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(54) **Title**: METHOD AND DEVICE FOR REPORTING DRIVE TEST MEASUREMENTS TO A MOBILE NETWORK

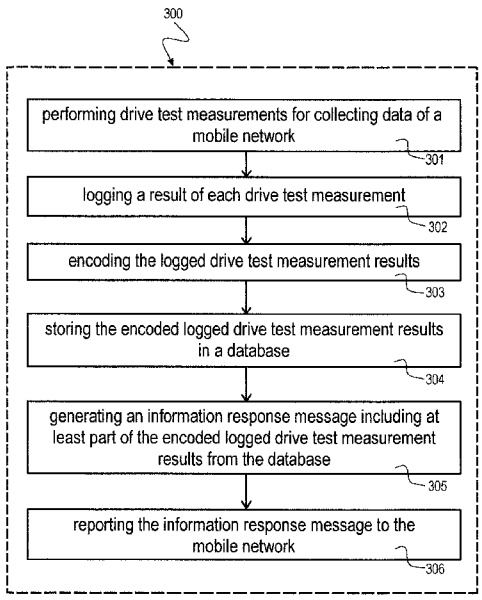


Fig. 3

(57) **Abstract**: A method for reporting drive test measurements to a mobile network includes: performing a plurality of drive test measurements for collecting data of the mobile network; logging a result of each drive test measurement; encoding the logged drive test measurement results; storing the encoded logged drive test measurement results in a database; generating an information response message comprising at least part of the encoded logged drive test measurement results from the database; and reporting the information response message to the mobile network.

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METHOD AND DEVICE FOR REPORTING DRIVE TEST MEASUREMENTS TO A MOBILE NETWORK

FIELD

[0001] The disclosure relates to a method and a device for reporting drive test measurements to a mobile network, in particular Minimization of Drive Tests (MDT) according to a mobile network specification such as 3GPP. In particular, the disclosure relates to logged MDT measurement techniques.

BACKGROUND

[0002] Minimization of Drive Tests (MDT) as shown in Figures 1 and 2 is a 3GPP feature to aid cellular operators to optimize their network (NW) 110 by instructing UEs 120 that support this feature to log certain measurements 102, 104 and report them 102, 106. MDT is for example specified in 3GPP TR 36.805 "Study on Minimization of drive-tests in Next Generation Networks", Version 9.0.0, December 2009 and TS 37.320 Version 11.3.0 "Radio measurement collection for Minimization of Drive Tests (MDT)", March 2013. This feature facilitates reducing complexity and costs of NW optimization for network operators. In LTE, MDT is divided into an immediate MDT mode 101 and a logged MDT mode 103. Immediate MDT mode 101 involves MDT measurements 102 that are performed by the LTE UE 120 in RRC_CONNECTED state 107 and immediately reported 102 in this state. Logged MDT mode 103 involves MDT measurements 104 that are logged by the LTE UE 120 in IDLE state 108 and connected state 107, if configured by the NW 110, and at a later point in time 105 reported 106 to the NW 110 when the NW 110 requests their reporting.

[0003] Due to limited resources in the UE for performing drive test measurements it may be desirable to provide a concept for optimizing memory consumption of drive test measurements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The accompanying drawings are included to provide a further understanding of aspects and are incorporated in and constitute a part of this specification. The drawings illustrate aspects and together with the description serve to explain principles of aspects. Other aspects and many of the intended advantages of aspects will be readily appreciated as they become better understood by reference to the following detailed description. Like reference numerals designate corresponding similar parts.

[0005] Fig. 1 is a schematic diagram of a mobile communication system 100 supporting Minimization of Drive Test (MDT) measurements.

[0006] Fig. 2 is a message sequence diagram 200 illustrating configuration and reporting of LTE logged MDT measurements.

[0007] Fig. 3 is a schematic diagram illustrating an exemplary method 300 for reporting drive test measurements to a mobile network according to the disclosure.

[0008] Fig. 4 is a schematic diagram illustrating an exemplary device 400 for reporting drive test measurements to a mobile network according to the disclosure.

[0009] Fig. 5 is a schematic diagram illustrating an exemplary method 500 for reporting MDT measurements to a mobile network according to the disclosure.

[0010] Fig. 6 is a schematic diagram illustrating an exemplary method 600 for reporting MDT measurements to a mobile network according to the disclosure.

[0011] Fig. 7 is a schematic diagram illustrating an ASN.1 encoded MDT database 700 according to the disclosure.

[0012] Fig. 8 is a schematic diagram illustrating an exemplary structure of an information response message 800 according to an ASN.1 implementation.

DETAILED DESCRIPTION

[0013] In the following detailed description, reference is made to the accompanying drawings, which form a part thereof, and in which is shown by way of illustration specific aspects in which the invention may be practiced. It is understood that other aspects may be utilized and structural or logical changes may be made without departing from the scope of the present invention. The following detailed description, therefore, is not to be taken in a limiting sense, and the scope of the present invention is defined by the appended claims.

[0014] The following terms, abbreviations and notations will be used herein:

MDT:	Minimization of Drive Tests
3GPP:	3rd Generation Partnership Project,

LTE:	Long Term Evolution,
LTE-A:	LTE Advanced, Release 10 and higher versions of 3GPP LTE,
RF:	Radio Frequency,
UE:	User Equipment,
OFDM:	Orthogonal Frequency Division Multiplex,
NodeB, eNB:	base station,
RRC:	Radio Resource Control
RRC_ CONNECTED:	connected state of UE in LTE
IDLE, RRC_IDLE:	idle state of UE in LTE
UL:	uplink
DL:	downlink
PER:	Packet Encoding Rules
DCCH:	Dedicated Control Channel
NW:	Network
PDCP:	Packet Data Convergence Protocol
SU:	Service Unit
ASN.1	Abstract Syntax Notation One
EUTRAN:	Evolved UMTS Terrestrial Radio Access Network

[0015] The methods and devices described herein may be implemented in wireless communication networks, in particular communication networks based on mobile communication standards such as LTE, in particular LTE-A and/or OFDM. The methods and devices described below may further be implemented in a base station or a mobile device (or mobile station or User Equipment (UE)). The described devices may include integrated circuits and/or passives and may be manufactured according to various technologies. For example, the circuits may be designed as logic integrated circuits,

analog integrated circuits, mixed signal integrated circuits, optical circuits, memory circuits and/or integrated passives.

[0016] The methods and devices described herein may be configured to transmit and/or receive radio signals. Radio signals may be or may include radio frequency signals radiated by a radio transmitting device (or radio transmitter or sender) with a radio frequency lying in a range of about 3 Hz to 300 GHz. The frequency range may correspond to frequencies of alternating current electrical signals used to produce and detect radio waves.

[0017] The methods and devices described herein after may be designed in accordance to mobile communication standards such as e.g. the Long Term Evolution (LTE) standard or the advanced version LTE-A thereof. LTE (Long Term Evolution), marketed as 4G, 5G LTE and beyond, is a standard for wireless communication of high-speed data for mobile phones and data terminals.

[0018] The methods and devices described hereinafter may be applied in OFDM systems. OFDM is a scheme for encoding digital data on multiple carrier frequencies. A large number of closely spaced orthogonal sub-carrier signals may be used to carry data. Due to the orthogonality of the sub-carriers crosstalk between sub-carriers may be suppressed.

[0019] The methods and devices described hereinafter may use ASN.1 syntax for encoding measurement results. Abstract Syntax Notation One (ASN.1) is a standard and notation that describes rules and structures for representing, encoding, transmitting, and decoding data in telecommunications and computer networking. The formal rules enable representation

of objects that are independent of machine-specific encoding techniques. Formal notation makes it possible to automate the task of validating whether a specific instance of data representation abides by the specifications, i.e., software tools can be used for the validation. ASN.1 is a joint standard of the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), and International Telecommunication Union Telecommunication Standardization Sector ITU-T. The latest revision of the X.680 series of recommendations is the 5.0 Edition, published in 2015. X.691 specifies ASN.1 Packed Encoding Rules (PER).

[0020] The methods and devices described herein may be based on drive test measurements, in particular MDT measurements. Drive tests are used for collecting data of mobile networks. This data is needed for the configuration and the maintenance of mobile networks. In order to execute drive tests, each device which is active in the network can be used. This concept that is referred to as "Minimization of Drive Test (MDT)" means that standard mobiles are used for measurements to provide data for the operators.

[0021] The methods and devices described herein may be based on MDT measurements, in particular according to the mobile communications specifications 3GPP 36.300 and 3GPP 36.331. 3GPP mandates that an LTE UE 120 allocates a minimum size of 64 Kbytes for storing the Logged MDT measurements 104. The reporting 106 of the Logged MDT measurements 104 to the NW 110 is performed through UL-DCCH(UEInformationResponse) 106b RRC signaling message. Figure 2 shows the signaling between UE 120 and the network "EUTRAN" 110. A configuration message DL-

DCCH(Logged MeasurementConfiguration) 103 from UE 120 to EUTRAN 110 initiates the logging 104 at UE 120. After the logging 104 reporting between UE 120 and EUTRAN 110 is performed via the messages UL-DCCH(UEInformationRequest) 106a and UL-DCCH(UEInformationResponse) 106b.

[0022] 3GPP mandates a minimum of 64 Kbytes of storage for Logged MDT measurements. Regardless of whether an OEM allocates 64Kbytes or more/less, those measurements require a very large foot print, and it is desired to reduce the amount of allocated memory without reducing value/performance. According to the mobile communication specification 3GPP 36.323, LTE UE's PDCP SDU for either control plane or data plane cannot exceed 8188 octets. The number of MDT measurements to be logged cannot exceed 4060 entries according to 3GPP 36.331 Specification's ASN.1 description (i.e. maxLogMeas-r10 INTEGER ::= 4060). Again and according to the same 3GPP Specification above, a single UL-DCCH (UEInformationResponse) sent in UL cannot have the number of entries of logged MDT measurements exceeding 520 (i.e. maxLogMeasReport-r10 INTEGER ::= 520).

[0023] 3GPP has made the database to be used to store the Logged MDT measurements open-ended. Protocol stack chipsets OEMs can use any database as they like. However due to simplicity reasons, most Logged MDT implementations require that the measurements are stored in a database based on C/C++ data structures of the corresponding MDT ASN.1 IEs (Information Elements). These requirements together with the constraints as described above limit the number of entries of MDT measurements that can be logged. This traditional database approach is not optimal in memory.

