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EFFICIENT HANDLING OF 5G/4G NETWORK INITIATED PAGING

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ABSTRACT

Techniques are described herein for highly optimized 4G/5G inter-working and seamless mobility within dual access connectivity networks. Briefly, mobile providers deploying 5G in a dense area are very likely to have coverage holes. Those coverage holes may be efficiently managed using Smart Area Lists (SmALs).

DETAILED DESCRIPTION

5G architecture defines different options for dual-connectivity for radio by converging into a unified core (e.g., Non-Standalone (NSA) or Standalone (SA)). In most likely scenarios, coverage by a 5G gNodeB (gNB) is much smaller (due to the relatively high frequency spectrum) than a 4G macro eNodeB (eNB). The challenge is to optimize signaling and paging for dual access registered User Equipment (UE) when frequent handovers occur between 5G and 4G. In some scenarios, the UE may enter an idle state in either access mechanism (5G or 4G radio) and for network initiated paging (downlink data). Paging signals may be lost if the UE has moved out of the last known access coverage. Furthermore, mobility signaling events (e.g., 4G tracking area updates or 5G registration procedures) will be significant when subscriber hops occur between 5G/4G access mechanisms. Accordingly, an automated mechanism is provided herein to optimize signaling and improve paging performance for an inter-working network.

When a UE enters an idle state in 5G coverage, it is likely that it will move to 4G coverage area because 5G New Radio (NR) coverage is small (due to cell radius or low signal). Therefore, the network needs to be able to page the 5G NR and 4G Radio Access Network (RAN) to ensure the UE reconnects to the network via any accessible RAN. This was known as Idle-mode Signaling Reduction (ISR) in 3G and 4G mobile networks. However, a solution needs to be optimized for other ISR-like scenarios.

When the Session Management Function (SMF) pages the UE on 5G and 4G, it needs to treat the Mobility Management Entity (MME) as another Access and Mobility Management Function (AMF). This requires extensions for the N11 interface (referred to herein as N11' or N11 prime) between the SMF and MME. First the MME queries the AMF over the N26 interface for the context of the UE to establish the credentials. The SMF obtains the Tracking Area (TA) list of the 4G coverage from the Network Data Analytics Function (NWDAF), which is used to indicate to the MME which eNB(s) to page.

Figure 1 below illustrates dual access paging for a subscriber in idle state.

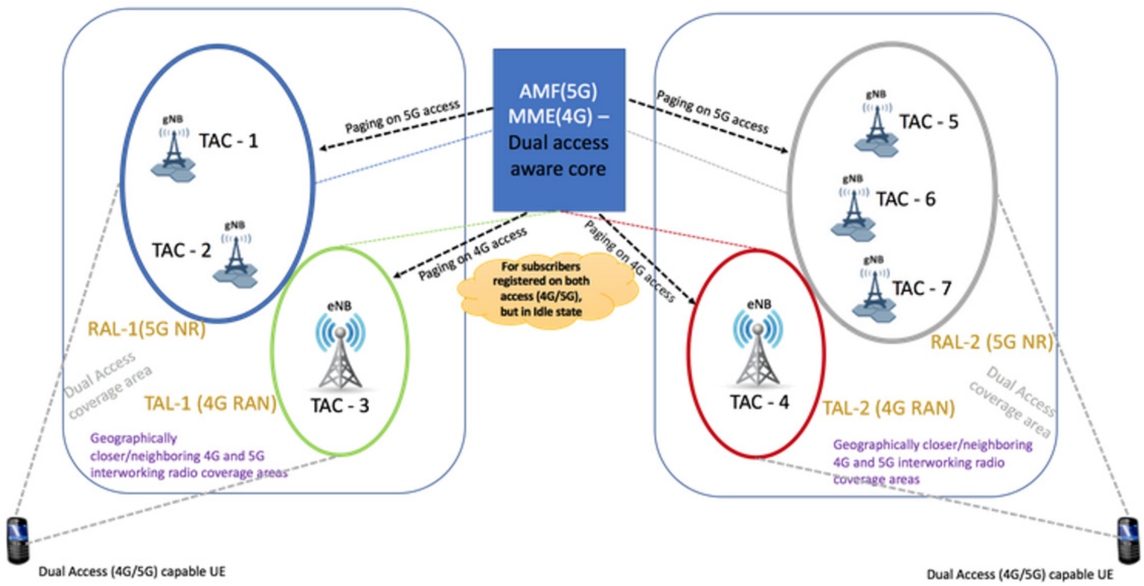

Figure 1

Described herein are techniques for optimization of signaling and paging performance for dual attached/registered UEs when they frequently hop between different access mechanisms in idle mode. The traditional unoptimized architecture can be very expensive and create unnecessary signaling on the radio access side.

