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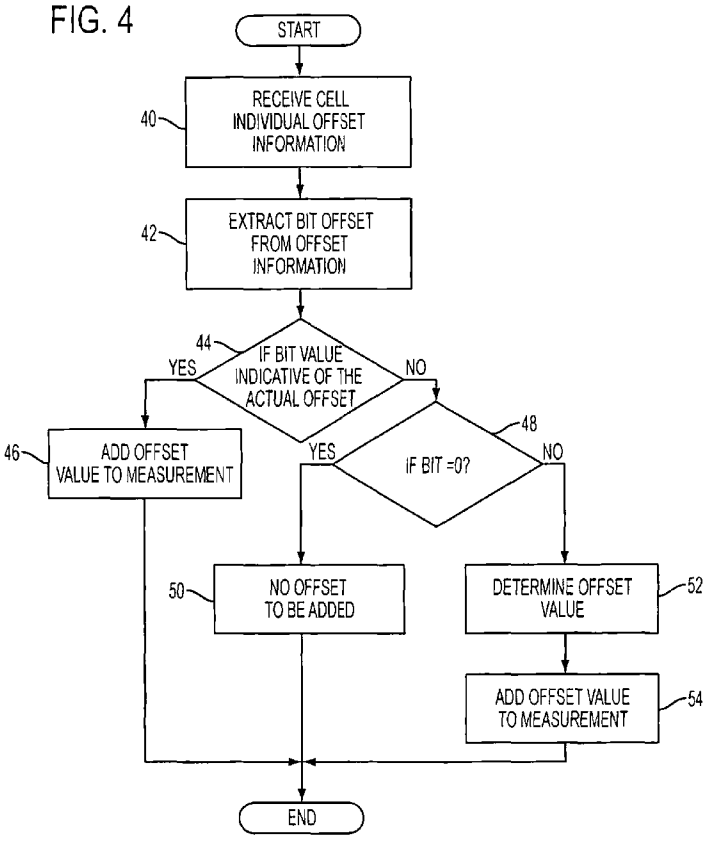
[Continued on next page]

(54) Title: DEVICE AND METHOD FOR TRANSMITTING CELL OFFSET IN TELECOMMUNICATION SYSTEM

FIG. 4



(57) Abstract: A terminal unit, base station, computer readable medium and method for transmitting cell individual offset information from a base station in a cell in a communication network, to a user terminal that applies the cell individual offset information to measurement reports and/or events associated with the cell, including, generating the cell individual offset information; mapping the cell individual offset information on at least one channel that is different from a broadcast channel; and transmitting the mapped cell individual offset information.

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Device and Method for Transmitting Cell Offset in Telecommunication System

TECHNICAL FIELD

[0001] The present invention generally relates to radio communication systems, devices, software and methods and, more particularly, to mechanisms and techniques for transmitting information related to a cell individual offset of a telecommunication network.

BACKGROUND

[0002] During the past years, the interest in radio access technologies for providing services for voice, video and data has increased. There are various telecom technologies used in cellular communications. The most widespread radio access technology for mobile communication is digital cellular. Increased interest is shown in 3G (third generation) systems. 3G systems and, then, even higher bandwidth radio communications introduced by Universal Terrestrial Radio Access (UTRA) standards made applications like surfing the web more easily accessible to millions of users.

[0003] Even as new network designs are rolled out by network manufacturers, future systems which provide greater data throughputs to end user devices are under discussion and development. For example, the so-called 3GPP Long Term Evolution (LTE) standardization project is intended to provide a technical basis for radiocommunications in the decades to come.

[0004] To ensure competitiveness of Universal Mobile Telecommunications Service (UMTS) networks for the future, new concepts for UMTS Long Term Evolution (LTE) have been investigated. The objectives are a high-data-rate, low-latency and packet optimized radio access technology. Therefore, E-UTRA (Evolved UMTS Terrestrial Radio Access) and E-UTRAN (Evolved UMTS Terrestrial Radio Access Network) have been launched to address these objectives.

[0005] In E-UTRAN, Orthogonal Frequency Division Multiple Access (OFDMA) technology is used in the downlink. OFDM is a modulation scheme in which the data to be transmitted is split into several sub-streams, where each sub-stream is modulated on a separate sub-carrier. Hence, in OFDMA based systems, the available bandwidth is sub-divided into several resource blocks or units prior to being transmitted. A resource block may be defined in both time and frequency. According to the current assumptions in UTRAN, a resource block size is 180 KHz and 0.5 ms in frequency and time domains, respectively. The overall uplink and downlink transmission bandwidth can be as large as 20 MHz.

[0006] An overall architecture for an E-UTRAN system is shown in Figure 1. The E-UTRAN includes one or more E-UTRAN NodeBs (eNBs) 10, providing the E-UTRAN user plane and control plane protocol terminations towards the user terminal 12. The eNBs 10 are interconnected with each other by the X2 interface 14. The eNBs 10 are also connected by the S1 interface 16 to the MME (Mobility Management Entity) 18 by the S1-MME and to the Serving Gateway (S-GW) 18 by the S1-U.

[0007] In the following, various technological aspects and features related to E-UTRAN as well as UTRAN systems are described. Regarding downlink

neighboring cell measurements, in E-UTRAN, the user terminal performs a number of neighbor cell measurements. These measurements may be used for handovers, cell reselection in idle mode, etc. Examples of such measurements are Reference Symbol Received Power (RSRP) and E-UTRAN carrier Received Signal Strength Indication (RSSI). These measurements (e.g., RSRP) are generally performed on known reference signals. Carrier RSSI is however measured over all the symbols sent over the entire carrier frequency. In UTRAN, similar measurements are used for idle and for connected mode mobility. Examples of UTRAN measurements are (Common Pilot Channel) CPICH RSCP, CPICH Ec/N0 and UTRA carrier RSSI, as disclosed for example in 3GPP TS 25.215, "Physical layer measurements (FDD)," the entire content of which is enclosed herewith by reference.

[0008] However, a conventional telecommunication network can support more than one carrier frequency. In that case, the user terminal is required to perform the above discussed measurements on both frequencies: intra-frequency and inter-frequency measurements. Intra-frequency neighboring cell measurements and inter-frequency neighboring cell measurements may be defined as follows. Neighboring cell measurements performed by the user terminal are intra-frequency measurements when the current and target cells operate on the same carrier frequency. Neighboring cell measurements performed by the user terminal are inter-frequency measurements when the neighboring cell operates on a different carrier frequency, compared to the current cell.

[0009] The structure of the measurement reporting to be performed by the user terminal is discussed next. The serving cell (the cell that currently serves

the user terminal) generally configures the user terminal to perform neighboring cell measurements for mobility and to report the measurement reports to a base station of the serving cell. The term "base station" is used in the following as a generic term. As it is known, in the Wideband Code Division Multiple Access (WCDMA) architecture, a NodeB may correspond to the base station. In other words, a base station is a possible implementation of the NodeB. However, the NodeB is broader than the conventional base station. The NodeB refers in general to a logical node. A NodeB in WCDMA is handling transmission and reception in one or several cells. For the LTE architecture, there is a single node, the eNodeB. Although conventionally the term "base station" is narrower than the NodeB of the WCDMA architecture or the eNodeB of the LTE architecture, the term "base station" is used in the following exemplary embodiments as defining the NodeB, eNodeB or other nodes specific for other architectures. Thus, the term "base station" defined and used in the present disclosure is not limited to the conventional base station unit of a network.

