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Introduction

The theory of Darwinism has carried over to the mobile world as mobile voice services continue to evolve to keep pace with the changing environment along with user behaviors. We can see this in the dissolving distinction between voice and data plans, with many mobile subscription plans now including a mix of voice and data, and making both billing and revenue allocation more difficult.

Traditional voice services have also endured a fairly moderate downturn in usage, with recent reports acknowledging that voice traffic has fallen from 50 percent to only 5 percent that of data traffic. But voice will not simply disappear. It’s still an essential service for mobile devices and continues to become more attractive as it morphs into the world of IP-based telephony.

In fact, one form of IP-based voice, Voice over LTE (VoLTE), will account for $120 billion in annual revenues by the year 2020, according to SNS Research. This projected revenue from VoLTE can be attributed in many ways to the expanded applications that can be associated to and enhanced with the inclusion of voice services.

VoLTE allows for faster connection and call setup times, a superior quality voice on the level of high definition, and the incorporation of Rich Communication Services (RCS) that integrate voice into various applications.

What’s more, subscribers are demanding technological advances. With the continuing sophistication of smartphones, operators will need to continually advance their infrastructure to support new services as well as remain competitive by lowering costs.

VoLTE, whether it be via roaming or interconnect, offers operators the ability to become more efficient by consolidating equipment, spectrum allocation, and usage; providing new high-quality services that further induce revenue generation; reducing subscriber churn; and ultimately bringing greater efficiency to their business.

In this guide, we’ll examine VoLTE and explore services for VoLTE interconnect and VoLTE roaming. Specifically, we’ll focus on VoLTE roaming and facilitate a better understanding of this application by better defining its benefits, advantages, and challenges.
Market Movement Toward IP-Based Mobile Services

With the rapid adoption of 4G-based LTE networks by global operators, the opportunities for the continued development of IP-centric mobile devices and the applications that run on them have grown exponentially. According to the GSA, this growth reached 537 commercially launched LTE or LTE-Advanced networks in 170 countries. The GSA forecasts 560-plus commercially launched LTE networks by end 2016.

Revenues for LTE will **soar** as high as **$997** billion by 2020, with a projected **CAGR of 58.2%** from 2013-2020.

Allied Market Research
The number of global voice over LTE (VoLTE) subscribers will exceed 1 billion by 2020

While the number of LTE deployments begins to level off in developed countries as a result of almost 100 percent adoption, the implementation trend will continue an upward trajectory for developing countries. LTE deployments in developing countries provide operators with an opportunity to bypass aging technologies, such as 2G and 3G; skip the costly infrastructure costs of implementing intermediary networks; and instead focus on new and even next-generation device and network support.

LTE network deployments, based on IP, open additional doors, including developing future and next-generation services. Mobile network operators and device manufacturers have shifted gears to focus resources and development around next-generation technologies. According to the GSA:

- There are 126 operators are investing in VoLTE and enabling an HD voice experience for LTE users.
- There are 370 VoLTE-capable devices (including carrier and frequency variants), including 342 smartphones announced and offered by all the leading vendors.

As these new technologies take a stronger foothold, the eventual shift toward supporting a single network is becoming more of a reality. The allure of the potential cost savings resulting from maintaining one 4G/LTE network is strong, but the full benefit of this may be years off since 3G will remain a relatively solid mobile network platform through 2020.
Why Should Mobile Network Operators Consider VoLTE Services?

As with previous trends to move communication services to IP, mobile operators around the globe are in a position where they need to consider the transitioning of their voice services to IP using VoLTE. As the case for VoLTE continues to evolve, those mobile operators that have yet to research or implement VoLTE services need to consider the potential impact to their business. In addition to improving the subscriber experience, operators need to also consider various other factors.

These include the following:

**Revenue Loss**

- Greenfield and 4G-only operators are springing up everywhere and are looking for partners that can serve their subscribers while roaming.
- With not having a VoLTE solution, there is a risk of losing potential new revenue streams with expanding roaming partnerships.

