Reduce core network signaling with a field-proven MME

LTE offers faster speeds, lower latencies, and a flatter, simpler, all-IP network that is more efficient to operate while delivering services at a lower cost per-byte. It also reduces the complexity of the evolved packet core (EPC) by separating the control and data plane functions into different nodes. This results in an increased signaling load on the **Mobility Management Entity** (MME), the EPC control plane node. To keep your network operating at top speed, your MME needs to leverage the best available technologies and field-proven software.

With LTE, mobile operators are finally in a position to innovate beyond traditional best-effort data services and deliver the media-rich, personalized new services subscribers want. However, along with the vast improvements to service performance and flexibility come new challenges, such as a massive increase in the number of users and devices, as well as per-user bandwidth and per-device signaling requirements. Alcatel-Lucent Bell Labs traffic studies indicate:

- By 2017, the average per-user bandwidth per month could be as much as 5 GB.
- With LTE, core network signaling rates have increased up to 166% over 3G networks during the busy hours of the day.

Increases in per-device signaling are being driven by:

- Increase in mobile data users and smartphones/tablets
- Increase in mobile application use (more service requests)
- "Chatty" (signaling-intensive) apps
- Idle-to-active and active-to-idle device transitions
- Frequent LTE/3G/Wi-Fi®/small cells coverage handovers

LTE FIELD EXPERIENCE MAKES THE DIFFERENCE

At Alcatel-Lucent, we believe mobile operators can address these new signaling requirements by deploying an MME with advanced signaling reduction techniques and with new innovative techniques to handle network failures. We explore these topics in the following articles contained in this ebook:

With careful planning and appropriate infrastructure investments, core network signaling traffic can be effectively managed. It starts with an MME carrier-grade computing platform with the capacity, scalability and high performance processing you need to meet the expected signaling load. But that in itself isn't sufficient. You also need MME software that's field proven in large-scale LTE networks to intelligently manage LTE traffic and reduce overall core signaling with, for example, enhanced paging and tracking area management procedures.

While small cells enable you to offer the capacity, coverage and quality of experience subscribers expect, they also increase scaling requirements, signaling volume and tracking areas. Alcatel-Lucent has developed small cell Closed Subscriber Group (CSG) capabilities to address these signaling challenges.

Early implementations of LTE had issues maintaining subscriber sessions when an MME outage occurred, creating the potential for attach storms. These problems can be avoided with the Alcatel-Lucent 9471 WMM Session Restoration Server.

LTE is changing the mobile communications experience and creating many opportunities for growth and enhanced services. To ensure your network can keep up with what the future has to offer, invest wisely in your **MME.**

Michael J. Hawley, Senior Director
Alcatel-Lucent 9471 WMM R&D

Alcatel·Lucent

Managing LTE core network signaling traffic

David Nowoswiat and **Gordon Milliken**

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HIGHLIGHTS

- The volume of core network signaling will increase with LTE, particularly on the Evolved Packet Core (EPC) **Mobility Management Entity** (MME)
- The MME can reduce signaling traffic by implementing smart signaling management techniques
- Improved network analytics help identify the cause of signaling problems

LTE SIGNALING MUST BE MANAGED

Packet core signaling volumes in the early deployments of large-scale **LTE** networks are significantly higher than in existing 2G/3G core networks. This is partly due to the flatter, all-IP architecture of LTE where the macro and **metro cell** is directly connected to the MME – the dedicated control plane element in the EPC. Analysis of field data from several large LTE network deployments found that a **MME** can experience a sustained signaling load of over 500-800 messages per user equipment (UE) during the normal peak busy hours and up to 1500 messages per user per hour under adverse conditions.

The rise in core signaling can also be attributed to an overall increase in network usage by LTE subscribers. In some large US metropolitan markets where LTE is available, network peak usage is as high as 45 service requests per UE per hour in peak busy hours. As LTE grows in popularity, signaling in the EPC will continue to rise, which increases the potential for control plane congestion and signaling storms if not properly managed.

