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(54) Title: METHODS AND ARRANGEMENTS FOR TIME-STAMPING OF REPORTS

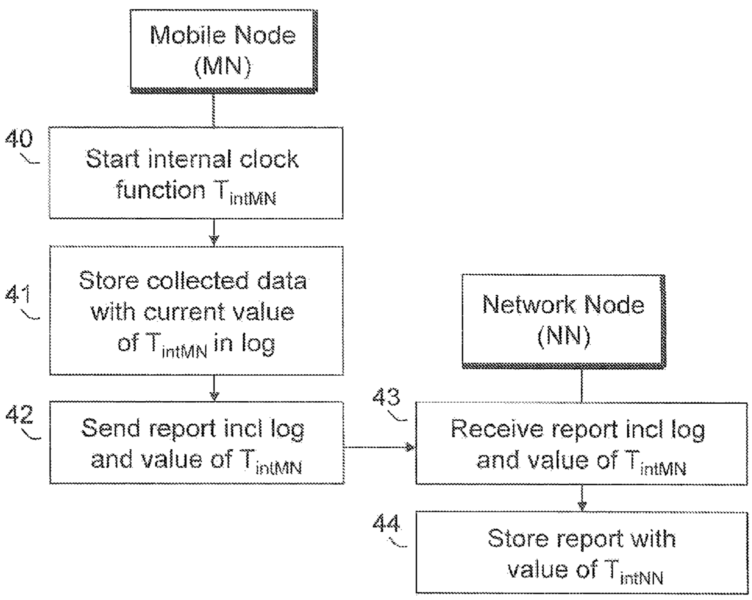

Fig 4

(57) Abstract: The present disclosure relates to a mobile node and a network node, and to related methods for time-stamping of reports. Embodiments provide a mobile node that uses an internal clock function to timestamp collected data when the data is stored in a log in the mobile node. The mobile node further timestamps a report comprising the collected data when the report is sent to a network node. The network node receives the report and stores it with a reception timestamp corresponding to a current value of an internal clock function, of the network node upon reception of the report, thereby indicating a time of receiving the report.

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METHODS AND ARRANGEMENTS FOR TIME-STAMPING OF REPORTS

TECHNICAL FIELD

The present disclosure relates to time-stamping reports in a communication system. More particularly, the present disclosure relates to arrangements and methods for time-stamping reports in a mobile node and a network node comprised in the communication system.

BACKGROUND

For next generation of mobile telecommunications systems 3rd Generation Partnership Project (3GPP) is in the process of defining solutions for user equipment (UE) measurement logging function and immediate reporting function called the Minimization of the Drive Tests (MDT). The MDT study aims at assessing the feasibility, benefits and complexity of automating the collection of UE measurements to minimize the need of manual drive-tests. The work under the MDT study should define use cases and requirements for minimizing drive-tests in next generation Long Term Evolution (LTE) and/or HSPA networks. Also, based on the defined use cases and requirements, the MDT should focus on study the necessity of defining new UE measurements logging and reporting capabilities for minimizing drive tests and analyze the impact on the UE.

The use cases for the MDT will be given as following.

- Radio coverage optimization
- Mobility optimization
- Network capacity optimization
- Parameterization for common channels
- Quality of Service verification

For the purpose of the coverage optimization use case, UE measurements or similar functionality considered for UE-internal logging include, but are not limited to:

- periodic (e.g., one every 5 seconds) downlink pilot signal strength/quality measurements;
- serving cell becomes worse than threshold, i.e. radio environment measurements are logged when serving cell metric becomes worse than the configured threshold; and

- transmit power headroom becomes less than threshold, i.e. transmit power headroom and radio environments measurements are logged when UE transmit power headroom becomes less than the configured headroom.

The network can request the UE to perform logging of measurements. The UE executes measurements, e.g. periodical downlink pilot measurements, and logs these measurements internally in a sequential manner. The UE can store its measurements in a measurement log for certain duration. Typically, the log stored internally in the UE will contain, e.g., some hours of logged measurement information. This procedure is illustrated in **Figure 1**. The network node, e.g. an evolved NodeB (eNB) or a RNC (Radio Network Controller), sends in a step 10 an indication, *IdleLoggingConfigurationmessage*, to the UE, whereupon the UE starts in a step 11 executing measurements and logging the measurement data.

When the UE has logged measurements the UE indicates to the network that it has an available measurement log. The network may then request the UE to deliver the measurement log. This procedure is illustrated in **Figure 2**. The UE sends in a step 20 an indication to the network node, e.g. the eNB or the RNC, that it has an available measurement log. In a step 21 the network node then determines whether is wants to request the measurement log. If it determines to request the measurement log it sends in a step 22 a request to the UE. Thereupon the UE delivers in a step 23 the measurement log to the network node. Moreover, the network node typically forwards in a step 24 the reported measurement logs to an Operation And Maintenance (OAM) server or similar, e.g. a trace collection centre (TCE) for evaluation and handling.

According to current 3GPP specifications, a UE is required to maintain only one measurement log at a time and that log contains measurements collected on the serving cell of the UE, i.e. on only one radio access technology (RAT), such as LTE or Universal Mobile Telecommunication System (UMTS). If a UE is requested to start logging, any old log stored in the UE is erased. The UE can indicate log availability and report a log when the UE is in connected mode.

Moreover, the logging configuration message includes a network absolute timestamp that is generated by the sending network node and is used by the UE as a time reference for the UE's relative timestamp that identify logged measurement. The UE's timestamp is counted in seconds from the moment the logging configuration is received at the UE, relative to the absolute timestamp in the configuration message. The absolute timestamp is the current network time at the point when Logged MDT is configured to the UE. The UE echoes the absolute reference time back to the evolved NodeB (eNB) and/or RNC, and the time format in a logged measurement report is *DD HH-MM-SS*, where *DD* identifies a date, *HH* identifies an hour, *MM* identifies a minute, and *SS* identifies a second.

The echoing of the absolute timestamp received from the network is done in the measurement report (step 23 in **Figure 2**), which can be a "UEInformationResponse message" according to current 3GPP specifications. Table 1 is a portion of a "UEInformationResponse message", wherein the network absolute timestamp is called "absoluteTimeStamp-r10" and the UE relative timestamp is called "timeInfo-r10". The network absolute timestamp format is DD HH-MM-SS. The UE relative timestamp is a timestamp relative the absolute timestamp and is typically a value in seconds.

Table 1

```
MDT-Report-r10 ::=                              SEQUENCE {
     absoluteTimeStamp-r10                      BIT STRING,          --
Size of the bit string is FFS
     mdt-MeasurementInfoList-r10                MDT-MeasurementInfoList-
r10              OPTIONAL,
     mdt-ReportAvailable-r10                    ENUMERATED {true}
                 OPTIONAL,
     ...
}


MDT-MeasurementInfoList-r10 ::=                 SEQUENCE (SIZE
(1..maxLogMeasReport)) OF MDT-

     MeasurementInfo-r10

MDT-Measurement-Info-r10 ::=
     SEQUENCE {
     locationInfo-r10                           LocationInfo-r10
     OPTIONAL,
     timeInfo-r10                                           INTEGER (0)
```

```
            -- details FFS
    servCellIdentity                                CellGlobalIdEUTRA,
    servCarrierFreq                                 ARFCN-ValueEUTRA,      --
FFS if included, may be

    derived from CGI
    measResultServCell                              SEQUENCE {
            rsrpResult                                      RSRP-Range,
            rsrqResult                                      RSRQ-Range
    },
    measResultNeighCells                            SEQUENCE {
            measResultListEUTRA
    MeasResultList3EUTRA                    OPTIONAL,
            measResultListUTRA
    MeasResultList3UTRA                     OPTIONAL,
            measResultListGERAN
    MeasResultListGERAN                     OPTIONAL,
            measResultsCDMA2000
    MeasResultList3CDMA2000                 OPTIONAL

            --FFS if included
    }
                                            OPTIONAL,
...
}

MeasResultList3EUTRA ::=                            SEQUENCE (SIZE
(1..maxFreqLog)) OF SEQUENCE {
    carrierFreq
    ARFCN-ValueEUTRA,
    measResultList
    MeasResultList4EUTRA
}

MeasResultList4EUTRA ::=                            SEQUENCE (SIZE
(1..maxCellReport)) OF MeasResult4EUTRA

MeasResult4EUTRA ::=                                        SEQUENCE {
    physCellId                                              PhysCellId,
    measResult                                              SEQUENCE {
            rsrpResult
    RSRP-Range,
```

```
                rsrqResult
        RSRQ-Range,
                ...
        }
}

MeasResultList3UTRA ::=                         SEQUENCE (SIZE
(1..maxFreqLog)) OF SEQUENCE {
        carrierFreq
        ARFCN-ValueUTRA,
        measResultList
        MeasResultList4UTRA
}

MeasResultList4UTRA ::=                         SEQUENCE (SIZE
(1..maxCellReport) OF MeasResult4UTRA

MeasResult4UTRA ::=                                     SEQUENCE {
        physCellId
        PhysCellIdUTRA-FDD,
        measResult                                      SEQUENCE {
                utra-RSCP
        INTEGER (-5..91),
                utra-EcN0
        INTEGER (0..49),
                ...
        }
}

MeasResultList3CDMA2000 ::=                             SEQUENCE (SIZE
(1..maxFreqLog)) OF SEQUENCE {
        carrierFreq
        ARFCN-ValueEUTRA,
        measResultList
        MeasResultList4CDMA2000
}


MeasResultList4CDMA2000 ::=                     SEQUENCE (SIZE
(1..maxCellReport)) OF SEQUENCE

        MeasResult4CDMA2000
```

```
MeasResult4CDMA2000 ::=    SEQUENCE {
     physCellId
     PhysCellIdCDMA2000,
     measResult                                                  SEQUENCE {
                pilotPnPhase
     INTEGER    (0..32767)          OPTIONAL,
                pilotStrength
     INTEGER (0..63),
                ...
     }
}
```