More than half of the countries with a live 4G network are in the developing world. The growing number of LTE rollouts in these markets is driving rapid migration to mobile broadband in the developing world.
Maintain Balance

- Core services are getting commoditized, and operators need to offer improved technology and service enhancements to differentiate their offers.
- Operators face losing voice revenues and loss of subscribers if a competing operator offers those services within the serving area.
- With competitive price compression to keep existing subscribers, operators have to balance revenues, margins, technology moves, and costs when moving to LTE and all IP-based services like VoLTE.
- There is a need to streamline and build RAN efficiencies to enable a mobile operator to rapidly move subscribers from 3G to 4G services as well as free up spectrum for LTE or support more voice calls over LTE, compared to voice calls on 3G.

Stagnation

- Not moving forward with a VoLTE offering can make an operator be perceived as not being innovative or forward-thinking.
- An operator can become perceived as a last-choice route or low-quality route because of the inability to provide high-quality voice or video services.
- Negative perception can exponentially impact continuing declining voice revenue.

Infrastructure Investment

- The need to invest in the necessary infrastructure components to support VoLTE services is critical.
- With voice services now sharing the “pipe” with other data services, like web browsing, video streaming, and social media, the ability to manage the speed, quality, volume and Diameter signaling associated with VoLTE is critical to providing a positively differentiated experience.
- Supporting two networks, both 3G and 4G, can be both resource- and cost-intensive.

Competition

- Users are reacting with enthusiasm for over-the-top (OTT) services that not only provide voice services, but also integrated video and messaging.
- Not having a solution puts an operator at risk and not being able to attract subscribers as it transitions to IP services.
- With VoLTE, operators can gain preferred roaming partner status with other operators.
- VoLTE’s ability to offer high-quality voice and faster call setup time solves significant operational challenges for operators; at the same time, it enables more spectrum to be allocated to LTE to meet the increasing demand for mobile data services.
VoLTE Interconnect vs. Roaming

Before moving further into the specifics of VoLTE roaming, it’s necessary to understand two current service types: roaming and interconnect.

Both the terms “interconnect” and “roaming” are not new to the mobile telecom community, but they have created some confusion as far as how they pertain to VoLTE. The distinction between the two is quite significant, but can easily be defined.

VoLTE interconnect is simply a subscriber calling another subscriber on a different network. More specifically, the action of interconnect is a non-roaming method where two VoLTE subscribers of different network providers place a call, video session, or media session to one another in their respective home markets. The interface designation between partner networks is called IMS Network to Network Interface (IMS NNI).
For the purpose of comparison, if we look at non-VoLTE interconnect service, a call, video or media session has to typically run through multiple operator networks to facilitate the connection to a specific destination or destinations. The prime difference between non-VoLTE and VoLTE interconnect is that the VoLTE session can be handled over just one type of network between two wireless carriers – a secure IP network via IPX.

VoLTE Interconnect

VoLTE Roaming Scenarios

VoLTE roaming, on the other hand, requires the subscriber to move, or travel to another operator’s service area and utilize that operator’s network. VoLTE roaming is also defined by two roaming scenarios: home-based routing (S8HR) and local breakout (LBO).

VoLTE Roaming
VoLTE calls are served by the visited network provider as an LTE data roaming session, similar to the way that internet traffic is handled by utilizing the visited networks evolved packet core (EPC) network. The interface designation between the server and home is called S8, which is where “S8HR” comes from.

Within the S8HR scenario, the home network contains the IP Multimedia Subsystem (IMS) core network, while the visited or serve network does not. Both networks have a relationship to support LTE data roaming, and this same network is used to support VoLTE services for the roamer. The connection for the roamer is tunneled back to the home network from the visited network through the IPX connection.

**Advantages of S8HR VoLTE Roaming**

- S8HR uses the same GTP tunnel as LTE data roaming traffic, so technically it’s faster to deploy than LBO. With the rapid growth and adoption of LTE networks, the S8HR solution has almost instantaneous global reach.
- S8HR uses the same components already in the EPC. This is because IMS is not used in the visited operator’s network. Also, since most roaming calls usually go back to the home country, the home operator can leverage its existing voice infrastructure and operator interconnections to complete calls in a reliable and cost-effective manner. As an example, when a subscriber roams on to a different network and makes phone calls and uses data, the serving network is effectively using the same data or bearer channel that would be used to do LTE data roaming, to enable the services being utilized by VoLTE.
S8HR is seen as data using a specific access point name (APN), and with a specific quality-of-service class identifier (QCI), by the visited operator. The same data interoperator tariff charges can and are being used between roaming partners, and there is no need to modify roaming agreements for IMS services. However, operators can decide to charge differently from normal 3G and LTE data.