As a result, Mobile Network Operators (MNOs) must take steps when moving to LTE to ensure that their core control plane network can support the expected increase in signaling volume. Specifically, MNOs need to deploy a carrier-grade, next-generation MME/**Serving GPRS Support Nodes** (SGSNs) platform that not only has the capacity, scalability and CPU processing performance, but also the capability to intelligently manage this traffic to reduce overall core signaling. Two areas where signaling efficiencies can be gained are in MME paging and Tracking Area (TA) management procedures.

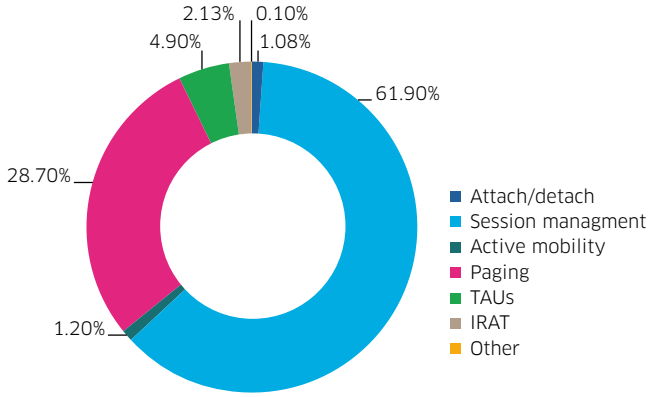
PAGING AND TA MANAGEMENT CHALLENGES

Paging procedures are signaling messages between the MME, the **eNodeB** and the UE. Paging is required to locate a UE in the network when it is in an Idle state, making its exact location in the network unknown. Paging procedures are used by the network to:

- Request establishment of a non-access stratum (NAS) signaling connection between the MME and the UE to support a network service request.
- Prompt the UE to reattach itself to the network after a network failure.
- Initiate a mobile Circuit Switched Fallback (CSFB) procedure.

In LTE, the signaling traffic generated by MME paging the UE is significant. Figure 1 illustrates field data from a US LTE service provider in a large metropolitan market. It shows that paging is more than 28% of the total signaling load on the MME. Thus, finding methods to reduce the paging on the MME will help MNOs lower the overall network signaling load and manage their MME capital costs.

Figure 1. Distribution of MME signaling events in a U.S. LTE network



A TA represents a group of contiguous cells within the Evolved Universal Terrestrial Radio Access Network (E-UTRAN). It is used by the MME to track and locate the UE when in Idle mode as it moves through the network. A TA list is a group of adjacent TAs that is managed by the MME and periodically sent to the UE. The MME sends paging messages to the cells that are included in either the TA or TA list in which the UE is registered. A Tracking Area Update (TAU) procedure is initiated only when the UE crosses the TA boundary into another TA that is not in its TA list or when the periodic TAU timer expires.

TAU procedures can generate a lot of signaling if a UE is moving along the border between TAs that are not all part of its TA list, especially when the TA size is large (e.g. 50-100 eNodeBs in one TA). This is known as "toggling" effect because of the multiple registrations with the MME that occurs as the UE moves in and out of TA boundaries which generates additional TAU signaling.

In addition to high generating signaling volumes, both paging and TAU procedures are a significant power drain the UE battery. It is therefore important to carefully design TAs so they are neither too large to minimize the volume of paging, nor too small to prevent frequent TAUs and avoiding toggling at TA borders.

SMART PAGING AND TA MANAGEMENT TO REDUCE SIGNALING

Next-generation MME /SGSNs, such as the **Alcatel-Lucent 9471 Wireless Mobility Manager** (WMM), allow MNOs to tailor the MME paging policies for each type of service. This helps MNOs lower the volume of paging while still meeting end-user quality of experience expectations for each type of service.

