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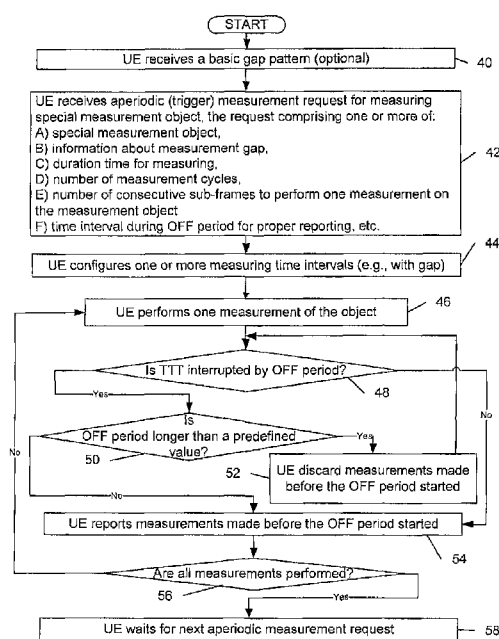
(54) **Title:** FLEXIBLE MEASUREMENTS IN UNLICENSED BAND

Figure 4

(57) **Abstract:** The specification and drawings present a new method, apparatus and software related product (e.g., a computer readable memory) for implementing enhanced and flexible radio aperiodic measurements, e.g., on an unlicensed band in LTE wireless systems and providing effective and timely reporting. A UE may receive from a wireless network an aperiodic measurement request to measure a special measurement object (e.g., a neighbor cell) specified in the aperiodic measurement request, e.g., in an unlicensed band. In response to the aperiodic measurement request, the UE may perform the measurement of the special measurement object until a further instruction from the wireless network or for a determined period of time. Inter-frequency measurements may be performed during the measurement gap determined from the aperiodic measurement request.



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FLEXIBLE MEASUREMENTS IN UNLICENSED BAND

Technical Field

The exemplary and non-limiting embodiments of this invention relate generally to
 5 wireless communications and more specifically to implementing flexible (e.g., aperiodic)
 measurements of a special measurement object in an unlicensed band in LTE wireless systems.

Background Art

The following abbreviations that may be found in the specification and/or the drawing
 10 figures are defined as follows:

	3GPP	Third Generation Partnership Project
	ANR	Automatic Neighbor Relation
	BW	Bandwidth
15	CA	Carrier Aggregation
	CC	Component Carrier
	CDM	Code Division Multiplexing
	CRS	Cell Specific Reference Signal
	DCI	Downlink Control Information
20	DL	Downlink
	DRX	Discontinuous Reception
	eICIC	Enhanced Inter-Cell Interference Coordination
	E-UTRA	Evolved Universal Terrestrial Radio Access
	eNB	Evolved Node B /Base Station in an E-UTRAN System
25	E-UTRAN	Evolved UTRAN (LTE)
	FDD	Frequency Division Duplex
	FDM	Frequency Division Multiplexing
	IE	Information Element
	ISM	Industrial, Scientific, Medical
30	L3	Layer 3 (network layer)
	LTE	Long Term Evolution
	LTE-A	Long Term Evolution Advanced
	MAC	Medium Access Control
	MAC CE	MAC Control Element
35	MGRP	Measurement Gap Repetition Period
	PDCCH	Physical Downlink Control Channel
	PDSCH	Physical Downlink Shared Channel
	PCell	Primary Cell
	PHY	Physical Layer
40	PUCCH	Physical Uplink Control Channel
	PUSCH	Physical Uplink Shared Channel
	RAT	Radio Access Technology
	RNTI	Radio Network Temporary Identity

	RRC	Radio Resource Control
	RRM	Radio Resource Management
	Rx	Reception, Receiver
	SCell	Secondary Sell
5	SFN	System Frame Number
	SI	System Information
	TA	Timing Advance
	TD	Timing Delay
	TDD	Time Division Duplex
10	TDM	Time Division Multiplexing
	TTI	Transmission Time Interval
	TTT	Time To Trigger
	Tx	Transmission, Transmitter
	UE	User Equipment
15	UL	Uplink
	UTRAN	Universal Terrestrial Radio Access Network

20 LTE-A (Long Term Evolution Advanced) aims at providing significantly enhanced
 services by means of higher data rate and lower latency with a reduced cost. Carrier
 Aggregation (CA) is one of key technologies to greatly improve the data rate. In Release 10 of
 3GPP, the current discussion is mainly about CA of either FDD-FDD system or TDD-TDD
 system on licensed LTE bands, which are scarce resources.

25 Unlicensed band utilization for LTE systems is a subject of recent research as it may
 offer an operator an opportunity to offload traffic from a crowded licensed LTE band to an
 unlicensed band if necessary. This is likely to be considered in Release 12 of 3GPP and beyond
 releases of 3GPP documents. By using the unlicensed band and licensed band CA, we can get
 some valuable benefits such as balancing the traffic load when necessary, improving the peak
 data rate, and improving the spectrum efficiency in general for the operator.

30 The available unlicensed bands are different in different geographical locations around
 the world. The most commonly considered unlicensed spectrum is 2.4GHz ISM band with BW
 of 83.5MHz, the 5GHz unlicensed band with BW larger than 100MHz, and White Space
 spectrum which comprises unused parts (bands) of TV spectrum in the 54-698 MHz range
 (now only US). However, quite a few challenges for the unlicensed band need to be resolved
 35 before efficient utilization can be made. One critical issue is the unlicensed band's inherent
 "share" property. For example for ISM bands, there may be WIFI systems (IEEE
 802.11a/b/g/n/ac), as well as BLUETOOTH, ZIGBEE, WIRELESSUSB, CORDLESS
 PHONE, MICROWAVE, etc. As for White Space spectrum bands, there may be some other

systems also trying to use those spectrum bands. In order to deploy the LTE system on the unlicensed band, an eNB will need to turn off its use of unlicensed bands from time to time due to a large interference or due to giving another system a chance to transmit. An irregular ON/OFF mechanism of LTE system is described in PCT Application PCT/CN2011/001167
5 filed July 14, 2011.

Before configuring a SCell to a UE, it is important that the eNB knows whether or not the concerned UE is in the coverage of the corresponding carrier. Currently, in the LTE system, the UE will do RRM measurement on any configured measurement object, but the choice of which object to measure is up to a UE implementation. Since the LTE system may have an
10 irregular ON/OFF mechanism on the unlicensed band, leaving the measurement object choice purely to the UE may have some problem because during the OFF period, the UE may not be able to detect the CRS which may impact accuracy of the measurement and cause detection errors.