When the UE enters an idle state through either access mechanism (5G or 4G radio) for network initiated paging (downlink data), paging signals may be lost if the UE has moved out of the last known access coverage. Mobility signaling events (e.g., 4G tracking area updates or 5G registration procedures) may be significant when the subscriber hops between the 5G/4G access mechanisms.

Figure 2 below illustrates a high level dual-connectivity architecture.

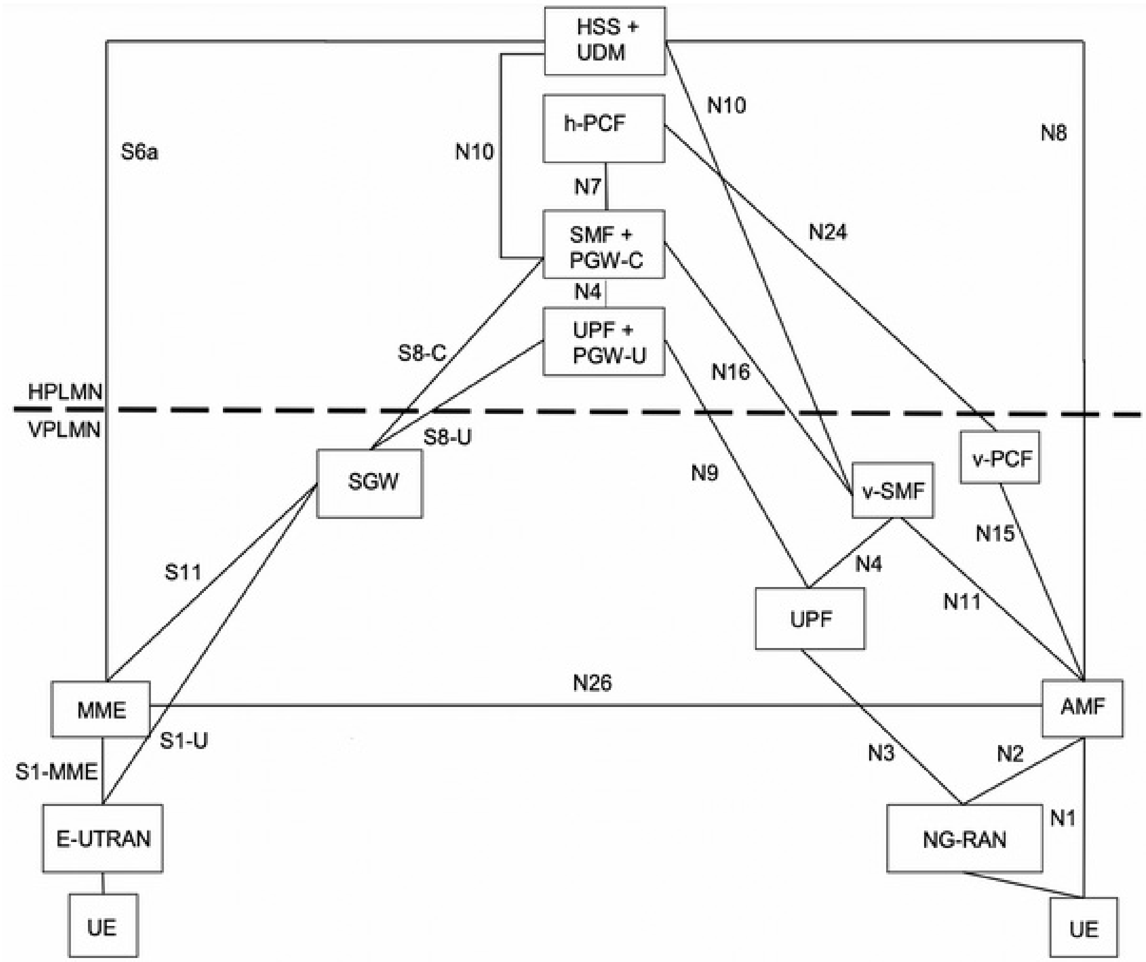

Figure 2

It is assumed that the UE and core(s) can have dual registration. A notification of the UE's state is provided from one access core to another (e.g., if the UE was last connected to the 5G access mechanism and enters an idle state, this is notified to the 4G access mechanism, and vice versa). The UE state may then transition from active mode to idle mode or from idle mode to active mode. Thus, a notification regarding one access mechanism may be provided to the other access mechanism.

Figure 3 below illustrates a call-flow sequence diagram for a dual-connected UE last registered for 4G access before entering an idle state.

