INTERNATIONAL INTERCONNECTION FORUM

FOR SERVICES OVER IP

(i3 FORUM)

(www.i3forum.org)

Source:

Working Group "IMS-based services and related interconnections"

i3 forum keyword: Voice, IMS

IMS-Based Services: Technical and Commercial Analysis of International Interconnection and Roaming Services

(Release 3.0) September 2018

This document provides the i3 forum`s perspective on IMS services development, focusing on the role of and the impact on the International Carriers. It does not intend to duplicate other existing specifications or documents on the same issue, but to complement these documents with the perspective of the International Carrier members of i3 forum.

EXECUTIVE SUMMARY

The rise of LTE technology in mobile networks together with the increasing FTTx deployment in the access section of fixed networks have been pushing a strong interest for IMS based services at the international level. These technological developments are paired at the service level by the wide-spread growth of LTE data services and by the deployments in Asia and in the USA, and more recently also in Europe, of Voice over LTE (VoLTE) services with HD voice capabilities.
Further 5G has started to grow and will influence future telecommunications' technology.

In the wake of this trend, i3 forum has considered a priority to deliver a document devoted to describing the current strategic environment, the architectures, the interfaces, the protocols and the related business models to be adopted for the support of International IMS services between two IMS Service Providers or between an IMS Service Provider and non IMS Service Provider adopting, in line with previous deliverables, an IPX model at the transport level.

Among the wide set of IMS-based services, in this second release, in addition to a strong focus on Voice over IMS (encompassing both Voice over IP originated by a fixed network and Voice over LTE) covering both the basic international call and the roaming cases, the scope is enlarged also to Video over LTE (ViLTE) and Enhanced Messaging Services (RCS).

As a result, the document addresses:

1) a short reference of the basic technologies (e.g. LTE, FTTx) which support the evolution towards IMS together with the alternative given to MNOs from OTT-like services;
2) the state of the art of emerging technologies/services such as HD Voice, LTE, IMS/VoLTE in terms of current and projected adoption;
3) a discussion on the Voice over IMS business model, reconfirming the existing Sending-Party-Pays business model with a charging scheme based on call duration/destination;
4) a discussion on business models of other IMS-based services such as Signalling Services and Enhanced Messaging services;
5) a short analysis of the features and capabilities of the hubbing mode between Service Provider and IPX Provider.

The ultimate objective of the document is to provide a unique analysis of the impact on Carriers' / IPX Providers' platforms of the provisioning of IMS based services, giving priority to the Voice over IMS service. The focus is given not only to the selection of the proper standard(s) to be adopted within a comprehensive IPX architectural and commercial model, but also to the discussion of the various alternatives to be dealt with and their related results with respect to the end-to-end service.

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Scope and objective of the document

Over the last years, the rise of LTE technology in mobile networks together with the increasing FTTx deployment in the access section of fixed networks have been pushing a strong interest for IMS-based services at the international level.

The mentioned technological development is matched at the service level by the wide-spread growth of LTE data services and by the deployments in Asia and in the USA, and more recently also in Europe, of Voice over LTE (VoLTE) services with HD voice capabilities.

In the wake of this trend, i3 forum has considered a priority to deliver a document devoted to describing the current strategic environment, the architectures, the interfaces, the protocols and the related business models to be adopted for the support of International IMS services between two IMS Service Providers or between an IMS Service Provider and non IMS Service Provider adopting, in line with previous deliverables, an IPX model at the transport level.

Among the wide set of IMS-based services, in this third release, in addition to a strong focus on Voice over IMS (encompassing both Voice over IP originated by a fixed network and Voice over LTE) covering both the basic international call and the roaming cases, the scope is enlarged also to Video over LTE (ViLTE) and Enhanced Messaging Services (RCS). In terms of call type, both the basic international call and the roaming cases are dealt with.

As a result, the scope of this document is the following:

1) to provide a description in Sec. 3 of the basic technologies (e.g. LTE) which support the evolution towards IMS together with a reference to the OTT's services;
2) to describe the state of the art of emerging technologies/services (Sec. 3) in order to provide a solid commercial background to the discussion of the related business model (Sec. 5);
3) to discuss the architectural framework based on IPX (Sec. 4);
4) to discuss the hubbing capabilities for an IP/IMS Interconnection (Sec. 6).

The final objective of the document is to provide a unique analysis of the impact on Carriers' / IPX Providers' platforms of the provisioning of IMS-based services, giving priority to the voice over IMS service. The focus is given not only to the selection of the proper standard(s) to be adopted within a comprehensive IPX architectural and commercial model, but also to the discussion of the various alternatives to be faced and their related results with respect to the end-to-end service.

In this document, though the interconnection between two IMS-based Service Providers can always be provided by a generic International Carrier, since IPX is the recommended model by i3 forum and GSMA for supporting such interconnection, from Sec. 5 onwards, the terminology IPX Provider is always used for identifying an International Carrier.

Additional information describing EUM between Carriers / IPX Providers or between a Service Provider and its IPX Providers is found in the i3 forum deliverable "*IMS-Based Services: Service Interoperability*" [1].

Symbols and Acronyms

3GPP	3rd Generation Partnership Project
ALG	Application Level Gateway
AMR-WB	Adaptive Multi-Rate Wide Band
BG	Border Gateway
BGCF	Border Gateway Control Function
CSCF	Call Switching Control Function
DNS	Domain Name Service
ENUM	E.164 NUmber Mapping
ETSI	European Telecommunications Standards Institute
FNO	Fixed Network Operator
FTTx	Fiber To The “x” (n=network, c=curb, b=building, h=home)
GRX	GPRS Roaming eXchange
GSM	Global System for Mobile Communications
GSMA	GSM Association
HD	High Definition
HPMN	Home Public Mobile Network
HSS	Home Subscriber Server
IBCF	Interconnection Border Control Function
I-CSCF	Interrogating CSCF
IEEE	Institute of Electrical and Electronic Engineers
Ici	Reference Point between an IBCF and another IBCF belonging to a different IP Multimedia core network subsystem network
IETF	Internet Engineering Task Force
IMS	IP Multimedia Subsystem
IoT	Internet of Things
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
IPX	IP eXchange
IPX P	IPX Provider
ISDN	Integrated Services Digital Network
ITU	International Telecommunications Union
Izi	Reference Point between a TrGW and another TrGW or media handling node belonging to a different IP Multimedia core network subsystem network
KPI	Key Performance Indicator
LBO	Local Break Out
LTE	Long Term Evolution
MNO	Mobile Network Operator
M2M	Machine to Machine
NNI	Network to Network Interface
OTT	Over The TOP
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
QCI	Quality Coded Indicator
QoS	Quality of Service
RCS	Rich Communication Suite
RFC	Request For Comments
RTP	Real-Time Protocol
S8HR	S8 Home Routing
SBC	Session Border Controller
SD	Standard Definition
SIP	Session Initiation Protocol

SIP URI	SIP protocol URI
SMS	Short Message System
SN	Subscriber Number
SP	Service Provider
SRVCC	Single Radio Voice Call Continuity
TDM	Time Division Multiplexing
tel-URI	Telephone URI
TRF	Transit and Roaming Function
TrGW	Transition Gateway
URI	Uniform Resource Identifier
ViLTE	Video over LTE
VoIMS	Voice over IMS
VoIP	Voice over IP
VoLTE	Voice over LTE
VoWifi	Voice over Wifi
VPMN	Visited Public Mobile Network
Wifi	Wireless Fidelity

3. References

[1] i3forum, "IMS-Based Services: Service Interoperability, Release 1, (May 2017)".

[2] i3Forum, "Internet of Things, Release 1.0, May 2017".

[3] 3GPP, "TS 23.228; IP Multimedia Subsystem (IMS); Stage 2".

[4] GSMA, "IR.34; Guidelines for IPX Provider networks (Previously Inter-Service Provider IP Backbone Guidelines)".

