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Device History Recall Optimization with Virtual, Locally-Stored Acquisition Databases Using Previously Encountered Communication Access Points and Services

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ABSTRACT

A mobile communication device of an end user (user equipment or "UE") can use more than one radio access technology ("RAT") such as GSM, WCDMA, TDS-CDMA, LTE, and NR. Searching for information needed by the UE to use a specific RAT can consume large amounts of power and time. Locally stored acquisition databases ("PLMN Info DBs") of previously encountered communication access points and services can speed up searches, but can be limited by the storage capacity of the UE. Also a locally stored PLMN Info DB may be invalided when a UE moves to a location that is distant from locations where access points and services were previously encountered; *e.g.,* when the UE is moved to a new region, state, or country.

A Virtual PLMN Info DB stored on a remote server (e.g., "in the cloud") can contain a more complete set of acquisition information. A full or abbreviated copy of the Virtual PLMN Info DB can be loaded onto UE from a server or from a peer UE device. Access information contained in the Virtual PLMN Info DB can be obtained by crowdsourcing data acquisition or by peer-to-peer communication. The Virtual PLMN Info DB can be implemented as a database or as a logic entity with specific functions to enable the acquisition of corresponding data elements on demand.

INTRODUCTION

A mobile UE can include components to enable a device to use more than one RAT. Commonly supported and implemented RATs include GSM, WCDMA, TDS-CDMA, LTE, and

NR. A device may also support multiple radio frequency ("RF") bands for each supported RAT. As a consequence, when a mobile communication device begins a process to select a public land mobile network ("PLMN") to join, the device may be required to search a large number of RF bands. Such a search can consume power, cause significant delay in acquisition of a wireless communication service, and thereby degrade the usage experience of the end-user of the mobile communication device.

One common method used to reduce the resources needed to perform the process of selecting a PLMN is to reference a PLMN Info DB that includes historical data referring to previously acquired communication services of a PLMN. This historical data in the PLMN Info DB can include carrier frequencies, cellular communication node identifiers, and other information on cellular node parameters from previously received measurement control elements or previously detected cellular communication nodes.

The ability to use of historical data in this manner can be limited by the amount of storage space available for the PLMN Info DB. Additionally, the historical information stored in the PLMN Info DB may not apply to all RF environments. The problem of non-applicability of information can be especially acute when the mobile communication device moves to a new location, region, or country. In this case, the PLMN Info DB stored in the mobile communication device can contain information that is different from the information that describes available services of a PLMN in the new location, region, or country.

Virtual PLMN Info DB

The limitations described above of a PLMN Info DB that is stored locally on UE can be avoided through the use of a Virtual PLMN Info DB. The Virtual PLMN Info DB can be used in place of, or in addition to, a locally stored PLMN Info DB. Information stored in the Virtual

PLMN Info DB can be the same as that stored in a local PLMN Info DB. Alternatively, the Virtual PLMN Info DB can include more information, including non-cellular-related information of the UE, than a locally stored copy of the PLMN Info DB to make the Virtual PLMN Info DB a more comprehensive source of information for the UE.

