Assignment Four: VoLTE & VoWiFi

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**1. Describe the difference between VoWiFi cellular preferred and WiFi preferred.**

Cellular Preferred: In this mode, the mobile device prioritizes using the cellular network (2G, 3G, or LTE) for voice calls even if connected to a WiFi network. WiFi is primarily used for data services, and the device only switches to WiFi for voice calls when no cellular network is available, such as in basements or rural areas. This mode ensures that the quality of ongoing calls remains consistent while cellular coverage is present. A downside is that handovers can only occur between LTE and WiFi; if the device is on 2G or 3G, the call cannot be handed over to WiFi, potentially resulting in call drops. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 360)

WiFi Preferred: In this mode, the device connects to the ePDG (Evolved Packet Data Gateway) over WiFi as soon as WiFi connectivity is available, using WiFi for voice calls even when a cellular network is also available. This approach helps avoid call drops when moving between cellular and WiFi coverage areas. However, it may lead to voice quality issues if the WiFi network is congested or has limited uplink capabilities, such as DSL connections with lower bandwidth. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 360)

**2. Describe the main steps in handing over an ongoing VoLTE call to WiFi.**

The handover process from VoLTE (LTE) to WiFi involves several key steps managed by the IP Multimedia Subsystem (IMS) and the ePDG (Evolved Packet Data Gateway):

1. *ePDG Session Establishment*: When a device connected to the LTE network switches to WiFi, an IPSec tunnel is established between the device’s IMS client and the ePDG, which acts as an access point to the WiFi network. This tunnel ensures secure communication and the transfer of the IMS default bearer from LTE to WiFi. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 359)
2. *Transfer of IMS Bearer:* The ongoing call's IMS bearer, which was initially managed by LTE, is handed over to the ePDG. During this process, the IP address of the LTE IMS bearer is transferred into the IPSec tunnel managed by the ePDG, ensuring the continuity of the session without requiring a new IP address. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 359)
3. *Routing Adjustment:* The Packet Data Network Gateway (PDN-GW) reroutes the GTP (GPRS Tunneling Protocol) core network tunnel from the Serving-Gateway (S-GW) to the ePDG. This step is critical to maintain the speech path during the handover and minimizes interruptions. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 359)
4. *Re-registration of IMS:* The IMS registration updates with a P-Access-Network Identifier parameter to reflect the change in radio network technology. Although this registration ensures consistency within the IMS, it does not interrupt the ongoing VoLTE call. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 359)
5. *Completion of Handover*: The handover process completes with the seamless continuation of the call over WiFi. The session maintains its established parameters without the user noticing any significant disruptions. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 359)

**3. How are call forwarding settings managed in VoLTE?**

In VoLTE, call forwarding settings are managed using the IMS (IP Multimedia Subsystem) network architecture, specifically through the use of SIP (Session Initiation Protocol) messages. The IMS uses an application server that implements the Multimedia Telephony (MMTEL) specification as outlined in the 3GPP TS 22.173 standard. This server controls the establishment and maintenance of VoLTE sessions by handling SIP messages, including those related to call forwarding. The user’s profile in the IMS can be configured to forward SIP messages to several Application Servers, allowing for various supplementary services such as call forwarding, conference calls, call hold, and more. This flexible approach allows VoLTE to provide call forwarding by modifying SIP messages in real-time, ensuring that call routing follows the user's preferences and configurations.(From GSM to LTE-Advanced Pro and 5G, 2021, p. 328)

**4. How are emergency calls handled in VoLTE networks?**

In VoLTE networks, emergency calls are routed to the nearest Public Safety Answering Point (PSAP) based on the caller’s current location, ensuring connection to the appropriate emergency services. These calls are prioritized above all others, preempting non-emergency calls during network congestion. Instead of using the regular VoLTE SIP connection, a dedicated emergency bearer is established when an emergency number is dialed, allowing for immediate identification and priority handling. Initially, some VoLTE implementations relied on Circuit-Switched Fallback (CS-Fallback) to GSM or UMTS if VoLTE did not support emergency calls, but modern networks use System Information Broadcast (SIB) messages to indicate their emergency call capabilities. Emergency calls can still be made even if the device isn’t fully registered or is using a competitor’s network, always ensuring access to assistance. (From GSM to LTE-Advanced Pro and 5G, 2021, pp. 350-351)

