Next-generation Interconnection and Roaming Analysis for Mobile Services

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Executive Summary

With the mobile device having moved to the centre of communications, Mobile Network Operators (MNOs) are just one possible player to provide network access and services to smartphone users, both consumers and corporates. Services today are largely provided via the internet. MNOs used to have a monopoly on these services, this is being challenged and hence the operators are in a defensive position. A sustainable business strategy including next-generation interconnections has to be developed to adapt to this situation.

The adoption of next-generation IP Interconnections still lags behind expectations. Although IPX interconnections are accelerating, they are far from being the industry default. Key reasons have been the lack of business benefits, as well as ambiguity and complexity of the IPX model. From an Operator perspective, the most obvious benefits of IPX interconnects are universal reach, OPEX reduction and CAPEX avoidance. Many Operators, especially mid-size tier 2 and 3 Operators are waiting to realise additional revenue opportunities before investing in new infrastructure and migrating interconnects to an all-IP environment. However, the more MNOs invest into their domestic networks, the better the infrastructure becomes to support alternative OTT services. Investments into resilient, secure and very efficient IPX interconnection platforms have the potential to enable service differentiation. Without investment into IP interconnections universal reach for Operator mobile services will never to come fruition.

The industry must tackle this challenge and urgently needs to develop profit-generating differentiating services, combining universal reach to any existing mobile subscriber with quality and security for personal or business critical applications. Consumer products should be integrated into the handset or operating system by the MNO and 'appear free', i.e. as part of a packaged service bundle.[1]

Existing and upcoming IPX wholesale services and functionalities must be able to support innovative mobile services addressing retail and corporate customers. MNOs should strategically partner with IPX Providers to leverage this potential.

Overall, the mobile industry needs to simultaneously pursue both, differentiation from OTT services and cost reduction by removing the following complexities:-

(1) Multiple legacy network costs towards an interconnected all-IP world
(2) Ambiguity of specifications and variety of user profiles (e.g. messaging)
(3) Definition of an a simplified interconnection charging model to replace the current model

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[1] Outcome of GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris, 22nd March in Tampa, Florida and 25th May in Hong Kong

The GSMA should play an active role, working with industry partners and support this process by amending specification and industry standards, especially the underlying business models to facilitate both acceptance and implementation of the next-generation of IP Interconnections.

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ACRONYMS, DEFINITIONS

Term	Description
AS	In the Internet model, an Autonomous System (AS) is a connected segment of a network topology that consists of a collection of sub networks (with hosts attached) interconnected by a set of routes.
A2P message	Application to Person message
DoS	Denial of Service
FNO	Fixed-network Operator
FTR	Fixed-network Termination Rate
GRX	GPRS Roaming eXchange Service. An IPX service which provides for routing, Interconnecting and some additional services, such as Domain Name System (DNS). Generally used for GPRS/UMTS/LTE roaming, MMS interworking and WLAN roaming.
HPMN	Home Public Mobile Network in a roaming scenario
Inter-connection	The connection of Service Providers in order to exchange traffic between them
Inter-working	The ability for a service offered to subscribers of one network to communicate with a similar service offered to subscribers of a different network
IPX	IP Packet eXchange is a telecommunications interconnection model for the exchange of IP-based services between customers of separate Mobile and fixed operators as well as other types of service provider (such as ISP), via IP based private network to network interface, the IPX network. In the interconnection context, IPX is used to mean an interconnection at the service level (not at the network level).
IPX Network	Inter-Service Provider IP backbone which comprises the interconnected networks of various IPX Providers.
IoT	Internet of Things, also 'Machine-to-machine communications'
ISP	Internet Service Provider with own AS
LBO	Local break-out home routing roaming model
MNO	Mobile Network Operator ('Operator')
MTR	Mobile Termination Rate
OSP	Online Service Provider or Over-the-Top (OTT) Provider
OTT Providers	Over the top Providers offer services over service unaware internet connectivity. In the mobile context also called 'over-the-air providers'
QoE	Quality of Experience
QoS	Quality of Service
SMS	Short Message Service
S8HR	Payload home routing roaming model
TDM	Time division multiplexing
VPMN	Visited Public Mobile Network in a roaming scenario
WAP	Wireless Access Protocol

1 INTRODUCTION

The purpose of this document is to analyse the next-generation of (all-IP) interconnection and roaming models for mobile services, especially from a business and wholesale perspective. It complements the GSMA documents IR.34 'Guidelines for IPX Provider networks', IR.25 'VoLTE Roaming Testing' and IR.65 'IMS Roaming and Interworking Guidelines' where technical aspects are covered in detail.

This business and wholesale analysis aims to support the GSMA goal of doubling the number of next-generation IP interconnections. Key questions of this investigation are:

1. Why is the adoption of next-generation IP Interconnections behind expectations?
2. Which benefits would motivate MNOs to accelerate an adoption? Which wholesale services are required to realise such benefits?
3. Which amendments in terms of specification and business model could facilitate acceptance and implementation of next-generation IP Interconnections?

While a number of Mobile Network Operators (MNOs) position themselves as pure data service providers both for private and corporate customers, the greater part of the mobile industry offers their customers a full-range of mobile connectivity services, often embedded in a broader connectivity and information strategy that includes fixed communications, TV and other managed services. This document covers both approaches by taking into account both service-aware and service-unaware interconnection models.

Chapter 2 provides the background of a changing market for mobile services and the need for new next-generation all-IP interconnection models.

In chapter 3, we describe the existing technical and commercial interconnection models, analyse the main reasons for a slow adoption of the IPX model and its competitive positioning towards other models. This chapter also provides an overview of the commercial interconnection tools that are available, highlights key industry driver trends and their possible impact on future interconnection models.

Chapter 4 identifies diverse next-generation IP interconnection models and tries to shape an industry level business case for IPX and its business metrics, including charging models. Based on market assumptions it proposes a business model for next-generation IP interconnections. It also emphasizes the key benefits for MNOs including value added services and links them to the support by wholesale carriers based on the new capabilities of an IPX ecosystem.

Chapter 5 aims to suggest amendments of industry standards at the level of general technical architecture as well as on business and charging models.

2 Change of Mobile Communications Market

In order to deduct appropriate answers, it is crucial to understand the development of the market ecosystem for international mobile communications.

Up until ten years ago, mobile operators were at the centre of the mobile communications market. Whether mobile services were provided on-net or through interconnections with other operators, everyone was totally dependent on MNOs regarding phone calls, SMS / MMS, push-mails and an early use of web browsers (WAP).

Over the years, different kinds of walled-garden-approaches from operators and equipment vendors emerged, in the form of proprietary operating systems and operators' services and applications e.g. Vodafone 360. The truth is that, with the exception of Apple's ecosystem, most of these concepts have failed due to the lack of openness for external third parties and a lack of innovation and hence they have never reached substantial scale.

In the new mobile communications ecosystem, the 'smart phone' has moved the role of the device moved beyond its traditional communications role into the nucleus of key aspects of the customer's life covering information, entertainment, social life and mobility. Besides basic communications, a smart phone supports all kind of applications such as music and video streaming, file sharing, collaborative applications (e.g TeamViewer), satellite navigation and more.

Another transformation of the industry was produced by the availability of other wireless access networks such as Wi-Fi and emergence of mobile virtual network operator giving the mobile users different routes to attain internet connectivity[2].

This development was pushed by the success of IP protocol and the internet. It has become clear to all industry players that multi-protocol legacy networks and interconnections will be replaced by an all-IP technology.

As a consequence, MNOs are no longer the dominant player for the supply and exchange of mobile services. Figure 1 illustrates the shift from a unilateral, network-centric communications market to an environment with many market players around the user and its powerful device.

A further consideration stems from the analysis of the transformation in the supply of communications services. The existing regulatory framework generally applies only to telecoms operators for fixed and mobile telecommunications services whilst content providers and OTT players not subject to the same level of regulation when providing the same or similar service. The framework has not adapted to the digital ecosystem characterised by modularity, global service providers and increasing dynamism. The consequences are market distortions and regulations which do not always apply to similar services - this can be seen to be out of step with market realities. [3]

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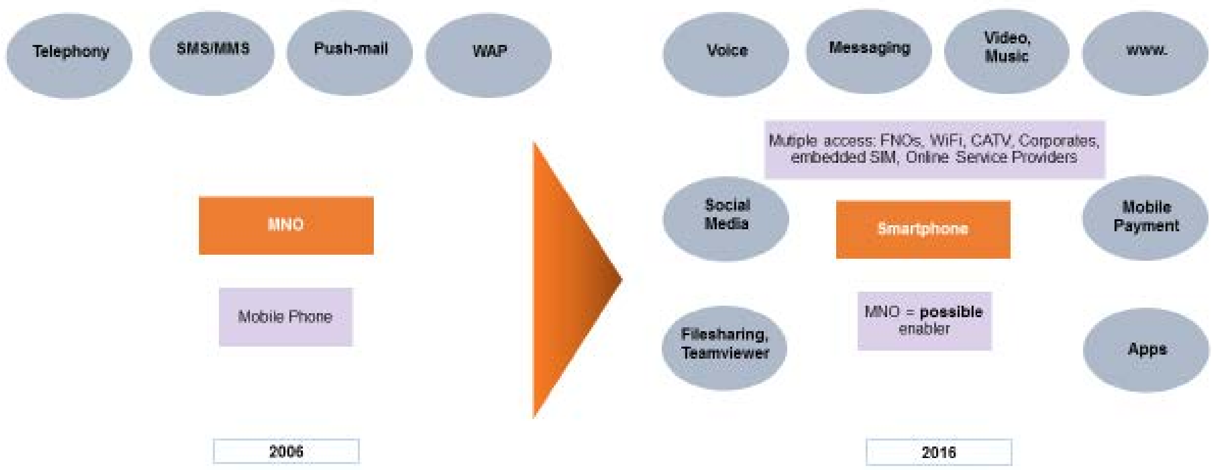
[2] Source: McKinsey, http://www.mckinsey.com/industries/telecommunications/our-insights/e-sim-for-consumers-a-game-changer-in-mobile-telecommunications

[3] NERA Economic Consulting: A new regulatory framework for the digital ecosystem, 2015

Figure 1 Change of Communications Market for private subscribers



Source: DÏA – Digital Infrastructure and Internet Applications

Unlike 10 years ago, MNOs are no longer in the centre of mobile services used by their customers. Today they are one possible player to provide access and services to the smartphone user. This is vital to understand in order to define a future business strategy also on next-generation interconnections.

3 Industry Analysis

3.1 Scope

The focus of this industry analysis is existing interconnection models and arrangements within the Industry for Mobile Services, the adoption of IPX models, an overview of commercial tools as well as market and industry driver trends anticipated until 2020.

3.2 Interconnection Models

In determining a the most suitable model for national, international and roaming interconnection of the future it may become necessary to adopt several of the available types of interconnection depending on the criteria selected.

As a first step, it is important to understand the existing interconnection models and whether they should be considered legacy or if instead they could be suitable candidates to support future requirements.

3.2.1 Interconnection models and regulatory differences

Generally speaking there are two prevailing interconnection models: national interconnection and international interconnection with the following characteristics:

- **National / domestic** with (regulatory) differences per region / country, especially mobile termination rates (MTR) and fixed termination rates (FTR), legislation on lawful intercept, emergency calls, data protection, etc.
- **International**: regulations on (a) mobile / fixed termination rates and (b) roaming charges in Europe and on (c) regional regulations (e.g. Net Neutrality in USA and Europe)

  (a) MTR: In the EU, North America and Australia, MTR and FTR have decreased significantly, whilst they have continued to grow in many countries especially in Eastern Europe, Africa, Asia with extremely high growth in specific cases like Cuba and North Korea (Annex 1). Recent increases of termination rates in some countries caused both reduction of incoming traffic and higher rates for outgoing calls[4]. In some cases, such as Turkey, the domestic Regulator has introduced a spread between (low) national and (high) international termination rates. The complexity to be supported by an interconnection model may increases due to supporting upcoming number ranges for mobile networks, service numbers and number portability.

  (b) Roaming charges have moved in different directions across different regions around the world. Whereas in some regions roaming charges are considered

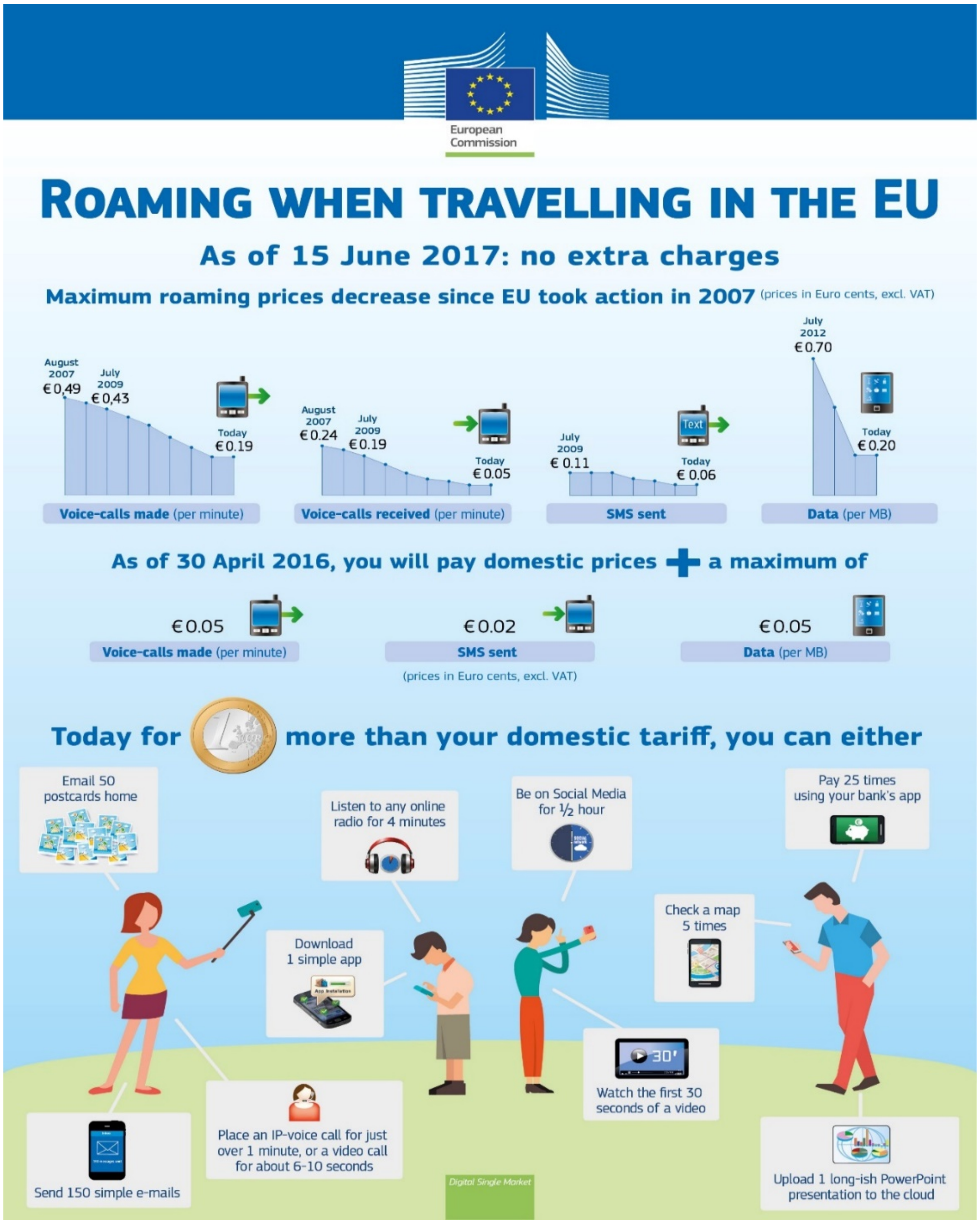
[4] OECD (2014), “International Traffic Termination”, OECD Digital Economy Papers, No. 238, page 29. OECD Publishing. http://dx.doi.org/10.1787/5jz2m5mnlvkc-en

higher, the EU has decided to abolish roaming fees for voice and data by June 2017[5] between EU members. Many regions around the world are considering similar approaches to reduce roaming prices for consumers, for example the GCC (Gulf Co-operation Council) has implemented price regulation on roaming services in the region.

Although roaming charges and prices within the European Union have been reduced through regulation, it has been noted that roaming charges by some European operators for non-European operators have increased – it must be noted that this may also happen in other regions around the world where roaming regulation applies.

[5] Official Journal of the European Union: REGULATION (EU) 2015/2120 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 November 2015

Figure 2 Roaming charges in Europe



Source: European Commission, https://ec.europa.eu/digital-single-market/en/news/new-rules-roaming-charges-and-open-internet

(c) The regulatory framework for internet traffic has traditionally been different than for voice termination and roaming. In recent years however, both the European Union and the United States of America have enacted regulation in relation to the open internet. The key aspects of these regulations include the following:

- Blocking, throttling and paid prioritization is prohibited
- 'Reasonable' traffic management, specialized services and zero-rated offers are allowed

- Exceptions are subject to ex-post assessment by the regulators on a case-by-case basis

The underlying minute based price structure for voice termination and roaming as well as the considerable **complexity** described in (a) and (b) has determined the need for a **minute based** wholesale **charging model**. A minute based wholesale charging model is also the most suitable to take into account the **asymmetries in traffic flows** for some countries. This charging model leads to the need for a high routing and accounting granularity for voice and roaming including software support (see chapter 3.4).

Considerations on Asymmetries:

While termination and roaming rates in within the EU have been brought close to zero a number of markets have increased rates to a level of old incumbent world or introduced surcharges for traffic from non-EU countries. For example, traffic to Croatia originating from Switzerland is charged 50 times higher that traffic originating from Austria or Germany. It is obvious that such behaviour will push MNO's customers and traffic to OTT telephony providers. Not only are there significant differences in the level of MTRs and roaming charges but also in terms of traffic volumes. In Spain, Malta and Greece inbound voice roaming traffic are three times larger than the amount generated by their subscribers abroad[6].

For roaming data traffic, even more some significant differences can be observed. For example, countries like Croatia and Cyprus had very high inbound/outbound ratios of 42:1 and 11:1 for 2014, respectively.[7] The ratios for touristic destinations like the Maldives or St. Lucia are expected to be even higher.

This phenomenon of dramatic discrepancies in value and volume has a significant impact on the business logic applied regarding next-generation interconnection models (see chapter 4.5).

As the **internet** traffic is less complex to support the prevailing **charging model is bandwidth-based,** either per used bandwidth in/out (usage model) or per provided port bandwidth (flat model). In the retail market the mobile internet traffic is generally charged by volume of traffic.

There could be an opportunity to shape a **next-generation interconnection model in a less complex way and therefore reduce costs** for implementation of charging**.** The next generation interconnection model could be made to be closer to the existing internet interconnection regimes (IP peering and transit), at least for any service beyond voice.

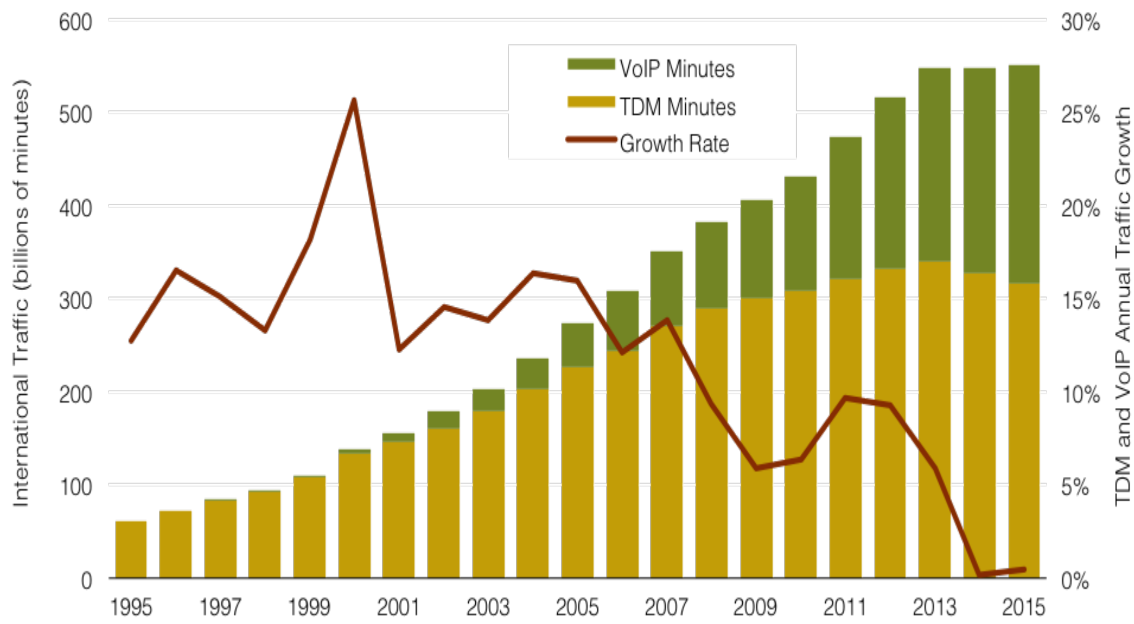
[6] BEREC Report on Wholesale Roaming Market, February 2016 (Data for EU)
[7] BEREC Report on Wholesale Roaming Market, February 2016 (Data for EU)

3.2.2 Per Service and/or Technology

Traditionally, specific telecommunications and mobile services used to be interconnected separately and until recently mainly using legacy technology / protocols. A detailed analysis is outside the scope of this document, however, an overview can be found below.