A UE measurement timestamp in a measurement report is supposed to give the network, e.g. eNB, RNC or such as an OAM node and any other node that needs to have the data, knowledge of when the respective measurement was made by the respective UE. The network absolute timestamp currently provided by 3GPP makes that impossible unless all network nodes are synchronized and use the same time base e.g., Greenwich Mean Time (GMT). As currently specified, the absolute timestamp echoed by a UE can be on a time base that is not the same as the time base used in the node receiving the measurement report, which includes no information about the time base of the echoed absolute timestamp. A network can have nodes, such as eNBs and RNCs, that use different time bases because, for example, the nodes have different manufacturers or have different network management systems/operations. It can also be so that there was simply no need to have a synchronized absolute time clock in the nodes or that the nodes' clocks drift independently, resulting in time differences between nodes.

In addition, a UE timestamp in an MDT measurement report may not give the network knowledge of when the respective measurement was made due to problems in the UE. For example, a UE may clear its current MDT configuration when a corresponding timer, e.g. a periodic logging timer, expires, and that also clears the network absolute timestamp that is to be echoed back to the network in a measurement report. Thus, either old absolute timestamps must be retained in the UE's internal information storage, or the handling of current MDT configuration variables and signaling needs to be more complicated.

SUMMARY

The object of the present disclosure is to address some of the problems and disadvantages outlined above, and to provide methods and arrangements that provide time-stamping of reports in communication system.

The above stated object is achieved by means of the methods and the arrangements according to the independent claims.

In accordance with a first aspect of embodiments, a method in a mobile node of time-stamping reports is provided. The mobile node is configured to communicate with a network node. The method comprises starting an internal clock function and storing, in a log, collected data with a data timestamp corresponding to a current value of the internal clock function. Thereby a time of collecting the data is indicated. Furthermore, the method comprises sending a report to the network node. The sent report includes the log and a report timestamp corresponding to a current value of the internal clock function, thereby indicating a time of sending the report.

In accordance with a second aspect of embodiments, a method in a network node of time-stamping reports is provided. The network node is configured to communicate with a mobile node for collecting data. The method comprises receiving a report from the mobile node. The report comprises data collected by the mobile node and the data is stored with a data timestamp corresponding to a value of an internal clock function of the mobile node indicating a time of collecting the data. The report also comprises a report timestamp corresponding to a value of the internal clock function of the mobile node indicating a time of sending the report. The method further comprises storing the report with a reception timestamp corresponding to a current value of an internal clock function of the network node upon reception of the report, thereby indicating a time of receiving the report.

In accordance with a third aspect of embodiments, a mobile node arranged to time-stamp reports is provided. The mobile node is configured to communicate with a network node. The mobile node comprises a memory unit and processor unit adapted to start an internal clock function and to store collected data with a data timestamp corresponding to a current value of the internal clock function in a log in the memory unit, thereby indicating a time of collecting the data. Furthermore, the mobile node comprises a transceiver unit adapted to send a report to the network node. The report includes the log and a report timestamp corresponding to a current value of the internal clock function, thereby indicating a time of sending the report.

In accordance with a fourth aspect of embodiments, a network node arranged to time-stamp reports is provided. The network node is configured to communicate with a mobile node for collecting data. The network node comprises a radio circuit adapted to receive a report from said mobile node. The report comprises data collected by the mobile node and the data is stored with a data timestamp corresponding to a value of an internal clock function of the mobile node indicating a time of collecting the data. The report also comprises a report timestamp corresponding to a value of the internal clock function of the mobile node indicating a time of sending the report. The network node further comprises a control processor unit configured to store the report with a reception timestamp corresponding to a current value of an internal clock function of the network node upon reception of the report, thereby indicating a time of receiving the report.

An advantage of particular embodiments is that they provide a solution to the stated object which offers simple implementation and operational simplicity without requiring complex arrangements in the mobile node or in the network.

A further advantage of particular embodiments is that they provide a solution which does not require synchronization of clocks in the mobile node nor in the network.

Further advantages and features of embodiments will become apparent when reading the following detailed description in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding, reference is made to the following drawings and preferred embodiments.

Figure 1 illustrates the prior art procedure of requesting logging of measurements.

Figure 2 illustrates the prior art procedure of reporting of the measurement log from the user equipment to the network.

Figure 3 depicts an outline of scenario used in the exemplary embodiments.

Figure 4 shows a flowchart of an exemplary embodiment of a method in a mobile node and a network node for time-stamping of reports.

Figure 5 is an exemplary signalling diagram illustrating the procedure of time-stamping reports in accordance with an exemplary embodiment.

Figures 6 is a block diagram illustrating the mobile node according to embodiments.

Figures 7 is a block diagram illustrating the network node according to embodiments.

DETAILED DESCRIPTION

In the following description, for purposes of explanation and not limitation, specific details are set forth, such as particular sequences of steps and particular device configurations in order to provide a thorough understanding of the embodiments. It will be apparent to one skilled in the art that the embodiments may be practiced in other embodiments that depart from these specific details. In the drawings, like reference signs refer to like elements.

Embodiments are described herein by way of reference to particular example scenarios. Particular aspects are described in a non-limiting general context in relation to measurements made in a cellular communication system. It should though be noted that the disclosure and its exemplary embodiments may also be applied to other types of collection of data in other types of communication networks for time-stamping reports.

The term "network node" is used herein to refer to a node which may be a fixed communication node, an operation and maintenance node, or other type of centralized network node that support the operation in other network nodes. A "fixed communication node" is used to refer to a node with a fixed location, which is provided with means for wireless communication over a radio interface. A fixed communication node may e.g. be a radio base station, a repeater or a relay.

A "mobile node" is a node without a fixed location, which is provided with means for wireless communication over a radio interface. The mobile node may e.g. be a mobile terminal or some other type of mobile user equipment.

A time stamp mechanism is provided that allows the network, OAM, and any other node to determine the absolute time when a measurement is done without requiring absolute time synchronization between all nodes involved. The methods and apparatus described below use cellular communication networks (e.g., LTE and UMTS) as targets, but it should be understood that the embodiments described in the following apply in general to any kind of network that collects data and/or measurements, stores them, and then later sends them to one or more nodes that would like to receive them and also know the time when they were collected.

In accordance with aspects of exemplary embodiments, a user equipment (UE) time stamps the report when it is about to be sent to the network from the UE, using a term such as "submit to lower layers for transmission". An outline of scenario used in the exemplary embodiments is illustrated by **Figure 3**.

