



SIMPLIFIED VOLTE ROAMING

FROM DREAM TO REALITY



metaswitch

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INTRODUCTION

Voice over LTE (VoLTE) is one of the most significant evolutions to have hit the voice world in many years, finally migrating one of the last bastions of traditional circuit switched calling to an IP based service. The migration is not without its issues however, requiring the deployment of a potentially complex infrastructure in the mobile network (known as IP Multimedia System or IMS) together with the skills enhancements required among the technical staff in those networks.

Although 4G or LTE has been deployed quickly by close to 600 mobile operators globally, the migration of voice services to VoLTE is progressing much more slowly, mainly because it is dependent on the upgrade of their voice network to an IMS structure.

If you then consider one of the key benefits of a globally integrated network structure – the fact that your smartphone works smoothly wherever you travel – then extending these VoLTE deployments to cover international interconnect and roaming would seem to be a key next step. In fact, that is moving even more slowly as it requires each network to have adopted the IMS architecture and that peering between networks has been established.

This white paper looks at some of the technical reasons for the delays, and addresses some core issues about complexity and how this can be simplified to smooth the path to full global VoLTE deployment and interconnectivity.

Steve Heap
CTO, HOT TELECOM

KEY MESSAGES

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- ✓ **VoLTE roaming is key to future success**
 - ✓ **Initial rollout using S8HR can only be temporary**
 - ✓ **Local Breakout is a minor upgrade on IMS Interconnect**
 - ✓ **Local Breakout with Optimized Media is the goal and provides ideal solution**
 - ✓ **IPX providers can offer value added roaming functions**
 - ✓ **IPX providers can do much to simplify VoLTE roaming**
 - ✓ **Working with leading vendors will ease the transition**
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VOICE ROAMING

THE BASICS

Voice Roaming – The background

Roaming in general has always been a part of mobile networks, providing extended coverage in the home country, as well as service when the customer travels to a distant country. This has been achieved by a rigorous set of technical guidelines promulgated by the GSMA, together with commercial agreements between mobile operators and their international partners not only to make it work technically, but also to support the necessary charging and settlement arrangements between the players.

Prior to the rollout of 4G/LTE, voice roaming followed an essentially simple path. When the phone was turned on in a distant network, the registration processes would signal back to the Home Location Register (HLR) in the home network to confirm that the phone was allowed to roam and that voice calling was supported.

With the phone now attached to the visited network and authorized to make calls, it essentially worked in exactly the same way as any other phone on that network. Domestic calls were routed to their correct destination in country, international calls were routed via the carrier partners of the visited network, and emergency calls or any legal interception requirements handled in the standard ways that applied in that visited country.

To all intents and purposes, the roaming phone was identical to a local phone on the same network. The networks involved need to keep track of usage, obviously, and the exchange of these files of Call Detail Records (CDRs) enabled the home network to bill the customer for roaming calls and also to pay a roaming fee to the visited network.

The visited network pays the international carriers to terminate the call using their normal wholesale arrangements.

Inbound calls to the roaming phone are always routed to the home network first and then on to the visited network using the international carrier partners of the home network.

In these scenarios, these circuit switched calls simply provided basic connectivity at legacy voice quality levels. There are no significant added features or capabilities – the users can talk and separately text, but that is about it!

At the same time, historically, roaming has been very expensive for the end user and still is in some countries. This significant revenue stream was well able to support the complexity of making these arrangements, exchanging records, settlement etc.

However, as IP based applications providing free voice and messaging developed and the regulators, particularly in Europe, looked at the impact of roaming costs on economic development, the retail cost of roaming has reduced to the extent that it is sometimes equivalent to making the same call as if you were in your home network.

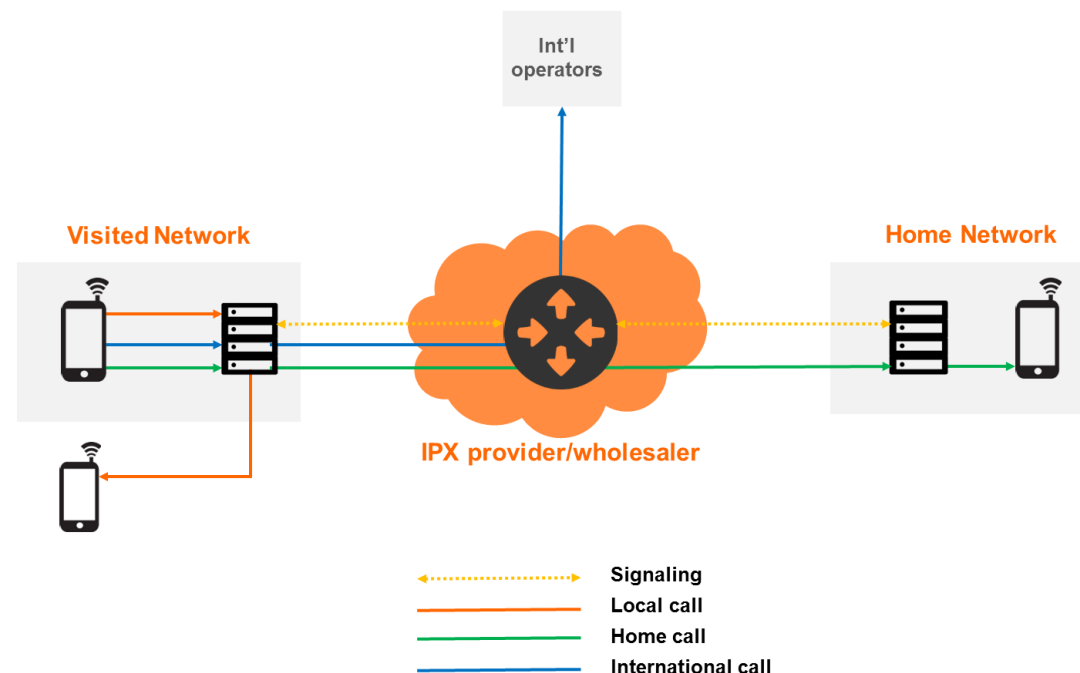
In parallel, smartphone usage has grown enormously and with it, the availability of applications that provide messaging, voice and video calling at no direct cost to the user.