[0010] There are two approaches, as disclosed in 3GPP TS 25.331, "RRC protocol specification," the entire content of this document being incorporated by reference here, for performing the measurements. A first approach is based on a blind identification and measurement on cells performed by the user terminal and a second approach is based on received list of neighboring cells. In the first approach, the serving cell instructs the user terminal to identify and measure, and if necessary, to also report P best neighboring cells, i.e., cells from which a signal having certain parameters is detected by the user terminal. No list of the neighboring cells is provided by the serving cell to the user terminal according to

this approach. The user terminal identifies and measures the best neighboring cells and reports the events and/or measurements to the serving cell.

[0011] In the second approach, the serving cell provides an explicit list of neighboring cells (R) to the user terminal and the user terminal is instructed to measure only those R cells. The list may include instructions to report only the best P neighboring cells out of the existing R cells. The cell list provided by the serving cell may include only the identity of the neighboring cells.

[0012] In WCDMA systems, both these approaches are used. However, the second approach is more suitable to WCDMA systems due to better performance requirements. In E-UTRAN systems, the first approach (i.e., without neighboring cell list) is considered to better fit the requirements of this system. However, the user terminal should apply a cell individual offset to each cell for which a measurement is performed or an event is determined as will be discussed later. The cell individual offset is specific to each cell and it is the value of this offset that the user terminal needs to apply when reporting to the serving cell an event or when taking mobility related decisions such as cell reselection, handover etc. Next, it is discussed the reporting of events and measurements by the user terminal.

[0013] In RRC_CONNECTED (Radio Resource Control) mode, the user terminal reports the measurements collected from the neighboring cell to the serving cell (i) periodically, (ii) event triggered, and/or (iii) event triggered in a periodical fashion. According to the last mechanism, after the occurrence of an event occurs (e.g., neighbor cell quality becomes x dB greater than that of the serving cell), the user terminal starts periodical reporting of the measurement(s). In addition, in the RRC_CONNECTED mode the user terminal also reports a

number of events based on the performed measurements. For instance, an event is generated in the user terminal when a particular measurement quantity in a neighboring cell exceeds or falls below a threshold level. Another example of an event is when a certain measured quantity in a neighboring cell exceeds or falls below the same quantity in another neighboring cell or the serving cell. One skilled in the art would appreciate other events in UTRAN or E-UTRAN.

[0014] To perform the required measurements or determine the specific events, the user terminal, according to a first approach, needs to read the system information of each neighboring cell to be measured via the broadcast channel (BCH) to acquire the neighboring cell individual offset. Thus, the user terminal has to read the system information of all the neighboring cells for which measurement reports or associated events are to be sent to the serving cell. The drawback of this approach is the delay in reading the system information since the system information is sent with some periodicity (e.g., 40 or 80 ms or even longer) due to the structure of the broadcast channel. Another drawback is that the user terminal's processing time will increase. Furthermore, the user terminal is required to read system information even if the offset of the neighboring cell is 0 dB (i.e., there is no offset).

[0015] According to a second approach, the serving cell instructs the user terminal whether it should apply neighboring cell offsets or not when reporting the measurements and/or events. This instruction is the same for all neighboring cells. However, a drawback of this approach is in the case that the serving cell instructs the user terminal not to apply the offset. Then, the user terminal will not apply the offset even if there are cells requiring the offset. This approach may lead to inappropriate event triggering in cells with offsets and also may lead to

capacity loss, as suggested in 3GPP R4-070914, "Use of cell specific offsets and reading neighbor BCH," the entire content of which is incorporated here by reference.

[0016] A third approach is to not require the user terminal to read the system information to receive the cell offsets. Thus, in this instance, the user terminal reports measurements and events to the serving cell without any offsets. In order to achieve 0 dB offset (i.e., no offset) all cells should have the same coverage (e.g., a common channel power setting) and there should be no loss due to uplink and downlink imbalance. However, this objective is difficult to be achieved because all cells in all the coverage scenarios would not have the same coverage and/or uplink and downlink imbalances. Thus, in a practical case, where there will be non-zero offsets at least in some cells within the coverage area, the user terminal may trigger undesired events (early or delayed depending whether the offset is negative or positive), which lead to the loss in capacity.

SUMMARY

[0017] According to one exemplary embodiment, there is a method for transmitting cell individual offset information, associated with an offset of a cell, to a user terminal, which is configured to communicate with the cell in addition to a serving cell. The method included generating the cell individual offset information; mapping the cell individual offset information on at least one channel that is different from a broadcast channel; and transmitting the mapped cell individual offset information.

[0018] According to another exemplary embodiment, there is a method for determining whether to apply cell individual offset information at a user terminal,

which is configured to be connected to a cell in a communication network in addition to a serving cell, to measurement reports and/or events associated with the cell. The method includes receiving at least one channel, different from a broadcast channel, in which the cell individual offset information has been mapped; extracting the cell individual offset information from the at least one channel; and determining from the cell individual offset information whether the offset is present in the cell.

[0019] According to another exemplary embodiment, there is a base station in a cell configured to send cell individual offset information to a user terminal, the base station and the user terminal are connected to a communication network, and the user terminal applies the cell individual offset information to measurement reports and/or events associated with the cell. The base station includes a processor configured to generate the cell individual offset information; the processor being configured to map the cell individual offset information on at least one channel that is different from a broadcast channel; and an antenna connected to the processor and configured to transmit the mapped cell individual offset information received from the processor.

[0020] According to another exemplary embodiment, there is a user terminal connected in a communication network to a base station in a cell, the user terminal being configured to determine whether to apply cell individual offset information to measurement reports and/or events associated with the cell. The user terminal includes an antenna configured to receive at least one channel in which the cell individual offset information has been mapped, the at least one channel being different from a broadcast channel; a processor connected to the antenna and configured to extract the cell individual offset information from the

received at least one channel; and the processor being further configured to determine from the cell individual offset information whether the offset is present in the cell.

[0021] According to still another exemplary embodiment, there is a computer readable medium that stores instructions, which when executed on a processor in a base station in a cell in a communication network, send cell individual offset information to a user terminal that applies the cell individual offset information to measurement reports and/or events associated with the cell. The instructions include generating the cell individual offset information; mapping the cell individual offset information on at least one channel that is different from a broadcast channel; and transmitting the mapped cell individual offset information.

[0022] According to another exemplary embodiment, there is a computer readable medium that stores instructions, which when executed on a processor in a user terminal, which is connected to a cell in a communication network, determine whether to apply cell individual offset information to measurement reports and/or events associated with the cell. The instructions include receiving at least one channel, different from a broadcast channel, in which the cell individual offset information has been mapped; extracting the cell individual offset information from the at least one channel; and determining from the cell individual offset information whether the offset is present in the cell.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate one or more embodiments and, together with the description, explain these embodiments. In the drawings:

[0024] Figure 1 is a schematic diagram of a E-UTRAN communication system including a base station and a user terminal;

[0025] Figure 2 is a schematic diagram of a communication system having at least two cells;

[0026] Figure 3 is a schematic diagram of a base station or a user terminal;

[0027] Figure 4 is a flow chart illustrating the determination of an offset of a cell from transmitted cell individual offset information;

[0028] Figure 5 is a flow chart illustrating the mapping of the cell individual offset information in a base station; and

[0029] Figure 6 is a flow chart illustrating the extraction of the cell individual offset information in the user terminal.

DETAILED DESCRIPTION

[0030] The following description of the exemplary embodiments refers to the accompanying drawings. The same reference numbers in different drawings identify the same or similar elements. The following detailed description does not limit the invention. Instead, the scope of the invention is defined by the appended claims. The following embodiments are discussed, for simplicity, with regard to the terminology and structure of UTRAN and E-UTRAN systems described above. However, the embodiments to be discussed next are not limited to these systems but may be applied to other existing telecommunications systems.

[0031] Reference throughout the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with an embodiment is included in at least one embodiment of the present invention. Thus, the appearance of the phrases "in one embodiment" or "in an embodiment" in various places throughout the specification are not necessarily all referring to the same embodiment. Further, the particular features, structures or characteristics may be combined in any suitable manner in one or more embodiments.

