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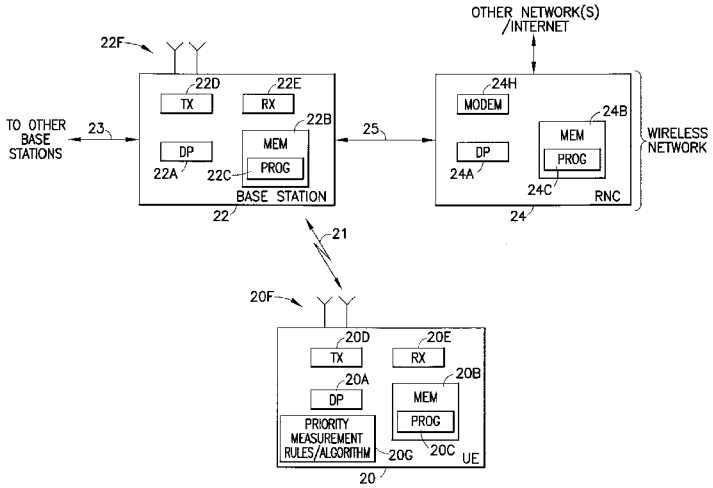

FIG.7

(57) **Abstract**: Based on the determined signal strength of a serving cell, a choice is made whether to utilize a cell-FACH measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search. The lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service. In specific examples the search may be inter- frequency for frequency layers with higher or lower priority than a serving layer of the serving cell, or the search may be inter-RAT such as the lower priority GERAN search and a higher priority E-UTRAN search if the serving cell is WCDMA. In one example there are two thresholds for the signal strength, and if higher than both then the measurement occasion is used for an E-UTRAN search regardless of whether GERAN or inter-frequency neighbour cells have been configured for the UE practicing the invention.

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PRIORITY MEASUREMENT RULES FOR CHANNEL MEASUREMENT OCCASIONS

TECHNICAL FIELD:

[0001] The exemplary and non-limiting embodiments of this invention relate generally to wireless communication systems, methods, devices and computer programs and, more specifically, relate to inter-frequency and inter-radio access technology measurements made by a user equipment.

BACKGROUND:

[0002] The following abbreviations that may be found in the specification and/or the drawing figures are defined as follows:

3GPP	third generation partnership project
BSIC	base station identification code
DL	downlink
E-UTRAN	evolved UTRAN (LTE)
FACH	forward access channel
GERAN	GSM-enhanced data rates for global evolution (EDGE)
GSM	global system for mobile communications
HSPA	high speed packet access
LTE	long term evolution
RAT	radio access technology
TDD	time division duplex
UE	user equipment
UL	uplink
UTRAN	universal terrestrial radio access network
WCDMA	wideband code division multiple access

[0003] The exemplary embodiments detailed herein are in the context of the WCDMA and HSPA (GSM) wireless systems to resolve problems in measuring inter-frequency and inter-RAT neighbor cells. These teachings are not limited only to those wireless systems but are more generally applicable; the examples merely illustrate specific implementation details relevant to those systems.

[0004] In the WCDMA/HSPA system the UE can make these inter-frequency and inter-RAT neighbor cell measurements when in the FACH state, which is when the UE is camped on a cell and has a signalling connection established with the network. The UE makes such measurements only during what is termed a measurement

occasion. Currently, the inter-RAT measurement occasions are specified for GERAN only, but as E-UTRAN becomes more ubiquitous these neighbor cells are expected to be measured by the UE camped in the WCDMA/HSPA system also. A problem arises when increasing the number of measurement occasions to include E-UTRAN.

[0005] Generally, measurement occasions are infrequent and are shared equally between all the measurement types configured for the UE, so the effectiveness of these measurement gaps is quite poor. When E-UTRAN is introduced for the inter-RAT measurements the effectiveness may become even worse if the current measurement occasion concepts are simply extended to include E-UTRAN neighbors.

[0006] First, consider the current measurement occasion practice which is set forth at 3GPP TS 25.133. The measurement repetition T_{meas} in milliseconds (ms) is determined by the following algorithm:

$$T_{meas} = \left[\left(N_{FDD} + N_{TDD} + N_{GSM}\right) \cdot \mathrm{N_{TTI}} \cdot \mathrm{M\_REP} \cdot 10\right];$$

where:

M_REP is the measurement occasion cycle length where K is given in Table 8.10A of 3GPP TS 25.133 (K is the FACH measurement occasion length coefficient, which is specified in 3GPP TS 25.331)

[0007] The FACH measurement occasion of N_{TTI} frames will be repeated every N_{TTI} * M_REP frame. This means that the measurement time T_{meas} increases uniformly for each RAT supported, which has a detrimental impact on inter-frequency and inter-RAT measurements and therefore UE mobility. Since currently only GERAN neighbor cells account for the inter-RAT measurements this has not yet become a problem in practice.

[0008] To quantify the impact of adding E-UTRAN cells to the inter-RAT measurements, consider a typical FACH configuration as follows: inter-frequency (N_{FDD}=1); inter-RAT (GERAN) (N_{GSM} =1), where K is 3 (MREP = 8) and N_{TTI} = 1. In this configuration, T_{meas} = (1+0+1) * 1 * 8 * 10 = 160ms.

[0009] In this scenario there is an inter-frequency measurement occasion every 160ms, but since it takes about five measurement occasions to perform a search then there can be a search only every 800 ms. Also in this scenario a GERAN (inter-RAT) measurement occasion is also configured every 160 ms, which as seen at Figure 1A yields a BSIC verification time of 7.68 seconds and at Figure 1B a BSIC refresh time of 6.4 seconds.

[0010] Now extend this same measurement occasion protocol to include the possibility of E-UTRAN neighbor cells. In this straightforward extension the measurement time T_{meas} in milliseconds is then defined as:

$$T_{meas} = \left[\left(N_{FDD} + N_{TDD} + N_{GSM} + N_{EUTRA}\right) \cdot \mathrm{N_{TTI}} \cdot \mathrm{M\_REP} \cdot 10\right]$$

Using the same FACH configuration as above then T_{meas} = (1+0+1+1) * 1 * 8 * 10 = 240ms.

[0011] There is therefore an inter-RAT measurement occasion for E-UTRAN every 240ms, but in this case it takes as few as one measurement occasion to perform an E-UTRAN search so there is a search every 240 ms. This also provides an inter-frequency measurement occasion every 240 ms, and since it still will take about five measurement occasions to perform a search then there can be an inter-frequency search only every 1200 ms.

[0012] The inter-frequency measurements would be impacted by including E-UTRAN because the number of cell-FACH measurement occasions is reduced by a third. This also results in a GERAN measurement every 240ms, which results in a BSIC verification time of 29.76 seconds as seen at Figure 2A, and a BSIC refresh time of 17.28 seconds as seen at Figure 2B. This is seen to be too long of a time for GERAN measurements. The teachings below address this problem, but as indicated have utility beyond only the GSM/GERAN/E-UTRAN systems which are used only for specific illustration of the principles.