All that is required to make this happen is an internet connection, which could be via roaming data or WiFi, and from there, mobile users can communicate for as long as they like for free, and often with better quality than that “old telephony” connection.

The mobile industry is now facing a major challenge – not only is the revenue from roaming falling from an already low level, but there are

potentially better solutions available at no, or very low, cost. While it is not the case that VoLTE was developed to meet this threat, it is clear that the enhanced features provided by VoLTE, when coupled with commercial models that work, provide a key means of addressing these competitive threats.

3G roaming call and signaling flow



VoLTE – The benefits

Mobile Operators launched 4G or LTE services for a key reason – to provide the high speed internet connection that users are demanding, and are willing to pay for. The range of applications on smartphones is now immense and almost all of them demand some connectivity to perform fully. Video applications in particular demand high speed and reliable bandwidth and LTE provides this.

However, in most cases, voice and messaging, which are key elements of the service package, still require access to the 3G networks as they are essentially still circuit switched in nature, which requires operators to maintain the radio and spectrum assigned to these services.

Moving everything to an LTE connection frees up that radio spectrum for reuse and enables much more advanced services available over IP. So the move to VoLTE is key to operators; from a cost point of view as it enables the efficient use of expensive wireless spectrum, and from a service flexibility capability, as it enables the integration of voice and messaging (with video and other IP based services) into one solution for their customers.

VoLTE Roaming – The challenges

Assuming VoLTE has been rolled out in the home network, what happens when a VoLTE enabled customer roams to a different country and wants to make a call? Today, unless they are in a handful of countries with trials or even fewer with commercial VoLTE roaming service, the handset may well attach to an LTE network and get high speed data service while roaming, but in most other instances, the phone will downgrade itself to 3G, connect to a 3G network and make a standard voice call in the visited network.

All the higher quality and service mash-up features that the customer sees at home are discarded in this approach, commonly known as Circuit Switched Fall Back (CSFB). For the networks, it is easier to implement compared to VoLTE roaming as it makes use of their legacy 3G infrastructure. For the customer, it is just business as usual!

True VoLTE roaming requires a number of key additional aspects, which brings considerable initial complexity. At a minimum, it requires a connection to an LTE network with a good data service. Ideally, this is complemented with much deeper interaction between the visited and the home networks (where the services that this customer can utilize are hosted) in order to access those VoLTE services.

This latter point is essentially known as IMS interconnect or peering, and, as we will see, this brings its own challenges, but also its own benefits. Finally, the wide range of VoLTE enabled devices is itself raising issues as each manufacturer applies its own understanding of the interworking standards to establish what is known as the UNI – User Network Interface.

While operators can ensure that devices launched in the home country interwork properly, confirming that all devices work to all VoLTE/IMS implementations around the world is much more complex.

To explore this in more detail, we will look at how VoLTE roaming has been defined to work.

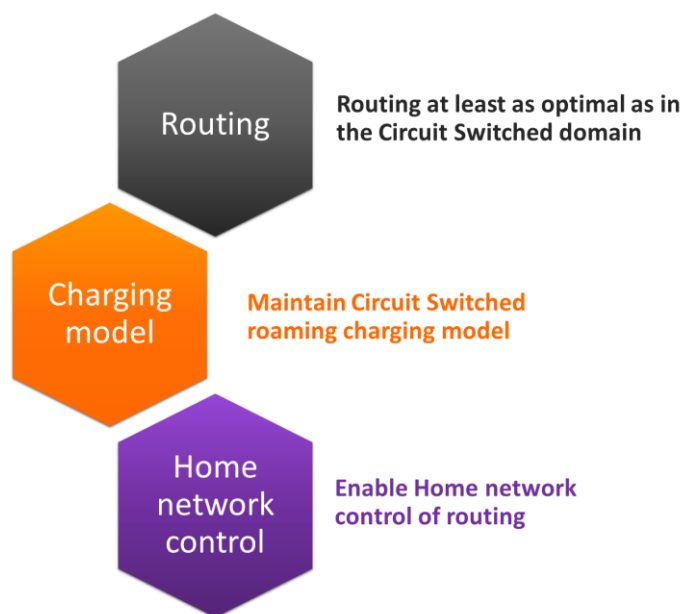
VOLTE ROAMING

THE NEXT STEP

Roaming architecture – The basics

The VoLTE roaming architecture was designed by the GSMA to meet three key requirements:

GSMA key VoLTE Roaming requirements



This architecture developed into the Local Breakout (LBO) design for VoLTE roaming with two variants. These are:

1. Local Breakout with Visited network Routing (LBO-VR, also known as RAVEL): With this roaming option, there is an interaction between the visited network and the home network to establish features and capabilities, with the call

finally being routed by the visited network using its carrier relationships.