[0032] As shown in Figure 2, according to an exemplary embodiment, a general telecommunication network N includes at least two cells 20 and 21 and at least one user terminal 12. The user terminal 12, when physically present in cell 20, receives a signal 22 from the base station 10 of cell 20. However, the user terminal 12 may also receive a signal 24 from the base station 10 of cell 21. In other words, cell 20 is the serving cell at that instant and cell 21 is a potential future serving cell. In one exemplary embodiment, each cell has a specific cell individual offset. However, it is possible that two or more cells have a common cell offset. The cell individual offset value may incorporate, according to an exemplary embodiment, a number of deployment and impairment aspects of a particular cell. More specifically, the cell individual offset represents the uplink and downlink imbalances caused due to cable losses associated with tower mounted amplifiers (TMA). Another factor that may contribute to a specific cell individual offset is the different settings of common channel powers in different cells.

[0033] For instance, in one exemplary scenario, transmit power levels of the reference symbols in E-UTRAN (or CPICH power in UTRAN) in neighboring

cells may not be the same. The difference can be due to various deployment reasons such as giving more power to data symbols. The reference symbol power directly affects the cell coverage. This is because the neighboring cell measurements (e.g., RSRP) are based on reference symbols. Thus a mismatch in the transmit reference symbol power in different neighboring cells may lead to inappropriate generation of events. If the network is aware of this mismatch, the network may be configured, as will be discussed next, to use the cell individual offset and thus, solve the above noted problem present in the traditional networks. Thus, at least for these reasons, the operators of the cells would like this offset to be used by the user terminal when reporting events and measurements to the base station.

[0034] The cell individual offset are not calculated/determined to assist the network to improve a sync process between a user terminal and a cell. For the synch process, a frequency offset is used but the frequency offset is different from the cell individual offsets discussed in this application. The cell individual offsets are applied to measurements and events, which are performed after cells are properly in sync and identified.

[0035] A structure of the base station 10 is shown in Figure 3. In this regard, it is noted that the structure shown in Figure 3 may be the structure of the user terminal. The base station may include a processor 26 that performs the processing of the incoming and outgoing signals. The signals are transmitted via an antenna 28 that is connected to the processor 26. The processor 26 may include a specialized processing unit (not shown) for mapping, coding, decoding, extracting, etc. of various symbols as would be recognized by one skilled in the art. The base station may optionally have a memory 30 for storing data. The

processor 26 may be configured to read and store data to the memory data. In addition, the base station may include an amplifier 32 (the TMA for example) and corresponding cables for amplifying transmitted signals. The above components of the base station may be implemented as electrical circuitry, computer instructions or a combination thereof.

[0036] The cell individual offset can be negative or positive. In WCDMA systems, the cell individual offset can have any value between -10 to +10 dB. The actual value in a cell depends upon the common power setting, uplink/downlink imbalance, antenna configuration, etc. in that particular cell. The cell individual offset can be the same or it can be different for intra-frequency and inter-frequency measurements. According to an exemplary embodiment, the largest contributor to the offset may be the loss due to the cables of the TMA 32. Therefore, in a particular base station site, all the cells using the same TMA and cable may have the same uplink and downlink imbalance. Thus, the same offset value may be used for intra and inter frequency measurements for the base stations in this particular example. However, the actual implementation depends upon the particular network deployment and operators' choice.

[0037] The measurements to be taken by the user terminal are conventionally performed in various ways, as discussed next. In a WCDMA system, the measurement method is based on the neighboring cell list, i.e., the serving cell sends the complete list of the associated cell individual offset values to the user terminal. The cell offset values are sent to the user terminal in idle as well as in RRC connected modes. Thus, the user terminal can apply an appropriate offset when reporting events associated with one or more neighboring cells. This approach does not require the user terminal to read the

system information of any of the neighboring cells to determine the offset value of those cells. In E-UTRAN systems, one approach is to request the user terminal to measure and report the results from P best cells. This approach reduces the downlink signaling overheads, as transmitting the neighboring cell list consumes considerable resources. However, the neighboring cell list based measurement approach is optional in E-UTRAN. Thus, in the conventional E-UTRAN approach, the serving cell cannot indicate the cell individual offsets of the neighboring cells since there is no neighboring cell list. To correct this problem, the conventional E-UTRAN systems mandate the user terminal to read the system information of the neighboring cells to determine the cell offset value. Under these circumstances, the user terminal applies the determined offsets to the measurements or the events before transmitting them to the serving cell. However, a problem of the conventional systems is that the user terminal needs to read the system information on the broadcast channel to determine the offset, which will cause delays, will increase the user terminal power consumption, and which will require the user terminal to process more information. The resulting delays arise due to the fact that the system information is sent via the broadcast channel, which is sent with a certain periodicity, as previously discussed.

[0038] According to the following exemplary embodiments, the above problems of the conventional telecommunication systems may be avoided by transmitting the cell individual offset information on channels other than the broadcast channels, e.g., channels including reference or pilot symbols, as will be discussed next.

[0039] A brief overview of the reference symbol channels and other channels used by the telecommunications systems, according to exemplary

embodiments, to transmit system information is presented here, before presenting the solution to the above noted problems in the conventional systems. A reference symbols channel is considered in UTRAN or E-UTRAN a channel or pattern that contains a well defined sequence of pilot or reference symbols. In WCDMA for example, such channels are: Primary Synchronization Channel (P-SCH), Secondary Synchronization Channel (S-SCH) and Common Pilot Channel (CPICH) channels, as discussed in TS 25.211, "Physical channels and mapping of transport channels onto physical channels (FDD)," the entire content of which is incorporated here by reference. In E-UTRAN systems, such channels are: P-SCH, S-SCH and Reference Signals (RS), as discussed in TS 36.211, "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and mapping of transport channels onto physical channels (FDD)," the entire content of which is incorporated here by reference. All the documents mentioned in this disclosure and pertaining to LTE systems are available on the web site of 3GPP, 650 Route des Lucioles, Sophia Antipolis Valbonne, France.

[0040] The P-SCH and S-SCH channels may be used by the user terminal for achieving the synchronization of symbol timing, frequency, frame boundary etc. The other channels such as CPICH (in WCDMA) and Reference Signals (RS) may be used for cell identification and for performing neighboring cell measurements.

[0041] In E-UTRAN systems, the broadcast channel may be transmitted in the center of the cell transmission bandwidth. The bandwidth of the broadcast channel, according to one exemplary embodiment, is 1.25 MHz. The broadcast channel may not be continuously transmitted. In this exemplary embodiment, there is a primary broadcast channel (P-BCH) and also a dedicated broadcast

channel (D-BCH). The primary broadcast channel may contain information necessary to the transmission of data, and this channel is therefore sent periodically, for example every 40 or 80 ms according to an exemplary embodiment. Other time periods are also possible. The dedicated broadcast channel is not sent in a periodic manner and its resource allocation information may be sent on the primary broadcast channel.

[0042] In WCDMA systems, the broadcast channel is sent in every frame according to an exemplary embodiment. The cell individual offset to be used by the user terminal in idle mode is therefore sent on the broadcast channel. The user terminal in the RRC_CONECTED mode receives the offset values via a dedicated control channel (DCCH) from its serving cell.