**5. How is it ensured that a SIP-message can only be sent by an authenticated device?**

To ensure that a SIP message is sent only by an authenticated device, VoLTE networks use a security context established during the SIP registration process. This context relies on the IMSI stored on the SIM card, the secret key Ki, and authentication algorithms also used in GSM, UMTS, and LTE for device identification. During registration, integrity checks are applied to all signaling messages to verify they haven't been altered intentionally or accidentally. Optionally, encryption can be applied to further secure the signaling messages between the device and the Proxy-Call Session Control Function (P-CSCF), ensuring that only authenticated devices can send SIP messages. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 329)

**6. Name the major IMS network components and give a short description of each function.**

* *P-CSCF (Proxy-Call Session Control Function):* Acts as the initial point of contact in the IMS network. It manages SIP signaling, represents the user toward the IMS system, and handles Quality of Service (QoS) settings during voice sessions by creating a dedicated radio bearer for voice data packets.
* *I-CSCF (Interrogating-Call Session Control Function):* Routes incoming requests and queries the HSS to retrieve subscriber information, determining the appropriate S-CSCF to handle the session.
* *S-CSCF (Serving-Call Session Control Function):* The central session manager responsible for processing SIP registrations, handling session control, and interacting with other CSCF elements.
* *HSS (Home Subscriber Server):* A database containing subscriber profiles, authentication data, and service settings essential for routing and managing sessions within the IMS.
* *MMTEL (Multimedia Telephony Application Server):* Provides telephony services such as voice, SMS, and supplementary services over the IMS.

**7. What are “Preconditions” and how does the mechanism work?**

Preconditions in VoLTE are used to ensure that Quality of Service (QoS) requirements are met before a call is established. During call setup, the SIP precondition mechanism confirms that both the local and remote ends of the call can support the necessary QoS for the speech path. The process starts with a SIP INVITE message, where the mobile device informs the network that preconditions are mandatory. The network responds, and subsequent messages confirm whether QoS resources are reserved on both sides. Only when both parties agree that the required QoS is in place does the call proceed, ensuring stable voice quality from the start. This mechanism is crucial for managing voice traffic in real-time, maintaining call quality, and minimizing delays.

**8. Why are Asserted Identities required?**

Asserted Identities are essential in VoLTE because they ensure the integrity and authenticity of the caller’s identity during SIP communication. When a SIP message is sent from a device, the network adds a P-Asserted-Identity header, which contains the true identity of the caller (e.g., phone number). This process is necessary because the originating device cannot be fully trusted to insert its real identity. The network, through elements like the P-CSCF, S-CSCF, and Telephony Application Server, modifies and verifies the message to confirm that the correct identity is transmitted to the terminating device. This mechanism prevents identity spoofing, ensures proper billing, and provides security and traceability in VoLTE calls. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 341)

**9. Why is “floor control” required in Mission Critical Push to Talk Communication?**

Floor control is essential in Mission Critical Push-to-Talk communication to manage who can speak at any given time in a group call, ensuring orderly communication. Unlike analog systems where multiple users could speak simultaneously, leading to garbled audio, MCPTT uses a server-based approach where the “floor” is controlled centrally. When a user presses the Push-to-Talk button, a floor request is sent directly to the MCPTT server, which grants speaking rights if the floor is available. The server ensures that only one person can talk at a time, maintaining clear communication. Priority levels can also be set, allowing higher-priority users to override others if necessary. This mechanism prevents conflicts, ensures efficient use of the communication channel, and maintains discipline during critical operations. (From GSM to LTE-Advanced Pro and 5G, 2021, p. 371)

**10. Why is header compression beneficial in VoLTE?**

Header compression, specifically Robust Header Compression (RoHC), plays a crucial role in enhancing VoLTE performance by minimizing the size of IP headers in voice data packets. This reduction in header overhead increases transmission efficiency and conserves bandwidth between the mobile device and the base station. In VoLTE, where small packets are frequently sent, compressing headers reduces data volume, lowers latency, and improves call quality, leading to a better overall user experience during voice communications over LTE networks. (From GSM to LTE-Advanced Pro and 5G, 2021, pp. 335-337)

# References

From GSM to LTE-Advanced Pro and 5G. (2021). In M. Sauter, *And Introduction to Mobile Networks and Mobile Broadband* (pp. 15 - 100). Hoboken, New Jersey: John Wiley and Sons Ltd.