Virtual PLMN Info DB as a Database

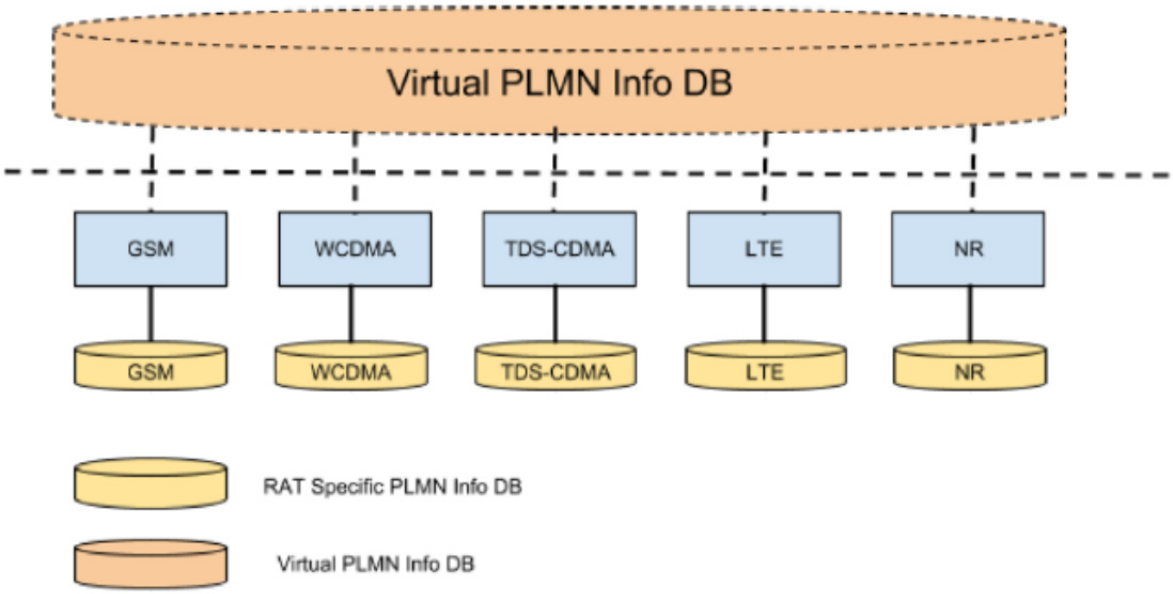

Figure. 1 - Virtual PLMN Info DB as a Database

Figure 1 depicts the Virtual PLMN Info DB implemented as a database. At the virtual layer, the Virtual PLMN Info DB can provide database-like behavior and functionality to obtain information about RATs stored in RAT-specific PLMN Info DBs. The RATs included can be, for example, specifically selected RATs or all RATs useable by the device. Information stored in the Virtual PLMN Info DB can include, but is not limited to, data values for system information, location information, and/or one or more: PLMNs, RATs, frequency bands; frequency band classes; carrier frequencies including absolute radio frequency channel numbers ("ARFCNs"); universal terrestrial radio access networks ("UTRANs") absolute radio frequency

channel numbers (“UARFCNs”); evolved UTRAN (“E-UTRANs”), E-UTRAN ARFCNs (“EARFCNs”); new radio-ARFCNs (“NR-ARFCNs”); tracking area codes (“TACs”); location area codes (“LACs”); routing area codes (“RACs”); cell identifiers, physical cell identifiers (“PCIs”); and/or associated WiFi media access control (“MAC”) addresses.

The Virtual PLMN Info DB can be stored on a remote networked server or “in the cloud,” and/or a copy can be stored on the UE can be a full copy of the complete Virtual PLMN Info DB or an abbreviated version that contains a subset of the information contained in the full copy. The abbreviated version of the Virtual PLMN Info DB can be based on service or on specific procedures. An instance of a full copy or an abbreviated version of the Virtual PLMN Info DB can be preconfigured and dynamically downloaded to the UE from a cloud-based server. Specifically, the UE can accept a copy of the instance of the full copy or of the abbreviated version of the Virtual PLMN Info DB pushed to it by the server. The UE can also pull a copy of the instance to itself from the server.

Peer devices in proximity to the UE can also be used to deliver the PLMN Info DB to the UE. A peer-to-peer cellular connection can be used to transmit a copy of the PLMN Info DB to the UE. Other communication channels, including a WiFi (e.g., IEEE 802.11) connection, a Bluetooth (e.g., IEEE 802.16) connection, a sidelink of an LTE-Direct connection, or another peer-to-peer communication method can be used.