[0043] To avoid the delays and other disadvantages (discussed above) associated with transmitting the cell individual offset information on the broadcast channel, according to an exemplary embodiment, the cell individual offset related information is signaled by each neighboring cell to the user terminal via the reference or pilot symbols, i.e., coding this information on synchronization and/or reference symbols used for demodulation of neighboring cell measurements. In another exemplary embodiment, the cell individual offset information is transmitted on channels different from the broadcast channel or the reference symbols channel. The cell individual offset information, which is sent on the reference symbols, may either be in the form of a single bit indicating the presence or absence of the cell offset, or may be more detailed information containing the actual offset value of the cell. According to another exemplary embodiment, the user terminal is not required to read the system information of

the neighboring cell to acquire the cell individual offset when the actual offset value of the cell is transmitted to the user terminal.

[0044] In one exemplary embodiment, the user terminal receives only a bit indicative of the presence or absence of the offset at the cell. Figure 4 shows in step 40 that the cell individual offset information is received. In step 42, the user terminal extracts from the cell individual offset information the bit offset. The bit offset may be indicative of the presence or absence of the offset of the cell or may include the actual value of the offset. In step 44, this determination is performed. If the bit offset includes the actual value of the offset, then in step 46 the offset value is added to the measurement and the process for determining the cell offset ends. However, if in step 44 is determined that bit offset does not include the actual value of the offset, the process advances to step 48 in which it is determined what bit is received. For example, the user terminal may receive a bit "0" when there is no offset at the neighboring cell and a bit "1" when there is an offset in the cell. If the extracted bit is determined to be "0" in step 48, the user terminal concludes that no offset is needed at the neighboring cell and decides in step 50 to add no offset when reporting the measured data to the serving cell. However, if the bit is determined in step 48 to be "1," the user terminal determines in step 52 the offset of the neighboring cell. The user terminal may determine the offset value by analyzing the system information transmitted on the broadcast channel by the neighboring cell. Once the offset value is determined, the user terminal adds that offset value in step 54 to the measurement report and sends the report to the serving cell. Thus, in this exemplary embodiment, the user terminal does not have to search the broadcast

channel of those neighboring cell that have a zero offset. Encoding the cell individual offset information is discussed next.

[0045] In E-UTRAN systems, the cell individual offset of each cell may be coded on one or more channels containing reference or pilot symbols signals of the same cell. For example, one of the Primary Synchronization Channel (P-SCH), Secondary Synchronization Channel (S-SCH), or the Reference symbols can be used to encode the cell individual offset. The P-SSCH/S-SCH channels may be used in one embodiment by the user terminal to acquire synchronization data such as, for example, frequency, symbol timing, sub-frame timing, frame timing etc., and also, for example, to identify the neighboring cell (i.e., neighboring cell physical layer identity). Similarly, the reference signals may be used by the user terminal to perform neighboring cell measurements (e.g., RSRP) of the cells identified during synchronization procedure.

[0046] These channels or reference signals are read by the user terminal for cell identification and neighboring cell measurements. Therefore, if the cell individual offset information of the neighboring cell is coded or embedded in one or more of these reference symbol channels, the user terminal may acquire the corresponding offset without reading the system information of the neighboring cell, in contrast to the conventional telecommunication systems. As discussed above, the cell individual offset should not be confused with other offsets used in a telecommunication system, such as frequency or time offsets, which serve different purposes. It is known that the system information in the conventional telecommunication systems is mapped on the broadcast channel. Thus, coding the cell individual offset information in one exemplary embodiment on channel(s) containing reference signals reduces the delay in acquiring the cell offset. In

another exemplary embodiment, the user terminal may be configured to not read the system information, which further reduces the processing time and computational effort of the user terminal. Thus, the user terminal of this embodiment may save battery power consumption.

[0047] There are different possible mechanisms to signal or code the cell individual offsets information on channels including the reference signals. The signaling may be based on an implicit indication of the cell offset in one exemplary embodiment or may be based on an explicit indication of the cell offset. These two embodiments are discussed next.

[0048] In the implicit cell offset indication embodiment, the user terminal is informed via reference symbols (P-SCH or S-SCH or reference signal or combination thereof) whether the cell individual offset is zero or non zero. This information may be coded in the form of one or more bit of information, e.g., "0" indicates that the cell offset is zero (i.e., 0 dB) and "1" indicates that the cell offset is non zero or vice versa. The values "0" and "1" are exemplary and not intended to limit the exemplary embodiments. In one exemplary embodiment, when the coded bit indicates the zero offset (no offset), the user terminal does not need to read the system information of the cell having the zero offset. If the coded bit(s) indicates a non-zero offset (i.e., there is an offset), only then the user terminal reads the system information of the cell having the non-zero offset to acquire the actual offset value. One advantage of this method is that the user terminal does not have to read the broadcast channel of all the cells when the coded bit indicates a zero offset. In the traditional techniques, the user terminal reads the broadcast channel of all the cells, regardless of whether cell individual offset exists or not in a particular cell. Typically, only a sub-set of cells have the cell

individual offset non-zero. Thus, the traditional method requires the user terminal to perform more searching than necessary, which results in a delay in reporting events and measurement reports. This in turn deteriorates the mobility (cell reselection and handover) performance of the network.

[0049] More specifically, a real system generally has some of the cells with zero offsets and the remaining cells with non-zero offsets. Thus, for real systems, according to this exemplary embodiment, the user terminal reads the system information of the cells less frequently compared to the case when the user terminal has to read the system information of all the cells (including the cells with zero offsets) to acquire the offsets because the user terminal of this exemplary embodiment does not need to read the system information for those cells for which the offset values are zero. To the contrary, the conventional telecommunication systems read the system information of all the cells irrespective whether the offset value is zero or non-zero. The same information may also be used by the serving cell to indicate whether the user terminal should apply or not the cell offset in a particular cell, even when there is an offset (non-zero value) for a cell. This approach involves low overheads and it is a fast way of knowing whether a particular cell has an offset or not.

[0050] In the explicit cell offset indication exemplary embodiment, the user terminal acquires the actual cell offset used in the cell via the reference signals. This approach does not require the user terminal to read the neighboring cell system information for the purpose of acquiring the cell individual offset.

[0051] Next, the signaling of the information associated with the offset information of the cells is discussed. For values of the cell individual offset between -10 dB to +10 dB, up to 5 or 6 bits may have to be signaled on reference

symbols (P-SCH, S-SCH or reference signals channel) to the user terminal. The signaling may be performed in a number of ways. Two exemplary methods are discussed next.

[0052] According to an exemplary embodiment, an offset indication per occurrence of reference symbol channels method is discussed. The complete offset value or the one or more bits associated with the offset value is coded on one or more of the channels containing reference symbols. In other words, all bits (N) representative of the offset value or the single bit indicating the presence or absence of the cell offset are sent on the same channel: P-SCH or S-SCH or reference signals channel. In another exemplary embodiment, some bits are sent on one channel whereas the remaining bits are sent on another channel(s). One advantage of this method is that the user terminal acquires the cell individual offset information quickly since the entire information is mapped on one or more channels. The acquisition time may depend upon the radio conditions. For example, for good conditions, e.g., when received SINR of the P-SCH/S-SCH is above -3dB, the delay may be just one occurrence of these channels (e.g., 5 or 10 ms in case of P-SCH/S-SCH). However, according to this embodiment, more overhead transmission per channel occurrence is involved.

[0053] According to another exemplary embodiment, an offset indication via successive occurrences of reference symbol channels method is discussed. In this method, all the bits (N) containing the offset value or the bit indicative of the presence or absence of the cell offset are periodically sent via K (K = N/M) successive or every Lth reference signal channel(s). For L=1, the information is sent in every successive reference signal channels. The value M (M < N) is the number of bits sent per reference channels. As an example not intended to limit

the exemplary embodiments, for N = 4 (i.e., 16 offset values) and M = 1, the cell offset value is sent over 4 successive reference channels in time. In other words, one bit is sent during the transmission of each reference symbol channel. However, more than one bit (e.g., 2 bits) may also be sent per reference channel transmission. In that case, the offset cell value will be sent over K = 2 successive transmissions of the corresponding reference channel(s).