1. **TDM Voice interconnection (**with SS7 Signalling and e.164 addressing). The evolution of TDM versus VoIP minutes is illustrated in Figures 3 and 4): The growth of international voice minutes on TDM dropped to zero in 2013 and is expected to continue decreasing[8]

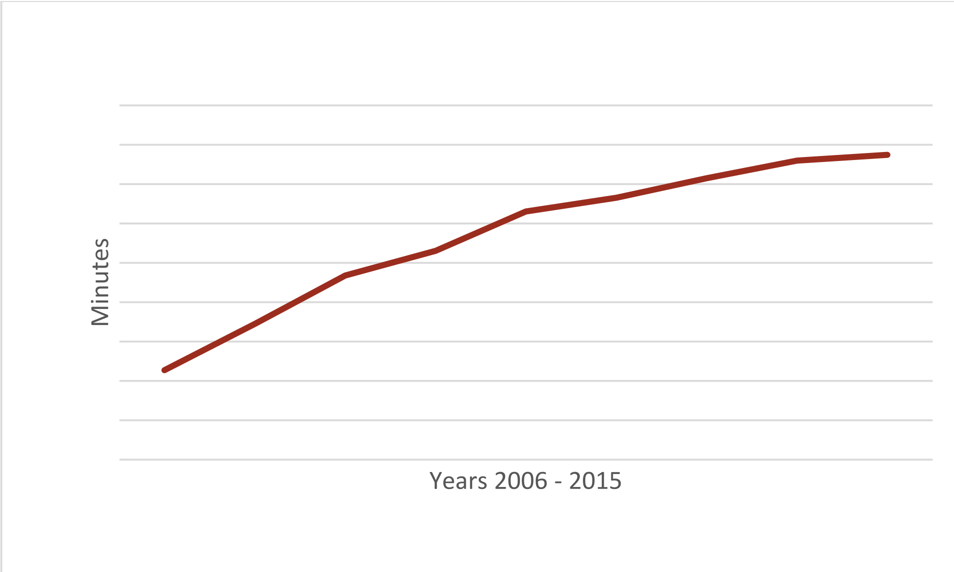
Figure 3: International Call Volumes and Growth Rates



Source: https://www.telegeography.com/research-services/telegeography-report-database/

[8] Telegeography, https://www.telegeography.com/research-services/telegeography-report-database/

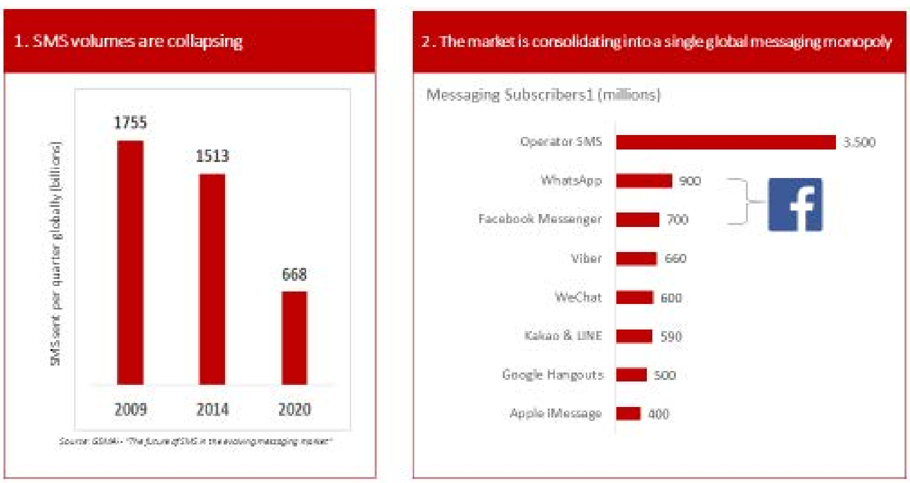
Figure 4: Switched Mobile Voice Minutes 2006 - 2015



Source: GSMAi data, own calculation (GSMA confidential)

2. **SMS Messaging**: With a subscriber base of 3.5 billion, MNOs have the biggest messaging platform but SMS/MMS is in dramatic decline. At the same time, global messaging platforms are moving towards a messaging monopoly

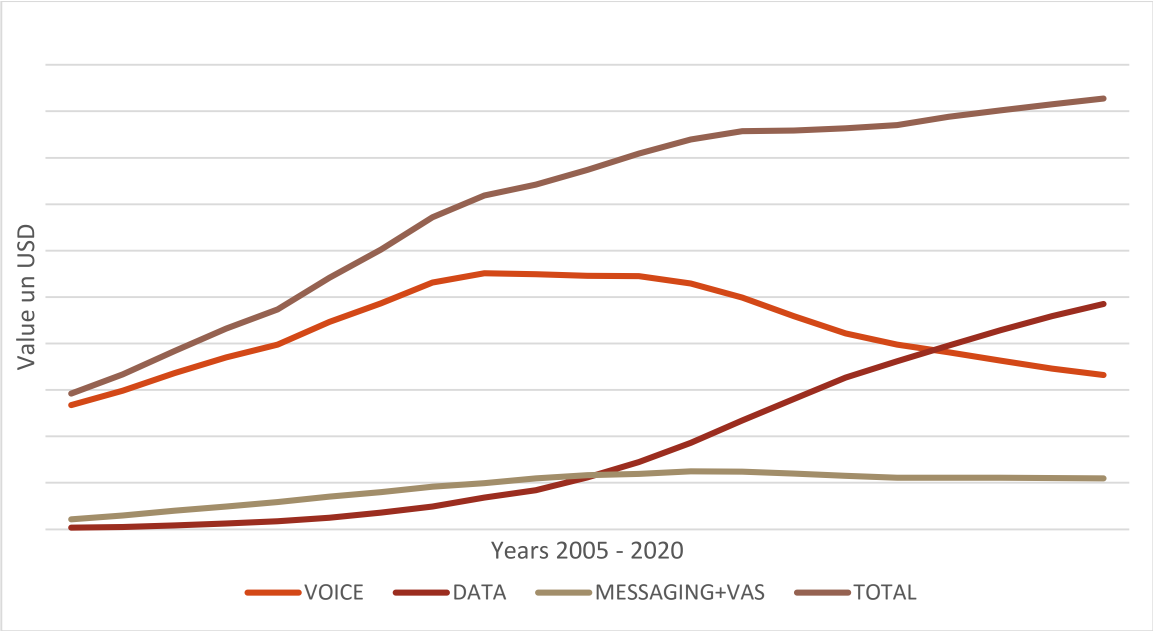
Figure 5: Messaging from Mobile operators vs. global messaging platforms



Sources: GSMAi & VisionMobile (Riding the back of a Tiger report, December 2015, GSMA confidential)

The combined global revenue of mobile for voice and messaging peaked in 2010/11 and has been in decline since 2012 with a current rate of -7% p.a. The combined revenue of all services is currently stable with growing approximately by 1% per annum. As an increasing share of customers buy bundles of voice, messaging and data, we assume that this is partly due to the shrinking allocation of bundled revenue to voice and messaging services by the operators. [9]

Figure 6: Mobile Revenue Voice, Data, Messaging 2000 – 2015, including forecast until 2020



Source: GSMAi data, own calculation (GSMA confidential)

3. **Roaming for mobile voice and data**: provision to customers on visited network (VPMN) on behalf of their home network (HPMN)[10]

4. **MPLS, bandwidth:** service agnostic provision of layer 2 (transport) or 3 (IP) capacity (outside the scope of this document)

5. **Dedicated IP interconnection**, e.g. for Messaging, Voice, Video (single service, see chapter 4.3)

6. **Service hubs** for advanced messaging including files, location, etc. (e.g. Google Jibe, see chapter 4.3).

7. **Internet Interconnection: IP Peering and Transit.** 'Internet' is a mesh of computer networks, so-called Autonomous Systems (AS). Connected through IP routing that choses the shortest available path in term of number of hops.
   Internet Peering: Interconnection of two peer computer networks in order to exchange data traffic, either on a public or private (dedicated) peering point, e.g. De-CIX, LINX

[9] GSMAi data, own calculation (GSMA confidential)
[10] GSMA IR.25 VoLTE Roaming Testing

Internet Transit: internet connectivity to the world (one to all).

8. **Multi-Service IMS IP interconnection**., e.g. IPX

Internet Packet Exchange (IPX) is a model for IP interconnection that aims to deliver high quality, privacy and security connectivity for mobile and other services (see chapter 4.4)

Based on service and/or technology segmentation, the interconnection models 1.-3 described above are considered legacy models, whereas 4. is beyond scope of this document. Therefore, only 5.-8. will discussed in more depth in chapter 4.

3.3 Wholesale Interconnection Models

3.3.1 Scope

This chapter illustrates the commercial differences of existing interconnection models for termination and roaming of the most important mobile services.

Wholesale interconnection models typically follow the Pareto Principle with an 80:20 type of rule[11]. Most of the traffic typically goes to a few destination networks negotiated on a bilateral basis between the two Operators. The remainder of the traffic goes via hubs, which may pass the calls on to (multiple) other hubs to finally reach the destination (example for voice termination service)[12].

3.3.2 Termination

The underlying concept of wholesale interconnection arrangements for termination is based on a few principles:

- Calling party network pays (except USA, Albania, Barbados, Cameroon, Russia, Singapore, Ukraine)[13]
- Cascaded charging
- Cost plus, i.e. the Carrier charges a unit-based margin on top to the termination rate for its service
- No charging for signalling

Over time, three main models of wholesale interconnection arrangements have prevailed:-

1. Bilateral direct routes including group-to-group agreements - with or without volume or value commitment, send-or-pay commitments, volume or revenue swaps and often with historical accounting rate regimes[14] with special price thresholds.

[11] Institute of Management Services, http://www.ims-productivity.com/page.cfm/content/ABCPareto-analysis/

[12] Margin Geddes Consulting, IPX – Salvation or Suffering, http://www.martingeddes.com/think-tank/ipx-telecoms-salvation-suffering/

[13] OECD (2012), “Developments in Mobile Termination”, OECD Digital Economy Papers, No. 193, OECD Publishing

[14] ITU: https://www.itu.int/newsarchive/press/WTPF98/Whatisaccountrate.html

2. Hubbing or Refile arrangements, are often referred to as "least cost routing" where wholesale providers resell their bilateral direct routes or own least cost routing.
3. Web-based reverse auctions usually for a 3 or 6 month period

3.3.2.1 For Voice

As described in 3.1.1, the charging for voice termination (often regulated) is minute-based MTR/FTR per destination plus a typical wholesale margin. As long as domestic MTR/FTR apply, it is expected that voice will continue to be charged on a per-minute basis.

Termination rates have decreased significantly in many countries, but have not disappeared. The OECD has identified, that on average they were at $ 0.06 in 2012 compared to $ 0.19 in 2004.[15]

At the same time, the average margins for wholesale carriers (cost plus) have been constantly shrinking close to zero for destinations with high competition. The voice termination business is still very important in revenue but has been losing ground in terms of contribution margin. In addition, the reported international wholesale volume has been shrinking by 2.7% year over year.[16]

We must also consider the administration of wholesale voice agreements typically incurring considerable management costs.

3.3.2.2 For SMS

Similar to voice, termination of SMS/MMS services usually bases on termination fees per destination plus a wholesale margin. However, this service is charged session-based event-rated, i.e. price per SMS/MMS to a specific destination.

3.3.3 Roaming

3.3.3.1 Background information

The commercial industry standard for 2G/3G roaming services is local break-out home routing (LBO) where the visiting network manages local and international termination for the visitor and charges back to the home network. The home network is not in control of service and quality provided to its customers. As the large majority of international calls terminate back to the home country or even network this means that the home network pays expensively for termination into his own market.

Summary of roaming wholesale arrangements:

- Bilateral Agreements (any to any) which is typically used for the top 80-95% roaming traffic of a given MNO
- Roaming Hubs: typically 5-20% value of a given MNO[17]

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[15] OECD (2012), "Developments in Mobile Termination", OECD Digital Economy Papers, No. 193, OECD Publishing
[16] Hot Telecom: The Future of International Carriers

[17] Source: Comfone

- Group Roaming Hubs, i.e. concentration of an e.g. Vodafone Roaming Service, Telenor, and an increasing number of mobile groups are adopting this model. This model is used for bilaterals to other groups or as sales platform to individual mobile networks[18]

Roaming charging and accounting for bilateral agreements are as complex as bilateral termination. They often include volume forecasts and commitments, base rate, special incremental rate, etc. and incur considerable administration costs. Furthermore, many of these agreements nowadays are still manually accounted, leading to substantial commercial management costs and inherent system vulnerabilities (e.g. disputes).

3.3.3.2 For Voice Traffic

The commercial industry standard for roaming is local break-out (LBO)

Summary of LBO:

- Local break-out by visited network (VPMN) and cascaded charging to home network (HPMN) as described for voice termination (see 3.2.1), and
- Payment of international tariffs (IOT) for voice roaming plus margin from HPMN to VPMN

3.3.3.3 For SMS/MMS

Existing wholesale interconnection models for roaming rely on the following principles:

- Local break-out by visited network (VN)
- No charging (via wholesale carriers) to home network (HN), i.e. bill & keep model on interconnection level plus
- Payment of international tariffs (IOT) for SMS/MMS roaming plus margin from HN to VN

3.3.3.4 For Mobile Data Traffic

The analogue model as for SMS/MMS described in the chapter above.

Some Data roaming charges are disconnected from the actual cost and in non-regulated cases they can be significantly higher for example to aim at making higher profit from existing asymmetries (see chapter 3.1.1). This has not to be problematic for the interconnection industry in itself. However, the effect on the retail side has been dramatic as the higher charges are often passed to the consumers, resulting in higher retail prices for consumers. It is not surprising that many international travellers avoid using data roaming, especially after receiving what the industry refers to as “bill-shock”. The alternatives are multiple, low cost or even free: local data SIM cards, WiFi (paid or free) or just avoidance. This is why both the data roaming wholesale business and even more so, the retail businesses for the visited and home network is unlikely to

18 Example for Roaming Hub offerings: Vodafone Roaming Service is Vodafone's central wholesale roaming team for 21 Vodafone networks managing all aspects of Vodafone’s roaming relationships with more than 700 MNOs in almost every country of the world. Source: http://www.vodafone.com/content/index/what/roaming.html#.

be meeting their market potential. According to Informa, roaming customers consume only 8% as much data as they consume at home[19].

3.3.4 For Internet traffic

The internet ecosystem operates a completely **different charging principle** to the termination and roaming model adopted by MNOs. Generally, both parties pay, i.e. sender and receiver of a request and of a download. This is true for both, the relationship MNO/FNO to their customer as well as between an internet carrier and its customers: MNO, FNO, content provider, etc.

Internet based wholesale Arrangements:

1. **Internet Peering**: Interconnection and bilateral agreement between ISPs to carry traffic for each other and for their respective customers. Peering does not include the obligation to carry traffic to third parties[20]. Commercial arrangement can be:-
   a) Free / settlement free, either private (one to one) or on a public peering point, e.g. De-CIX (one to many). The payment of both parties is contractually waived. This model applies not only for ISPs of similar size but also of very different dimensions, as long as the settlement-free relation is equally beneficial for both.
   b) Paid peering, commercial variation of a) in case one ISP is willing to pay to the other to gain access to its customer base.

When entering into peering arrangements, Tier 1 ISPs (also referred to as 'core ISPs'[21]) seek to minimize their interconnection costs while providing sufficient reach and interconnection bandwidth to support their customer base and their growth and for Tier 2 ISP is the primary motivation is reduced transit fees.[22]

Figure 7: Considerations on asymmetries in internet peering relations

	ISP A	ISP B
No of subscribers	10	1000
No and size of requests / file transfer per subscriber	1 / 1 Mbyte	1 / 1 Mbyte
Volume calculation	10 x 1 x 1000	1000 x 1 x 10
Volume sent / received	10 000 / 10 000	10 000 / 10 000

[19] Informa, 2012
[20] WIK-Consult
[21] Stanford University: Competitive Effects of Internet Peering Policies
[22] Dr Peering: The Art of Peering

Peering arrangements between ISPs of different size have shown balanced volume (or bandwidth) usage as long as the customer patterns are similar (e.g. VDSL or LTE users so-called 'eyeballs') and asymmetries in peering relations arise from different customer patterns, e.g. 'eyeballs' vs. content providers.

2. **Internet Transit**: internet connectivity to the world (one to all) where the transit provider ('core ISP') maintains a full internet routing table and carries traffic for the transit customer ISP. This ISP, in return, is not under any obligation to carry traffic for the transit provider. The transit customer pays the provider[23]. Studies conclude that a cost-minimizing industry organization must consist essentially of a limited number of core ISPs who supply transit to a larger number of non-core ISPs[24].

The predominant charging model for internet connectivity both for Peering and Transit is **bandwidth based charging** (95%ile or flat). Even on Settlement-free peering arrangements, the traffic flows are monitored on a used bandwidth basis.

In chapter 4.5 we will analyse how existing wholesale interconnection models could be transferred to an all-IP world. These future models will have to factor in the business conditions set by the retail.

3.4 Adoption of IPX interconnects

Over a decade ago, the GSMA designed the IPX model to be attractive and consistent within an IP ecosystem. However, the relevant **specifications** gave (and still give) considerable **room for interpretation** (e.g. no maximum number of IPX Providers).[25]

Therefore, it is not surprising that we have seen product and market implementations in many different interpretations, for example, IPX access over the public internet. This ambiguity and lack of clarity in terms of benefits for the MNOs customers (MNOs) have diluted the original concept of IPX. The above-mentioned variations in IPX deployments have resulted in **increased complexity** when it comes to **interconnecting IMS based services**.

3.4.1 Reasons for slow adoption of IPX From at MNOs

The first products available on IPX platforms were GRX and VoIPX with VoIPX **not able to offer any compelling commercial benefits** to MNOs in comparison to their existing solutions due to the commercial model; neither in terms of lower termination costs nor on the level of quality improvements compared to a Mobile – Carrier – Mobile direct connection on TDM[26].

The **economic framework** after first commercial launches of IPX services in 2010 has been mainly unfavourable. Strict CAPEX/OPEX management following the worldwide economic crisis, plus market consolidation activities, have all **slowed down the migration** of existing traffic to IP

[23] WIK-Consult

[24] Stanford University: Competitive Effects of Internet Peering Policies

[25] GSMA IR.34: Guidelines for IPX Provider networks

[26] Source: Hot Telecom

technologies As the phase-out of legacy networks was expected to take several years, MNOs have been reluctant in incurring such additional CAPEX/OPEX to achieve future savings. Most TDM equipment has been ageing and becoming costly to maintain, but did avoid the need for immediate capital expenditure. Carriers like BT have developed their product portfolio for operators who wish to sustain traditional networks services as long as they are cost effective[27]. In many cases, the typical solution has been to maintain the legacy network and to outsource via a legacy interface.

The more established and incumbent a market player (MNOs, FNOs, and Carriers) is, the higher the probability of legacy networks and little growth. In these cases, the effort and cost to migrate to a new technology is considerable as there are up to 100% **sunk investments** in legacy networks. New entrants often have both, growth and a green field situation; they can start directly with IP networks. Challengers are in between, usually with growth but also with legacy networks. As a consequence, as in fixed markets, it is often easier to start IP interconnections with new entrants and do network expansions on IP with challengers.

The financial pressure also accelerated the trend of **outsourcing** to save OPEX and reduce complexity. This could also have been a reason to migrate towards all-IP networks and interconnections. Reality often proved that long-term savings are less compelling than the avoidance of immediate capital expenditure.

Either there was a lack in understanding **the commercial and operational advantages,** quantified in chapter 4.6.2 or these advantages where simply not strong enough. Experts expect that LTE roaming will be the application to finally push MNOs' move to a next-generations interconnection and roaming model for mobile services, mainly due to the required new IP-based diameter signalling (see also 4.3.3).[28]

As the large majority of revenues for MNOs origin from domestic products, the innovation **focus** is traditionally **on domestic**, sometimes on-net products, too. In the past, this was a viable approach since established fall-back routes for off-net and international connectivity were largely available, e.g. e.164-based routing through an incumbent Fixed Operator. With the move to IP all this needs to be established, especially in cases when the network principles are changing (e.g. diameter signalling).

In the meantime, data consumption has rocketed also on mobile networks. The success of OTT solutions especially Apps fuelled this data consumption even more. With OTT solutions becoming attractive and available, the migration to IP / IPX has been further deprioritized. The **unequal regulatory environment** between the telecoms sector and Internet, Content and OTT Provides has also played its role in enabling the success of alternative communication services (see chapter 2). Compound by the ever increasing quality and speed of, OTT services have been able to grow to an extent that fundamentally challenge existing business models[29].

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[27] BT: Successfully migrate your international voice business from TDM to IP
[28] Hot Telecom: Pathway to IPX Innovation
[29] NERA Economic Consulting: A new regulatory framework for the digital ecosystem, 2015

Another problem is that the typical **organizational structure** of MNOs does not define a combined responsibility for international connectivity across all services. Not only there is a split between services and functions but also between revenues and costs: inbound revenues are often at retail units whereas costs for international connectivity allocate in technology or international divisions. The responsibility for global connectivity of a given Operator's services based on a next-generation IP based solution should clearly reflect in organizational structure. This would help to phase-out legacy connectivity solutions and accelerate adoption of next-generation IP based solutions.

Relation between Operators and their suppliers for international connectivity has evolved over the years. In times of incumbent, often state-owned Operators, international connectivity was bilaterally secured by multilateral direct interconnects plus stable suppliers for the long-tail. Nowadays, the relation usually has a customer – supplier character focusing direct cost reductions. In exchange, with a **strategic partnership** between MNOs and IPX Provider both could move towards a joint longer term service development for the retail side.[30] This could deliver both, faster migration to of next-generation IP based solutions and improved positioning of the MNO in its market (i.e. against MNO competitors and OTT players).

Although all of the above-mentioned reasons have contributed to a slow migration towards an all-IP world the **main obstacle** emphasized by MNOs in Europe, America and Asia is the **lack of** a differentiating and **profit-generating** set of consumer and corporate **products** that would clearly justify the required costs.[31] First considerations for such products and services are set forth in section 4.6.3.

3.4.2 Reasons for slow adoption of IPX at IPX Providers

Early movers in the IPX ecosystem came from to different backgrounds. Since 2010, several voice-driven wholesale providers have been deploying IP-based voice platforms via a managed backbone especially between mobile networks ('mobile direct'). In a second step, they added roaming support for LTE networks via IPX.

In parallel, established GRX roaming wholesale providers migrated their 2/3G roaming offerings and then upgraded to 4G diameter roaming over IPX networks.

On one hand, the IPX model defined by the GSMA left room for interpretation. On the other hand, different - partly contradictory - interests existed. Therefore, it is not surprising that we have a large **variety of IPX concepts** today. Some IPX Providers wish to have a guideline about what the key parameters of IPX including a **GSMA label** or even certification.

---

[30] Source: BICS

[31] GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris, 22nd March in Tampa, Florida and 25th May in Hong Kong

Different concepts are unproblematic as long as they work as islands. Problems arise, however, when these islands wish to interconnect to broaden their reach for their customers' benefit. For example, what **charging model** should be applied for ViLTE interconnection traffic if IPX Provider A runs only minute-based and IPX Provider B volume-based charging? Without simplifying the charging model it will remain extremely difficult to achieve an efficient and global reach.