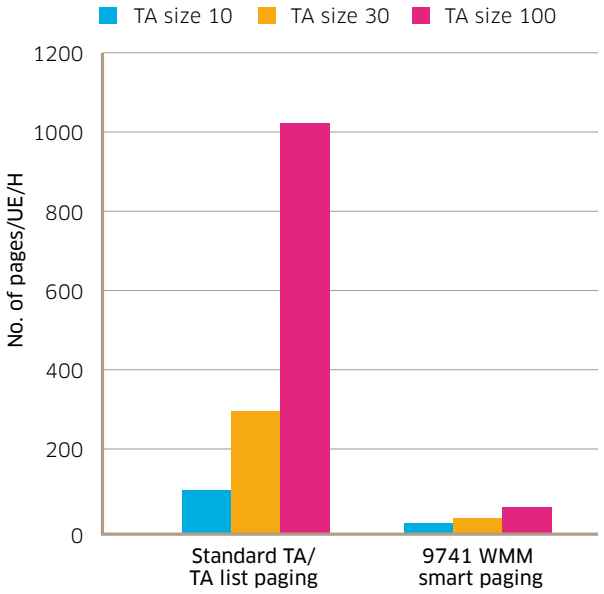
The 9471 WMM paging policy supports the following configurable parameters:

- Paging by service type
- Number of page attempts
- Timing between page attempts
- Paging method used in each attempt

The paging policies are fully compliant with 3rd Generation Partnership Project (3GPP) standards and deployable in networks with any vendors' eNodeBs.

As illustrated in Figure 2, smart paging and TA features can reduce signaling messaging over basic TA and TA list paging methods by as much as 80% depending on the TA size.

Figure 2. Smart paging significantly reduces signaling volume



Dynamic TA list management techniques can further reduce MME signaling loads. These techniques optimize the number of TAs in the UE TA list as the UE moves through the network. When cyclic patterns in the UE movement are detected, the TAs are automatically added from the UE's registered TA list as it crosses the boundaries of either 2 or 3 TAs (Figure 3). By constantly updating and optimizing the UE TA list, fewer TAU requests are generated, reducing the toggling effect at TA boundaries.

TAU procedures also drain UE battery life – consuming an estimated 10 mW of UE power per procedure in a current-generation smartphone. Table 1 shows the UE power and battery life savings for a smartphone using dynamic TA management features as compared to a smartphone using basic TA list management capabilities. This TAU procedure power estimate includes the TAU messaging as well as the scanning effort and eNodeB attachment. The comparison is for an LTE smartphone with a power consumption profile of:

- 800 mW for transmit
- 500 mW for receive
- 5.5 mW for idle

Figure 3. Dynamic TA list management further reduces MME signaling loads

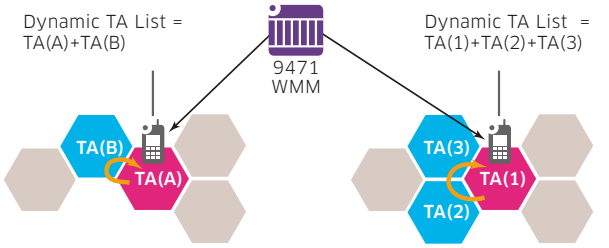


Table 1. Dynamic TA list management reduces smartphone battery consumption

TA size (eNodeBs)	Basic TA management: UE power consumed	Dynamic TA management: UE power consumed	UE power savings	UE battery life saved (active time)
10	1493 mW	299 mW	1194 mW	2 h
30	853 mW	192 mW	611 mW	1.1 h
100	480 mW	130 mW	350 mW	0.56 h

Table 1 shows that dynamic TA list management techniques consume less UE battery power and can extend smartphone battery life up to several hours depending on TA size and the subscriber's smartphone usage.

ANALYTICS TO OPTIMIZE LTE RADIO FREQUENCY AND CORE NETWORKS

With LTE and its all-IP architecture, a new set of analytical tools is necessary to maintain the network. Using traditional Radio Access Network (RAN) management tools is time consuming, resource intensive and has a number of limitations:

- Drive testing provides only a sample of the network coverage at ground level. It is also time constrained and reactive.
- Service measurements aggregate data across all users. This aggregation is useful for detecting hardware faults but not for detecting individual customer performance issues.
- Using call tracing to solve specific customer complaints can require the subscriber to make test calls while troubleshooting takes place. This is not always practical. It is also time consuming and may still result in the need for a costly field visit to replicate the user behavior.