[5] GSMA, "IR.65; IMS Roaming and Interworking Guidelines".

[6] i3forum, "Common functionalities and capabilities of an IPX platform, Release 2, May 2014".

[7] i3forum, "Voice over IPX Service Schedule".

[8] i3forum, "Enabling HD voice continuity in international calls, Release 1.0, May 2014".

[9] GSMA, "BA.27; Charging Principles".

[10] GSMA, "IN.27; Interconnection and Interworking Charging Principles, Version 5.0, 8 February 2016".

[11] i3forum, "LTE Data Roaming over IPX Service Schedule, Release 1, May 2014".

[12] GSMA, "IR.92; IMS Profile for Voice and SMS".

[13] 3GPP, "TS 24.341; Support of SMS over IP networks; Stage 3".

[14] i3Forum, "Whitepaper on IPX Transport Service (Release 1.0, May 2014)".

[15] GSMA, "IPX White paper," 2007.

4. Business & Technological considerations in 2017-2018

This section contains market drivers and technology pushes related IMS and its implementations. Specifically, a discussion is carried out on the technologies that enable IMS (fixed and mobile), on the IMS services (e.g. HD Voice and VoLTE) and on possible alternative solutions to be implemented via OTT-like services.

With the increasing development of fiber and 4G access broadband technologies, usage is converging on an all- IP environment, and on data consumption services. This is a structural move emphasized by the development of cloud-based and data intensive services. Further 5G has started to grow and will influence future telecommunications' technology.

On interpersonal communication, massive smartphone adoption and mobile internet growth are offering opportunities for enhanced service experience for voice, video and messaging communication.

In this scenario, IMS is a solution that assures seamless services in this new environment and, as of today, it is becoming a reality since Service Providers (FNOs/MNOs) are deploying IMS fixed and mobile VoLTE platforms, assuring trusted and secure services and native features on LTE terminals.

In addition to the above described evolution path, it is worth mentioning that an alternative stream of evolution has been pushed by the OTT players for the entire suite of communication services (voice, video and messaging). A subsection below discusses the challenges and opportunities posed by this approach.

4.1. Access technologies to IMS

4.1.1. Fixed access

The deployment of Fiber To The Neighborhood/Curb/Building/Home increases Fixed Broadband penetration. This creates an opportunity for operators to converge their services onto IP and simplify their operations. From a service perspective, it facilitates the support of multi-play offers as well as Fixed-Mobile convergence. This means that the migration to IP of TV, telephony and supplementary services can be managed from a single IMS infrastructure.

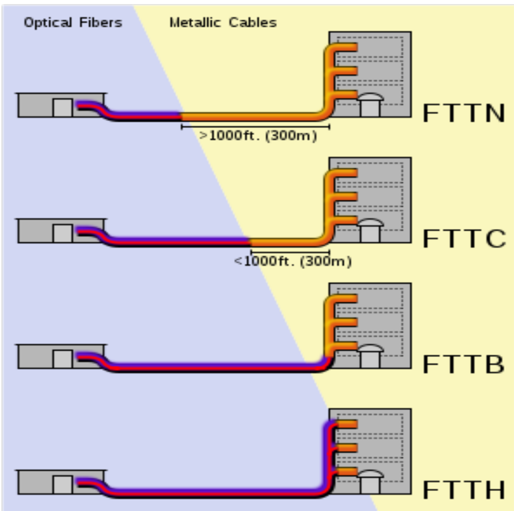


Figure 1 – FTTx topology

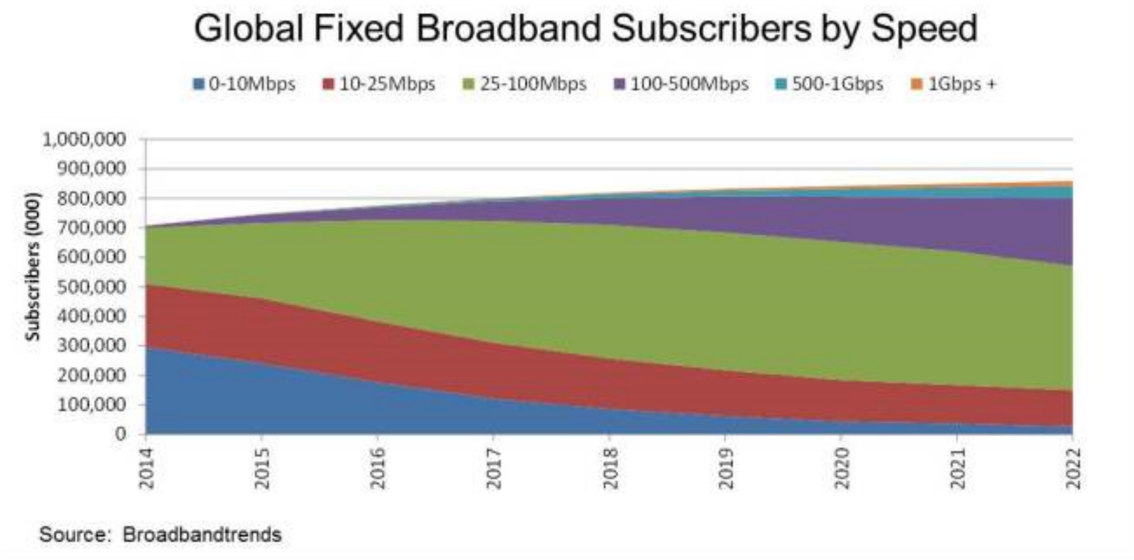


Figure 2 – Global Fixed Broadband Trends

Source: https://broadbandtrends.wordpress.com/2017/01/18/ftth-to-represent-nearly-50-of-fixed-broadband-subscribers-by-2022/

4.1.2. Radio access

Mobile operators are deploying high speed 4G data networks designed to match fixed broadband performance and thus enabling the migration of mobile services onto IMS and make progress in developing 5G.

While 4G has been driving and enabling the transition from the connected consumer to the digital consumer from 2010 on, 5G will play a key role in the transition to the augmented consumer in the longer term. Today's digital consumers are the key addressable market for 5G services. Many of these consumers will increasingly adopt a range of technologies that are expected to benefit from the faster speeds and lower latencies promised by 5G. These include advanced video capabilities (i.e. 4K, 8K, 3D video, 360-degree video for sports broadcasting), applications for gaming and immersive TV, autonomous cars, and digital services and content for connected stadia and smart cities.

5G-based fixed wireless offers a potentially lower cost and faster means – compared to FTTH – of expanding high-speed offerings to households and businesses, bringing the opportunity to gain market share and incremental revenue.

In 2019, 4G will become the leading mobile network technology worldwide by number of connections (more than 3 billion). Meanwhile, the mobile industry continues to make progress with 5G, including successful trials around the globe and the approval of the non-standalone 5G new radio specifications in December 2017.

A number of mobile 5G commercial launches are expected over the next three years in North America and major markets across Asia and Europe. China, the US and Japan will be the leading countries by 5G connections in 2025, while Europe as a whole will continue to make progress with 5G deployments. By 2025, two thirds of mobile connections (excluding IoT) across the world will operate on high-speed networks, with 4G accounting for 53% of total mobile SIMs and 5G at 14%. Source – GSMA 2018.