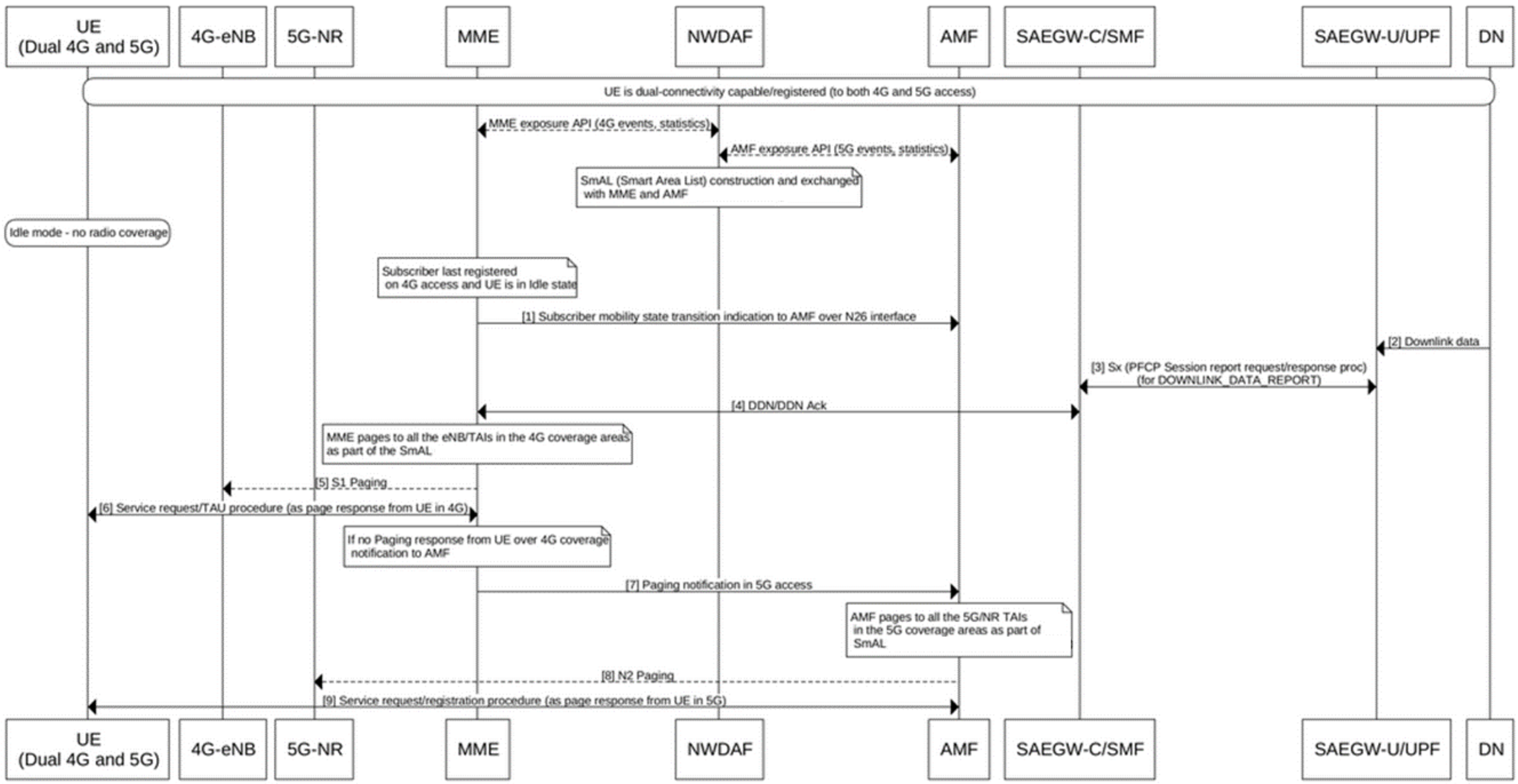

Figure 3

Figure 4 below illustrates a call-flow sequence diagram for a dual-connected UE last registered for 5G access before entering an idle state.

