Utilizing Supported Band Grouping and Display of Partial Search Results to Expedite Manual PLMN Selection Procedure

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Abstract:

This publication describes techniques and apparatuses that expedite the procedure for manual ("on-demand") Public Land Mobile Network (PLMN) selection by a user using a user equipment (UE). To create a PLMN search priority when performing a manual PLMN selection procedure, the process is divided into a system information database (SI DB), a mobile country code database (MCC DB), and a Remainder database (Remainder DB). The SI DB includes a predefined number (*e.g.*, ten) of the last absolute radio-frequency channel numbers (ARFCN) acquired on each radio access technology (RAT). The MCC DB is a band of frequencies identifying the PLMN location by country (*e.g.*, the United States of America, Australia, Germany). The Remainder DB groups a band of frequencies that are not in the MCC DB. When the user initiates the manual PLMN selection procedure, the UE searches for available PLMNs according to a grouping priority, in three phases: an SI DB, an MCC DB, and a Remainder DB search phase. The user receives periodic updates on the available PLMN list, and the user, at any time, can select the target PLMN without needing to wait for the UE to complete the whole search process.

Keywords:

Hardware supported band, supported band, frequency band grouping, Public Land Mobile Network, manual PLMN selection, on-demand PLMN selection, system information database, SI

DB, mobile country code, MCC database, Remainder database, available PLMN list, partial PLMN list.

Background:

The 3rd Generation Partnership Project (3GPP) specification (*e.g.*, 3GPP TS 23.22, Section 4.4.3.1.2) defines a procedure for manual ("on-demand") Public Land Mobile Network (PLMN) selection by a user. The procedure begins when the user provides an input to the user interface (UI) of the user equipment (UE) requesting manual PLMN selection.

Responsive to the request, the UE scans for available PLMNs. Under the current 3GPP specification, the UE considers all supported radio access technologies (RATs), such as GSM, Wide Band Code Division Multiple Access (WCDMA), Time Division-Synchronous Code Division Multiple Access (TDSCDMA), Long Term Evolution (LTE), 5G) in all hardware supported frequency bands (supported bands) when performing PLMN selection. The scan process can frequently take 60 to 120 seconds to complete.

As the UE determines information relating to available PLMNs, the UE caches available PLMN information. Once the UE considers all RATs in all supported bands, the scan is considered complete. Upon the completion of the scan, the UE updates the UI to present a sorted list (sorted with priority based on the 3GPP specification) of all available PLMNs (available PLMN list).

The user may indicate a target PLMN from the available PLMN list presented in the UI. Responsive to receiving an indication of the target PLMN, the UE selects a suitable cell of the target PLMN, camps on the cell, initiates a Location Update Procedure, and sends a Location Registration (LR) request to register on the target PLMN. If the result of cell selection and location registration is successful, the successful result is indicated to the user on the UI.

Due to the considerable time it takes for the user to manually perform a PLMN selection procedure, it is desirable to provide techniques and apparatuses that improve and expedite the manual PLMN selection procedure.

Description:

This publication describes techniques and apparatuses that use supported band grouping and a periodic display of partial search results that are selectable by the user to expedite a manual PLMN selection procedure. As used herein, the terms "supported bands," "supported frequency bands," and "hardware supported bands," refer to the frequency bands that are supported by the UE.

The 3GPP specification (at 3GPP TS 136.101 V15.3.0 (2018-10)) provides a set of supported frequency bands for communication, each designated by a frequency and a band number (representing a range of frequencies with a specific smallest and largest frequency), and directs (at 3GPP TS 23.22, Section 6.1) the UE to "consider all supported access technologies in all supported bands when performing PLMN selection." For example, in North America, the 2G, 3G, 4G LTE, and 5G frequencies, include: 600, 700, 750, 800, 850, 1900, 2100 (AWS), 2300 (WCS), 2500, and 2600 MHz, whereas the bands are: 2, 4, 5, 7, 12, 13, 17, 25, 26, 29, 30, 41, 66, and 71.

To create a PLMN search priority when performing a manual PLMN selection procedure, it is advantageous to divide all supported bands into a mobile country code database (MCC DB), and a Remainder database (Remainder DB), as is illustrated in Figure 1.