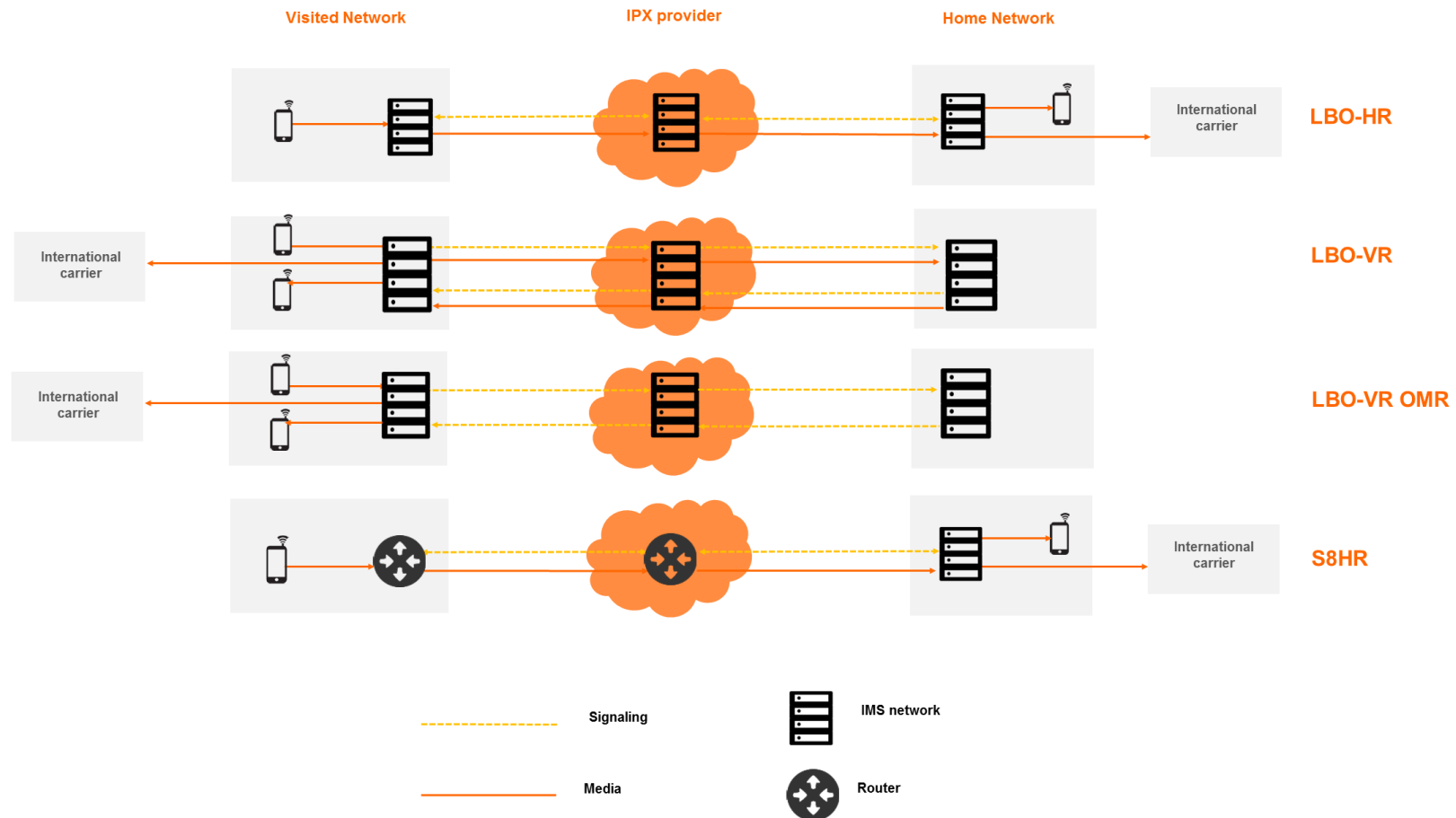
2. Local Breakout with Home network Routing (LBO-HR): In this design, the call is passed by the visited network to the home network and subsequent routing decisions managed by that network.

A couple of key factors underpin the implementation of these two designs however. The first is that VoLTE has been launched in both networks and their IMS systems have been fully interconnected and tested. This allows the interaction between the IMS components of each network necessary to support LBO routing. The second element, which will be discussed later in this white paper, is that local breakout of data services, particularly for IMS call media, needs to have been implemented between the networks.

Based on these pre-requisites, the industry rapidly realized that establishing VoLTE roaming using these architectures would be delayed and so a third approach was developed to allow VoLTE handsets to roam. This uses the LTE roaming data channel to, in effect, connect the handset to the home network and use all the services normally available in that network. This is known as S8HR, with S8 being the defined data interface being used and HR representing “Home Routing.” Although this was perhaps intended as a short-term workaround, it is the main method presently in use supporting current trials and commercial services for VoLTE roaming.

We will now look at the technical, commercial and regulatory implications of each approach.

VoLTE Roaming Routing options



Roaming architecture - Deep dive

Home routing using the S8 Interface

The starting point for S8HR is the need for the roaming customer to connect to a visited LTE network and to acquire the authorization to use data roaming. From there, for voice calls (and other IMS based services) to be connected, the handset needs to establish a path through the data connection traversing the visited network and the IPX and connect to the IMS environment in the home network as though it was locally connected in-country.

All voice sessions are then routed by the home network using its normal carrier interconnects. The media is carried over the data channel to the home network and then onwards to the destination. This does not impact latency for calls being terminated in the home network (which is about 80% of total roaming calls), but any calls being made to numbers in the visited network will be routed to the home country, then via international carriers or the IPX back to the visited network, potentially adding significant latency to the call.

A similar situation occurs for calls being terminated to destinations other than the home or visited networks. The latest standards allow the specification of a higher quality (in terms of packet loss, jitter and latency) IPX service for these voice calls to give them priority over general browsing traffic, for instance, to reduce any risk of congestion or other degradations.

The biggest advantage of this solution for operators is that it is relatively simple to establish. There is no requirement for IMS to IMS interworking between home and visited network (in fact the visited

network does not need to have established VoLTE or IMS at all), and a call can be established as though it was simply locally-based.

Nevertheless, this simplicity comes with some clear disadvantages as outlined below.

Key disadvantages of S8HR roaming option



Emergency calls support can be complex:

Firstly, because the visited network is unaware of what the customer is doing, no locally based information can be used for routing. Although some standardisation work has been undertaken, interworking issues between the VoLTE device and the visited network can arise. In some cases, emergency calls must fall-back to 3G and be routed in the visited network without any supplementary VoLTE information, such as precise location, being available.

In addition, emergency numbers in use in a particular country may not be recognized globally and so the home operator needs processes in place to recognize all potential emergency numbers and route them appropriately.