Diagnostic tools, such as the Alcatel-Lucent Per Call Measurement Data (PCMD) (Figure 4) software capability for LTE networks, provides an integrated record of call procedures involving the UE, eNodeB and the MME. These tools are different from traditional RAN performance tools in that they utilize subscribers' mobile devices to collect a rich set of signaling and bearer data about the device and the network. Unlike call traces, PCMD call procedures for all the UEs are captured. This provides a more accurate view of the end user's experience with the network. In addition, because the end-user mobile devices are used to collect the data, the need for drive testers is significantly reduced.

Improved network analytics bring benefits across the MSP organization:

- **Customer care:** Personnel can quickly identify coverage and device issues to provide rapid responses that can improve customer satisfaction and lower call hold times.
- **Operations:** Personnel have the data analysis and reports needed for continuous improvement and quality management. For example, with data from end-user devices, coverage holes, dropped calls and cell performance issues can be identified and key performance indicator (KPI) targets for improvement can be set.
- **Engineering and network planning:** Personnel can use traffic pattern analysis with accurate radio frequency (RF) measurements to predict and verify coverage requirements. This information also assists in RF coverage and capacity planning and utilization, helping to lower capital costs with more targeted RAN investments.

NEW TECHNOLOGIES DEMAND NEW NETWORK CAPABILITIES

As smartphones and tablets with always-on applications and services proliferate and the competitive push to move to LTE increases, MSPs must consider how they will address signaling challenges.

A high-performance and scalable SGSN and MME that supports expected signaling volumes and provides smart paging and TA management techniques helps MSPs address LTE signaling challenges:

- Reducing signaling volumes enables MSPs to support more subscribers per MME and to defer additional MME capital investments.
- Dynamic TA management ensures that the UE always has an optimized TA list that minimizes TAUs and extends UE battery life.

In addition, advanced diagnostic and troubleshooting tools help MSPs manage and support the LTE network. MSPs can resolve customer issues faster and improve network performance to increase customer satisfaction and reduce churn.

Moving to LTE is a significant investment for MSPs. Those who make it a priority to address the signaling challenges that come with this move will be in a better position to achieve a timely return on their investment.

Figure 4. Diagnostics tools such as PCMD provide valuable analytics for LTE networks

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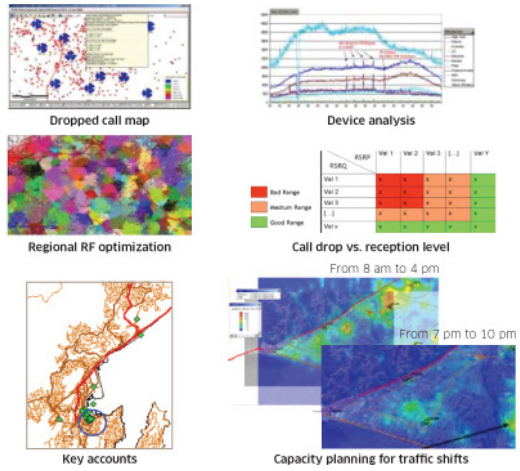

Mitigate the signaling impact of small cells

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David Nowoswiat

Thinking of adding small cells to your LTE macro network? You're not alone. LTE small cells are now broadly accepted as a necessary part of a mobile network. But adding small cells can introduce fresh challenges, especially for the Evolved Packet Core (EPC) where the signaling load on your Mobility Management Entity (MME) will grow.

There are multiple factors to consider when determining how much additional signaling volume will hit the core network – and what steps you should take to help ease the impact. I talk about this in my podcast and in a new Application Note **The Impact of Small Cells on MME Signaling.**

WHAT CAUSES THE MOST SIGNALING IN THE CORE?

What procedures cause the most signaling in the core network? Based on our LTE traffic analysis of large-scale networks in dense urban areas we have identified the top three:

1. Service Requests (62%)
2. Paging (29%)
3. Tracking Area Updates (5%)

It will be important to find ways to reduce this signaling traffic in the combined LTE macro and small cell network.

WHICH FACTORS SHOULD I TRACK?

As you add LTE small cells to provide the capacity, coverage and quality of experience needed to support today's mobile broadband services, you will need to consider multiple aspects of your small cell deployment and how they affect the signaling network. These include:

- The number of small cells that are added to the network
- The type of small cells, for example, you could introduce metro, enterprise or home cells – or a mix of all three
- The small cells network deployment architecture, which can either be directly connected to the EPC (Figure 1) or through a small cells gateway
- The access mode of the small cell – be it open, hybrid or closed – will also matter

WHAT'S THE IMPACT?