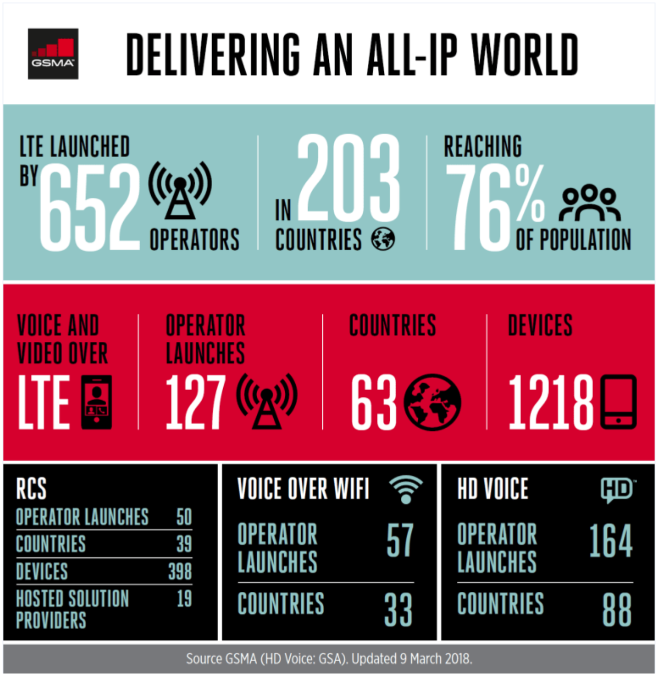


Figure 3a – Global LTE Coverage – GSMA 2018

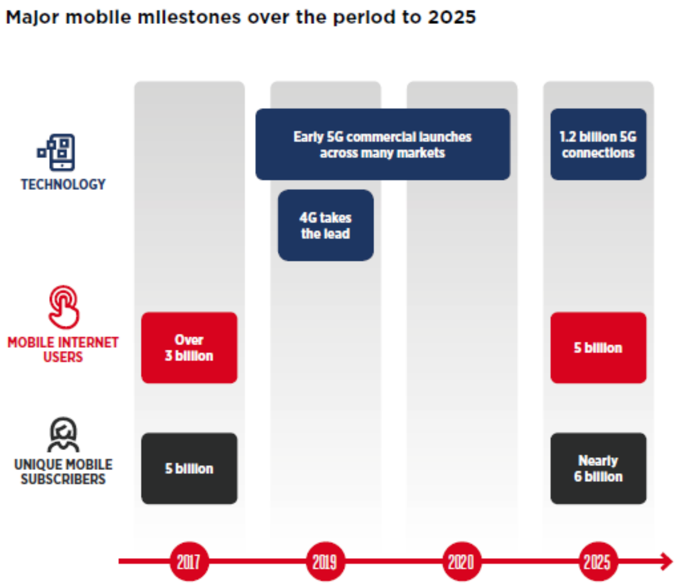


Figure 3b – 4G vs 5G – GSMA 2018

Despite its impressive growth, the deployment of domestic homogeneous LTE coverage and performance is still a challenge:

1. The average LTE cell coverage has overtaken 3G already, 5G is starting growing.
2. National geographical characteristics and radio network topology impacts the level of effort required to provide quality LTE coverage which matches that of legacy technology.
3. As LTE access drives increased mobile data usage, areas with high population density can create congestion, which significantly degrades the performance of the network and user experience.

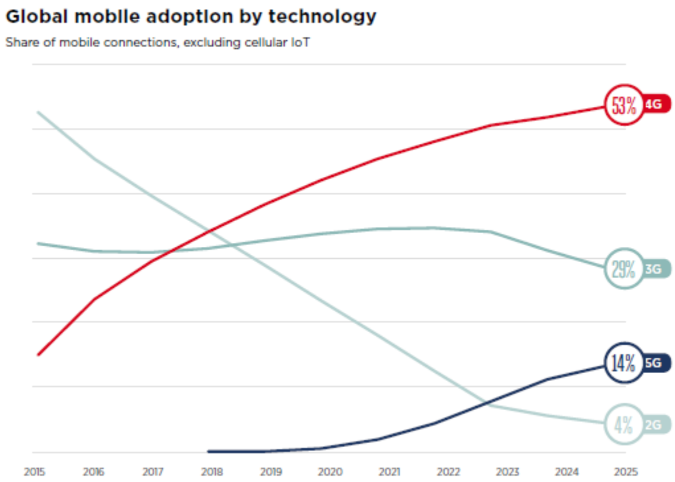
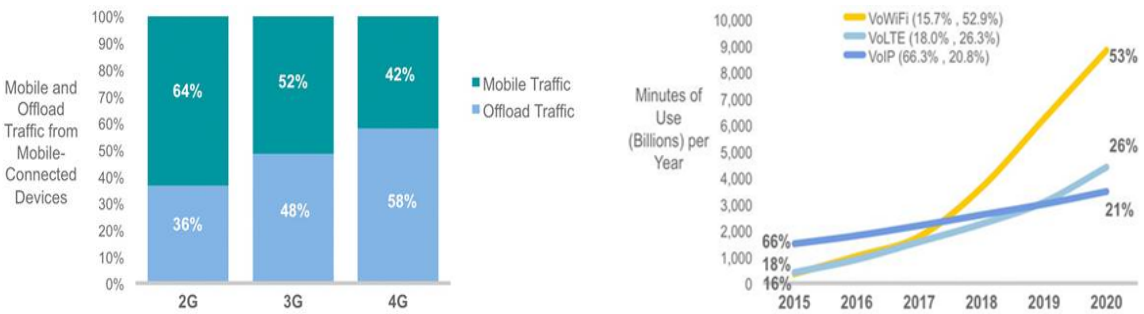


Figure 3c – Global Mobile Adoption – GSMA 2018

Because of geography, congestion and costs, it may take years to deploy an LTE network with the required ubiquity and performance. In the meantime, LTE "blind spots" will have so far been filled with legacy radio access, which means that ubiquitous and performing LTE-accessed services has reached the same level of coverage as in 2G/3G radio access while 5G has just started.

4.1.3. Wifi access

Wifi offload provides an opportunity to mitigate LTE coverage and performance hurdles. The Wifi ecosystem is undergoing an evolution in coverage, speed and security. It is projected that 53% of LTE capable mobile traffic will be offloaded to Wifi by 2020.



Source: Cisco VNI Mobile, 2016

Figure 4 - Wifi global figures

Wifi brings forth some challenges of its own, such as security and congestion. However, there are coordinated efforts underway such as those of the Wireless Broadband Association to define what evolution path Wifi should take, in order to make the option as productive as envisioned.

Vendors are also deploying VoWifi technology such as enhanced gateways and mobile devices with VoWifi capable features (iOS8, Lollipop). This equipment will support the offloading of an estimated 53% of mobile IP voice traffic to WiFi by 2019, according to 2015 ACG and Cisco research. As of today, VoWiFi is a key component of the MNOs' VoLTE service offering and its related network platforms. (See below section 3.1.1).

4.1.4. Internet of Things (IoT)

The Internet of Things (IoT) is the use of connected devices and systems that delivers data gathered by embedded systems consisting of sensors and communication modules in machines and other objects like cars, containers, meters etc. IoT is expected to increase rapidly in numbers of devices over the coming years and we will see new services that improve the quality of life of consumers and productivity of enterprises. This is what the GSMA refers to as the 'Connected Life'.
Several analysts have forecasted that in 2020 there will be approximately 25 billion devices connected to the Internet. As part of its networks 2020 program, the GSMA is working to establish common capabilities among mobile operators to enable a network that supports value creation for all stakeholders. These capabilities include security, billing and charging and device management, all of which can enhance the Internet of Things by enabling the development of new services. Through the provision of these value-added services, operators can move beyond connectivity and act as a trusted partner for their customers. Operator capabilities need to be tailored for the emergent M2M business model, building a trusted infrastructure that all stakeholders can rely on – and profit from.

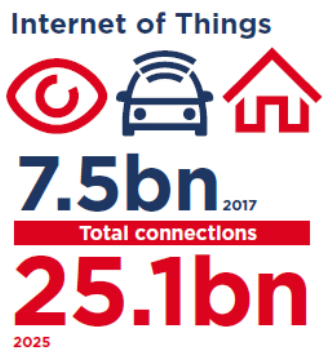


Figure 5 – IoT – Total Connections – GSMA 2018

The explosion of the number of connected objects might have impacts on carriers interconnect and roaming models both on the technical side and on the business side.