In the legacy LTE system, measurement gaps are configured to let UE to do
15 measurement for other (inter-frequency) neighbor cells or other RATs. Once configured, the measurement gap happens periodically and the UE can do measurements of the neighbor cells it selects using the same gap pattern. In other words, during the measurement gaps, the UE performs its inter-frequency and inter-RAT measurements and it depends on the UE implementation which measurement object is measured at which particular measurement gap.
20 Thus, it is difficult for the network to control the measurements for the unlicensed band using the conventional measurement gaps to ensure that the measurements would only happen during the LTE ON period. A more flexible solution is needed.

In the current LTE systems, there are two types of measurements: one type requires the measurement gaps and the other type doesn't require these gaps. The UE reports the gap
25 requirement to the eNB with UE capability signaling and it is up to the eNB to configure the gaps if the corresponding measurement is needed. In the Stage 2 specifications 3GPP TS 36.300 V10.4.0 (2011-06), there are example schematics illustrating some scenarios on whether the measurement gap is needed as shown in Figure 1 (where the current and target cells operating at the same carrier frequency) or the measurement gap is not needed as shown in
30 Figure 2 (where the current and target cells operating at different carrier frequencies). These

A measurement gap could be configured to trigger the UE to do inter-frequency and inter-RAT measurement. The UE behavior is described in RRC specifications 3GPP TS 36.331

V10.2.0 (2011-06) as follows:

The UE shall:

- 1> if *measGapConfig* is set to *setup*:
 - 2> if a measurement gap configuration is already setup, release the measurement gap configuration;
 - 2> setup the measurement gap configuration indicated by the *measGapConfig* in accordance with the received *gapOffset*, i.e., each gap starts at an SFN and subframe meeting the following condition:

$$\text{SFN mod } T = \text{FLOOR}(\text{gapOffset}/10);$$

$$\text{subframe} = \text{gapOffset mod } 10;$$
 with $T = \text{MGRP}/10$ as defined in TS 36.133 [16];
- 1> else:
 - 2> release the measurement gap configuration;

Furthermore, the measurement gap can have two possible periodicity configurations, as described in RRM requirements specification 3GPP TS 36.133 V10.3.0 (2011-06), as shown in Table 1 below.

Table 1. Measurement gap patterns specified in 36.133

Gap Pattern Id	MeasurementGap Length (MGL, ms)	Measurement Gap Repetition Period (MGRP, ms)	Minimum available time for inter-frequency and inter-RAT measurements during 480ms period (Tinter1, ms)	Measurement Purpose
0	6	40	60	Inter-Frequency E-UTRAN FDD and TDD, UTRAN FDD, GERAN, LCR TDD, HRPD, CDMA2000 1x
1	6	80	30	Inter-Frequency E-UTRAN FDD and TDD, UTRAN FDD, GERAN, LCR TDD, HRPD, CDMA2000 1x

The measurement gaps happen periodically once configured, and the eNB cannot control which measurement object is measured during each gap.

Additionally, a method called enhanced inter-cell interference coordination (eICIC) has been defined in Release 10 of 3GPP. In this method, the eNB is able to affect slightly more specifically the measurement instants when the UE does intra-frequency measurements. However, this mechanism so far (up to Release 10 of 3GPP) is only possible for the intra-frequency measurements (which never require measurement gaps), so is not directly applicable to the measurements requiring measurement gaps. Moreover, the eICIC does not provide a certainty of when the UE does the measurements, and the 40 ms periodicity that the eICIC patterns have may limit its usefulness to the unlicensed band usage.

The Release 8 of 3GPP for the LTE includes a measurement mechanism called Automatic Neighbor Relation (ANR), see 3GPP TS 36.300 V10.4.0 (2011-06) and 3GPP TS 36.331 V10.2.0 (2011-06) for description of the procedure, wherein the eNB instructs the UE to do measurements in a “best effort” basis for a specific measurement purpose, i.e., acquiring the SI from a neighbor cell, a procedure which is normally not supported during active transmission. The measurement is given with a timer attached to control how long the UE does the measurement. The idea is that the UE is expected (to the best of its ability) to use idle periods in transmission (e.g., DRX, unused measurement gaps) for this specific measurement purpose, with the limitation that the measurement should not cause degradation to the normal UE operation. Once the UE has either completed the specific measurement purpose (i.e., has acquired the required SI information from the specified neighbor cell) or the timer attached to the specific measurement purpose expires, the UE automatically reports the results of this procedure to the eNB, i.e., letting the eNB know whether the measurement was successful and if it was, what the results were. After this, the specific measurement purpose is removed until the eNB chooses to re-configure it. However, it should be noted that the ANR procedure places no restrictions as to when the UE does the measurement.

Summary

According to a first aspect of the invention, a method comprises: receiving by a user equipment from a wireless network an aperiodic measurement request to measure a special measurement object specified in the aperiodic measurement request; and measuring the special management object in response to the aperiodic measurement request until a further instruction from the wireless network or for a determined period of time.

According to a second aspect of the invention, an apparatus comprises: at least one processor and a memory storing a set of computer instructions, in which the processor and the memory storing the computer instructions are configured to cause the apparatus to: receive from a wireless network an aperiodic measurement request to measure a special measurement object specified in the aperiodic measurement request; and measure the special management object in response to the aperiodic measurement request until a further instruction from the wireless network or for a determined period of time.

According to a third aspect of the invention, a computer readable memory encoded with a computer program comprising computer readable instructions recorded thereon for

execution a method comprising: receiving by a user equipment from a wireless network an aperiodic measurement request to measure a special measurement object specified in the aperiodic measurement request; and measuring the special management object in response to the aperiodic measurement request until a further instruction from the wireless network or for a
5 determined period of time.

According to a fourth aspect of the invention, a method comprises: determining, in a wireless network, parameters for an aperiodic measurement request to measure a special measurement object by a user equipment, the parameters include the special measurement object; and sending the aperiodic measurement request comprising the parameters to the user
10 equipment for measuring the special management object.

According to a fifth aspect of the invention, an apparatus comprises: at least one processor and a memory storing a set of computer instructions, in which the processor and the memory storing the computer instructions are configured to cause the apparatus to: determine parameters for an aperiodic measurement request to measure a special measurement object by a
15 user equipment, the parameters include the special measurement object; and send the aperiodic measurement request comprising the parameters to the user equipment for measuring the special management object.

According to a sixth aspect of the invention, a computer readable memory encoded with a computer program comprising computer readable instructions recorded thereon for
20 execution a method comprising: determining, in a wireless network, parameters for an aperiodic measurement request to measure a special measurement object by a user equipment, the parameters include the special measurement object; and sending the aperiodic measurement request comprising the parameters to the user equipment for measuring the special management object.