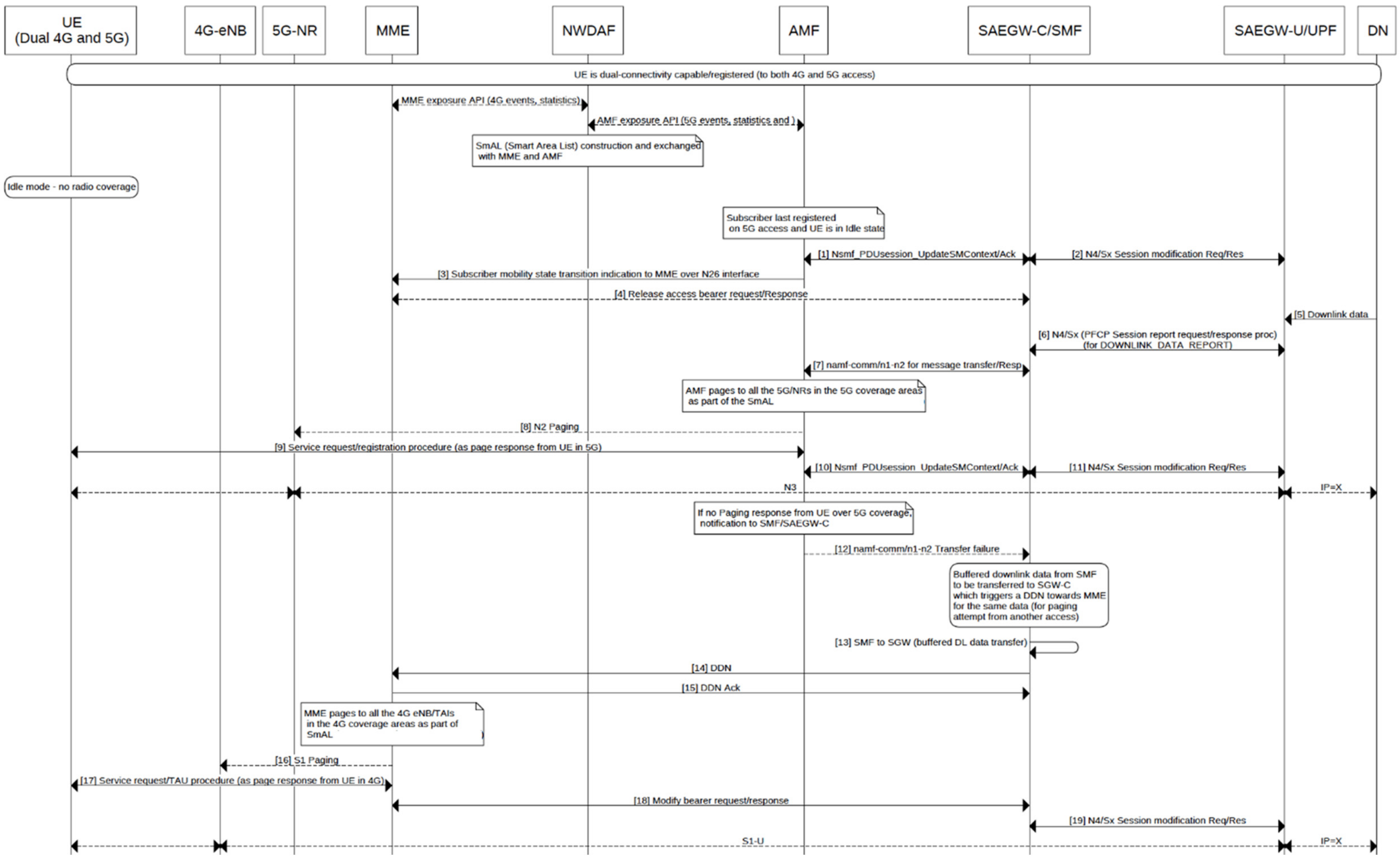

Figure 4

When a paging attempt on one access mechanism is timed-out or fails, techniques described herein provide an automated mechanism/apparatus setup such that the buffered data is be transferred to the other access mechanism (e.g., SMF to Serving Gateway – Control (SGW-C)). In the case of a paging fail over 5G, the system may attempt to send a page towards the UE for the same downlink data over 4G. In this case, the chances are very high that the dual access registered UE may latch onto 4G macro cell coverage and the UE may provide a response to the page. A similar method may be used in the reverse case as well. This may enrich the paging performance in dual access based networks.

The subscribers may be dual-connectivity capable, and may be registered with both 4G and 5G access and also signaled for the core with a Smart Area List (SmAL). A SmAL is an optimized list prepared from the neighboring 4G and 5G radio coverage areas. The subscriber may seamlessly move within these areas without any signaling (e.g., Tracking Area Update (TAU) in 4G or registration procedure in 5G as part of subscriber movement within the SmAL boundary). This may lead to a significant amount of signaling reduction on the radio access side.

The UE may perform idle mode mobility to 4G as per 3rd Generation Partnership Project (3GPP) Technical Specifications (TSs) 23.501/502. In many cases, the 5G signal may be present alongside the 4G signal, but for propagation reasons the page on 5G can easily fail. In such cases there needs to be an efficient mechanism to page the subscribers on both access mechanisms (when the devices are dual connectivity capable) and also capable enough to register with both access mechanisms (e.g., 4G and 5G networks) simultaneously.

A page attempt may be triggered on 4G even if the UE was not last camped on the 4G network. A page attempt may be similarly triggered on 5G even though the UE was not last camped on 5G network. This improves the paging success rate Key Performance Indicator (KPI) as paging attempts would otherwise be sequentially attempted across both 4G and 5G access. The approach described herein provides a better opportunity for a dual