[0054] According to the exemplary embodiment discussed above, for the cell offset value (e.g., N=4 and M=1) sent over P-SCH or/and S-SCH, a minimum time necessary for the user terminal to acquire the cell offset information is the time of K = 4 successive SCH channel transmissions. In LTE systems, this time corresponds to 20 ms since P-SCH/S-SCH appears once every 5 ms. Thus, based on this exemplary embodiment, a reduction in overheads is achieved since one bit is sent per reference channels. A disadvantage of this method is the slightly longer delay (i.e., N/M times) compared to the previous method. However, the delay in this embodiment is minimal because the user terminal does not need to read the system information to acquire the offset individual cell, and because the user terminal demodulates the reference channels several times for synchronization or for neighboring cell measurements.

[0055] In this exemplary embodiment, the N bit of information (or the offset value) is repeated after every K×L occurrences of the reference signal channel. Thus, the user terminal needs to be aware when the pattern of N-bits starts. According to one exemplary embodiment, the user terminal may be configured to start the pattern at the boundary of the slot, sub-frame or frame or any other well defined time-offset or signal boundary known to the user terminal. Because the user terminal acquires, during the synchronization procedure, the frame, sub-

frame and slot boundaries, the user terminal is able to correctly interpret the meaning of the N bits representing the cell offset information after synchronizing the N bits with any of these boundaries.

[0056] The exemplary embodiments discussed in this application are applicable not only to UTRAN or E-UTRAN systems but to any telecommunication system in which the user terminal needs to use the cell individual offset information and where the cell (e.g., the serving cell) does not signal the neighboring cell list to the user terminal.

[0057] Figure 5 shows the steps to be followed when implementing a method for transmitting cell individual offset information, associated with an offset of a cell, to a user terminal, which is configured to communicate with the cell in addition to a serving cell. The method includes, in step 50, generating the cell individual offset information, in step 52 mapping the cell individual offset information on at least one channel that is different from a broadcast channel, and in step 54 transmitting the mapped cell individual offset information.

[0058] Figure 6 shows a method for determining whether to apply cell individual offset information at a user terminal, which is configured to be connected to a cell in a communication network in addition to a serving cell, to measurement reports and/or events associated with the cell. The method includes, in step 60, receiving at least one channel, different from a broadcast channel, in which the cell individual offset information has been mapped, in step 62 extracting the cell individual offset information from the at least one channel, and in step 64 determining from the cell individual offset information whether the offset is present in the cell.

[0059] In one exemplary embodiment, the cell individual offset information mapped on reference signals may be the same for intra-frequency and inter-frequency measurements and events. In a different exemplary embodiment, there are different offsets for intra and inter frequency measurements.

[0060] The disclosed exemplary embodiments provide a user terminal, a system, a method and a computer program product for sending cell individual offset information from a base station in a cell in a communication network, to a user terminal that applies the cell individual offset information to measurement reports and/or events associated with the cell. It should be understood that this description is not intended to limit the invention. On the contrary, the exemplary embodiments are intended to cover alternatives, modifications and equivalents, which are included in the spirit and scope of the invention as defined by the appended claims. Further, in the detailed description of the exemplary embodiments, numerous specific details are set forth in order to provide a comprehensive understanding of the claimed invention. However, one skilled in the art would understand that various embodiments may be practiced without such specific details.

[0061] As also will be appreciated by one skilled in the art, the exemplary embodiments may be embodied in a wireless communication device, a telecommunication network, as a method or in a computer program product. Accordingly, the exemplary embodiments may take the form of an entirely hardware embodiment or an embodiment combining hardware and software aspects. Further, the exemplary embodiments may take the form of a computer program product stored on a computer-readable storage medium having computer-readable instructions embodied in the medium. Any suitable computer readable medium may be utilized including hard disks, CD-ROMs, digital versatile disc (DVD), optical

storage devices, or magnetic storage devices such a floppy disk or magnetic tape. Other non-limiting examples of computer readable media include flash-type memories or other known memories.

[0062] The present exemplary embodiments may be implemented in a user terminal, a base station, and generally in a wireless communication network or system comprising both the user terminal and the base station. The exemplary embodiments may also be implemented in an application specific integrated circuit (ASIC), or a digital signal processor. Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine. A processor in association with software may be used to implement a radio frequency transceiver for use in the user terminal, the base station or any host computer. The user terminal may be used in conjunction with modules, implemented in hardware and/or software, such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth module, a frequency modulated (FM) radio unit, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any wireless local area network (WLAN) module.

[0063] Although the features and elements of the present exemplary embodiments are described in particular combinations, each feature or element can

be used alone without the other features and elements of the embodiments or in various combinations with or without other features and elements disclosed herein. The methods or flow charts provided in the present application may be implemented in a computer program, software, or firmware tangibly embodied in a computer-readable storage medium for execution by a general purpose computer or a processor.

WTHAT IS CLAIMED IS:

1. A method for transmitting cell individual offset information, associated with an offset of a cell [21], to a user terminal [12], which is configured to communicate with the cell [21] in addition to a serving cell [20], comprising:

generating the cell individual offset information;

mapping the cell individual offset information on at least one channel that is different from a broadcast channel; and

transmitting the mapped cell individual offset information.

2. The method of Claim 1, wherein the generating comprises:

generating the cell individual offset information independent of a cell synchronization of the user terminal with the cell or independent of a cell frequency offset used in a synchronizing process between the cell and the user terminal.

3. The method of Claim 1, wherein the mapping comprises:

selecting the at least one channel to be at least one of a reference symbols channel, a primary synchronization channel, a secondary synchronization channel, and a combination thereof.

4. The method of Claim 1, wherein the cell individual offset information comprises a cell offset indication bit indicative of whether there is or not an offset in the cell and the cell offset indication bit comprises one of first and second bits of information.

5. The method of Claim 4, wherein the first bit configures the user terminal to not apply a cell individual offset value when reporting events or measurements of the cell to the serving cell.

6. The method of Claim 4, wherein the second bit configures the user terminal to apply a cell individual offset value when reporting events or measurements of the cell to the serving cell and the cell individual offset value is acquired from system information of the broadcast channel of the cell.

7. The method of Claim 1, wherein the cell individual offset information comprises a cell individual offset value of the cell.

8. The method of Claim 1, wherein the mapping comprises:

mapping the cell individual offset information on every occurrence of a frame of the at least one channel.

9. The method of Claim 1, wherein the mapping comprises:

mapping the cell individual offset information on every "N" occurrence of a frame of the at least one channel, wherein N is an integer number equal or larger than 2.

10. The method of Claim 1, further comprising:

preventing the serving base station, which is serving the user terminal, from transmitting a list of neighboring cells of the user terminal.

11. A method for determining whether to apply cell individual offset information at a user terminal [12], which is configured to be connected to a cell [21] in a communication network [N] in addition to a serving cell [20], to measurement reports and/or events associated with the cell [21], comprising:

receiving at least one channel, different from a broadcast channel, in which the cell individual offset information has been mapped;

extracting the cell individual offset information from the at least one channel; and

determining from the cell individual offset information whether the offset is present in the cell [21].

12. The method of Claim 11, wherein the at least one channel is one of a reference symbols channel, a primary synchronization channel, a secondary synchronization channel, and a combination thereof.

13. The method of Claim 11, wherein the cell individual offset information comprises a cell offset indication bit indicative of whether there is or not an offset in the cell and the cell offset indication bit comprises one of first and second bits of information.

14. The method of Claim 13, further comprising:

when the first bit is detected, determining to not search for and to not apply a cell individual offset value of the cell when reporting events or measurements of the cell to the serving cell.