Complexity of 3G mid-call handover:

If the caller moves out of an LTE area during the call, the handover to 3G is under the control of the home network and is complex and time consuming and may result in a dropped call. Although the GSMA is considering workarounds to improve this, they no longer view this as a viable option because of the level of complexity.

Numbering plan management complexity for locally defined numbers:

Locally defined numbers (such as 800 numbers) must be “decoded” in the home network so that they can be onward routed to the correct destination in the visited network. Similarly, any local short-codes must be handled in the home network, which implies a lot of co-ordination and intelligence gathering about the numbering plan of many different networks.

Challenge to maintain roaming revenue:

Commercially, it may appear to be a “home run” in the sense that no call routing charges need to be paid to the visited network, as they are all routed by the home network itself. Hence, any calls to the home country will either be in-network or local calls, and any international calls will be paid for at low wholesale rates via the home network’s carrier of choice.

However, while this reduces the cost of supporting roaming for their own customers, the operator loses the roaming revenue from people visiting their network and so the net effect will vary and depend on the inbound/outbound roaming profile of each country.

This shift of the business model will need careful monitoring to ensure that all parties feel adequately compensated.

Legal intercept issues:

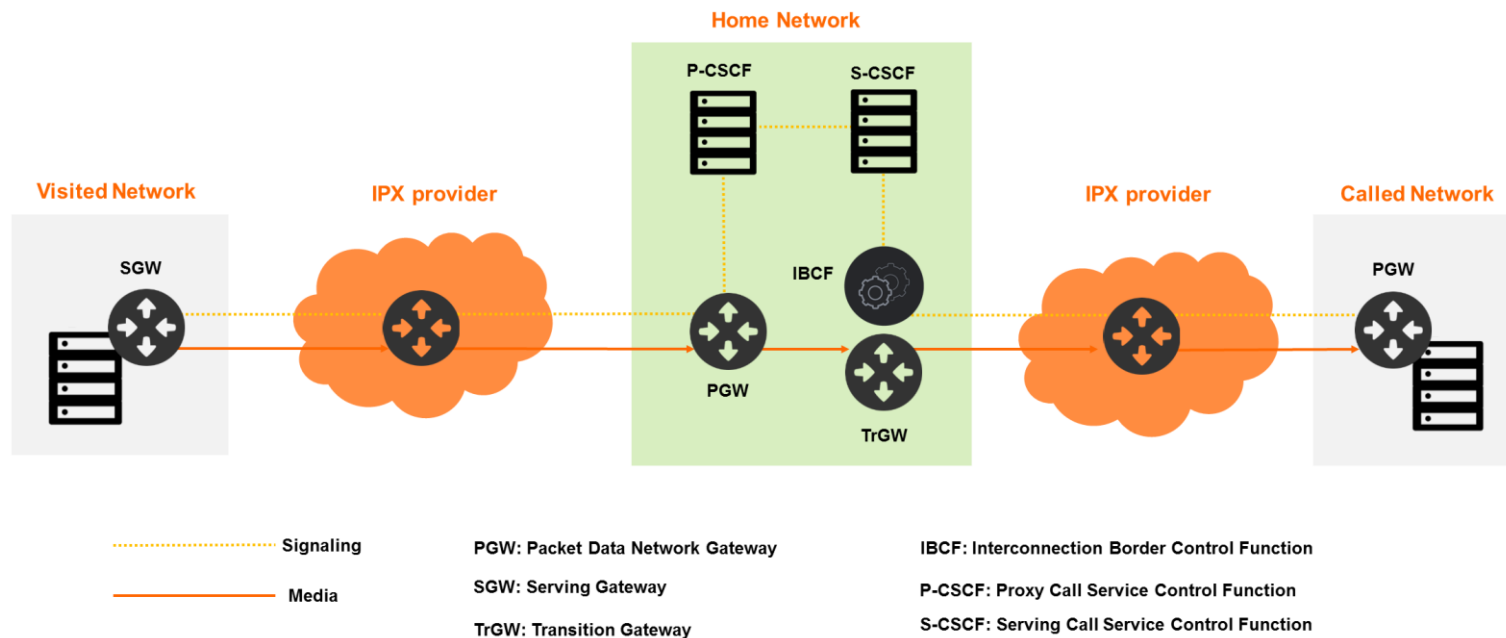
Regulatory issues must be tackled, and may not, in some countries, be overcome. For example, legal interception is one of those complex issues that may cause a roadblock to the implementation of S8HR where the “call” only really starts to exist in the IMS structure in the home network.

Therefore, if someone uses a roaming LTE phone as their main communications channel, how would the local authorities track any call usage on that device? Any encryption that normally is used in a visited network for their own customers must be disabled for these S8HR roaming connections.

This adds to the complexity of implementation and requires considerable co-ordination with roaming partners at the same time as the revenue they may gain from roaming is being reduced.

Although both the GSMA and 3GPP have been working to resolve these issues with various incremental (and sometimes complex) solutions, S8HR is viewed as an intermediate step or a stop-gap, to allow some roaming support whilst LBO matures.

S8HR architecture



Local Breakout

As stated earlier in this paper, there are actually two variants of Local Breakout - Visited Network Routing and Home Network Routing – however as there are a number of similarities between them we will start by describing their underlying principle.

In both variants of Local Breakout, the visited network is aware that a voice call is being established and is responsible for selecting the most appropriate IPX provider to route the signalling (and sometimes the media) to the home network.

As a result, the visited network can ensure that all the normal functions that need to take place in their country are provided: emergency calling, legal intercept, data retention and so on. The first step in the call is therefore to determine the home provider and establish a connection via an IPX to that network.

The actual destination of the call (the B-Party) is provided as a “lower level” address in the SIP header. The Home network receives and processes the call, providing whatever incremental service features the customer is requesting and has access to.

Depending on the policy adopted (and signalled) by the Home network, it can either route the call onwards to its destination (LBO-HR) or loops the session back to the visited network for them to route and terminate (LBO-VR). In principle, that is how it works. However, the devil is always in the detail of the implementation!