SUMMARY:

[0013] In a first exemplary embodiment of the invention there is an apparatus comprising at least one processor and at least one memory storing a computer program. In this embodiment the at least one memory with the computer program is configured with the at least one processor to cause the apparatus to at least: determine signal strength of a serving cell; and choose, based on the determined signal strength, whether to utilize a measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search. In this embodiment the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

[0014] In a second exemplary embodiment of the invention there is a method comprising: determining signal strength of a serving cell; and choosing, based on the determined signal strength, whether to utilize a measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search. In this embodiment the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

[0015] In a third exemplary embodiment of the invention there is a computer readable memory storing a computer program, in which the computer program comprises: code for determining signal strength of a serving cell; and code for choosing, based on the determined signal strength, whether to utilize a measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search. In this embodiment the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

[0016] By example, the measurement occasion in any of the above exemplary embodiments may be a cell-FACH measurement occasion. These and other embodiments and aspects are detailed below with particularity.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0017] Figure 1a is a table showing times for identifying a GSM base station for different measurement occasion times governed by measurement repetition T_{meas} calculated to include measuring inter-frequency and GSM.

[0018] Figure 1b is a table showing times for verifying a GSM base station for different measurement occasion times governed by measurement repetition T_{meas} calculated to include measuring inter-frequency and GSM.

[0019] Figure 2a is a table similar to Figure 1a but extended to include searching for an E-UTRAN neighbor cell.

[0020] Figure 2b is a table similar to Figure 1b but extended to include searching for an E-UTRAN neighbor cell.

[0021] Figure 3 is a reproduction of section 5.2.6.1.2a of 3GPP TS 25.304 V9.3.0 (2010-09)

[0022] Figure 4 is a diagram showing dynamic selection between high priority and low priority searching for and measuring of neighbor cells based on signal strength received from a user equipment's serving cell according to an exemplary embodiment of the invention.

[0023] Figures 5a-e illustrate various choices made for a series of seven measurement occasions based on the signal strength received from a UE's serving cell according to exemplary embodiments of the invention.

[0024] Figure 6 is a logic flow diagram that illustrates the operation of a method, and a result of execution of computer program instructions embodied on a computer readable memory, in accordance with the exemplary embodiments of this invention.

[0025] Figure 7 is a simplified block diagram of the UE in communication with a wireless network illustrated as a base station and a RNC, which are exemplary electronic devices suitable for use in practicing the exemplary embodiments of this invention.

DETAILED DESCRIPTION:

[0026] Exemplary embodiments of these teachings address the above problem by enabling a UE to dynamically switch between coverage and service based measurements, thereby utilizing its cell-FACH measurement occasions more effectively. As quantified above, sharing the cell-FACH measurement occasions limits the UE's mobility while in the cell-FACH state and introducing E-UTRAN to these measurement occasions will more severely limit that mobility. As will be seen below, these teachings enable the UE to maximize the effectiveness of the limited time available. In one aspect of these teachings the relative importance of the different types of measurements, whether the measurements are for coverage or for service for example, will vary as the strength of the serving cell changes. For example, *coverage* is important when the serving cell is weak to better assure an alternate cell for the UE in case signal strength from its serving cell continues to deteriorate. Service, such as looking for hot spot coverage to enable additional or enhanced mobile services beyond simply cellular call coverage, is more important when signal strength from the serving cell is stronger and basic cellular coverage from the serving cell is not reasonably in doubt in the near term.

[0027] With these general principles in mind, now consider a priority re-selection algorithm in the E-UTRAN system. By this algorithm the network can prioritize either a frequency layer or a RAT over another. This means that the available measurement occasions can be used more efficiently depending on the strength of the serving cell. When E-UTRAN is supported the UE will perform measurements based on the Release 8 measurement rules specified in 3GPP TS 25.304, reproduced at Figure 3. The Release 99 mechanism for applying measurement occasions based on a fixed measurement purpose, measuring either inter-frequencies or a RAT, can therefore be improved.

[0028] The new Release 8 priority definitions means that the measurement occasion gaps can be used for different purposes based on the priorities identified by the network. These can be applied based on the variable Sprioritysearch1 or Sprioritysearch2. This mechanism for overriding the Release 99 measurement purpose can be applied to both the Release 99 inter-frequency and inter-RAT measurement occasions or just inter-RAT measurement occasions, at the network's choosing.

[0029] Figure 4 illustrates conceptually an exemplary embodiment of the invention, divided into three areas of serving cell signal strength. When the serving cell strength is strong and in the higher priority search region, above a second threshold which corresponds for example to the "Sprioritysearch" parameter as shown at Figure 4, the UE can override the Release 99 measurement purposes and use the measurement occasions to detect high priority RATs and/or inter-frequencies. In the specific examples below the higher priority is the E-UTRAN system, but in another exemplary embodiment can be a UTRAN inter-frequency layer. So a lower priority neighbor cell search better aids the UE in maintaining wireless connectivity, while a higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell, such as for example increased data rates E-UTRAN offers over WCDMA/HSPA. This connectivity/service priority distinction is true whether the searches are inter-frequency or inter-RAT searches,

[0030] Further at Figure 4, when the serving cell signal strength drops below that second threshold to lie within the "ALL priority" search region shown there, the UE can chose to schedule the measurement occasions based on either GERAN or E-UTRAN based on their determined signal strengths, or prioritize the lower priority RAT which in this case is GERAN. When the serving cell signal strength drops further to fall below a first threshold shown in Figure 4 as "Thresh Serving low", coverage becomes a more pressing concern and so the UE utilizes its measurement occasions to search for inter-frequency and GERAN neighbor cells according to conventional Release 99 measurement occasion purposes.

[0031] Figures 5a-e illustrate use of the UE's measurement occasions in various instances according to an exemplary embodiment of the invention, in which each figure illustrates seven consecutive measurement occasions for a UE. Figure 5a illustrates the UE's conventional (Release 99 measurement purpose is fixed) use of them; each alternate measurement occasion is used for an inter-frequency search and measurement of neighbor cells (the FDD blocks), and for an inter-RAT search and measurement of neighbor cells operating according to GERAN (the GERAN blocks). The search pattern of Figure 5a might also result from the UE's serving cell signal strength lying between the first and second thresholds of Figure 4 (so the UE can choose which inter-RAT neighbor to measure).

[0032] The search pattern of Figure 5b represents the case in which the UE's serving cell signal strength is very good, above the second threshold of Figure 4 which means coverage by the serving cell is assured and the measurement occasions are used to search for better/enhanced coverage. At Figure 5b the UE uses its inter-RAT measurement occasions to search and measure neighbor E-UTRAN cells and uses its inter-frequency measurement occasions to search and measure neighbor cells on a different frequency layer than its serving cell. The same pattern of Figure 5b may also result from the serving cell signal strength lying between the first and second thresholds as in Figure 5a.

[0033] Figure 5c also considers the case in which the serving cell signal strength is above the higher second threshold, but in this example the UE utilizes both its inter-frequency FDD measurement occasions and its inter-RAT measurement occasions for high priority searching, which in this case is for E-UTRAN neighbor cells.

[0034] Figure 5d represents the case in which the signal strength from the UE's serving cell is below the lower first threshold of Figure 4, in which case all the UE's measurement occasions are low priority searches to better assure that basic wireless coverage is maintained. Figure 5e shows specifics for the low priority search occasions of Figure 5d, which in this case is the same as Figure 5a and the conventional alternating between inter-frequency searching and inter-RAT searching for neighbors operating in the GERAN system.

