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Anonymous

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## **Emergency Call Improvements in Areas with Marginal Wireless Coverage**

### **ABSTRACT**

In an emergency call, it is critical to provide accurate location and identity from the user equipment (UE) to the emergency service. However, the identity of the user equipment (UE) is known to the emergency service only when the UE is registered with the network. UE registration can be unreliable or unsuccessful in regions of marginal wireless coverage. This disclosure describes techniques to enable a UE, e.g., a smartphone or other mobile device, to attempt registration on a public land-mobile network (PLMN) for emergency calls in areas with marginal wireless coverage. If previous registration failure is traced to poor wireless coverage, the PLMN is placed on a disable-PLMN list. Upon the dialing of an emergency call, the PLMN is removed from the list. A stored-frequency scan enables a rapid attachment to the (previously disabled) PLMN. The techniques enable faster emergency service with accurate and relevant user information provided quickly to the PSAP server.

### **KEYWORDS**

- Emergency call (E-911)
- Emergency service
- Emergency attach
- Public safety access point (PSAP)
- Public land-mobile network (PLMN)
- Stored-frequency scan
- Full-band scan
- Marginal wireless coverage

## **BACKGROUND**

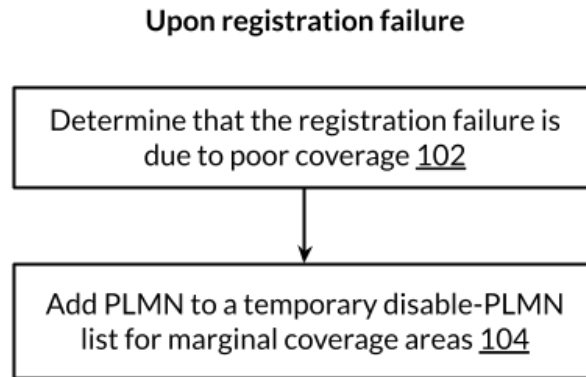
In an emergency (E-911) call from a mobile device (user equipment, UE), it is critical to provide accurate location and identity to the emergency service. However, the identity of the UE is known to the public safety access point (PSAP) only when the UE is registered with the network. When the identity of the UE is unknown to the network/PSAP, routing is suboptimal, potentially leading to a life-threatening delay. There are also high chances of the network rejecting the emergency attach/emergency packet data network (PDN) establishment and delaying emergency service to the user.

Cellular operators typically expect the UE to make at least one attempt to acquire normal/full service and to attempt registration before attempting an emergency call, even under conditions of limited service ('emergency attach'). On the other hand, attempting a full-service scan and normal registration in an emergency situation can result in a waste of precious time during call connection. Furthermore, the UE can only register with a public land-mobile network (PLMN) as long as that PLMN is not a forbidden PLMN (FPLMN) and is currently not being blocked for packet-switched (PS) services, e.g., when the timer T3402 is not running [1]. A fine balance is needed between spending time attempting full-service acquisition and call setup delay.

Currently, a PLMN disabled at the UE is unable to serve an emergency call. If an emergency call is made under the circumstances of a disabled PLMN, the UE is forced to attempt a time-consuming full-band scan followed by registration on a roaming partner, or perform limited scans and an emergency attach/registration on a visiting PLMN, resulting in a very high time-to-connect, if at all a connection is made.

## DESCRIPTION

This disclosure describes techniques to enable a UE to attempt registration on a PLMN for emergency calls when the UE has encountered the maximum permissible number of registration failures in areas with poor or marginal wireless coverage.



**Fig. 1: Action upon registration failure**

As illustrated in Fig. 1, upon registration failure, e.g., when the UE has attempted the maximum number of registration attempts (as specified in the standard) and HAS failed to register, the UE determines whether the registration failure is due to poor wireless coverage (102). If the registration failures are indeed traced to poor wireless coverage, then the PLMN is added to a temporary disable-PLMN list for marginal coverage areas (104). These are explained in greater detail below.