Figure 3 depicts a communication network 30 and messages among network nodes for minimization of drive tests measurements in accordance with exemplary embodiments. As depicted in **Figure 3**, a UE 31 receives an MDT configuration message 32 sent by an eNB/RNC 33 in a first cell in a manner such as that illustrated by step 10 in **Figure 1**. The eNB/RNC 33 can be called a Configuring Radio Access Network (RAN) node. After receiving the configuration message, the UE 31 moves across a border 34 between the first cell and a second cell, whereupon the UE 31 undergoes for example a handover (HO) procedure 35 from the eNB/RNC 33 to an eNB/RNC 36, which is a second RAN node. Another example may be when the UE 31 undergoes a cell re-selection procedure when the UE 31 is in idle mode. While in the second cell, the UE 31 sends a measurement report 37 to the eNB/RNC 36, which can be called a Receiving RAN node (see steps 20-24 in **Figure 2**). The Receiving RAN node can send 38 the measurement report, possibly with other measurement reports from the UE 31 and/or other

UEs, to an OAM node 39, e.g., a TCE node.

It is currently preferred that the UE starts an internal clock and/or counter when it receives the MDT configuration message sent by the network node 33 and time-stamps every measurement when it is made with a timestamp indicated by its internal clock and/or counter.

In addition, the UE includes a current timestamp indicated by its internal clock and/or counter in the measurement report when the UE sends the measurement report to the Receiving RAN node 36. It will be understood that it has been assumed that the time needed for sending and receiving a measurement report is negligible, but if that time is not negligible, it can be compensated by including a suitable offset.

In that way, the Receiving RAN node 36 can relate or transform the UE's timestamps in the measurement report to its own (local) absolute time. The node 36 can optionally add a timestamp or other suitable indication of its own absolute time to the measurement report upon forwarding a stored measurement report to another network node, such as the OAM and/or TCE node 37. In general, any network node that is between the UE and a final network node that utilizes the UE's measurement report, that stores the measurement log, and that is not synchronized with the final network node, can add a timestamp or other suitable indication of its own (local) absolute time to a measurement report.

By including the indication of the UE's internal clock and/or counter and optionally, the indication of the local absolute time of an intermediate node, in a measurement report when the report is sent or forwarded, the handling of the network absolute timestamp of a configuration message that needs to be echoed back with a measurement report is simplified, and the actual times of measurements described in a measurement report can be determined.

An exemplary embodiment includes one or more of the following steps; a UE starts or initializes an internal counter and/or clock upon receiving an MDT configuration message for logging; the UE uses the internal counter and/or clock value to time-stamp measurements, such as periodic log events, thereby indicating the time of the measurements; and the UE includes the current value of the counter and/or clock in a measurement report message when the UE sends the report message, thereby indicating the time of sending the report message.

A network node, e.g., an eNB or RNC, that receives and stores a UE measurement report carries out a method having one or more of the following steps; upon receiving the report message the network node adds a real time stamp, e.g., the absolute time, on receiving and/or storing the message/measurements in the node, thereby indicating the time of receiving the report message; a network node that generates a final report message to be sent to an OAM node includes an additional absolute time stamp in the final report message. The final report message thus comprises the report of the UE and an additional time stamp indicating the time of sending the final report message.

It will thus be understood that an "absolute time value" need not be configured in the UE, or "echoed" by the UE in every measurement report message. Instead, the UE can simply add an indication of the time when it sends the report message to a RAN node, and forwarding nodes can simply add respective indications of the times when each forwarded the report message to another node. Thus, methods and apparatus in accordance with this disclosure solve several problems that exist with report procedures currently specified by 3GPP, and do not require complicated arrangements in either a UE or a network for keeping their clocks synchronized.

In **Figure 4** an exemplary embodiment of a method in a mobile node (MN) and a network node (NN) for time-stamping reports is illustrated. The mobile node is configured to communicate with a network node comprised in a communication system. In a first step 40 the mobile node starts an internal clock function T_{intMN}. The mobile node then starts collecting data. The data collected may, for example, be data collected during executing the measurements as previously described. In one embodiment the measurement may be any of the measurements required for MDT functionality, e.g., the measurement executed may be a downlink pilot signal strength measurement of serving or neighbour cell, a downlink pilot signal quality measurement of serving or neighbour cell, etc. It should be noted that the measurements could be executed periodically in the mobile node. In a step 41 the mobile node stores the collected data in a log with a data timestamp corresponding to a current value of the internal clock function T_{intMN}, thereby indicating the time of collecting the data. The data timestamp is equivalent to an absolute timestamp previously mentioned. The mobile node sends in a step 42 a report to the network node, including the log and a report timestamp corresponding to a current value of the internal clock function T_{intMN} indicating the time of sending the report.

Furthermore, in a step 43 the network node receives the report from the mobile node. The received report comprises the log and the report timestamp. In a further step 44, the network node stores the report with a reception timestamp corresponding to a current value of the network node's internal clock function T_{intNN} upon reception of the report, thereby indicating a time of receiving the report.

In a further exemplary embodiment the network node determines a correlation between the internal clock function of the network node T_{intNN} and the internal clock function of the mobile node T_{intMN} by comparing the reception timestamp and the report timestamp.

Figure 5 illustrates yet a further exemplary embodiment, wherein the mobile node such as a UE receives 50 a message to start collecting data from the network node. The message may be a MDT configuration message as previously described. The network node is e.g. an eNB or a RNC. In a step 51 the mobile node starts the internal clock function T_{intUE}. The mobile node then starts collecting data. The data collected may, for example, be data collected during executing the measurements as previously described. In one embodiment the measurement may be any of the measurements required for MDT functionality, e.g., the measurement executed may be a downlink pilot signal strength measurement of serving or neighbour cell, a downlink pilot signal quality measurement of serving or neighbour cell, etc. It should be noted that the measurements could be executed periodically in the mobile node. When the measurements are executed the UE stores 52 the measurement data in a measurement log, such as a MDT measurement log, in the UE. The measurement data is stored with a current value of the internal clock function T_{intUE} in the measurement log i.e. the measurement data is stored with a timestamp in the log. The UE sends 53 an indication to the network node that the measurement log is available. Next, the network node may send 54 a request to deliver the measurement log to the UE. The UE receives the request from the network node and then delivers 55 a report comprising the measurement log comprising the timestamped measurement data and a report timestamp corresponding to the current value of the internal clock function T_{intUE} indicating the time of sending the report to network node. The network node receives the report from the mobile node and stores 56 the report with a reception timestamp corresponding to a current value of an internal clock function of the network node $T_{RANreal}$ upon reception of the report. The reception timestamp $T_{RANreal}$ indicates the local time of receiving the report.

In an exemplary embodiment the network node may determine the correlation between the internal clock function of the network node $T_{RANreal}$ and the internal clock function of the mobile node T_{intUE} by comparing the reception timestamp and the report timestamp. The network node may then further process the measurement data in the network node. However, in another exemplary embodiment the described network node may be an intermediate network node of which there may be one or several in a communication system. The intermediate network node may send 57 a final report to a further network node, e.g., another eNB, a OAM and/or TCE. This final report may include the report received from the UE, i.e. the report including the measurement data with the data timestamp and the report timestamp, and the reception timestamp and a timestamp corresponding to a current value of the internal clock function of the intermediate network node $T_{RANreal}$, thereby indicating a time of sending the final report from the intermediate network node. The final report sent from the intermediate network node may comprise reports received from several UEs in the communication system. The further network node receives the final report and stores 58 the report with a reception timestamp corresponding to a current value of an internal clock function of the further network node $T_{OAMreal}$ upon reception of the final report. The reception timestamp $T_{OAMreal}$ indicates the local time of receiving the final report. The reception timestamp is equivalent to an absolute timestamp previously mentioned.

The further network node may determine the correlation between the internal clock function of the further network node $T_{OAMreal}$ and the internal clock function of the intermediate network node $T_{RANreal}$ by comparing the reception timestamp and the final report timestamp. The network node may then further process the measurement data comprised in the measurement log in the further network node.

Figure 6 is a block diagram of a typical mobile node 400, such as a user equipment, mobile phone, computer, etc., for generating and handling messages as described in this application.