The MME is impacted in a number of ways with the addition of small cells.

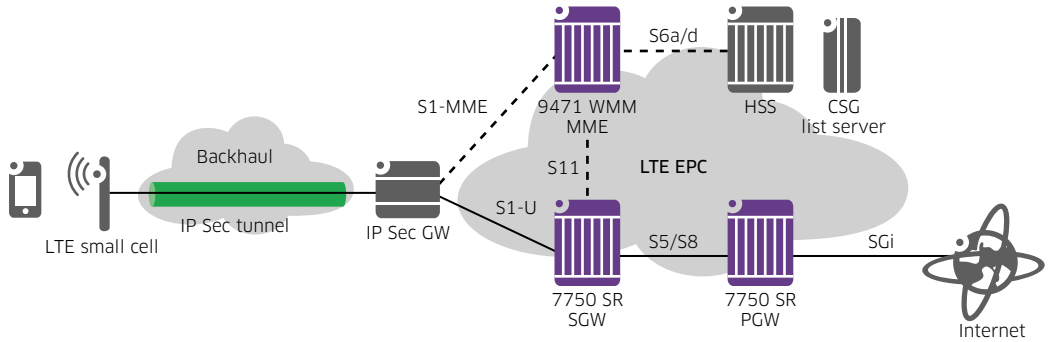
- It must provide higher scaling in the number of nodes (eNodeBs, Home eNodeBs) and S1-MME control links
- It must support a larger number of tracking areas per pool
- It must be able to cope with the additional signaling volume on top of the core network signaling of the LTE macro network

WHAT ARE MY OPTIONS?

At Alcatel-Lucent, we have gained both field experience from large-scale LTE network deployments and expertise in mobility management. We have now developed idle mobility smart signaling capabilities on the Alcatel-Lucent 9471 Wireless Mobility Manager (WMM), which acts as the MME/SGSN in the Wireless Packet Core solution.

These 3GPP-compliant smart signaling capabilities can reduce signaling caused by paging and tracking area (TA) management in LTE networks by up to 80 percent as well as extend mobile device battery life. The 9471 WMM also supports Closed Subscriber Group (CSG) paging optimization, which further reduces network signaling. Both of these paging optimization methods can be combined in small cell deployments to maximize the benefits.

Figure 1. LTE small cell architecture, variant 2



LTE signaling: Prevent attach storms

David Nowoswiat

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LTE is hitting its stride. Today close to 300 LTE networks are commercially launched in more than 100 countries. And that number is set to grow as almost 500 network operators have announced their commitment to deploy LTE*.

With success comes very high expectations though. Users insist that LTE networks be fast, reliable and available; and those users will often go elsewhere when the network does not meet expectations. Since all user traffic passes through the Evolved Packet Core (EPC), it's at the heart of ensuring high service reliability and availability as LTE traffic increases.

There are some important steps operators should consider as they design an EPC that will keep customer satisfaction high.

LTE SIGNALING STORMS

It's important that mobile operators design the EPC to prevent equipment or link failures from propagating to other nodes in the network and triggering additional issues such as LTE signaling storms and overload conditions that further disrupt user services.