[0035] In another embodiment there is only one threshold so that the higher priority searches are done when the signal strength of the UE's serving cell is higher than that threshold, and the lower priority searches are done when that signal strength is lower than the threshold.

[0036] Exemplary embodiments of these teachings exhibit the technical effect of enabling the UE to use GSM Release 99 measurement occasions rules in an algorithm which allows the UE to also search for another higher priority RAT and/or frequency. Conventionally, while a UE is in the CELL FACH state it has no mobility to an E-UTRA neighbor cell and so the CELL FACH UE will stay within the UTRA system (GSM and GERAN in these examples) and will not be able to re-select to a neighbor which offers the higher data rates that E-UTRA or some other higher priority layers might offer. Performance of re-selections to UTRA and GERAN frequencies should not be inhibited because the purpose for which the measurement occasion is used switches back and forth, based on the strength of the UE's serving cell. Another technical effect is that there is no change on the network side and so these solutions are quite straightforward to implement despite the highly structured nature of wireless cellular communications.

[0037] Figure 6 is a logic flow diagram which describes an exemplary embodiment of the invention from the perspective of the UE. Figure 6 may be considered to illustrate the operation of a method, and a result of execution of a computer program stored in a computer readable memory, and a specific manner in which components of an electronic device are configured to cause that electronic device to operate. The various blocks shown in Figure 6 may also be considered as a plurality of coupled logic circuit elements constructed to carry out the associated function(s), or specific result of strings of computer program code stored in a memory.

[0038] Such blocks and the functions they represent are non-limiting examples, and may be practiced in various components such as integrated circuit chips and modules, and that the exemplary embodiments of this invention may be realized in an apparatus that is embodied as an integrated circuit. The integrated circuit, or circuits, may

comprise circuitry (as well as possibly firmware) for embodying at least one or more of a data processor or data processors, a digital signal processor or processors, baseband circuitry and radio frequency circuitry that are configurable so as to operate in accordance with the exemplary embodiments of this invention.

[0039] At block 602 the signal strength of a serving cell is determined. In an embodiment that serving cell is operating according to a 1st radio technology, which in the above examples is the WCDMA or HSPA. At block 604, based on that determined signal strength a selection or choice is made whether to utilize a measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search. The lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell. In a specific embodiment, the measurement occasion of block 604 is a cell-FACH measurement occasion.

[0040] The remainder of Figure 6 illustrates more specific implementations for blocks 602 and 604. Block 606 refers to the inter-frequency search, so the higher priority neighbor cell search of block 604 is at block 606 a search in a frequency layer higher in priority than the serving layer of the serving cell. Similarly, the lower priority neighbor cell search of block 604 is at block 606 a search in a frequency layer having a priority that is lower than or equal to priority of the serving layer of the serving cell.

[0041] Block 608 refers to the inter-RAT search, which is generally stated there as the serving cell operating according to a first radio access technology RAT, the higher priority neighbor cell search of block 604 is at block 608 a search in a third RAT, and the lower priority neighbor cell search of block 604 is at block 608 a search in a second RAT.

[0042] Block 610 details the specific RATs from the above examples and also the second threshold from Figure 4: the first RAT is WCDMA, the second RAT is GERAN, the third RAT is E-UTRAN, the threshold is a first threshold and the measurement occasion is utilized for the E-UTRAN neighbor cell search if the determined signal strength is above a second threshold higher than the first threshold.

[0043] Block 612 refers to the specific inter-RAT example of Figure 5c in which the measurement occasion is utilized for the E-UTRAN neighbor cell search (higher priority inter-RAT search) if the determined signal strength is above the second threshold regardless of whether the measurement occasion is an inter-RAT measurement occasion or an inter-frequency measurement occasion. Conventionally the different measurement occasions themselves are not specifically allocated for inter-frequency or inter-RAT purposes; 3GPP TS 25.133 only states that they are to be shared equally by the modes which the UE has capability for and that are in the monitored set signaled by the network. It then follows that for a UTRAN-specific implementation, the above concept may be more precisely stated as seen at block 312: the cell-FACH measurement occasion is utilized only for the E-UTRAN neighbor cell search regardless of whether GSM (GERAN) or inter-frequency neighbour cells have been configured for the UE which is operating under the serving cell noted at block 602.

[0044] In a specific embodiment, Figure 6 may be considered to represent actions of a modem which may be apart from or disposed within the above UE.

[0045] Embodiments of the invention may be implemented as an apparatus which has determining means and choosing means. The determining means is for determining signal strength of a serving cell as in block 602 of Figure 6, and may by example be a measuring means. Specific embodiments of such determining/measuring means may be for example a radio receiver and/or a processor. The choosing means is for choosing whether to utilize a (e.g., cell-FACH) measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search, and as shown at block 604 of Figure 6, this choosing means bases its choice on the signal strength determined by the determining means. Specific embodiments of such choosing means may be for example at least one processor in conjunctions with computer instructions such as an algorithm or priority measurement rules stored on a computer readable memory. As above, the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

[0046] Reference is now made to Figure 7 for illustrating a simplified block diagram of various electronic devices and apparatus that are suitable for use in practicing the exemplary embodiments of this invention. In Figure 7 a wireless network (base station 22 and RNC 24) is adapted for communication over a wireless link 21 with an apparatus, such as a mobile terminal or UE 20, via a network access node such as a base station/NodeB 22 or relay station. The network may include a radio network controller RNC 24, which provides connectivity with further networks (e.g., a publicly switched telephone network PSTN and/or a data communications network/Internet).

[0047] The UE 20 includes processing means such as at least one data processor (DP) 20A, storing means such as at least one computer-readable memory (MEM) 20B storing at least one computer program (PROG) 20C, communicating means such as a transmitter TX 20D and a receiver RX 20E for bidirectional wireless communications with the base station 22 via one or more antennas 20F. Also stored in the MEM 20B at reference number 20G is the priority measurement rules, more particularly an algorithm for choosing, based on signals strength of the serving cell 22, whether to use a next measurement occasion for a high priority search (E-UTRAN in the inter-RAT examples) or a low priority search (GERAN in the inter-RAT examples) as detailed above.

[0048] The base station 22 also includes processing means such as at least one data processor (DP) 22A, storing means such as at least one computer-readable memory (MEM) 22B storing at least one computer program (PROG) 22C, and communicating means such as a transmitter TX 22D and a receiver RX 22E for bidirectional wireless communications with the UE 20 via one or more antennas 22F. There is a data and/or control path 25 coupling the base station 22 with the RNC 24, and another data and/or control path 23 coupling the base station 22 to other base stations/node Bs/access nodes.

[0049] Similarly, the RNC 24 includes processing means such as at least one data processor (DP) 24A, storing means such as at least one computer-readable memory

(MEM) 24B storing at least one computer program (PROG) 24C, and communicating means such as a modem 24H for bidirectional wireless communications with the base station 22 via the data/control path 25. While not particularly illustrated for the UE 20 or base station 22, those devices are also assumed to include as part of their wireless communicating means a modem which may be inbuilt on an RF front end chip within those devices 20, 22 and which also carries the TX 20D/22D and the RX 20E/22E.