The mobile node 600 includes a transceiver 602 that is suitable for exchanging electronic signals with one or more of network nodes. Information carried by those signals is handled by a processor 604, which may include one or more sub-processors, and which executes one or more software modules and applications, including for example modules and applications that cause the processor to respond to configuration messages, to cause the mobile node to obtain measurements, to generate time stamps and measurement reports, and to carry out the operations of the mobile node 600 described above. User input to the mobile node 600 is provided through a keypad, remote control, or other device 606, and information presented to the user is provided to a display 608. If the display has touch-screen capabilities, user input can be provided through the display. Software applications may be stored in a suitable application memory 610, and the mobile node may also download and/or cache desired information in a suitable memory 612. The mobile node 600 may also include an interface 614 that can be used to connect other components, such as a computer, microphone, etc., to the mobile node 600. Based on its programming, the processor 604 forms the appropriate messages and sends them to the network via transceiver 602, and acts on messages and information received from the network. Such activity can include the methods described above.

In an exemplary embodiment the mobile node 600 comprises a memory unit 612 and processor unit 604 adapted to start an internal clock function and to store collected data with a data timestamp corresponding to a current value of an internal clock function in a log in the memory unit 612, thereby indicating a time of collecting the data. The mobile node 600 further comprises a transceiver unit 602 which is adapted to send a report to a network node. The report includes the log and a report timestamp which corresponds to a current value of the internal clock function, thereby indicating a time of sending the report. In another exemplary embodiment the mobile node 600 the transceiver unit 602 is further adapted to receive a message to start collecting data from the network node. Moreover, it is adapted to send an indication to the network node that the log is available, and to receive a request to deliver the log from the network node.

Figure 7 is a block diagram of a portion of a network node 700, such as an eNB, RNC, etc., and other such transmitting nodes in a network that can communicate with mobile nodes by implementing the methods described above. Other than the radio-related portions, the block diagram is also typical of other nodes in the network, such as OAM, TCE, etc. It will be appreciated that the functional blocks depicted in **Figure 7** can be combined and re-arranged in a variety of equivalent ways, and that many of the functions can be performed by one or more suitably programmed digital signal processors and other known electronic circuits.

The network node 700 is operated by a control processor 702, which typically and advantageously is a suitably programmed digital signal processor. The control processor 702 typically provides and receives control and other signals from various devices in the network node 700. For simplicity in **Figure 7**, the control processor 702 is shown exchanging information with a scheduler and selector 704, which receives digital words to be transmitted to respective mobile nodes or to be broadcast from a suitable data generator 706. The scheduler and selector 704 implements resource block and resource element (RB/RE) scheduling and selection in an LTE system, for example, and implements code allocation in other communication systems, for example.

The control processor 702 can be configured to monitor the load on the network node, which can be determined for example simply by counting the RBs and REs to be transmitted in a sub-frame, frame, or group of them. A processor such as the control processor 702 can also be configured to generate configuration messages and other messages that are sent to the mobile node, for example, messages in connection with handovers to other cells. In addition, a processor such as the control processor 702 can be configured to handle received measurement report messages and generate and add time stamp information as described above.

Information from the scheduler and selector 704 is provided to a modulator 708 that uses the information to generate a modulation signal suitable for the particular communication system. For example, the modulator 708 in an LTE system is an orthogonal frequency division multiplex (OFDM) modulator. The modulation signal generated by the modulator 708 is provided to a suitable radio circuit 710 that generates a wireless signal that is transmitted through at least one transmit antenna 712. Wireless signals transmitted by mobile nodes are captured by at least one receive antenna 714 that provides those signals to the radio 710 and a demodulator 716. The artisan will understand that the same antenna can be used for transmission and reception, as is often done in a mobile node.

It will be understood that the control processor 702 can be configured such that it includes one or more other devices depicted in **Figure 7**, which can be implemented by dedicated programmed processors or other suitable logic configured to perform their functions. The combination of the data generator 706, scheduler and selector 704, and modulator 708 produces DL frames or sub-frames to be transmitted. The modulator 708 converts the information into modulation symbols that are provided to the radio 710, which impresses the modulation symbols on one or more suitable carrier signals. In an LTE system for example, the radio 710 impresses the modulation symbols on a number of OFDM subcarriers. The modulated subcarrier signals are transmitted through the antenna 712.

In an exemplary embodiment the network node 700 comprises a radio circuit 710 adapted to receive a report from the mobile node, such as the mobile node illustrated in **Figure 6**. The report comprises data collected by the mobile node 600 and the data is stored with a data timestamp corresponding to a value of an internal clock function of the mobile node 600 indicating a time of collecting the data. The report also comprises a report timestamp corresponding to a value of the internal clock function of the mobile node 600 indicating a time of sending the report to the network node 700. The network node 700 further comprises a control processor unit 702 which is configured to store the report with a reception timestamp corresponding to a current value of an internal clock function of the network node 700 upon reception of the report, thereby indicating a time of receiving the report. In a further exemplary embodiment the control processor unit 702 is further configured to determine a correlation between the internal clock function of the network node 700 and the internal clock function of the mobile node 600 by comparing the reception timestamp and the report timestamp. In yet another further exemplary embodiment, the radio circuit 710 is further adapted to send the report to another network node including the reception timestamp and a timestamp corresponding to a current value of the internal clock function of the network node 700, thereby indicating a time of sending the report.

In a further exemplary embodiment, the radio circuit 710 is adapted to send a message to start collecting data to the mobile node 600. The radio circuit 710 is further adapted to receive an indication from the mobile node 600 that a report is available and send a request to deliver the report to the mobile node 600.

It will be appreciated that methods described above can be carried out repetitively as necessary, for example, to respond to changes in communication links properties. Assemblies implementing the teachings of this disclosure can be included in, for example, mobile phones, computers, servers, wireless communication network nodes, and the like.

To facilitate understanding, many aspects of this disclosure are described in terms of sequences of actions that can be performed by, for example, elements of a programmable computer system. It will be recognized that various actions could be performed by specialized circuits (e.g., discrete logic gates interconnected to perform a specialized function or application-specific integrated circuits), by program instructions executed by one or more processors, or by a combination of both.

Moreover, this disclosure can additionally be considered to be embodied entirely within any form of computer-readable storage medium having stored therein an appropriate set of instructions for use by or in connection with an instruction-execution system, apparatus, or device, such as a computer-based system, processor-containing system, or other system that can fetch instructions from a medium and execute the instructions. As used here, a "computer-readable medium" can be any means that can contain, store, or transport the program for use by or in connection with the instruction-execution system, apparatus, or device. The computer-readable medium can be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device. More specific examples (a non-exhaustive list) of the computer-readable medium include an electrical connection having one or more wires, a portable computer diskette, a random-access memory (RAM), a read-only memory (ROM), and an erasable programmable read-only memory (EPROM or Flash memory).

Thus, the teachings of this disclosure may be embodied in many different forms, not all of which are described above. The particular embodiments described above are merely illustrative and should not be considered restrictive in any way. It is contemplated that alternatives, modifications, permutations, and equivalents thereof will become apparent upon reading this description and the drawings.

It is emphasized that the terms "comprises" and "comprising", when used in this application, specify the presence of stated features, integers, steps, or components and do not preclude the presence or addition of one or more other features, integers, steps, components, or groups thereof.

CLAIMS

1. A method for time-stamping reports in a mobile node (600), said mobile node configured to communicate with a network node (700), the method comprising

starting (30, 51) an internal clock function,

storing (31, 52) collected data with a data timestamp corresponding to a current value of said internal clock function in a log, thereby indicating a time of collecting said data, and

sending (32, 55) a report to said network node, wherein said report includes said log and a report timestamp corresponding to a current value of said internal clock function, thereby indicating a time of sending said report.

2. The method according to claim 1, wherein the internal clock function is a counter.

3. The method according to claim 1 or claim 2, further comprising

receiving (50) a message to start collecting data from said network node,

sending (53) an indication to said network node that said log is available, and

receiving (54) a request to deliver said log from said network node.

4. The method according to claim 3, wherein said message is a Minimization of the Drive Tests, MDT, configuration message.

5. The method according to any of claims 1 to 4, wherein said log is an MDT measurement log.

6. The method according to any of claims 1 to 5, wherein said network node is comprised in a cellular communication system.

