data/lcs-mo-data	GET	Retrieve the UE's subscribed LCS Mobile Originated Subscription Data
NiddAuthorizationData	/subscription-data/{ueId}/nidd-authorization-data	GET	Retrieve the UE's NIDD Authorization Data

[0107] Secondly, four new service operations are proposed for management of the MT-SMS waiting context for re-attempt: PUT: Create/Update an individual MT-SMS waiting context for re-attempt; DELETE: Delete an individual MT-SMS waiting context for re-attempt; PATCH: Update an individual MT-SMS waiting context for re-attempt; GET: Retrieve an individual MT-SMS waiting context for re-attempt.

[0108] With the new Nudr interface and related service operations introduced, SMS waiting context data for 5G SMS re-attempt can be supported by UDR. Thereby, stateless UDM could work as front-end NF and UDR could work as the back-end common repository to support 5G SMS over NAS service especially for the re-attempt use cases. The unsuccessful MT-SMS delivery re-attempt can be supported in a 5GC deployment, in a private deployment for the vertical customers who do not have legacy generation of mobile networks deployed yet.

[0109] Following (5.2.X) is a change request (CR) proposal for the description of SmsWaitingContext resource and the corresponding four serviceoperations, compared to the latest 3GPP TS 29.505 16.1.0 (2019-12). All the contents are new sections. The expression "5.2.X" means once accepted by 3GPP, this sub-chapter is under 5.2, but X should be decided when get published.

[0110] 5.2.X Resource: SmsWaitingContext

[0111] 5.2.X.1 Description

[0112] This resource represents the dynamic MT-SMS waiting data for a UE. It is created, deleted, updated, or queried by the UDM during the MT-SMS delivery procedures (see clause 4.13.3.9 of 3GPP TS 23.502 [18]).

[0113] This resource is modelled with the Document resource archetype (see clause C.1 of 3GPP TS 29.501 [7]).

[0114] 5.2.X.2 Resource Definition

[0115] Resource URI: {apiRoot}/nudr-dr/<apiVersion>/subscription-data/{ueId}/context-data/sms-waiting

[0116] This resource shall support the resource URI variables defined in table 5.2.X.2-1.

TABLE 5.2.X.2-1

Resource URI variables for this resource	
Name	Definition
apiRoot	See 3GPP TS 29.504 [2] clause 6.1.1
ueId	Represents the Subscription Identifier SUPI or GPSI (see 3GPP TS 23.501 [4] clause 5.9.2) pattern: "^(imsi-[0-9]{5,15}|nai-.+|msisdn-[0-9]{5,15}|extid-[^@]+@[^@]+|.+)$"

[0117] 5.2.X.3 Resource Standard Methods

[0118] 5.2.X.3.1 PUT

[0119] This method shall support the URI query parameters specified in table 5.2.X.3.1-1.

TABLE 5.2.X.3.1-1

URI query parameters supported by the GET method on this resource				
Name	Data type	P	Cardinality	Description
n/a				

[0120] This method shall support the request data structures specified in table 5.2.13.3.1-2 and the response data structures and response codes specified in table 5.2.13.3.1-3.

TABLE 5.2.X.3.1-2

Data structures supported by the PUT Request Body on this resource			
Data type	P	Cardinality	Description
SmsWaitingContext	M	1	The SMS waiting data created for a MT-SMS delivery failure which needs to be re-attempted upon UE reachable event notification or UE memory available event notification

TABLE 5.2.X.3.1-3

Data structures supported by the PUT Response Body on this resource				
Data type	P	Cardinality	Response codes	Description
SmsWaitingContext	M	1	201 Created	Upon success, a response body containing the created SMS waiting context shall be returned.

NOTE:

In addition common data structures as listed in table 5.5-1 are supported.

[0121] 5.2.X.3.2 DELETE

[0122] This method shall support the URI query parameters specified in table 5.2.X.3.2-1.