[0050] At least one of the PROGs 20C/20G in the UE 20 is assumed to include program instructions that, when executed by the associated DP 20A, enable the device to operate in accordance with the exemplary embodiments of this invention, as detailed above. The base station 22 may also have software stored in its MEM 22B to implement certain aspects of these teachings as detailed above, s as to know or better anticipate how the UE 20 will utilize its measurement occasions. In this regard the exemplary embodiments of this invention may be implemented at least in part by computer software stored on the MEM 20B, 22B which is executable by the DP 20A of the UE 20 and/or by the DP 22A of the base station 22, or by hardware, or by a combination of tangibly stored software and hardware (and tangibly stored firmware). Electronic devices implementing these aspects of the invention need not be the entire UE 20 or base station 22, but exemplary embodiments may be implemented by one or more components of same such as the above described tangibly stored software, hardware, firmware and DP, modem, system on a chip SOC or an application specific integrated circuit ASIC.

[0051] In general, the various embodiments of the UE 20 can include, but are not limited to personal portable digital devices having wireless communication capabilities, including but not limited to cellular telephones, navigation devices, laptop/palmtop/tablet computers, digital cameras and music devices, and Internet appliances.

[0052] Various embodiments of the computer readable MEMs 20B and 22B include any data storage technology type which is suitable to the local technical environment, including but not limited to semiconductor based memory devices, magnetic 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 DPs 20A and 22A include but are not limited to general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and multi-core processors.

[0053] Various modifications and adaptations to the foregoing exemplary embodiments of this invention may become apparent to those skilled in the relevant arts in view of the foregoing description. While the exemplary embodiments have been described above in the context of the UTRAN Release 99 system, it should be appreciated that the exemplary embodiments of this invention are not limited for use with only this one particular type of wireless communication system, and that they may be used to advantage in other wireless communication systems.

[0054] 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.

CLAIMS:

What is claimed is:

1. An apparatus, comprising:

at least one processor; and

at least one memory storing a computer program;

in which the at least one memory with the computer program is configured with the at least one processor to cause the apparatus to at least:

determine signal strength of a serving cell; and

choose, based on the determined signal strength, whether to utilize a cell forward access channel measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search,

in which the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

2. The apparatus according to claim 1, in which the measurement occasion is utilized for the lower priority neighbor cell search if the determined signal strength is below a threshold.

3. The apparatus according to claim 2, in which the higher priority neighbor cell search comprises a search in a frequency layer higher in priority than a serving layer of the serving cell, and the lower priority neighbor cell search comprises a search in a frequency layer having a priority that is lower than or equal to priority of the serving layer of the serving cell.

4. The apparatus according to claim 2, in which the serving cell operates according to a first radio access technology RAT, the higher priority neighbor cell search comprises a search in a third RAT, and the lower priority neighbor cell search comprises a search in a second RAT.

5. The apparatus according to claim 4, in which the first RAT is WCDMA, the second RAT is GERAN, the third RAT is E-UTRAN, the threshold is a first threshold

and the measurement occasion is utilized for the E-UTRAN neighbor cell search if the determined signal strength is above a second threshold higher than the first threshold.

6. The apparatus according to claim 5, in which the measurement occasion is utilized only for the E-UTRAN neighbor cell search if the determined signal strength is above the second threshold regardless of whether GERAN or inter-frequency neighbour cells have been configured.

7. The apparatus according to any one of claims 1 through 6, in which the apparatus comprises a user equipment operating in a forward access channel state of a WCDMA system.

8. The apparatus according to any one of claims 1 through 6, in which the apparatus comprises a modem.

9. A method, comprising:

determining signal strength of a serving cell; and

choosing, based on the determined signal strength, whether to utilize a cell forward access channel measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search,

in which the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

10. The method according to claim 9, in which the measurement occasion is utilized for the lower priority neighbor cell search if the determined signal strength is below a threshold.

11. The method according to claim 10, in which the higher priority neighbor cell search comprises a search in a frequency layer higher in priority than a serving layer of the serving cell, and the lower priority neighbor cell search comprises a search in a frequency layer having a priority that is lower than or equal to priority of the serving layer of the serving cell.

12. The method according to claim 10, in which the serving cell operates according to a first radio access technology RAT, the higher priority neighbor cell search comprises a search in a third RAT, and the lower priority neighbor cell search comprises a search in a second RAT.

13. The method according to claim 10, in which the first RAT is WCDMA, the second RAT is GERAN, the third RAT is E-UTRAN, the threshold is a first threshold and the measurement occasion is utilized for the E-UTRAN neighbor cell search if the determined signal strength is above a second threshold higher than the first threshold.

14. The method according to claim 13, in which the measurement occasion is utilized only for the E-UTRAN neighbor cell search if the determined signal strength is above the second threshold regardless of whether GERAN or inter-frequency neighbour cells have been configured.

15. The method according to any one of claims 9 through 14, in which the method is executed by a user equipment operating in a forward access channel state of a WCDMA system.

16. A computer readable memory storing a computer program comprising:

code for determining signal strength of a serving cell; and

code for choosing, based on the determined signal strength, whether to utilize a cell forward access channel measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search,

in which the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

17. The computer readable memory according to claim 16, in which:

the measurement occasion is utilized for the lower priority neighbor cell search if the determined signal strength is below a threshold;

the higher priority neighbor cell search comprises a search in a frequency layer

higher in priority than a serving layer of the serving cell; and

the lower priority neighbor cell search comprises a search in a frequency layer having a priority that is lower than or equal to priority of the serving layer of the serving cell.

18. The computer readable memory according to claim 16, in which:

the measurement occasion is utilized for the lower priority neighbor cell search if the determined signal strength is below a threshold;

the serving cell operates according to a first radio access technology RAT;

the higher priority neighbor cell search comprises a search in a third RAT; and

the lower priority neighbor cell search comprises a search in a second RAT.

19. The computer readable memory according to claim 18, in which the first RAT is WCDMA, the second RAT is GERAN, the third RAT is E-UTRAN, the threshold is a first threshold and the code for choosing utilizes the measurement occasion for the E-UTRAN neighbor cell search if the determined signal strength is above a second threshold higher than the first threshold.

20. The computer readable memory according to claim 19, in which the code for choosing utilizes the measurement occasion only for the E-UTRAN neighbor cell search regardless of whether GERAN or inter-frequency neighbour cells have been configured.

21. An apparatus, comprising:

determining means for determining signal strength of a serving cell; and

choosing means for choosing, based on the determined signal strength, whether to utilize a cell forward access channel measurement occasion for a lower priority neighbor cell search or for a higher priority neighbor cell search,

in which the lower priority neighbor cell search is for maintaining wireless connectivity and the higher priority neighbor cell search is for accessing enhanced wireless service as compared to the serving cell.

22. The apparatus according to claim 21, in which:

the determining means comprises a radio receiver and at least one processor; and

the choosing means comprises the at least one processor and a computer readable memory storing computer instructions.

