Syniverse Guide to LTE Roaming and Interoperability

Introduction

With LTE now becoming ubiquitous, mobile network operators (MNOs) need a strategy to support global roaming reach and connectivity. For LTE, a best-effort connection relying on the public Internet is no longer credible, given the requirements for delivery of an assured quality of experience (QoE) and quality of service (QoS). The 4G/LTE environment is complex, and LTE roaming and network interoperability requires connection with an IP Packet Exchange (IPX) to help manage IP (Internet protocol) interworking complexity and assure service-level guarantees.

LTE has long ceased to be an exercise in monitoring the number of network launch announcements. With nearly 280 live LTE networks globally as of mid-2014, together with public announcements associated with another 400-plus planned network launches, according to GSMA, LTE has definitely crossed the chasm from early adoption toward being a mainstream technology. With a critical mass of networks supporting LTE services, the focus now evolves from providing domestic on-network services toward expanding network interoperability and launching LTE roaming services. The initial focus is on data-only roaming, but with an expectation that next-generation services including voice (specifically VoLTE) will be accommodated in the near future.

The introduction of LTE roaming also brings the need for an updated infrastructure to support the new services. This includes moving beyond SS7 MAP services to Diameter signaling, establishing new roaming connections, OPEX and CAPEX expenditures, and implementing IPX networks to establish global connectivity and seamless interoperability. This guide is designed to offer additional insights into the challenges and opportunities associated with the migration to LTE roaming.

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1. Global LTE Connectivity and Interoperability Challenges

LTE network interoperability is a significant issue. Due to a lack of consistent spectrum band allocation, mobile network operators (MNOs) have had to build their LTE networks with incompatible spectrum frequencies. The result of this spectrum frequency fragmentation has resulted in the support of multiple frequencies within regions. For example, some MNOs in North America are using 700 MHz spectrum, others are using 800 MHz, and yet others are using 1900 MHz. Spectrum allocation in other regions of the world also varies, with 2,500 MHz used in the Latin America region, while in Europe and Asia, the spectrum range varies from 800 MHz through to 2,600 MHz. Spectrum fragmentation can also cause interoperability issues within different sections of a specific spectrum band.

Region	LTE Spectrum Allocation
Asia	1800, 2600 MHz
Australia and New Zealand	1800, 2300 MHz
Europe	800, 900, 1800, 2600 MHz
Latin America	2500 MHz
North America	700, 750, 800, 850, 1900, 1700/2100 (AWS), 2600 MHz

Table 1: Global Spectrum Allocation for LTE Services

This problem is exacerbated by the fact that there are different flavors of LTE being deployed. Apart from the advent of TD -LTE in China, each network equipment provider might deploy technology using varying technical specifications. This requires rigorous and time-consuming interoperability testing between networks. LTE also needs to be backward compatible with 2G/2.5G and 3G legacy networks (GSM/EDGE, UMTS, and CDMA 1XRTT). There is a requirement to ensure that there are no wholesale traffic flow discontinuities. This ensures that mobile subscribers can continue to receive network coverage in those areas not covered by LTE. It also provides an opportunity for voice circuit switched fallback (CSFB), such that data traffic may be carried over an LTE network and voice traffic carried efficiently on a legacy network.