7. The method according to claim 6, wherein said cellular communication system is a Long Term Evolution or a Universal Mobile Telecommunication System.

8. The method according to claim 6 or claim 7, wherein said mobile node is a user equipment, and said network node is a radio base station or a radio network controller.

9. A method for time-stamping reports in a network node (700), said network node configured to communicate with a mobile node (600) for collecting data, the method comprising

receiving (33, 55) a report from said mobile node, wherein said report comprises data collected by said mobile node and said data is stored with a data timestamp corresponding to a value of an internal clock function of said mobile node indicating a time of collecting said data, and said report comprises a report timestamp corresponding to a value of said internal clock function of said mobile node indicating a time of sending said report, and

storing (34, 56) said report with a reception timestamp corresponding to a current value of an internal clock function of said network node upon reception of said report, thereby indicating a time of receiving said report.

10. The method according to claim 9, further comprising

determining a correlation between said internal clock function of said network node and said internal clock function of said mobile node by comparing said reception timestamp and said report timestamp.

11. The method according to claim 9 or 10, wherein said internal clock function of said mobile node is a counter.

12. The method according to any of claims 9 to 11, wherein said report is report of a Minimization of the Drive Tests, MDT, measurement log, and said message is an MDT configuration message.

13. The method according to any of claims 9 to 12, wherein said network node is comprised in a cellular communication system.

14. The method according to any of claims 9 to 13, wherein said cellular communication system is a Long Term Evolution or a Universal Mobile Telecommunication System.

15. The method according to any of claims 9 to 14, wherein said mobile node for collecting data is a user equipment.

16. The method according to any of claims 9 to 15, wherein said network node is an operation and maintenance node.

17. The method according to any of claims 9 to 15, further comprising

sending (57) said report to another network node including said reception timestamp and a timestamp corresponding to a current value of said internal clock function of said network node, thereby indicating a time of sending said report.

18. The method according to any of claims 9 to 15 or 17, further comprising

sending (50) a message to start collecting data to said mobile node,

receiving (53) an indication from said mobile node that a report is available, and

sending (54) a request to deliver said report to said mobile node.

19. The method according to any of claims 9 to 15 or 17 to 18, wherein said network node is a radio base station or a radio network controller.

20. A mobile node (600) arranged to time-stamp reports, said mobile node is configured to communicate with a network node (700), the mobile node comprising a memory unit (612) and processor unit (604) adapted to

start an internal clock function,

store collected data with a data timestamp corresponding to a current value of said internal clock function in a log in the memory unit (612), thereby indicating a time of collecting said data, and further comprising a transceiver unit (602) adapted to

send a report to said network node (700), wherein said report includes said log and a report timestamp corresponding to a current value of said internal clock function, thereby indicating a time of sending said report.

21. The mobile node (600) according to claim 20, wherein the internal clock function is a counter.

22. The mobile node (600) according to claim 20 or claim 21, wherein said transceiver unit (602) is further adapted to

receive a message to start collecting data from said network node (700),

send an indication to said network node (700) that said log is available, and

receive a request to deliver said log from said network node (700).

23. The mobile node (600) according to claim 22, wherein said message is a Minimization of the Drive Tests, MDT, configuration message.

24. The mobile node (600) according to any of claims 20 to 23, wherein said log is an MDT measurement log.

25. The mobile node (600) according to any of claims 20 to 24, wherein said network node (700) is configured to be comprised in a cellular communication system.

26. The mobile node (600) according to claim 25, wherein said cellular communication system is a Long Term Evolution or a Universal Mobile Telecommunication System.

27. The mobile node (600) according to claim 25 or claim 26, wherein said mobile node (600) is a user equipment, and said network node (700) is a radio base station or a radio network controller.

28. A network node (700) arranged to time-stamp reports, said network node is configured to communicate with a mobile node (600) for collecting data, said network node (700) comprising a radio circuit (710) adapted to

receive a report from said mobile node (600), wherein said report comprises data collected by said mobile node (600) and said data is stored with a data timestamp corresponding to a value of an internal clock function of said mobile node (600) indicating a time of collecting said data, and said report comprises a report timestamp corresponding to a value of said internal clock function of said mobile node (600) indicating a time of sending said report, and the network node (700) further comprising a control processor unit (702) configured to

store said report with a reception timestamp corresponding to a current value of an internal clock function of said network node (700) upon reception of said report, thereby indicating a time of receiving said report.

29. The network node (700) according to claim 28, wherein said control processor unit (702) is further configured to

determine a correlation between said internal clock function of said network node (700) and said internal clock function of said mobile node (600) by comparing said reception timestamp and said report timestamp.

30. The network node (700) according to claim 28 or 29, wherein said internal clock function of said mobile node (600) is a counter.

31. The network node (700) according to any of claims 28 to 30, wherein said report is report of a Minimization of the Drive Tests, MDT, measurement log, and said message is an MDT configuration message.

32. The network node (700) according to any of claims 28 to 31, wherein said network node (700) is configured to be comprised in a cellular communication system.

33. The network node (700) according to any of claims 28 to 32, wherein said cellular communication system is a Long Term Evolution or a Universal Mobile Telecommunication System.

34. The network node (700) according to any of claims 28 to 33, wherein said mobile node (600) for collecting data is a user equipment.

35. The network node (700) according to any of claims 28 to 34, wherein said network node (700) is an operation and maintenance node.

36. The network node (700) according to any of claims 28 to 34, wherein said radio circuit (710) is further adapted to

send said report to another network node including said reception timestamp and a timestamp corresponding to a current value of said internal clock function of said network node (700), thereby indicating a time of sending said report.

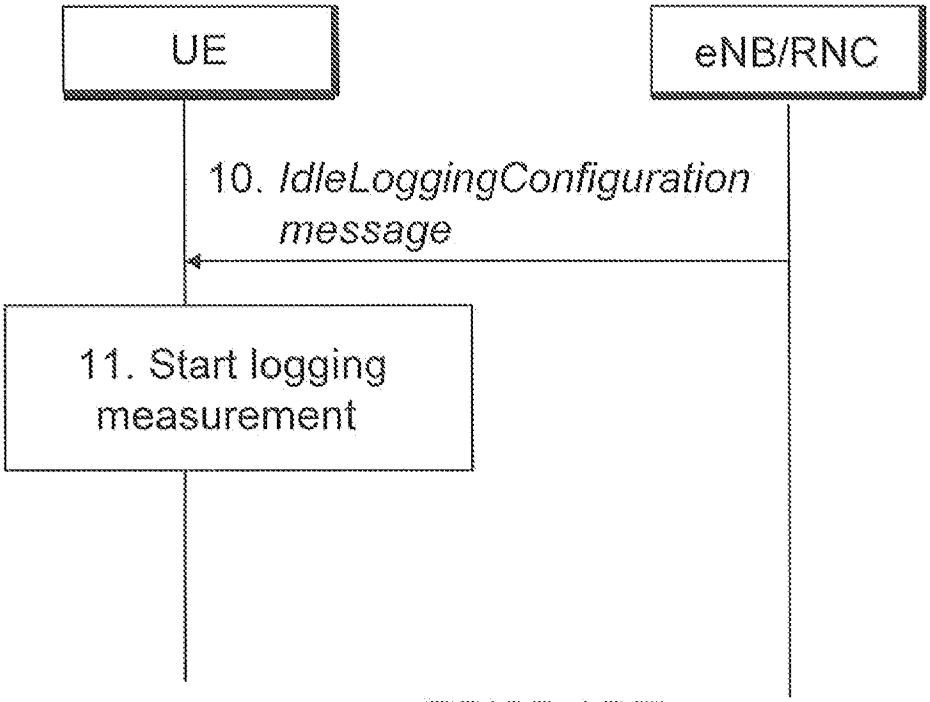
37. The network node (700) according to any of claims 28 to 34 or 36, wherein said radio circuit (710) is further adapted to

send a message to start collecting data to said mobile node (600),

receive an indication from said mobile node (600) that a report is available, and