Figure 8: Figure 7: IPX Providers and their customers in 2015

IPX Providers	IPX customers
BICS	190
BT	400[32]
Comfone	120
Deutsche Telekom	76
Etisalat	65
Hutchison	20
iBasis	91
NTT Com	30
Orange	120
PCCW	60
SAP MS	Confidential
Syniverse	228
TATA	195
Telefonica	28
Telekom Austria	19
Telstra	82
TeliaSonera International Carrier	165
TI Sparkle	Confidential
Vodafone	20
Total no of customers connected	1909

Source: HOT TELECOM's report: 'IPX Competitive Analysis 2015'

Furthermore, IPX-Providers have tended to equate "control" with "quality". Control through numerous SBCs along the path do provide control but they also harm quality and increase

[32] BT is utilizing its IPX for IP based services including such using the public internet. Hence this count may not be directly comparable with other IPX Providers.

complexity and cost, especially by adding interoperability challenges. IPX-Providers are sometimes charging for the mechanisms, not for the quality outcomes, i.e. delivered QoE to the user.[33]

According to both, research institutes and IPX Providers the demand for IPX offerings is reaching the tipping point with the increased roll-out of domestic **LTE deployments**, including VoLTE and ViLTE services[34].

By 2015 - more than 10 years after creation of the IPX model – the top 20 IPX Service providers reported a total of more than 1900 customer connected.[35]

The total number of customers connected can be misleading due to BT's wider definition of 'IPX via Internet' and double counting. According to Hot Telecom, major wholesale players like AT&T and Verizon do not offer IPX services yet.[36]

The following assumptions shall operationalize the share of MNOs among the reported customer connections:

- globally approximately 800 MNOs exist, all of them need GRX services
- 1 MNO has (at least) 2 GRX providers
- all IPX Providers have migrated GRX on their IPX but 20% of MNOs remain on legacy access with a conversion performed by the IPX Provider
- 800 MNOs x 2 = 1600 x 0,8 = 1280 IPX MNOs customers among the total number, with one or more services
- remaining approximately 500 connections are FNOs and a few OTTs

Although the figures still look impressive the share of traffic and value on IPX versus legacy interconnections is behind expectations. A joint research by Hot Telecom and the i3forum among 18 IPX Providers published in May 2016 revealed that, although IPX is accelerating in terms of interconnects, customer traffic and services offered, there is **still a long way to go**. The migration to IPX based interconnections is still a long way from being completed and is taking longer than expected. Half of the respondent carriers said that they have less than 25% of their customers connected to their respective IPX platform. On the other hand, the most advanced 14% have more than 75% of their customers connected to their IPX platform.[37]

[33] Margin Geddes Consulting, IPX – Salvation or Suffering, http://www.martingeddes.com/think-tank/ipx-telecoms-salvation-suffering/

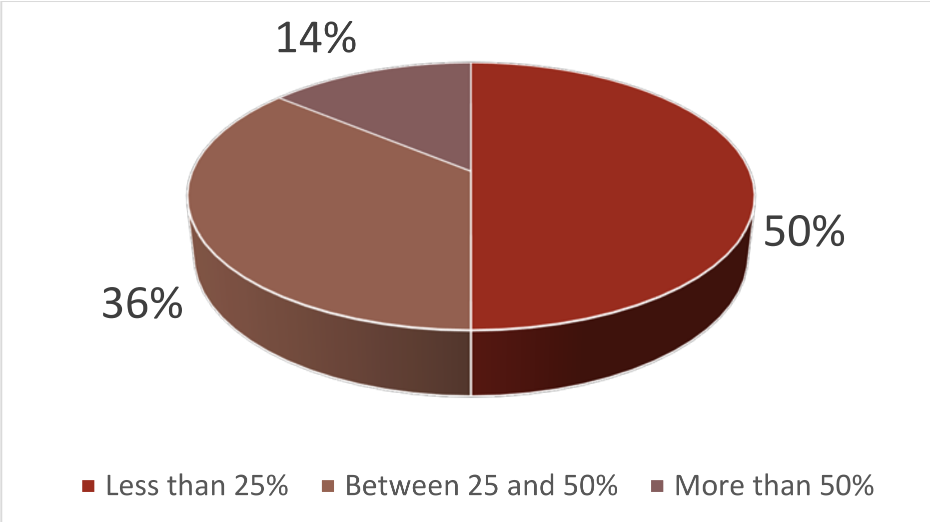
[34] Source: Hot Telecom

[35] Source: Hot Telecom

[36] Hot Telecom

[37] Hot Telecom: Status of IP and IPX Migration Status Report, May 2016

Figure 9: Ratio of customers connected onto IPX



Hot Telecom: Status of IP and IPX Migration Status Report, May 2016

The migration to IPX is mainly driven by strategic considerations from wholesale carriers. The main obstacle for IPX is that there is no clear business case to migrate, followed by 'no interest from customers' and 'unclear product definition'.[38]

(Why) Is IPX behind expectations?

- IPX interconnections are accelerating but they are far away from an industry standard
- Cost and complexity are a barrier of entry for new IPX Providers and new IPX customers
- Major obstacles are financial, i.e. the lack of profit-generating products to justify migration costs for MNOs and the unclear business case for carriers
- LTE termination and roaming will drive MNOs' demand for IPX services

3.5 Commercial Interconnection Tools

The complexity illustrated in chapter 3.1 has created a demand and market opportunities for the development of commercial tools to manage the commercials of international voice interconnections and roaming relations.

We acknowledge that it would go too far to discuss details, advantages and disadvantages of different commercial wholesale tools in depth. In this document, it is however worth shedding light on commercial tools in the context of next-generation interconnection models. Especially regarding

- Need: When and why is there a need for such tools?

[38] Hot Telecom: IP and IPX Migration Status Report, May 2016

- Timing: when to implement?
- What are the cost, what the expected advantages?

There are **two major players** in the field of commercial wholesale / interconnection tools: CSGI/Ascade and Telarix. Both hold an expected combined market share of approximately 80%.

Ascade, a Swedish originated solution acquired by **CSGI.** With their 'Wholesale Business Management Solution (WBMS), the company offers the leading choice of telecom operators worldwide**'.** [39]

Telarix, a US based software supplier considers itself as 'the market leader in OSS/BSS, audit and reconciliation'. In addition to the product scope below, Telarix offers iXLink, a 'de-facto standard in electronic information exchange with over 3300 individual companies connected'. [40]

The headline product scope of both companies covers a similar set of use cases, especially:

- **Optimal routing**: consideration of capacities, real/near-time quality, costs, eliminating the financial risks of dial code discrepancies, modelling, dial code management
- **Trading**: short term buying and selling of routes, similar to spot markets, arbitrage management, price list management
- **Testing**: test of quality and service parameters for international interconnection and roaming calls
- **Billing**: wholesale invoices as well as the basis for reconciliation based on system pricing information, included tiered pricing, dispute management, credit management
- **Optimization** for volume commitments, rates, quality and much more. Profitability: visibility into true costs and margins, data analysis, decision making, fraud detection and prevention

Other suppliers with minor market shares exist. Their products offer similar functionalities.

The **need** for the above-mentioned or comparable tools arises from the complexity illustrated in chapter 3.1 in order to assure a high routing and accounting granularity, process stability and support documentation. This complexity has been increasing due to:

- Increased numbers of market players
- asymmetries in traffic flows for some country-to-country relations (like e.g. UK – Pakistan termination or roaming UK – Spain as holiday destination)
- constantly upcoming new number ranges (for mobile, premium services, etc.),
- number portability

[39] Source: http://www.csgi.com/solutions/revenue-management/partner-management
[40] Source: http://www.telarix.com/

- fraudulent market players
- increased speed of price changes and market transactions

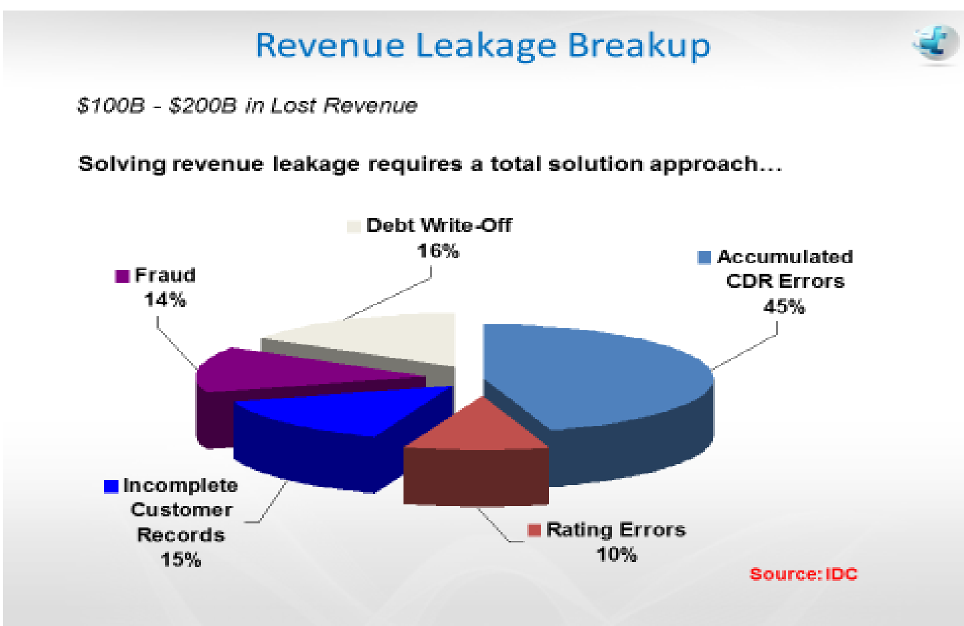
The ability to systematically monitor and manage traffic flows is vital for a professional carrier wholesale business. Therefore, almost all relevant players have deployed such systems. Nevertheless, about 30-40% of Telarix' customer base use their tool exclusively for outbound voice or SMS traffic i.e. cost management[41].

Commercial interconnection and roaming tools require investment in CAPEX, OPEX and time that should not be neglected. Depending on the size of operator, service scope and managed volumes aggregated 5 year costs could range from €100 000 to several millions

Such tools however allow to monetisation of **hidden process opportunities,** notably time (faster routing implementation, real-time monitoring and reaction), information (dial-code management, fraud cases) and complexity (invoice validation, less management costs, less faults, synergies in labour costs). Typical deployments show **cost savings** between 5% and over 20%[42].

In the case of wholesale deployment, additional **revenue and margin** of typically 10% are reported by stopping revenue leakage. A case study by IDC revealed that their main problem was accumulated CDR records, followed by incomplete customer records, debt write-off and fraud.[43]

Figure 10: Revenue leakage breakup with commercial interconnection tools



[41] Telarix
[42] CSGI and Telarix
[43] IDC, http://www.idccommunications.com

Overall, ROI figures can typically achieve 300% or more with a payback period below year.[44]

The transition towards an all-IP interconnection network within a business model following the traditional charging principles could be an appropriate **timing** to select and implement a commercial interconnection tool. A generic timing suggest by CSG would be [45]:

1. Implement commercial interconnections tool (routing, testing, etc.) sufficiently before migration of TDM to IP interconnections
2. Start migration of TDM to IP interconnections
3. Monitor and optimize quality and services during migration with commercial tools
4. Complete migration

As long as voice interconnection and roaming refers to a minute-based MTR/FTR, the use of commercial tools as described above is helpful to guarantee efficiency and flexibility in managing commodities, especially for B and C relations / destinations (long-tail).

Recently, suppliers start to receive requests from IPX Providers and operators regarding the management of IPX interconnection relations. The solutions are expected to differentiate between different services and charging models, e.g. per bandwidth or Mbit/s 95%ile billing.[46]

3.6 Industry Driver Trends

The evaluation of existing and possible future models for interconnection and roaming for mobile services depends heavily on the evolution of the entire ecosystem for mobile services. This is not limited to the traditional mobile industry of MNOs and equipment / IT vendors but also encompasses much of the internet and ITC industry.

Industry driver trends of the ITC industry leading up to 2020 and the expected effect on next-generation interconnection models (**major** / minor) include the following:

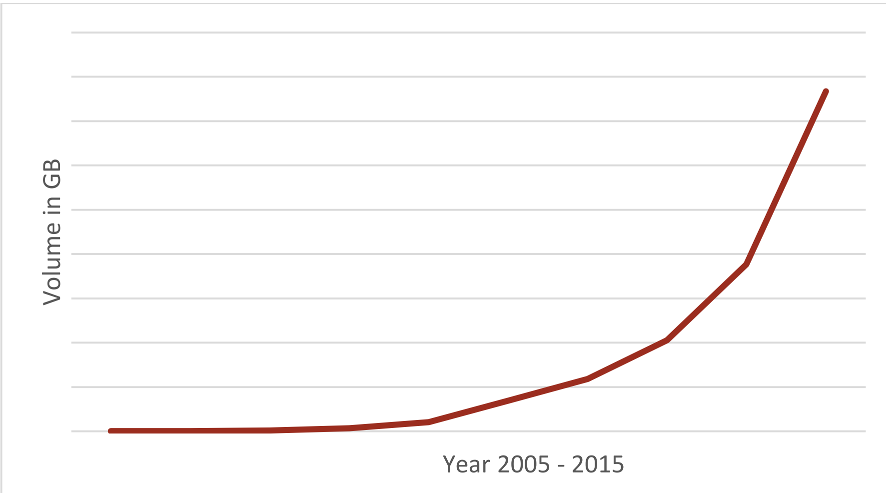
- Mobility / everything wireless (minor)
- **Everything data, exponential growth (major)**
- Everything IP / IP protocol used in network AND handset (minor)
- **Everything 'free' (major)**
- **Virtualization of operators' networks & of customers' IT (major)**
- Speed: need for low latency (SLIDE 5G – bandwidth/latency) - (minor)
- **Internet of Things (IoT) – (major)**
- **Embedded SIM (eSIM) - (major)**

Discussion of the key driver trends for the choice of interconnection model

[44] Source: Telarix
[45] Source: CSG
[46] Source: Telarix

1. **Everything data, exponential growth, everything 'free':** Customer perception of data consumption is 'free', although paid within a growing data plan at stable ARPU. The large majority of data traffic runs over the public internet and is exponentially growing[47]. It has proven to be the efficient interconnection model of choice for everyday use like streaming, downloads, social media, file sharing and all kind of Apps. However, there is a need for an alternative to address more critical services in terms of quality, security or reach.

Figure 11: Mobile Data Usage 2005 – 2015 in GB



Source: GSMAi data, own calculation

2. **Virtualization of operators' networks & of customers' IT:** (Mobile) operators can outsource an increasing degree of the low-end of their value chain to wholesale carriers and focus on their customer needs. The latter might themselves wish to outsource part of their IP & connectivity to their operators. Next-generation wholesale carriers, in exchange, will be able to focus on quality, security, privacy, interworking & interoperability using appropriate interconnection models.

Another type of promising virtualization is a combination of best-available mobile data and Wi-Fi connectivity as launched by Googlein the United States (Project Fi). The decision regarding which network to connect to is based on the fastest available speed and bandwidth.[48]

According to a study of IDC Research, all-IP carrier routing network equipment sales to service providers will show a CAGR of 3.1%, increasing to $12.7 billion by the end of 2020. This growth is

[47] GSMAi data, own calculation

[48] Source: McKinsey, http://www.mckinsey.com/industries/telecommunications/our-insights/e-sim-for-consumers-a-game-changer-in-mobile-telecommunications

fuelled by the rapid growth of video, voice, and data services, along with cloud infrastructure expansion and deployments of new virtualized carrier network solutions.[49]

3. **IoT**: Experts expect an enormous additional data growth fuelled by IoT applications. Market forecasts indicate that by 2020, the number of connected devices in the world will grow to 25.6 billion[50]. Traffic will run mainly over the internet (see 1), partly however, i.e. for critical IOT with special requirements on security, latency, etc. more appropriate interconnect models are required.

4. **Embedded SIM (eSIM):** As a result of both, the strong growth in the number of IoT devices and the development of consumer e-SIM specifications by the GSMA, the distribution of e-SIMs is expected to outgrow that of traditional SIM cards over the next several years by a large margin. Some Research Institutes see game changing potential of this new technology.[51] Operators like Deutsche Telekom expect a phase-out the physical SIMs within 10 years[52].
   In the context of interconnections models, three aspects seem of special interest[53]:
   (a) Architecture & Access, especially a new Universal Discovery server (UD)
   (b) Wholesale models for ad-hoc use of network connectivity
   (c) International 'Roaming' offers by strong global brands supporting over-the-air provisioning of multiple electronic user profiles.

In (b) wholesalers contracting with several network operators in a market could offer a tariff selection without disclosing which network is providing the connectivity. The customer could then be "auctioned" dynamically among network operators for a period of time. Electronic profiles could even be switched among operators seamlessly for the client.[54]

The disruptions caused by eSIM could have a **major impact on volume and value of** operators' traffic on next-generations interconnection and roaming models.

3.7 Competitive analysis of IPX model

In Strategy and Marketing studies it is often helpful to conduct a competitive SWOT analysis in order to better understand the strengths and opportunities but also the weaknesses and threats of a given subject. This method works for a specific product, line of business or entire company and in addition expresses the positioning of respective competitors.

[49] IDC Research: http://www.idc.com/search/
[50] Source: Marina Research
[51] Source: McKinsey & Company: http://www.mckinsey.com/industries/telecommunications/our-insights/e-sim-for-consumers-a-game-changer-in-mobile-telecommunications
[52] Source: Deutsche Telecom
[53] Source: McKinsey & Company: http://www.mckinsey.com/industries/telecommunications/our-insights/e-sim-for-consumers-a-game-changer-in-mobile-telecommunications
[54] Source: McKinsey & Company: http://www.mckinsey.com/industries/telecommunications/our-insights/e-sim-for-consumers-a-game-changer-in-mobile-telecommunications

In our context, the following figure summarizes a brief SWOT snapshot of the IPX model from an MNO perspective versus other next generation interconnection models mentioned in chapter 3.1.2, namely

- Dedicated private IP interconnection, e.g. for RCS, HD Voice, HQ Video (single service)
- Service hubs for advanced messaging
- Internet Interconnection: IP Peering and Transit

Figure 12: SWOT Snapshot of IPX model

STRENGHS: • Multi-service • One-to-many (hub concept) • Quality (network, service) • Security & privacy • Interworking & interoperability • Universal reach • Efficiency	WEAKNESSES: • Ambiguity of specifications • Complexity of technical and commercial agreements between multiple parties • Cost for planning & implementation • Temporary parallel OPEX & CAPEX to legacy networks
OPPORTUNITIES: • To become single Interconnect platform for critical services • To generate new values for MNO • Lower OPEX and CAPEX compared to multiple ICs per service and a any2any interconnection model	THREATS: • Dominance of internet interconnection • Incumbency of operators due to significant investments in legacy networks • Alternative offerings are moving faster and could win over time

A more detailed comparison of next-generation interconnection models can be found in chapter 4.

3.8 Summary and Evaluation

With the mobile device having moved to the centre of communications, MNOs are just **one possible** player to provide **access** and **services** to the smartphone user. A sustainable business strategy on next-generation interconnections has to adapt to this situation.

The combined global revenue of MNOs for voice and messaging is in decline since 2012 with the OTT successfully attacking both services.

We have seen that, depending on the criteria adopted, a diversity of interconnection models could be suitable. The underlying concept of wholesale interconnection arrangements for **voice** and **SMS** termination is generally based on '**sender party pays', cascaded charging** and no charging for signalling. The charging for voice refers to MTR/FTR and is therefore generally minute-based. Complex billing and accounting systems were justified in times of high prices and margins.

A completely different charging principle is dominant in the **internet** ecosystem: **both parties pay** on a **bandwidth based** charging model. From a billing and accounting perspective, this is extremely **efficient** and lean. The challenge will be to transfer existing wholesale interconnection models to an all-IP world by cutting complexity and costs.

After definition of the IPX model, the relevant specifications have given room for interpretation so there have been product and market implementations in many different 'flavours'. These variations increase **complexity** when it comes to interconnecting IMS based services. In order to accelerate adoption of IPX deployments, obstacles should be removed both, at Mobile Operator side (e.g. product responsibility including international connectivity) as well as on IPX Service Provider side.

In a discriminating regulatory environment for the mobile industry and few rules for the internet, content and over-the-top word internet-based services have rocketed and have slowed down the deployment and interconnection of next-generation mobile services.

Commercial interconnection tools require an investment in CAPEX/OPEX and time that should not be underestimated. In a transition towards and all-IP interconnection model that remains it at the level of charging and accounting it is recommended to take the opportunity and migrate the existing commercial tools (or select and implement new ones) at the same time.

There are few but powerful **industry driver trends** expected to influence future models for interconnection and roaming for mobile services, namely exponential data growth, virtualization of network and IT, the Internet of Things, and eSIM.

IPX is a promising interconnection model for premium and critical services but it has major weaknesses and threats compared to other IP interconnection models. It will be crucial to better define the concept and to cut off as much complexity and costs as possible while leveraging undisputable strengths and opportunities.

4 Industry Level Business Case of a Next-generation Interconnection model

4.1 Market assumptions

In the context of this document, the term ‘market’ refers to the technological and economic environment for next-generation models for (all-IP) interconnections and roaming.

The first point of reference are the key **industry driver trends** described in 3.5:

- Everything data, exponential growth, everything ‘free’: the public internet is established for large majority of applications; opportunity for alternative interconnection models for selected critical services; MNOs’ main competitors are OTT players and avoidance by customers;
- Virtualization of operators’ networks & of customers’ IT: trend towards virtual operators’ network and corporate IT systems require wholesale carriers focusing on quality, security, privacy, interworking & interoperability
- Internet of Things (IoT): opportunity for critical IoT applications based on highly efficient, reliable and secure interconnection
- Embedded SIM (eSIM): new options for access information (UD), use of network connectivity and international ‘roaming’ are assumed

The difficulty to define an appropriate next-generation interconnections and roaming model for mobile services mainly arises from the following question:

What will be long-term (‘end game’) scenario of the mobile industry?

Rather than attempting to provide a definitive answer to the question, we propose **four scenarios** that make different assumptions on the role of a typical future MNO:

MNO provides…

1. Data access only WITHOUT customer ownership (based on eSIM not controlled by the MNO)
2. Data access only WITH customer ownership
3. Additional selected services
4. Additional full service

Based on the economic principles of externalities (cost or benefit from an economic transaction that parties "external" to the transaction receive) a ‘**network externality**’ means that new customer who joins a network enhances the value of the network to all network users, because there is one more person that they might conceivably contact[55]. This is why **interconnection** and **interoperability** between Operators is of vital importance necessary for the above-mentioned scenarios 2-4, i.e. service provisioning beyond a pure data access.

What will be long-term (‘end game’) scenario of the interconnection market?

[55] WIK-Consult

The analysis of possible IP interconnection models will be conducted along the following aspects:

- Network reach
- Quality, security, privacy
- Complexity of technical deployment
- Complexity of charging

Another assumption is that **quality** and **security** are of vital **importance** to operators.