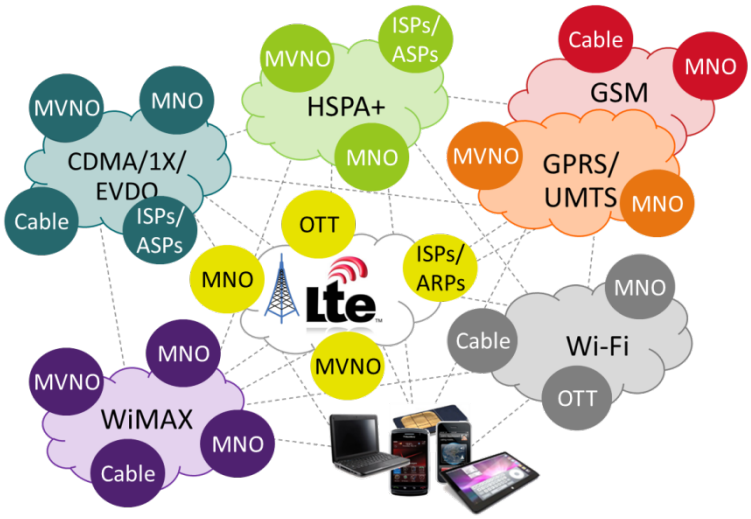


Figure 1: LTE and Increasing Mobile Ecosystem Complexity

2. LTE Roaming and Interworking Infrastructure

Inevitably, the introduction of an all-IP communications network also introduces a new set of network elements in the radio access and core network. A discussion of the new LTE network elements is beyond the scope of this guide. However, some of the elements are introduced below.

The diagram below presents a simplified view of LTE roaming traffic exchange, using IPX for interworking. Other elements to consider in this diagram are Diameter signaling protocol and signaling and data transport.

- **IPX-** IP Packet Exchange is a pivotal network element in LTE, providing network interworking and guaranteed end-to-end quality of service (QoS) – an evolution of GRX/CRX.
- **Diameter signaling protocol -** This is used for authentication, authorization, and accounting (AAA), and it replaces the SS7/MAP protocol in a 2G/3G environment and is used to manage a range of location, subscriber, access, authentication, security, identity management and handover services.
- **SIP protocol -** This protocol is used to establish, manage and tear down user sessions in an IP communications network, and it is an important protocol for the integration of Voice-over LTE (VoLTE).
- **Signaling (GTP-C) and Data Transport (GTP-U):** These are protocols primarily used to set up and tear down a session in addition to communicating charging data between network elements and billing functions.

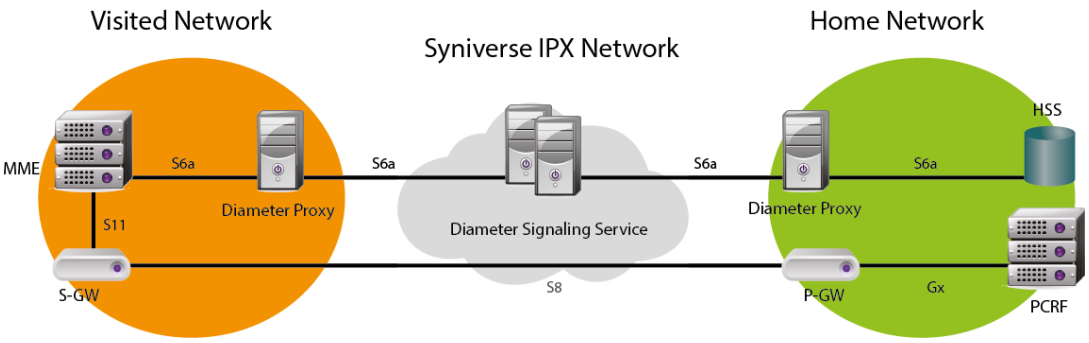


Figure 2: LTE Roaming and Interworking Overview

A common objective for all communication service providers supporting roaming services, whether wireless or wireline, is to be able to deliver traffic to each other efficiently and cost effectively. For LTE, this means adoption of the Internet protocol (IP) as the communications medium.

With the adoption of LTE and the advent of LTE roaming, MNOs are turning to IPX providers to enable reach to multiple roaming and interworking partners with a single connection. IPX is a transparent private IP-based network that provides high-speed, reliable and robust networking services supporting the following:

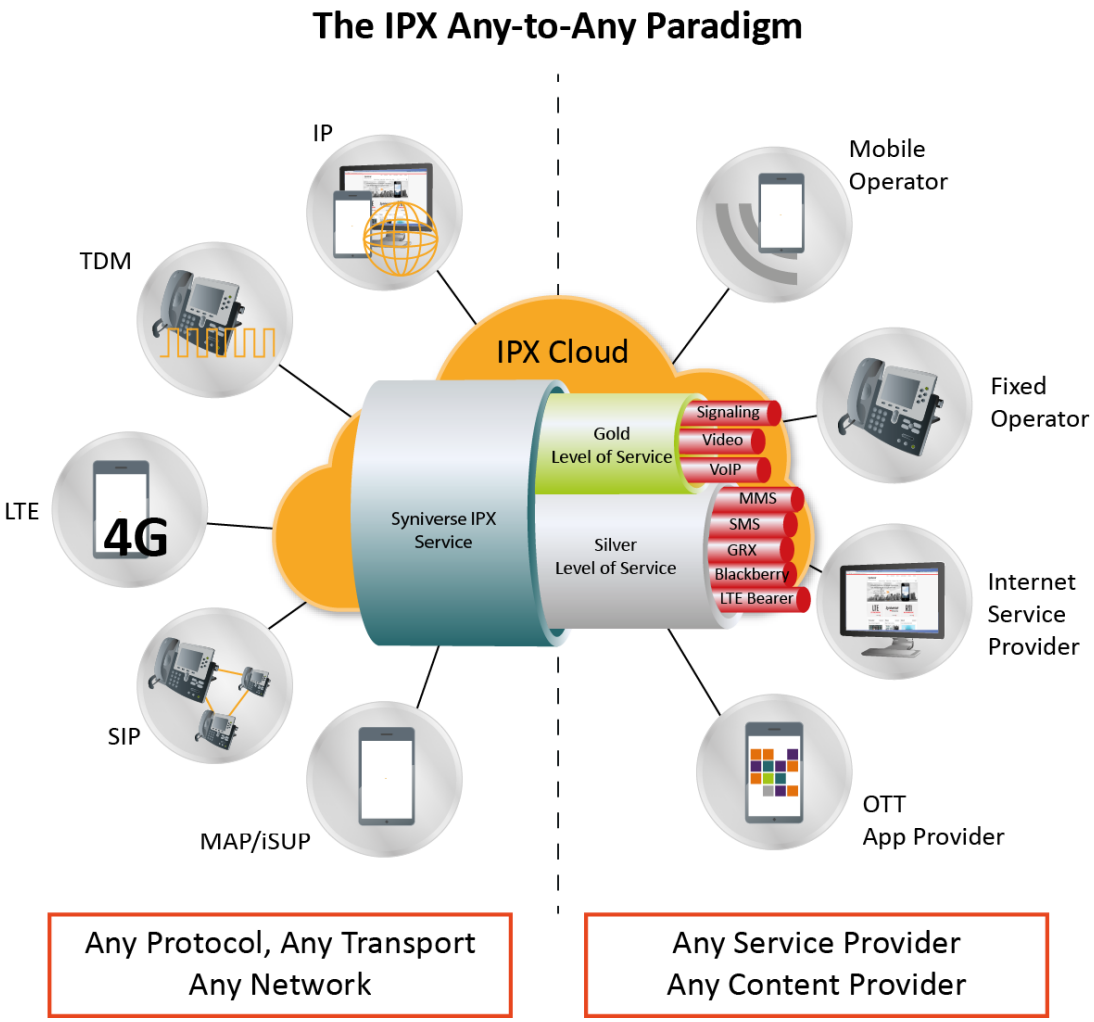
- Connectivity between GSM and non-GSM MNOs and service providers
- End-to-end QoS for roaming and interworking (not supported by all GRX)
- IP interworking based bilateral interworking support for specified services and multi-lateral interworking support for specified services over a single connection

- Support for any IP services on a bilateral basis also with end-to-end QoS.

IPX provides (QoS) levels allowing operators to deliver end-to-end service guarantees and policy-based control of a network's performance measures. This delivers network services at levels established by service level agreements, offering subscribers high-quality service commitments and elevated security.

The implementation of an IPX also provides enhanced abilities to group traffic into categories or classes, based on common service requirements. Unlike the GRX, which limited the flow of data to a best-effort model in which all data packets are treated the same with respect to prioritization, IPX introduces Class of Service (CoS) that allows data packets to be prioritized based on the services they support. An example is the prioritization of voice packets limiting the chances of packet delays resulting in voice jitter.

The following diagram illustrates the service levels supported through CoS.



