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Study for *Organismo Supervisor de Inversión Privada en Telecomunicaciones (OSIPTEL)*, Peru

# Interconnection in Next Generation Networks (NGNs)

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## Executive Summary

This is the Executive Summary of a report on Interconnection in Next Generation Networks (NGNs) prepared for OSIPTEL, the Peruvian regulator, by WIK-Consult GmbH.

Throughout the world, there is a trend for networks to evolve from yesterday's circuit switched technologies to Next Generation Networks (NGNs) based on the packet-switched Internet protocol (IP) technologies of today and tomorrow. This technological transformation is accompanied by substantial changes in the character of the communications marketplace. Regulation needs to adapt to these changes, or in some respects to anticipate them.

Regulation typically seeks to address various forms of market failure. The regulation of interconnection is largely a response to *market power*, and especially to the *termination monopoly*. The termination monopoly is the form of market power that a network operator possesses because there is typically only a single network operator that can complete a call to a given telephone number. The migration to NGN does little to change the termination monopoly; consequently, regulation remains just as essential going forward as it has been in the past.

In this Executive Summary, we review the technology and the economics of the migration to NGN. We consider the migration period itself. Finally, we provide recommendations specific to Peruvian circumstances.

## The technology of NGN interconnection

The NGN architecture includes the NGN access network, the NGN core network, and the NGN service control layer. The NGN core network is an IP network that is deployed on a geographically widespread basis and that provides the interconnection to other networks and to central services and applications. Several technologies can be used for the access network: xDSL, FTTx, cable networks, mobile access (HSDPA), or Fixed Wireless Access. Today, the most widely implemented Next Generation fixed access technologies are FTTC/VDSL, FTTH PON and FTTH P2P. The NGN service control layer is in charge of controlling elements such as nomadicity and mobility of services, network security issues, and quality of service.

The IMS is an architecture that can be used by service providers and network operators to control the provisioning of services in an NGN network.

Whereas in a circuit-switched environment the interconnection is in principle done by means of the SS7 signaling system, the interconnection in an IP NGN environment is done by using an IP-based protocol. IP interconnection today is implemented under transit and peering agreements between ISPs. Internet Exchange Points (IXPs) can be used for public peering interconnection. Large network operators use the Border Gateway Protocol (BGPv4) to route traffic among themselves. The IMS can be used for the interconnection of NGN networks at the level of the control plane.

A VoIP operator has several possibilities at the moment of choosing the VoIP technique that it will implement. The best known non-proprietary VoIP systems are H.323, SIP, and MGCP/Megaco. For the interconnection between a VoIP network and a circuit-switched network, it is necessary to install equipment with the functions of Media Gateway and Signaling Gateway. On the other hand, a softswitch architecture can be used to control the Media Gateways and the Signaling Gateways. ENUM is an IETF standard used for the mapping of PSTN E.164 telephone numbers to IP-based resource identification information of the VoIP service provider that serves that phone number. Number portability and access to emergency services are issues that should be addressed at the moment of interconnecting VoIP networks.

## The economics of NGN interconnection

The economics of interconnection in switched networks has been dominated by the analysis of voice telephony. Retail arrangements today tend to be either *Calling Party Pays (CPP)*, where the party that places the call pays per minute, and the receiving party pays nothing; or else some form of *flat rate*, where the user pays a fixed monthly fee for all calls (up to some maximum number of minutes).

Wholesale arrangements are typically based on *Calling Party's Network Pays (CPNP)*, where the network of the party that placed the call (the *originating network*) makes a wholesale payment to the network of the party that received the call (the *terminating network*). CPNP suffers from the defect that the terminating network possesses a form of market power (the *terminating monopoly*) that enables it to charge fees at wholesale that are well in excess of true usage-based marginal cost. Regulation can mitigate this problem, but regulators rarely force network operators to charge a termination fee that is sufficiently low.

Inflated termination fees are usually associated with inflated retail prices; with a tendency to exclude calls to off-net mobile operators from flat rate retail plans; and from a substantial reduction in the number of calls placed. On the positive side, they tend to encourage mobile penetration (possibly at the cost of fixed penetration), which is an important benefit in a country like Peru.

IP-based Internet interconnection is based primarily on forms of *peering* and of *transit*. Voluntary commercial arrangements usually work satisfactorily; very few countries have found it necessary to regulate IP interconnection.

Experience throughout the world is the conversion of the network core from switched telephony to an IP-based NGN does not automatically result in evolution of interconnection arrangements from circuit switched SS7 to IP-based interconnection. Small VoIP service providers tend to prefer IP-based interconnection to one another, as do some cable television operators, but most fixed and mobile operators remain with traditional interconnection long after they convert their respective core networks.