15. The method of Claim 13, further comprising:

when the second bit is detected, determining to apply a cell individual offset value and the cell individual offset value is acquired from system information of the broadcast channel of the cell.

16. The method of Claim 11, wherein the cell individual offset information comprises a cell individual offset value of the cell.

17. The method of Claim 16, wherein the cell individual offset value of the cell is indicative of an actual offset of the cell.

18. The method of Claim 15, further comprising:

applying the cell individual offset value when reporting events or measurements of the cell to the serving cell.

19. The method of Claim 11, wherein the extracting comprises:

extracting the cell individual offset information on every occurrence of a frame in the at least one channel.

20. The method of Claim 11, wherein the extracting comprises:

extracting the cell individual offset information on every "N" occurrence of a frame in the at least one channel, wherein N is an integer number equal to or larger than 2.

21. A base station [10] in a cell [21] configured to send cell individual offset information to a user terminal [12], the base station [10] and the user terminal [12] are connected to a communication network [N], and the user terminal [12] applies the cell individual offset information to measurement reports and/or events associated with the cell [21], comprising:

a processor [26] configured to generate the cell individual offset information;

the processor [26] being configured to map the cell individual offset information on at least one channel that is different from a broadcast channel; and

an antenna [28] connected to the processor [26] and configured to transmit the mapped cell individual offset information received from the processor [26].

22. The base station of Claim 21, wherein the processor is further configured to select the at least one channel to be one of a reference symbols channel, a primary synchronization channel, a secondary synchronization channel, and a combination thereof.

23. The base station of Claim 21, wherein the cell individual offset information comprises a cell offset indication bit indicative of whether there is or not an offset in the cell and the cell offset indication bit comprises one of first and second bits of information.

24. The base station of Claim 23, wherein the first bit configures the user terminal to not apply a cell individual offset value when reporting events or measurements of the cell to a serving cell.

25. The base station of Claim 23, wherein the second bit configures the user terminal to apply a cell individual offset value when reporting events or measurements of the cell to a serving cell and the cell individual offset value is acquired from system information of the broadcast channel of the cell.

26. The base station of Claim 21, wherein the processor is further configured to map the cell individual offset information on every occurrence of a frame of the at least one channel.

27. A user terminal [12] connected in a communication network [N] to a base station [10] in a cell [21], the user terminal [12] being configured to determine whether to apply cell individual offset information to measurement reports and/or events associated with the cell [21], comprising:

an antenna [28] configured to receive at least one channel in which the cell individual offset information has been mapped, the at least one channel being different from a broadcast channel;

a processor [26] connected to the antenna [28] and configured to extract the cell individual offset information from the received at least one channel; and

the processor [26] being further configured to determine from the cell individual offset information whether the offset is present in the cell [21].

28. The user terminal of Claim 27, wherein the processor is further configured to determine that the at least one channel is one of a reference symbols channel, a primary synchronization channel, a secondary synchronization channel, and a combination thereof.

29. The user terminal of Claim 27, wherein the cell individual offset information comprises a cell offset indication bit indicative of whether there is or not an offset in the cell and the cell offset indication bit comprises one of first and second bits of information.

30. The user terminal of Claim 29, wherein the processor is further configured to:

when the first bit is detected, to not search for and to not apply a cell individual offset value of the cell when reporting events or measurements of the cell to a serving cell.

31. The user terminal of Claim 29, wherein the processor is further configured to:

when the second bit is detected, search for a cell individual offset value when of the cell.

32. The user terminal of Claim 27, wherein the cell individual offset information comprises a cell individual offset value of the cell.

33. The user terminal of Claim 27, wherein the processor is further configured to extract the cell individual offset information on every occurrence of a frame in the at least one channel.

34. The user terminal of Claim 27, wherein the processor is further configured to extract the cell individual offset information on every "N" occurrence of a frame in the at least one channel, wherein the N is an integer number equal to or larger than 2.

35. A computer readable medium that stores instructions, which when executed on a processor [26] in a base station [10] in a cell [21] in a communication network [N], sends cell individual offset information to a user terminal [12] that applies the cell individual offset information to measurement reports and/or events associated with the cell [21], the instructions comprising:

generating the cell individual offset information;

mapping the cell individual offset information on at least one channel that is different from a broadcast channel; and

transmitting the mapped cell individual offset information.

36. A computer readable medium that stores instructions, which when executed on a processor [26] in a user terminal [12], which is connected to a cell [21] in a communication network [N], determine whether to apply cell individual offset information to measurement reports and/or events associated with the cell [21], the instructions comprising:

receiving at least one channel, different from a broadcast channel, in which the cell individual offset information has been mapped;

extracting the cell individual offset information from the at least one channel; and

determining from the cell individual offset information whether the offset is present in the cell [21].

37. A base station [10] in a cell [21] configured to send cell individual offset information to a user terminal [12], the base station [10] and the user terminal [12] are connected to a communication network [N], and the user terminal [12] applies the cell individual offset information to measurement reports and/or events associated with the cell [21], comprising:

means for generating [26] the cell individual offset information;

means for mapping [26] the cell individual offset information on at least one channel that is different from a broadcast channel; and

means for transmitting [28] the mapped cell individual offset information.

38. A user terminal [12] connected in a communication network [N] to a base station [10] in a cell [21], the user terminal [12] being configured to determine whether to apply cell individual offset information to measurement reports and/or events associated with the cell [21], comprising:

means for receiving [28] at least one channel in which the cell individual offset information has been mapped, the at least one channel being different from a broadcast channel;

means for extracting [26] the cell individual offset information from the received at least one channel; and

means for determining [26] from the cell individual offset information whether the offset is present in the cell [21].

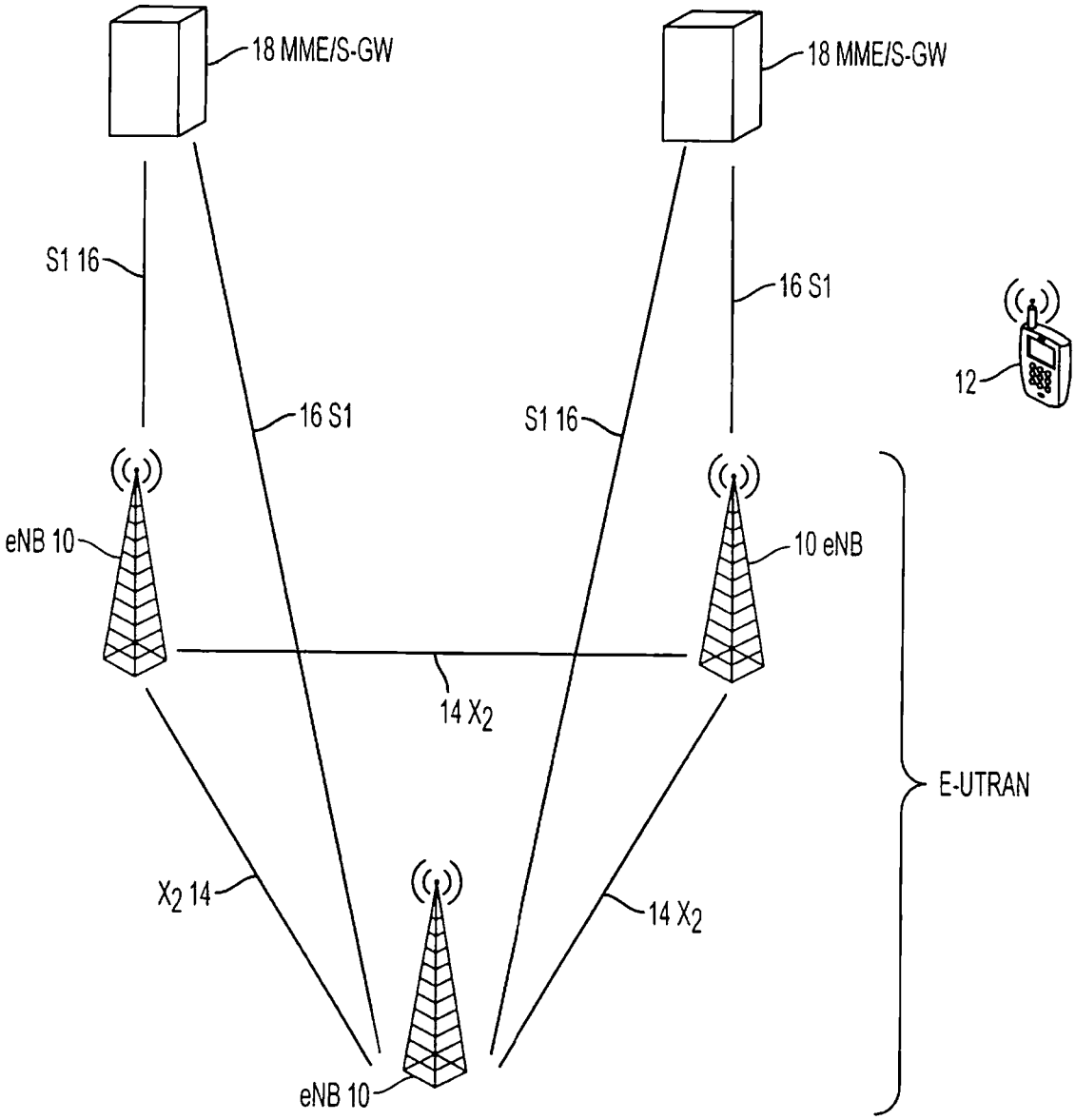
18 MME/S-GW
18 MME/S-GW
S1 16
16 S1
16 S1
S1 16
12
eNB 10
10 eNB
14 X2
E-UTRAN
X2 14
14 X2
eNB 10