The first question is whether the media must automatically follow the signalling and be looped back via the home network? In a basic implementation, this is how it would work, but the addition of functions providing Optimized Media Routing in certain vendor implementations allows the signalling to go to the home network and return to the visited network with the media simply routing out of the visited network to the destination.

Before we delve further into the implementation challenges of LBO for VoLTE, it is worth considering one related topic – local breakout for data while roaming. The traditional approach for data roaming was not the same as adopted for voice.

Data roaming has always taken the data traffic originated and terminated by the handset and routed it direct to the home network, regardless of the website the user is trying to reach. In 3G roaming, this made use of a GRX platform interconnecting service providers, in LTE, the GRX is evolved into an IPX.

Regardless, the handset only is aware of the home network in terms of IP routing and the home network takes care of the forwarding of those packets to the destination server or website and returns the packets to the handset via the same route.

This was introduced primarily for measurement reasons – data was expensive, people may have a limited usage plan, and the home network needs to manage and monitor that usage, providing warnings of overages and being able to bill for roaming traffic.

However, LTE is introducing some real issues for this model, as data usage continues to grow exponentially. Some companies are offering unlimited data plans and extending those to at least some of the countries available for roaming.

As a result, the amount of data being routed over IPXs is growing rapidly, with the resultant cost of providing that routing also increasing, although more gradually. HOT TELECOM estimates that LTE data roaming traffic routed over IPX will grow by 85% in 2017 and by a compound annual growth rate (CAGR) of 42% over the next 4 years.

5G introduces even more critical challenges. Besides the increased speed that is expected, there will also be service offerings with low and guaranteed latency. In this scenario, routing IP packets around the world, to potentially reach a cloud centre in the visited country, will never meet those challenging standards. As a result, local breakout of data has always been on the road map for operators, and the time is fast approaching when it will have to be implemented.

This is well defined in the standards, but does require measurement, management and co-ordination between the operators. The home network often relies on the statistics provided by the visited operator to correctly bill the end user, to pay settlement charges for the use of the roaming service and to track, close to real time, whether the customer is going to exceed any thresholds and hence need to be provided with warnings about overage charges.

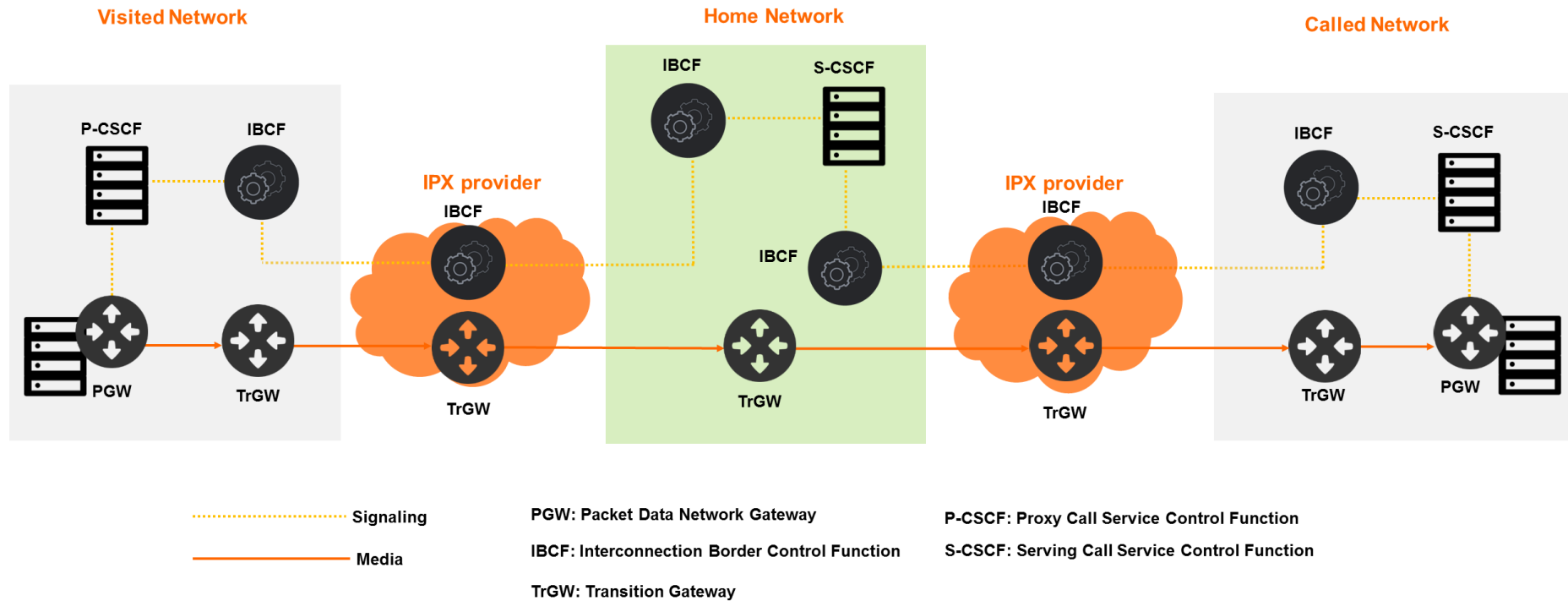
Home routing of data is relatively simple and speedy to implement, and so local breakout for data has not been a key priority to date.

What does this mean for VoLTE roaming? In practical terms, a lot! Without local breakout of data, all a roaming LTE handset can “see”, in IP terms, is the home network. As a result, all data flows there, which means that all signalling and media associated with VoLTE automatically goes there as well.