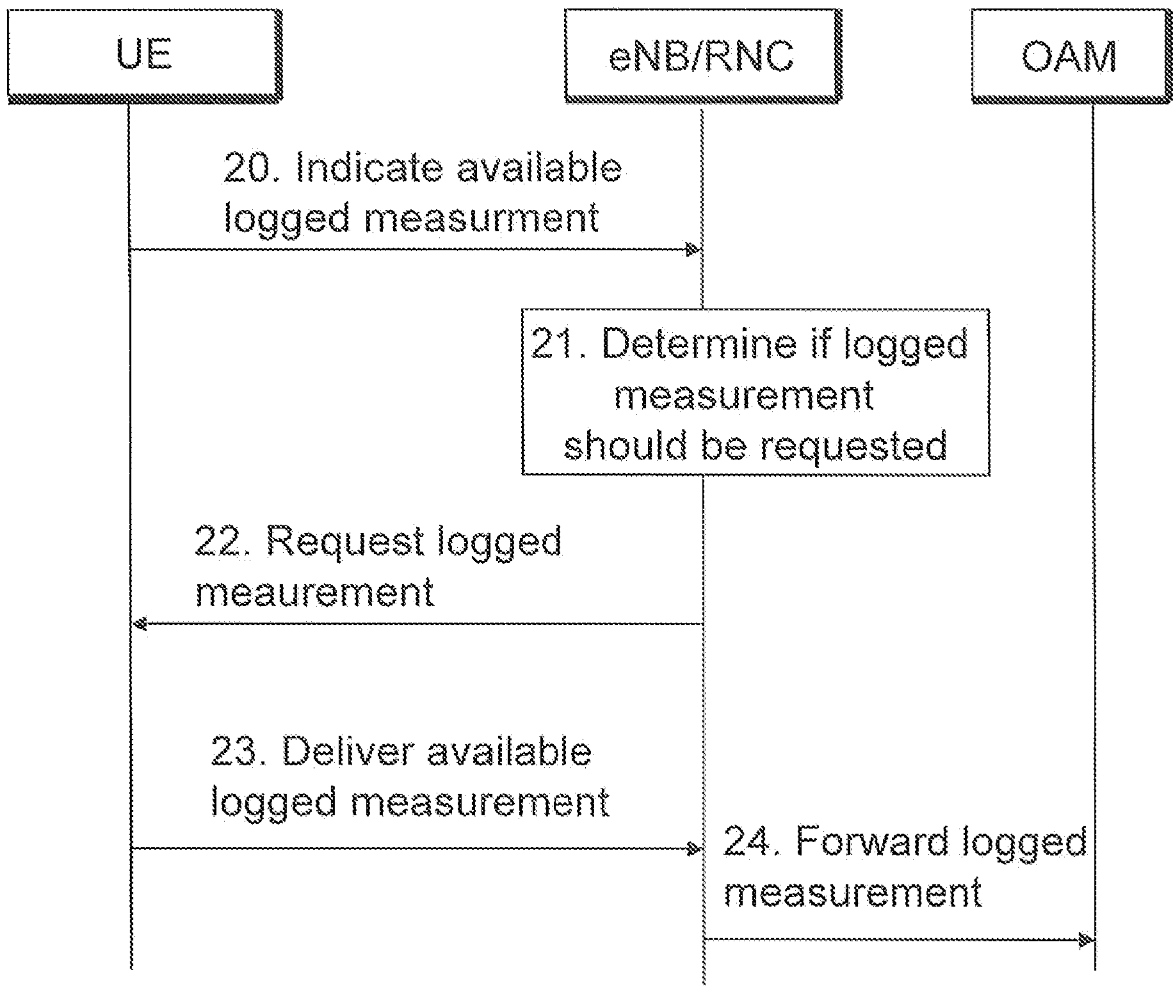
send a request to deliver said report to said mobile node (600).

38. The network node (700) according to any of claims 28 to 34 or 36 to 37, wherein said network node (700) is a radio base station or a radio network controller.



(PRIOR ART)

Fig 1



(PRIOR ART)