Brief Description of the Drawings:

For a better understanding of the nature and objects of the present invention, reference is made to the following detailed description taken in conjunction with the following drawings, in which:

30 Figure 1 is a schematic diagram of measurement conditions (A, B and C scenarios) which don't need measurement gap;

Figure 2 is a schematic diagram of measurement conditions (D, E and F scenarios)

which need measurement gap;

Figure 3 is a diagram of a possible MAC CE to trigger an aperiodic measurement according to an exemplary embodiment of the invention;

Figure 4 is a flow chart demonstrating implementation of exemplary embodiments of the invention performed by a user equipment;

Figure 5 is a flow chart demonstrating implementation of exemplary embodiments of the invention performed by a network element (e.g., eNB); and

Figure 6 is a block diagram of wireless devices for practicing exemplary embodiments of the invention.

Detailed Description

A new method, apparatus, and software related product (e.g., a computer readable memory) are presented for implementing enhanced and flexible radio measurements on an unlicensed band, e.g., in LTE wireless systems and providing effective and timely reporting.

Because of irregular ON/OFF pattern in the LTE systems (in which a UE's OFF period is when it may measure neighbour cells and its ON period is when it must listen to its serving cell), a more flexible and controllable RRM measurement mechanism should be used. There may be also some differences for the two different types of measurements, i.e., those measurement requiring gaps (e.g., for inter-frequency measurements) and those that do not need gaps (e.g., for intra-frequency measurements). Below, a few examples of embodiments for enabling a flexible measurement on the unlicensed band and subsequent reporting in the LTE system are presented.

Example 1: According to this embodiment, a new aperiodic measurement process in the unlicensed band may be triggered by the eNB to provide a measurement that is strictly controlled to certain time instants and tied to a special (possibly pre-defined) measurement object.

First, the eNB may configure a special measurement object (and related configuration) to a UE. Then, RRC, MAC and/or PHY layer signalling is sent to the UE to trigger the measurement usage. The following may apply for this procedure.

The UE is signalled a basic gap pattern that may be dynamically altered via other means (e.g., events, further signalling), so that the UE may not make measurements linked to the special measurement object in the same way as the normal measurements, i.e., not using the

periodical measurement gap or other normal measurement procedures (e.g., S-measure mechanism defining when the UE is required to perform measurements, see 3GPP TS 36.331 V10.2.0 (2011-06) Section 5.5.3.1, should not be applied for measurements linked to the special measurement object). Moreover, the UE may not be allowed to perform measurements outside the specified measurement gap pattern, regardless of its capabilities. In other words, the measurements are restricted to only the signalled measurement pattern.

According to this embodiment, the eNB may send a trigger signal (e.g., an aperiodic trigger measurement request) which can be, e.g., MAC CE or PHY control channel signalling, either via broadcast message or via dedicated signalling to the UE. Upon receiving the trigger signal the UE may start doing measurements on the configured special measurement object according to following rules: if the measurement gap is needed (e.g., for inter-frequency measurements) similarly as with normal gap configuration, the eNB should also indicate (e.g., in the aperiodic trigger measurement request) the starting point, duration and repetition of the measurement gap so the UE knows how many measurements it is expected to perform (e.g., to make measurements for a specified period of time). The same gap duration as with legacy gap procedure may be used here to ensure the UE can find the target carrier signal. If, however, no measurement gap is needed, the eNB may just signal (via broadcast or dedicated signalling) whether the measurement is prohibited or not and leave implementation details to the UE.

The special measurement object may be a carrier frequency, a set of carrier frequencies, or in general, a legacy measurement object, e.g., various measurement IE can be found in 3GPP TS 36.331 V10.2.0 (2011-06) Section 6.3.5.

The eNB should configure the measurement object and corresponding measurement parameters beforehand. To quickly and flexibly trigger the measurement, the eNB may use MAC CE or PHY control channel; it could just include the information that it is a measurement trigger and which measurement object is triggered. Figure 3 shows an exemplary MAC CE for such signaling, i.e., to trigger aperiodic measurement (R stands for “reserved”).

Another way may be to use the event configuration, i.e., have the events themselves describe whether the measurement object they are linked to should have special handling (this would also enable the linking of these special measurement events to “normal” measurement objects, if so desired). An example is shown below:

```
ReportConfigEUTRA ::=
    triggerType
```

```
SEQUENCE {
    CHOICE {
```

	event	SEQUENCE {	
	eventId	CHOICE {	
	eventA1	SEQUENCE {	
	a1-Threshold	ThresholdEUTRA	
5	},		
	eventA2	SEQUENCE {	
	a2-Threshold	ThresholdEUTRA	
	},		
10	eventA3	SEQUENCE {	
	a3-Offset	INTEGER (-30..30),	
	reportOnLeave	BOOLEAN	
	},		
	eventA4	SEQUENCE {	
15	a4-Threshold	ThresholdEUTRA	
	},		
	eventA5	SEQUENCE {	
	a5-Threshold1	ThresholdEUTRA,	
	a5-Threshold2	ThresholdEUTRA	
	},		
20	...,		
	eventA6	SEQUENCE {	
	a6-Offset	INTEGER (-30..30),	
	a6-ReportOnLeave	BOOLEAN	
	}		
25	},		
	hysteresis	Hysteresis,	
	timeToTrigger	TimeToTrigger	
	},		
30	periodical	SEQUENCE {	
	purpose	ENUMERATED {	
		reportStrongestCells, reportCGI}	
	}		
	},		
35	triggerQuantity	ENUMERATED {rsrp, rsrq},	
	reportQuantity	ENUMERATED {sameAsTriggerQuantity, both},	
	maxReportCells	INTEGER (1..maxCellReport),	
	reportInterval	ReportInterval,	
	reportAmount	ENUMERATED {r1, r2, r4, r8, r16, r32, r64, infinity},	
	...,		
40	[[si-RequestForHO-r9	ENUMERATED {setup}	OPTIONAL, --
	Cond reportCGI		
	ue-RxTxTimeDiffPeriodical-r9	ENUMERATED {setup}	OPTIONAL -- Need
	OR		

```

    ]],
    [[ includeLocationInfo-r10          ENUMERATED {true}      OPTIONAL,    --
Cond reportMDT
    reportAddNeighMeas-r10          ENUMERATED {setup}    OPTIONAL -- Need
5  OR
    ]]
    specialPurpose          BOOLEAN          OPTIONAL    -- Need
UnlicensedBand
}
10 ThresholdEUTRA ::=          CHOICE{
    threshold-RSRP          RSRP-Range,
    threshold-RSRQ          RSRQ-Range
}
-- ASN1STOP
15

```

This would enable all the same events to be used as for legacy measurements, just with the distinction that the measurements are actually done differently.