For IP interconnection, certain applications (primarily real time two way voice) would benefit from strong assurances of the quality with which the IP data is to be delivered. The technology to assure Quality of Service (QoS) has existed for a decade, and is widely implemented *within* networks, but very rarely *between* networks. Voice is likely to represent only a small fraction of the traffic of most IP-based networks; thus, if QoS were used primarily for voice, QoS assurance would have relatively little impact on cost.

Efforts have been under way in New Zealand to establish interconnection among all market players that can support a level of QoS suitable for IP-based voice. Telecom New Zealand (TNZ), the incumbent, would offer IP interconnection free of charge within each of 29 service areas (local peering). This is a novel and promising approach. It is potentially relevant to Peru.

The issue of Network Neutrality takes on particular urgency as voice telephony migrates to an IP basis. There are concerns that network operators with market power might intentionally favor affiliated traffic over unaffiliated traffic (e.g. traffic to competing VoIP service providers). Given that communications markets in Peru are fairly concentrated, this could be a significant concern.

## The migration to NGN

There are a number of different technical routes to NGN. The report provides an overview of patterns of network evolution across different countries. The most prominent role on the agenda of network operators and regulators alike is played by the migration towards Next Generation *Access* Network infrastructures. Core network migration is also underway (or at least envisaged) in many countries, however, the competition policy and regulatory concerns of access network migration seem to be more challenging. Moreover, the Chapter focuses on the driving forces of the different migration scenarios across countries. In addition, policy challenges during the migration phase are analyzed. We perceive the following issues to be the most important ones: (a) the change in the number and nature of points of interconnection, (b) the apparent changes in the cost structure brought about by NGN, (c) the possibility of setting different termination rates for traffic in view of the risk of arbitrage, (d) the risk that arrangements never evolve beyond current arrangements, and (e) interoperability testing during the transition period.

Regulatory developments regarding VoIP, the NGN core and the NGN access infrastructure have been quite distinct. The report draws on experience in the United States, many European and Asia-Pacific countries. For VoIP, key issues have included access to numbers, access to emergency services, and lawful intercept (wiretapping). For NGN access, the migration to fiber has tended to complicate the regulatory task of introducing competition into the last mile of fixed networks. A general challenge is linked to a reduction in the number of Points of Interconnection associated with the migration to NGN.

The report also considers likely developments in Peru. Based on our interviews, the evolutionary scenarios depicted in Table 1 seem most likely. Core networks are evolving in the direction of NGN, some more rapidly than others. The mobile network is clearly evolving in the direction of 3G, but the fixed market players see little economic basis for upgrading the access network to fiber in the near term.

Table 1: Evolutionary scenarios for migration to IP-based NGN in Peru

| | **Core Network** | **Access Network** |
|---|---|---|
| **Evolutionary Scenario 1** | Telefonica Moviles, Claro and Telmex Peru complete the migration quickly to an IP NGN core, TdP upgrades only opportunistically and sporadically. | High speed broadband deploys in coastal metropolitan areas, but migration to fibre-based NGA is rare. |
| **Evolutionary Scenario 2** | Telefonica Moviles, Claro, Telmex Peru, and TdP all complete the migration quickly to an IP NGN core quickly. | High speed broadband deploys in coastal metropolitan areas, but migration to fibre-based NGA is rare. |
| **Evolutionary Scenario 3** | Telefonica Moviles, Claro, Telmex Peru, and TdP all complete the migration quickly to an IP NGN core quickly. | High speed broadband deploys in coastal metropolitan areas, accompanied by significant migration to fibre-based NGA in those same areas. |

## The Recommendations

In the course of the interviews that we conducted under OSIPTEL auspices, we saw few indications that market players are hungry for IP-based interconnection today (even though several of the major networks in Peru have already transitioned in varying degrees to IP-based core networks); however, a number of interviewees indicated that at least one reason why they had not considered IP-based interconnection was that they felt that the current Peruvian regulatory framework did not allow it.

We do not see any compelling public interest that would argue that OSIPTEL should mandate IP-based interconnection of NGN voice services. IP data interconnection is already working satisfactorily. Circuit switched voice interconnection may be less technically efficient than IP-based voice interconnection, but we do not see an argument that the consumer benefits of IP-based voice interconnection should override the economic and technical judgments of network operators, who apparently are not motivated to make the leap just yet.

Nonetheless, there is a great deal that can be done *today* to evolve interconnection arrangements in ways that make sense for Peruvian end-users and market players, and that selectively smooth the way to an eventual migration to IP-based NGN interconnection for voice and data.