[0024] It is understood that comments made in connection with a described method may also hold true for a corresponding device configured to perform the method and vice versa. For example, if a specific method step is described, a corresponding device may include a unit to perform the described method step, even if such a unit is not explicitly described or illustrated in the figures. Further, it is understood that the features of the various exemplary aspects described herein may be combined with each other, unless specifically noted otherwise.

[0025] Fig. 3 is a schematic diagram illustrating an exemplary method 300 for reporting drive test measurements to a mobile network according to the disclosure.

[0026] The method 300 includes performing 301 a plurality of drive test measurements for collecting data of the mobile network; logging 302 a result of each drive test measurement; encoding 303 the logged drive test measurement results; storing 304 the encoded logged drive test measurement results in a database; generating 305 an information response message comprising at least part of the encoded logged drive test measurement results from the database; and reporting 306 the information response message to the mobile network.

[0027] The information response message may be generated based on a re-using of the at least part of the encoded logged drive test measurement results as they are stored in the database. The information response message may be generated without further decoding or encoding the encoded logged drive test measurement results as they are stored in the database.

[0028] The method 300 may further include performing the plurality of drive test measurements by a user equipment (UE). The method 300 may further include logging the results of the drive test measurements in a Radio Resource Control (RRC) idle mode of the UE, e.g. according to 3GPP Technical Specification 36.331. Idle mode is the state of the UE when there is no RRC connection established and the UE continues to perform functions such as PLMN selection, cell selection and reselection, reception of system information to enable it to establish RRC connection for signaling and data transfer, e.g. PLMN selection, cell selection and reselection, location registration, reception of system information and to enable the UE to establish an RRC connection for signaling or data transfer as well as be able to receive possible incoming connections via paging. RRC connected means the case where the UE is connected to the network.

[0029] The plurality of drive test measurements may include Minimization of Drive Test (MDT) measurements, e.g. according to 3GPP TR 36.805 "Study on Minimization of drive-tests in Next Generation Networks", Version 9.0.0, December 2009 and TS 37.320 Version 11.3.0 "Radio measurement collection for Minimization of Drive Tests (MDT)", March 2013.

[0030] The logged drive test measurement results may be encoded according to an Abstract Syntax Notation One (ASN.1) specification and according to Packet Encoding Rules for ASN.1, e.g. as defined in ITU-T Specification X.691. Alternatively, the logged drive test measurement results may be encoded by using any other kind of encoder, for example a zip-encoder or a rar-encoder.

[0031] The encoded logged drive test measurement results may be compressed based on Packet Encoding Rules (PER) according to the ASN.1 specification, e.g. as defined in ITU-T Specification X.691. Alternatively, any other compression technique may be used, e.g. according to zip or rar.

[0032] The method 300 may further include: receiving a measurement configuration message from the mobile network, e.g. a DL-DCCH(LoggedMeasurementConfiguration) 103 as described above with respect to Figs. 1 and 2; and initiating the logging of the results of the drive test measurements responsive to receiving the logged measurement configuration message.

[0033] The method 300 may further include: receiving an information request message from the mobile network, e.g. a DL-DCCH(UEInformationRequest) 106a as described above with respect to Fig. 2; and generating and reporting the information response message, e.g. a DL-DCCH(UEInformationResponse) 106b as described above with respect to Fig. 2, responsive to receiving the information request message 106a.

[0034] The method 300 may further include: segmenting the encoded logged drive test measurement results into segmentation blocks; and storing the segmentation blocks in the database. Any size of segmentation blocks may be applied.

[0035] The information response message 106b may have a predetermined format. A size of each segmentation block may be aligned to the format of the information response message, e.g. aligned with structures, e.g. C structures, used for defining the information response message.

[0036] The method 300 may further include: determining a size of information elements (IEs) not related to drive test measurements to be stored in the information response message; and filling a space of the information response message remaining for storage of information elements related to the drive test measurements with at least part of the segmentation blocks stored in the database. Hence, the information response message may include information elements not related to drive test measurements and information elements related to drive test measurements. A format of these IEs related to drive test measurements may be changed with respect to its original definition due to the generation of the information response message based on the encoded logged drive test measurement results.

[0037] The method 300 may further include: adjusting a size of the segmentation blocks to the space of the information response message remaining for storage of information elements related to the drive test measurements. This means that the information response message can be efficiently filled with encoded logged measurement results without leaving an empty space.

[0038] The limit on the PDCP PDU may be predefined, and this introduces a limit on how big the encoded information response message can be. The size of the information respectively message is not predetermined, but may be limited by a standard. The size of the segmentation blocks may be predetermined based on the standardization limit in size of information respectively message.

[0039] The method 300 may further include: creating an ASN.1 encoded information response message comprising a dummy section of logged drive test measurement information elements; and replacing the dummy section with the at least part of the encoded logged drive test measurement results.

[0040] The ASN.1 encoded information response message may be created without optional information elements and without byte alignment. Such optional information elements and byte alignment may be defined in the ASN.1 structures, however these definitions may not be applied for the created ASN.1 encoded information response message according to the disclosure. Further, mandatory information elements of the information response message may have a minimum number of elements according to the ASN.1 specification.

[0041] Fig. 4 is a schematic diagram illustrating an exemplary device 400 for reporting drive test measurements to a mobile network according to the disclosure.

[0042] The device 400 includes a transceiver 401, a data logger 402, an encoder 403, a database 404, a controller 405 and an interface 406 to the mobile network. The transceiver 401 is configured to perform a plurality of drive test measurements 410 for collecting data of the mobile network. The data logger 402 is configured to log a result 411 of each drive test measurement 410. The encoder 403 is configured to encode the logged drive test measurement results 411 to provided encoded logged drive test measurement results 412. The database 404 is configured to store the encoded logged drive test measurement results 412. The controller 405 is configured to generate an information response message 414 comprising at least part of the encoded logged drive test

measurement results 413 from the database 404. The interface 406 to the mobile network is configured to report 415 the information response message 414 to the mobile network. The information response message 414 may correspond to the information response message as described above with respect to Fig. 3 or the UEInformationResponse message as described below with respect to Figs. 6 and 8.

[0043] The information response message may be generated based on a re-using of the at least part of the encoded logged drive test measurement results as they are stored in the database. The information response message may be generated without further decoding or encoding the encoded logged drive test measurement results as they are stored in the database.

[0044] The encoder 403 may be configured to encode the logged drive test measurement results 411 according to an Abstract Syntax Notation One (ASN.1) specification, e.g. as defined in ITU-T Specification X.691. Alternatively, encoder 403 may encode the logged drive test measurement results 411 by using any other kind of encoder, for example a zip-encoder or a rar-encoder.

[0045] The controller 405 may be configured to create an information response message comprising a dummy section of logged drive test measurement information elements, e.g. as described below with respect to Figs. 6 to 8, to encode the information response message according to the ASN.1 specification, and to replace the dummy section with the at least part of the encoded logged drive test measurement results, e.g. as described below with respect to Figs. 6 to 8.

[0046] The controller 405 may be configured to create the information response message without optional information elements and without byte alignment; and to assign mandatory information elements of the information response message a minimum number of elements according to the ASN.1 specification, e.g. as described below with respect to Figs. 6 to 8.

[0047] Fig. 5 is a schematic diagram illustrating an exemplary method 500 for reporting Minimization of Drive Test (MDT) measurements to a mobile network according to the disclosure.

[0048] The method 500 includes: performing 501 a plurality of MDT measurements for collecting data of a mobile network; logging 502 a result of each MDT measurement; encoding 503 the logged MDT measurement results according to an ASN.1 specification; storing 504 the encoded logged MDT measurement results in a database; generating 505 an information response message according to the ASN.1 specification, wherein the information response message comprises a dummy section of MDT measurement results; encoding 506 the information response message according to the ASN.1 specification; replacing 507 the dummy section of MDT measurement results with at least part of the encoded logged MDT measurement results from the database; and reporting 508 the information response message to the mobile network.

[0049] The Minimization of Drive Test (MDT) measurements may be defined according to 3GPP TR 36.805 "Study on Minimization of drive-tests in Next Generation Networks", Version 9.0.0, December 2009 and TS 37.320 Version 11.3.0

"Radio measurement collection for Minimization of Drive Tests (MDT)", March 2013.

[0050] The method 500 may further include: receiving a logged measurement configuration message from the mobile network, e.g. a DL-DCCH(LoggedMeasurementConfiguration) 103 as described above with respect to Figs. 1 and 2; and initiating the logging of the results of the MDT measurements responsive to receiving the measurement configuration message.

[0051] The method 500 may further include: receiving an information request message from the mobile network, e.g. a DL-DCCH(UEInformationRequest) 106a as described above with respect to Fig. 2; and replacing the dummy section and reporting the information response message to the mobile network responsive to receiving the information request message, e.g. an information response message DL-DCCH(UEInformationResponse) 106b as described above with respect to Fig. 2.

[0052] The method 500 may further include: logging the results of the MDT measurements by a user equipment (UE) in a Radio Resource Control (RRC) idle mode of the UE, e.g. as described above with respect to Fig. 3.

[0053] Fig. 6 is a schematic diagram illustrating an exemplary method 600 for optimally storing of MDT measurements and efficiently these measurements to a mobile network according to the disclosure. The method 600 is an implementation of the method 300 as described above with respect to Fig. 3 and can be implemented by a device 400 as described above with respect to Fig. 4. The method 600 may

also be seen as an implementation of the method 500 as described above with respect to Fig. 5.

[0054] The method 600 starts with a first block 601 "perform MDT measurement". In a second block 602 "fill up MDT LOG Meas ASN.1 (LogMeasInfo), results of the MDT measurement are logged. These results are ASN.1 encoded in an eighth block "ASN.1 Encode LOG MDT Meas (LogMeasInfo)" 608 and stored 609 in a database in a tenth block 610 of the method 600. In a third block "Send LOG MDT Meas?" 603 a check is performed if the logged measurement results shall be sent to the mobile network. If the answer is "No", further MDT measurements are performed by jumping to block 601. If the answer is "Yes", in a fourth block "Fill up UL-DCCH (UEInforationResponse), the information response message is filled with some data structures, e.g. data structures as defined by ASN.1 that are not directly related to the MDT measurements. This can be initialization values or parameters describing a measurement environment that is valid for the respective measurement. In a fifth block "ASN.1 encode UL-DCCH (UEInformationResponse), the information response message including the parameters filled by block 604 is encoded according to ASN.1. Additionally, at least a part of the encoded logged drive test measurement results as stored in the database are retrieved from the database and included in the information response message. This is illustrated by the box 611 "Re-use the list of entries of encoded LogMeasInfo in UEInformationResponse".