All Supported Frequencies and Bands of Frequencies

Frequency in SI DB ⎯ ⎯ ⎯ Frequency in SI DB

MCC DB   **Remainder DB**

Band of Frequencies in
MCC DB

Band of Frequencies in
Remaninder DB
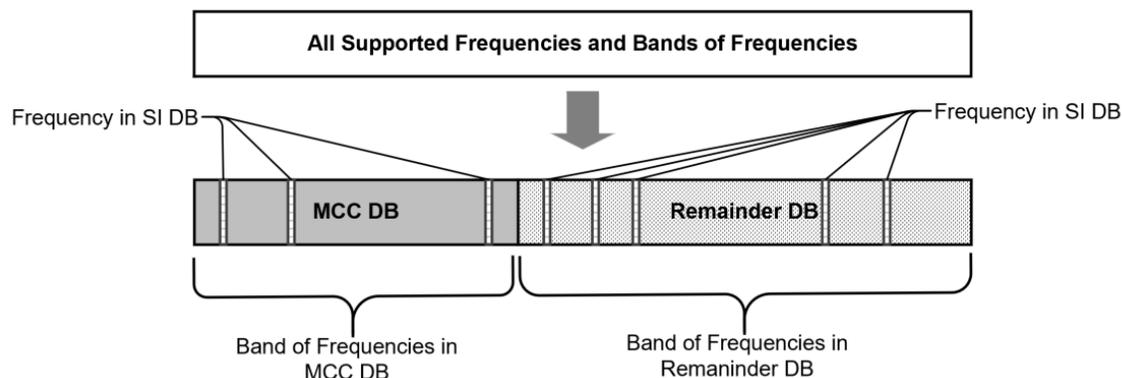
Figure 1

Figure 1 illustrates that all supported frequencies and bands of frequencies by the UE fall into one or more of the following categories: the SI DB, the MCC DB, and the Remainder DB. The SI DB includes a predefined number (*e.g.*, ten) of the last absolute radio-frequency channel numbers (ARFCNs) acquired on each RAT (*e.g.*, GSM, WCDMA, TDSCDMA, LTE, 5G). The last ARFCNs are stored in a first-in, first-out (FIFO) buffer in non-volatile memory in the UE. The stored ARFCNs in the SI DB may be a good starting point for the manual PLMN selection procedure.

Consider, a UE operates under a mobile plan from *Carrier "A,"* and the user and the UE are traveling in the United States of America (USA) from Reno, Nevada (NV) to Las Vegas, NV. The user may have already performed a manual PLMN selection procedure in Reno. As the user drives from Reno to Las Vegas, they may drive through areas of the USA with no PLMN coverage. As the user arrives at a small town between Reno and Las Vegas, they may perform a manual PLMN selection procedure. Chances are that the frequency (ARFCN) that the user is looking to connect while in the small town was already stored in the SI DB in response to the manual PLMN selection procedure that occurred back in Reno. Thus, the SI DB may speed up the manual PLMN selection procedure. Still, the manual PLMN selection procedure can be sped up in other ways.

Frequently, the SI DB contains the surrounding network signal after a first system selection at a "Power On" stage of the UE. As is illustrated in Figure 1, some of the supported bands by the UE are in the MCC DB, which is a band of frequencies identifying the PLMN location by country (*e.g.*, the USA, Australia, Germany). Figure 2 illustrates the MCC DB for the USA.


MCC DB for the USA:

310, 311, 312, 313, 314, 315, and 316.

Carrier "A" LTE bands:

2, 4, 5, 13, 46, 48, and 66.

Carrier "B" LTE bands:

25, 26, and 41.

Carrier "C" LTE bands:

2, 4, 5, 12, 14, 29, 30, 46, and 66.

Carrier "D" LTE bands:

2, 4, 5, 12, 46, 48, 66, and 71.
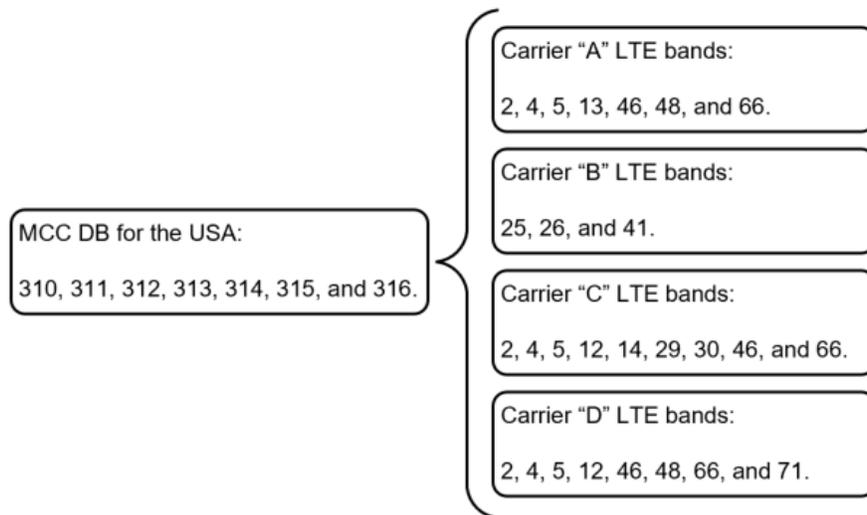
Figure 2