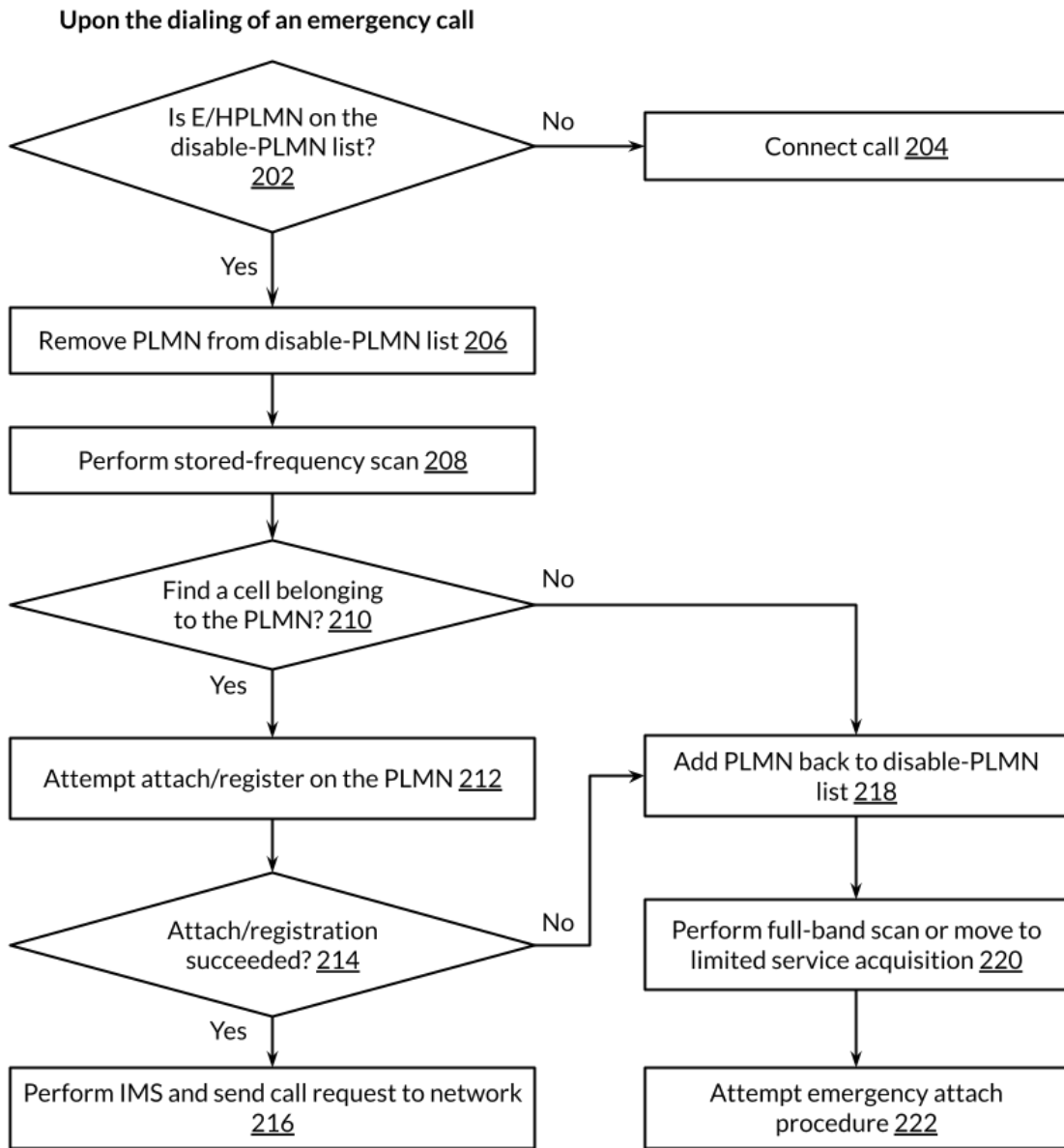
### Determining that registration failure is due to poor wireless coverage (102)

Common reasons for attach/registration failure in poor wireless coverage areas include the inability of the UE to send the complete attach request to the network before the network timer times out; lower layer failures such as radio resource control (RRC) connection establishment failures; etc. The UE can determine that the maximum number of registration

failures is reached due to marginal wireless coverage using various techniques, such as the following. The UE maintains thresholds for signal quality parameters such as RSRP, RSRQ, SINR, RSSI, etc. that are indicative of marginal signal conditions. Under marginal coverage, when an attach request fails, the UE notes down values of the signal quality parameters and maintains a counter for attach-request failures.