Dimensions of 'Quality'[56]:

- Service: e.g. for voice call set-up time, average call duration, answer-seizure-ratio
- Backbone network: service availability, latency (depending on shortest possible path), packet loss, jitter
- Access network: available technology (Edge, HSDPA, 3G, 4G), number of users who share the bandwidth available at this radio access point at a given moment

Dimensions of 'Security'

- Device: encryption
- Backbone network: resilience, firewall
- Compliance with data protection laws

Although the general statement 'quality and security' was supported, a poll among MNOs and IPX Providers participating in a GSMA workshop in Hong Kong revealed that in practice this depends on a few factors that determine how much financial room exists to fund quality and security measures[57]:

- Commercial value generated by the service
- Maturity of the service
- Positioning of an operator on its market

In other words, there is very **limited room** above the OTT benchmark to fund additional **quality** and **security**.

Furthermore, our analysis of interconnection and roaming relations between operators rely on a categorization in volume and/or value based on the Pareto Principle into A, B and C relations[58].

Apart from industry trends, end-game scenario and criteria for an interconnection model we also made **assumptions** on **network operations, IT/billing and commercial parameters**:

(a) operational:
  a. operational management systems: are available and inelastic to the number of connections to be monitored

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[56] For detailed information refer to IR.34, section 6

[57] GSMA workshop on ' Accelerating IP Interconnections for IMS-based Services' 25th May in Hong Kong

[58] Institute of Management Services, http://www.ims-productivity.com/page.cfm/content/ABCPareto-analysis/

b. operational manpower: 1 work day per connection per month

(b) IT/billing:

a. IT/billing systems: are available but elastic to the number of connections (price lists) to be managed, data to be stored. Assumption: 0.51 % of CAPEX

b. IT/billing manpower: 0.25 work day per connection (price list) at interconnection team and IT/billing team respectively, total of 0.5 work day per connection[59]

(c) commercial:

a. account management: average of 1 work day per account per month

b. dispute management: 0,1 work day per account per month[60]

c. wholesale services: no significant impact

d. retail services: no significant impact, additional opportunities are described in 4.6.3.

The key drivers on a network operational, IT/billing and commercial level are OPEX savings.

Key assumptions:

(1) Long-term ('end game') scenario for the MNOs' role is not clear
(2) Interconnection and interoperability between Operators is necessary for service offering
(3) Quality and security are of vital importance to these operators
(4) The suggested interconnection model has to provide guidance for the transition from legacy deployments (often per service) towards and all-IP interconnection world
(5) It also has to fit for all main future 'end game' scenarios

4.2 Possible models for next-generation IP interconnection

In chapter 3.1 we have seen an overview of existing interconnection models. At this stage, we leave the legacy protocols and models behind. However, which IP based models could be suitable for future exchange of mobile services in terms of use reach, quality and security?

Based on the assumption on the importance of **quality** and **security** for operators (see 0), the table below classifies nine possible interconnection models and relates them to relative costs of the respective models.

[59] can be reduced by deployment of a commercial tool as described in chapter 0

[60] can be reduced by deployment of a commercial tool as described in chapter 0

Figure 13: All-IP Interconnection Models

IP Interconnection Model	Network Reach	Quality	Security	Relative cost
1. Private Internet Peering (PRP)	1 to 1	best-effort	best-effort	$
2. Public Internet Peering (PUP)	1 to many	best-effort	best-effort	$
3. Internet Transit (ITR)	1 to many	best-effort	best-effort	$
4. Sponsored wholesale platform (SWP)	1 to 1	best-effort	best-effort	$
5. Service-aware Interconnection via public internet (SIP)	1 to 1	best-effort	best-effort	$
6. Single Service Hub, e.g. for messaging (SSH)	1 to many	best-effort	best-effort	$
7. Interconnection via public internet with tunnelling via IP-Sec (IPS)	1 to 1	best-effort	medium	$$
8. Interconnection via public internet with Quality of Service (QOS)	1 to 1	medium	best-effort	$$
9. Dedicated IP interconnection per service (DIP)	1 to 1	High	high	$$$
10. IPX hub model (IPX)	1 to many	High	High	$$$

Brief evaluation of all-IP interconnection models:

1. Private Internet Peering. Cost efficient option for quality insensitive traffic, service unaware. Best-effort quality and security

2. Public Internet Peering: variance of 1 with access to many networks with one physical access
3. Internet Transit: Hub model for internet interconnection with global reach. For quality insensitive traffic, service unaware, cost efficient
4. Sponsored wholesale platform, commercial variance of 1. Interesting alternative for Operators since the content provider pays for the network use to the subscriber. Could be an option if best-effort quality and security are sufficient. Example: AT&T / Netflix
5. Service-aware Interconnection via public internet: cost-efficient solution without any quality or security guarantee. Similar result as services via 1.-3.
6. Single Service Hub, e.g. for messaging: traffic exchange via the internet as 1.-3. but with traffic management on a dedicated service platform
7. Interconnection via public internet with tunnelling via IP-Sec. Alternative to 5. at same quality but with a virtually secured IP-Sec connection. Medium security
8. Interconnection via public internet with QOS: Niche case for specific applications, e.g. monitoring of medical systems, connected cars / driving, baby-alarm systems, etc. Subject to ex-post regulations. Medium quality
9. Dedicated private IP interconnection between two operators per service: popular model for high-volume and quality-sensitive relations on a domestic level. High quality and security
10. IPX Hub. Private multi-service IP interconnection via IPX service providers. Efficient alternative to 6-9 for all kind of quality-sensitive mobile services. High quality and security. For a deeper analysis please refer to chapters 4.4.

Interconnection models with **single service** and 1 to 1 reach stay within the traditional bilateral logic. They can be efficient on a domestic level for high-volumes and depending on quality sensitivity. Even in an international scenario, e.g. neighbouring countries, group-to-group this could be a viable option.

Multi service and 1 to many models (**hub concept**) replicate the idea of internet peering points (e.g. De-CIX, LINX, MAE-East) where 1 access provides connectivity to all ISPs present at the specific peering point (individual agreements required).

Internet Peering and Transit models (1-3) are used for an estimated > 90% of data traffic, e.g. downloads, streaming, file-sharing, apps, etc.

Dedicated IP interconnection (9.) and IPX (10.) are the only models that can fulfil both, high quality and high security requirements.

IPX is only model that can provide multi service (e.g. VoLTE, messaging, etc.), a 1 to many reach and high quality and high security requirements.

4.3 Possible interconnection model per service

4.3.1 For Voice Termination

At the time of writing (mid 2016) VoLTE services have been launched by 70 Operators in 38 markets and is supported by hundreds of devices. Also VoWiFi has been accelerating with 21 launches in 14 countries. However, the end-to-end interconnection coverage is lacking behind. [61]

A part from a simple voice over internet connection without any quality and security requirements, three models for voice (VoLTE, VoWiFi) interconnection will be discussed:

- Interconnection via public internet with IP-Sec tunnelling
- Dedicated private IP interconnection per service
- IPX hub model

(a) Interconnection via public internet with IP-Sec tunnelling

This service-aware Interconnection via public internet can be a cost-efficient solution for voice offers from operators that are positioned free or very competitive. Although the best-effort quality is likely to show OTT-like results, the virtual tunnelling via IP-Sec enables operators to exchange traffic in a bilateral relation at minimum network cost and at a certain security level.

The **administration** and **operation cost** of a bilateral interconnection network is, however, considerable: individual business relations need to be established and managed, contracts negotiated and supervised, multilateral price information be exchanged and processed. Regarding operations, all these virtual links must be monitored, maintained and optimized. Based on the assumptions above: a total of 21.7 working days + additional OPEX of 0.5% of related IT CAPEX per connection per year, see 4.1).

An interconnection via public internet with tunnelling via IP-Sec may be considered for a limited number of quality insensitive relations.

(b) Dedicated private IP interconnection per service

This model replicates the traditional bilateral between two operators per service. It is undebatable in terms of quality and security. It has, however, the same **challenges** regarding **administration** and **operations** as the model (a) above.

Example: an operator with 250 connections would have 7,800 man days plus additional OPEX of 125% of related IT CAPEX per year, whereas its competitor with 5 connections would have only 156 man days and 2,5% additional OPEX to bear.

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[61] Source: GSMA Network2020 Report, 31st May 2016

For a limited number of quality and security sensitive high-volume interconnection relations (A relations) this model can be a good option. Such relations can be found in oligopoly domestic markets or between Tiers 1 telecommunication Groups (e.g. AT&T, China Mobile, Deutsche Telecom, Orange, Telefónica, Verizon, Vodafone, etc).

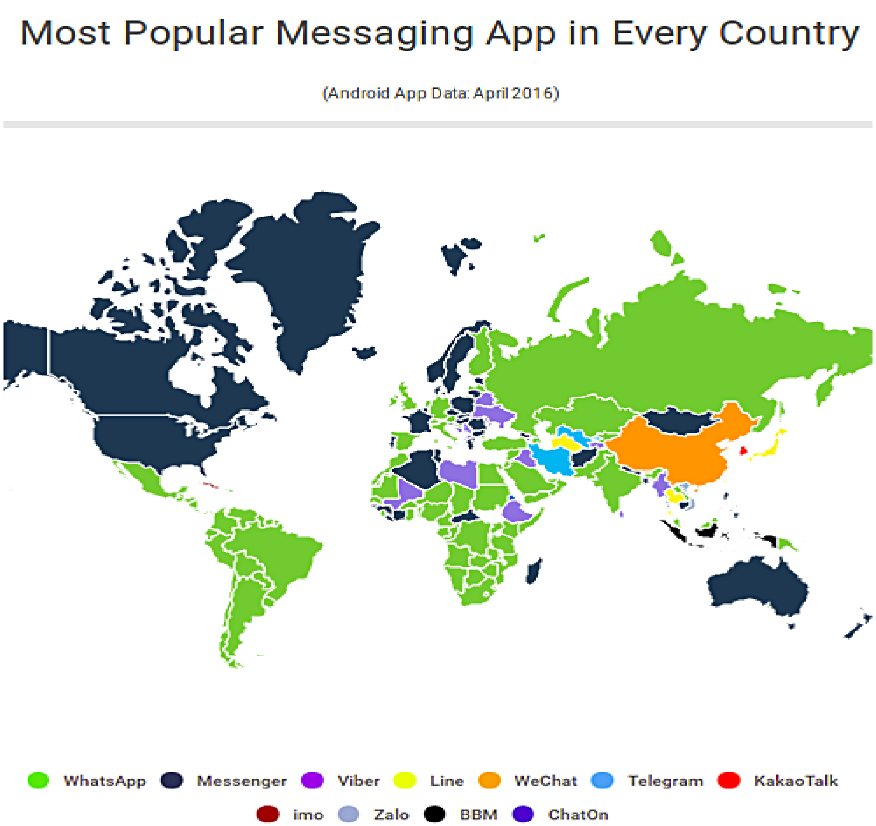
(c) IPX hub model

The IXP hub model as described in 4.4 ranges in the same category of high quality and security as model (b). However, it avoids the disadvantages of having to manage many relations. It is therefore suitable for quality and security sensitive A, B and C relations.

4.3.2 For Messaging

According to a report published by Similar Web May 2016 WhatsApp has become the most popular Android app in the world in terms of downloads. Compared to its messaging competitors, it dominates 109 countries (e.g. Brazil, Mexico, India, Russia, and many other countries in South America, Europe, Africa and Asia). It is followed by the Facebook Messenger app, claiming a total of 49 countries (such as Australia, Canada, US). In total, there are more than 150 out of 187 analysed countries where Facebook has command over the mobile messaging space. Viber, Line, and WeChat rounded up the top five.[62]

Figure 14: Global map of messaging apps



Source: Similar Web

[62] Source: Similar Web: https://www.similarweb.com/blog/worldwide-messaging-apps

In other words, the messaging market is consolidating into a single global monopoly owned by Facebook with a rapidly growing customer base of currently 1.6 billion. On the other hand, MNOs still have 3.5 billion subscribers to built-in but legacy SMS messaging.[63]

A survey asking for relevance and uniqueness of Operators' advanced communications services that would offer features like importance and subject before a call have shown a 79 - 89% positive result.[64]

RCS services have been commercially launched by 48 Operators in 35 countries and are supported by 156 devices[65]. Nevertheless, the number of RCS interconnections and market relevance remain very low.

Today, the dominating messaging providers are OTT players. This means that the interconnection prevailing model for advanced messaging service is the public internet. Two more interconnection models will be discussed in this chapter: a single service hub and IPX.

(a) Public Internet

This efficient and inexpensive solution used for all advanced messaging OTT services described above. Nevertheless, they have a few disadvantages that might not be acceptable to all users and / or for all use cases:

- Best-effort quality
- Limited privacy (some providers have started to offer encryption)
- No clear data protection

(b) Single Service Hub, e.g. for messaging

Facebook is playing successfully on the exponential power of network externality without any need for a service interconnect. The more customer they have the more attractive it becomes new customers to join (see 4.1). The challenge of a fast growing de-facto monopoly on advanced messaging for the mobile industry is clear: how to transfer the 3.5 billion SMS subscribers to a built-in advanced messaging service. An answer promoted by a partnership between Google and the GSMA is single messaging hub 'Jibe' and an integration of the RCS service into the next Android OS release. The objective is to leverage the MNOs' customer base of 3.5 billion for SMS and transfer them into an advanced messaging service.

The cornerstones of the partnership with Google are[66]:

- Operators transition toward a common, universal profile based on the GSMA's RCS specifications
- Google develops an Android RCS Messaging client implementing the universal profile

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[63] Source: GSMA Intelligence

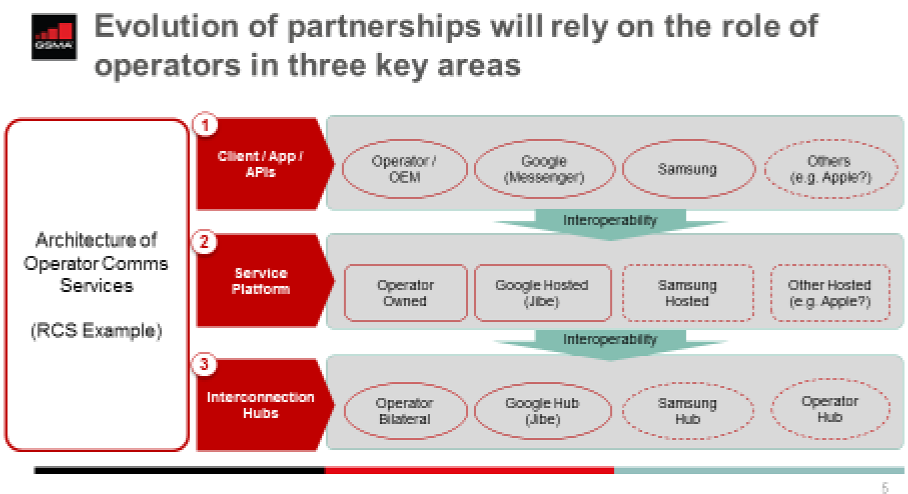
[64] Source: GSMA research, February 2016 among 4045 users in China, India, Spain and the USA

[65] Source: GSMA , 31st May 2016

[66] Mobile World Congress 2016, https://www.mobileworldcongress.com/news/press-releases/global-operators-google-and-the-gsma-align-behind-adoption-of-rich-communications-services/

- Services include SMS, MMS and RCS
- No links to Google services such as Hangouts, Google Voice
- Google will provide APIs to operators for their client extensions and their own customisations
- Google will not have access to customer data, however there will be controlled access, using anonymised data, for service improvements

Figure 15: Evolution of messaging hubs



Source: GSMA

Google will operate a messaging hub and is suggesting for all MNOs, service providers and carriers to connect to this single hub.

Figure 16: Single messaging hub suggested by Google

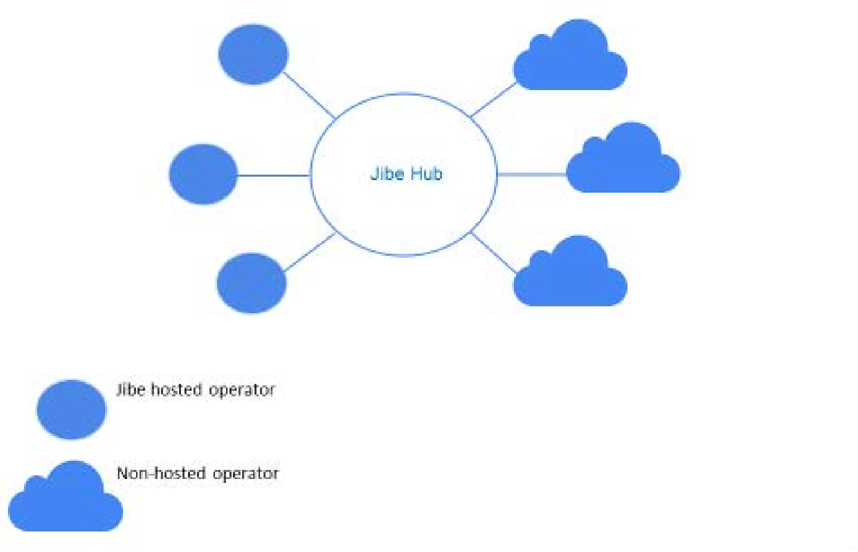


Figure 17: Pros and Cons of a single messaging hub

Pros	Cons
Fulfills interconnection agreements	Google may be able to influence/change NNI (indeed have a proprietary NNI)
Provides CDRs for settlement	Handing control over interconnect market
Interconnect point for all Jibe hosted carriers	Reduced competition in market - Google gain strong market position
Interconnect point with non-Jibe hosted carriers	Jibe hub only supports messaging, VoLTE interconnection not considered
Reduced complexity	

Source: GSMA Network2020

Typically, walled-garden OTT messaging services such as WhatsApp are based on the Extensible Messaging and Presence Protocol (XMPP), developed by the Jabber open-source community in 1999 for near real-time, instant messaging (IM), presence information, and contact list maintenance. XMPP is generally implemented and used as a client-server distributed architecture.[67]

From a service unaware internet interconnection perspective, this means that both, the OTT messaging provider and the users' MNOs pay for the bandwidth used to exchange a determined message. These cost-wise equal conditions between an OTT an MNO messaging service disappears and **new challenges** arise for as soon as the OTT provider only steers its subscribers' traffic from A to B and filters and collects relevant information at the XMPP server level.

Such single messaging hub would be the **fastest option** to roll out RCS coverage and connectivity globally for the MNOs and to jointly fight Facebooks competition. However, the mobile industry would partly lose control over the interconnected messaging traffic.

(c) Network of Tiers 1 IPX Hubs

What could be an alternative to a messaging hub both independent and interoperable with the Jibe hub. Such alternative would need to offer additional benefits at minimum charges (since Google is expected to offer its Jibe hub at very attractive conditions).

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[67] Sindhu Mercy: A Technical Report on WhatsApp, www.academia.eu

A domestic IPX (DIX) was established in Finland to support IP interconnection for RCS and other services (VoLTE, ViLTE). The business case was positive and beneficial for the participants as it was a multi-service deployment for RCS, VoLTE, and ViLTE[68].

Innovative international IPX Providers like BICS[69] have developed a portfolio to scale-up RCS adoption from domestic launch and IPX connectivity, moving to enabling interworking based on RCS proxies to a full commercial coverage by connecting RCS hubs and leverage of business intelligence. Ibasis is suggesting a centralized interworking intelligence between all (regional) profiles and dialects. [70]

Therefore, an alternative to the Google Jibe hub could be a network of few interworking capable IPX hubs with excellent coverage (Tiers 1 IPX Providers). This would offer the following additional benefits:

- Worldwide reach of next-generation messaging beyond the coverage of Android OS
- Incorporation of legacy messaging services into RCS and expansion of reach through fall-back to E.164-based messaging
- Regional (e.g. European) hubs could offer a messaging hub under European data protection law

Since the introduction of RCS many different RCS profiles have been developed per country and / or Operator. This was as a direct consequence of too many options in the RCS and IPX specifications and caused extremely complex and sometimes unsolvable interconnection and interworking scenarios[71]. The GSMA has managed to reduce the varieties down to **three regional profiles** (American, European, Asian) and is working on a definition of a single **universal profile** by end 2016[72].

Only if interoperability between local RCS deployments can be eliminated, a network of Tiers 1 IPX Providers could act as an alternative to a single messaging hub. Otherwise, the disadvantage of operating different data bases would always be more expensive and vulnerable than a centralized solution.

Currently it is also open how interoperability between Jibe and the IPX ecosystem could look like, i.e. whether Jibe will become part of the IPX ecosystem or one or more mediating hubs are required.

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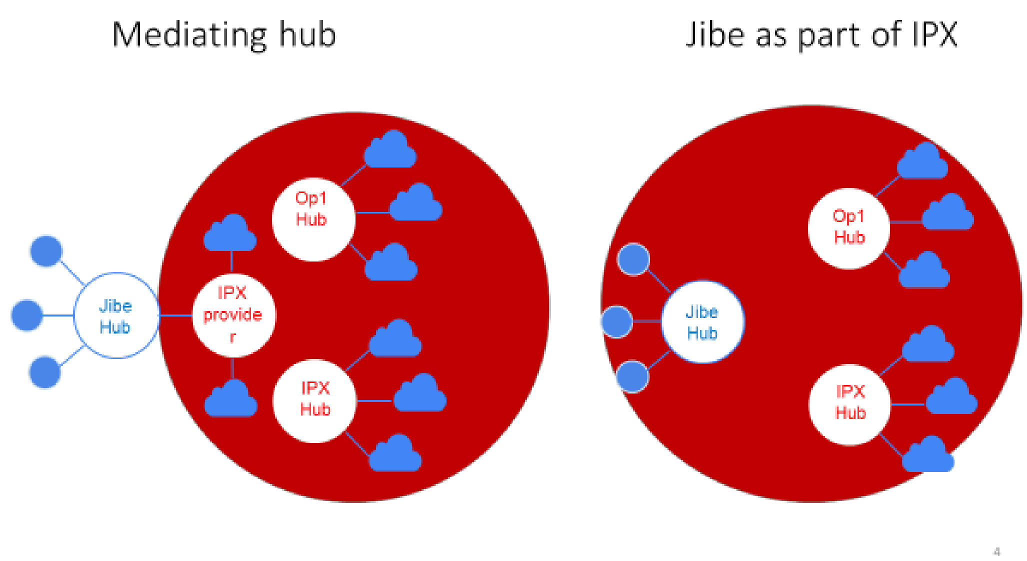
[68] Source TeliaSonera, Paris 26.01.16, tero.jalkanen@teliasonera.com
[69] BICS RCS ecosystem
[70] ibasis: RCS Interworking – A disruptive model to make it work

[71] GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services', 22nd March in Tampa, Florida
[72] GSMA Network2020 Programme

Figure 18: Interoperability options between Jibe and an IPX-based alternative



Source: GSMA Network2020

With a view to the very limited room for business, IPX Providers might consider settlement-free IPX Peering for such messaging service and only charge (or package) towards MNOs.