Fig 2

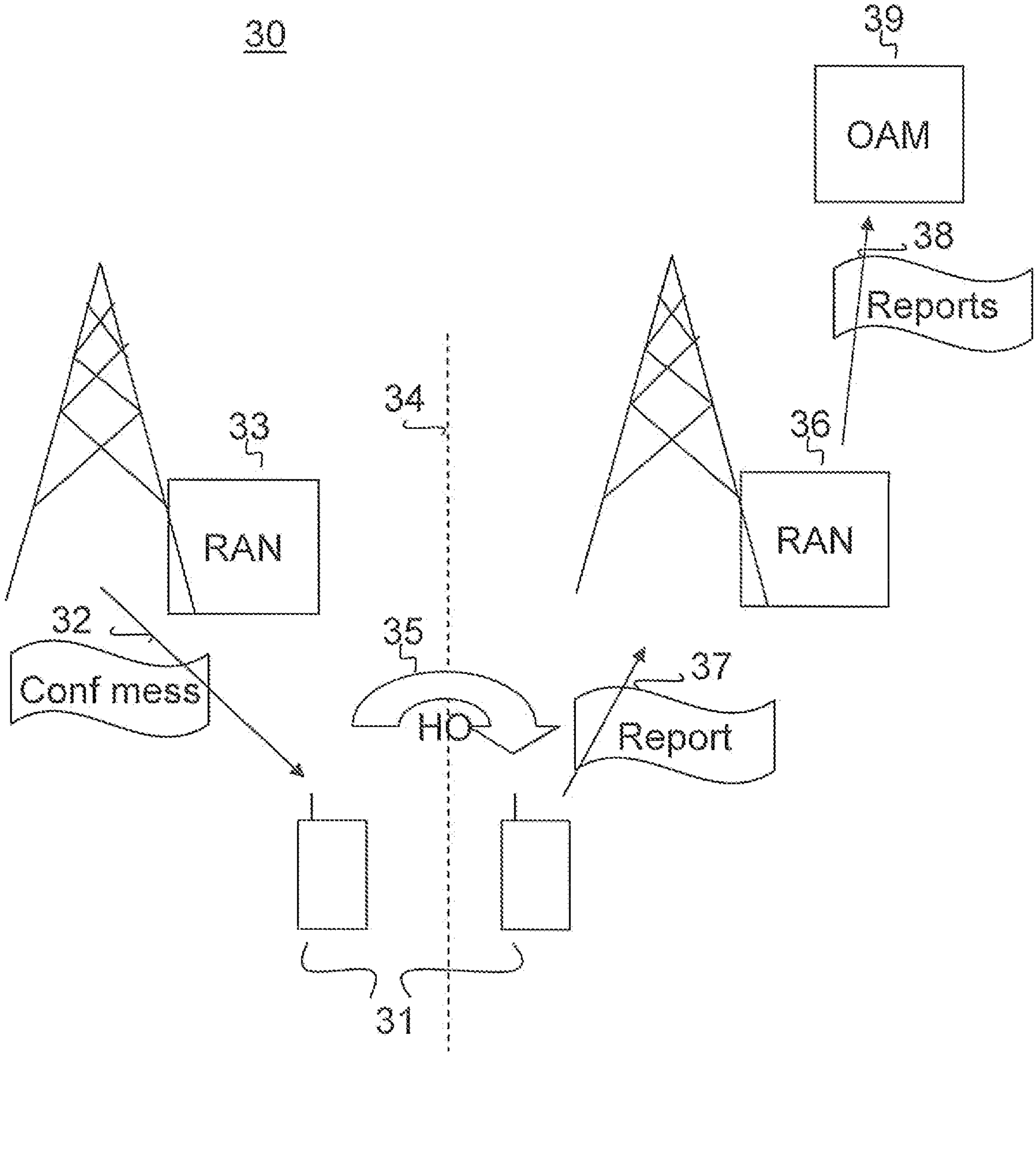

30
39
OAM
38
Reports
34
33
36
RAN
RAN
32
35
37
Conf mess
HO
Report
31

Fig 3

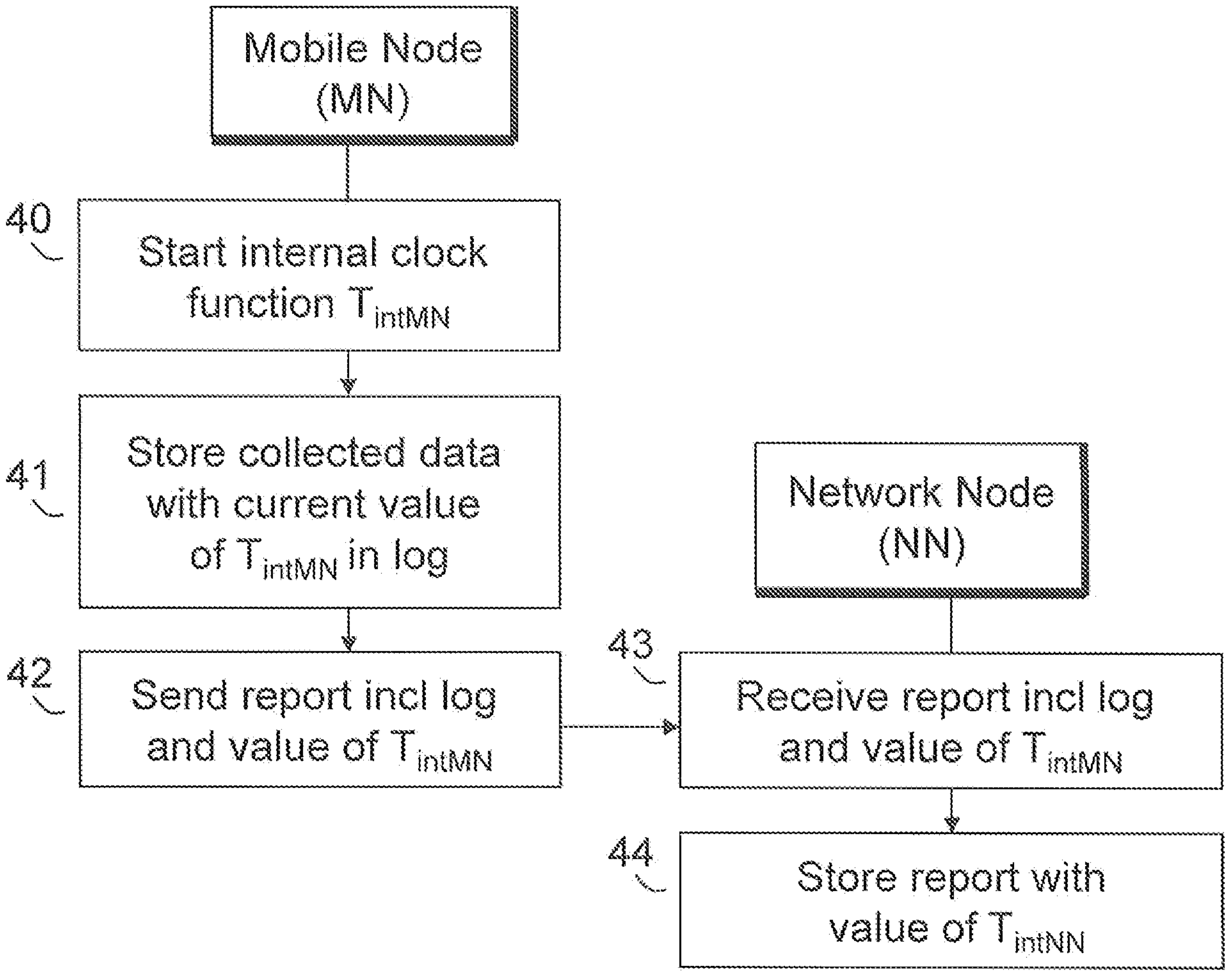

Mobile Node (MN)
40
Start internal clock function T_{intMN}
41
Store collected data with current value of T_{intMN} in log
42
Send report incl log and value of T_{intMN}
Network Node (NN)
43
Receive report incl log and value of T_{intMN}
44
Store report with value of T_{intNN}

Fig 4

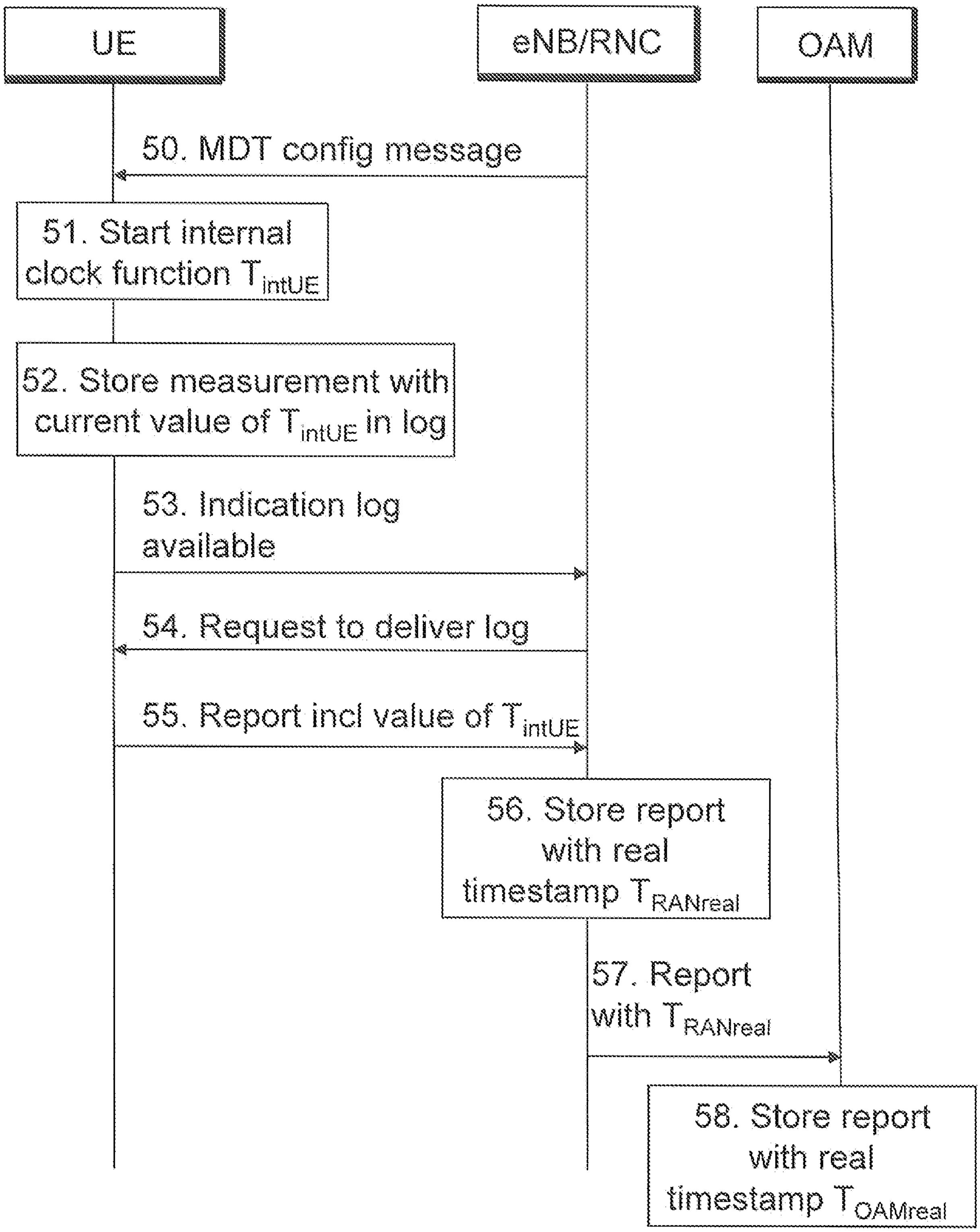

UE
eNB/RNC
OAM
50. MDT config message
51. Start internal clock function T_{intUE}
52. Store measurement with current value of T_{intUE} in log
53. Indication log available
54. Request to deliver log
55. Report incl value of T_{intUE}
56. Store report with real timestamp $T_{RANreal}$
57. Report with $T_{RANreal}$
58. Store report with real timestamp $T_{OAMreal}$