Use of IPX enables rapid roaming service rollout and market reach, new interworking revenues for IP services, and operational efficiency through multilateral agreements. For roaming services and interconnection scenarios, IPX has clear advantages, making it the solution of choice for LTE roaming and interconnection.

3. LTE and the Commercial Wholesale Environment

Fortunately, with LTE there is likely to be relatively little impact on existing data clearing, invoicing, financial clearing and settlement processes. Charging for data services over LTE is not significantly different to charging for data over 2G/3G, although the concept of QoS-based charging is introduced, and there can be some additional charging parameters based on combinations of data, usage, and duration to consider. For voice roaming services, MNOs will maintain their legacy voice roaming charging and termination principles. LTE charging principles are not likely to be radically different to what exists in the 2G/3G environment. Nevertheless, it is important to be able to address all possible charging scenarios, including origination and termination; home routing and local breakout; IP Multimedia Subsystem (IMS) and non-IMS; and voice service with CSFB and VoLTE.

With LTE, different types of billing accounting records are available, including bearer accounting records, TAP (Transferred Account Procedures) billing records, and IMS accounting records. It is important to be able to identify all possible sources for call detail records (CDRs) in both the home public mobile network (HPMN) and visited public mobile network (VPMN) and how retail billing and wholesale charging can be accomplished. It is also important to define how online charging and offline charging interfaces will be used for all scenarios. As far as LTE support for TAP records, this is already defined from TAP v3.12 onward.

Where challenges might arise is over support for VoLTE, due to correlation issues and possible variations in completeness of TAP data. As with the launch of any new roaming service agreement, the launch of a new LTE agreement requires a launch letter (one each for voice, data and SMS). For LTE definitions, VoLTE includes both voice service and SMS. The GSMA view is that commercial principles should be technology neutral and VoLTE service invocation should be subject to “normal” interoperator tariffs (IOT) for voice service and SMS with a single IOT for these services. As quality of service is a particular differentiator for LTE services, then potential differences in the way that quality of service is managed need to be considered. Another requirement is that charges can only be made for the service element and NOT for a combination of service and bearer.

Some updates should be noted for roaming agreement exchange (RAEX) and operational data processes. As TAP file formats are being used for LTE, there is minimum impact on existing data clearing, invoicing, financial clearing and settlement processes. Near-real-time roaming data exchange (NRTRDE) and invoicing continues as before. New TAP records are used for VoLTE. Despite this seeming smooth continuity, there are nevertheless some issues to consider. Event correlation might be an issue as no single network element will contain all charging elements, so there is no direct equivalent in VoLTE for visited mobile switching center (MSC) in circuit switching. This requires some data correlation from SGSN/S-GW/P-CSCF CDRs and is not a standard or familiar scenario, except for combination of partial records. While the charging ID is available from the P-CSCF to identify each unique call and is also available from the S-CSCF in the home network, this will take time to get used to, rather than relying on TAP files, where information is usually complete to identify calls.

Roaming fraud management processes and NRTRDE are subject to very minor impact. TD.35 (NRTRDE specification) was updated to support data over LTE as long ago as October 2010.As with TAP, only minor, primarily editorial, changes are required to support new network elements (S-GW, P-GW) and new “cause for termination” value. GPRS is not mandatory in NRTRDE, and the GSMA Fraud Forum is not pursuing NRTRDE updates for VoLTE.

4. New Retail Roaming Models

The impact of LTE on retail roaming is twofold. The first impact is tactical and relates to the way that services, such as steering of roaming and Virtual Home Environment are provided. The second impact is more strategic in nature, presenting a significant opportunity to change the way that MNOs interact with their roaming subscribers and manage the roaming experience.

First, the tactical issues will be examined before turning to the more strategic ones. New interfaces have replaced current protocols for many of the value-added services indicated above. These types of services rely on SS7 signaling procedures. In LTE, a series of new interfaces (S6a/S6d [vMME-hHSS], S9 [vPCRF-hPCRF], S8 [LTE roaming] interfaces) have replaced legacy Gr, Gf, D interfaces. S6a, S6d, S13, S13' interfaces are all based on Diameter, so the ecosystem around these services needs to evolve to support multiple services, protocols and scenarios. An example of this is that the circuit switched fallback (CSFB) approach may have an impact on the way that steering of roaming is managed, whether Diameter / MAP interworking may be needed.