A network of Tiers 1 IPX Providers with one harmonized data base and universal RCS profile would ensure the mobile industry's control over interconnected messaging traffic. However, the work to harmonize the RCS profiles and improving the IPX model (see chapter 5) will need some time. The OSP competition could further grow and optimize its offering towards a de-facto monopoly.

4.3.3 For Roaming (VoLTE, ViLTE)

According to a study jointly published by OVUM and iBasis in February 2016[73], 80% of respondents expect to have launched **domestic VoLTE** within the next 12 months, and nearly half expect to have launched international VoLTE interconnection and roaming in the same timeframe.

The study also reveals a significant uncertainty of MNOs about the future model for VoLTE roaming, either S8 home-routed (S8HR) or local breakout home routed (LBO). When it comes to charging, there is a 50/50 split between data and voice models for VoLTE roaming. One out of six operators expect to charge a premium for VoLTE roaming.

According to OVUM, many operators expect VoLTE to offer the best quality service for high-ARPU customers at home and abroad and to strengthen their competitive position verses OTT providers.[74]

We recognize the business impact of future concepts related to VoLTE roaming – namely S8 home-routed (S8HR) and local breakout home routed (LBO) – on use of an IPX ecosystem. The discussion

[73] OVUM: Confusing Reigns over VoLTE, ViLTE and RCS Roaming, February 2016
[74] OVUM: Confusing Reigns over VoLTE, ViLTE and RCS Roaming, February 2016

of advantages and disadvantages of the future roaming concepts is, however, beyond scope of this document. More detailed considerations on the differences, advantages and challenges between these two models are illustrated by IPX PROVIDER, e.g. Syniverse [75].

An increasing number of MNOs have supported S8HR in the last few month and a solution on Legal Intercept and Emergency Calls is currently under work.

Depending on the model that will prevail, roaming traffic over IPX would be treated differently. In the **S8HR** scenario, (diameter) signalling steers the traffic and routes international traffic back to the home network on an **IPX transport** service, including traffic to the home country that statistically counts for a large majority.

When Local break-out with Visited Network delegation is applied, all traffic is switched to the destination by the visited network. The quality and routes largely depend on the visited network, the home network pays for termination in its own market based on the Visited Network's tariffs. In case the broken-out traffic is routed via IPX (possible but not necessary) the service is **VoLTE termination** of roaming traffic within the service-aware IMS offering. A second local breakout model is also defined whereby, as for S8HR (as well as the majority of existing CS roaming traffic) the call is routed to the subscriber's home network and from there to the destination.

There are already over 500 million LTE subscribers around the world and that number is set to grow to 2.3 billion by 2019[76]. As subscriber numbers grow, MNOs need to take action and be ready with reliable and profitable LTE roaming services, especially with regards to new challenges in routing (dynamic), transport (importance of network reach), interworking (between diameter variants), network intelligence and security (against DoS attacks).[77]

Therefore, it is undisputed in the industry that LTE roaming will push the move to a next-generations interconnection and roaming model for mobile services. The key reasons are that LTE and the related new diameter signalling require a reliable end-to-end IP path and therefore an IP based interconnection. Therefore, almost all IPX Providers have launched LTE roaming / diameter services.[78]

A suitable future-poof roaming model has to provide a one: many reach, high quality and high security. As analysed in section 4.8, the IPX model is the only one that can assure the fulfilment of all aspects required.

Although the interconnections and roaming model via IPX seems clear, there is a disruptive model for traditional roaming use cases coming from the industry driver trend e-SIM described in 3.5. According to McKinsey & Company, the combination of global brand power with the technology of reprogrammable e-SIMs and over-the-air provisioning of user profiles can be turned into easy-

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[75] Syniverse: http://synergy.syniverse.com/2015/12/understanding-volte-roaming-for-s8-home-routed-and-local-breakout-architectures/

[76] Telegeography

77 Tatacommunications: LTE Roaming – Revenue Growth in a new Area of Roaming

[78] Hot Telecom: Pathway to IPX innovation

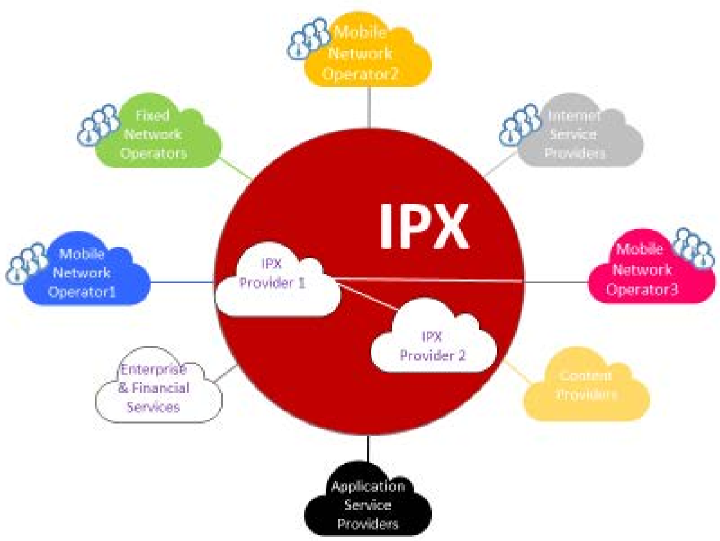
to-use offers for global travellers. These transparently priced global roaming services would allow users to choose a local network with a few clicks on the device.[79] In such scenario there would be no need of a roaming platform.

From an MNO perspective this scenario might be a second chance for European operators to come up with value proposition for visitors: temporary flat use of 'visiting network' per day, week, etc.

4.4 IPX Model

In the early 2000s, the GSMA developed a telecommunications interconnection model for the interoperable exchange of IP based services between customers of separate MNOs via IP based network-to-network interface, the 'IP Packet eXchange' or IPX network. The model is open to other players of the broader telecommunications ecosystem such as fixed operators, other types of service providers (Internet Service Providers-ISP, Application Service Providers-ASP, Content Providers, Enterprise Services, and Financial Services).[80]

Figure 19: IPX model ecosystem



Source: TeliaSonera: http://www.whatisipx.com/whats-ipx/

In the interconnection context, IPX refers to the service level (not the network level).[81] By clarifying the mandatory use of a **private IP backbone network** by IP Providers and the connection of Service

[79] McKinsey & Company: http://www.mckinsey.com/industries/telecommunications/our-insights/e-sim-for-consumers-a-game-changer-in-mobile-telecommunications

[80] TeliaSonera: http://www.whatisipx.com/whats-ipx/

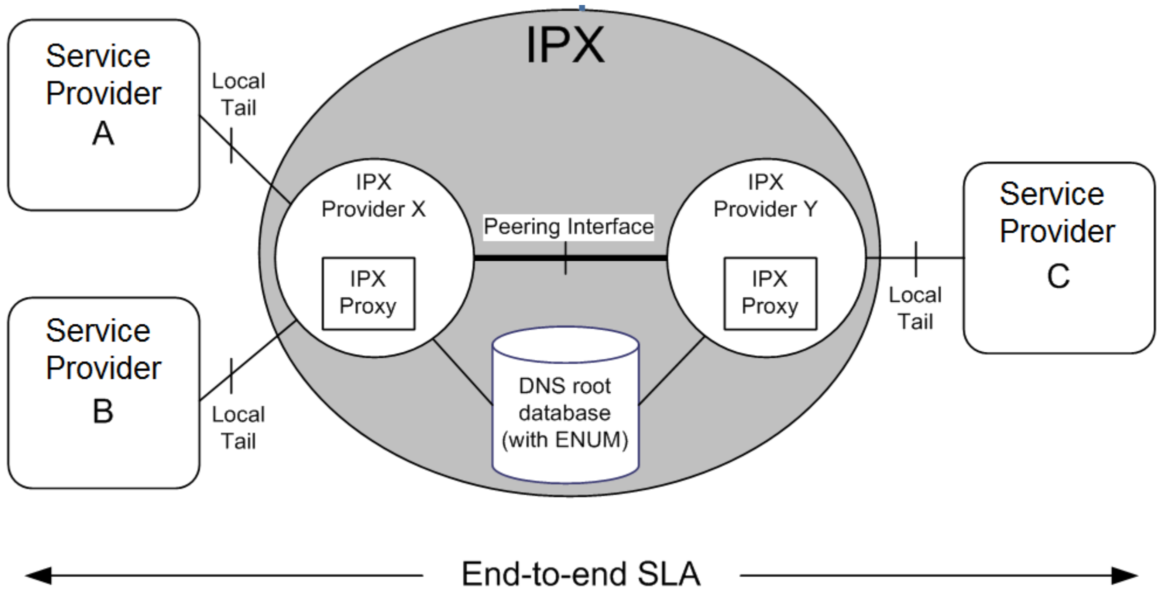
[81] GSMA, IR.34 - Guidelines for IPX Provider networks

Providers to their IPX Provider(s) through local tail(s)[82], the GSMA have removed a major reason for confusion about the IPX concept that hindered faster adoption of IPX deployments (see 3.3).

Nevertheless, in its architecture model, the GSMA insists on an **end-to-end service-level** of the IPX Provider(s). This is **problematic** since the MNOs' networks or even the subscribers' devices are beyond control and responsibility of the IPX Providers. A technically possible implementation of such end-to-end SLA would dramatically increase complexity and cost to be borne by MNOs[83].

In order to shape the future IPX as efficient and lean as possible we recommend to **modify** the **IPX architecture** specified in IR.34, 3.2 accordingly.

Figure 20: IPX architecture model suggested by GSMA



Source: GSMA, IR.34 - Guidelines for IPX Provider networks

Principles[84]:

- Based on private IP Domain which spans from Service Provider to Service Provider
- Hub Model (i.e. one to many access) with maximum 2 hops
- Multi-service capable
- Allows a cascading business model
- Guarantees quality, security and service assurance across the whole IPX domain
- Mediation / interworking capabilities

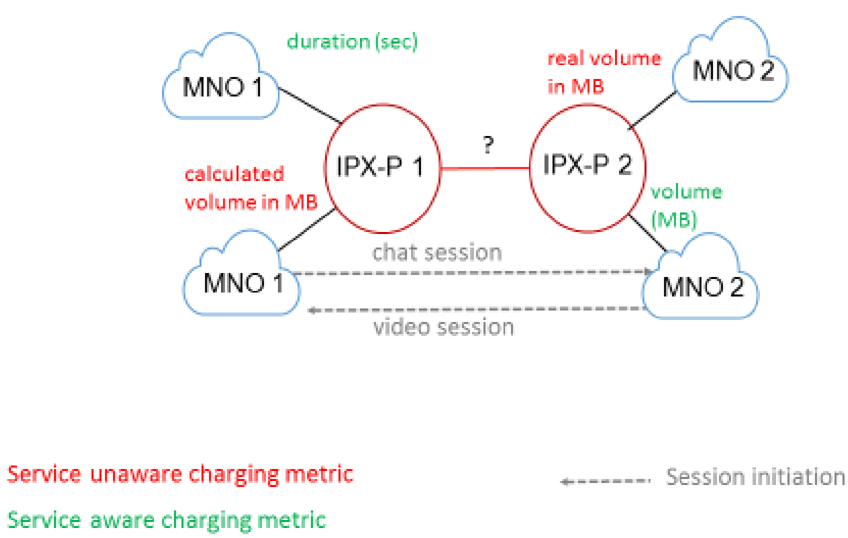
[82] GSMA, IR.34 - Guidelines for IPX Provider networks
[83] i3forum statement during the GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris
[84] GSMA workshop on 'Accelerating IP Interconnections for IMS-based Services' 22nd March in Tampa, Florida

MNOs can fully enjoy the advantage of the IPX model with providers who do both, own a high coverage network with low latency and maintain interconnections to other Tiers 1 IPX-Providers for multiple services. For example, Telenor and Vodafone have expanded their initial 4G signaling service to 2G/3G signaling, direct voice and SMS traffic, all interconnected via joint IPX capabilities[85].

4.5 Business Model and Metrics

The existing IPX business and charging model (IPX 1.0) is highly complex mainly due to too many charging options. The following figure illustrates the result of IN.25 charging options for RCS video share in an expensive but unsolvable interconnection scenario.[86] On top of this, a video session initiated by the subscriber of MNO2 would add to an existing chat session started by the subscriber of MNO1. In this situation, interconnection charging causes IT and management challenges and costs for no customer value.

Figure 21: Complex IN.25 charging principles, example of RCS Video Share



As per the market assumptions made in 4.1 each interconnection business model designed for the next few years should also be **suitable for longer term.** There is a large consensus that in the current transition from legacy deployments towards and all-IP interconnection world commercial

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85 CapacityMedia: Vodafone and Telenor partner to deliver multi-service IPX: http://www.capacitymedia.com/Article/3553497/Vodafone-and-Telenor-partner-to-deliver-multi-service-IPX.html

86 IR.25 VoLTE Roaming Testing

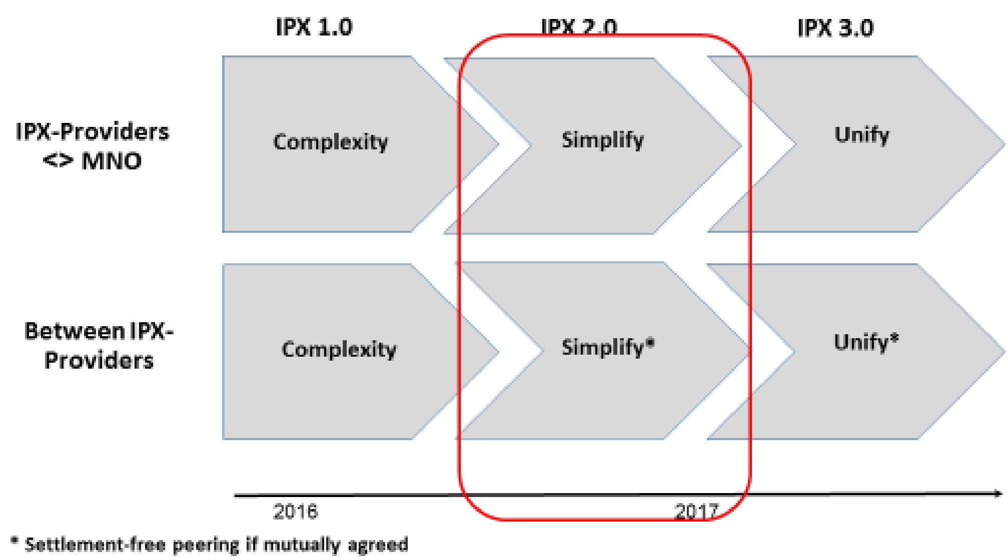
principles and charging models have to be simplified[87]. Even if today MNOs have partly customer-ownership (SIM, telephony) and still do provide numerous services this commercial model need to be adaptable to all future scenarios for the industry described in 4.1 including the extreme one 'data access only without customer ownership'.

The **focus** of this document is the transformation of the existing complex, and often confusing, IPX commercial model (IPX 1.0) into a **simplified commercial model (IPX 2.0)** that supports both, MNOs and IPX Providers to accelerate the move towards and all-IP interconnection world. The proposed commercial principles aim to foster the growth of IP interconnections for IMS based mobile services in order to assure a universal reach as soon as possible.

In a second step, the GSMA could analyse through **commercial trials** how this simplified model (IPX 2.0) could be implemented by some of its members and supported by IPX Providers.

It is also beneficial to take a longer term view on an appropriate timeline as well as challenges and opportunities of a possible charging unification, both between IPX Providers and MNO and between IPX Providers. Some initial considerations on this aspect are captured in chapter 4.5.2.

Figure 22: Evolution of IPX business model



The goal should be to move from the existing situation of complex, diverse and sometimes inefficient and costly interconnection charging situation towards a pragmatic and efficient model that can be implemented at short notice.

87 GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris, 22nd March in Tampa, Florida and 25th May in Hong Kong

4.5.1 COMMERCIAL CHARGING MODEL

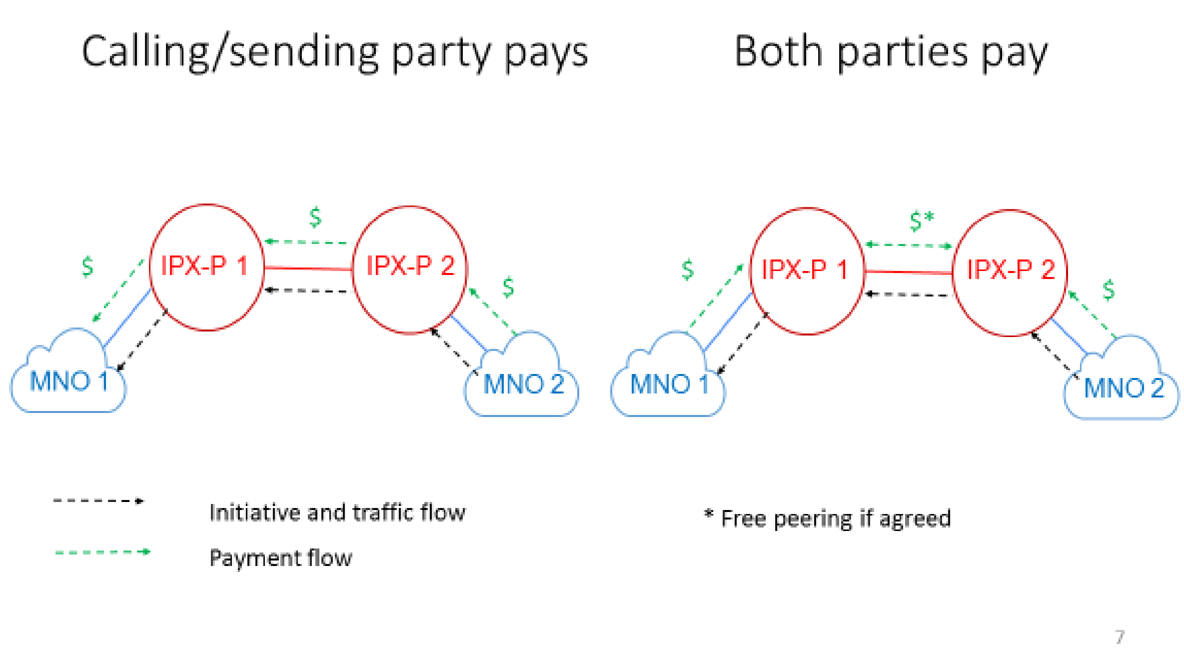
We assume that for the step towards simplification (IPX 2.0) is to assume that the main existing commercial principles for terminations services will not change for voice services: **Calling (or sending) party network pays** (CPP, worldwide principle applied except USA, Albania, Barbados, Cameroon, Russia, Singapore, Ukraine)[88].

Market reality has abolished the principle from legacy interconnection 'No charging for signalling', in fact all IPX Providers do offer signalling as a service. With a view to roaming signalling or interconnection supporting (premium) IoT this development seems justified as nowadays there are SIMs that only generate signalling traffic.

In the Calling (or sending) party pays model, a cascaded payment flow follows traffic flow. The initiator is responsible and bears all the cost of transport, routing, monitoring and termination into the called (or sent-to) network, e.g. for a call or a file of 5 Mbytes sent to the subscriber to MNO 1 (see below). This means that termination rates would continue to exist.

The **both-parties-pay** model takes into account that communication is both-ways and both parties benefit from it, e.g. for a call or a file of 5 Mbytes sent to the subscriber to MNO 1. Therefore, both Operators pay to their IPX Provider who amongst themselves can mutually charge or waive charging. This model is already used for internet data access, both at an interconnection and retail level. No termination rates exist in this scenario.

Figure 23: Traffic and payment flows of CPP and BPP charging principles



[88] OECD (2012), "Developments in Mobile Termination", OECD Digital Economy Papers, No. 193, OECD Publishing

A pragmatic approach would be to combine the information available at IMS level and existing billing systems to come to a **simplified charging model** per service reusing a cascaded calling/sending party pays model. Access bandwidth between IPX Provider and MNO would be charged separately at both ends to the Operators.[89]

Figure 24: Simplified IPX Charging Model of IPX 2.0

Layer	Charging unit	Charging principle	Termination
Service Layer	Session-based unit-rated	Calling/sending party pays	Cascaded termination fee
IPX Access Layer	Bandwidth-based	Both parties pay (to their IPX-Provider)	n.a.

One of the advantages is that SIP is the common protocol for all IMS services (Voice, Video, and RCS) and already largely deployed for VoIP services (fixed and mobile). All current billing systems support a session related minute-based charging.

During the course of a series of worldwide GMSA workshops on ‘Accelerating IP Interconnections for IMS-based Services’, a total number of 21 Operators and 16 IPX Providers have developed a possible way forward to simplify charging in the near future[90].

Although the work has revealed a significant diversity of preferred models per respective market player, all operators and carriers are willing to support a fall-back charging model. It became also clear that **one fall-back charging model per service** is required (proposed fall-back models see below). For clarity: the market players are entirely free to mutually agree on alternative models (e.g. per Mbit/s, bill & keep). In case two parties cannot reach an agreement on the charging mechanism to be applied, they could refer (fall-back) to this predefined industry-wide accepted principle.

[89] Source: Orange at WSOLU Meeting Vienna, June 2016

[90] GSMA workshops on ‘Accelerating IP Interconnections for IMS-based Services’ 25th January in Paris, 22nd March in Tampa, Florida and 25th May in Hong Kong

Figure 25: Simplified IPX 2.0 Charging Model (fall-back model per service)

Service	Between IPX-Ps	IPX-P <> Operator	Charging principle
VoIMS (VoLTE, VoWiFi)	Session-based minute-rated	Session-based minute-rated	Calling party pays, cascading
ViLTE	Session-based minute-rated	Session-based minute-rated	Calling party pays, cascading
Messaging*	Session-based event-rated	Session-based event-rated	Calling party pays, cascading
Signaling	Session-based event-rated	Session-based event-rated	Calling party pays, cascading
IPX Access Layer		Bandwidth-based	Both parties pay (to their IPX-Provider)

* Voice or Video call starting from RCS message to be charged as Voice or Video

Maintaining termination rates for the next-generation of Voice over IMS (VoIMS: VoLTE, VoWiFi, ViLTE) and advanced messaging (RCS, chat) will **assure** a **revenue contribution** to the Operators for their services provided to other players of the ecosystem. This is especially vital for asymmetric termination of A2P messages or calls to incoming destinations highly depending on the related incoming revenue (see chapter 3.1.1).