T_meas (ms)	N_TTI=1 FRAME $T_{identify,\ GSM}$ (ms)	N_TTI=2 FRAMES $T_{identify,\ GSM}$ (ms)	N_TTI=4 FRAMES $T_{identify,\ GSM}$ (ms)	N_TTI=8 FRAMES $T_{identify,\ GSM}$ (ms)
80	2880	1280		–
160	7680	2880	1280	640
240	29760	5280		–
320	14080	6400	2560	1280
480	34560	12480	2880	1920
640	34560	12800	5120	2560
960	*	24960	5760	3840
1280	*	20480	10240	5120
1920	*	34560	15360	7680
NOTE * : THERE ARE NO PERFORMANCE REQUIREMENTS FOR THESE COMBINATIONS OF PARAMETERS BECAUSE THEY RESULT IN LONG IDENTIFICATION TIME				

FIG.1A

T_meas (ms)	N_TTI=1 FRAME $T_{re-confirm,\ GSM}$ (ms)	N_TTI=2 FRAMES $T_{re-confirm,\ GSM}$ (ms)	N_TTI=4 FRAMES $T_{re-confirm,\ GSM}$ (ms)	N_TTI=8 FRAMES $T_{re-confirm,\ GSM}$ (ms)
80	2880	1600	–	
160	6400	3200	2240	1600
240	17280	4800	–	–
320	14080	6400	4480	3200
480	22080	9600	6720	4800
640	26880	12800	10240	6400
960	*	17280	13440	9600
1280	*	33280	17920	12800
1920	*	*	26880	19200
NOTE * : THERE ARE NO PERFORMANCE REQUIREMENTS FOR THESE COMBINATIONS OF PARAMETERS BECAUSE THEY RESULT IN LONG RECONFIRMATION TIME				

FIG.1B

T_meas (ms)	N_TTI=1 FRAME $T_{identify,\ GSM}$ (ms)	N_TTI=2 FRAMES $T_{identify,\ GSM}$ (ms)	N_TTI=4 FRAMES $T_{identify,\ GSM}$ (ms)	N_TTI=8 FRAMES $T_{identify,\ GSM}$ (ms)
80	2880	1280		–
160	7680	2880	1280	640
240	29760	5280		–
320	14080	6400	2560	1280
480	34560	12480	2880	1920
640	34560	12800	5120	2560
960	*	24960	5760	3840
1280	*	20480	10240	5120
1920	*	34560	15360	7680
NOTE * : THERE ARE NO PERFORMANCE REQUIREMENTS FOR THESE COMBINATIONS OF PARAMETERS BECAUSE THEY RESULT IN LONG IDENTIFICATION TIME				

FIG.2A

T_meas (ms)	N_TTI=1 FRAME $T_{re-confirm,\ GSM}$ (ms)	N_TTI=2 FRAMES $T_{re-confirm,\ GSM}$ (ms)	N_TTI=4 FRAMES $T_{re-confirm,\ GSM}$ (ms)	N_TTI=8 FRAMES $T_{re-confirm,\ GSM}$ (ms)
80	2880	1600	–	–
160	6400	3200	2240	1600
240	17280	4800	–	–
320	14080	6400	4480	3200
480	22080	9600	6720	4800
640	26880	12800	10240	6400
960	*	17280	13440	9600
1280	*	33280	17920	12800
1920	*	*	26880	19200
NOTE * : THERE ARE NO PERFORMANCE REQUIREMENTS FOR THESE COMBINATIONS OF PARAMETERS BECAUSE THEY RESULT IN LONG RECONFIRMATION TIME				

FIG.2B

5.2.6.1.2a MEASUREMENT RULES FOR INTER-FREQUENCY AND INTER-RAT CELL RESELECTION WHEN ABSOLUTE PRIORITIES ARE USED

THE MEASUREMENT RULES BELOW APPLY IN IDLE, URA_PCH, CELL_PCH STATES. IN CELL_FACH STATE THE UE IS REQUIRED TO PERFORM MEASUREMENTS OF INTER-FREQUENCY AND INTER-RAT CELLS LISTED IN SYSTEM INFORMATION ACCORDING TO REQUIREMENTS SPECIFIED IN [10]. UE SPECIFIC PRIORITIES ARE NOT APPLIED IN CAMPED ON ANY CELL STATE.

IF THE UE HAS RECEIVED ABSOLUTE PRIORITY INFORMATION FOR INTER-FREQUENCY LAYERS, THE UE SHALL FOLLOW THESE RULES:

- THE UE SHALL PERFORM MEASUREMENTS OF INTER-FREQUENCY LAYERS WITH A PRIORITY HIGHER THAN THE PRIORITY OF THE CURRENT SERVING LAYER.

NOTE: THE RATE OF THESE MEASUREMENTS MAY VARY DEPENDING ON WHETHER Srxlev AND Squal OF THE SERVING CELL ARE ABOVE OR BELOW $S_{prioritysearch1}$ AND $S_{prioritysearch2}$. THIS IS SPECIFIED IN [10].

- WHEN THE UE IN CAMPED NORMALLY STATE, HAS ONLY DEDICATED PRIORITIES OTHER THAN FOR THE CURRENT FREQUENCY, THE UE SHALL CONSIDER THE CURRENT FREQUENCY TO BE THE LOWEST PRIORITY FREQUENCY (i.e. LOWER THAN THE EIGHT NETWORK CONFIGURED VALUES).
- FOR INTER-FREQUENCY LAYERS WITH A PRIORITY EQUAL OR LOWER THAN THE PRIORITY OF THE CURRENT SERVING LAYER:
  - IF $Srxlev_{ServingCell} > S_{prioritysearch1}$ AND $Squal_{ServingCell} > S_{prioritysearch2}$ THE UE MAY CHOOSE NOT TO PERFORM MEASUREMENTS OF INTER-FREQUENCY LAYERS OF EQUAL OR LOWER PRIORITY.
  - IF $Srxlev_{ServingCell} <= S_{prioritysearch1}$ OR $Squal_{ServingCell} <= S_{prioritysearch2}$ THE UE SHALL PERFORM MEASUREMENTS OF INTER-FREQUENCY LAYERS OF EQUAL OR LOWER PRIORITY.
- THE UE SHALL NOT PERFORM MEASUREMENTS OF INTER-FREQUENCY LAYERS FOR WHICH THE UE HAS NO ABSOLUTE PRIORITY.

IF THE UE HAS RECEIVED ABSOLUTE PRIORITY INFORMATION FOR INTER-RAT LAYERS, THE UE SHALL FOLLOW THESE RULES:

- THE UE SHALL PERFORM MEASUREMENTS OF INTER-RAT LAYERS WITH A PRIORITY HIGHER THAN THE PRIORITY OF THE CURRENT SERVING CELL.

NOTE: THE RATE OF THESE MEASUREMENTS MAY VARY DEPENDING ON WHETHER Srxlev AND Squal OF THE SERVING CELL ARE ABOVE OR BELOW $S_{prioritysearch1}$ AND $S_{prioritysearch2}$. THIS IS SPECIFIED IN [10].