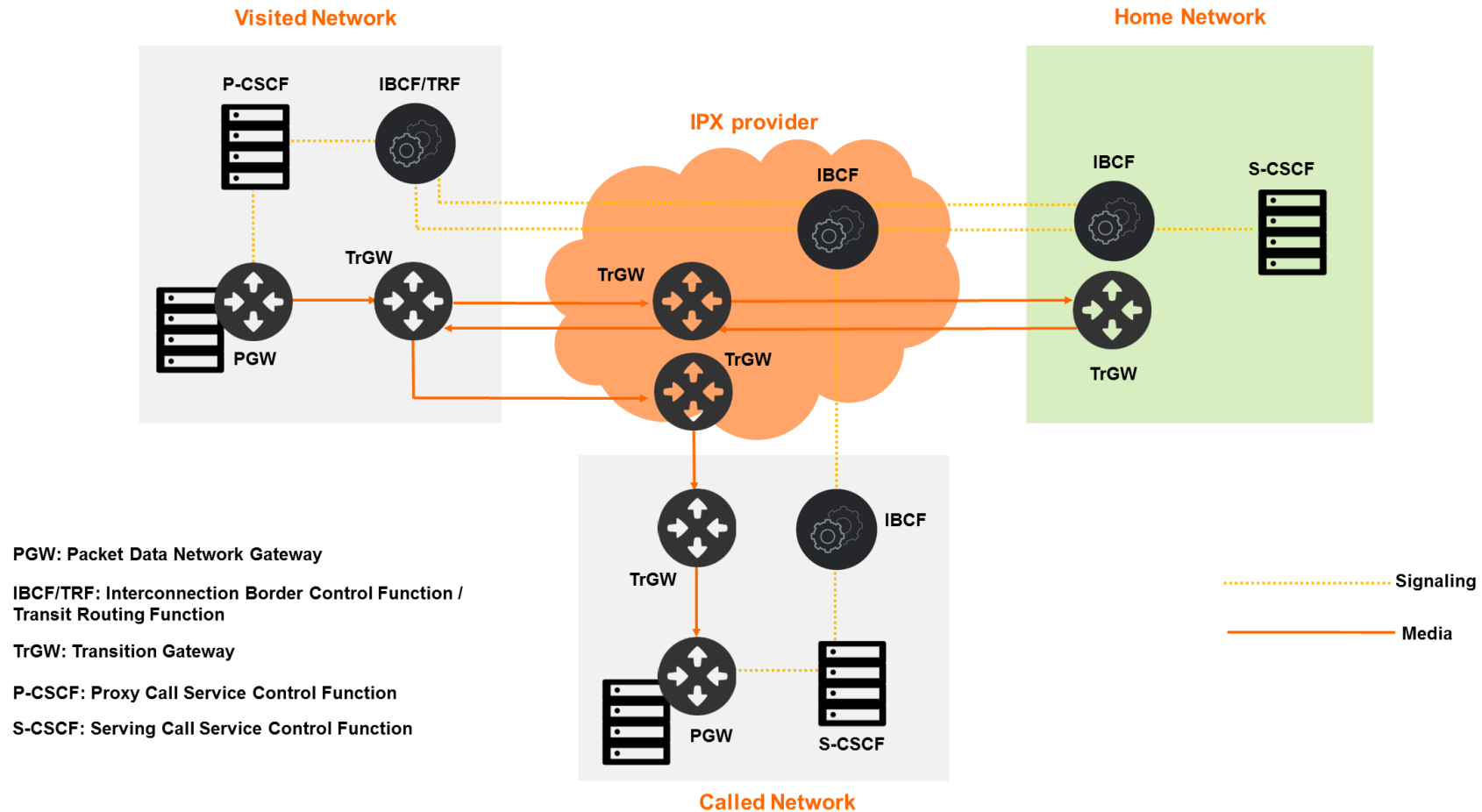
Without local access to an IP network, all calls will by nature be looped via the home network. It could be possible to split out VoLTE data traffic from regular browsing or other IP traffic, but this is complex at a commercial level and has not been tested in depth, and so the end result is that VoLTE LBO follows on from establishing Data LBO.

With that in place, the actual steps of implementing local breakout for VoLTE are not actually very complex as many of the technical and commercial/operational agreements will already be in place. As a result, this should be seen as a relatively minor and obvious step for operators to take.

LBO-HR architecture



LBO-VR architecture



Pros and cons of different VoLTE roaming methodologies

Roaming methodology	Pros	Cons
LBO - VR	<ul style="list-style-type: none">▪ Provides greater options in terms of routing and roaming functions▪ Emergency call and regulatory requirements met▪ Better adapted to the upcoming 5G environment▪ More efficient call routing▪ OMR allows optimal routing of calls from visited network	<ul style="list-style-type: none">▪ IMS UNI (connection to device) can be complex▪ IMS NNI required▪ Requires local breakout of data to be set-up first
LBO - HR	<ul style="list-style-type: none">▪ Provides greater options in terms of routing and functions▪ Emergency call and regulatory requirements met▪ Better adapted to the upcoming 5G environment	<ul style="list-style-type: none">▪ IMS UNI (connection to the device) can be complex▪ IMS NNI required▪ Call Loop-back required for calls to visited country means sub-optimal media routing▪ Requires local breakout of data to be set-up first
S8HR	<ul style="list-style-type: none">▪ Simpler to deploy without much co-ordination▪ No need for IMS UNI or NNI▪ Lower costs for home network for voice calling▪ Home network controls the complete call flow	<ul style="list-style-type: none">▪ Significant emergency calling and legal intercept issues▪ Sub-optimal media routing for some international calls▪ Call Loop-back required for calls to visited country▪ Complexity and likely failure of 3G mid-call handover▪ Numbering plan management complexity for locally defined numbers▪ Potential loss of roaming revenue from other operators

VOLTE ROAMING

SIMPLIFIED WITH LBO

What do we need to do?