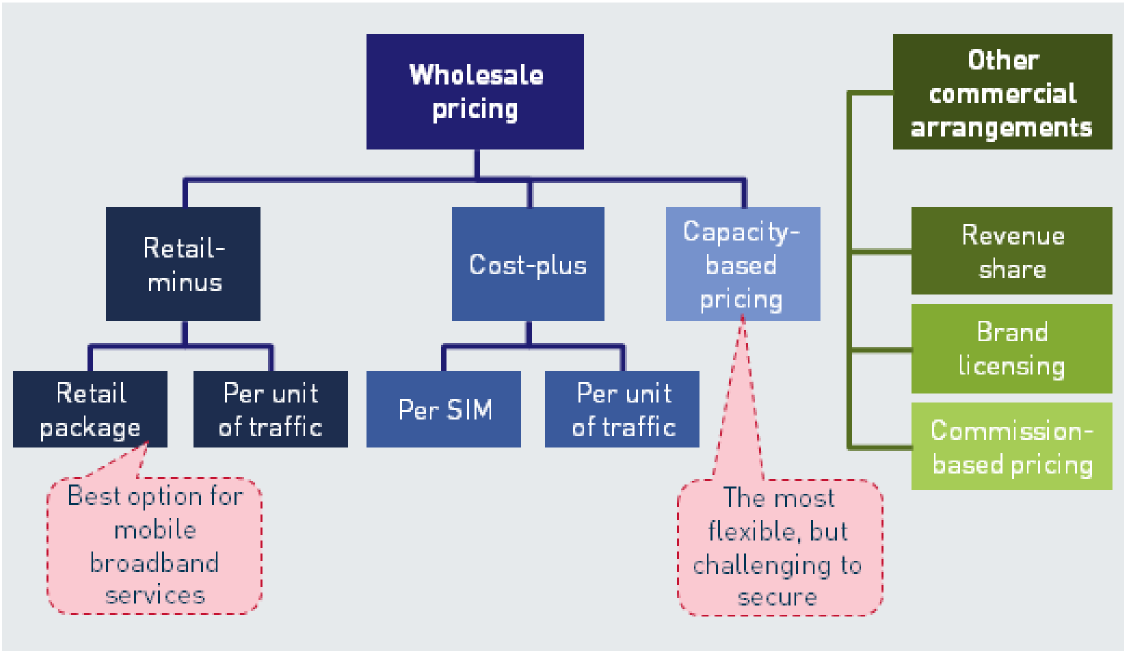
On the other hand, the bandwidth-based charge for the IPX access guarantees revenues and margin for IPX Providers that allow them to further invest and innovate.

With a view to **longer-term** unification, the GSMA should **evaluate** the possibility to move to a **bandwidth-based charging model**. This would represent a simple and lean mechanism avoiding potentially expensive investments in billing systems. It would also better reflect the data usage, e.g. for messages with large files attached. Overall, it would it would mean a faster move to an internet-oriented long-term model (see below).

Even though the focus of this document is on how to shape the transition from the existing complex charging situation towards a pragmatic and efficient model, below we describe a possible way to a **longer-term unified all-IP charging model**.

According to an Analysis Mason report on the wholesale environment between MNOs and MVNOs, unit-based approaches to pricing are losing relevance in a data-driven environment. In a capacity-based pricing model the host provides a percentage of its network capacity for a fixed fee. In this way, the MVNO has significantly more flexibility in data pricing, with no link to unit consumption.[91]

Figure 26: Wholesale Pricing Structures for MVNOs



Source: Analysis Mason: MVNOs 2.0 - new pricing models in a data-driven environment, 2015

The challenge for MNO between their retail and wholesale pricing towards their providers is not significantly different from the MVNO situation.

As described in 3.2.3, internet interconnection traffic is charged on a bandwidth-based model where both parties (MNO 1 and 2 above) pay. In IP peering or transit arrangements, the used bandwidth is calculated on a monthly basis. For MNOs usually downstream is higher and relevant due to their customer pattern with more downloads than uploads. The charging itself could have a price differentiation per Class of Service, e.g. on dedicated VLANs.

Figure 27: Possible long-term charging model of IPX 3.0

Service	Between IPX-Ps*	IPX-P <> Operator **	Charging principle
VoLTE	Bandwidth-based	Bandwidth-based	Both parties pay
ViLTE	Bandwidth-based	Bandwidth-based	Both parties pay
VoWiFi	Bandwidth-based	Bandwidth-based	Both parties pay
Messaging	Bandwidth-based	Bandwidth-based	Both parties pay
Signaling	Bandwidth-based	Bandwidth-based	Both parties pay

* Bill & keep (settlement-free peering possible on mutual consent)
** different classes of Service may have different price per mbps

[91] Analysis Mason: MVNOs 2.0 - new pricing models in a data-driven environment, 2015

OTT services have been attacking the mobile industry's most profitable traditional services: SMS and telephony. The value of complex charging models have vanished. In order to establish a private and secure quality alternative to the internet without, however, adding complexity cost the industry should evaluate the adoption of a bandwidth-based charging model within the next few years (depending on the business policies described in 4.5.2).

GSMA should co-ordinate this evaluation with its members and IPX Providers as well as verify if existing SBCs and billing systems collect and process bandwidth information. If this option is not supported a volume-based charging model (per Mbytes) would be an alternative.

4.5.2 BUSINESS POLICIES

In the predominant global economic system (telecommunications) companies aim to optimize their current and future value.

In chapter 3.1 we have seen examples for asymmetries in European roaming statistics, mainly due to tourism. The level of IOT applied to external visitors as well as termination rates and ratios have a strong impact on how important such income is for operators of a given country, too. Together with the technological advancement regarding the time required to an all IP (interconnection) network it is possible to indicate an **operator's business policy** related to a simplification or unification of a future IPX charging model. (IPX 2.0 and 3.0, see above).

The following table undertakes to classify operators of different countries and deduct a business policy towards an all-IP interconnection and charging model IPX 3.0 (full table see Annex 1). Such attitude is not directly linked to one aspect but the result of various factors. The main drivers for an operator's business policy are the level of MTR and roaming IOT to external visitors (e.g. from outside the EU), the traffic and roaming ratio and the relevance of the related revenue (mainly due to migration and/or incoming tourism vs. size of domestic market) as well as the technical advancement regarding an all-IP network.

According to this analysis, the weight of countries (by population) with a progressive attitude to an all-IP interconnection and charging model with 14 % is much smaller than the share of conservative countries (86%).

Figure 28: Business policies regarding IPX 3.0

(Per country based on country codes 2016 without a population below 30000 or a GDP below $USD 1 Billion. Extract example of countries[92])

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Afghanistan	93	29.121.286	high	high	high	high	longer	conservative
Albania	355	2.986.952	high	high	high	high	longer	conservative

[92] Source for country codes, population and GDP: https://countrycode.org/. Source for MTR, IOT, importance, all-IP: own research

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Algeria	213	34.586.184	high	high	high	high	longer	conservative
Angola	244	13.068.161	high	high	high	high	longer	conservative
Antigua and Barbuda	1-268	86.754	high	high	high	high	longer	conservative
Argentina	54	41.343.201	low	high	low	high	longer	conservative
Armenia	374	2.968.000	high	high	high	high	longer	conservative
Aruba	297	71.566	high	high	high	high	longer	conservative
Australia	61	21.515.754	low	high	low	low	short	progressive
Austria	43	8.205.000	low	high	high	low	short	progressive
Azerbaijan	994	8.303.512	high	high	high	high	longer	conservative
Bahamas	1-242	301.790	high	high	high	high	longer	conservative
Bahrain	973	738.004	high	high	high	high	longer	conservative
Bangladesh	880	156.118.464	high	high	high	high	longer	conservative
Barbados	1-246	285.653	high	high	high	high	longer	conservative
Belarus	375	9.685.000	high	high	high	high	longer	conservative
Belgium	32	10.403.000	low	high	low	low	short	progressive
Belize	501	314.522	high	high	high	high	longer	conservative
Benin	229	9.056.010	high	high	high	high	longer	conservative
Bermuda	1-441	65.365	high	high	high	high	longer	conservative
Bhutan	975	699.847	high	high	high	high	longer	conservative
Bolivia	591	9.947.418	high	high	high	high	longer	conservative
Bosnia and Herzegovina	387	4.590.000	high	high	high	high	longer	conservative
Botswana	267	2.029.307	high	high	high	high	longer	conservative
Brazil	55	201.103.330	low	high	low	low	short	progressive

Zimbabwe	263	11.651.858	high	high	high	high	longer	conservative

Population total	6.854.171.940	
thereof all-IP progressive	962.137.060	14%
thereof all-IP conservative	5.892.034.880	86%

* e.g. for EU countries towards non EU operators / visitors

** mainly due to migration and incoming tourism vs. size of domestic market

Business policy of **IPX Providers** regarding simplifying or even to abolishing charging in an IPX wholesale ecosystem are driven by other parameters:

- Importance of wholesale incoming revenue from other wholesale providers. The higher this importance the lower the willingness to move towards and IPX 3.0 model
- Number and share of customers migrated to IPX: advanced providers would have a competitive advantage (e.g. for on-net traffic they could charge twice). As a matter of fact, many leading IPX Providers have waived charging amongst themselves already.
- Small or new providers would like to enter into a settlement-free IPX peering. However, larger providers are unlikely to peer with smaller.
- Small providers could follow a niche strategy and increase their attraction to both, customers and tiers 1 providers

4.6 Competitive Benefits for MNOs and Industry opportunities

4.6.1 Considerations

In chapter 3.3 we have seen that, although IPX deployments are starting to take off, there is still a long way to go until a complete migration from legacy networks to an all-IP world is finalized for a large majority of operators. So what kind of benefits would motivate MNOs to accelerate an adoption of IP interconnection?

The more substantial the competitive benefits for MNOs the higher the speed of implementation of a new technology like IPX interconnect. Until recently, the perceived benefits were not compelling. With the rise of VoLTE, the re-start of RCS and a possible simplification of the business model, these competitive benefits will grow.

The term ‘competitive’ implies a clear market playing field. Other MNOs obviously remain competitors but today they are one possible player to provide access and services to the smartphone user. Additional threats have arisen from other players like WiFi networks, content providers and OTT players (see 2). Therefore, relevant benefits for MNOs must either be capable to provide a clear differentiation from these competitors or put the MNO into a strong positon to partner with such players.

4.6.2 Universal Reach

Over the last ten years, we have seen different kind of (internet-based) walled-garden-approaches like services and applications developed and promoted by federated telecommunications companies. Despite Operators enjoying privileged access to their customers in offering data connectivity (see chapter 2), these approaches failed mainly due to the lack of universal reach. Even if some of the walled-garden OTT services for next-generation messaging already reach 70-80% of smartphone users, they are still unable to offer this crucial feature..

The beauty of the 'good old' SMS has been the global reach based on the universal E.164 numbering scheme. The A customer has been able to contact B just by using B's MSISDN regardless of network operator, service provider, location, device, operating system, etc.

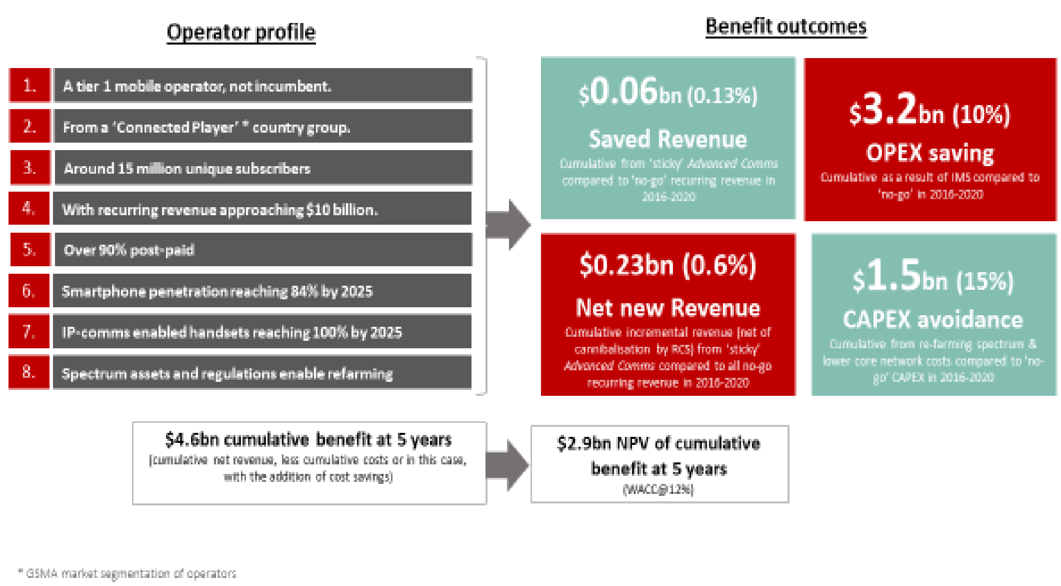
In the messaging space, a network of Tiers 1 IPX Providers with one harmonized data base and universal RCS profile would ensure both, a universal reach of messaging and the mobile industry's control over the related traffic.

In order to leverage the potential of the mobile industry to reach any device for next-generation messaging, voice or video services a joint routing and addressing solution is required and available. The combination of the ENUM scheme and the capabilities of the IPX model have the potential to replicate the universal reach for next-generations services.

4.6.3 Effect on Revenues, OPEX and CAPEX

Within its Network2020 Program the GSMA has developed a business case tool that was presented to the public during the Mobile World Congress Shanghai in June 2016. It allows operators to predict the financial effect of migrating to an all-IP world according to its individual profile. The model operator described below would generate a cumulative benefit of 4.6 bn. over 5 years with the main levers being OPEX savings (3.2 bn.) and CAPEX avoidance (1.5 bn.).

Figure 29: Operator business tool for all-IP



Revenue effects are expected to be minor and there are no indications yet for significant variations per service in an IPX environment. It is the mobile industry's challenge to proof that there is room for a service-aware interconnected product innovation. An experience from South Korea, one of the most advanced markets in terms of IP broadband coverage, shows however that new services as VoLTE are introduced silently. As a matter of fact, their number of VoLTE users have been growing rapidly after introducing the service on default mode at the same price than circuit-switched voice. The downside of this strategy obviously is the lack of a positive revenue effect.[93]

Depending on many factors, it is generally beneficial for an MNO to migrate its interconnectivity towards an all-IP environment. The more established and incumbent a market player is, the higher the probability of former legacy networks and slow growth. In order to quantify the benefits for an operator, the GSMA has developed a generic operator financial model that can be adjusted accordingly.

The anticipated savings originate from different sources such as re-farming radio spectrum, network operations, IT/billing and commercial operations in an all-IP network interconnected with an IPX hub concept (see 4.4).

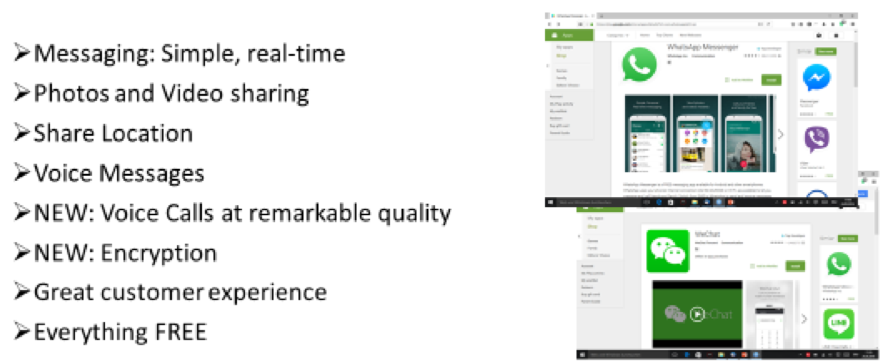
In spite of OPEX savings and CAPEX avoidance demonstrated by the GSMA tool, many MNOs are still reluctant to invest into IPX interconnections as revenue returns are low. This factor seems to separate the Tier 1 and the others, the former look at strategic benefits whilst the other are still very revenue centric.[94]

A case study in Finland showed that also a domestic IPX called DIX can be financially positive and beneficial as long as it is a multi-service deployment, e.g. for RCS, VoLTE, ViLTE[95].

4.6.4 Other Benefits for Operators

In chapter 3.5 we have described major industry driver trends and in 4.1 key market assumptions. Over the last few years, OTT players have been successfully attacking the mobile industry's core products and have recently also pushed towards quality and security features like encryption.[96]

Figure 30: OTT competition, example of messaging



[93] Source: SK Telecom presentation at GSMA workshop 'Accelerating IP interconnection of IMS-based services', 25th May in Hong Kong

[94] GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th May in Hong Kong

[95] Source TeliaSonera, Paris 26.01.16, tero.jalkanen@teliasonera.com

[96] e.g. What's App introduced voice calls and encryption, Skype reviews quality of each connection

Discussions with Operators from different regions, size and market position revealed that the mobile industry is largely suffering from an insufficient differential between its next-generations products and (1) traditional TDM-based services and (2) recent OTT offerings. Especially RCS and VoLTE are implemented without being marketed to consumers.

Products like enriched calls (VoLTE) or messaging (RCS) need to offer differentiating features, be firmly built into the handset or operating system by the MNO and '**appear free'**, e.g. as part of a data bundle. A survey conducted by GSMA indicated that customers would prefer such service over an OTT offering.[97]

Those MNOs that want to offer a service portfolio to their own customer base urgently need to come up with a new set of services. These new services need to **combine** the **universal reach** owned by the mobile industry **with** the **quality** and **security** capability of an interconnected ecosystem. The objective is to offer a large scale differentiating product value proposition that can generate substantial future revenue and profit.

Figure 31: Consumer and corporate services with global reach

Service	Use case
Mobile conferencing	Bridging in VoLTE/ViLTE (roaming) call to WebRTC or enterprise video conference
Critical IOT	Connected driving, health monitoring, baby alarm
A2P messaging	Banking, monitoring of critical systems
Behaviour-based services/actions	ad-hoc 4/5G offers in case customer encounters problem while using a navigation app
HD video / media content delivery	Premium and/or local media content

Through the course of the series of GSMA workshops on 'Accelerating IP interconnection of IMS-based services' it became clear that such **a product and business plan** would be key to both, convince financial markets about the industry's growth perspective and provide funding for network investments into a universal interconnectivity. Further investments into domestic

[97] GSMA Network2020

broadband networks will mainly fuel the use of OTT services. Only with a universal interconnectivity the mobile industry will gain reach for services offered by operators. The value for the customer has to be that compelling that he is prepared to pay a certain premium compared to OTT offerings.[98]

Consumer and corporate services are obviously beyond scope of this document. Therefore, the following table should only give some ideas of **profit-generating services** that leverage the capabilities of a service-aware all-IP network globally interconnected through IPX.

At the same time, the interconnection teams at future-oriented MNOs should **expand their IP-based interconnections coverage** to lay the foundation and be prepared for the success of differentiating services.

The capabilities of an interconnected all-IP world offer to MNOs the possibility to expand **customer** and **brand ownership** abroad in certain roaming scenarios.

Which benefits would motivate MNOs to accelerate an adoption of IPX?

- OPEX savings and CAPEX avoidance based on an all-IP network and lean billing system
- Profit-generating services combining universal reach with quality and security need to be defined by MNOs

4.7 Next-generation Wholesale Services

As we have seen in chapter 4.6.3 more and more traditional (telephony, messaging) but also new mobile services (payment, video, IoT, etc.) have been moving into the OTT world. MNOs are trying to compete through bandwidth and speed. The figures seem impressive as mid-size Operators like SFR have announced to invest 1.5 bn. Euros into their French network next year[99]. But the more MNOs invest into their domestic (broadband) networks without offering a differentiated and interconnected service portfolio the better become the conditions for future OTT offerings.

Therefore, it is vital for the mobile industry to do both, develop profit-generating services combining universal reach with quality and security and **build** a resilient and secure **interconnection platform** for existing and future service offering (beyond data access) as **quickly** as possible. As the window of opportunities is closing, Carriers and Operators could even think

[98] GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris, 22nd March in Tampa, Florida and 25th May in Hong Kong

[99] Source: SFR, June 2016

about implementing interconnection for critical services like RCS and start charging after the service have taken off beyond a certain threshold.

Before entering into specific services by IPX Providers it is important to recall the fundamental capabilities that provides an IPX ecosystem to MNOs:

- Quality, security and service assurance in a private IP domain
- Universal reach to any subscriber of any Operator
- Interworking, mediation, transcoding functionalities

The 'IP and IPX Migration Status Report' presented by Hot Telecom and the i3forum in May 2016[100] proved that nearly all IPX Providers offer the full portfolio of basic IPX services (VoIPX, Signalling over IPX) but only a minority already support VoLTE and VoLTE roaming. The large majority is currently working on VoLTE and VoLTE roaming over their IPX.

From an MNO perspective the order of priority a deployment usually is to kick-off with domestic services and interconnection, then move to roaming and finally tackle international interconnection of new services and features.[101]

The study also revealed that a majority already offers value added IPX services, mainly fraud management services (69%) and HD voice (62%). More than 50% offer transcoding, number portability in call and signalling interoperability on their IPX platform. It is this kind of wholesale services that leverages the power of universal reach in an interconnected service-aware world of mobile services.

Only 31% offer analytics services and 27% offer number portability query services. As few as 8% offer WiFi roaming support, while other 8% are currently deploying this capability. A 58% of the respondents stated that VoLTE in call transition to video was already on their road map, 17% said they are considering offering the service and 25% said they were not considering it. It may seem surprising that there are no RCS hubbing offers yet and only 15% having such service their roadmap. [102] But this is largely due to a combination of factors, especially the lack of RCS installed at customers' devices, diverging domestic / group RCS deployments and unsolved RCS interconnection charging models.