[0055] In a sixth block 606 ASN.1 is checked for an encoding error. If such an encoding error is found "Yes", an alarm may be generated or the whole measurement or at least parts thereof may be repeated (not depicted in Fig. 6). If no such

encoding error is found "No", the information response message is sent to the network in the seventh block 607 "Send UL-DCCH (UEInformationResponse).

[0056] The method 600 provides an optimal-memory database solution for MDT measurements storage. Anytime an MDT measurement may be available, it may be ASN.1 encoded and the encoded bytes/bits stream may be stored rather. Because the ASN.1 encoded MDT measurements may be compressed based on Packed Encoding Rules (PER), other compression algorithms or tools are not required, and as a result, the UE can store more measurements.

[0057] The method 600 introduces re-using the ASN.1 encoded MDT measurement entries in the database, without decoding and re-encoding in order to send UL-DCCH(UEInformationResponse) message to the NW.

[0058] The database may be designed for efficient and effective handling of MDT Logging and Reporting Constraints with respect to the UE implementation constraints. The following are the UE constraints with respect to the logging and reporting: 3GPP mandates a minimum of 64 Kbytes of storage for Logged MDT measurements. Regardless of whether an OEM allocates 64Kbytes or more/less, those measurements require a very large foot print, and it is desired to reduce the amount of allocated memory without reducing value/performance. According to 3GPP 36.323 Specifications, LTE UE's PDCP SDU for either control plane or data plane cannot exceed 8188 octets. The number of MDT measurements to be logged cannot exceed 4060 entries according to 3GPP 36.331 Specification's ASN.1 description (i.e. maxLogMeas-r10 INTEGER ::= 4060). Again and

according to the same 3GPP Specification above, a single UL-DCCH(UEInformationResponse) sent in UL cannot have the number of entries of logged MDT measurements exceeding 520 (i.e. maxLogMeasReport-r10 INTEGER ::= 520).

[0059] UL_DCCH(UEInformationResponse) may comprise MDT IEs and other IEs, and those other IEs are for other purposes. The encoded size of these 2 groups of IEs should not exceed PDCP Size of 8188 bytes. By segmenting the MDT measurements into manageable blocks and storing them in an MDT database, where each block is the size of the maximum of UEInformationResponseminus the non MDT IEs, will lead to easy compilation and re-using of the MDT database contents. There are two solutions here in determining the size of the MDT database content/block which can be sent in a single UL_DCCH(UEInformationResponse) message: The first one is the following: During the final compilation and encoding of the UL_DCCH(UEInformationResponse), the encoded size of the other IEs (not the MDT IEs) can be determined and the space left to fulfill the PDCP SDU Size of 8188 bytes will be the content of the MDT database to be re-used. The second one is the following: The size of a block in the MDT database can be pre-determined based on a pre-determined maximum size of the encoded UL_DCCH(UEInformationResponse), less Non-MDT IEs. 2KB has been determined to be sufficient to handle the size of UL_DCCH(UEInformationResponse), less MDT IEs, even if new IEs are added in future 3GPP releases. That leaves a block in the MDT database to be 6KB.

[0060] The latter is easy to handle during the compilation and facilitates the re-using method which is detailed below with respect to Fig. 8.

[0061] There is some level of loss in efficiency if in a single UL_DCCH(UEInformationResponse) sent, 2KB above is not fully consumed by the encoded size of the other IES (not the MDT IEs). But considering that 3GPP has no restriction on how many UL_DCCH(UEInformationResponse) is sent in UL in order to forward all the stored MDT measurements to the NW, this loss in efficiency becomes insignificant in the end, if NW requests to send all stored MDT measurements.

[0062] The method 600 and devices implementing such method 600 provide the following benefits: A memory-optimal database based on ASN.1 encoded Logged MDT measurements can be adopted. The ASN.1 encoded Logged MDT measurement in the database can be efficiently re-used when sending UL-DCCH(UEInformationResponse), without decoding and re-encoding. No significant temporary memory is needed for storing a decompressed copy of the measurements to be sent. The final message can be composed easily no matter how much space is needed for the additionally requested information. Also, and it holds true with other compression algorithms, UE can store more Logged MDT measurements, thereby reducing complexity and costs in NW optimization. E.g. while 64kB of memory can only hold some 45 measurements in uncompressed form (i.e. in the C-structure), some 1700 entries in compressed ASN.1 format can be stored. A memory optimal database based on ASN.1 encoded MDT measurements, e.g. as described below with respect to Fig. 7, taking into consideration of the MDT Logging and Reporting Constraints as described above, allows to easily pre-segment the measurement results in the temporary storage into big chunks of some 6K and does

not require to keep track of the thousands of individual contained measurements. The latter would be necessary if the size of the message to be sent was determined at transmit time.

[0063] Fig. 7 is a schematic diagram illustrating an example of an ASN.1 encoded MDT database 700 according to the disclosure. In this example, the database 700 may have a memory size restriction allowing maximum size of 64 kilobytes. The database 700 includes a plurality of memory blocks 701, 702, 703, e.g. blocks of ASN.1 encoded logged MDT measurement entries that can be sent in a single message UL-DCCH(UEInformationResponse). The size of each memory block j can be determined in this example as: size(Block j)<=[size(PDP SDU) - size(Encoded UEInformationResponse without MDT measurement results]. A total number of MDT entries in a single block may be less or equal than 520 in this example. The sum over all blocks j may be less or equal than 64KB in this example. A total number of entries in all blocks may be less or equal than 4060 in this example.

[0064] This disclosure addresses the fact that, in order to adopt a memory-optimal Logged MDT database based on ASN.1 encoded MDT measurements as depicted in Figure 7, these ASN.1 encoded measurements can be efficiently re-used during the encoding of UL-DCCH(UEInformationResponse) without decoding and re-encoding, e.g. according to the above description of Fig. 6.

[0065] In the following sections an exemplary ASN.1 implementation is described.

[0066] Fig. 8 is a schematic diagram illustrating an exemplary structure of an information response message 800 according to an ASN.1 implementation. For the sake of brevity, only the relevant Information Elements (IEs) of interest are shown in Fig. 8.

[0067] For further details on the encoding rules, a specification for encoding ASN.1 using Packed Encoding Rules (PER) is given in ITU-T specification X.691.

[0068] In the following exemplary implementation the focus is on LTE's Logged MDT measurements. 3GPP 36.331 describes the details of the ASN.1 description for reporting the UL-DCCH(UEInformationResponse).

[0069] In Figure 7 as described above, each block (numbered from 0 to N) in the database may neither have number entries of MDT measurements exceeding 520 nor may it size in bytes exceed PDCP SDU Size minus number of bytes of encoded UL-DCCH(UEInformationResponse) without MDT measurements.

[0070] Each MDT measurement entry may be the ASN.1 encoded bytes/bits of LogMeasInfo-r10 IE. The encoding may not be byte aligned i.e. no padding bits required.

[0071] The following blocks of procedures outline how to re-use these ASN.1 encoded entries in the database in Figure 7, without further decoding and re-encoding in order to send UL-DCCH(UEInformationResponse).

[0072] Block 1: Filling and Encoding UL-DCCH(UEInformationResponse):

1> If Logged MDT measurements need to be sent to the NW,

2> In UL-DCCH(UEInformationResponse), fill the sub IE logMeasInfoList-r10 (list of MDT measurements) of logMeasReport-r10 with some dummy, but valid information as per the ASN.1 description - no optional IEs should be included and every list should use the default minimum number of elements according to the ASN.1 description.

[0073] Note 1: The number of bits of encoded logMeasInfoList-r10 can easily be determined. Using the default, but valid values for a single entry of this list will lead to 77 bits, if encoded.

[0074] 2> Use the above dummy logMeasInfoList-r10 IE in logMeasReport-r10 IE. The rest of the sub IEs of logMeasReport-r10 must be filled correctly.

2> Include logMeasReport-r10 sub IE in nonCriticalExtension IE of the type UEInformationResponse-v1020-IEs.

2> If either connEstFailReport-r11 or nonCriticalExtension sub IEs or both should be included in nonCriticalExtension sub IE in UEInformationResponse-v1020-IEs.

3> Include nonCriticalExtension sub IE in UEInformationResponse-v1020-IEs, BUT

3> In this sub IE, exclude both connEstFailReport-r11 and nonCriticalExtension sub IEs for now.

[0075] Note 2: Even though both connEstFailReport-r11 and nonCriticalExtension sub IEs are not yet included in nonCriticalExtension of the type UEInformationResponse-v1030-IEs, the preamble bits (2 bits) will be available.

[0076] 2> Fill every other sub IE required in UL-DCCH(UEInformationResponse) accordingly and correctly.

2> Encode UL-DCCH(UEInformationResponse), but no byte alignment i.e. no padding.

[0077] Note 3: The encoded bits of the dummy logMeasInfoList-r10 plus the 2-bit preamble of the nonCriticalExtension of the type UEInformationResponse-v1030-IEs, if filled, will now constitute the total number of trailing bits of the encoded UL-DCCH(UEInformationResponse).

[0078] Block 2: Re-using the ASN.1 encoded entries of LogMeasInfo-r10 in Memory Optimal MDT database:

[0079] Note 4: From the above sequence of steps, there is now an ASN.1 encoded UL-DCCH(UEInformationResponse) available with a dummy logged MDT measurements, and this dummy encoded bits may be efficiently replaced with the MDT database content.

2> If nonCriticalExtension sub IE in UEInformationResponse-v1020-IEs was filled and encoded

3> Remove 2 bits (corresponding to the preamble for nonCriticalExtension of the type UEInformationResponse-v1030-IEs) from UL-DCCH(UEInformationResponse) encoded bits.