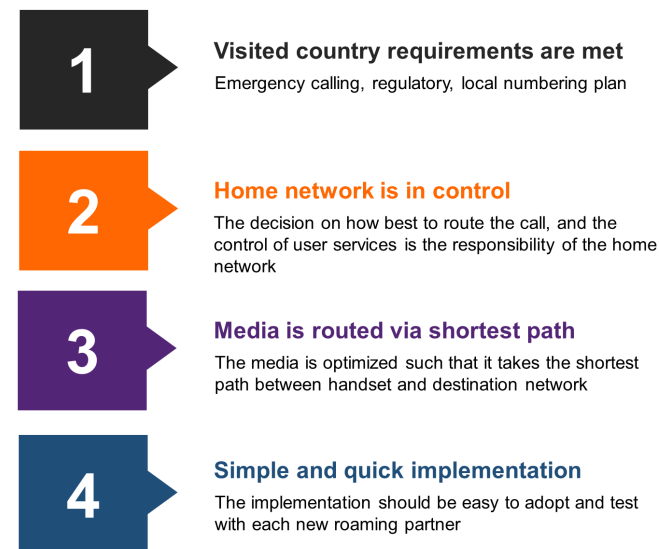
As is clear from our discussion in the prior section of this document, the initial use of S8HR for establishing VoLTE roaming is very much a temporary fix that is surrounded by issues that don't have a very easy solution.

Local breakout, with its capability of properly handling calls in the visited network and meeting emergency and regulatory needs, while still allowing the home network to set the policy for what is routed back to the home network, is definitely the architecture that is best suited for the long term.

However, as we have seen, local breakout looks complicated and time consuming to establish. Therefore, the key input into this decision process should now be – what can the industry do to make this a simpler and easier prospect? Luckily, there has been a lot of work undertaken by device manufacturers, vendors and operators to make the implementation of local breakout a much easier task. In our view, the ideal roaming arrangement would be one where the characteristics outlined in the diagram found on this page would be met.

Looking at these requirements, it is clear that equipment and partners (including IPX providers) must be able to properly utilize Optimized Media Routing (OMR). Recent tests by BT's Research Department have demonstrated clearly that the standards around OMR do meet the need, and the media can be "held" awaiting the completion of signalling to determine the correct path minimizing latency to the destination.

Characteristics of perfect roaming arrangement



This could be in the visited network or one of the IPX providers when non-home routing has been confirmed.

Similarly, those tests demonstrated that initially handling the call in the IMS of the visited network, followed by routing of signalling to the home network to attach service features prior to that network deciding, whether to continue and route the call or return signalling to the visited network for onward routing, also works correctly and efficiently.

These tests also showed that, from the technical standpoint of the IPX provider at least, LBO roaming is not a complicated step beyond the

establishment of VoLTE peering. Most operators already wish to extend the quality and service benefits of VoLTE to their international calls and so the interconnect (or peering) of the IMS architectures of mobile networks via IPXs is already on the road map. Extending that arrangement to support VoLTE roaming is a minor incremental step, both technically and commercially.

The vendor implementations are then a key consideration – many of the leading vendors have virtualized their equipment using Network Function Virtualization (NFV) techniques. This allows the application to run in software on industry standard servers and also to run in cloud server configurations, which opens up the possibility for elements of the home network functionality to reside in a cloud environment in either the visited network and/or the IPX.

This outsourcing of the proxy P-CSCF (the call service control function that applies policy to the call) closer to the origin of the call further simplifies implementation such that an IPX could create the necessary virtual environments that can be shared by all the mobile operators using the IPX for VoLTE roaming support. With the use of OMR, this would significantly reduce the tasks associated with rolling out a new roaming arrangement. Again, this functionality has been tested to be operationally successful in the BT Research Department test environment.

Taking this one step further, one of the first steps to establishing VoLTE roaming is to establish IMS interconnect/peering between the visited and home networks. Although this is well specified in the standards, the combination of the User-Network Interface (UNI) and Network-Network Interface (NNI) options for signalling encryption,

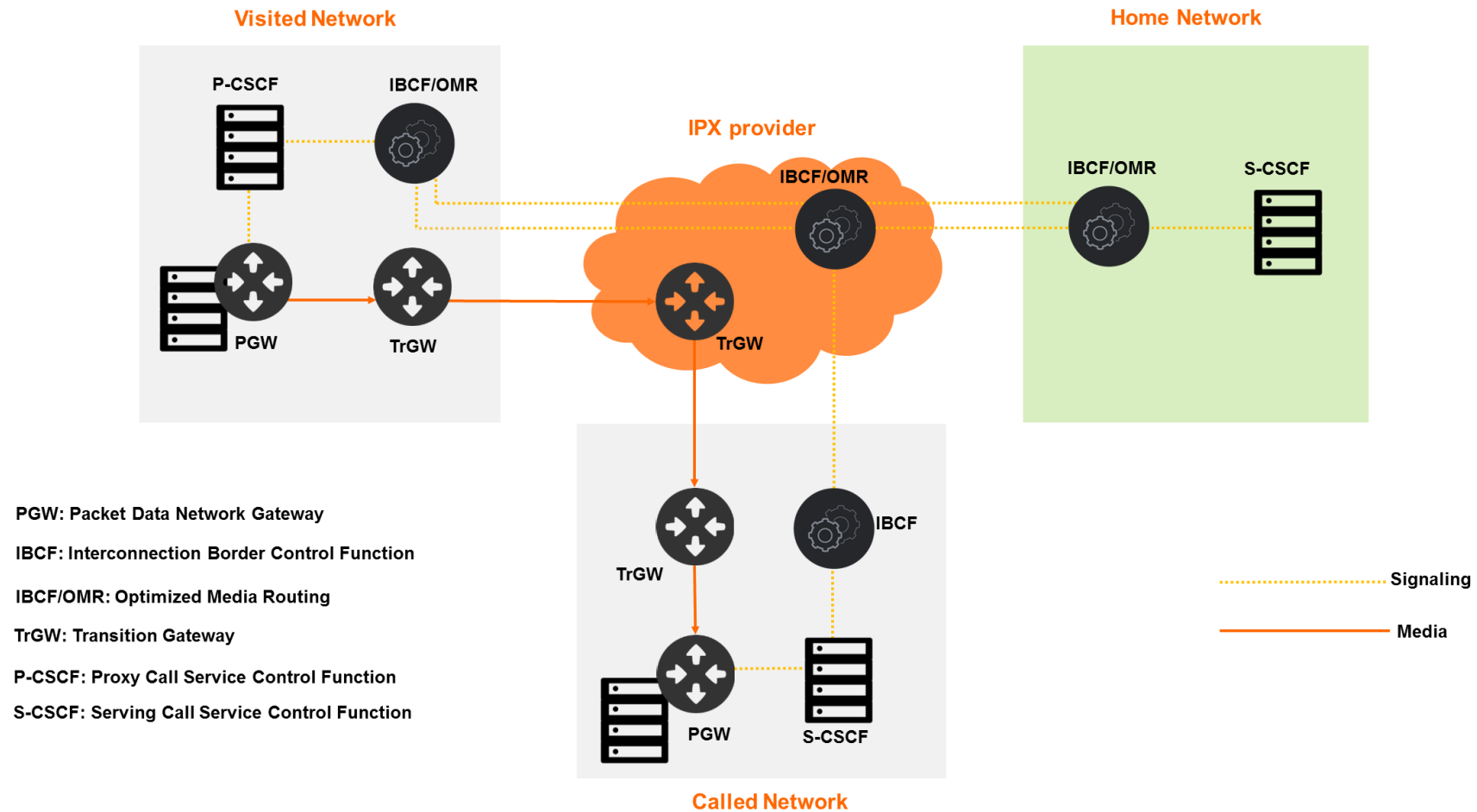
voice and video codec profiles, data profiles, support of circuit switched fall-back (SRVCC), country specific emergency procedures and SIP timers means that testing can be prolonged if done between each pair of operators.