TABLE 5.2.X.3.2-1

URI query parameters supported by the DELETE method on this resource

Name	Data type	P	Cardinality	Description
n/a				

[0123] This method shall support the request data structures specified in table 5.2.X.3.2-2 and the response data structures and response codes specified in table 5.2.X.3.2-3.

TABLE 5.2.X.3.2-2

Data structures supported by the DELETE Request Body on this resource

Data type	P	Cardinality	Description
n/a			The request body shall be empty.

TABLE 5.2.X.3.2-3

Data structures supported by the DELETE Response Body on this resource

Data type	P	Cardinality	Response codes	Description
n/a			204 No Content	Upon success, an empty response body shall be returned.

NOTE:
In addition common data structures as listed in table 5.5-1 are supported.

[0124] 5.2.X.3.3 PATCH

[0125] This method is used to modify the provisioned parameter data in the UDR.

[0126] This method shall support the URI query parameters specified in table 5.2.X.3.3-1.

TABLE 5.2.X.3.3-1

URI query parameters supported by the PATCH method on this resource

Name	Data type	P	Cardinality	Description
supported-features	SupportedFeatures	O	0 . . . 1	see 3GPP TS 29.500 [4] clause 6.6

[0127] This method shall support the request data structures specified in table 5.2.X.3.3-2 and the response data structures and response codes specified in table 5.2.X.3.3-3.

TABLE 5.2.X.3.3-2

Data structures supported by the PATCH Request Body on this resource

Data type	P	Cardinality	Description
array(PatchItem)	M	1 . . . N	Contains the delta data to the SMS waiting context

TABLE 5.2.X.3.3-3

Data structures supported by the PATCH Response Body on this resource

Data type	P	Cardinality	Response codes	Description
n/a			204 No Content	Upon successful modification there is no body in the response message. (NOTE 2)
PatchResult	M	1	200 OK	Upon success, the execution report is returned. (NOTE 2)

NOTE 1:

In addition common data structures as listed in table 5.5-1 are supported.

(NOTE 2):

If all the modification instructions in the PATCH request have been implemented, the UDR shall respond with 204 No Content response; if some of the modification instructions in the PATCH request have been discarded, and the NF service consumer has included in the supported-feature query parameter the "PatchReport" feature number, the UDR shall respond with PatchResult.

[0128] 5.2.X.3.4 GET

[0129] This method shall support the URI query parameters specified in table 5.2.X.3.4-1.

TABLE 5.2.X.3.4-1

URI query parameters supported by the GET method on this resource

Name	Data type	P	Cardinality	Description
n/a				

[0130] This method shall support the request data structures specified in table 5.2.X.3.4-2 and the response data structures and response codes specified in table 5.2.X.3.4-3.

TABLE 5.2.X.3.4-2

Data structures supported by the GET Request Body on this resource

Data type	P	Cardinality	Description
n/a			

TABLE 5.2.X.3.4-3

Data structures supported by the GET Response Body on this resource

Data type	P	Cardinality	Response codes	Description
SmsWaitingContext	M	1	200 OK	Upon success, a response body containing the SMS waiting context shall be returned.

NOTE:

In addition common data structures as listed in table 5.5-1 are supported.

[0131] The data model proposed by the CR is as following: 5.4.2.X Type: SmsWaitingContext

TABLE 5.4.2.X-1

SmsWaitingContext

Attribute name	Data type	P	Cardinality	Description
scAddressList	array(SmsScAddress)	C	1 . . . N	SMS-SC address list
mnrfIndicator	boolean	O	0 . . . 1	MNRF indicator for the MT-SMS failure reason
mcefIndicator	boolean	O	1 . . . N	MCEF indicator for the MT-SMS failure reason
reattemptReason	MtsmsReattemptReason	O	1 . . . N	The reason for MT-SMS re-attempt
reattemptValidTime	DateTime	O	0 . . . 1	The time point until which MT-SMS re-attempt is valid
mcefValidTime	DateTime	O	0 . . . 1	The time point until which MCEF is valid