2> Remove the corresponding encoded bits for the dummy logMeasInfoList-r10 sub IE of logMeasReport-r10 from the remaining encoded bits of UL-DCCH(UEInformationResponse). This should be 77 bits, as calculated.

2> In the memory-optimal MDT database, count the number of encoded entries of LogMeasInfo-r10 in a single

block that need to be sent to the NW. Encode this number using PER encoding scheme.

[0080] Note 5: Based on the ASN.1 description for maxLogMeasReport-r10, only 10 bits are required to encode the number of entries in a single block in the MDT database that need to be sent currently to the NW.

[0081] 2> Append the encoded 10 bits (from the step above) to the tail-stripped encoded bits of UL-DCCH(UEInformationResponse).

2> Now, append the corresponding bits of the block of entries of LogMeasInfo-r10 in the MDT database, whose total was encoded above, to the encoded bits of UL-DCCH(UEInformationResponse).

[0082] Note 6: At this point in time, the encoded bits of the dummy logMeasInfoList-r10 are accurately replaced by the encoded logged MDT measurement entries of interest in the memory-optimal MDT database, without any loss of generality.

[0083] Block 3: Re-align those IEs after logMeasInfoList-r10:

2> If the immediate sibling sub IE of logMeasInfoList-r10 in UEInformationResponse-v1020-IEs i.e. nonCriticalExtension of the type UEInformationResponse-v1130-IEs, must be included in UL-DCCH(UEInformationResponse),

3> Encode this independently, by including its 2 sub-IEs connEstFailReport-r11 and nonCriticalExtension, if they must be included. The encoded bits must not be byte aligned i.e. no padding bits required.

3> Append the above encoded bits to the encoded UL-DCCH(UEInformationResponse).

[0084] Note 7: Now there are UL-DCCH(UEInformationResponse) encoded bits that need to be sent to the NW.

[0085] 2> Now, ensure that UL-DCCH(UEInformationResponse) encoded bits are byte aligned i.e. add appropriate padding bits.

2> Send in UL the UL-DCCH(UEInformationResponse).

2> If UL-DCCH(UEInformationResponse) is successfully sent to the NW, remove from the MDT database, the corresponding block of encoded Logged MDT measurements used in this UL message.

[0086] Note 8: The whole procedure can be repeated if there are more encoded Logged MDT measurements in the MDT database and NW should request for their reporting.

[0087] The concept of re-using the compressed ASN.1 encoded MDT measurements in an MDT database during the final compilation and encoding of UL-DCCH(UEInformationResponse) can be extended to UMTS MDT (both WCDMA and TD-SCDMA). However the steps in the algorithm above will be different, as the UMTS RRC MDT ASN.1 IEs descriptions are different from that of LTE RRC MDT ASN.1 IEs.

[0088] Implementation results are as follows: Using the MDT database approach without using the concept according to the disclosure, if each entry contains 3 GSM frequencies' results + service cell results, without any location information, the UE stores approx. 45 entries (or 45 MDT cycles) in a 64KB memory.

[0089] Using the solution according to this disclosure, with same measurement information in each entry, UE can store 1700+ entries (MDT cycles) in same 64KB memory.

[0090] This logged MDT concept according to the disclosure may be extended for MBMS (multicast broadcast measurements) even when the UE is in RRC_CONNECTED state, and thus will also require more memory from the UEs, this along with actual deployment by operators, will force vendors to investigate mechanisms to optimize like the one disclosed in this document.

[0091] The methods, systems and devices described herein may be implemented as software in a Digital Signal Processor (DSP), in a micro-controller or in any other side-processor or as hardware circuit on a chip or within an application specific integrated circuit (ASIC).

[0092] Embodiments described in this disclosure can be implemented in digital electronic circuitry, or in computer hardware, firmware, software, or in combinations thereof, e.g. in available hardware of mobile devices or in new hardware dedicated for processing the methods described herein.

[0093] The present disclosure also supports a computer program product including computer executable code or computer executable instructions that, when executed, causes at least one computer to execute the performing and computing blocks described herein, in particular the methods 300, 500, 600, 700 as described above with respect to Figs. 3, 5, 6 and 7. Such a computer program product may include a readable storage medium storing program code thereon for use by a

processor, the program code comprising instructions for performing any of the method 300, 500, 600, 700 blocks as described above.

EXAMPLES

[0094] The following examples pertain to further embodiments. Example 1 is a method for reporting drive test measurements to a mobile network, the method comprising: performing a plurality of drive test measurements for collecting data of the mobile network; logging a result of each drive test measurement; encoding the logged drive test measurement results; storing the encoded logged drive test measurement results in a database; generating an information response message comprising at least part of the encoded logged drive test measurement results from the database; and reporting the information response message to the mobile network.

[0095] In Example 2, the subject matter of Example 1 can optionally include performing the plurality of drive test measurements by a user equipment (UE).

[0096] In Example 3, the subject matter of Example 2 can optionally include logging the results of the drive test measurements in a Radio Resource Control (RRC) idle mode of the UE.

[0097] In Example 4, the subject matter of any one of Examples 1-3 can optionally include that the plurality of drive test measurements comprises Minimization of Drive Test (MDT) measurements.

[0098] In Example 5, the subject matter of any one of Examples 1-4 can optionally include that the logged drive test measurement results are encoded according to an Abstract Syntax Notation One (ASN.1) specification.

[0099] In Example 6, the subject matter of Example 5 can optionally include that the encoded logged drive test measurement results are compressed based on Packet Encoding Rules (PER) according to the ASN.1 specification.

[0100] In Example 7, the subject matter of any one of Examples 1-6 can optionally include: receiving a measurement configuration message from the mobile network; and initiating the logging of the results of the drive test measurements responsive to receiving the measurement configuration message.

[0101] In Example 8, the subject matter of any one of Examples 1-7 can optionally include: receiving an information request message from the mobile network; and generating and reporting the information response message responsive to receiving the information request message.

[0102] In Example 9, the subject matter of any one of Examples 1-8 can optionally include: segmenting the encoded logged drive test measurement results into segmentation blocks; and storing the segmentation blocks in the database.

[0103] In Example 10, the subject matter of Example 9 can optionally include that the information response message has a predetermined format; and that a size of each segmentation block is aligned to the format of the information response message.

[0104] In Example 11, the subject matter of Example 10 can optionally include: determining a size of information elements not related to drive test measurements to be stored in the information response message; and filling a space of the information response message remaining for storage of information elements related to the drive test measurements with at least part of the segmentation blocks stored in the database.

[0105] In Example 12, the subject matter of Example 11 can optionally include: adjusting a size of the segmentation blocks to the space of the information response message remaining for storage of information elements related to the drive test measurements.

[0106] In Example 13, the subject matter of any one of Examples 9-12 can optionally include that a maximum size of the information response message is predetermined.

[0107] In Example 14, the subject matter of Example 13 can optionally include that a size of the segmentation blocks is predetermined based on the predetermined size of the information response message.

[0108] In Example 15, the subject matter of any one of Examples 1-14 can optionally include: creating an ASN.1 encoded information response message comprising a dummy section of logged drive test measurement information elements; and replacing the dummy section with the at least part of the encoded logged drive test measurement results.

[0109] In Example 16, the subject matter of Example 15 can optionally include that the ASN.1 encoded information response message is created without optional information elements and without byte alignment; and that mandatory information elements of the information response message have a minimum number of elements according to the ASN.1 specification.

[0110] Example 17 is a device for reporting drive test measurements to a mobile network, the device comprising: a transceiver, configured to perform a plurality of drive test measurements for collecting data of the mobile network; a data logger, configured to log a result of each drive test measurement; an encoder, configured to encode the logged drive test measurement results; a database, configured to store the encoded logged drive test measurement results; a controller, configured to generate an information response message comprising at least part of the encoded logged drive test measurement results from the database; and an interface to the mobile network, configured to report the information response message to the mobile network.

[0111] In Example 18, the subject matter of Example 17 can optionally include that the encoder is configured to encode the logged drive test measurement results according to an Abstract Syntax Notation One (ASN.1) specification.

[0112] In Example 19, the subject matter of Example 18 can optionally include that the controller is configured: to create an information response message comprising a dummy section of logged drive test measurement information elements, to encode the information response message according to the ASN.1 specification, and to replace the

dummy section with the at least part of the encoded logged drive test measurement results.

[0113] In Example 20, the subject matter of Example 19 can optionally include that the controller is configured: to create the information response message without optional information elements and without byte alignment; and to assign mandatory information elements of the information response message a minimum number of elements according to the ASN.1 specification.

[0114] Example 21 is a method for reporting Minimization of Drive Test (MDT) measurements, the method comprising: performing a plurality of MDT measurements for collecting data of a mobile network; logging a result of each MDT measurement; encoding the logged MDT measurement results according to an ASN.1 specification; storing the encoded logged MDT measurement results in a database; generating an information response message according to the ASN.1 specification, wherein the information response message comprises a dummy section of MDT measurement results; encoding the information response message according to the ASN.1 specification; replacing the dummy section of MDT measurement results with at least part of the encoded logged MDT measurement results from the database; and reporting the information response message to the mobile network.

[0115] In Example 22, the subject matter of Example 21 can optionally include: receiving a measurement configuration message from the mobile network; and initiating the logging of the results of the MDT measurements responsive to receiving the measurement configuration message.

[0116] In Example 23, the subject matter of Example 22 can optionally include: receiving an information request message from the mobile network; and replacing the dummy section and reporting the information response message to the mobile network responsive to receiving the information request message.

[0117] In Example 24, the subject matter of any one of Examples 21-23 can optionally include: logging the results of the MDT measurements by a user equipment (UE) in a Radio Resource Control (RRC) idle mode of the UE.

[0118] Example 25 is a computer readable non-transitory medium on which computer instructions are stored which when executed by a computer, cause the computer to perform the method of one of Examples 1 to 16 or 21 to 24.

[0119] Example 26 is a device for reporting drive test measurements to a mobile network, the device comprising: means for performing a plurality of drive test measurements for collecting data of the mobile network; means for logging a result of each drive test measurement; means for encoding the logged drive test measurement results; means for storing the encoded logged drive test measurement results in a database; means for generating an information response message comprising at least part of the encoded logged drive test measurement results from the database; and means for reporting the information response message to the mobile network.