After the measurement is done at the UE side, it is quite important to report the results to the eNB. The UE may reports the measurement results according to usual measurement
20 configuration rules. The configuration of the actual measurement event may be as per legacy procedures, or follow special rules as described below (e.g., see Example 2). Normal event-triggered or event-triggered periodical measurement event configuration may be used for triggering a report, but there could also be modified configurations to avoid problems due to the more restricted measurement protocol. For example, the parameter *time to trigger* (TTT)
25 may be longer than the ON period of the LTE system or there might be an overlap of the OFF LTE period and the TTT. These situations are further discussed in Example 2 below.

Example 2: According to this embodiment, the UE may be configured e.g., using a legacy measurement event with event triggered measurement reporting scheme but with modified treatment as to when the measurement report is triggered in relation to ON/OFF
30 periods of the LTE cell (e.g., a current cell of the UE).

With a normal TTT operation, once TTT is started, it will continue regardless of the measurement state. For example, when an OFF-period starts, since the UE would not do any new measurements, a running TTT could expire also during the OFF period. Additionally, if the TTT still runs when the next ON-period starts, mixing the measurement result from the new
35 ON-period with the results from previous ON-period (e.g., in a L3 filter) may also cause some inaccuracy because UE radio conditions might have been altered if the OFF-period was long

enough. Hence, according to this embodiment, the TTT may be modified as follows.

In one embodiment, the TTT may be determined as a multiple of the measurement gap occasions, i.e. 0...N measurements during the gaps (in other words, the TTT is expired after a predefined number of measurement gaps), irrespective of the ON/OFF cycles of the cell (i.e., the TTT is paused when the OFF duration begins).

In another embodiment, the TTT may be truncated so that if the TTT is running when the OFF period begins, a measurement report is always triggered, i.e., the report of the event is sent along with the value of the TTT timer when the OFF period began. (i.e., the OFF period always triggers the report). This provides more information to the eNB about the UE measurement status when the OFF period starts. In other words, if a TTT period is interrupted by an OFF period of the current serving cell of the UE, the measurement report is automatically triggered and sent with an indication of the value of the time to trigger period when the OFF period of the cell started.

In a further embodiment a validity timer, e.g., called as "*MeasurementValidTimer*" may be configured to ensure the measurement result is valid as follows: once the LTE system enters the OFF period, the UE would start the *MeasurementValidTimer* (and stop measuring), and if the LTE system enters the ON period before the *MeasurementValidTimer* expires, the UE would stop the timer and continue forwarding the new measurement results normally, e.g., for L3 filtering. However, if the *MeasurementValidTimer* expires before the LTE system enters the ON period, the UE flushes the previous L3-filtered measurement results and restarts the L3 filtering from the first valid measurement result. The expiration time of the *MeasurementValidTimer* may be a predefined value configured by the eNB and signalled to the UE, e.g., in the aperiodic measurement request. In other words, when the TTT period is interrupted by the OFF period of the current serving cell of the UE, if the duration of the OFF period is smaller than a predefined value, the measurement report includes measuring results collected before starting the OFF period, and if the duration of the OFF period is larger than a predefined value, the measurement report excludes measuring results collected before starting the OFF period.

One possible RRC IE to configure the special measurement object with the *measurementValidTimer* may be as follows:

```
MeasObjectEUTRAonUnlicensedBand ::= SEQUENCE {
    carrierFreq          ARFCN-ValueEUTRA,
```

allowedMeasBandwidth	AllowedMeasBandwidth,	
presenceAntennaPort1	PresenceAntennaPort1,	
offsetFreq	Q-OffsetRange	DEFAULT dB0,
measurementValidTimer	ENUMERATED {t1, t2, t3, ...}	

5 }

Example 3. According to this embodiment, in order to get a more flexible/fast measurement and reporting, the eNB may also use the PHY control channel to send the measurement request (e.g., aperiodic measurement request) and let the UE do consecutive measurement for x subframes. The UE reports the measurement result as soon as possible after the measurement is finished. The eNB may send the measurement request to the UE which includes a pattern during which the measurements are done and a number of subframes on which the UE should consecutively do one corresponding measurement. The UE reports the measurement results after the measurement is finished.

Moreover, the measurement request (e.g., aperiodic measurement request) may contain a UL grant that has a different timing compared to the legacy LTE system (e.g., the timing for the TTI may be longer than the legacy maximum (i.e., 4 subframes for FDD and 7 subframes for TDD). Then, the UE reports the measurement result using the resources given by the UL grant.

Furthermore, the measurement report may be sent after a fixed duration, but the measurements (and the gap pattern) may also continue until further notice from the eNB or for a fixed number of measurement cycles. The UE could continue measuring, and a new report could be generated and sent after ending each fixed cycle. For example, if there is a cycle of X ms, the UE does measurements for the duration of the cycle, reports the results and continues with a new cycle of the same length. Alternatively, the eNB may send specific UL grant to the UE to request the measurement results, which would trigger the UE to send the results with the UL transmission keyed to the UL grant.

The eNB may send on PDCCH a measurement request containing UL grant. It could have a new DCI format or addressed to a new RNTI. The measurement request may include at least the following information:

1. The subframe n+x when the UL transmission should happen, where n is the subframe when the UL grant is transmitted;
2. The measurement object index;

3. The time-frequency resource for the UL transmission.

It is further noted that according to a further embodiment, the methodologies described in Examples 1-3 above demonstrating aperiodic measurements and reporting for a special measurement object may be applied not only to unlicensed bands.

Figure 4 shows an exemplary flow chart demonstrating implementation of embodiments of the invention performed by the user equipment. It is noted that the order of steps shown in Figure 4 is not absolutely required, so in principle, the various steps may be performed out of the illustrated order. Also certain steps may be skipped, different steps may be added or substituted, or selected steps or groups of steps may be performed in a separate application.

In a method according to this exemplary embodiment, as shown in Figure 4, in a first step 40 a UE receives from a wireless network (e.g., from the eNB of the current cell) a basic gap pattern (this step may be optional). In a next step 42, the UE receives aperiodic (trigger) measurement request for measuring special measurement object (e.g., in the unlicensed band) as described herein using different embodiments of the invention. The request may comprise (but is not limited to) one or more of: A) a special measurement object, B) information about measurement gap (e.g., whether the measurement gap is needed, a starting point of the measurement gap, a duration of the measurement gap, and/or a repetition rate of the measurement gap, etc.); C) a duration time for measuring, D) a number of measurement cycles, E) a number of consecutive sub-frames to perform one measurement on the measurement object, and/or F) a time interval during the OFF period for a proper reporting, etc.