Virtual PLMN Info DB Functionality

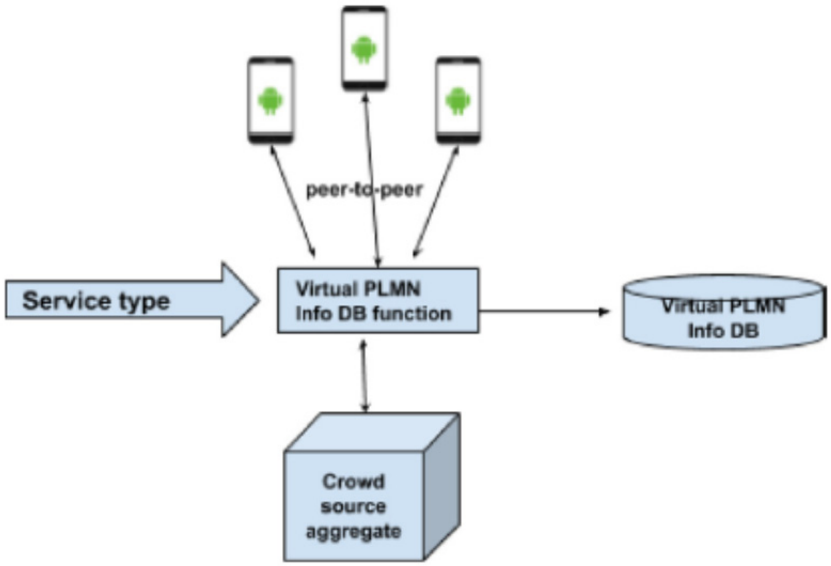

Figure 2 - Virtual PLMN Info DB as a Function

Figure 2 indicates that the Virtual PLMN Info DB can be implemented as an abstraction of the available information or as a logic entity with specific functions to enable the acquisition of corresponding data elements on demand. The Virtual PLMN Info DB function can also involve peer-to-peer communication to acquire part or all of the information to be contained in the PLMN Info DB from peers. Figure 2 indicates that information in the Virtual PLMN Info DB can be obtained through crowd-sourced data collection and/or via peer-to-peer connections. If crowd-sourced, cellular data from one or more carriers and/or one or more locations can be collected and aggregated on a network server.

The Virtual PLMN Info DB can be created based on different service types. As examples, a Mobile Country Code (MCC) Virtual PLMN Info DB can be based on one or more MCC service types, a PLMN Virtual PLMN Info DB can be based on one or more PLMN service types, a cellular service Virtual PLMN Info DB can be based on one or more cellular-service service types, a WiFi Hotspot Virtual PLMN Info DB can be based on one or more WiFi

service types and/or on WiFi hotspot. A Location Virtual PLMN Info DB can be based on service types associated with one or more locations (*e.g.,* latitude/longitude pairs). In some examples, the Location service type can be tied to a Virtual PLMN Info DB that contains all cellular information associated with a geolocation.