- FOR INTER-RAT LAYERS WITH A PRIORITY LOWER THAN THE PRIORITY OF THE CURRENT SERVING CELL:
  - IF $Srxlev_{ServingCell} > S_{prioritysearch1}$ AND $Squal_{ServingCell} > S_{prioritysearch2}$ THE UE MAY CHOOSE NOT TO PERFORM MEASUREMENTS OF INTER-RAT LAYERS LOWER PRIORITY.
  - IF $Srxlev_{ServingCell} <= S_{prioritysearch1}$ OR $Squal_{ServingCell} <= S_{prioritysearch2}$ THE UE SHALL PERFORM MEASUREMENTS OF INTER-RAT LAYERS OF LOWER PRIORITY.
- THE UE SHALL PERFORM MEASUREMENTS ACCORDING TO SUBCLAUSE 5.2.6.1.1 FOR INTER-RAT LAYERS FOR WHICH THE UE HAS NO ABSOLUTE PRIORITY. FOR ALL INTER-RAT LAYERS BELONGING TO ONE RAT, EITHER THE RULES ABOVE OR THE RULES IN SUBCLAUSE 5.2.6.1.1 OR 5.2.6.1.2 SHALL APPLY.

FIG.3

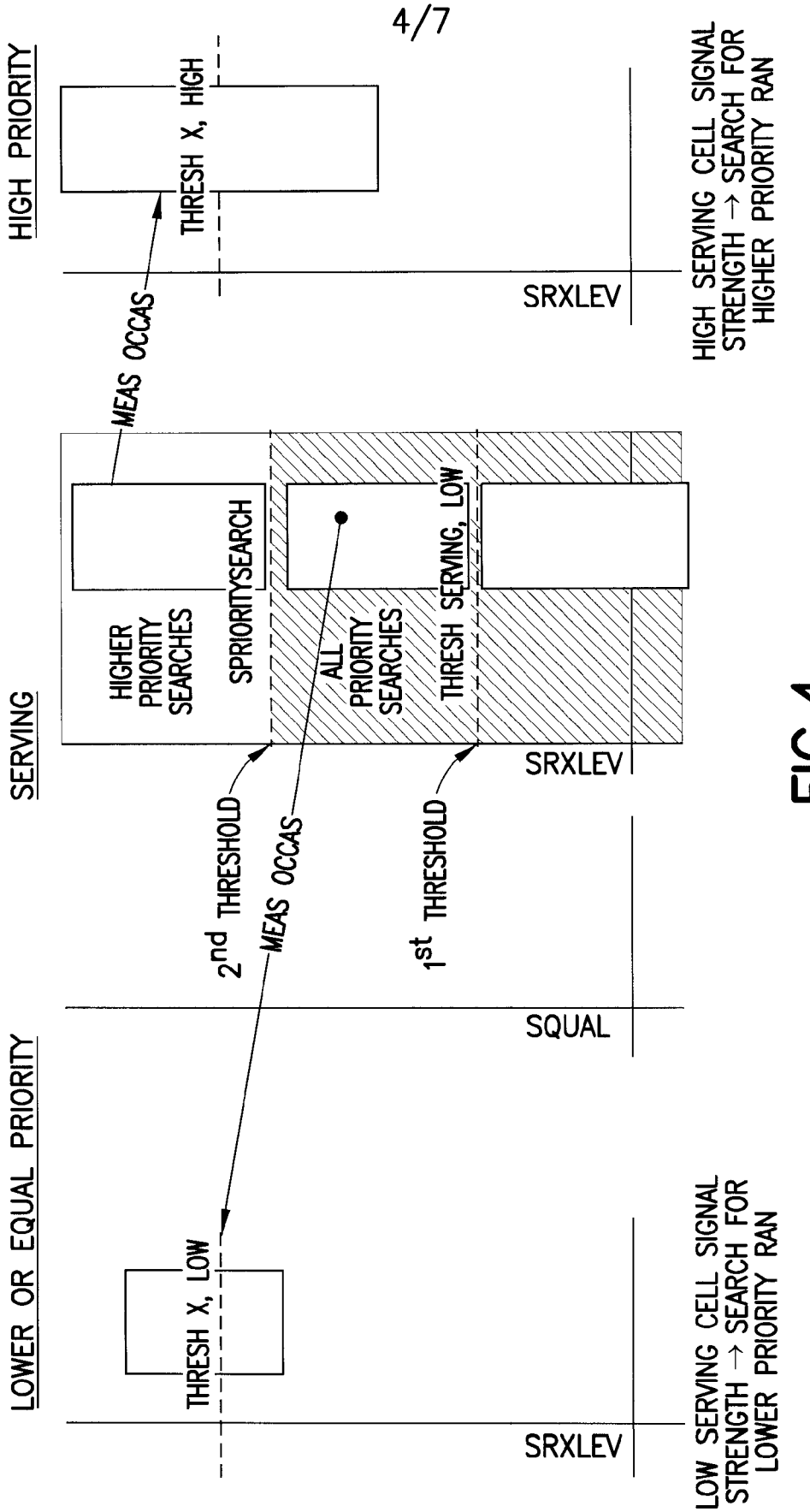
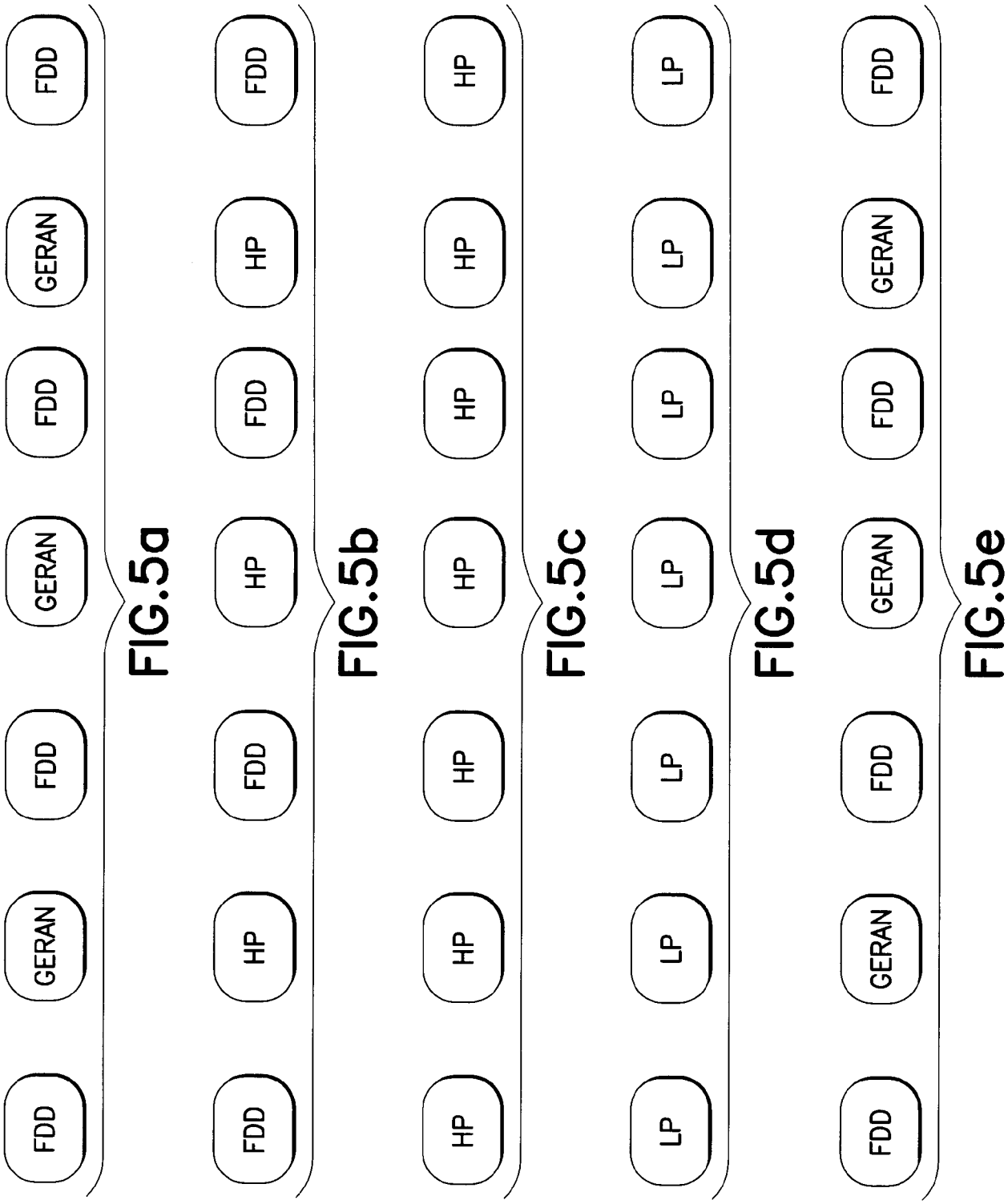