Fig 5

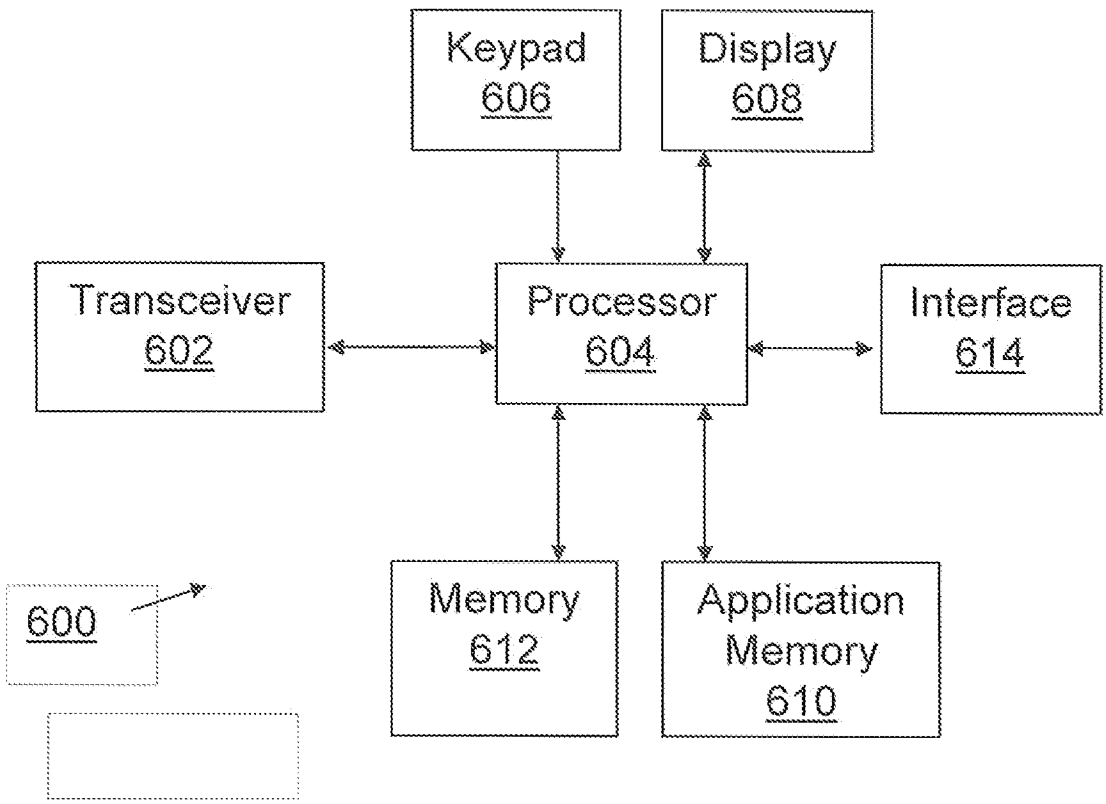

Keypad
606
Display
608
Transceiver
602
Processor
604
Interface
614
600
Memory
612
Application
Memory
610

Fig 6

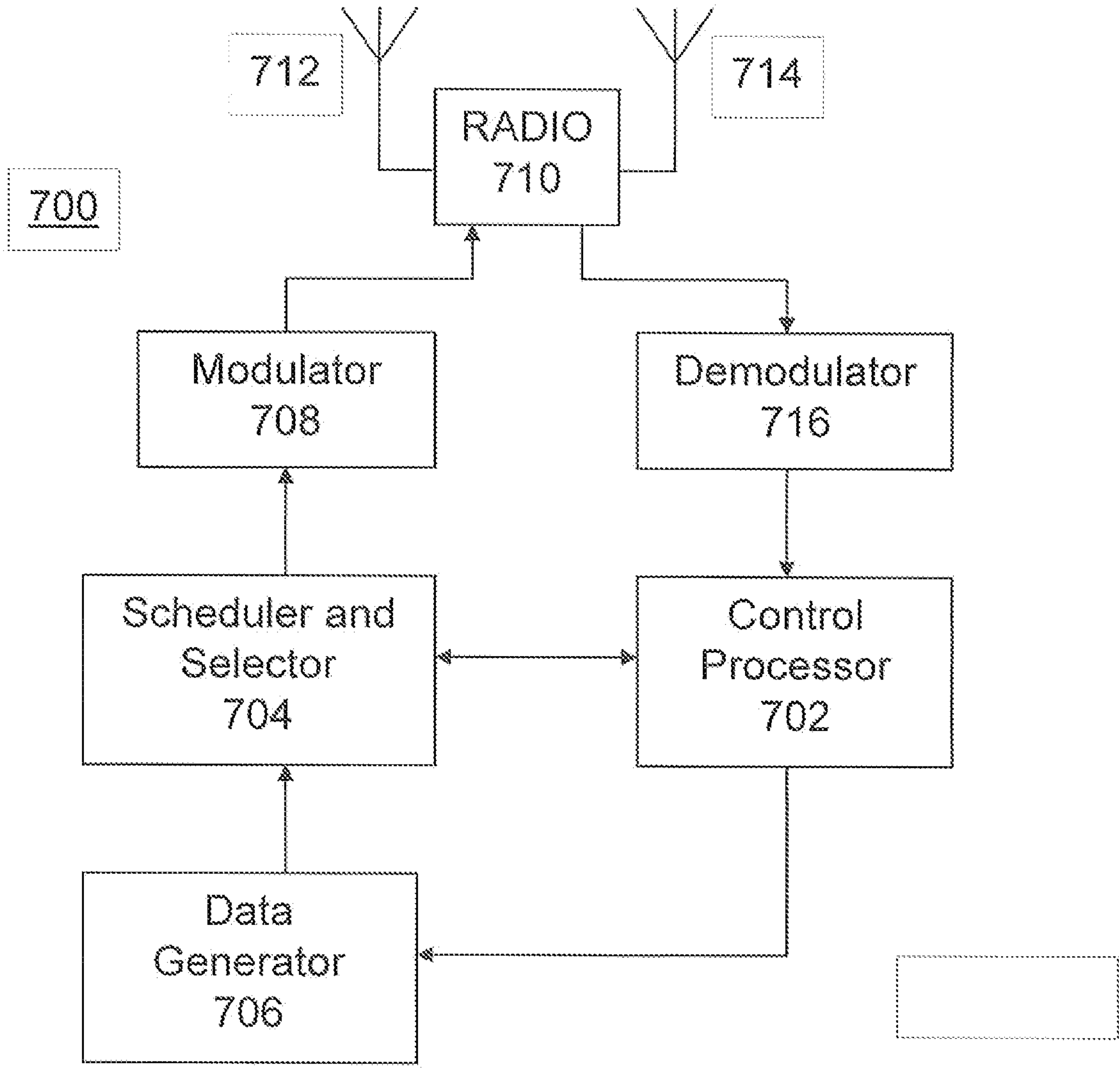

712
714
RADIO
710
700
Modulator
708
Demodulator
716
Scheduler and
Selector
704
Control
Processor
702
Data
Generator
706

Fig 7

INTERNATIONAL SEARCH REPORT

International application No
PCT/SE2011/051145

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W24/02
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 practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	TD TECH: "Time stamp achievement and reporting in MDT", 3GPP DRAFT; R2-101117_TIME STAMP ACHIEVEMENT AND REPORTING IN MDT, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. San Francisco, USA; 20100222, 15 February 2010 (2010-02-15), XP050421610, [retrieved on 2010-02-15]	1,2, 5-17, 19-21, 24-36,38
Y	the whole document	3,4,18, 22,23,37

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

[ ] See patent family annex.

* Special categories of cited documents :

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

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

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

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

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 January 2012	06/02/2012

Name and mailing address of the ISA/	Authorized officer
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1

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON: "Triggers for logged MDT measurement reporting", 3GPP DRAFT; R2-101426 TRIGGERS FOR NON-REAL TIME MDT REPORTING, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. San Francisco, USA; 20100222, 16 February 2010 (2010-02-16), XP050421823, [retrieved on 2010-02-16] the whole document -----	3,4,18, 22,23,37
X,P	ERICSSON ET AL: "Correction of time stamp handling for Logged MDT", 3GPP DRAFT; R2-106346 CORRECTION TO TIME STAMP METHOD, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE, vol. RAN WG2, no. Jacksonville, USA; 20101115, 9 November 2010 (2010-11-09), XP050492243, [retrieved on 2010-11-09] the whole document -----	1-38

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