Further information is described in i3 forum "Internet of Things Whitepaper, 2017" [2].

4.2. IMS-based Services

The IP Multimedia Subsystem (IMS) is a telecommunications model enabling a standardized IP-based access to services of different networks. It was originally specified by ETSI TISPAN and then further developed by the 3rd Generation Partnership Project (3GPP), providing fixed and mobile operators with the opportunity to converge their services onto a unified core network.

IMS' main service features are:

- Interconnection with legacy networks both mobile (PLMN with 2G/3G radio access) and fixed (PSTN, ISDN, VoIP networks);
- Integrated provisioning of secure voice services both originated by fibre access and LTE access (i.e. VoLTE) by means of the same signalling protocol (i.e. SIP);
- Integrated provisioning of secure videocall services both originated by fibre access and LTE access (i.e. ViLTE);
- Provisioning of legacy SMS service together with a suite of enhanced messaging services (e.g. Rich Communication Suite).

IMS's convergence strategic objectives are to simplify the network architecture, to enhance the features of existing services and to create the opportunity to deploy new services. As mobile IMS-based services are entering the market, the following challenges will have to be tackled:

1. A full IP migration with related legacy network platform decommissioning will take time and significant investments to be completed due to the LTE coverage hurdles mentioned above, as well as the need to support non-IMS capable devices for the foreseeable future.

2. Though an all-IP service environment will provide MNOs with more options, ease of deploying new services, and will enable them to get closer to the OTTs' agility, MNOs will not be able to equal it. Unlike OTTs Service Providers cannot operate their services independently of considerations related to maintaining service continuity, interoperability and infrastructure.

3. The worldwide uptake of IMS-based services still remains to be assessed by the market. This success will depend upon the Service Providers' ability to be competitive with their offering of a full set of communications services (voice, video & RCS) versus OTT apps.

4.2.1. Voice over LTE

Voice is the first service MNOs are migrating onto IMS. As of March 2018, 127 operators have announced their commitment to VoLTE and are at various testing or deployment stages. MNOs have launched a commercial VoLTE offer in 63 countries (Source: GSMA March 9, 2018).

While the level of commitment and progress seems promising for VoLTE, the actual availability of VoLTE on networks that have launched is limited. In the critical path are LTE coverage limitations, national interoperability and device interoperability, which pose the following challenges:

- *Commercial challenges:*

the definition of a proper IMS VoLTE profile taking into account the market conditions; the set of supplementary services already provided via the 2G/3G networks and what has to be deleted / added in the new IMS VoLTE profile;

- *Technical challenges*

the integration of the fully IP-based IMS and 4G radio access networks with the legacy TDM-based radio and switching networks; the support of SRVCC (Single Radio Voice Call Continuity) capability and the related specification is a key milestone of this technical integration in order to achieve a smooth hand-over between 4G radio cells and the 2G/3G ones during a call.

- *Devices Interoperability*

Devices which support VoLTE are only high-end (premium-priced) devices and interoperability among them requires long and careful testing sessions.

Service Providers who do deploy VoLTE will need to also consider off-net SIP interoperability, as well as breakout to circuit-switched networks. This is an incentive for Service providers to accelerate the migration to IP of their current TDM-based interconnections; IPX providers are well positioned to address this.

Voice over LTE encompasses HD voice as a key feature which increases the value of mobile voice, as expressed by Mobile HD Voice users who do confirm their satisfaction with the quality and experience of HD Voice.

4.2.2. VoWiFi

VoWiFi is driven by lack of indoor LTE coverage. Additionally, it offloads the LTE radio network and guarantees the outdoor-indoor continuity of the voice communication experience.

Many vendors offer IMS platforms with integration with Voice over Wifi capabilities in terms of addressing schemes, signaling protocols, codecs and billing functionality.
All recent VoLTE deployments include VoWiFi features as this has become an integral part of the service offering, given the expectations of continuity of service by the end-users.

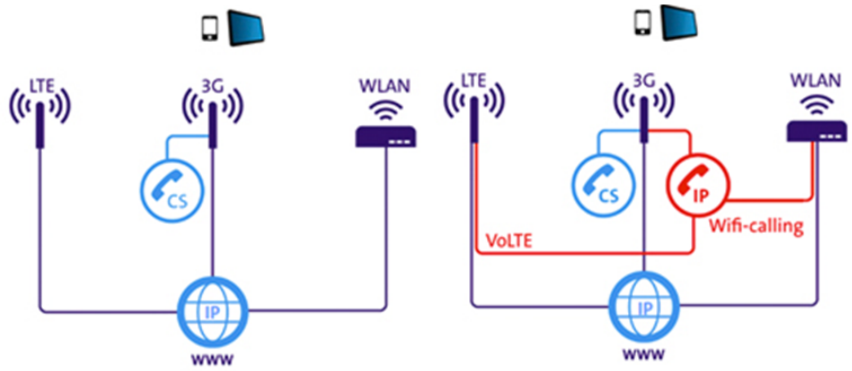


Figure 6a –
Mobile Voice today only through 2G/3G

Figure 6b -
Voice tomorrow enhanced with VoLTE and VoWIFI

Fig. 6 above provides a sketch representation of integration of VoLTE and VoWIFI.

4.2.3. HD Voice service

Successful off-net HD Voice termination requires the call path to be end-to-end-IP, and all voice devices within the path to be HD compliant. These requirements mean that delivering international HD Voice creates additional costs for direct routing, number portability correction and transcoding. For instance, because of the lack of national number portability database available to carriers, such as in South Korea and UK, ensuring HD compliant routing may be technically and economically more challenging in some cases.

Despite the 164 HD voice commercial launches in 88 countries (GSMA, March 2018) HD Voice complexity in delivering actual end-to-end international HD Voice service will grow at a slower pace with respect to the adoption of domestic VoLTE. This implies that international carriers, in particular IPX Providers, can play a key role in enabling and accelerating HD voice growth.

In addition, the HD Voice ecosystem is fragmented along the lines of which HD codec is used. This fragmentation produces interoperability issues which have to be addressed with specific transcoding equipment and codec negotiation arrangements between carriers. In the context of VoLTE, this means that international VoLTE has more technical challenges and therefore could be more costly to terminate than non-VoLTE traffic.

In the longer run, as technologies and services based on HD codecs gain traction, high definition communications will eventually become ubiquitous and a default feature of all voice services. The growth of VoLTE, together with the growing number of HD-enabled devices and networks, will contribute to simplify the continuity of international HD Voice.
OTTs have been successful in providing their users with on-net (within a single OTT Provider`s ecosystem) HD voice using codecs not initially specified in the recognized international standardization bodies. As an example, the Opus codec is endorsed in the current IETF draft for WebRTC codec requirements as the mandatory-to-implement high definition codec (while G.711 is the narrowband mandatory codec). It is a marketing and technical decision of Carriers/IPX Providers whether or not to implement such a capability.

4.2.4. RCS Services

IMS can support enhanced messaging services and specifically Rich Communication Services as proposed by the GSMA. The goal for RCS is to complement MNOs' traditional services by providing services similar to or better than those which have made OTTs successful. RCS' latest version includes:

- Enhanced Phonebook
- Enhanced Messaging
- Enriched Calls
- Social presence information
- Group Chat
- Content sharing

50 operators have commercially launched RCS in 27 countries with 159 million active monthly users. Over the next 12 months, the GSMA forecasts additional launches by more than 40 new operators in 30 countries, resulting in RCS' availability in 5 regions across the world. GSMA Intelligence is estimating that, by Q4 2018, there will be 350 million users. (Source: GSMA Network 2020 May 2018). The GSMA forecasts to exceed 140 Interconnections worldwide by the end of March 2018 (source: GSMA Press Release Interconnect MWC 2018).