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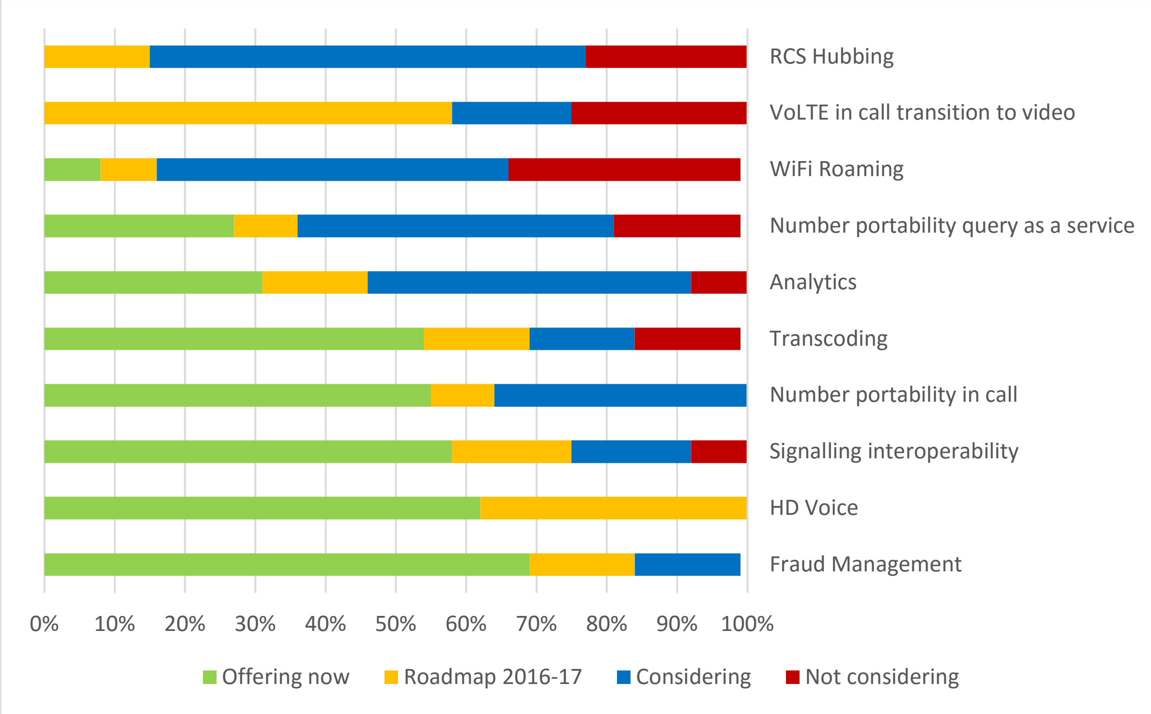
[100] Hot Telecom and i3forum: IP and IPX Migration Status Report, May 2016

[101] GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris, 22nd March in Tampa, Florida and 25th May in Hong Kong

[102] Hot Telecom and i3forum: IP and IPX Migration Status Report, May 2016

Figure 32: Value added IPX wholesale services and capabilities



Source: Hot Telecom and i3forum: IP and IPX Migration Status Report, May 2016

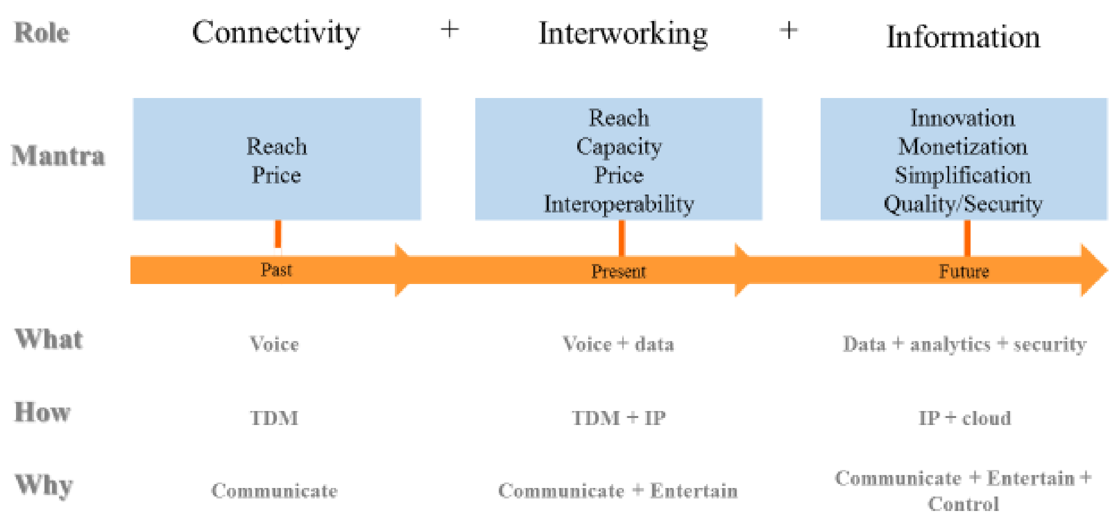
Based on the unique capabilities that provides an IPX interconnection platform, wholesale services already available or on the roadmap today have the potential to support to MNOs' product strategy.

Figure 33: Wholesale services supporting MNO product innovation

MNO Service	Ubiquity of IPX features	Wholesale Service
Mobile conferencing	Interworking, transcoding, security universal reach	• Wifi Roaming • Transcoding • Signalling interoperability
Critical IOT	Latency, security, universal reach	• Big data analytics
A2P messaging	Security, universal reach	• RCS hubbing
Behaviour-based services/actions	Real-time availability of user big data	• Big data analytics
HD video / media content delivery	Interworking, transcoding, latency, universal reach	• Transcoding • Signalling interoperability

It is necessary and beneficial for IPX wholesale providers to keep on innovating along the anticipated requirements of their customers, i.e. from providing connectivity, across interworking towards information[103].

Figure 34: Carriers' roadmap up the value chain



Which wholesale services are required allow MNOs to achieve the required benefits?

- Full portfolio of basic IPX services: VoIPX, Signalling over IPX, speed-up VoLTE and VoLTE roaming
- Value added IPX services: fraud management services, transcoding, number portability in call and signalling interoperability to leverages the power of universal reach in an interconnected service-aware world of mobile services
- IPX wholesale services already available or on the roadmap today support MNO product strategy

4.8 Summary and Evaluation

As the long-term ('end game') scenario for the MNOs' role is not clear, the selected interconnection model and has to fit for all main future 'end game' scenarios. The table below refers to the models discussed in chapter 4.2 and assumes four possible market scenarios. It undertakes to **evaluate** the effect of different **interconnection models per market scenario** for MNOs in positive, neutral and negative (for the sake of clarification it is NOT an evaluation of the respective market scenarios). For example, MNOs positioned as premium and full- service provider would earn negative results by mainly relying on an internet-based interconnection network. In return, an Operator purely providing data access to its customers has to be extremely lean and

[103] Hot Telecom: Above and beyond connectivity

efficient and, per definition, cannot afford to maintain a complex interconnection model such as IPX.

Figure 35: Evaluation of different IP interconnection models per future market scenario
(From MNO perspective in terms of complexity costs and contribution to business success)

No in 0	IC via… / MNO provides…	Data access w/o customer ownership	+ sim & customer ownership	+ select services	+ full service
1-3,5	Internet (PRP, PUP, ITR, SIP)	+	+	o	o
4	Sponsored wholesale platform (SWP)	+	+	o	o
6	Single Service Hub, e.g. Messaging (SSH)	+	+	o	o
7	Internet IC with tunnelling IP-Sec (IPS)	-	-	o	o
8	Internet IC with QoS Prioritization (QOS)	-	o	o	-
9	Dedicated IP IC per service (DIP)	-	-	+	+
10	IPX 1.0 complexity	-	-	o	o
10	IPX 2.0 simplification	-	o	+	+
10	IPX 3.0 unification	-	+	+	+

(o neutral, + positive, - negative)

In none of the four market scenarios, MNOs could rely on one single IP interconnection model. However, interconnection and interoperability between Operators is required for any mobile service scenario. A **combination of different models** (hybrid model) is required. However, which are the factors that an Operator should consider? The decision matrix for IP interconnection illustrates decision drivers, limiting factors and cost factors (access and transport cost only!) for three principal IP interconnection models: dedicated IP interconnection, IPX and Internet interconnection.

Figure 36: Decision Matrix for IP interconnection

	Dedicated private IP-Interconnect	IPX-Interconnect	Internet-Interconnect
Decision driver	Volume	Quality, security	Cost
Limiting factor	Granularity, Reach	Complexity, Cost	Quality, Security
Price factor per monthly bandwidth (Mbit/s)*	1	50	1

* access and transport cost only, especially without termination fees

Example (number of interconnect relations per model):

Operator 1[104]	10	150	40
Operator 2[105]	5	15	180

One of the key questions for the industry is whether it will manage to **reduce complexity and**, as a consequence, **costs** of using and IPX interconnections. Even though the other models benefit from significant **economies of scale**, the premium that Operators are willing and able to pay is limited (see: importance of quality and security for the individual operator in chapter 4). The mobile industry and wholesale players jointly find themselves in a Catch22 situation: due to slow adoption of IPX interconnection the volumes are relatively low and the costs are high.

The financial reference point is an interconnection via the Internet. It is clearly set by the market price of IP Transit of about $ 0.50 per Mbit/s in competitive regions to $4 in hard to reach regions. Dedicated IP-Interconnects are assumed to vary between $ 0.2 and $ 5 depending on use case and volume. The IPX decision matrix above shows a price per monthly bandwidth (Mbit/s) which is approximately **factor 50 higher** than the IP Transit reference prices.[106]

As **short-term** fall-back charging model for IPX 2.0 we suggest a combination of session-based calling party pays with **bandwidth-based** both parties pay for the access to the IPX Provider. For VoIMS (VoLTE, VoWiFi) and Video the service charge would be minute-based, for messaging and signalling session event-based. It promises a fast move towards an internet oriented long-term lean model, avoids new termination rates and investments in billing systems.

A potential transition to an all-IP environment in general and more specific to a bandwidth-based IPX 3.0 is expected to take shorter or longer depending on the anticipated business policy of different countries that are largely based on commercial, regulatory and technical conditions.

The mobile industry must urgently **develop** profit-generating **services** combining universal reach with quality and security. The more MNOs invest into their domestic networks without offering a differentiated and interconnected service portfolio the better become the conditions for future OTT offerings. For the mobile industry this means to do both, develop its service portfolio and **build** a resilient, secure and very efficient **interconnection platform** for existing and future service offering. Existing and upcoming IPX wholesale services and functionalities are apt to support innovative mobile services addressing retail and corporate customers.

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104 Example of an Operator 1 with a premium positioning in its market, mature services, substantial value generated from related services

105 Example of an Operator 2 with a price-oriented positioning in its market, recently launched services, low value generated from related services

106 GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris, 22nd March in Tampa, Florida and 25th May in Hong Kong

A specific strategic choice needs to be taken in the **messaging** space. If the aim of the mobile industry is to quickly catch-up with Facebook's soon to become a *de-facto* monopoly, then a single messaging hub is best bet (potentially followed by an IPX-based alternative). If the priority lies on control of the messaging traffic, then a network of IPX Providers managing the Operators' messaging service on an optimized future IPX model will be needed.

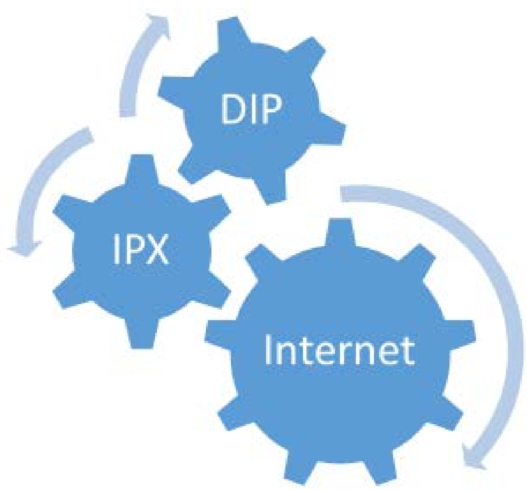
5 Proposition of Specifications Changes

5.1 Technical Architecture

A look around the broader ecosystem shows that typically content and OTT players rely on infrastructure deployed by fixed or mobile operators. However, there are seemingly contradictory cases: already back in 2012 Google announced its intention to build and run an own fibre infrastructure to the home business.[107] Since then, the dominant internet player has laid thousands of miles of fibre cabling and offers high-speed connections up to 1000 Mbit/s in five US cities.[108] Even if the short- term return for Google might be low the company strategically aims to make the Internet more valuable and generating more traffic online which eventually drives their core business activities. [109]

For MNO, the optimal technical architecture for IP interconnections is highly dependent on the situation of each MNO and the specific use case And any of the possible models for IP interconnection described in 4.2 might have its advantage. However, in order to simplify and reduce time to market for IP interconnections, reduce the infrastructure cost and optimize the transport of data we generally suggest operators to follow a hybrid strategy of three main models:

Figure 37: Hybrid Interconnection Approach



[107] Wired Business, http://www.wired.com/2012/12/google-fiber-not-just-kansas-city/
[108] Google Fiber, https://fiber.google.com
1.1 109 MIT Technology Review, James Surowiecki: The Wait-for-Google-to-Do-It Strategy, 2015
2

(1) Dedicated Private IP interconnection (DIP):

This architecture model, a dedicated, direct and private IP-connection between the routers and SBCs of two Operators, has been proved as an efficient option for key service-aware interconnection relations. Such relations dominate in oligopolistic domestic markets or between Tiers 1 telecommunication Groups.

Service-aware	High-volume	Isolation from Internet
Quality sensitive	Security sensitive	Limited number of relations

(2) IPX hub model (IPX)

This is the best solution for most use cases as it offers best quality and security and avoids the disadvantages of having to manage many dedicated relations (as long as the routes of the selected IPX Providers follows the shortest possible path and guarantees the lowest possible latency parameter). It is therefore suitable for quality and security sensitive A, B and C interconnection relations. Different from the other two models, if offers additional features based on its specialized hub concept like interoperability, mediation/interworking and bid data analytics.

Service-aware and unaware	High and low volume	Isolation from Internet
Interoperability	Mediation, interworking	Big data analytics
Quality sensitive	Security/privacy sensitive	Unlimited reach

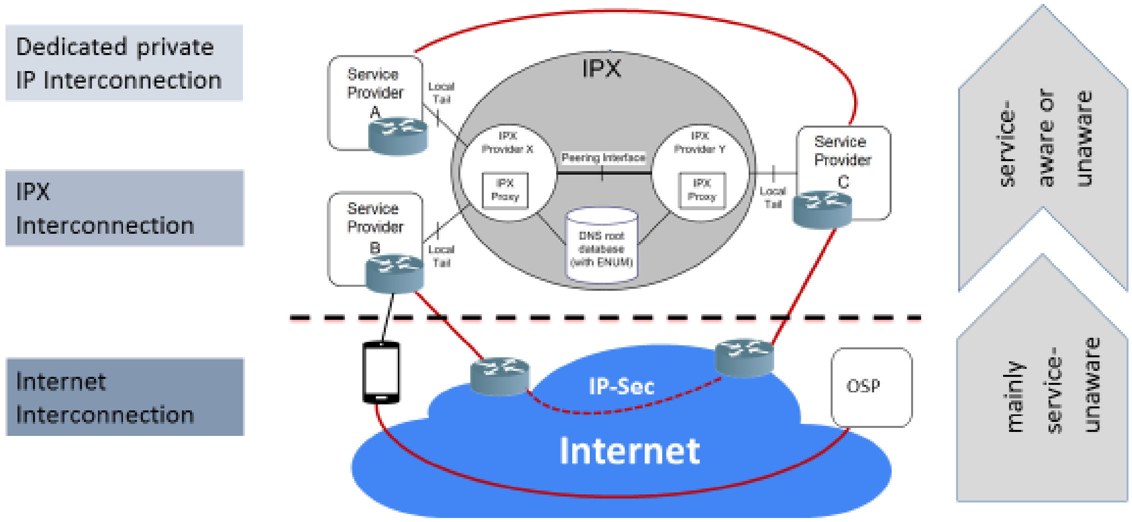
(3) Interconnection via public internet

Whilst this model is predominant for service-unaware IP interconnection via public (IP Peering, IP Transit) it has not been widely adopted for service-aware interconnections. The latter would combine results of OTT offerings with management cost of bilateral interconnections. Only in specific cases (low cost products, very remote networks) it might be an option and in all cases it should use virtual tunnelling via IP-Sec.

Mainly service-unaware	High and low volume	Low cost
Quality insensitive	Security insensitive	Unlimited reach

The graph below illustrates a combined hybrid architecture of dedicated IP interconnection (DIP), IPX interconnection and Internet interconnection via IP-Sec. Any given Operator needs to calibrate the weight of each component taking into account the commercial value generated by own services, maturity of the service, positioning of an operator on its market.

Figure 38: Hybrid Interconnection Architecture and estimated Traffic Share



The hypothesis for the definition of an interconnection architecture is that usage (traffic) has been moving and will continue to move to the internet resulting in operators and carrier become transport networks. The estimates provided below definitely require further research, however, the tendency they suggest seems obvious: Operators will lose major part of their international voice termination and roaming as well as data roaming to internet OSPs.

Figure 39: Share and Growth of IP-interconnection traffic for Mobile Services (estimate)

Type of IP-traffic (off-net)	Share 2016	Growth rate p.a.	Share 2018
VOICE			
DOMESTIC	100%	0%	100%
Private IP interconnection	90 %	- 4 %	83 %
IPX interconnection	5 %	+ 10 %	6 %
Internet IP-Sec	0 %	0 %	0 %
Internet OSP	5 %	+50 %	11 %
INTERNATIONAL	100 %	0 %	100 %
Private IP interconnection	70 %	-25 %	40 %
IPX interconnection	10 %	+10 %	14 %
Internet IP-Sec	10 %	-20 %	6 %
Internet OSP	10 %	+100 %	40 %
ROAMING	100 %	0 %	100 %
Private IP interconnection	20 %	-12 %	15 %
IPX interconnection	70 %	-20 %	45 %
Internet IP-Sec	0 %	0 %	0 %

Internet OSP & other roaming avoidance	10 %	+100 %	40 %
DATA			
ROAMING	100 %	0 %	100 %
Private IP interconnection	0 %	0 %	0 %
IPX interconnection	70 %	-35 %	30 %
Internet IP-Sec	0 %	0 %	0 %
Internet OSP & other roaming avoidance	30 %	+50 %	70 %

Beyond the optimal technical architecture for a given MNO, we would like to draw attention to a specific point that seems to be missing in the IPX ecosystem: a **fundamental network parameter** (**"network science")** which links together cost, user QoE and network performance (i.e. quality) for packet networks, just as Erlangs have done for TDM ones[110].

5.2 Specifications and Industry Standards

In order to provide a reliable environment for next-generation interconnection and roaming of mobile services, the GSMA should clarify some of the relevant specifications and promote clear industry standards.

5.2.1 Definition of IPX

By clarifying the mandatory use of a **private IP backbone network** by IP Providers and the connection of Service Providers to their IPX Provider(s) through local tail(s)[111], the GSMA have removed a major reason for confusion about the IPX concept that hindered faster adoption of IPX deployments (see 3.3).

Nevertheless, in order to assure the best possible quality and security, GSMA should clarify in its document IR.34, section 3.3.3 (Connectivity Options, IP Service Hub) that an IPX connection in such Hub concept should be limited to **maximum 2 IPX Providers.** This would both, facilitate QoS management and responsibility and simplify charging between IPX Providers. In practice, each IPX Provider could charge its customers (e.g. MNOs) and agree to a settlement-free peering amongst themselves. It could also accelerate the shake-out of an increasing number of IPX Providers as players with an excellent network and MNO coverage may charge twice in case they own the MNO customer on both ends.

Another area where complexity ambiguity should be removed is around **end-to-end SLA**. Even though the definition of end-to-end in IR.34 explains that service-providers' (MNOs') core and access-network are excluded [112] this is problematic since other parts of MNOs' networks (e.g. the local tail) might be beyond control and responsibility of the IPX Providers. A technically possible

[110] Margin Geddes Consulting, IPX – Salvation or Suffering, http://www.martingeddes.com/think-tank/ipx-telecoms-salvation-suffering/

[111] GSMA, IR.34 - Guidelines for IPX Provider networks

[112] GSMA, IR.34 - Guidelines for IPX Provider networks

implementation of such end-to-end SLA would dramatically increase complexity and cost finally to be borne by MNOs[113]. With a view to practicality, IR.34, section 3.2 and 6.1 should **clarify** that SLA parameters only applies to **IPX ecosystem** but include the IPX networks of all IPX Providers involved (should be maximum 2, see above).

Apart from introducing changes in the GSMA documents, an alignment with the community of IPX Providers around a common understanding of IPX key aspects and configuration would potentially reduce time to market for future IPX deployments.

5.2.2 INDUSTRY STANDARDS

The main industry standards beyond IPX specifications are around the charging model and user profiles.

The GSMA should increase its efforts to reduce the varieties of user profiles for messaging from three regional profiles (American, European, and Asian) down to one **universal profile** as soon as possible. Reducing the need for interworking would remove a major obstacle to a global roll-out of RCS interconnected either through the Google Jibe single messaging hub or a network of limited number of IPX Providers (see 4.3.2).

The GSMA and the mobile industry need to give clear guidance towards pragmatic and efficient model that can be implemented at short notice. As a result of the set of workshops on 'Accelerating IP-interconnection for IMS-based services' we suggest promote a simplified **fall-back charging model** for IPX interconnection. It combines the well-established traditional session-based cascaded sending/calling party pays principle with the future-oriented bandwidth-based model from the internet world. The high-level model is illustrated in the figure below. The endorsement of such model would imply an amendment and simplification of the related GSMA documents, especially IN.25 and IN.27.

Figure 40: Simplified charging model of IPX 2.0 combining tradition and future

traditional

Service	Between IPX-Ps	IPX-P <> Operator	Charging principle
VoIMS (VoLTE, VoWiFi)	Session-based minute-rated	Session-based minute-rated	Calling party pays, cascading
ViLTE	Session-based minute-rated	Session-based minute-rated	Calling party pays, cascading
Messaging*	Session-based event-rated	Session-based event-rated	Calling party pays, cascading
Signaling	Session-based event-rated	Session-based event-rated	Calling party pays, cascading
IPX Access Layer	future-proof	Bandwidth-based	Both parties pay (to their IPX-Provider)

* Voice or Video call starting from RCS message to be charged as Voice or Video

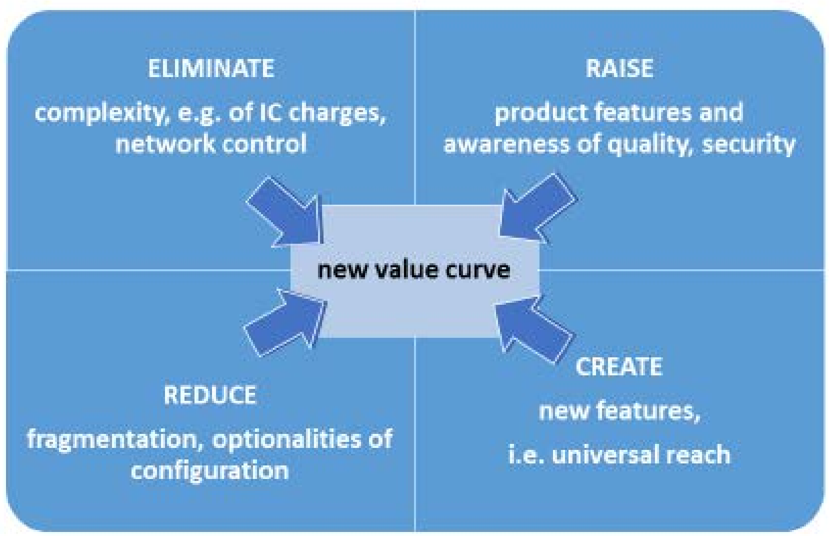
[113] i3forum statement during the GSMA workshops on 'Accelerating IP Interconnections for IMS-based Services' 25th January in Paris

6 RECOMMENDATIONS

The mobile industry has to move faster since the **window of opportunity** for interconnected service offerings is closing. With a next move by the OTT messaging providers e.g. a linkage between Facebook messaging (WhatsApp, Messenger) and Apple's iMessage or a traffic steering from A to B at the XMPP server level without transporting the media might be game changing for the future messaging market.