[0132] 5.4.2.Y Type: SmsScAddress

TABLE 5.4.2.Y-1

SmsScAddress

Attribute name	Data type	P	Cardinality	Description
scAddress	E164Number	M	0 . . . 1	SMS-SC number address
expireTime	DateTime	O	0 . . . 1	The time point until which MT-SMS re-attempt by the SMS-SC is valid

[0133] 5.4.3.X Enumeration: MtsmsReattemptReason

TABLE 5.4.3.X-1

Enumeration MtsmsReattemptReason

Enumeration value	Description
"MS_PRESENT"	The UE is reachable for MT-SMS re-attempt

TABLE 5.4.3.X-1-continued

Enumeration MtsmsReattemptReason	
Enumeration value	Description
"MEMORY_AVAILABLE"	UE memory is available for MT-SMS re-attempt

[0134] As 5G is based on service-based architecture (SBA) and the interface used between network functions (NFs) are based on service-based interface (SBI), the interface is modeled as open API and defined in yaml files. The following is our CR proposal for the Nudr-Dr open API delta updates:

```
/subscription-data/{ueId}/context-data/sms-waiting:
  put:
    summary: Create/Update an individual MT-SMS waiting context for re-attempt
    operationId: CreateSmsWaitingContext
    tags:
      - SMS Waiting Context (Document)
    parameters:
      - name: ueId
        in: path
        description: UE id
        required: true
        schema:
          $ref: 'TS29571_CommonData.yaml#/components/schemas/VarUeId'
    request Body:
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/SmsWaitingContext'
    responses:
      '201':
        description: Expected response to a valid request
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/SmsWaitingContext'
      default:
        description: Unexpected error
        content:
          application/problem+json:
            schema:
              $ref: 'TS29571_CommonData.yaml#/components/schemas/ProblemDe-
tails'
  delete:
    summary: Delete an individual MT-SMS waiting context for re-attempt
    operationId: DeleteSmsWaitingContext
    tags:
      - SMS Waiting Context (Document)
    parameters:
      - name: ueId
        in: path
        description: UE id
        required: true
        schema:
          $ref: 'TS29571_CommonData.yaml#/components/schemas/VarUeId'
    responses:
      '204':
        description: Upon success, an empty response body shall be returned
      default:
        description: Unexpected error
        content:
          application/problem+json:
            schema:
              $ref: 'TS29571_CommonData.yaml#/components/schemas/ProblemDe-
tails'
  patch:
    summary: Update an individual MT-SMS waiting context for re-attempt
    operationId: UpdateSmsWaitingContext
    tags:
      - SMS Waiting Context (Document)
    parameters:
      - name: ueId
        in: path
        description: pp data for a UE
        required: true
        schema:
          $ref: 'TS29571_CommonData.yaml#/components/schemas/VarUeId'
```

-continued

```
        - name: supported-features
          in: query
          description: Features required to be supported by the target NF
          schema:
            $ref: 'TS29571_CommonData.yaml#/components/schemas/SupportedFeatures'
      request Body:
        content:
          application/json-patch+json:
            schema:
              type: array
              items:
                $ref: 'TS29571_CommonData.yaml#/components/schemas/PatchItem'
        required: true
      responses:
        '204':
          description: Expected response to a valid request
        '200':
          description: Expected response to a valid request
          content:
            application/json:
              schema:
                $ref: 'TS29571_CommonData.yaml#/components/schemas/PatchResult'
        '403':
          description: modification is rejected
          content:
            application/problem+json:
              schema:
                $ref: 'TS29571_CommonData.yaml#/components/schemas/ProblemDe-
tails'
        default:
          description: Unexpected error
          content:
            application/problem+json:
              schema:
                $ref: 'TS29571_CommonData.yaml#/components/schemas/ProblemDe-
tails'
    get:
      summary: Retrieve an individual MT-SMS waiting context for re-attempt
      operationId: QuerySmsWaitingContext
      tags:
        - SMS Waiting Context (Document)
      parameters:
        - name: ueId
          in: path
          description: UE id
          required: true
          schema:
          Sref: 'TS29571_CommonData.yaml#/components/schemas/VarUeId'
      responses:
        '200':
          description: Expected response to a valid request
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/SmsWaitingContext'
        default:
          description: Unexpected error
          content:
            application/problem+json:
              schema:
                $ref: 'TS29571_CommonData.yaml#/components/schemas/ProblemDe-
tails'
```