For billing and settlement concerns, S8HR uses existing Transferred Account Procedure (TAP) and Roaming Agreement Exchange (RAEX) with only minor changes.

**Challenges for S8HR VoLTE Roaming**

- All of the calling activity is being tunneled to the home network. Lawful intercept and emergency calling must be addressed with S8 home routing in the following ways:
  - For lawful intercept, the home network has visibility to the necessary data, but the visited network may not. Lawful intercept may be further complicated because of various regulatory and geographic reasons.
  - With traffic routed back to the home network, emergency calling is not routed locally. For example, if an emergency number is dialed by a roamer in a visited network, those numbers dialed are being passed to the home network, and the home network is responsible for trying to complete the call. Depending on the subscriber’s location (country), those numbers may or may not properly translate. One interim solution is that operators are falling back to 3G for emergency calling.

- Another limitation of S8HR is that Single Radio Voice Call Continuity (SRVCC) is not available for seamless handover between packet- or circuit-switched voice. If you an operator is on a VoLTE or LTE data session network and has to move off the 4G network to a 3G network, there may likely be problems on the call handoff. The extent of the roaming partner’s LTE coverage will need to be considered when making the decision to use VoLTE roaming.

- There is limited service visibility for the visited network:
  - The only options for distinguishing data traffic from VoLTE are via the APN and QCI.
  - SMS is now being enabled via signaling and is no longer an SS7 transaction; it’s now an SIP Diameter signaling stream.
  - The home operator cannot issue retail bills based on TAP records, because the VoLTE call appears in TAP as data in megabytes for voice calls, video sessions and messages. IMS records within the home network must be used to determine the call information needed to retail-bill by minutes of use (MOUs). The home operator must use the charging ID if it wants to correlate its retail charges from the IMS records to its wholesale charges from TAP. Further, there has to be a determination how those megabytes can be extracted into buckets, such as for voice calls, videos, or file shares. A significant amount of correlation and aggregation has to occur in order to do what is accomplished through 3G networks.
Local Breakout

With local breakout (LBO), the serving network and the home network both have an evolved packet core IMS that is deployed.

Within the local breakout VoLTE roaming method, call control and bearer components are served by the visited network provider’s call and process servers designated for IMS, also known as an IMS core. The voice bearer can be handled by the visited market network or home market network. This is typically negotiated between the two parties. Both the serving network and the home network have an evolved packet core IMS deployed, and the interface designation between the two networks is called the IMS Roaming NNI or network-to-network interface.

What this means is that both the visited network and home networks can communicate with each other via IMS, connected by an IPX network with support for Diameter signaling and additional IMS controls for interoperability problems for S8HR and LBO, VoLTE-Wi-Fi handover, special routing, white and black listing, and call quality.

Advantages of VoLTE Local Breakout

Since both the home and the visited networks are using IMS, there is more visibility into the control plane and media plane aspects of a call or video during the session. This offers varying levels of prioritization based on the type of data.
Local breakout provides full ability to offer lawful intercept and emergency call handling. The visited network IMS core provides access to local signaling and content and media that may be required by local law enforcement agencies. Local breakout better supports emergency call handling. The visited network IMS core has visibility of the dialed digits and can satisfy the use case for correct dialed digits regardless of geography.

Single Radio Voice Call Continuity (SRVCC), the handoff from the IMS network to the 3G network, is possible, so there is continuity of a voice call when moving between LTE and circuit-switched networks. Circuit-switched networks will be around for the immediate future, so it’s critical to continue to support handoff from LTE to legacy systems. With local breakout, there is support for retail billing models through TAP. The visited network has visibility of the call information using its IMS records. Therefore, TAP records can be created to reflect MOUs.

**Challenges for Local Breakout**

While much more powerful and flexible, local breakout brings more complexity to the implementation and support for VoLTE roaming. One issue is interoperability between the home and visited networks that are located globally. For example, the design and deployment of IMS cores within networks and variations on implementation and configuration will occur between networks.

The implementation of a local breakout scenario presents a new interface, and with that comes the need for multiple feeds from many network elements for both visited and home operators. From a network perspective, an IMS core can introduce up to 25 new elements, specifications, or interfaces that may be built by a vendor based on its interpretation of the standards. Each vendor could have its own interpretation, which can create complexities.