Cell Selection Using a Virtual PLMN Info DB

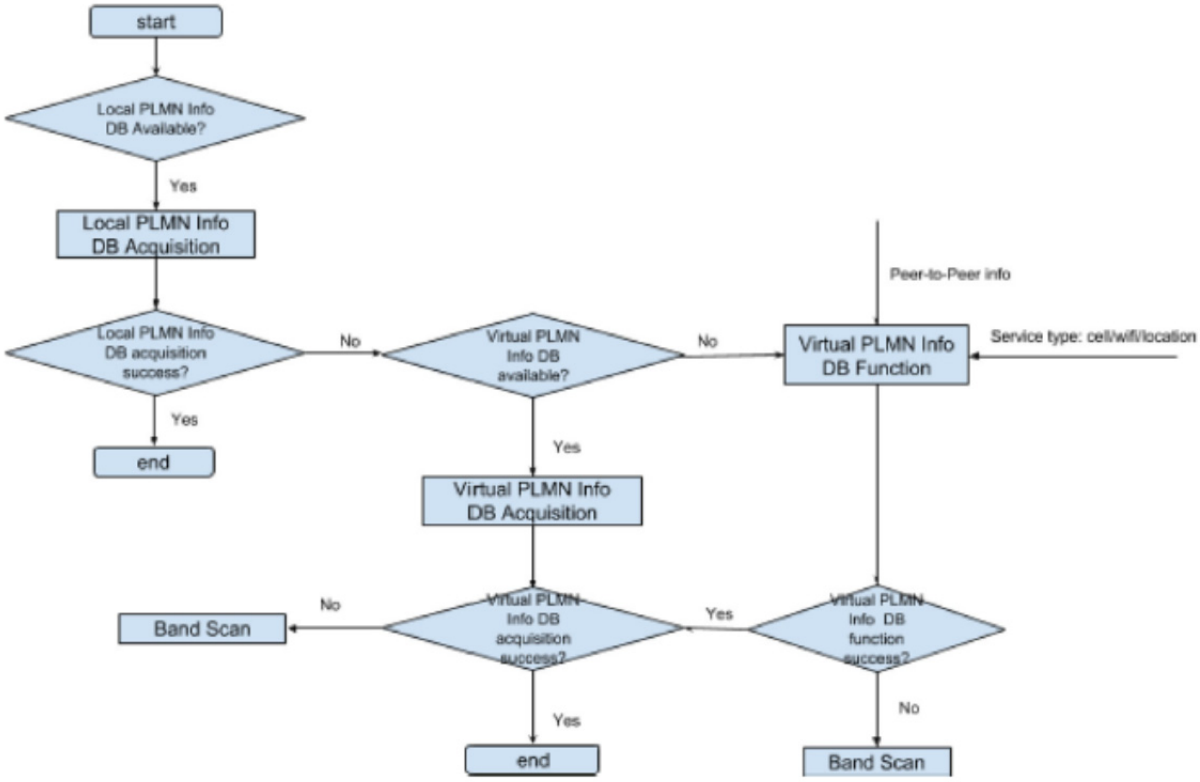

Figure 3 - Flow diagram of process of cellular communication selection.

A flow diagram for a process of selection of a cellular communication cell selection is shown in Figure. 3. The process of Figure 3 can begin when a UE determines whether a local PLMN Info DB is available for its use. If a local PLMN Info DB is available, the UE can attempt to acquire the available local PLMN Info DB. If acquisition of the available local PLMN Info DB is successful, the process of Figure 3 can end.

If acquisition of the local PLMN Info DB is unsuccessful, then the UE can determine whether a Virtual PLMN Info DB is available. If a Virtual PLMN Info DB is available, the UE can attempt to acquire the available Virtual PLMN Info DB. If acquisition of the available Virtual PLMN Info DB is successful, the process of Figure 3 can end. If acquisition of the available Virtual PLMN Info DB is unsuccessful, the UE can attempt to access a Virtual PLMN Info DB function with peer-to-peer information for a service type. If the UE successfully accesses the Virtual PLMN Info DB function, the process of Figure 3 can end. If the UE unsuccessfully accesses the Virtual PLMN Info DB function, the UE can perform a frequency band scan and the process of Figure 3 can end.