[0135] FIG. **16** is a block diagram showing an apparatus suitable for use in practicing some embodiments of the disclosure. For example, any one of the UDM entity and the UDR entity described above may be implemented through the apparatus **1600**. As shown, the apparatus **1600** may include a processor **1610**, a memory **1620** that stores a program, and optionally a communication interface **1630** for communicating data with other external devices through wired and/or wireless communication.

[0136] The program includes program instructions that, when executed by the processor **1610**, enable the apparatus **1600** to operate in accordance with the embodiments of the present disclosure, as discussed above. That is, the embodiments of the present disclosure may be implemented at least in part by computer software executable by the processor **1610**, or by hardware, or by a combination of software and hardware.

[0137] The memory **1620** may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, flash memories, magnetic memory devices and systems, optical memory devices and

systems, fixed memories and removable memories. The processor **1610** may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on multi-core processor architectures, as non-limiting examples.

[0138] FIG. **17** is a block diagram showing a UDM entity according to an embodiment of the disclosure. As shown, the UDM entity **1700** comprises a maintaining module **1702** configured to maintain an SMS waiting context for a terminal device, as described above with respect to block **602**. The SMS waiting context is information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery.

[0139] FIG. **18** is a block diagram showing a UDR entity according to an embodiment of the disclosure. As shown, the UDR entity **1800** comprises a maintaining module **1802** configured to maintain, for a terminal device, an SMS waiting context in response to a request from a UDM entity, as described above with respect to block **1002**. The SMS waiting context is information related to a re-attempt of an MT SMS delivery from at least one SMS-SC to the terminal device due to a failure of the MT SMS delivery. The modules described above may be implemented by hardware, or software, or a combination of both.

[0140] In general, the various exemplary embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the disclosure is not limited thereto. While various aspects of the exemplary embodiments of this disclosure may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0141] As such, it should be appreciated that at least some aspects of the exemplary embodiments of the disclosure may be practiced in various components such as integrated circuit chips and modules. It should thus be appreciated that the exemplary embodiments of this disclosure may be realized in an apparatus that is embodied as an integrated circuit, where the integrated circuit may comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor, a digital signal processor, baseband circuitry and radio frequency circuitry that are configurable so as to operate in accordance with the exemplary embodiments of this disclosure.

[0142] It should be appreciated that at least some aspects of the exemplary embodiments of the disclosure may be embodied in computer-executable instructions, such as in one or more program modules, executed by one or more computers or other devices. Generally, program modules include routines, programs, objects, components, data structures, etc. that perform particular tasks or implement particular abstract data types when executed by a processor in a computer or other device. The computer executable instructions may be stored on a computer readable medium such as a hard disk, optical disk, removable storage media, solid state memory, RAM, etc. As will be appreciated by one skilled in the art, the function of the program modules may be combined or distributed as desired in various embodiments. In addition, the function may be embodied in whole or in part in firmware or hardware equivalents such as integrated circuits, field programmable gate arrays (FPGA), and the like.

[0143] References in the present disclosure to "one embodiment", "an embodiment" and so on, indicate that the embodiment described may include a particular feature, structure, or characteristic, but it is not necessary that every embodiment includes the particular feature, structure, or characteristic. Moreover, such phrases are not necessarily referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with an embodiment, it is submitted that it is within the knowledge of one skilled in the art to implement such feature, structure, or characteristic in connection with other embodiments whether or not explicitly described.