HIGH PRIORITY
THRESH X, HIGH
MEAS OCCAS
SRXLEV
HIGH SERVING CELL SIGNAL STRENGTH → SEARCH FOR HIGHER PRIORITY RAN
SERVING
HIGHER PRIORITY SEARCHES
SPRIORITYSEARCH
ALL PRIORITY SEARCHES
THRESH SERVING, LOW
SRXLEV
2nd THRESHOLD
MEAS OCCAS
1st THRESHOLD
SQUAL
LOWER OR EQUAL PRIORITY
THRESH X, LOW
SRXLEV
LOW SERVING CELL SIGNAL STRENGTH → SEARCH FOR LOWER PRIORITY RAN

FIG.4


FDD
GERAN
FDD
GERAN
FDD
FIG.5a
FDD
HP
FDD
HP
FDD
FIG.5b
HP
HP
HP
HP
HP
FIG.5c
LP
LP
LP
LP
LP
FIG.5d
FDD
GERAN
FDD
GERAN
FDD
FIG.5e

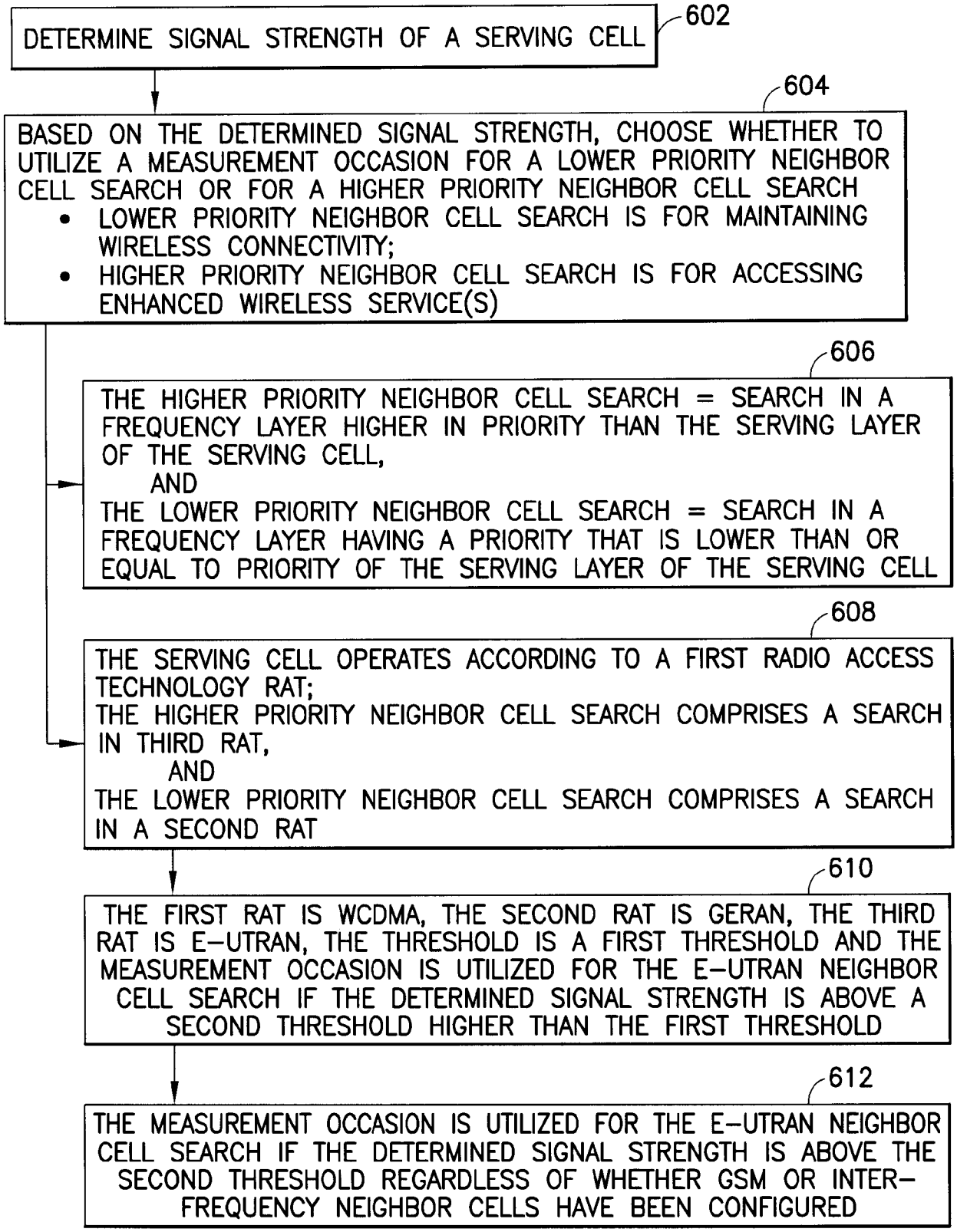

DETERMINE SIGNAL STRENGTH OF A SERVING CELL
602
604
BASED ON THE DETERMINED SIGNAL STRENGTH, CHOOSE WHETHER TO UTILIZE A MEASUREMENT OCCASION FOR A LOWER PRIORITY NEIGHBOR CELL SEARCH OR FOR A HIGHER PRIORITY NEIGHBOR CELL SEARCH
• LOWER PRIORITY NEIGHBOR CELL SEARCH IS FOR MAINTAINING WIRELESS CONNECTIVITY;
• HIGHER PRIORITY NEIGHBOR CELL SEARCH IS FOR ACCESSING ENHANCED WIRELESS SERVICE(S)
606
THE HIGHER PRIORITY NEIGHBOR CELL SEARCH = SEARCH IN A FREQUENCY LAYER HIGHER IN PRIORITY THAN THE SERVING LAYER OF THE SERVING CELL,
AND
THE LOWER PRIORITY NEIGHBOR CELL SEARCH = SEARCH IN A FREQUENCY LAYER HAVING A PRIORITY THAT IS LOWER THAN OR EQUAL TO PRIORITY OF THE SERVING LAYER OF THE SERVING CELL
608
THE SERVING CELL OPERATES ACCORDING TO A FIRST RADIO ACCESS TECHNOLOGY RAT;
THE HIGHER PRIORITY NEIGHBOR CELL SEARCH COMPRISES A SEARCH IN THIRD RAT,
AND
THE LOWER PRIORITY NEIGHBOR CELL SEARCH COMPRISES A SEARCH IN A SECOND RAT
610
THE FIRST RAT IS WCDMA, THE SECOND RAT IS GERAN, THE THIRD RAT IS E-UTRAN, THE THRESHOLD IS A FIRST THRESHOLD AND THE MEASUREMENT OCCASION IS UTILIZED FOR THE E-UTRAN NEIGHBOR CELL SEARCH IF THE DETERMINED SIGNAL STRENGTH IS ABOVE A SECOND THRESHOLD HIGHER THAN THE FIRST THRESHOLD
612