*Adding the PLMN to a temporary disable-PLMN list (104)*

When the UE reaches the maximum number of registration failures due to marginal coverage area, the UE adds the PLMN to a temporary blocking list for the T3402 timer and to another temporary disable-PLMN list for marginal coverage areas.



**Fig. 2: Action upon the dialing of an emergency call**

As illustrated in Fig. 2, when an emergency call is dialed, the UE checks if a home PLMN (HPLMN) or equivalent HPLMN (EHPLMN) is present in the aforementioned disable-PLMN list (202). If not present, the UE connects (204) the call. If present, the UE can follow one of two techniques, described below, for faster emergency call connect.

### Technique A

Under this technique, the UE removes the PLMN from the disable-PLMN list (206), e.g., the UE enables camping and registration on the PLMN, and notes the time remaining in the T3402 timer. The UE performs a stored-frequency scan (208) from previously known scan databases or histories. If the UE finds a corresponding cell belonging to the (previously avoided) PLMN suitable for registration (210), the UE attempts an attach/registration on the PLMN (212). If the attach/registration procedure succeeds (214) then the UE performs IMS (IP multimedia subsystem) registration and sends the call request (invite) to the network for the emergency call (216).

If the attach/registration fails (214), then the UE adds the PLMN back to the disable-PLMN list for the remainder of the T3402 timer (218). The UE performs either a full-band scan or moves to limited service acquisition (220) to attempt an emergency-attach procedure (222).

### Technique B

Under this technique, the UE performs a quick stored-frequency scan from previously known scan databases or histories. Based on the result of the stored-frequency scans, if the UE is able to find a cell of the (previously blocked) PLMN, and if the signal strength or quality of the cell is better than the signal quality thresholds configured for marginal coverage, the UE removes the PLMN from the disable-PLMN list and notes the remaining time on the T3402 timer. The UE enables camping and registration on the PLMN. The UE attempts attach/registration on the PLMN. If the attach/registration procedure succeeds, the UE performs IMS registration and sends the call request (invite) to the network for the emergency call. If the attach/registration fails, the UE adds the PLMN back to the disable-PLMN list for the remainder of the T3402

timer, and performs either a full-band scan or moves to limited service acquisition and attempts an emergency-attach procedure.

Some advantages of the described techniques include:

- The UE is enabled to attempt registration on a PLMN that was previously blocked/disabled due to having reached a maximum number of registration failures due to marginal or poor coverage/signal, significantly reducing the time to search for other acceptable cells for emergency attach.
- The UE being registered on the network, the emergency call is routed faster to the PSAP server.
- Calls are connected faster and in a registered state with the network.

The described techniques generally enable faster emergency service with accurate user location and other relevant user information provided quickly to the PSAP server.

## **CONCLUSION**

This disclosure describes techniques to enable a UE, e.g., a smartphone or mobile device, to attempt registration on a public land-mobile network (PLMN) for emergency calls in areas with marginal wireless coverage. If previous registration failure is traced to poor wireless coverage, the PLMN is placed on a disable-PLMN list. Upon the dialing of an emergency call, the PLMN is removed from the list. A stored-frequency scan enables a rapid attachment to the (previously disabled) PLMN. The techniques enable faster emergency service with accurate and relevant user information provided quickly to the PSAP server.



## REFERENCES

1. “Non-access stratum (NAS) protocol for evolved packet system (EPS); Stage 3” 3GPP Specification 24.301:5.5.1.2 available online at <https://portal.3gpp.org/desktopmodules/Specifications/SpecificationDetails.aspx?specificationId=1072> accessed Dec. 24, 2022.