[0144] It should be understood that, although the terms "first", "second" and so on may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another. For example, a first element could be termed a second element, and similarly, a second element could be termed a first element, without departing from the scope of the disclosure. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed terms.

[0145] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the present disclosure. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises", "comprising", "has", "having", "includes" and/or "including", when used herein, specify the presence of stated features, elements, and/or components, but do not preclude the presence or addition of one or more other features, elements, components and/or combinations thereof. The terms "connect", "connects", "connecting" and/or "connected" used herein cover the direct and/or indirect connection between two elements.

[0146] The present disclosure includes any novel feature or combination of features disclosed herein either explicitly or any generalization thereof. Various modifications and adaptations to the foregoing exemplary embodiments of this disclosure may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings. However, any and all modifications will still fall within the scope of the non-Limiting and exemplary embodiments of this disclosure.

1-32. (canceled)

33. A method performed by a unified data management, UDM, entity, comprising:

transmitting an HTTP request to unified data repository, UDR, entity to maintain a short message service, SMS, waiting context for a terminal device, at the UDR entity, wherein the SMS waiting context is information related to a re-attempt of a mobile terminating, MT,

SMS delivery from at least one SMS service center, SMS-SC, to the terminal device due to a failure of the MT SMS delivery,

wherein the SMS waiting context is maintained by at least one of the following steps:

querying the UDR entity for an SMS waiting context for the terminal device, by sending a hypertext transfer protocol, HTTP, GET request to the UDR entity;

creating an SMS waiting context for the terminal device, by sending an HTTP PUT request to the UDR entity; and

updating the SMS waiting context for the terminal device, by sending an HTTP PUT or PATCH request to the UDR entity, and

wherein the HTTP PUT request comprises the SMS waiting context for the terminal device, and/or wherein the HTTP PATCH request comprises an indication indicating at least one of the SMS waiting context for the terminal device.

34. The method of claim **33**, further comprising receiving an HTTP GET response in response to HTTP GET request, wherein the HTTP GET response comprises the SMS waiting context for the terminal device.

35. The method according to claim **33**, further comprising:

alerting the at least one SMS-SC that the re-attempt of the MT SMS delivery can be started for the terminal device, based on the maintained SMS waiting context.

36. The method according to claim **35**, further comprising:

deleting the maintained SMS waiting context after alerting the at least one SMS-SC.

37. The method according to claim **36**, wherein the maintained SMS waiting context is deleted from a UDR entity.

38. The method according to claim **35**, wherein the deleting is performed by sending an HTTP DELETE request to the UDR entity.

39. The method according to claim **33**, wherein the SMS waiting context for the terminal device contains at least one of:

a list of an address of the at least one SMS-SC;

a list of an expiry time of the at least one SMS-SC until which the re-attempt of the MT SMS delivery by the at least one SMS-SC is valid;

a first indicator indicating that a reason for the failure of the MT SMS delivery is the terminal device being not reachable;

a second indicator indicating that the reason for the failure of the MT SMS delivery is a memory capacity of the terminal device being exceeded;

a third indicator indicating a reason for the re-attempt of the MT SMS delivery;

a first time point until which the re-attempt of the MT SMS delivery is valid; and

a second time point until which the second indicator is valid.

40. The method according to claim **39**, wherein the third indicator have a first value indicating that the terminal device is reachable for the re-attempt, and/or a second value indicating that the terminal device has available memory for the re-attempt.

41. The method according to claim **39**, wherein maintaining the SMS waiting context at the UDR entity for the terminal device comprises:

in response to being informed about a failure of the MT SMS delivery, querying the UDR entity for an SMS waiting context for the terminal device;

when there has been no SMS waiting context stored at the UDR entity for the terminal device, creating an SMS waiting context at the UDR entity for the terminal device; and

when there has been an SMS waiting context stored at the UDR entity for the terminal device and the failure of the MT SMS delivery relates to a different SMS-SC than that of the SMS waiting context, updating the SMS waiting context at the UDR entity for the terminal device.