FIG. 1

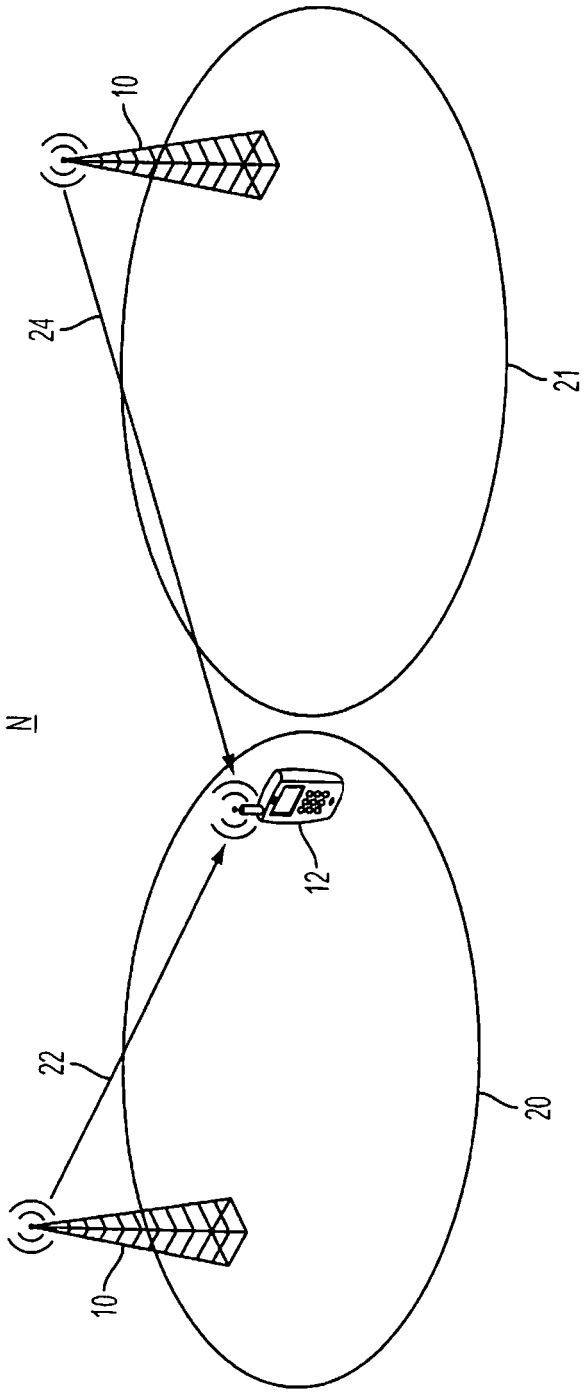

FIG. 2

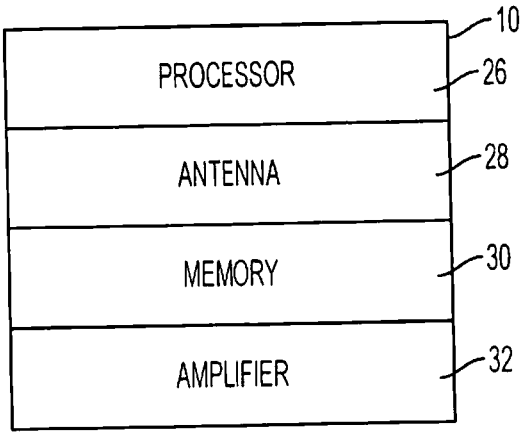

FIG. 3

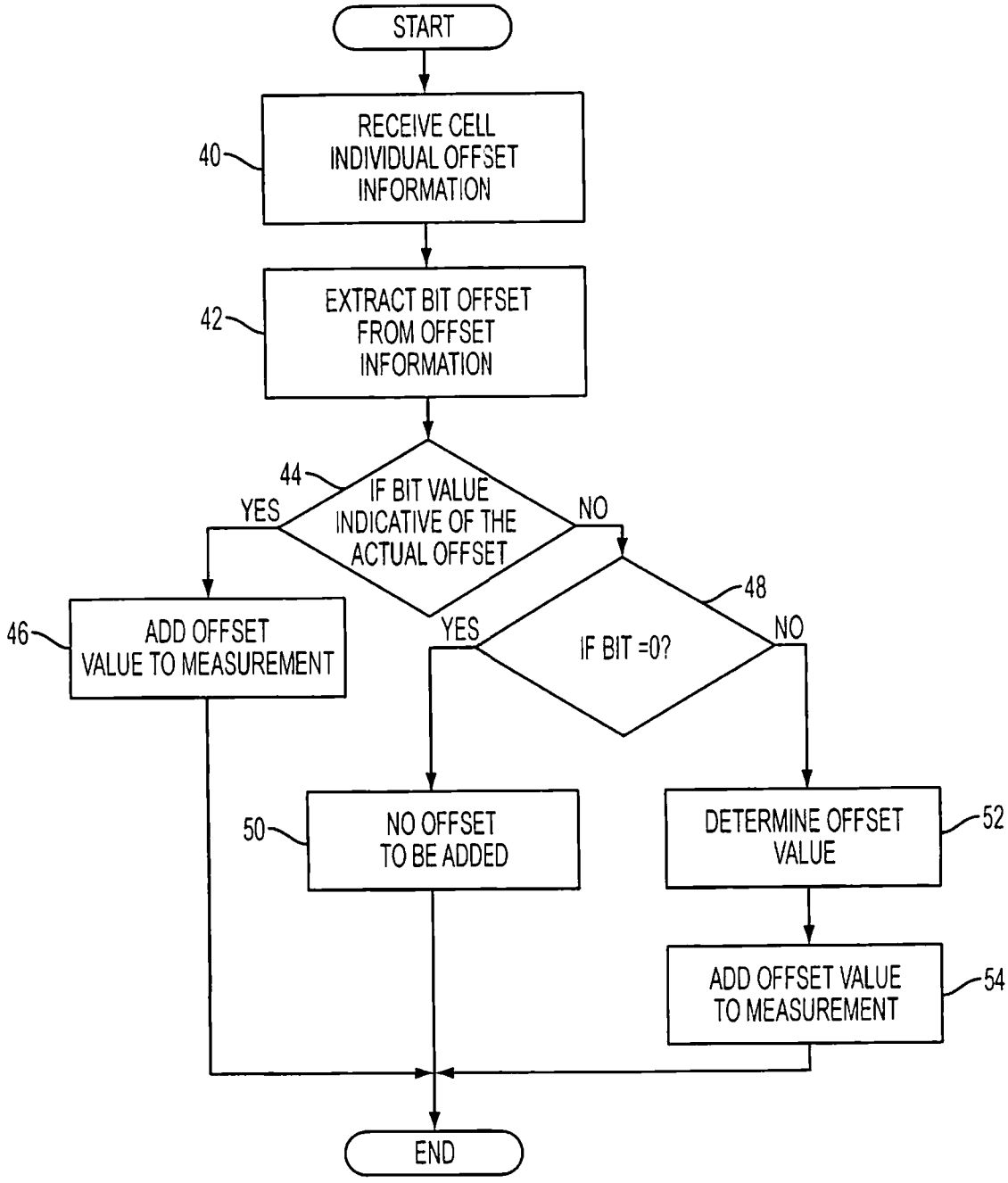
START
RECEIVE CELL INDIVIDUAL OFFSET INFORMATION
40
EXTRACT BIT OFFSET FROM OFFSET INFORMATION
42
IF BIT VALUE INDICATIVE OF THE ACTUAL OFFSET
44
YES
NO
ADD OFFSET VALUE TO MEASUREMENT
46
IF BIT =0?
48
YES
NO
NO OFFSET TO BE ADDED
50
DETERMINE OFFSET VALUE
52
ADD OFFSET VALUE TO MEASUREMENT
54
END