access registered UE to be paged across both access mechanisms and respond to the page from current access networks. Thus, the downlink data may be received, thereby significantly improving paging success rates and in turn ensuring that the downlink data is delivered to the UE (i.e., no data loss) when it connects back to the network.

Additionally, because the UE is registered and context is preserved with both access mechanisms, it is free to move across any access mechanisms without additional signaling. This reduces signaling on the radio access side and also conserves mobile battery power. Because every signaling operation performed by the UE requires battery usage, the techniques provided herein also enable optimal battery usage by the UE.

Signaling towards the Home Subscriber Server (HSS) (in 4G) and towards the Unified Data Management (UDM) / Authentication Server Function (AUSF) (in 5G) may also be reduced. This is because there may be no need for the UE to re-authenticate or re-register when they hop frequently between 4G and 5G access coverage areas. With dual access (4G and 5G) registration capability, signaling optimization on these links is also possible.

Techniques described herein enable signaling optimization on the radio/access side, towards the HSS (from the MME), towards the AUSF/UDM (from the AMF), and other interfaces. Without this signaling optimization (especially the radio access side), the UE/mobile battery would become drained sooner due to heavy signaling that would otherwise be induced.

This optimization logic may be implemented throughout the inter-working core networks. This dual access registration capability may be implemented in the UE, 4G and 5G core elements (e.g., MME, AMF, System Architecture Evolution Gateway - Control (SAEGW-C), SMF, HSS, UDM, etc.). An overall outcome may thus be implemented in inter-working (4G and 5G) networks to improve user experiences.

In summary, techniques are described herein for highly optimized 4G/5G inter-working and seamless mobility within dual access connectivity networks. Briefly, mobile providers deploying 5G in a dense area are very likely to have coverage holes. Those coverage holes may be efficiently managed using SmALs.