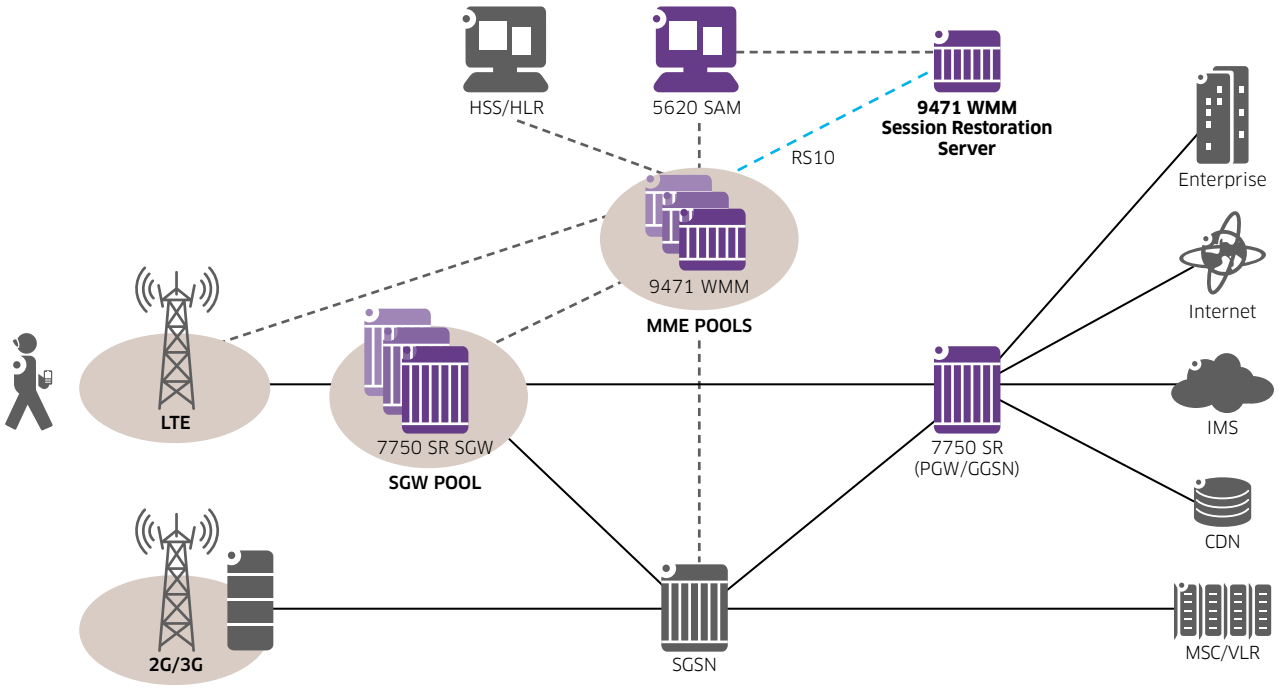
High reliability and availability is especially important in the LTE signaling and control plane so that subscriber sessions for voice or data services are not affected when the **MME**/S4-**SGSN** fails or must restart. But prior to the 3GPP release 10.5, the restoration procedures were not adequate to ensure reliable service. The impact on the LTE subscriber and the network was significantly different if the user was in "Idle" versus "Active" mode.

RESTORATION FOR IDLE USERS

A subscriber in idle mode is not currently in a voice call or active data session. Prior to 3GPP 10.5, if an LTE subscriber in idle state was connected to the network and assigned to an MME/S4-SGSN that subsequently failed (or restarted), that subscriber might not receive any services for an extended period of time. The network would not have sufficient device information nor the restoration procedures in place to "reattach" the device to the network. This could have serious subscriber consequences and be a source of major customer dissatisfaction.

Fortunately, members of the 3GPP CT4 working group led changes to Network Terminated Service Requests (TS 29.274) and to the Core Network and Terminal Restoration Procedure technical specifications (TS 23.007) that were implemented in Release 10.5 to resolve this deficiency. These updated procedures ensured that the subscriber and the mobile device were reachable, even after an MME node failure.

Figure 1. Alcatel-Lucent 9471 WMM SRS network architecture



* According to findings from research by the GSA (Global mobile Suppliers Association) and **published in its latest Evolution to LTE report** – May 6, 2014.