[0120] In Example 27, the subject matter of Example 26 can optionally include means for performing the plurality of drive test measurements by a user equipment (UE).

[0121] In Example 28, the subject matter of Example 27 can optionally include means for logging the results of the drive test measurements in a Radio Resource Control (RRC) idle mode of the UE.

[0122] In Example 29, the subject matter of Example 26 or 27 can optionally include that the plurality of drive test measurements comprises Minimization of Drive Test (MDT) measurements.

[0123] Example 30 is a device for reporting Minimization of Drive Test (MDT) measurements, the device comprising: means for performing a plurality of MDT measurements for collecting data of a mobile network; means for logging a result of each MDT measurement; means for encoding the logged MDT measurement results according to an ASN.1 specification; means for storing the encoded logged MDT measurement results in a database; means for generating an information response message according to the ASN.1 specification, wherein the information response message comprises a dummy section of MDT measurement results; means for encoding the information response message according to the ASN.1 specification; means for replacing the dummy section of MDT measurement results with at least part of the encoded logged MDT measurement results from the database; and means for reporting the information response message to the mobile network.

[0124] In Example 31, the subject matter of Example 30 can optionally include means for receiving a logged measurement configuration message from the mobile network; and means for initiating the logging of the results of the MDT measurements

responsive to receiving the measurement configuration message.

[0125] Example 32 is a system for reporting drive test measurements to a mobile network, the system comprising: a transceiver subsystem, configured to perform a plurality of drive test measurements for collecting data of the mobile network; a data logger subsystem, configured to log a result of each drive test measurement; an encoder subsystem, configured to encode the logged drive test measurement results; a database subsystem, configured to store the encoded logged drive test measurement results; a controller subsystem, configured to generate an information response message comprising at least part of the encoded logged drive test measurement results from the database; and an interface to the mobile network, configured to report the information response message to the mobile network.

[0126] In Example 33, the subject matter of Example 32 can optionally include that the encoder subsystem is configured to encode the logged drive test measurement results according to an Abstract Syntax Notation One (ASN.1) specification.

[0127] Example 34 is a system for reporting Minimization of Drive Test (MDT) measurements, the system comprising: a transceiver subsystem configured to perform a plurality of MDT measurements for collecting data of a mobile network; a data logging subsystem, configured to log a result of each MDT measurement; a log encoding subsystem, configured to encode the logged MDT measurement results according to an ASN.1 specification; a database subsystem, configured to store the encoded logged MDT measurement results; a message handling subsystem, configured to generate an information

response message according to the ASN.1 specification, wherein the information response message comprises a dummy section of MDT measurement results; a message encoding subsystem, configured to encode the information response message according to the ASN.1 specification; a replacement subsystem, configured to replace the dummy section of MDT measurement results with at least part of the encoded logged MDT measurement results from the database subsystem; and a reporting subsystem, configured to report the information response message to the mobile network.

[0128] In Example 35, the subject matter of Example 34 can optionally include: a receiver subsystem, configured to receive a measurement configuration message from the mobile network; and an initiating subsystem, configured to initiate the logging of the results of the MDT measurements responsive to receiving the logged measurement configuration message.

[0129] Example 36 is a circuit for reporting drive test measurements to a mobile network, the circuit comprising: a transceiver circuit, configured to perform a plurality of drive test measurements for collecting data of the mobile network; a data logger circuit, configured to log a result of each drive test measurement; an encoder circuit, configured to encode the logged drive test measurement results; a database circuit, configured to store the encoded logged drive test measurement results; a controller circuit, configured to generate an information response message comprising at least part of the encoded logged drive test measurement results from the database; and an interface circuit to the mobile network, configured to report the information response message to the mobile network.

[0130] In Example 37, the subject matter of Example 36 can optionally include that the encoder circuit is configured to encode the logged drive test measurement results according to an Abstract Syntax Notation One (ASN.1) specification.

[0131] In Example 38, the subject matter of Example 21 can optionally include that the ASN.1 encoding is used for the logged MDT measurement results in the database and also for the information response message.

[0132] In Example 39, the subject matter of Example 21 can optionally include that the ASN.1 encoding of the logged MDT measurement results to be stored in the database are not byte aligned.

[0133] In Example 40, the subject matter of Example 21 can optionally include that the encoding of the information response message with dummy logged measurements are not byte aligned.

[0134] In Example 41, the subject matter of Example 21 can optionally include that a final compilation of the encoded information response message with the encoded logged MDT measurement results in the database are byte aligned.

[0135] In addition, while a particular feature or aspect of the invention may have been disclosed with respect to only one of several implementations, such feature or aspect may be combined with one or more other features or aspects of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the terms "include", "have", "with", or other variants thereof are used in either the detailed description

or the claims, such terms are intended to be inclusive in a manner similar to the term "comprise". Furthermore, it is understood that aspects of the invention may be implemented in discrete circuits, partially integrated circuits or fully integrated circuits or programming means. Also, the terms "exemplary", "for example" and "e.g." are merely meant as an example, rather than the best or optimal.

[0136] Although specific aspects have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations may be substituted for the specific aspects shown and described without departing from the scope of the present invention. This application is intended to cover any adaptations or variations of the specific aspects discussed herein.

Claims

1. A method for reporting drive test measurements to a mobile network, the method comprising:

performing a plurality of drive test measurements for collecting data of the mobile network;

logging a result of each drive test measurement;

encoding the logged drive test measurement results;

storing the encoded logged drive test measurement results in a database;

generating an information response message comprising at least part of the encoded logged drive test measurement results from the database; and

reporting the information response message to the mobile network.

2. The method of claim 1, comprising:

performing the plurality of drive test measurements by a user equipment (UE).

3. The method of claim 2, comprising:

logging the results of the drive test measurements in a Radio Resource Control (RRC) idle mode and an RRC connected mode of the UE.

4. The method of claim 1 or 2,

wherein the plurality of drive test measurements comprises Minimization of Drive Test (MDT) measurements.

5. The method of claim 1 or 2,

wherein the logged drive test measurement results are encoded according to an Abstract Syntax Notation One (ASN.1) specification.

6. The method of claim 5,

wherein the encoded logged drive test measurement results are compressed based on Packet Encoding Rules (PER) according to the ASN.1 specification.

7. The method of claim 1 or 2, comprising:

receiving a logged measurement configuration message from the mobile network; and

initiating the logging of the results of the drive test measurements responsive to receiving the logged measurement configuration message.

8. The method of claim 1 or 2, comprising:

receiving an information request message from the mobile network; and

generating and reporting the information response message responsive to receiving the information request message.

9. The method of claim 1 or 2, comprising:

storing the encoded logged drive test measurement results in segmentation blocks in the database.

10. The method of claim 9,

wherein the information response message has a predetermined format; and

wherein a size of each segmentation block is aligned to the format of the information response message.

11. A device for reporting drive test measurements to a mobile network, the device comprising:

means for performing a plurality of drive test measurements for collecting data of the mobile network;

means for logging a result of each drive test measurement;

means for encoding the logged drive test measurement results;

means for storing the encoded logged drive test measurement results in a database;

means for generating an information response message comprising at least part of the encoded logged drive test measurement results from the database; and

means for reporting the information response message to the mobile network.

12. The device of claim 11, comprising:

means for performing the plurality of drive test measurements by a user equipment (UE).

13. A system for reporting Minimization of Drive Test (MDT) measurements, the system comprising:

a transceiver subsystem configured to perform a plurality of MDT measurements for collecting data of a mobile network;

a data logging subsystem, configured to log a result of each MDT measurement;

an log encoding subsystem, configured to encode the logged MDT measurement results according to an ASN.1 specification;

a database subsystem, configured to store the encoded logged MDT measurement results;

a message handling subsystem, configured to generate an information response message according to the ASN.1

specification, wherein the information response message comprises a dummy section of MDT measurement results;

a message encoding subsystem, configured to encode the information response message according to the ASN.1 specification;

a replacement subsystem, configured to replace the dummy section of MDT measurement results with at least part of the encoded logged MDT measurement results from the database subsystem; and

a reporting subsystem, configured to report the information response message to the mobile network.

14. The system of claim 13, comprising:

a receiver subsystem, configured to receive a measurement configuration message from the mobile network; and

an initiating subsystem, configured to initiate the logging of the results of the MDT measurements responsive to receiving the measurement configuration message.

15. A circuit for reporting drive test measurements to a mobile network, the circuit comprising:

a transceiver circuit, configured to perform a plurality of drive test measurements for collecting data of the mobile network;

a data logger circuit, configured to log a result of each drive test measurement;

an encoder circuit, configured to encode the logged drive test measurement results;

a database circuit, configured to store the encoded logged drive test measurement results;

a controller circuit, configured to generate an information response message comprising at least part of the

encoded logged drive test measurement results from the database; and

an interface circuit to the mobile network, configured to report the information response message to the mobile network.

16. The circuit of claim 15,

wherein the encoder circuit is configured to encode the logged drive test measurement results according to an Abstract Syntax Notation One (ASN.1) specification.

17. A device for reporting drive test measurements to a mobile network, the device comprising:

a transceiver, configured to perform a plurality of drive test measurements for collecting data of the mobile network;

a data logger, configured to log a result of each drive test measurement;

an encoder, configured to encode the logged drive test measurement results;

a database, configured to store the encoded logged drive test measurement results;

a controller, configured to generate an information response message comprising at least part of the encoded logged drive test measurement results from the database; and

an interface to the mobile network, configured to report the information response message to the mobile network.

18. The device of claim 17,

wherein the encoder is configured to encode the logged drive test measurement results according to an Abstract Syntax Notation One (ASN.1) specification.

19. The device of claim 18, wherein the controller is configured:

to create an information response message comprising a dummy section of logged drive test measurement information elements,

to encode the information response message according to the ASN.1 specification, and

to replace the dummy section with the at least part of the encoded logged drive test measurement results.

20. The device of claim 19, wherein the controller is configured:

to create the information response message without optional information elements and without byte alignment; and

to assign mandatory information elements of the information response message a minimum number of elements according to the ASN.1 specification.