THE MEASUREMENT OCCASION IS UTILIZED FOR THE E-UTRAN NEIGHBOR CELL SEARCH IF THE DETERMINED SIGNAL STRENGTH IS ABOVE THE SECOND THRESHOLD REGARDLESS OF WHETHER GSM OR INTER-FREQUENCY NEIGHBOR CELLS HAVE BEEN CONFIGURED

FIG.6

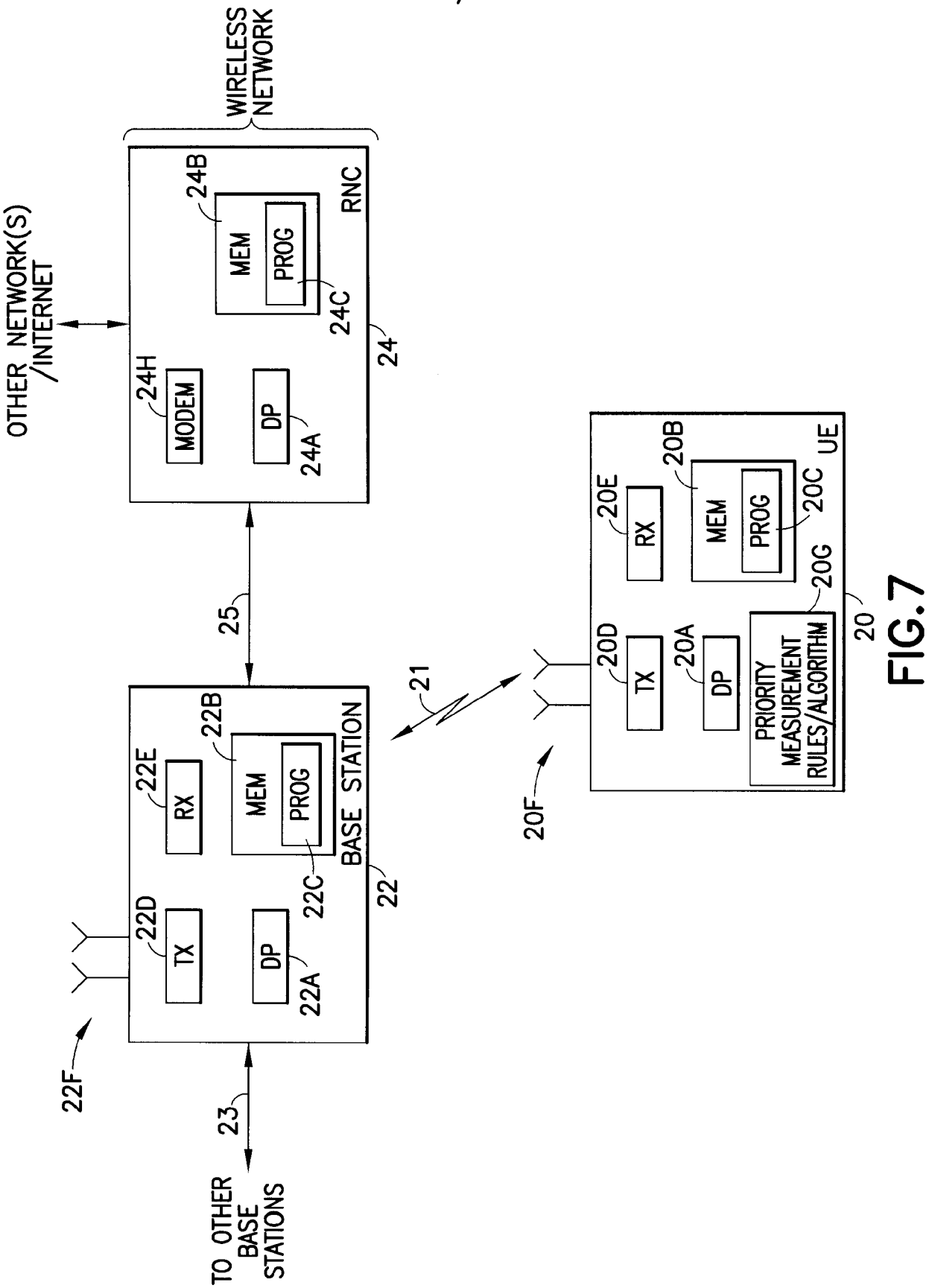

WIRELESS NETWORK
OTHER NETWORK(S) /INTERNET
RNC
24
24B
MEM
PROG
24C
24H
MODEM
DP
24A
25
BASE STATION
22
22B
MEM
PROG
22C
22E
RX
22D
TX
DP
22A
22F
23
TO OTHER BASE STATIONS
21
UE
20
20B
MEM
PROG
20C
20E
RX
20D
TX
20A
DP
PRIORITY MEASUREMENT RULES/ALGORITHM
20G
20F

FIG.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2012/050564

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

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

B. FIELDS SEARCHED

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

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/287127 A1 (WU PING [US] ET AL) 20 November 2008 (2008-11-20) abstract; figure 2 paragraphs [0002], [0003] paragraphs [0011] - [0014]	1,9,16, 21
A	WO 2005/048529 A1 (ERICSSON TELEFON AB L M [SE]; SAGNE JACQUES [FR]; EDLUND PETER [SE]; B) 26 May 2005 (2005-05-26) page 2, lines 20-32 page 10, lines 12-30 page 14, line 19 - page 15, line 3 abstract; claim 1	1,9,16, 21

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

"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
25 May 2012	08/06/2012

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2012/050564

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008287127 A1	20-11-2008	CN 101755470 A	23-06-2010
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		RU 2009146301 A	20-06-2011
		US 2008287127 A1	20-11-2008
		WO 2008144194 A1	27-11-2008
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		EP 1683300 A1	26-07-2006
		JP 4510026 B2	21-07-2010
		JP 2007511166 A	26-04-2007
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		US 2007030830 A1	08-02-2007
		WO 2005048529 A1	26-05-2005