4.2.5. ViLTE Services

4G IMS Video (ViLTE), enables Service Providers to offer Video Calling to VoLTE customers with HD standard quality levels as a smartphone embedded capability, without the need to download and install a specific application.
According to the GSMA March 2018 statistics, VoLTE and ViLTE have been implemented, or plan to be implemented, by 127 operators in 63 countries. Some examples in Canada/USA are Verizon, T-Mobile, and Rogers, while in Europe Bouygues Telecom, 3UK and Salt Switzerland. Most of these operators are offering ViLTE as a free option, included in the VoLTE/VoWifi service profile.

4.3. Alternative Solutions to IMS implementation

An alternative path for MNOs for driving the IP migration and offering a wide set of multimedia services is to leave, partially and/or totally, the standardized GSMA/3GPP environment relying on communications apps (voice, video, messaging. etc.) to be offered to their own customer basis.

It is well known that OTT apps are spread worldwide and indeed OTT Providers have already been offering HD voice and advanced calling embedded with other services such as directory management tools, status and presence features, instant messaging services, or conference call tools with multi calls connection or document sharing.
As of today, no MNO has totally been following this “radical approach” notwithstanding there are a number of implementations which partially especially for messaging/RCS try to combine in the user profile VoLTE service together with enhanced messaging based a OTT-like app.

If the basic advantages are simplicity, low cost, easy implementation and fast deployment, on the other hand interoperability with other Service Providers / IPX Providers could be a challenge in terms of codec, signalling, addressing and numbering.
In this framework WebRTC confirms the trend of blurring borders between the traditional telecom works and the OTT one by facilitating interoperability between Web-based applications and the PSTN. With WebRTC, apps or browsers can behave as a VoLTE device, as a front end for IMS network.

WebRTC has been gradually adopted by the most commonly used browsers - between them accounting for more than half of the world's browsers. In October of 2014, Microsoft committed to including a version of WebRTC on its Internet Explorer browser, leaving only Apple as the main holdout.
WebRTC will be a market worth $4.7 billion by 2018 predicts consulting firm Smith Point Analytics, while U.K based telecom/mobile industry consultant Dean Bubley calculates that over 2 bln people, approx. 60% of the likely internet population, will be using WebRTC by 2019.

IPX Providers may choose to deploy WebRTC gateways, thus taking over some of the interoperability functions and maximizing the continuity of WebRTC-based features. To date however, the majority of WebRTC instances are enterprise related, and typically will breakout to SIP or TDM destinations.

5. Architectural Framework based on IPX

Being independent from the access technologies, the IMS framework has been designed with the purpose of serving a set of multimedia applications and enhanced messaging in a full-IP environment. IMS is therefore, inherently a multi-service framework, encompassing services that are built over the transport infrastructure like VoLTE, ViLTE and RCS, as well as others that may be carried over IMS as an option, such as a WebRTC-based service.

By deploying an infrastructure capable of supporting IMS-based services, international carriers can enlarge their commercial offers by allowing IMS-capable Service Providers (Fixed, Mobile, OTT) to interconnect and extend the domestic customer experience to the international domain via interworking and roaming services.

With reference to the voice services over an IMS platform, it is worth underlining that it encompasses both voice originating from mobile networks (i.e. VoLTE) and voice originating from fixed networks (e.g. FTTx and Wifi customers connected to an IMS platform). In all cases, for Service Providers and International Carriers, interoperability between IMS-based networks and non-IMS legacy networks (e.g. PSTN and NGN VoIP), is a primary objective.

5.1. IMS Functional blocks for International Carriers

The IP Multimedia Subsystem encompasses a wide set of functional blocks (about 50) and interfaces covering access networks as well as core networks, whose specification and characteristics are thoroughly described in 3GPP specifications, starting from TS 23.228 [3].

The deployment of a complete IMS Core solution is in the scope of Service Providers' networks which, in any case, have to deploy any or all the following functional blocks in order to meet the interconnection and roaming requirements specified by 3GPP:

- S/P/I-CSCF (Serving/Proxy/Interrogating - Call Switching Control Function)
- HSS (Home Subscriber Server)
- PCRF (Policy and Charging Rules Function)
- IBCF (Interconnect Border Control Function)
- TrGW (Transition Gateway)
- BGCF (Border Gateway Control Function)
- TRF (Transit and Roaming Function)

From a carrier perspective, the focus is to allow IMS networks to connect with each other at a service level, supporting the specified protocols, interfaces and profiles at the IMS Network-to-Network Interface. Hence, the carriers' IMS implementations are simpler, involving the deployment of a more limited number of functional blocks.

Considering the scope of this document, two connectivity options are described in the following sections:

a) *Service aware; i.e. based on the management of specific IMS protocols;*
b) *Service unaware; i.e. the Carrier's network does not manage any specific IMS protocol.*

5.1.1. Options for IMS NNI – Service aware

In compliance with the 3GPP IMS specification [3] and documents referenced therein, the service aware IMS interconnection configuration between Service Providers is described in Figure 7. The Ici interface provides signaling connectivity for the Control Plane based on SIP signaling. The Izi interface provides connectivity for session-based media (e.g. User Plane for the voice service).

Note: The SIP signaling across the Ici interface can also provide session-based services within the RCS suite.

The same logical interfaces, Ici and Izi, are applicable to both Service Provider-to-Carrier interconnections, as well as to Carrier-to-Carrier interconnections.

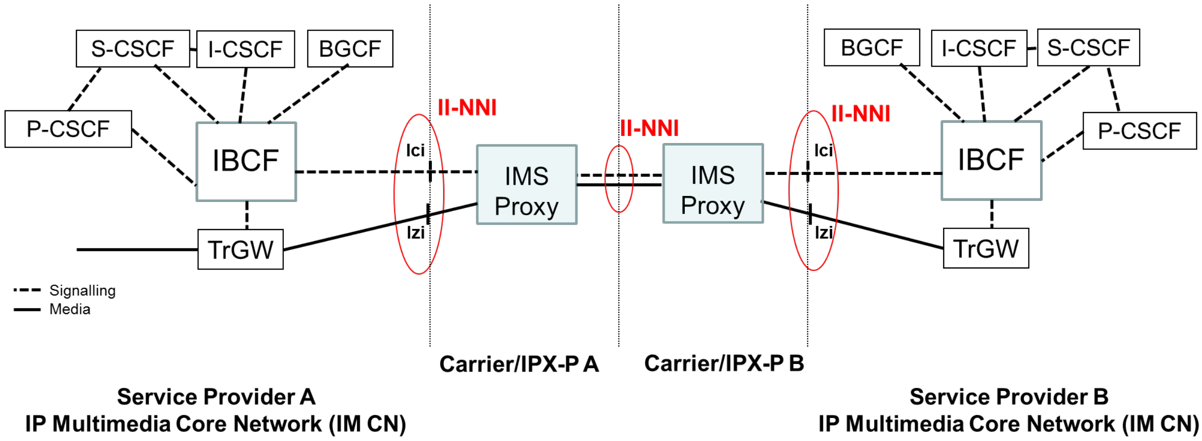


Figure 7 - IMS NNI – Service aware scheme

In addition to the connectivity interfaces, there are network and service level requirements that can be fulfilled by a Carrier in the scope of IMS. Some of these requirements do overlap with features developed under the IPX framework, such as global reach, network security, QoS, and others. Additional requirements like the handling of IMS signalling have to be deployed in new functional nodes that have to act as Proxies. Some of the capabilities that can be supported by an IMS proxy are:

- support of new addressing schemes and routing mechanisms used in the IMS (e.g. SIP URI, Route Header)
- screening of application information and parameters (e.g. SIP screening)
- interworking of different application implementations, manipulation of headers
- access control at both the network and application levels
- NAT/PAT or Application Level Gateway (ALG)
- User Plane adaptation (e.g. transcoding / transrating)
- support of DNS/ENUM
- break-in and break-out mechanisms to non-IMS networks.