Figure 2, shown above, illustrates the MCC DB for the USA, which includes the mobile country codes (MCCs) 310, 311, 312, 313, 314, 315, and 316. Note that the MCCs differ depending on the country or territory that the UE operates. For example, the MCC for Germany is 262, the MCCs for the United Kingdom are 234 and 235, the MCC for Australia is 505, and so forth. As is illustrated in Figure 2, the MCC DB for the USA is a grouping that represents PLMN bands from multiple carriers, such as *Carrier "A"* LTE bands 2, 4, 5, 13, 46, 48, and 66, *Carrier "B"* LTE bands 25, 26, and 41, *Carrier "C"* LTE bands 2, 4, 5, 12, 14, 29, 30, 46, and 66, *Carrier "D"* LTE bands 2, 4, 5, 12, 46, 48, 66, and 71, and so forth.

Finally, also illustrated in Figure 1, some of the bands supported by the UE that are not included in the MCC DB, are in the Remainder DB. Therefore, all bands supported by the UE are stored in at least one of these databases: the SI DB, the MCC DB, or the Remainder DB.

Figure 3, shown below, illustrates the manual PLMN selection procedure, which searches the SI DB, the MCC DB, and the Remainder DB.
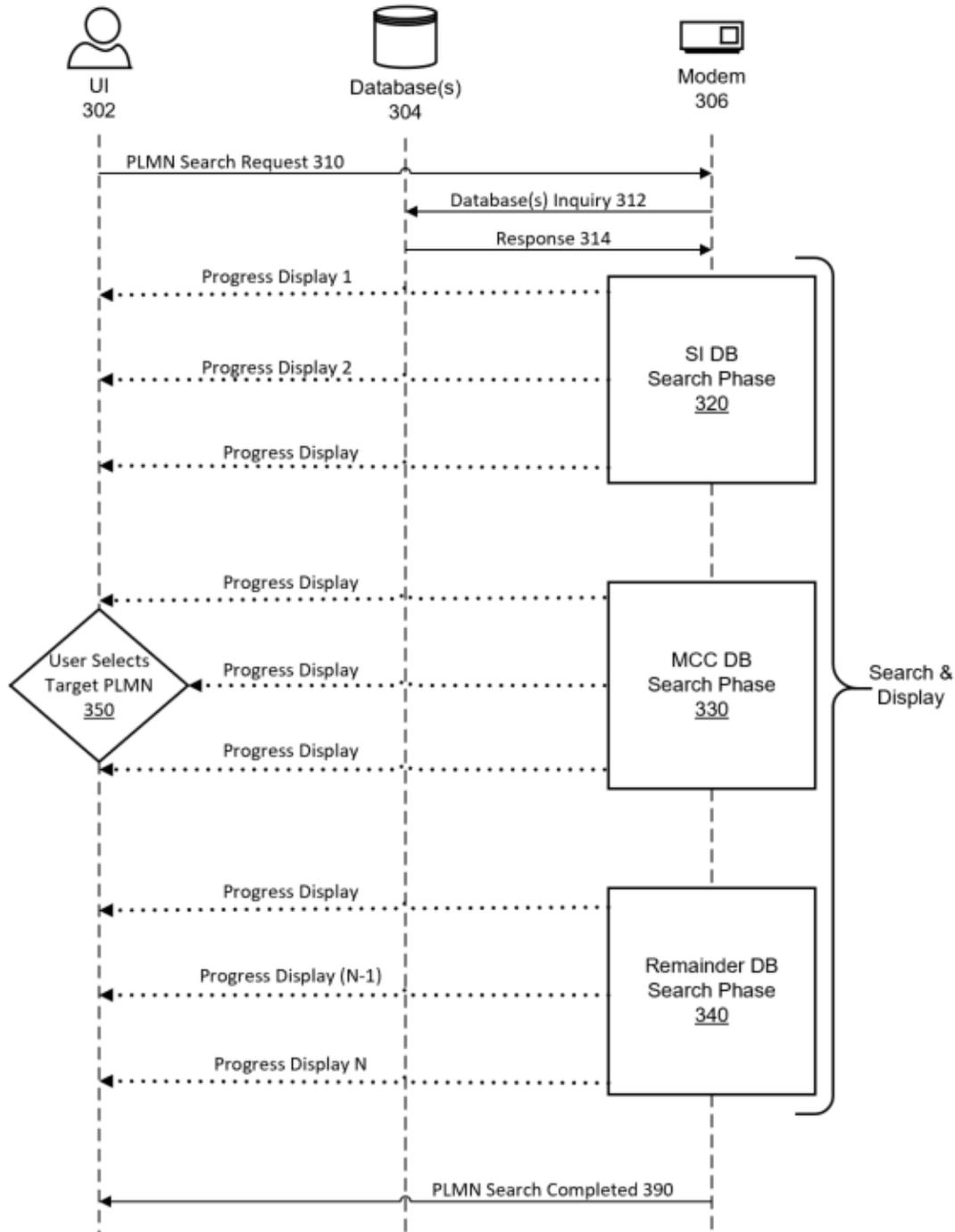