42. The method according to claim **41**, wherein the UDM entity is informed that the reason for the failure of the MT SMS delivery is the terminal device being not reachable; and

wherein the created or updated SMS waiting context contains the first indicator.

43. The method according to claim **41**, wherein the UDM entity is informed that the reason for the failure of the MT SMS delivery is the memory capacity of the terminal device being exceeded; and

wherein the created or updated SMS waiting context contains the second indicator.

44. The method according to claim **41**, wherein maintaining the SMS waiting context at the UDR entity for the terminal device comprises:

in response to an event indicating that the re-attempt can be started, querying the UDR entity for the SMS waiting context for the terminal device; and

updating the SMS waiting context at the UDR entity for the terminal device.

45. The method according to claim **44**, wherein the event is the UDM entity being informed that the terminal device is reachable;

wherein the queried SMS waiting context contains the first indicator and does not contain the second indicator; and

wherein the SMS waiting context is updated at the UDR entity by deleting the first indicator from the SMS waiting context.

46. The method according to claim **44**, wherein the event is the UDM entity being informed that the terminal device has available memory for the re-attempt;

wherein the queried SMS waiting context contains the second indicator and does not contain the first indicator; and

wherein the SMS waiting context is updated at the UDR entity by deleting the second indicator from the SMS waiting context.

47. The method according to claim **44**, wherein the event is the UDM entity being informed that the terminal device is reachable or has available memory for the re-attempt;

wherein the queried SMS waiting context does not contain the first indicator and the second indicator; and

wherein the SMS waiting context is updated at the UDR entity by adding the third indicator and the first time point into the SMS waiting context.

48. A method performed by a unified data repository, UDR, entity, comprising:

maintaining, for a terminal device, a short message service, SMS, waiting context in response to an HTTP request from a unified data management, UDM, entity, wherein the SMS waiting context is information related to a re-attempt of a mobile terminating, MT, SMS delivery from at least one SMS service center, SMS-SC, to the terminal device due to a failure of the MT SMS delivery,

wherein the SMS waiting context is maintained by at least one of the following steps:

responding to a query from the UDM entity for the SMS waiting context for the terminal device, wherein the query is a hypertext transfer protocol, HTTP, GET request;

creating the SMS waiting context for the terminal device, by receiving an HTTP PUT request from the UDM entity; and

updating the SMS waiting context for the terminal device, by receiving an HTTP PUT or PATCH request from the UDM entity, and

wherein the HTTP PUT request comprises the SMS waiting context for the terminal device, and/or wherein the HTTP PATCH request comprises an indication indicating at least one of the SMS waiting context for the terminal device.

49. The method according to claim **48**, further comprising:

deleting the maintained SMS waiting context in response to another request from the UDM entity.

50. The method according to claim **49**, wherein the deleting is performed by receiving an HTTP DELETE request from the UDM entity.

51. The method according to claim **48**, wherein the SMS waiting context for the terminal device contains at least one of:

a list of an address of the at least one SMS-SC;

a list of an expiry time of the at least one SMS-SC until which the re-attempt of the MT SMS delivery by the at least one SMS-SC is valid;

a first indicator indicating that a reason for the failure of the MT SMS delivery is the terminal device being not reachable;

a second indicator indicating that the reason for the failure of the MT SMS delivery is a memory capacity of the terminal device being exceeded;

a third indicator indicating a reason for the re-attempt of the MT SMS delivery;

a first time point until which the re-attempt of the MT SMS delivery is valid; and

a second time point until which the second indicator is valid.

52. The method according to claim **51**, wherein the third indicator have a first value indicating that the terminal device is reachable for the re-attempt, and/or a second value indicating that the terminal device has available memory for the re-attempt.

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