The 3GPP TS 23.228 [3] describes the case of an IMS Transit Network/Function in the chain between two IMS Core networks, providing inter-connectivity and transit/routing of IMS services, along with break-in/out to non-IMS Packet Switched and Circuit Switched domains.

To endorse and extend this concept, the GSMA has recognized the possibility for an IPX Provider to enable global interconnections of IMS networks and provide the mentioned features, by means of an “IPX Proxy” (ref. IR.34 [4]) encompassing the features of a subset of 3GPP logical nodes. The i3 forum recognizes the following list as the main logical components of an IMS enabled IPX Proxy:

- IBCF
- TrGW
- BGCF

From a technological standpoint, the deployment of the mentioned functional blocks can be achieved in a “single box”, or as standalone equipment. In the first case, i3 forum recognizes that the technical evolution of Session Border Controllers (SBC) can possibly address a subset of the required features, in particular, those of IBCF/TrGW related to security and access control matters.

5.1.2. Options for IMS NNI – Service unaware

Carriers may also provide a service-unaware NNI to their Customers in bilateral or multilateral mode (see Figure 8 from IR.65 [5]), which includes transport capabilities, as well as QoS control and monitoring and security. The IPX Transport service is an example of how this NNI can be implemented between two IMS Core networks.

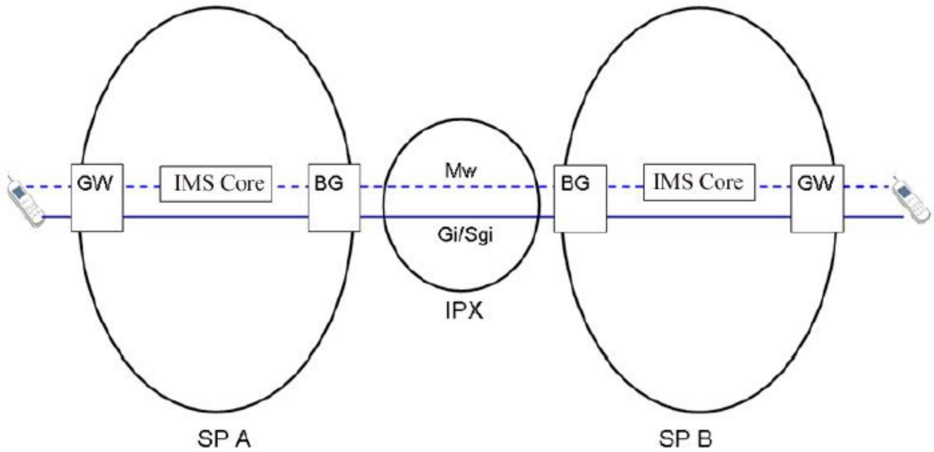


Figure 8 - IMS NNI – Service un-aware scheme

In the 3GPP reference model, the Mw interface is used for the exchange of SIP signaling messages between CSCF resources, while the Gi/Sgi interfaces connect data network nodes and are dedicated to the transport of the user plane (making use of GRE tunnels). The Border Gateways (BG) shown in figure 8 are SIP-unaware and provide control and filtering of incoming and outgoing IP traffic.

It has to be underlined that this service unaware option only supports IMS Core to IMS Core interworking; therefore, in such a transport mode, the carrier is not able to provide any break-in/out mechanisms or those features previously described above that require service-awareness.

5.2. Technical and commercial reference model for the international IP interconnection

5.2.1. Use of the IPX model

As stated in GSMA IR.65 [5], the use of the global IPX framework is not a mandatory requirement for implementing the IMS Interconnect and Roaming network environment. Different interconnection schemes may be used at the NNI level, such as Public Internet or physical / virtual private networks (e.g. leased line or VPN/IPSec.), provided that the requirements of IMS-based services are implemented over the mentioned platforms. These requirements call for specific technical and commercial features and capabilities such as openness, QoS control and monitoring, security, multi-protocol and multi-application support and DNS/ENUM resolution.

Nevertheless, it is recognized that there is no reason for Service Providers and IPX Providers to define and deploy a new technical architecture and commercial model specifically for IMS Interconnect & Roaming, different than IPX. A global IPX can already ensure most of the required commercial and technical features listed above; such as the need to achieve a global reach/coverage, and the need to segregate the IP addresses assigned to User Equipment, from the transport Carriers' networks.

As a further consideration even for the IMS services, the general principle of service community separation can be supported, but a joint careful analysis has to be carried out in order to define the set of optimal service configuration schemes at the NNI.

Based on the above rationale and for the sake of simplicity, only the IPX option is described in the following sections. The i3 forum reference IPX technical architecture is described in chapter 5.2 of i3 forum "Common functionalities and capabilities of an IPX platform" [6]. Figure 9 depicts the IPX Reference Model, with explicit indication of IMS-capable Service Providers that are interconnected to the IPX domain.

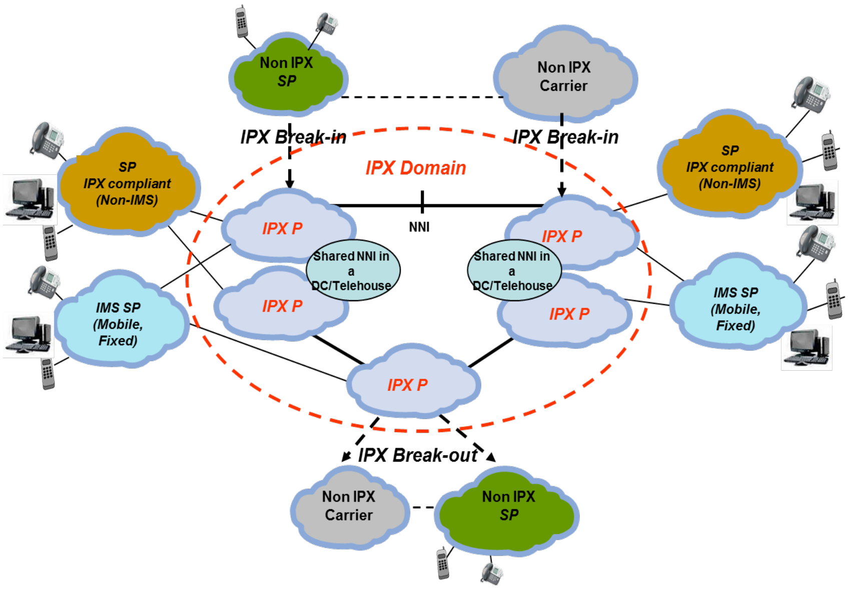


Figure 9 - General IPX reference model

5.2.2. Connectivity options

As specified by GSMA [4] and i3 forum [6] for the general IPX model, the available connectivity options for IMS-based services are the following:

- Bilateral – Transport Only (transport without service awareness)
- Bilateral – Service Transit (transport with service awareness)
- Multilateral – Hubbing (transport and hubbing with service awareness)

5.2.3. Break-in / break-out

Break-in and break-out options, that are generally possible in the IPX with certain constraints, can be applied to IMS services taking into account, case by case, proper rules and limitations.
It is recognized that Voice over IMS has to allow all possible interworking scenarios from/to legacy voice technologies, such as TDM PSTN/PLMN, Fixed and Mobile VoIP, OTT VoIP, etc. Hence, break-in and break-out are allowed with the same features and limitations as in the VoIPX (see Sec. 5.2 of the i3 forum “Voice over IPX Service Schedule” [7]).

5.3. Service schedule for Voice over IMS

In the Service Providers’ (fixed and mobile) access and core networks, the implementation of Voice over IMS (VoIMS) service has to be considered a technological step forward for its IP-based intrinsic nature. In the carriers’ networks, since the migration process towards IP has already started, some of the features and capabilities implemented over the years at the transport layer (e.g. IPX model) can be exploited to offer an effective and efficient management of the VoIMS service as well.