Figure 3

As is illustrated in Figure 3, the user provides an input to the UI 302 (UI) to manually start a PLMN search request 310 (search request) that is received by a modem 306 (modem) of the UE. The search request initiates the manual PLMN selection procedure, which proceeds to search for available PLMNs in three phases: an SI DB search phase 320 (SI search phase), an MCC DB search phase 330 (MCC search phase), and a Remainder DB search phase 340 (Remainder search phase). During all search phases, the modem continually sends a database(s) inquiry 312 (database inquiry) to the database(s) 304 (SI DB, MCC DB, or Remainder DB) and receives a response 314 (response) from the database(s) 304.

The first search phase is the SI search phase. The modem sends a database inquiry to the SI DB and receives a response on whether the SI DB is empty or non-empty. If the SI DB is non-empty, the search process can find few PLMNs within a short time (*e.g.*, in ten seconds or less). The user receives the available PLMN list on the UI of the UE periodically, by viewing on the UI a progress display 1, a progress display 2,…, a progress display (N-1), a progress display N. The time duration between each progress display (1, 2,…, (N-1), N) can be set by the UE manufacturer as a default value (*e.g.*, three seconds) or can be set by the user utilizing a user setting. Assume the user receives progress displays every three seconds; if the SI DB is empty, the first three periodic progress displays (progress display 1, progress display 2, and progress display 3) do not contain any PLMNs in the available PLMN list. In that case, the SI search phase ends, and the UE starts the second search phase, the MCC search phase.

During the MCC search phase, the modem sends the database inquiry to the MCC DB. The UE can obtain PLMN location information using global navigation satellite system (GNSS) (*e.g.*, GPS) technology, WiFi™, Bluetooth™, other communication protocols, or from user input (*e.g.*, current country location is the USA). During the MCC search phase, the search process

extracts an MCC band list from the MCC DB and applies the MCC band list to a lower layer. During the MCC search phase, if the user is located in an area with some service coverage, mostly all existing PLMNs surrounding the UE can be found and can be displayed to the user in the available PLMN list. As in the SI search phase, the user receives periodic updates on the available PLMN list, and the user, at any time, can select the target PLMN without needing to wait for the UE to complete the whole search process.

Normally, when the user performs a manual PLMN selection procedure, they can find the frequency they are looking for either in the SI DB or the MCC DB. In rare cases, such as in a case when *Carrier "A"* deploys a new frequency band, the newly-deployed frequency band may not be in either the SI DB or the MCC DB. During the third phase, the Remainder search phase, the user may still search for, find, and select the newly-deployed frequency band. The newly-deployed frequency band can be found in the Remainder DB when the user performs the manual PLMN selection procedure. As in the SI and MCC search phases, during the Remainder search phase, the user receives periodic updates on the available PLMN list. The user, at any time, can select the target PLMN without needing to wait for the UE to complete the whole search process.

In conclusion, the described techniques and apparatuses expedite the manual PLMN selection procedure by dividing all supported frequencies and bands of frequencies into groupings, searching each grouping by priority, periodically updating and displaying an available PLMN list, and enabling the user to end the search process at the time they find their target PLMN.

References:

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