21. A method for reporting Minimization of Drive Test (MDT) measurements, the method comprising:

performing a plurality of MDT measurements for collecting data of a mobile network;

logging a result of each MDT measurement;

encoding the logged MDT measurement results according to an ASN.1 specification;

storing the encoded logged MDT measurement results in a database;

generating an information response message according to the ASN.1 specification, wherein the information response message comprises a dummy section of MDT measurement results;

encoding the information response message according to the ASN.1 specification;

replacing the dummy section of MDT measurement results with at least part of the encoded logged MDT measurement results from the database; and

reporting the information response message to the mobile network.

22. The method of claim 21, comprising:

receiving a measurement configuration message from the mobile network; and

initiating the logging of the results of the MDT measurements responsive to receiving the measurement configuration message.

23. The method of claim 22, comprising:

receiving an information request message from the mobile network; and

replacing the dummy section and reporting the information response message to the mobile network responsive to receiving the information request message.

24. The method of claim 21, comprising:

logging the results of the MDT measurements by a user equipment (UE) in a Radio Resource Control (RRC) idle mode of the UE.

25. A computer readable non-transitory medium on which computer instructions are stored which when executed by a computer, cause the computer to perform the method of one of claims 1 to 10 or 21 to 24.

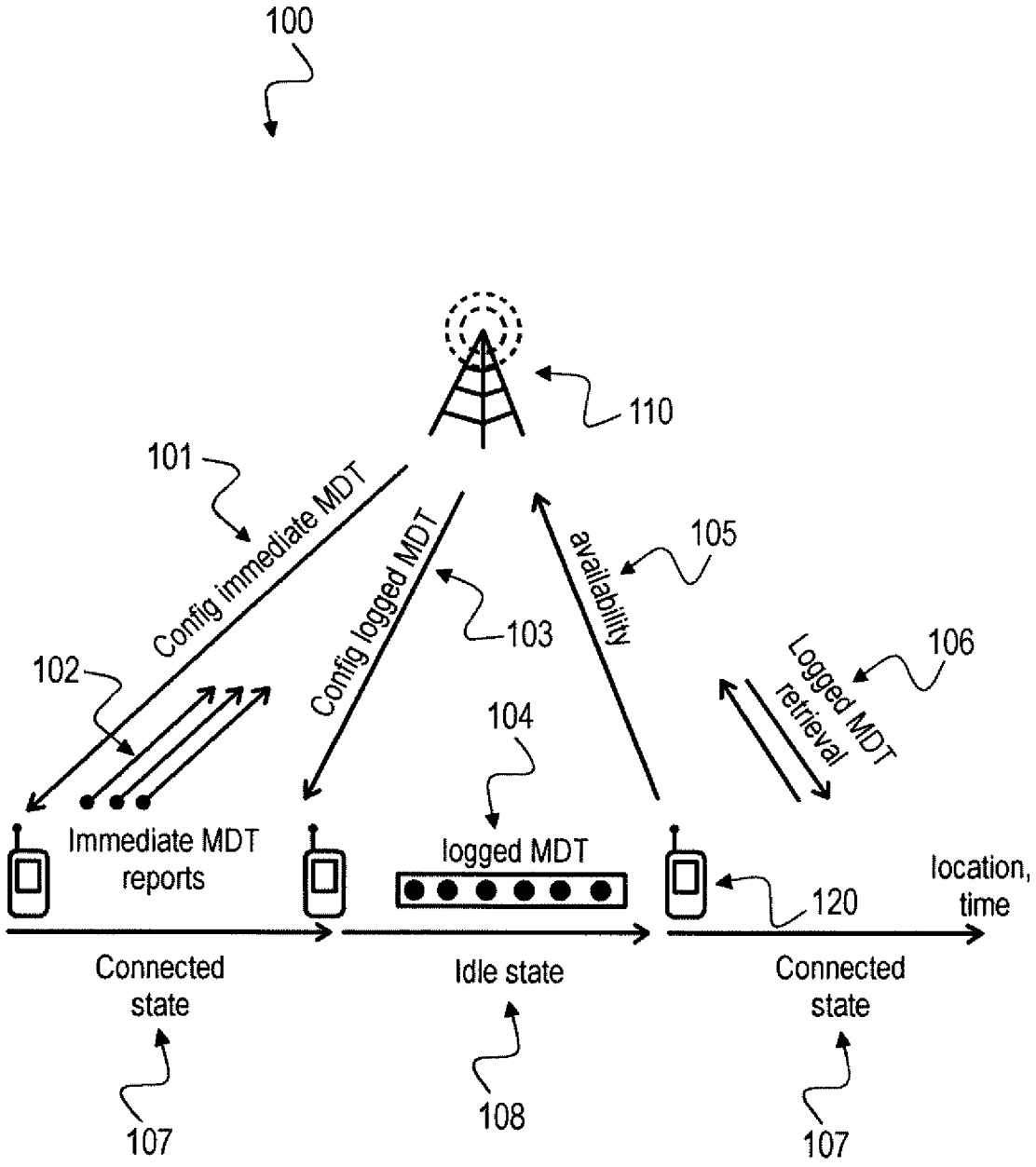

100
110
101
Config immediate MDT
Config logged MDT
103
availability
105
106
Logged MDT retrieval
102
104
Immediate MDT reports
logged MDT
120
location, time
Connected state
Idle state
Connected state
107
108
107

Fig. 1

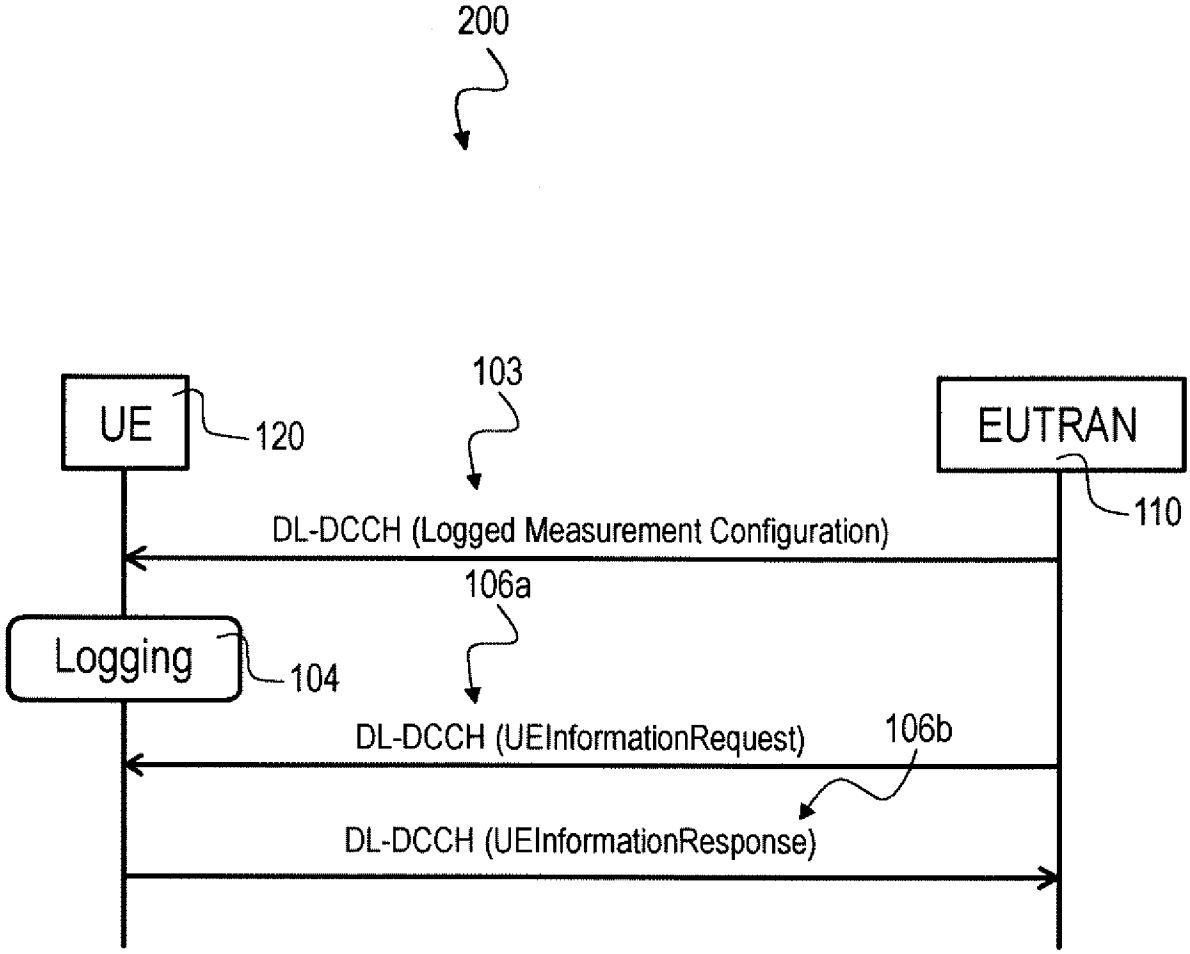

200
UE
120
103
EUTRAN
110
DL-DCCH (Logged Measurement Configuration)
106a
Logging
104
DL-DCCH (UEInformationRequest)
106b
DL-DCCH (UEInformationResponse)