In a next step 44, the UE configures one or more measuring time intervals, e.g. based on information including the aperiodic measurement request. In a next step 46, the UE performs one (e.g., first) measurement of the specified measurement object. In a next step 48 it is determined whether the TTT (time to trigger) period is interrupted by the OFF period of the current serving cell. If that is not the case, the process goes to step 54. However, if it is determined that the TTT period is interrupted by the OFF period of the current cell, it is further determined in a next step 50 whether the OFF period is longer than a predefined value (using, e.g., "MeasurementVaidTimer" as disclosed herein in Example 2). If that is the case, in step 52, the UE discards measurements made before the OFF period started. However, if it is determined that the OFF period is not longer than a predefined value, then in step 54 the UE reports of measurements made before the OFF period started.

In a next step **56**, it is determined whether all measurements are performed (in response to the aperiodic measurement request). If that is the case, then in a next step **58** the UE waits for a next aperiodic measurement request from the wireless network (eNB). However, if it is determined that not all measurements are performed, the process goes back to step **46** and next measurement of the specific measurement object is performed by the UE.

Figure 5 shows an exemplary flow chart demonstrating implementation of embodiments of the invention performed by a network element (e.g., the eNB shown on Figure 6). It is noted that the order of steps shown in Figure 6 is not absolutely required, so in principle, the various steps may be performed out of the illustrated order. Also certain steps may be skipped, different steps may be added or substituted, or selected steps or groups of steps may be performed in a separate application.

In a method according to this exemplary embodiment, as shown in Figure 5, in a first step **60** a network element (e.g., eNB) sends to the UE a basic gap pattern (this step may be optional). In a next step **62**, the network element determines parameters of an aperiodic (trigger) measurement request for measuring special measurement object (e.g., in the unlicensed band), as described herein using different embodiments of the invention. The parameters may comprise (but is not limited to) one or more of: A) a special measurement object, B) information about measurement gap (e.g., whether the measurement gap is needed, a starting point of the measurement gap, a duration of the measurement gap, and/or a repetition rate of the measurement gap, etc.); C) a duration time for measuring, D) a number of measurement cycles, E) a number of consecutive sub-frames to perform one measurement on the measurement object, and/or F) a time interval during OFF period for a proper reporting, etc. In a next step **64**, the network element (eNB) sends aperiodic (trigger) measurement request with the determined/selected parameter(s) in step **62**, which at least include the special measurement object, to the UE. In a next step **66**, the network element receives report(s) of measurement result(s) from the UE, so that in a next step **68**, the network element repeats steps **62** and **64** based on the received report(s).

Figure 6 shows an example of a block diagram demonstrating LTE devices including eNB **80** and UE **82** comprised in a cellular network **100**, according to an embodiment of the invention. Figure 6 is a simplified block diagram of various electronic devices and apparatus that are suitable for use in practicing the exemplary embodiments of this invention, e.g., in reference to Figures 4 and 5, and a specific manner in which components of an electronic

device are configured to cause that electronic device to operate. The UE **82** may be implemented as a mobile phone, a wireless communication device, a camera phone, a portable wireless device and the like.

The UE **82** may comprise, e.g., at least one transmitter **82a** at least one receiver **82b**, at
5 least one processor **82c** at least one memory **82d** and a measurement application module **82e**.
The transmitter **82a** and the receiver **82b** and corresponding antennas (not shown in Figure 6)
may be configured to provide wireless communications with eNB **80** (e.g., using the licensed
band) and perform measurement of the special measurement object(s) (e.g., using the
unlicensed band) respectively, according to the embodiment of the invention. The transmitter
10 **82a** and the receiver **82b** may be generally means for transmitting/receiving and may be
implemented as a transceiver, or a structural equivalence (equivalent structure) thereof.

Furthermore, the UE **82** may further comprise communicating means such as a modem
82f, e.g., built on an RF front end chip of the UE **82**, which also carries the TX **82a** and RX **82b**
for bidirectional wireless communications via data/control wireless links **87** and **83** (e.g. on the
15 licensed band), for sending/receiving signals (e.g., the aperiodic measurement request signal,
the measurement report signal) for communicating with the eNB **80**.

Various embodiments of the at least one memory **82d** (e.g., computer readable memory)
may include any data storage technology type which is suitable to the local technical
environment, including but not limited to semiconductor based memory devices, magnetic
20 memory devices and systems, optical memory devices and systems, fixed memory, removable
memory, disc memory, flash memory, DRAM, SRAM, EEPROM and the like. Various
embodiments of the processor **82c** include but are not limited to general purpose computers,
special purpose computers, microprocessors, digital signal processors (DSPs) and multi-core
processors.

25 The measurement application module **82e** may facilitate performing measurements of
the special measurement object(s) and reporting the results according to embodiments of the
invention, as described herein and illustrated, e.g., in Figure 4 (steps **40-58**). The module **82e**
may be implemented as an application computer program stored in the memory **82d**, but in
general it may be implemented as a software, a firmware and/or a hardware module or a
30 combination thereof. In particular, in the case of software or firmware, one embodiment may
be implemented using a software related product such as a computer readable memory (e.g.,
non-transitory computer readable memory), computer readable medium or a computer

readable storage structure comprising computer readable instructions (e.g., program instructions) using a computer program code (i.e., the software or firmware) thereon to be executed by a computer processor.

Furthermore, the module **82e** may be implemented as a separate block or may be combined with any other module/block of the UE **82** or it may be split into several blocks according to their functionality. Moreover, it is noted that all or selected modules of the UE **82** may be implemented using an integrated circuit (e.g., using an application specific integrated circuit, ASIC).

The eNB **80** may have similar components as the UE **82**, as shown in Figure 6, so that the above discussion about components of the UE **82** is fully applied to the components of the eNB **80**. The measurement scheduling module **80a** in the eNB **80** may facilitate providing the aperiodic measurements request with corresponding parameters for performing measurements of the special measurement object and analyzing the results of measurements for providing further instructions according to embodiments of the invention, as described herein and illustrated, e.g., in Figure 5 (steps **60-68**). The module **80a** may be implemented as a software, a firmware and/or a hardware module or a combination thereof. In particular, in the case of software or firmware, one embodiment may be implemented using software related product such as a computer readable memory (e.g., non-transitory computer readable memory), a computer readable medium or a computer readable storage structure comprising computer readable instructions (e.g., program instructions) using a computer program code (i.e., the software or firmware) thereon to be executed by a processor.

Furthermore, the module **80a** may be implemented as a separate block or may be combined with any other module/block of the eNB **80** or it may be split into several blocks according to their functionality. Moreover, it is noted that all or selected modules of the device **80** may be implemented using an integrated circuit (e.g., using an application specific integrated circuit, ASIC).

It is noted that various non-limiting embodiments described herein may be used separately, combined or selectively combined for specific applications.