Inspired the 'Blue Ocean Strategy' [114]the mobile industry needs to simultaneously pursue **product differentiation** (raise underrepresented or create new competing factors) and **cost reduction** (reduce or eliminate expensive and traditional competing factors) to break the value-cost trade-off. For example, legacy and complexity of interconnect charges or network control not providing any customer value should be eliminated (see chapter 3.3.2). In exchange, hard-to-copy product features underpinning quality, security, universal reach or new features should be strengthened or created.

Figure 41: Market Strategy for an interconnected Mobile Industry



Source: based on Kim, Mauborgne

Operators need to create service offerings that combine the universal reach owned by the mobile industry with the quality and security capability of an IPX interconnected ecosystem. The objective is to offer a large scale yet **differentiated product** value proposition that can generate substantial future revenue and profit. The GSMA should facilitate and drive this process with its members.

[114] W. Chan Kim and Renée Mauborgne: Blue Ocean Strategy

The target should be to have a plan for an industry product value proposition by end of 2016 – ideally in a joint effort by MNOs and IPX-Providers.

A specific strategic product choice – beyond service features - needs to be taken in the **messaging** space.
Is the industry's priority to catch-up with an evolving de-facto OSP monopoly as quickly as possible or to keep control of the existing next-generation messaging traffic? In the first case, a single messaging hub could be the way forward (with potentially an IPX-based alternative at a later stage).

The mobile industry also should intensify its work of convincing regulators and policymakers that a **modern regulatory regime** has to follow three principles[115]:

- functionality-based, market neutral and technology-neutral
- flexible regulation for dynamic and complex digital ecosystem markets
- less regulation competition for the digital ecosystem but additional regulation in other areas like privacy and cyber security

Regarding **reduction of complexity and costs** for interconnection the main obstacles to be removed are the legacy networks costs, the ambiguity of IPX specifications and the complexity of the interconnection charging models.

Each Operator could define and follow an individual **hybrid interconnection strategy with an IPX at the centre.** This depends on how much financial room exists to fund quality and security (commercial value generated by own services, maturity of the service, positioning of an operator on its market) and refers to the IPX decision matrix.

The industry needs a clear guideline on the **IPX model**. Apart from the IPX definitions described above it is recommended that the GSMA partners with the relevant market players, especially leading IPX Providers of the i3forum, to jointly define a high-level description of IPX to support the i3forum's Auto-Certification Project for IPX Providers. This should be a focus area in Phase 2 of the 'Next-generation Interconnection and Roaming Analysis for Mobile Services'.

Also, the proposed **IPX 2.0 business** and charging **model** should be discussed and endorsed by GSMA working groups (WSOLU, NG) and external stakeholders. This simple and pragmatic model could enable an acceleration of IPX interconnects and maintain a fair revenue share for MNOs and Carriers. It is recommend that the GSMA should co-operate with the i3forum regarding a Proof of Concept Plan (POC) and Development of aligned industry documentation. This should include:

- Alignment of the charging model
- Define template for interconnection configuration IPX-Provider – Operator
- Support i3forum's Auto-Certification Project for IPX-Providers

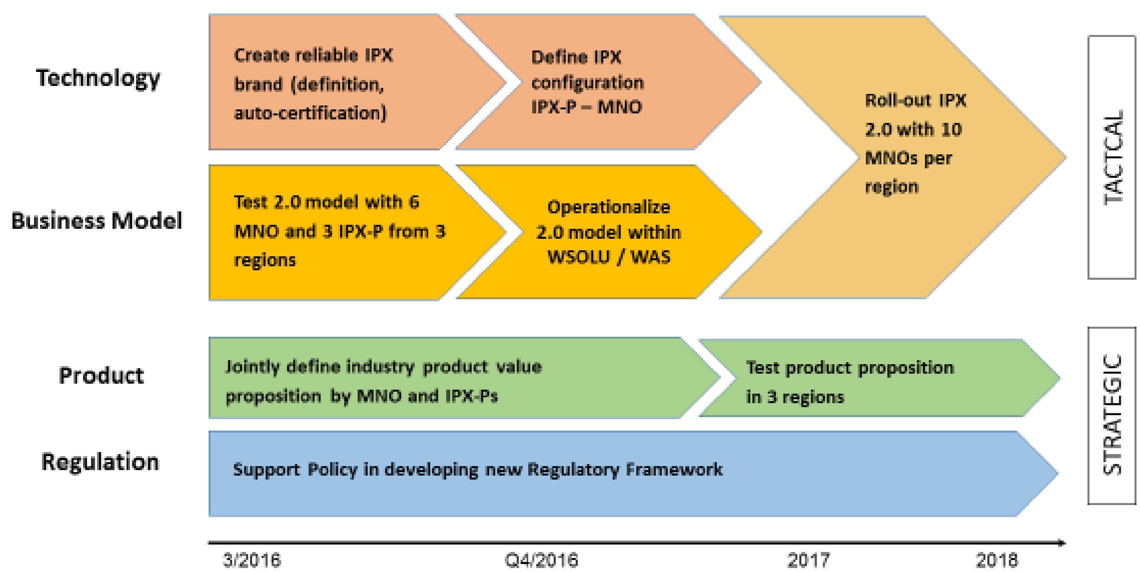
[115] NERA Economic Consulting: A new regulatory framework for the digital ecosystem, 2015

- Verification whether the necessary data is available and processed by existing operators' SBC and interconnection billing systems
- Initiate trials with friendly Operators and Carrier including charging models and design an action plan for commercial roll-out

The interconnection and network teams of Operators and Carriers need to make use of product experts to ensure a product base solution is reached. They should implement and grow in parallel an interconnected coverage for future IMS-based products, preferable through IPX.

The following figure proposes a way forward to build an interconnected environment for interconnected future mobile services by driving tactical aspects (technology, business model) and more strategic ones (product proposition and regulations) in parallel over the next 24 months.

Figure 42: Timeline for IPX interconnected Mobile Services



Finally, the GSMA should co-ordinate a debate around one **longer-term** unified all-IP business and **charging model**.

ANNEX 1: BUSINESS POLICIES REGARDING ALL-IP INTERCONNECTION AND CHARGING MODEL

Per country based on country codes 2016, without a population below 30,000 or a GDP below $USD 1 Billion.

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Afghanistan	93	29.121.286	high	high	high	high	longer	conservative
Albania	355	2.986.952	high	high	high	high	longer	conservative
Algeria	213	34.586.184	high	high	high	high	longer	conservative
Angola	244	13.068.161	high	high	high	high	longer	conservative
Antigua and Barbuda	1-268	86.754	high	high	high	high	longer	conservative
Argentina	54	41.343.201	low	high	low	high	longer	conservative
Armenia	374	2.968.000	high	high	high	high	longer	conservative
Aruba	297	71.566	high	high	high	high	longer	conservative
Australia	61	21.515.754	low	high	low	low	short	progressive
Austria	43	8.205.000	low	high	high	low	short	progressive
Azerbaijan	994	8.303.512	high	high	high	high	longer	conservative
Bahamas	1-242	301.790	high	high	high	high	longer	conservative
Bahrain	973	738.004	high	high	high	high	longer	conservative
Bangladesh	880	156.118.464	high	high	high	high	longer	conservative
Barbados	1-246	285.653	high	high	high	high	longer	conservative
Belarus	375	9.685.000	high	high	high	high	longer	conservative
Belgium	32	10.403.000	low	high	low	low	short	progressive
Belize	501	314.522	high	high	high	high	longer	conservative
Benin	229	9.056.010	high	high	high	high	longer	conservative
Bermuda	1-441	65.365	high	high	high	high	longer	conservative
Bhutan	975	699.847	high	high	high	high	longer	conservative
Bolivia	591	9.947.418	high	high	high	high	longer	conservative
Bosnia and Herzegovina	387	4.590.000	high	high	high	high	longer	conservative
Botswana	267	2.029.307	high	high	high	high	longer	conservative
Brazil	55	201.103.330	low	high	low	low	short	progressive
Brunei	673	395.027	high	high	high	high	longer	conservative

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Bulgaria	359	7.148.785	low	high	high	high	longer	conservative
Burkina Faso	226	16.241.811	high	high	high	high	longer	conservative
Burundi	257	9.863.117	high	high	high	high	longer	conservative
Cambodia	855	14.453.680	high	high	high	high	longer	conservative
Cameroon	237	19.294.149	high	high	high	high	longer	conservative
Canada	1	33.679.000	low	high	low	low	short	progressive
Cape Verde	238	508.659	high	high	high	high	longer	conservative
Cayman Islands	1-345	44.270	high	high	high	high	longer	conservative
Central African Republic	236	4.844.927	high	high	high	high	longer	conservative
Chad	235	10.543.464	high	high	high	high	longer	conservative
Chile	56	16.746.491	low	high	high	high	short	conservative
China	86	1.330.044.000	low	high	high	high	short	conservative
Colombia	57	47.790.000	low	high	high	high	longer	conservative
Costa Rica	506	4.516.220	high	high	high	high	longer	conservative
Croatia	385	4.491.000	high	high	high	high	longer	conservative
Cuba	53	11.423.000	high	high	high	high	longer	conservative
Curacao	599	141.766	high	high	high	high	longer	conservative
Cyprus	357	1.102.677	high	high	high	high	longer	conservative
Czech Republic	420	10.476.000	low	high	low	high	short	conservative
Democratic Republic of the Congo	243	70.916.439	high	high	high	high	longer	conservative
Denmark	45	5.484.000	low	high	low	low	short	progressive
Djibouti	253	740.528	high	high	high	high	longer	conservative
Dominican Republic	1-809, 1-829, 1-849	9.823.821	high	high	high	high	longer	conservative
East Timor	670	1.154.625	high	high	high	high	longer	conservative
Ecuador	593	14.790.608	low	high	high	high	longer	conservative
Egypt	20	80.471.869	high	high	high	high	longer	conservative
El Salvador	503	6.052.064	high	high	high	high	longer	conservative
Equatorial Guinea	240	1.014.999	high	high	high	high	longer	conservative

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Eritrea	291	5.792.984	high	high	high	high	longer	conservative
Estonia	372	1.291.170	low	high	high	high	short	conservative
Ethiopia	251	88.013.491	high	high	high	high	longer	conservative
Faroe Islands	298	48.228	low	high	low	low	short	progressive
Fiji	679	875.983	high	high	high	high	longer	conservative
Finland	358	5.244.000	low	high	low	low	short	progressive
France	33	64.768.389	low	high	high	high	short	conservative
French Polynesia	689	270.485	high	high	high	high	longer	conservative
Gabon	241	1.545.255	high	high	high	high	longer	conservative
Georgia	995	4.630.000	high	high	high	high	longer	conservative
Germany	49	81.802.257	low	high	low	low	short	progressive
Ghana	233	24.339.838	high	high	high	high	longer	conservative
Greece	30	11.000.000	low	high	high	high	short	conservative
Greenland	299	56.375	low	high	low	low	short	progressive
Guam	1-671	159.358	high	high	high	high	longer	conservative
Guatemala	502	13.550.440	high	high	high	high	longer	conservative
Guernsey	44-1481	65.228	high	high	high	high	longer	conservative
Guinea	224	10.324.025	high	high	high	high	longer	conservative
Guyana	592	748.486	high	high	high	high	longer	conservative
Haiti	509	9.648.924	high	high	high	high	longer	conservative
Honduras	504	7.989.415	high	high	high	high	longer	conservative
Hong Kong	852	6.898.686	low	high	low	low	short	progressive
Hungary	36	9.982.000	low	high	high	high	short	conservative
Iceland	354	308.910	low	high	low	low	short	progressive
India	91	1.173.108.018	low	high	high	high	short	conservative
Indonesia	62	242.968.342	high	high	high	high	longer	conservative
Iran	98	76.923.300	high	high	high	high	longer	conservative
Iraq	964	29.671.605	high	high	high	high	longer	conservative
Ireland	353	4.622.917	high	high	high	high	longer	conservative
Isle of Man	44-1624	75.049	high	high	high	high	longer	conservative
Israel	972	7.353.985	low	high	low	low	short	progressive

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Italy	39	60.340.328	low	high	high	high	short	conservative
Ivory Coast	225	21.058.798	high	high	high	high	longer	conservative
Jamaica	1-876	2.847.232	high	high	high	high	longer	conservative
Japan	81	127.288.000	low	high	low	low	short	progressive
Jersey	44-1534	90.812	high	high	high	high	longer	conservative
Jordan	962	6.407.085	high	high	high	high	longer	conservative
Kazakhstan	7	15.340.000	high	high	high	high	longer	conservative
Kenya	254	40.046.566	high	high	high	high	longer	conservative
Kosovo	383	1.800.000	high	high	high	high	longer	conservative
Kuwait	965	2.789.132	high	high	high	high	longer	conservative
Kyrgyzstan	996	5.508.626	high	high	high	high	longer	conservative
Laos	856	6.368.162	high	high	high	high	longer	conservative
Latvia	371	2.217.969	low	high	high	high	short	conservative
Lebanon	961	4.125.247	high	high	high	high	longer	conservative
Lesotho	266	1.919.552	high	high	high	high	longer	conservative
Liberia	231	3.685.076	high	high	high	high	longer	conservative
Libya	218	6.461.454	high	high	high	high	longer	conservative
Liechtenstein	423	35.000	low	high	low	low	short	progressive
Lithuania	370	2.944.459	low	high	high	high	short	conservative
Luxembourg	352	497.538	low	high	low	low	short	progressive
Macao	853	449.198	high	high	high	high	longer	conservative
Macedonia	389	2.062.294	high	high	high	high	longer	conservative
Madagascar	261	21.281.844	high	high	high	high	longer	conservative
Malawi	265	15.447.500	high	high	high	high	longer	conservative
Malaysia	60	28.274.729	high	high	high	high	longer	conservative
Maldives	960	395.650	high	high	high	high	longer	conservative
Mali	223	13.796.354	high	high	high	high	longer	conservative
Malta	356	403.000	low	high	high	high	short	conservative
Mauritania	222	3.205.060	high	high	high	high	longer	conservative
Mauritius	230	1.294.104	high	high	high	high	longer	conservative

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Mayotte	262	159.042	high	high	high	high	longer	conservative
Mexico	52	112.468.855	low	high	high	high	short	conservative
Moldova	373	4.324.000	high	high	high	high	longer	conservative
Monaco	377	32.965	low	high	high	high	short	conservative
Mongolia	976	3.086.918	high	high	high	high	longer	conservative
Montenegro	382	666.730	high	high	high	high	longer	conservative
Morocco	212	31.627.428	high	high	high	high	longer	conservative
Mozambique	258	22.061.451	high	high	high	high	longer	conservative
Myanmar	95	53.414.374	high	high	high	high	longer	conservative
Namibia	264	2.128.471	high	high	high	high	longer	conservative
Nepal	977	28.951.852	high	high	high	high	longer	conservative
Netherlands	31	16.645.000	low	high	low	low	short	progressive
Netherlands Antilles	599	136.197	high	high	high	high	longer	conservative
New Caledonia	687	216.494	high	high	high	high	longer	conservative
New Zealand	64	4.252.277	high	high	high	high	longer	conservative
Nicaragua	505	5.995.928	high	high	high	high	longer	conservative
Niger	227	15.878.271	high	high	high	high	longer	conservative
Nigeria	234	154.000.000	high	high	high	high	longer	conservative
North Korea	850	22.912.177	high	high	high	high	longer	conservative
Norway	47	5.009.150	low	high	low	low	short	progressive
Oman	968	2.967.717	high	high	high	high	longer	conservative
Pakistan	92	184.404.791	high	high	high	high	longer	conservative
Palestine	970	3.800.000	high	high	high	high	longer	conservative
Panama	507	3.410.676	high	high	high	high	longer	conservative
Papua New Guinea	675	6.064.515	high	high	high	high	longer	conservative
Paraguay	595	6.375.830	high	high	high	high	longer	conservative
Peru	51	29.907.003	high	high	high	high	longer	conservative
Philippines	63	99.900.177	high	high	high	high	longer	conservative
Poland	48	38.500.000	low	high	high	high	short	conservative
Portugal	351	10.676.000	low	high	high	high	short	conservative

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Puerto Rico	1-787, 1-939	3.916.632	low	high	high	high	short	conservative
Qatar	974	840.926	high	high	high	high	longer	conservative
Republic of the Congo	242	3.039.126	high	high	high	high	longer	conservative
Reunion	262	776.948	high	high	high	high	longer	conservative
Romania	40	21.959.278	low	high	high	high	short	conservative
Russia	7	140.702.000	high	high	high	high	longer	conservative
Rwanda	250	11.055.976	high	high	high	high	longer	conservative
Saint Lucia	1-758	160.922	high	high	high	high	longer	conservative
San Marino	378	31.477	high	high	high	high	longer	conservative
Saudi Arabia	966	25.731.776	high	high	high	high	longer	conservative
Senegal	221	12.323.252	high	high	high	high	longer	conservative
Serbia	381	7.344.847	high	high	high	high	longer	conservative
Seychelles	248	88.340	high	high	high	high	longer	conservative
Sierra Leone	232	5.245.695	high	high	high	high	longer	conservative
Singapore	65	4.701.069	high	high	high	high	longer	conservative
Slovakia	421	5.455.000	low	high	high	high	short	conservative
Slovenia	386	2.007.000	low	high	high	high	short	conservative
Solomon Islands	677	559.198	high	high	high	high	longer	conservative
Somalia	252	10.112.453	high	high	high	high	longer	conservative
South Africa	27	49.000.000	low	high	high	high	short	conservative
South Korea	82	48.422.644	low	high	low	low	short	progressive
South Sudan	211	8.260.490	high	high	high	high	longer	conservative
Spain	34	46.505.963	low	high	high	high	short	conservative
Sri Lanka	94	21.513.990	high	high	high	high	longer	conservative
Sudan	249	35.000.000	high	high	high	high	longer	conservative
Suriname	597	492.829	high	high	high	high	longer	conservative
Swaziland	268	1.354.051	high	high	high	high	longer	conservative
Sweden	46	9.555.893	low	high	low	low	short	progressive
Switzerland	41	7.581.000	low	high	high	high	short	conservative
Syria	963	22.198.110	high	high	high	high	longer	conservative

COUNTRY	COUNTRY CODE	POPULATION	Level of MTR*	Level of Roaming IOT external visitors*	Traffic and roaming ratio in/out**	Importance of incoming revenue ** (MTR/IOT)	Technical advancement / time to all-IP	Business policy to all-IP
Taiwan	886	22.894.384	low	high	high	high	short	conservative
Tajikistan	992	7.487.489	high	high	high	high	longer	conservative
Tanzania	255	41.892.895	high	high	high	high	longer	conservative
Thailand	66	67.089.500	high	high	high	high	longer	conservative
Togo	228	6.587.239	high	high	high	high	longer	conservative
Trinidad and Tobago	1-868	1.228.691	high	high	high	high	longer	conservative
Tunisia	216	10.589.025	high	high	high	high	longer	conservative
Turkey	90	77.804.122	low	high	high	high	short	conservative
Turkmenistan	993	4.940.916	high	high	high	high	longer	conservative
U.S. Virgin Islands	1-340	108.708	low	high	high	high	short	conservative
Uganda	256	33.398.682	high	high	high	high	longer	conservative
Ukraine	380	45.415.596	high	high	high	high	longer	conservative
United Arab Emirates	971	4.975.593	high	high	high	high	longer	conservative
United Kingdom	44	62.348.447	low	high	low	low	short	progressive
United States	1	310.232.863	low	high	low	low	short	progressive
Uruguay	598	3.477.000	high	high	high	high	longer	conservative
Uzbekistan	998	27.865.738	high	high	high	high	longer	conservative
Venezuela	58	27.223.228	high	high	high	high	longer	conservative
Vietnam	84	89.571.130	high	high	high	high	longer	conservative
Western Sahara	212	273.008	high	high	high	high	longer	conservative
Yemen	967	23.495.361	high	high	high	high	longer	conservative
Zambia	260	13.460.305	high	high	high	high	longer	conservative
Zimbabwe	263	11.651.858	high	high	High	high	longer	conservative

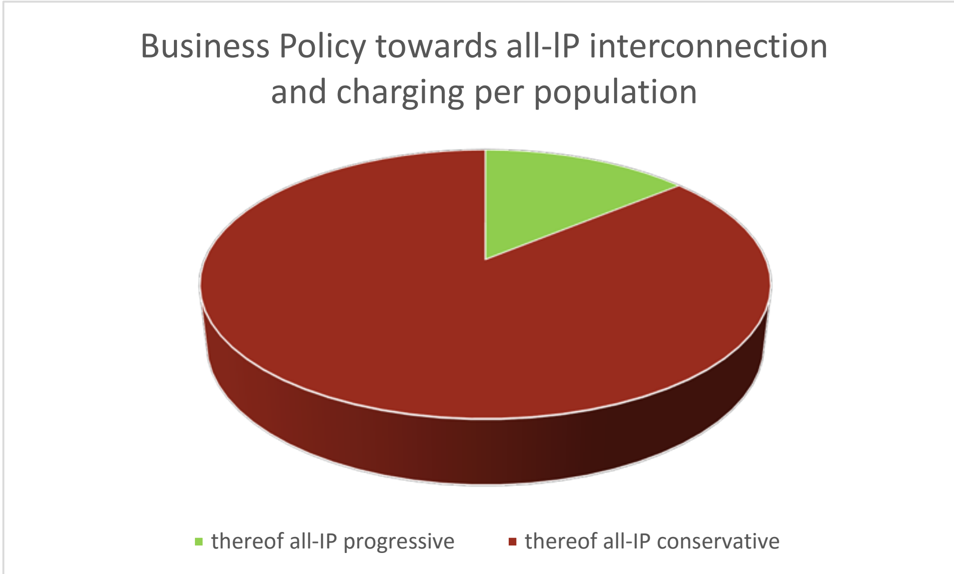
Population total	6.854.171.940	
thereof all-IP progressive	962.137.060	14%
thereof all-IP conservative	5.892.034.880	86%

* e.g. for EU countries towards non EU operators / visitors

** mainly due to migration and incoming tourism vs. size of domestic market

Source for Country codes, Population and GDP: https://countrycode.org/

Source for MTR, IOT, importance, all-IP: own research


Business Policy towards all-IP interconnection and charging per population
thereof all-IP progressive
thereof all-IP conservative