Manual Search Using a Virtual PLMN Info DB

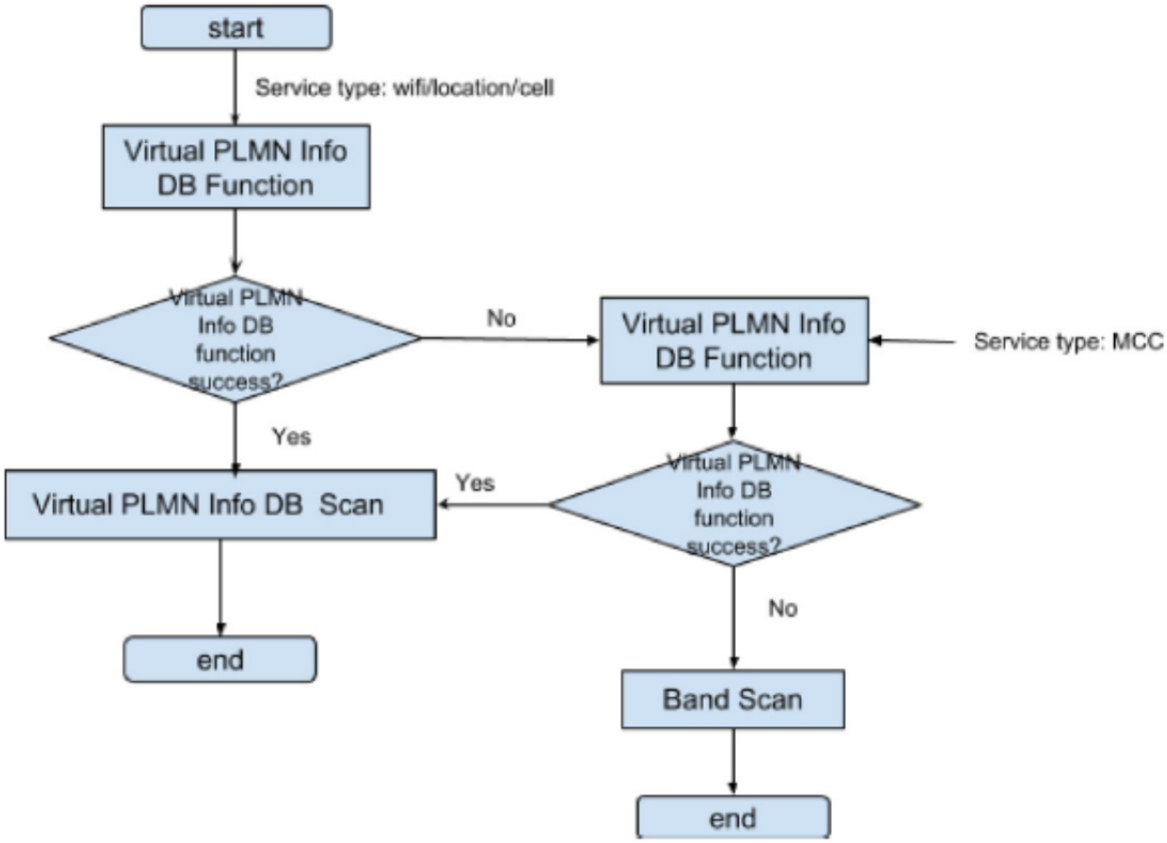

Figure 4 - Flow diagram of manual search process

A manual search process for finding searched-for information related to service types ST1 and ST2 (*e.g.,* an MCC service type, a PLMN service type, a cellular-service service type, a WiFi service type) is shown above in Figure 4. The process of Figure 4 can begin when a UE attempts to use a Virtual PLMN Info DB function to obtain information for a service type ST1 – an example where service type ST1 is one or more WiFi, location, and/or cellular-service service types is shown in Figure 4. If use of the Virtual PLMN Info DB function for service type ST1 is successful, the UE can perform a Virtual PLMN Info DB scan to locate the searched-for information, following which the process of Figure 4 can end. If unsuccessful, the UE can attempt to use the Virtual PLMN Info DB function for service type ST2 – an example where service type ST2 is an MCC service type is shown in Figure 4. If use of the Virtual PLMN Info DB function for service type ST2 is successful, the UE can perform a Virtual PLMN Info DB scan to locate the searched-for information, following which the process of Figure 4 can end. If unsuccessful, the UE can perform a band scan to locate the searched-for information, following which the process of Figure 4 can end.