In addition to the connectivity and break-in/out options described above, the deployment of VoIMS should follow some of the basic principles described in the “Voice over IPX Service Schedule” [7]. For routing and traffic Management, in line with general IPX requirements (see Sec. 12.2 of [7]), IPX Providers have to implement routing criteria for VoIMS in order to minimize QoS impairments due to network traversals, limiting as much as possible the number of networks to be crossed end-to-end.

Specific importance has to be given also to the setting and management of proper Class of Service (through IP Packet Marking, see Sec. 6.2 of [7]) onto all the networks in the call chain, so as to guarantee the End-to-End QoS expected in VoIMS service.

With regards to Security requirements, all the principles applicable for the IPX environment shall be kept for VoIMS. Future releases will address specific requirements applicable to IMS networks and services.

6. Business Models for IMS-based services

Within the IMS framework, different business models can be identified depending on the specific service to be offered (e.g. voice, video, messaging, signaling) and depending on whether the service provisioning involves interworking or roaming.

6.1. Voice over IMS service

For voice over IMS service, i3 forum recommends a model that promotes and facilitates a quick adoption. In order to make the transition easier in terms of counting, rating, invoicing, auditing and reconciliation, it is desirable for the IMS voice service to be compatible with the existing voice business model widely used today in TDM and IP networks.

Of course, IMS Service Providers and market forces could make possible other business models as well, but to promote IMS transition and adoption, it shall be possible, at least initially, for all players to use an existing standard default business model.

As a result, i3 forum recommends the IMS voice (HD or SD voice) service to be compatible initially with the current business model based on Sending Party Pays with cascading of the termination price among all involved Service Providers and Carriers/IPX Providers. Similarly, the pricing scheme based on call duration and destination shall be retained.

In addition, the following considerations / remarks have to be taken into account with regard to:

a) *Call Routing*: whenever possible, the VoLTE service requires direct routing to the destination network, either for continuity of HD voice or other associated services;

b) *Number portability resolution*: number portability management could be incurred by IPX Providers. It is the responsibility and choice of IPX Providers to negotiate with Service Providers, when these features are required and how the associated costs are charged.

c) *Transcoding*: in a number of call scenarios it could be the responsibility of an IPX Provider(s) to transcode media from an originating codec to a terminating codec (e.g. from mobile WB-AMR to fixed G.722). It is the responsibility and choice of the IPX Providers to negotiate with Service Providers when these features are required, and determine how the associated costs are charged. For more details refer to i3 forum document "*Enabling HD voice continuity in international calls (Release 1.0) May 2014*" [8].

d) For VoLTE roaming several models are available:
- Service aware or local breakout according to the GSMA terminology which implies two different routing schemes; Visited Network (VPMN) Routing and Home Network (HPMN) Routing
- Service unaware or S8HR, roaming via S8 interface according to the GSMA terminology.

With the service aware option, the visited network is service aware and therefore the visited and home network operators are able to apply existing voice roaming business models.

With S8HR, the voice roaming service runs over the S8 data interface. In this case the visited network is service unaware as the visited network does not know which service the data stream is transporting. Due to this service unawareness existing voice roaming business models cannot be applied. According to [9] data roaming charges with differentiated quality (QCI values) may apply for this type of traffic per the existing data roaming agreement.

It has to be noted that, as of today, existing data services rely on best effort quality without QCI differentiation. IPX providers are ready to support services based on QCI values.

6.2. Video over IMS (video call) service

The launch of Video over IMS service can be characterized as an extension of the already existing Voice over IMS service as it is described in Sec. 5.1. From a technical point of view such a service consists of a synchronized combination of both media types, video and audio the handling of which is known since many years. However, the setting up and maintenance of a video call service opens new market opportunities to an IMS Service Provider and in order to facilitate a quick adoption of such a service it is highly desirable to be compatible to already known and implemented business models that are in use in audio-only services worldwide.

For these reasons, i3 forum recommends the video call service to be compatible with the current business model based on the principle that the sending party pays for an initiated call with cascading of the termination price amongst all involved Service Providers and Carriers/IPX Providers. Similarly, the pricing scheme based on call duration and destination shall be retained. With this pricing scheme, the receiving IMS Service Provider may charge the sending IMS Service Provider a fee for the requested transportation and/or termination as described in [10].

Additionally, the following considerations have to be taken into account with regard to

a) *Call routing:* Whenever possible, the video call service should be directly routed to the destination network. If this is not possible, the number of traversed networks should be kept to a minimum, maximum two according to IPX specifications.
b) *Number portability*: Number portability management could be incurred by IPX Providers. It is the responsibility and choice of IPX Providers to negotiate with Service Providers, when these features are required and how the associated costs are charged.
c) *Transcoding:* Depending on the call scenario it could be the responsibility of an IPX Provider(s) to transcode audio respectively video media from an originating codec to a terminating codec. It is the responsibility and choice of the IPX Providers to negotiate with Service Providers when these features are required, and determine how the associated costs are charged.
d) *Roaming:* Any video call sent or received by a V-PLMN in the context of roaming, that is sent or received by an End User of an H-PLMN using the network of the relevant V-PLMN, is recommended to be charged according to the same principles as outlined above and as described in [10].

6.3. Signalling for IMS-based services

In this section the signaling services which enable IMS services encompass Diameter and SIP signalling.

Diameter signalling controls the transport layer allowing the registration, policy and charging over LTE networks, while SIP runs at the service layer allowing all session-based IMS services.

The H.248 protocol, being internal in Service Provider / IPX provider networks, is out of scope.

6.3.1. Diameter Signalling

For Diameter Signalling for IMS services, i3 forum recommends no major changes to what is already specified in "*LTE Data Roaming over IPX Service Schedule*" [11]. Specifically, the principles and methods related to Diameter signalling accounting, policing and charging have to be maintained.

In terms of business models, it is reconfirmed what was previously recommended in [11]:

<u>*Options for signalling service charging between Service Provider and IPX Provider:*</u>

- flat fee (with tiered levels based on usage or bandwidth)
- per-transaction fee

As of early 2018 the market response seems to prefer the flat fee option.

Options for signalling service charging between IPX Providers:

- settlement-free peering (sustainable if both SPs exchanging traffic are billed for the signaling service)
- paid peering, e.g.
  - flat fee for a given capacity level
  - transit per outgoing or incoming transaction based on bilateral negotiations between the two IPX-Ps

As of early 2018 the market response seems to prefer the settlement free option.

6.3.2. SIP Signalling for session-based services

A Carrier / IPX Provider has to manage SIP signalling for session based services for two different call scenarios:

a) for terminating a call between two Service Providers without any roaming party;
b) for managing a roaming call.

In the first case, the signalling information is associated with a media flow which is charged according to the interworking principles given in Sec. 5.1 above and no charge scheme applies to the signalling information**.** This principle also applies between IPX providers.

For charging the signalling of roaming calls, several options are available, depending on the type of roaming model applied. There are two roaming models approved by GSMA:

a. Service aware option: LBO HR or Ravel based on SIP IMS signalling being managed by all networks in the call chain and assuming the same business model of the CS scenario; and
b. Service unaware option: S8HR based on a data connection, exploiting the data layer of the LTE networks (S8 interface of Evolved Packet Core) from the Visited up to Home network where the IMS Core is located.

The charging options for the service aware model are listed:

Options for signalling service charging between Service Provider and IPX Provider, in service aware roaming model:

- flat fee (with tiered levels based on usage or bandwidth)
- per-transaction fee
- fee per roaming destination

Options for signalling service charging between IPX Providers, in service aware roaming model:

- settlement-free peering (sustainable if both SPs exchanging traffic are billed for the signaling service)
- paid peering, e.g.
  - flat fee for a given capacity level
  - transit per outgoing or incoming transaction based on bilateral negotiations between the two IPX-Ps
- fee per roaming destination

There is no market experience on charging for signalling related to roaming yet.