As far as the more strategic considerations of the impact of LTE, a new focus is required for retail roaming management in the LTE environment. A combination of tariff transparency, consistent user experience, convenience and subscriber level control are key user requirements needed to unlock LTE data service revenue. LTE deployment also lets MNOs make use of the potential associated with linking together real-time network intelligence, policy management, quality of service, real-time charging and subscriber interaction. Intelligent rate plans, differential pricing based on (QoS) and real-time fraud control all become complementary elements to enable more commercial control to be exercised over service delivery.

As MNOs evolve their LTE/4G offerings, the demand by their subscribers for more data-rich applications increases, developing the need for MNOs to integrate policy controls that can provide predictable service delivery, a better utilization of network resources, and a more defined control of QoS and billing. This so-called "control plane" comprises policy and charging rules functions, (PCRF) as well as traffic and network intelligence, to identify what services are being consumed and understand usage context.

The primary LTE focus for MNOs is data services. Data services require innovative and compelling charging models, beyond simple per megabyte charging. This is where real-time intelligence can prove its value, identifying visiting roamers on the network and providing insights to trigger online marketing and offering roaming data packs that enhance the customer roaming experience, while minimizing the threat of "bill shock."

- **Dynamic Subscriber Interaction** – This helps analyze and segment users, derive optimum price plans, and offer them in real time to roamers, helping to convert low and silent spenders.
- **Tariff Innovation** – An example of this innovation would be a roaming day pack that might be developed for $5 to let subscribers access their company VPN for a day while roaming.
- **Opt-in Roaming** – This includes data plans based on time (day pass), volume (data used), or application (specifying access to a specific list of apps)
- **Customer Self-Care** – This supports re-charge options, advice of charge, bill shock protection, and self-service activation.

Increasing data traffic load on the network is compounded by increasing signaling traffic. As demand for Diameter-based policy management solutions extend beyond basic traffic-shaping and quality-of-experience control (QoE), it is likely that a combination of policy management with real-time charging creates new service opportunities for MNOs to enable innovative marketing and support new business models.

Apart from requirements around real-time service delivery, policy management and charging, LTE is likely to be one of multiple network protocols and network generations, all of which will co-exist, possibly for more than a decade. This requires continuous support for interstandard roaming for LTE, including 2.5G/3G to 4G interworking, as well as CDMA to GSM, or GSM to Wi-Fi, to ensure a seamless roaming user experience.

5. Testing and Launch Options

The LTE interoperability issues highlighted in this document place even more focus on the need for rigorous testing, prior to the launch of any new LTE roaming route. New LTE-provisioned SIM cards need to be exchanged. MNOs need to test LTE roaming against existing roaming agreements. New roaming scenarios need to be considered, including LTE-to-LTE and LTE-to-2G/3G. And new test cases include LTE attach and detach, LTE cancel location and LTE operator determined barring.

As with most decisions on technical services, it is important to decide whether to be directly involved or to work with a 3rd party that can provide resources and expertise. The direct investment in testing and launch as well as the operational costs and opportunity costs have to be taken into account. Outsourcing part or all of the testing process can make a lot of sense. This ensures you engage with experts, working to very clearly defined test project plans, with defined outcomes. For CDMA MNOs migrating to LTE, the requirements to complete pre-launch activity are more demanding than for existing GSMA MNOs. In this case, there are requirements to establish international roaming agreements, learn about GSM procedures and terminology, complete TADIG and IREG tests for voice, data, and CAMEL services, and validate LTE network and billing compliance. A managed service option to complete some or all of these activities can be operationally and financially prudent.

6. What the Future Holds

LTE provides a significant change in both the speed and the nature of mobile connectivity. Low latency combined with much faster data rates means that the impact of LTE technology is likely to be felt across many different segments. LTE will be a key enabler of mass connectivity, connecting information, people and machines (M2M). Roaming is one of a number of issues that need to be considered in the migration to LTE. But MNOs are faced with an array of issues, including the need to deploy new techniques to optimize data volumes across their networks, launch new service combinations, and embrace new partnership models.