For billing, there isn’t just one CDR to obtain the needed information as there is in 3G. Operators need to get the information from multiple network elements and correlate them in order to create one TAP record. Likewise, the home network cannot just use one CDR. It also has to get the information required for retail billing from multiple network elements and consolidate that into one record.

Operators may choose to implement home routing for data, but local breakout for voice. In the case of VoLTE, voice can be handled via local breakout, but the data is still handled by the same path that handles LTE data. This “hybrid model” adds additional complexity to both implement and support.

The TAP record was updated to support VoLTE in 2012 with version 3.12. This version added two new TAP record fields including the mobile session record for VoLTE and the messaging event record for messaging. These new record types will need to be supported by both roaming partners in order to be able to use TAP and facilitate both wholesale and retail billing.
## Challenges and Solutions

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<td>Fragmentation between S8HR and LBO</td>
<td>Until IMS implementations become more ubiquitous, S8HR will be the predominant choice for most operator because it is faster to deploy and has less commercial negotiations required. LBO will grow with the increase in IMS implementations.</td>
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<td>Latency in VoLTE roaming</td>
<td>This is more of a problem with calling local numbers, because it is routed to the home network from the visited network and then back.</td>
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<td>Financial clearing and costs</td>
<td>Financial clearing is based on TAP for both S8HR and LBO, creating no difference in financial clearing costs from current voice roaming services.</td>
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<td>VoLTE charging</td>
<td>The operators that have already implemented VOLTE roaming are basing their wholesale rates on data – not minutes. Retail charging can still be based on minutes of use since the call is routed through the home operator’s IMS core.</td>
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<td>Requirement for near-real-time roaming data exchange (NRTRDE)</td>
<td>VoLTE local breakout will not even be supported by NRTRDE because all of the information to combat fraud is already available in the home network in real time. If operators are exchanging data records in NRTRDE (optional today), then S8 home-routed records would also be exchanged, but this is entirely optional and only exchanged when agreed upon between the roaming partners.</td>
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<td>S8HR support for enhanced 911</td>
<td>According to the GSMA REVOLVER, the solution for enhanced 911 over S8HR is to fall back to 3G for emergency calling.</td>
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<td>Bandwidth increase with VoLTE network</td>
<td>Bandwidth increase is dependent on the bit rate of the codec, busy-hour calculations, and MOUs per month. For example, for AMR WB at 12.65 kbps, a VoLTE call would take around 44 kbps with overhead. This equates to 22 concurrent calls per 1 Mbps (assuming 100 percent utilization).</td>
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<td>Inbound requirements for lawful intercept</td>
<td>Some countries are making inbound lawful intercept a requirement, and those operators are reviewing their options. In other regions, operators are stating that if they don’t have the records to provide, they can’t be held accountable. Others are exploring the ability to retrieve records from the serving gateway.</td>
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<td>Guaranteeing the quality of service for voice on an S8 home-routed scenario</td>
<td>Moving to an IPX network guarantees quality of service as well as class of service.</td>
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<td>VoLTE roaming migration in Europe</td>
<td>With the current voice codecs, and the current maximum wholesale and retail charges, the S8 home-routed model will be a lot less expensive than local breakout per minute voice call. EU operators with a lot of inbound EU roaming would get much more revenue from local breakout and 3G than they would from an S8 home-routed model.</td>
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Conclusion

The consensus among today’s global operators is that VoLTE roaming, in addition to Video over LTE (ViLTE) and Rich Communication Services (RCS), will make a significant addition to their all IP-based mobile services. The issue involves determining which implementation model, S8HR or LBO, will be the most appropriate solution for their operations and their subscribers. Both models have differing technical implications as well as the need for cross-organizational buy-in by the roaming and strategy teams.

Ultimately, mobile operators will need a supportive foundational interface that will create a secure and capable interconnection. An IPX connection is a suitable solution to provide the any-to-any connectivity to interwork multiple operator networks irrespective of the implemented roaming approach. An IPX connection will help to reduce the complexity of interconnecting different VoLTE roaming architectures, but it is also equipped to better manage regional connectivity. This improves call-routing efficiency (with the addition of ENUM services) and provides the ability to support data streaming with high levels of quality and class of service.

For additional information on VoLTE roaming, please listen to our webinar, in which VoLTE roaming and our lessons learned are explored.