RESTORATION FOR ACTIVE USERS

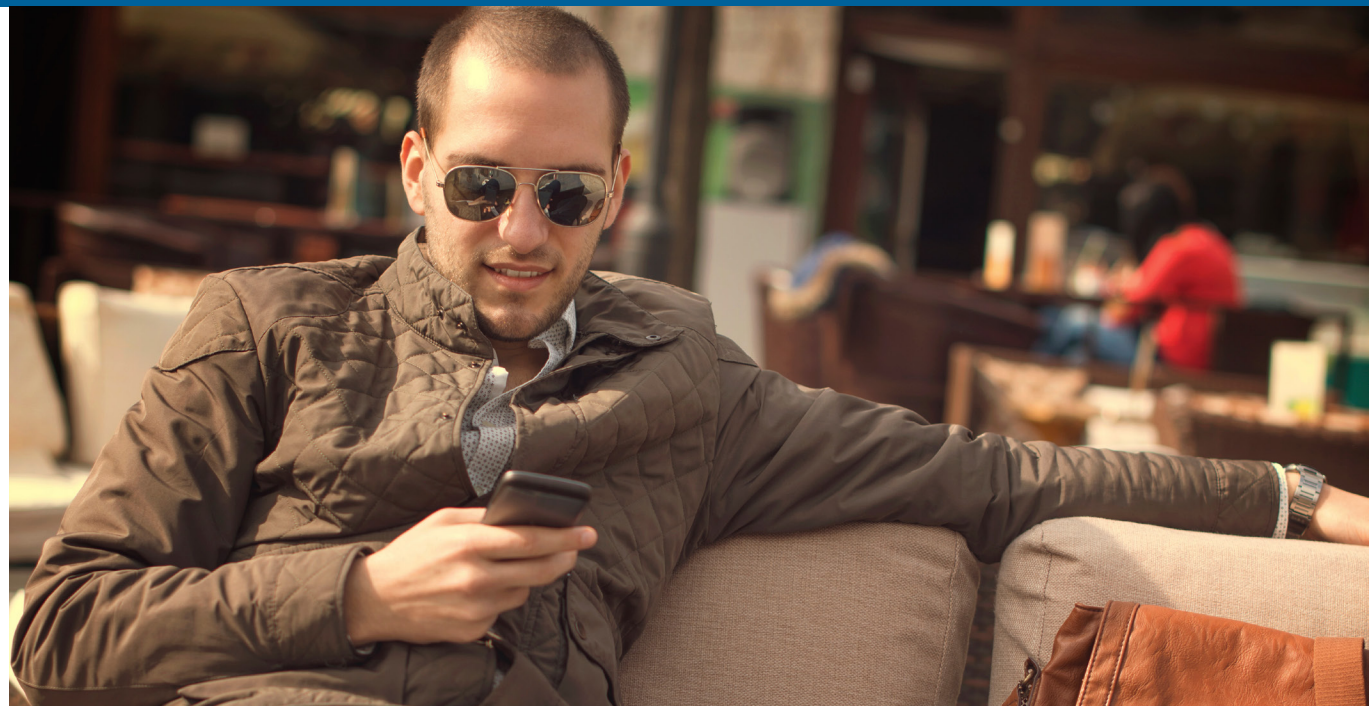
The situation for active users (ECM connected) is equally problematic. In case of MME/S4-SGSN failure, the user's session would immediately drop and the service would terminate.

Before an LTE service could resume, the user must initiate a procedure so that the device can reattach itself to the network (e.g. service request, tracking area update). This could generate an "attach storm" with potentially thousands of LTE subscribers assigned to the failed node simultaneously signaling the network to reattach.

SESSION RESTORATION SERVER

When an MME in the network fails or the link to the SGW fails, the user equipment (UE) context data on that MME and SGW is assumed to be stale and is purged from the node's database. Any LTE/IMS service being used by those users is also dropped. Only when the UE reattaches to the network can the user context data be relearned.

To address this issue, we have developed an innovative Session Restoration Server (SRS) solution. It stores and maintains a database of key parameters of the UE subscriber context data that can be immediately retrieved by the remaining MMEs in the pool.



This means the devices can be paged and the subscriber sessions restored without requiring the UEs to reattach to the network. The benefits of the SRS to the mobile operator and the LTE subscriber are:

- Service resiliency
  - ¬ Provided for either an MME or SGW failure with or without a restart
  - ¬ Achieves restoration of user session with minimal increase in network signaling
  - ¬ Eliminates the need for the UE to reattach to the network
- Dependability
  - ¬ Network originated IMS services (e.g. voice call, video) will not fail
  - ¬ A failed MME does not escalate into a potential LTE signaling attach storm

The SRS is a deployment option of the **Alcatel-Lucent 9471 Wireless Mobility Manager**, a high-performance, scalable MME/SGSN that is part of our **IP Mobile Core solution**.

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