Fig. 2

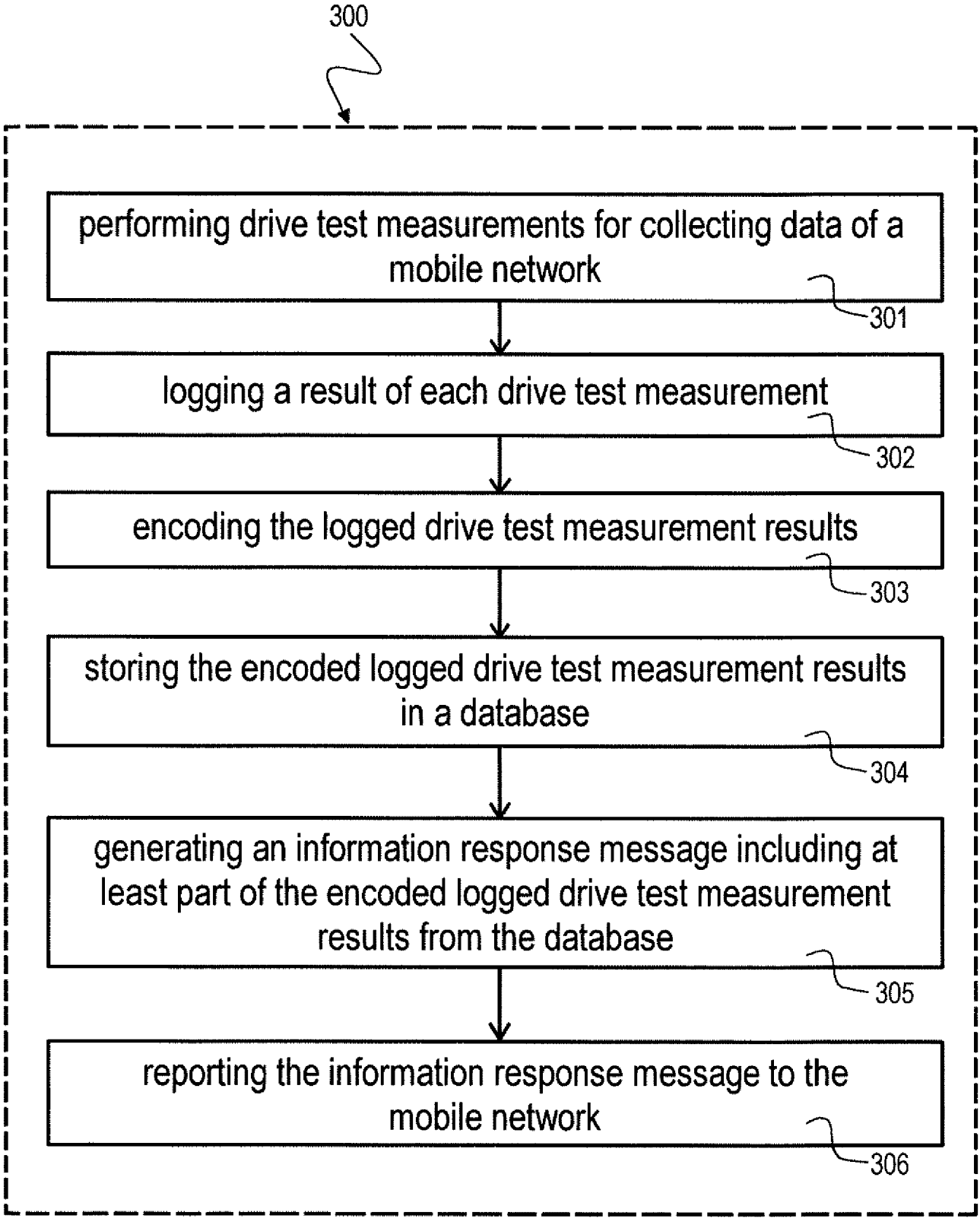

300
performing drive test measurements for collecting data of a mobile network
301
logging a result of each drive test measurement
302
encoding the logged drive test measurement results
303
storing the encoded logged drive test measurement results in a database
304
generating an information response message including at least part of the encoded logged drive test measurement results from the database
305
reporting the information response message to the mobile network
306

Fig. 3

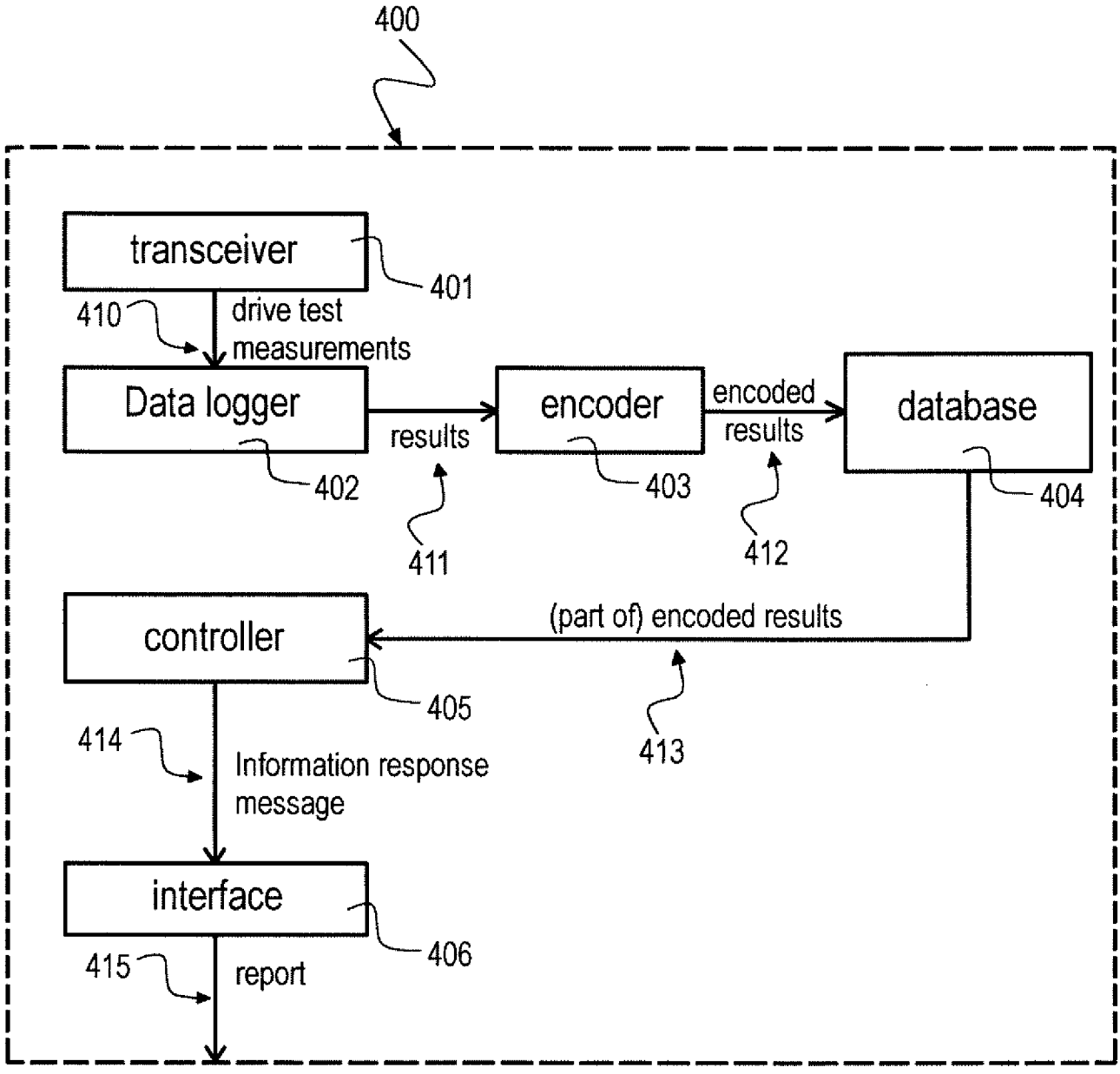

400
transceiver
401
410
drive test measurements
Data logger
402
results
encoder
403
encoded results
database
404
411
412
controller
405
(part of) encoded results
413
414
Information response message
interface
406
415
report

Fig. 4

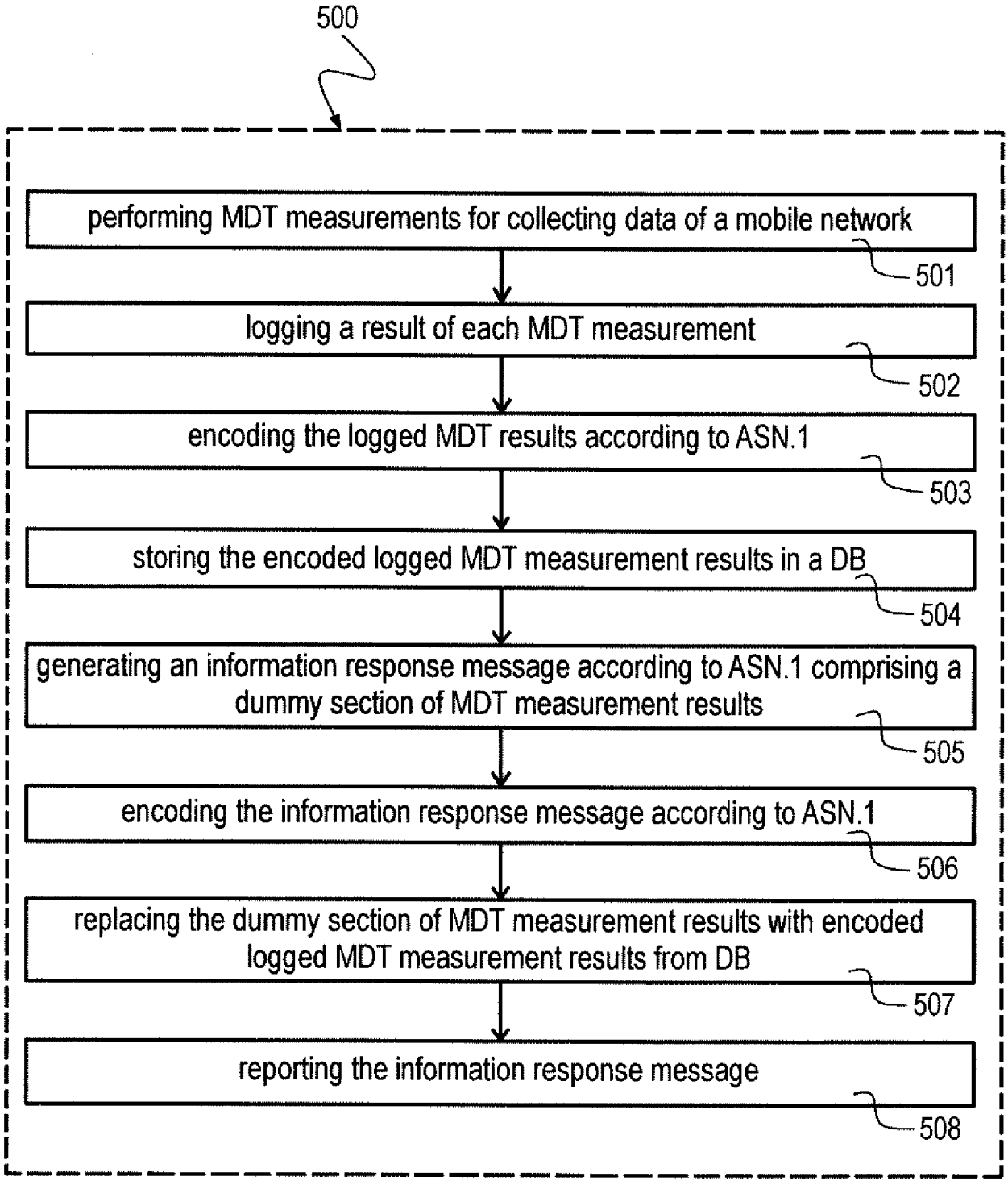

500
performing MDT measurements for collecting data of a mobile network
501
logging a result of each MDT measurement
502
encoding the logged MDT results according to ASN.1
503
storing the encoded logged MDT measurement results in a DB
504
generating an information response message according to ASN.1 comprising a dummy section of MDT measurement results
505
encoding the information response message according to ASN.1
506
replacing the dummy section of MDT measurement results with encoded logged MDT measurement results from DB
507
reporting the information response message
508