FIG. 4

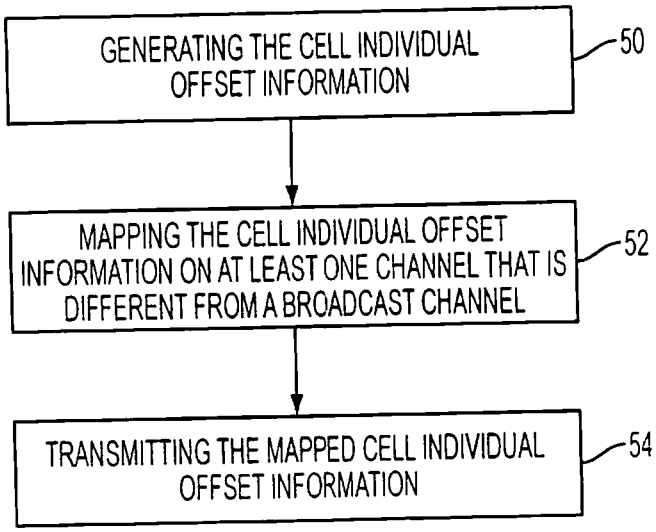
GENERATING THE CELL INDIVIDUAL OFFSET INFORMATION
50
MAPPING THE CELL INDIVIDUAL OFFSET INFORMATION ON AT LEAST ONE CHANNEL THAT IS DIFFERENT FROM A BROADCAST CHANNEL
52
TRANSMITTING THE MAPPED CELL INDIVIDUAL OFFSET INFORMATION
54

FIG. 5

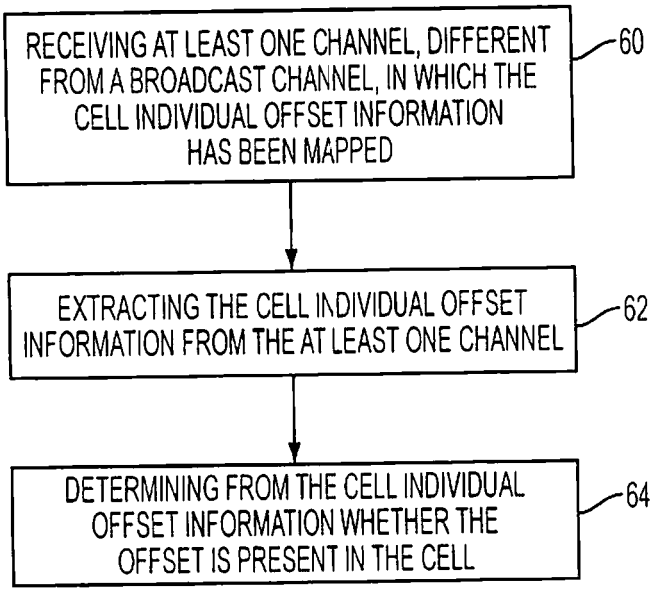
RECEIVING AT LEAST ONE CHANNEL, DIFFERENT FROM A BROADCAST CHANNEL, IN WHICH THE CELL INDIVIDUAL OFFSET INFORMATION HAS BEEN MAPPED
60
EXTRACTING THE CELL INDIVIDUAL OFFSET INFORMATION FROM THE AT LEAST ONE CHANNEL
62
DETERMINING FROM THE CELL INDIVIDUAL OFFSET INFORMATION WHETHER THE OFFSET IS PRESENT IN THE CELL
64

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2008/050429

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet
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: H04B, H04Q, H04L, H04J

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

SE,DK,FI,NO classes as above

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

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2005081437 A1 (HUAWEI TECHNOLOGIES CO., LTD.), 1 Sept 2005 (01.09.2005), page 4, line 4 - line 18; page 5, line 1 - line 30; page 11, line 19 - page 12, line 30, abstract --	1-38
A	US 20070140106 A1 (TSAI ET AL), 21 June 2007 (21.06.2007), claims 1,16,48-49, abstract, paragraphs [0007] - [0011]; [0029] - [0032]; [0044]; [0060] - [0062] --	1-38
A	EP 1672812 A1 (TELEFONAKTIBOLAGET LM ERICSSON (PUBL)), 21 June 2006 (21.06.2006), abstract, paragraphs [0034] - [0044]; [0078] - [0079]; [0098] - [0099] --	1-38

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent 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
11 November 2008	20 -11- 2008
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Behroz Moradi/PR Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 2008)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2008/050429

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1499147 A1 (MITSUBISHI ELECTRIC INFORMATION TECHNOLOGY CENTRE EUROPE B.V.), 19 January 2005 (19.01.2005), claim 11, abstract, paragraphs [0064] - [0070]	1-38
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P,A	WO 2007075463 A2 (INTERDIGITAL TECHNOLOGY CORPORATION), 5 July 2007 (05.07.2007), abstract, paragraphs [0063] - [0067]	1-38
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P,A	EP 1909523 A1 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 9 April 2008 (09.04.2008), abstract, paragraphs [0073] - [0074]; [0133]	1-38
	--	

International patent classification (IPC)
H04B 7/26 (2006.01)
H04J 4/00 (2006.01)
H04L 5/02 (2006.01)

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Use the application number as username.
The password is **RZVSCQVJHO**.

Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

WO	2005081437	A1	01/09/2005	EP	1763932	A	21/03/2007
US	20070140106	A1	21/06/2007	WO	2007075463	A	05/07/2007
EP	1672812	A1	21/06/2006	JP WO	2008524885 2006066844	T A	10/07/2008 29/06/2006
EP	1499147	A1	19/01/2005	JP	2005051767	A	24/02/2005
WO	2007075463	A2	05/07/2007	US	20070140106	A	21/06/2007
EP	1909523	A1	09/04/2008	NONE			