PLM/HPPLMN Search Using a Virtual PLMN Info DB

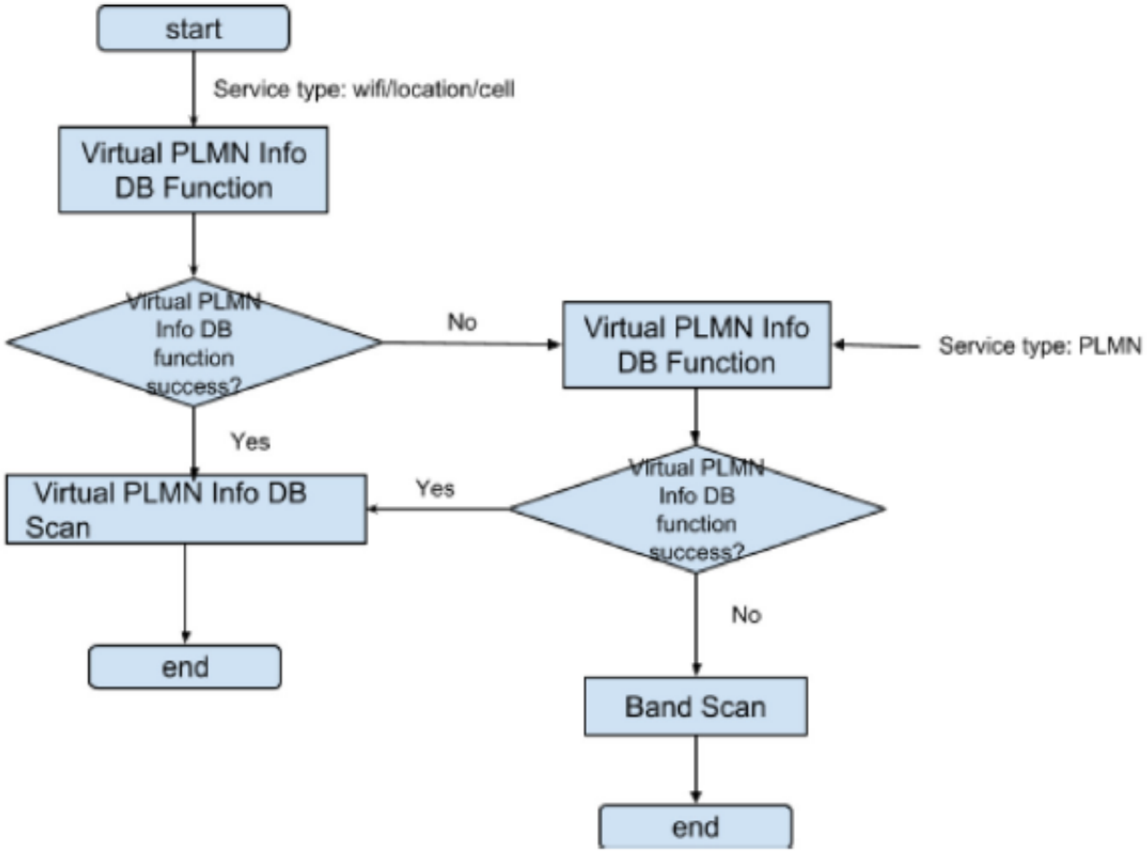

Figure 5 - Flow diagram of PLMN/HPPLMN search process

Another manual search process for finding searched-for information related to service types ST3 and ST4 (*e.g.,* an MCC service type, a PLMN service type, a cellular-service service type, a WiFi service type) is shown above in Figure 5. The process of Figure 5 can begin when a UE attempts to use a Virtual PLMN Info DB function to obtain information for a service type ST3 – an example where service type ST3 is one or more WiFi, location, and/or cellular-service service types is shown in Figure 5. If use of the Virtual PLMN Info DB function for service type ST3 is successful, the UE can perform a Virtual PLMN Info DB scan to locate the searched-for information, following which the process of Figure 5 can end. If unsuccessful, the UE can attempt to use the Virtual PLMN Info DB function for service type ST4 – an example where service type ST2 is a PLMN service type is shown in Figure 5. If use of the Virtual PLMN Info

DB function for service type ST4 is successful, the UE can perform a Virtual PLMN Info DB scan to locate the searched-for information, following which the process of Figure 5 can end. If unsuccessful, the UE can perform a band scan to locate the searched-for information, following which the process of Figure 5 can end.