Further, some of the various features of the above non-limiting embodiments may be used to advantage without the corresponding use of other described features. The foregoing description should therefore be considered as merely illustrative of the principles, teachings and exemplary embodiments of this invention, and not in limitation thereof.

It is to be understood that the above-described arrangements are only illustrative of the application of the principles of the present invention. Numerous modifications and alternative arrangements may be devised by those skilled in the art without departing from the scope of the invention, and the appended claims are intended to cover such modifications and

5 arrangements.

WHAT IS CLAIMED IS:

What is claimed is:

- 5
1. A method comprising:
receiving by a user equipment from a wireless network an aperiodic measurement
request to measure a special measurement object specified in the aperiodic measurement
request; and
10 measuring the special management object in response to the aperiodic measurement
request until a further instruction from the wireless network or for a determined period of time.
 2. The method of claim 1, wherein the aperiodic measurement request is to measure the
special measurement object in an unlicensed band.
 - 15 3. The method of claim 1, wherein before the measuring, the method comprising:
configuring one or more measuring time intervals based on the aperiodic measurement
request, the one or more measuring time intervals defining the determined period of time.
 - 20 4. The method of claim 3, wherein each of the one or more measuring time intervals
comprises a measurement gap for inter-frequency measurements, so that the measuring is
being performed during the measurement gap.
 - 5 The method of claim 1, wherein the aperiodic measurement request comprises
25 information about a measurement gap which includes one or more of:
whether the measurement gap is needed,
a starting point of the measurement gap,
a duration of the measurement gap, and
a repetition rate of the measurement gap.
 - 30 6. The method of claim 1, wherein the aperiodic measurement request comprises a
number of consecutive sub-frames to perform the measuring.

7. The method of claim 1, wherein the aperiodic measurement request is an aperiodic trigger measurement request so that the measuring starts immediately after receiving the aperiodic trigger measurement request.

5

8. The method of claim 1, wherein the aperiodic measurement request comprises a number of measurement cycles which determines the determined period of time.

9. The method of claim 1, wherein the aperiodic measurement request comprises an uplink grant for sending a measurement report.

10

10. The method of claim 1, wherein the special measurement object comprises one or more neighboring cells.

11. The method of claim 1, wherein a time to trigger a measurement report is counted by a number of the measurement gaps.

15

12. The method of claim 1, wherein the time to trigger period is interrupted by an OFF period of a current serving cell of the user equipment, and the measurement report is automatically triggered and sent with an indication of a value of the time to trigger period when the OFF period of the cell started.

20

13. The method of claim 1, wherein a time to trigger period is interrupted by an OFF period of a current serving cell of the user equipment,

25 where, if a duration of the OFF period is smaller than a predefined value, the measurement report includes measuring results collected before starting the OFF period, and if a duration of the OFF period is larger than a predefined value, the measurement report excludes measuring results collected before starting the OFF period.

14. The method of claim 13, wherein the predefined value is provided by the wireless network.

30

15. An apparatus comprising:

at least one processor and a memory storing a set of computer instructions, in which the processor and the memory storing the computer instructions are configured to cause the apparatus to:

5 receive from a wireless network an aperiodic measurement request to measure a special measurement object specified in the aperiodic measurement request; and

measure the special management object in response to the aperiodic measurement request until a further instruction from the wireless network or for a determined period of time.

10 16. The apparatus of claim 15, wherein the aperiodic measurement request is to measure the special measurement object in an unlicensed band.

17. The apparatus of claim 15, wherein the aperiodic measurement request comprises information about a measurement gap which includes one or more of:

15 whether the measurement gap is needed,
a starting point of the measurement gap,
a duration of the measurement gap, and
a repetition rate of the measurement gap.

20 18. The apparatus of claim 15, wherein the aperiodic measurement request comprises a number of consecutive sub-frames to perform the measuring.

19. The apparatus of claim 15, wherein the aperiodic measurement request is an aperiodic trigger measurement request so that the measuring starts immediately after receiving the
25 aperiodic trigger measurement request.

20. The apparatus of claim 15, wherein the aperiodic measurement request comprises a number of measurement cycles which determines the determined period of time.

30 21. The apparatus of claim 15, wherein the aperiodic measurement request comprises an uplink grant for sending a measurement report.

22. A non-transitory computer readable memory encoded with a computer program comprising computer readable instructions recorded thereon for execution a method comprising:

receiving by a user equipment from a wireless network an aperiodic measurement request to measure a special measurement object specified in the aperiodic measurement request; and

measuring the special management object in response to the aperiodic measurement request until a further instruction from the wireless network or for a determined period of time.

23. A method comprising:

determining, in a wireless network, parameters for an aperiodic measurement request to measure a special measurement object by a user equipment, the parameters include the special measurement object; and

sending the aperiodic measurement request comprising the parameters to the user equipment for measuring the special management object.

24. An apparatus comprising:

at least one processor and a memory storing a set of computer instructions, in which the processor and the memory storing the computer instructions are configured to cause the apparatus to:

determine parameters for an aperiodic measurement request to measure a special measurement object by a user equipment, the parameters include the special measurement object; and

send the aperiodic measurement request comprising the parameters to the user equipment for measuring the special management object.

25. A non-transitory computer readable memory encoded with a computer program comprising computer readable instructions recorded thereon for execution a method comprising:

determining, in a wireless network, parameters for an aperiodic measurement request to

measure a special measurement object by a user equipment, the parameters include the special measurement object; and

sending the aperiodic measurement request comprising the parameters to the user equipment for measuring the special management object.