Fig. 5

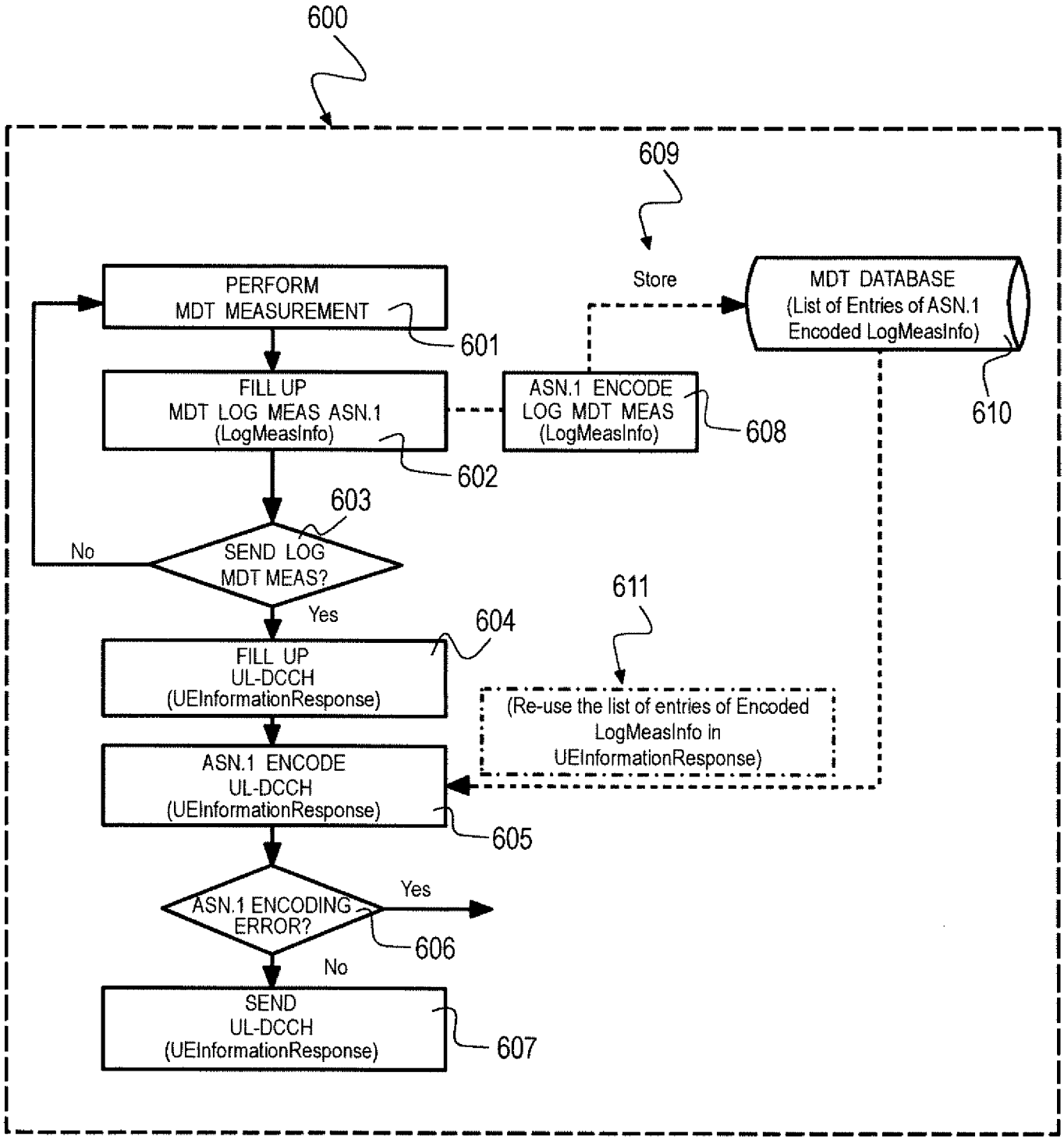

600
609
PERFORM MDT MEASUREMENT
601
Store
MDT DATABASE (List of Entries of ASN.1 Encoded LogMeasInfo)
610
FILL UP MDT LOG MEAS ASN.1 (LogMeasInfo)
602
ASN.1 ENCODE LOG MDT MEAS (LogMeasInfo)
608
603
No
SEND LOG MDT MEAS?
Yes
611
604
FILL UP UL-DCCH (UEInformationResponse)
(Re-use the list of entries of Encoded LogMeasInfo in UEInformationResponse)
ASN.1 ENCODE UL-DCCH (UEInformationResponse)
605
Yes
ASN.1 ENCODING ERROR?
606
No
SEND UL-DCCH (UEInformationResponse)
607

Fig. 6

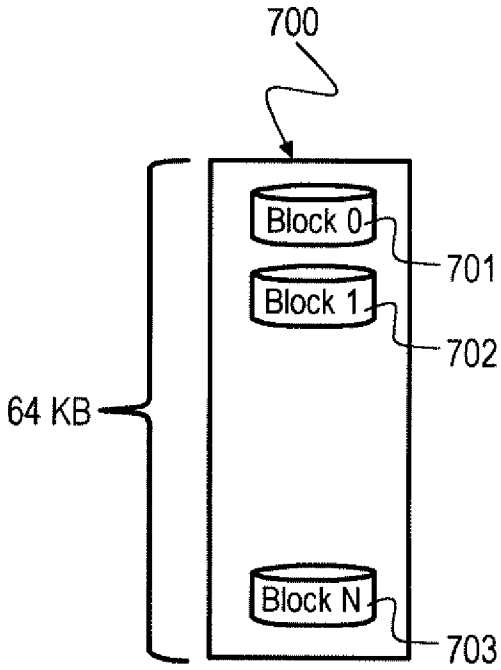


Fig. 7



UEInformationResponse message

```
-- ASN1START

-- Missing IEs here - intentional

-- Regular non critical extensions
UEInformationResponse-v930-IEs ::= SEQUENCE {
    lateNonCriticalExtension      OCTET STRING (CONTAINING UEInformationResponse-v9e0-IEs)  OPTIONAL,
    nonCriticalExtension          UEInformationResponse-v1020-IEs                           OPTIONAL
}

UEInformationResponse-v1020-IEs ::= SEQUENCE {
    logMeasReport-r10             LogMeasReport-r10                                         OPTIONAL,
    nonCriticalExtension          UEInformationResponse-v1130-IEs                           OPTIONAL
}

UEInformationResponse-v1130-IEs ::= SEQUENCE
    connEstFailReport-r11         ConnEstFailReport-r11                                     OPTIONAL,
nonCriticalExtension              UEInformationResponse-v1250-IEs                           OPTIONAL
}

-- Missing IEs here - intentional

LogMeasReport-R10 ::=             SEQUENCE {
    absolute TimeStamp-r10            AbsoluteTimeInfo-r10,
    traceReference-r10                Trace Reference-r10,
    traceRecordingSessionRef-r10  OCTET STRING (SIZE (2)),
    tce-Id-r10                        OCTET STRING (SIZE (1)),
    logMeasInfoList-r10               LogMeasInfoList-r10,
    logMeasAvailable-r10              ENUMERATED {true}                                     OPTIONAL,
    ...
}

LogMeasInfoList-r10 ::=   SEQUENCE (SIZE (1..maxLogMeasReport-r10)) OF LogMeasInfo-r10

--Missing IEs here - intentional

maxLogMeasReport-r10          INTEGER ::= 520 -- Added here for clarity
```

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/054805

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W24/10
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04W

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

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

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	"3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (Release 13)", 3GPP DRAFT; DRAFT_36331-D10_UPDATE2, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , 30 March 2016 (2016-03-30), XP051081605, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/tsg_ran/WG2_RL2/Specifications/201603_draft_specs_after_RAN_71/ [retrieved on 2016-03-30]	1-12, 15-20,25
Y	page 142 - page 148	13,14,

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 April 2017	04/05/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Lastoria, Gianluca

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Form PCT/ISA/210 (second sheet) (April 2005)

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	page 248 - page 254 page 473 - page 475 page 480 - page 481 -----	21-24
Y	VODAFONE: "MDT Logging when Out of Service", 3GPP DRAFT; R2-104548, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Madrid, Spain; 20100823, 16 August 2010 (2010-08-16), XP050451722, [retrieved on 2010-08-16] the whole document -----	13,14, 21-24
A	WO 2011/136611 A2 (SAMSUNG ELECTRONICS CO LTD [KR]; HIMKE VAN DER VELDE [NL]; VAN LIESHOU) 3 November 2011 (2011-11-03) paragraph [0038] - paragraph [0056] figure 4 -----	1-25
T	"3 Generation Partnership Project; Technical Specification Group Radio Access Network; Universal Terrestrial Radio Access (UTRA) and Evolved Universal Terrestrial Radio Access (E-UTRA); Radio measurement collection for Minimization of Drive Tests (MDT); Overall description; Stage 2 (Release 13)", 3GPP STANDARD; 3GPP TS 37.320, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. V13.1.0, 30 March 2016 (2016-03-30), pages 1-26, XP051088490, [retrieved on 2016-03-30] page 9 - page 14 -----	1-25

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/054805

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2011136611 A2	03-11-2011	EP 2564619 A2	06-03-2013
		GB 2479937 A	02-11-2011
		US 2013040659 A1	14-02-2013
		WO 2011136611 A2	03-11-2011