Note: It has to be noted that the above signalling charging scheme applies to the roaming service-aware option only in case of routing via V-PLMN

In case of the service unaware model, signaling is regarded as S8 data and charged as part of the S8 service.

6.3.3. SIP Signalling for IMS registration

For the time being, there is neither a specification nor market experience examples of how to deal commercially with the flow of signalling information for IMS registration generated by roaming end-users, since this traffic is not present in 2G/3G roaming cases.

i3 forum considers this type of traffic as chargeable traffic, which represents a component of the total traffic exchanged between the visited network and the home network for roaming customers. This applies for the signalling messages sent by both home and visited network (or an in-between IPX provider).

For charging the signalling of IMS registration, several options are available:

Options for signalling of IMS registration charging between Service Provider and IPX Provider:

- flat fee (with tiered levels based on usage or bandwidth)
- per-transaction fee

The pricing scheme of the two above options depends on also the roaming destination between IPX providers.

Options for signalling of IMS registration charging between IPX Providers:

- settlement-free peering (sustainable if both SPs exchanging traffic are billed for the signaling service)
- paid peering, e.g.
  - flat fee for a given capacity level
  - transit per outgoing or incoming transaction based on bilateral negotiations between the two IPX-Ps
- fee per roaming destination

There is no market experience on charging for signalling related to IMS registration yet.

6.4. IMS messaging services

6.4.1. SMS over IMS

For Short Messaging Services over IMS, i3 forum recommends for Service Providers and Carriers/IPX Providers to support GSMA PRD IR.92 “IMS Profile for Voice and SMS” [12] and related 3GPP standards. More specifically a MNO can choose either to fall back to the existing platform or to put in operation an IP Short Message Gateway (IP-SM-GW) as specified in 3GPP TS 24.341 [13].

At the international level, Carriers/IPX Providers provide SMS Transit and SMS Hubbing, and, with reference to the two scenarios mentioned above:

- in the case of a fall back SMS implementation, the existing business model and charging schemes apply; i.e. the charging of MSUs within a flow of SS7 legacy signalling or charging per event;
- in the case of the implementation of a IP Short Message Gateway, given a lack of market trend, it is likely that the same principles in 6.3.2 apply; namely, charging the SIP method “Message”.

6.4.2. Rich Communication Suite over IMS

The set of RCS services could be charged according to two categories:

- considering the service aware category charging could be done with time duration in minutes, events or volume in Mbytes (MB) depending on the service.
- considering the service unaware category only volume in MB can be applied.

These principles are compliant with GSMA “*PRD IN.25 Proposed national and international RCS Interworking Requirements”* [10] which specifies the following RCS services and related metrics.

RCS Service	Service Aware Metric	Service Unaware Metric
Chat	Sessions Volume (MBs)	Media MBs
File Transfer	Files Volume (MBs)	Media MBs
Image Share	Images Volume (MBs)	Media MBs
Video Share	Duration (Sec.s) Volume (MBs)	Media MBs
Messaging using Pager Mode	Messages	None (mutual Forgiveness) ***NOTE***
Messaging using Large Pager Mode	Volume (MBs)	Media MBs
Social Presence Information	Messages	Messages or Volume (MBs)
Capacity/ Capability / Discovery	None (mutual Forgiveness) ***NOTE***	None (mutual Forgiveness) ***NOTE***
Signaling	None (mutual Forgiveness) ***NOTE***	None (mutual Forgiveness) ***NOTE***
ENUM	None (mutual Forgiveness) ***NOTE***	None (mutual Forgiveness) ***NOTE***

Figure 10 – RCS Services

NOTE: In the International wholesale business the provisioning of these services has to be considered as an additional capability. Whether to be charged or not it depends on the commercial policy of each IPX Provider / International Carrier.

A CDR shall be created by the originating operator for all media services based on aggregate or measured volume in megabytes sent during the previous period, tallied by QoS as agreed by the parties.
Aggregate (estimated) or measured volume depends on carrier’s equipment ability but i3 forum recommended.

There is no real market experience for such a set of services with an international scope apart some trial experiences.

6.5. IPX Transport services for IMS

Even if there are no pure data services within the IMS framework, IPX Providers can offer service unaware IPX Transport solutions to Service Providers for the interconnection of IMS-based services. For more details, refer to i3 forum document “*Whitepaper on IPX Transport Service (Release 1.0, May 2014)*” [14].

As an example of such a service, IPX Providers may offer transport solutions connecting:

a) a couple of Service Providers;
b) one Service Provider to any other Service Provider (e.g. GRX, or voice roaming by means of service unaware S8HR);
c) one Service Provider and a selected group of one or more Service Providers.

In any case, the service offered will be an IP service unaware transport, with guaranteed QoS and Class of Services.

The business models can vary, but to ensure an easy adoption and facilitate IPX Providers and SPs in terms of counting, rating, invoicing, auditing and reconciliation, it would be preferable for the IMS data transport services to be compatible with the existing IP business widely used today for the GRX service. *The service should be counted and charged based on:*

- *Bandwidth*: Mbits-per-second (and not volume MB) with a 95th percentile or average or a maximum capacity allowed,
- *Class of Service*: the transport service(s) can be provided and sold with different Classes of Service that would guarantee different QoS commitments,
- *Destination*: the transport service can be sold without a price difference per network of destination (like today with GRX), or it could have a variable price per destination component.

In case of voice roaming by means of S8HR, the traffic uses the S8 interface and the visited network, and any other IPX provider in between is service unaware. Due to quality constraints, using charging based on Class of Service (QCI) makes sense for transporting this type of service.

For the latter, this would bring complexity to the network as well as IT requirements, and it can only be expected to be an option rather than the default model initially. However, in the medium term, due to a significant cost variance for the transport of 1Mbps between different regions (e.g. between WE Europe and East Coast in USA vs. between Europe and Far East), it is expected that the cost per destination will gradually be implemented.

A different counting per destination methodology can also enable other new business models that would require the cascading of a data termination fee by the terminating network. It is to be noted that a data termination fee would most likely be based in Volume and not in Bandwidth, which would require new network and IT developments.

7. Hubbing Capabilities for an IP/IMS Interconnection

The ”hubbing mode” (already described in GSMA “IPX White Paper”, 2007 [15]) is a technical and commercial interconnecting mode where only the adjacent parties (directly interconnected parties) maintain a technical and commercial relationship.

In the specific IP/IMS environment under analysis, an IPX Provider providing hubbing services offers a set of capabilities to the FNO/MNO Service Provider relieving it of any commercial negotiations and technical discussion with the terminating FNO/MNO parties. Among these capabilities it is worth outlining:

1) *Contractual relationship between adjacent parties only*: in most hubbing environments contractual agreements are between the Service Provider A and the IPX Provider. This simplifies not only the legal framework but avoids to the Service Provider any billing relationship (and related possible disputes) with the terminating parties.

   Although the specific contractual framework between the parties is out of the scope of this document it has to be noted that certain technical parameters (e.g. quality requirements, codec requirements) may have impact in contractual or billing aspects and should therefore be appropriately controlled.

2) *Service aware IP Transport* guaranteeing
   a. numbering compatibility and addressing resolution;
   b. all signaling protocols interoperability;
   c. codec transcoding where it applies;
   d. quality control and monitoring as well as security control;

   This alleviates Service Provider A from the responsibility of managing interconnectivity and achieving interoperability with each of the multiple termination parties.

3) *Service aware session termination with end-to-end routing* validating the ENUM response (according to the various schemes discussed in the previous Sec. 6.3) and identifying the proper routing among the various alternatives in terms of network status, quality data and pricing.

   As far as the session termination is concerned, there is a clear tendency to assign the resolution of the interworking activities to the Hub providers (i.e. IPX Provider).

4) *Service Assurance end-to-end* guaranteeing the achievement of the service assurance KPIs and alleviating the Service Providers’ NOC of any troubleshooting actions.