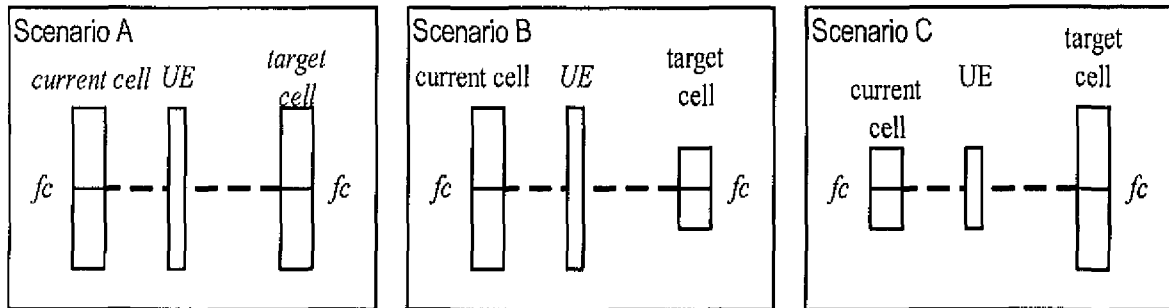


Figure 1

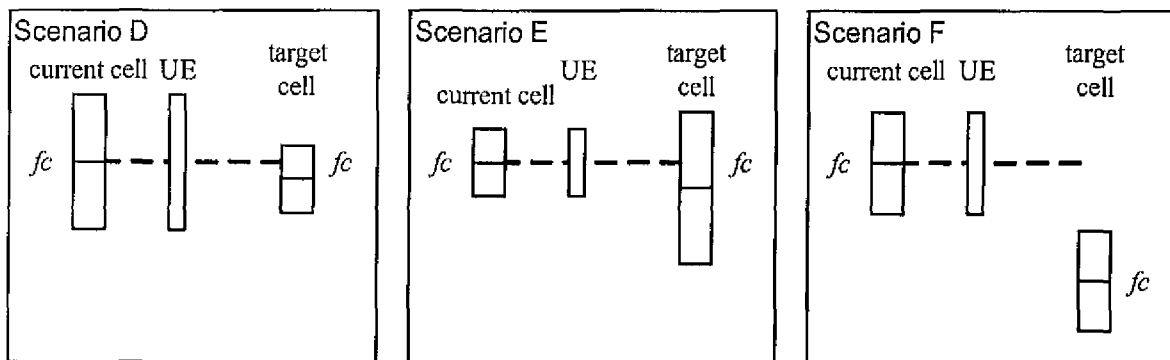


Figure 2

R	R	Measurement Object							

Figure 3

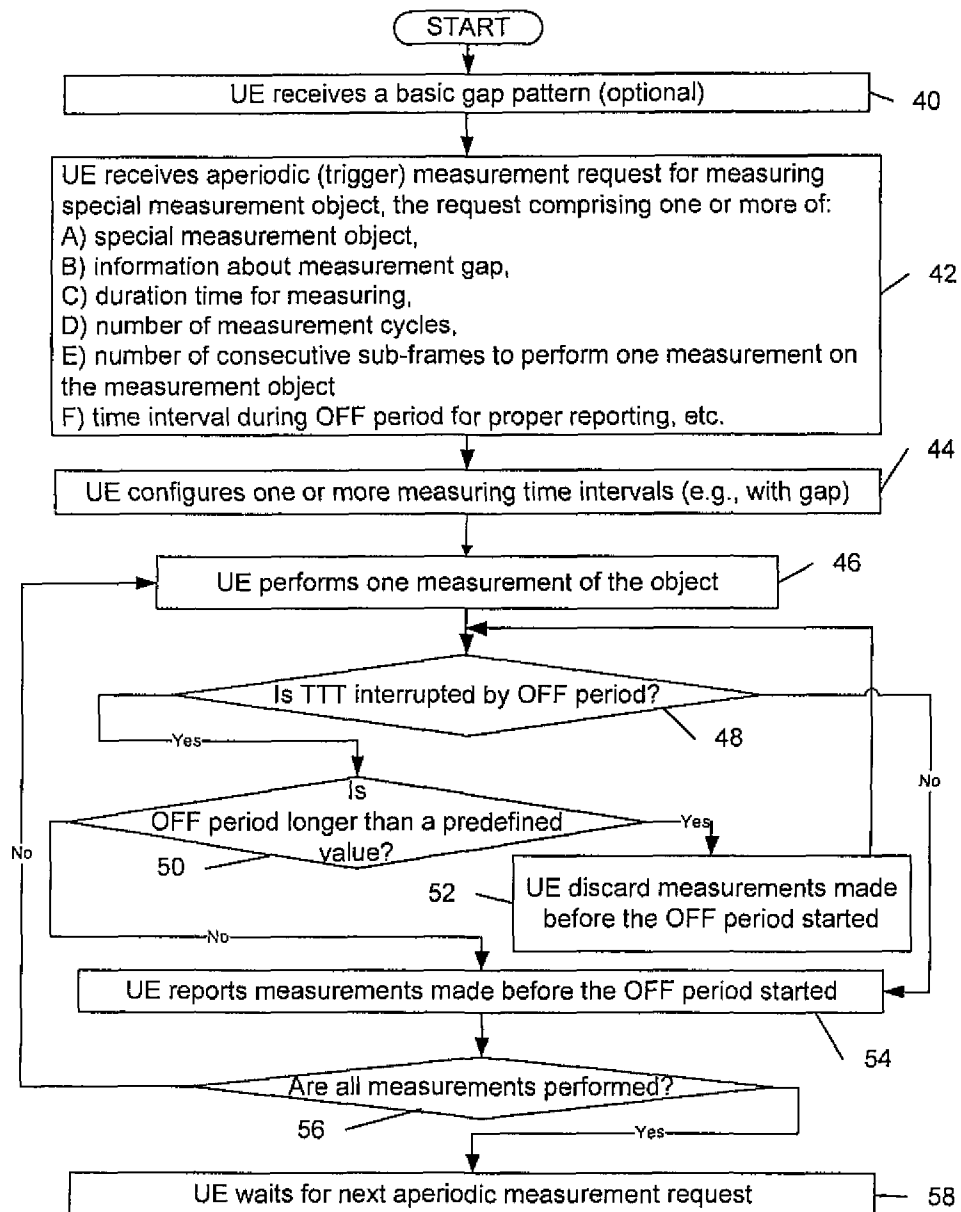


Figure 4

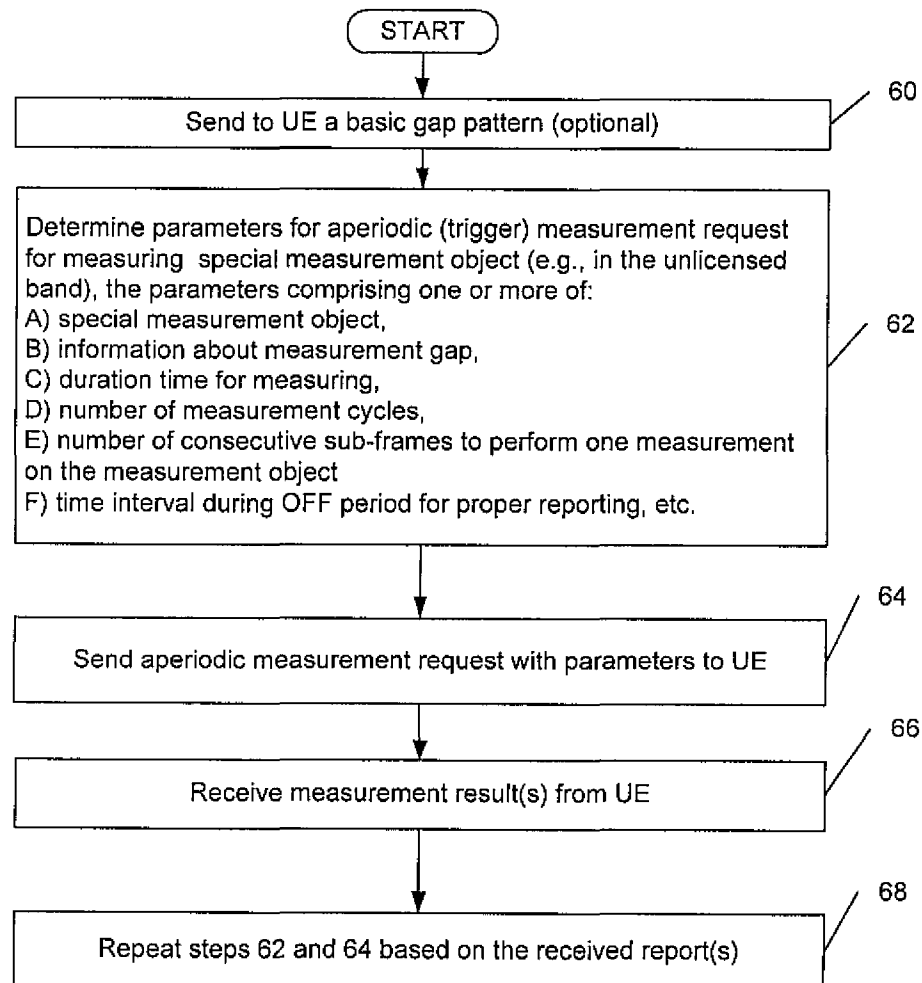
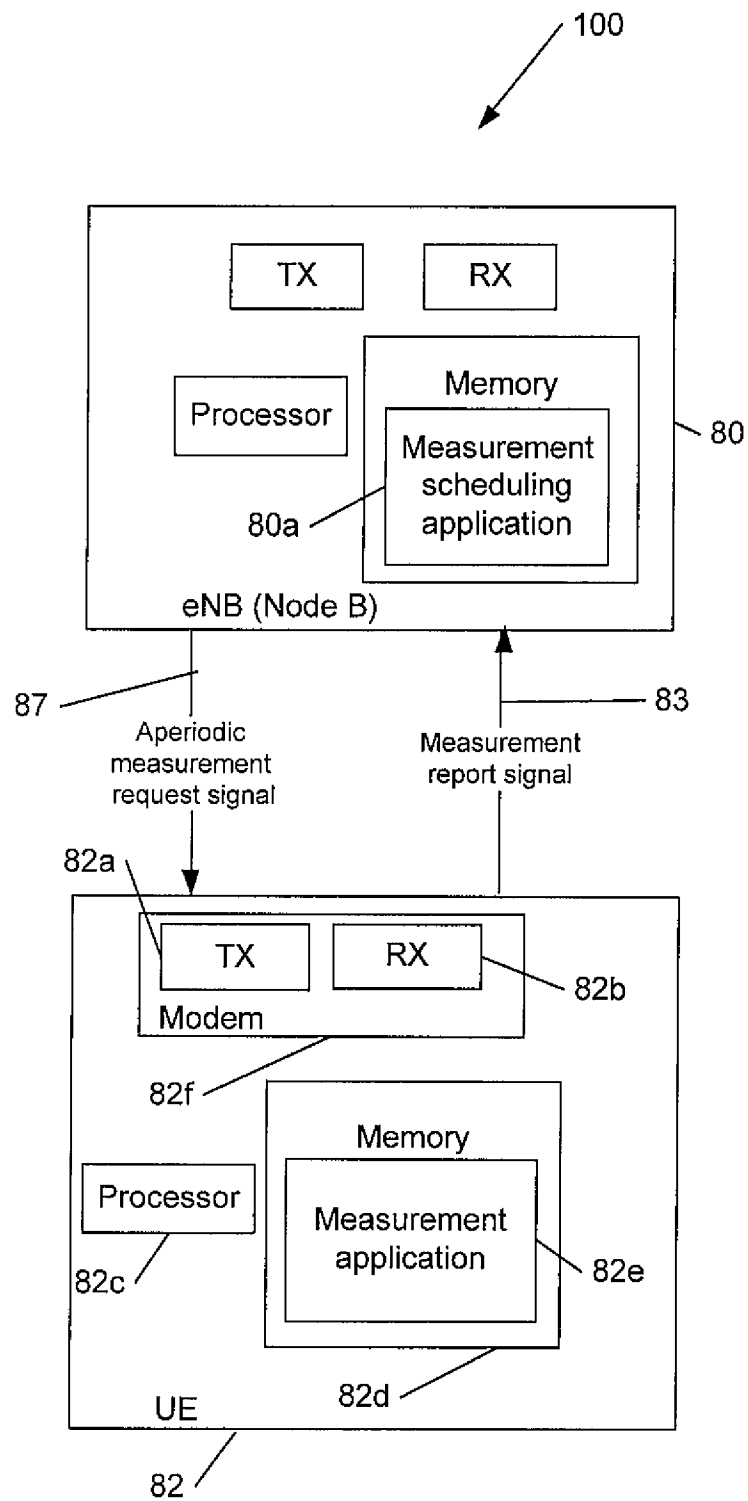


Figure 5

**Figure 6**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2011/081319

A. CLASSIFICATION OF SUBJECT MATTER

H04W24/10(2009.01)i

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)

IPC: H04W; H04Q; H04L; H04B

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)

VEN, CNABS, CNTXT, CNKI: RRM, radio resource, request, measure, periodic, aperiodic, special, specify, trigger, user equipment, UE, terminal, trigger, cell

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO2010087625A2(LG ELECTRONICS INC) 05 Aug. 2010(05.08.2010) description page 8, line 21 - page 12, line 7; page19, lines 1-27	1-25
A	CN101248597A (LG ELECTRONICS INC) 20 Aug. 2008(20.08.2008) the whole document	1-25
A	CN101496305A(MOTOROLA INC) 29 Jul. 2009(29.07.2009) the whole document	1-25

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	“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
“A” document defining the general state of the art which is not considered to be of particular relevance	“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
“E” earlier application or patent but published on or after the international filing date	“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
“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)	“&”document member of the same patent family
“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	

Date of the actual completion of the international search 15 Jul. 2012(15.07.2012)	Date of mailing of the international search report 09 Aug. 2012 (09.08.2012)
Name and mailing address of the ISA/CN The State Intellectual Property Office, the P.R.China 6 Xitucheng Rd., Jimen Bridge, Haidian District, Beijing, China 100088 Facsimile No. 86-10-62019451	Authorized officer LIU, Dan Telephone No. (86-10)62411509

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2011/081319

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