If the IPX providers take on this key role of interworking configuration, such that they establish a working interface with each operator individually and then manage the conversions of any necessary signalling or profiles when interworking between the operators, this will considerably add to the value add of an IPX and simplify the establishment of peering as a key step towards VoLTE roaming.

The final message of this section is clear – VoLTE roaming using the local breakout architectures defined by the GSMA evidently works and has been demonstrated to work as required in the highly detailed BT Research Dept. tests, which used a multi-vendor environment. It is also clearly preferable to S8HR for many regulatory, operational and business reasons. Handset interworking to IMS (UNI) can still be an issue, but BT has trialled both S8HR and LBO VoLTE roaming techniques and is actively working on future-proof roaming architectures.

The availability of compliant session border controllers (SBCs) and related technology from the leading vendors, such as Metaswitch, fully supports the architecture and, with virtualization, can be deployed quickly and cost effectively to support the rollout of LBO across the globe.

LBO-VR 'OMR' architecture



THE METASWITCH SOLUTION

Perimeta – At the centre of the VoLTE solution

VoLTE Roaming should not be complicated. Yet experience from around the globe has shown that this is not the case so far. Various proprietary simplifications, extensions and just differing standards interpretations mean most VoLTE networks are not directly interoperable. It is widely acknowledged that most MNO roll-outs of VoLTE are not interoperable, and the recent South Korean Operator Trials demonstrated major issues with VoLTE UNI fragmentation.

Metaswitch solution, the Perimeta SBC, can do all of this and more. It is designed from the ground up to be a best-of-breed SBC, compliant to the latest IMS architecture by acting as a Proxy-Call Session Control Function (P-CSCF), IMS-Access Gateway (IMS-AGW), Interconnect Border Control Function (IBCF) and Transition Gateway (TrGW).

Powerful message manipulation functionality, coupled with Metaswitch's unique Service Assurance Server provides the ability to see the protocol flows, even when they are encrypted, and quickly implement the adjustments needed to achieve and maintain your peering connections. It also includes the newly required functions, such as preconditions interworking and handling of new 3GPP headers. Functionality like TRF and OMR provides further benefits in deploying VoLTE Roaming, as discussed in this white paper.

In addition to supporting all roaming standards, Metaswitch solution can provide additional cost reduction or revenue increasing opportunities such as offering LBO using only one SBC, or allow IPX carriers to provide hosted LBO solutions for their partners.

Successfully deployed today in live networks in this exactly VoLTE roaming role, it is a proven best-of-breed solution, enabling MNOs or carriers to provide a service that allows their subscribers to roam across borders and maintain all of the benefits of VoLTE end to end.

Perimeta is recognized as the market leader in cloud-native SBCs, and provides a critical function towards the transition to a true all IP, all Cloud, software telcos. Virtualized Perimeta can provide MNO's and carriers the ability to dynamically scale in response to demand, working closely with the cloud orchestration layer to provide new options for managing and sharing idle resources, resulting in TCO reductions, vastly improved resource efficiencies, the ability to turn up new roaming interconnects quickly, and react fast to changing demands.

THE AUTHORS

Metaswitch

Metaswitch is powering the transition of communication networks into a cloud-based, software-centric, all-IP future. As the world's leading network software provider, we design, develop, deliver and support commercial and open source software solutions for network operators.

Our high performance software runs on commercial, off-the-shelf hardware, as appliances or in the cloud. We package this software into solutions that are redefining consumer and business communications and enabling the interconnection between diverse network services and technologies.

We also apply our software development expertise to removing network virtualization complexities in the data centre, with a solution that easily scales and secures workload interconnection in support of mission-critical IT and real-time communication applications.

For more information, please visit: <http://www.metaswitch.com/>

BT

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BT consists of six customer-facing lines of business: Consumer, EE, Business and Public Sector, Global Services, Wholesale and Ventures, and Openreach.

For the year ended 31 March 2016, BT Group's reported revenue was £19,042m with reported profit before taxation of £3,029m.

British Telecommunications plc (BT) is a wholly-owned subsidiary of BT Group plc and encompasses virtually all businesses and assets of the BT Group. BT Group plc is listed on stock exchanges in London and New York.

For more information, visit www.btplc.com



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