Closer alignment between wholesale revenue management processes, including roaming, billing, partner relationship management and financial settlement, creates the need for a common wholesale revenue management platform, with a multidimensional approach to the management and protection of wholesale revenue. Such an integrated platform should combine wholesale process management with wholesale revenue assurance to provide tangible cost benefits in terms of process alignment and efficiency gains. The use of shared data across multiple wholesale management functions ensures a more complementary approach, so that data from separate activities can be combined to provide insights into ways that MNOs can optimize their wholesale business.

With the notion of such a cross-functional wholesale revenue assurance platform in place, an MNO could embrace the value of wholesale business optimization, meaning the ability to enhance revenue and profits, manage margins, and minimize costs. To do this involves a more progressive approach to the use of business intelligence, going beyond standard operational reporting and dashboards to embrace big data concepts that provide detailed analytical and investigative capabilities to link and

correlate wholesale revenue assurance with roaming, interconnection, routing information, and partner settlement data.

7. Syniverse and LTE Roaming

Syniverse is helping MNOs prepare for LTE roaming using our comprehensive LTE roaming test environment, which allows our customers to conduct end-to-end LTE roaming testing via Syniverse's IPX network.

The tests have proven extremely beneficial to the Tier 1 MNOs participating in the trials, resolving challenges that could only be uncovered by putting the network to the test. Fortunately, Syniverse's history in helping MNOs evolve to future technologies and overcome interoperability complexities has enabled our team to troubleshoot and resolve many issues, helping ensure a seamless transition and deployment of LTE roaming. Three key lessons have been learned:

- **Ensuring that signaling is in place.**
  In order for an end user's mobile device to register and be authorized for service while roaming, the home and visited network's Diameter protocols must be able to communicate with each other. Because LTE interoperability is far more complex than legacy SS7 interoperability due to the new network architecture, part of the trial process included network element reconfigurations to ensure that the foundation for LTE roaming was in place.

- **Validating traffic flow.**
  Many issues can arise with LTE that prevent traffic from reaching its destination, which means that although an end user's device shows a signal on the visited network, it won't be capable of completing calls, sending messages or using data. Syniverse's real-time intelligence tool Visibility® monitored traffic as MNOs tested with one another. As a result, Syniverse was able to pinpoint issues undetected by standard testing procedures. Stringent firewall settings and routing discrepancies were found to be the blame for some of the traffic failures, and naturally the issues proved different for each roaming partner relationship. Fortunately, real-time intelligence made it simple to discover and remedy these challenges.

- **Complying with new clearing requirements.**
  LTE roaming requires operators to submit new CDR information to their clearing house in order for the records to be processed and converted into TAP file data accurately. In the testing environment, initial submissions did not include the necessary information, preventing accurate wholesale and retail billing. This shows why it is more important than ever for MNOs to use a trusted intermediary with experience in LTE for clearing and settlement.

8. Syniverse Services for LTE Roaming:

- **IPX and IMS/RCS interworking** – This multiservice network provides access to our full suite of roaming, messaging, network and real-time intelligence services via a single connection.
- **Diameter Signaling Service** (DSS) – This simplifies the configuration of a Diameter Edge agent, manages Stream Control Transmission Protocol associations and prevents a network from being affected by Diameter signaling storms.
- **Diameter Session Controller** (DSC) – This is a server platform that buffers and routes Diameter messages based on routing tables. It can serve as a Diameter proxy or Diameter router.
- **LTE Migration Service** – This is a fully scoped managed service to get your LTE roaming business up and running quickly.
- **Real-Time Intelligence Visibility®** - This service monitors network activity to detect abnormalities and analyze inbound and outbound roaming quality.
- **Interstandard Roaming** – This ensures seamless roaming among CDMA and GSM and LTE.
- **Messaging** – SMS, MMS and NGN messaging.
- **Clearing and Settlement** – Financial clearing, data clearing, NRTRDE.
- **Signaling** (via IP SigTran) – ISUP, interstandard roaming.
- **Network Database Services** - CNAM , LIDB, ENUM, 800, number portability.