Detailed regulation should be done as much as possible in a collaborative process with market players – who will often be better positioned than the regulator to recognize certain technological developments and market trends. We return to this point below.

Our specific list of recommendations appears in Table 2. A suggested schedule for implementing the recommendations appears at the end of this Executive Summary.

Table 2: List of recommendations

| | |
|---|---|
| Recommendation 1. | Apply regulation only to those entities that possess market power. |
| Recommendation 2. | Initiate a public consultation to identify any inefficiencies in current circuit-switched interconnection arrangements. |
| Recommendation 3. | Consult with market players as regards the appropriate number and nature of Points of Interconnection (PoI) for IP-based NGN voice. |
| Recommendation 4. | Promote the creation of a second or third NAP.Peru. |
| Recommendation 5. | Network operators need suitable flexibility, but OSIPTEL should continue to oversee the voice interconnection process. |
| Recommendation 6. | Initiate a public consultation to discuss a proposed long term direction that charging for IP-based NGN voice interconnection should be based either on CBC or on Bill and Keep. |
| Recommendation 7. | In the near to intermediate term, implement per minute charges substantially lower than those in use today. |
| Recommendation 8. | Initiate a public consultation to solicit input on possible improvements to rural service arrangements and fixed-to-mobile calls. |
| Recommendation 9. | OSIPTEL should indicate its intention, in the event that market players cannot agree on standards for QoS, to establish its own standards on the basis of the MIT QoS white paper. |
| Recommendation 10. | Retain non-discrimination provisions. |
| Recommendation 11. | Ensure that some suitable licensing category is available to third-party VoIP service providers. |
| Recommendation 12. | Ensure that VoIP service providers have access to suitable telephone numbers. |
| Recommendation 13. | Ensure that providers of voice telephony services (including VoIP) to Peruvian numbers provide access to emergency services. |
| Recommendation 14. | Ensure that surveillance can be applied to Internet data and to VoIP. |
| Recommendation 15. | Address any impediments to the emergence of a VoIP "working horse" in Peru. |
| Recommendation 16. | Peruvian spectrum management in the commercial sector should reflect the use of auctions and secondary markets |
| Recommendation 17. | Peruvian spectrum managers should keep current as regards emerging technologies. |
| Recommendation 18. | Peruvian spectrum management should be aware of emerging trends in the public sector, with a move away from permanent assignments without cost. |

## Review existing regulations and mitigate impediments to migration to NGN

The first step is to ensure that interconnection regulation applies to those parties, and *only* to those parties, where regulation is unambiguously necessary. (Recommendation 1. Apply regulation only to those entities that possess market power.) This seems to already be the case.

Peruvian regulation is applied to the *service*, not to the *technology*; consequently, existing regulation will automatically apply to NGNs, in general. In some cases, no further action is necessary. (Recommendation 10. Retain non-discrimination provisions.) There are however exceptions (for example, explicit references requiring that Signaling System 7 be used for interconnection), and also instances where regulation should not be carried forward without review and possible change. These are reflected in other recommendations.

The study identified a number of areas where Peruvian regulation appears to be problematic or rigid in ways that could interfere with the migration to NGN. In those instances, we are recommending that OSIPTEL conduct a public consultation in order to properly explore the issue and to solicit input from stakeholders, and implement any necessary corrective actions. (Recommendation 2. Initiate a public consultation to identify any inefficiencies in current circuit-switched interconnection arrangements. Recommendation 8. Initiate a public consultation to solicit input on possible improvements to rural service arrangements and fixed-to-mobile calls.)

## Provide a proper framework for Voice over IP (VoIP)

The existing regulatory framework is ambiguous as regards VoIP service providers who are not network operators. Licensing as a provider of value added services does not, for example, necessarily provide access to telephone numbers, nor does it necessarily confer rights to interconnection. This could be resolved either by altering the Ministry's licensing rules, or by enabling third parties to provide needed capabilities. We advocate both. (Recommendation 11. Ensure that some suitable licensing category is available to third-party VoIP service providers. Recommendation 15. Address any impediments to the emergence of a VoIP "working horse" in Peru.) VoIP service providers should have access to the kind of telephone numbers that their customers expect and demand. (Recommendation 12. Ensure that VoIP service providers have access to suitable telephone numbers.)

VoIP service providers should be subject to obligations comparable to those of fixed and mobile operators, to the extent that it is reasonably feasible for them to meet the obligations. (Recommendation 13. Ensure that providers of voice telephony services (including VoIP) to Peruvian numbers provide access to emergency services. Recommendation 14. Ensure that surveillance can be applied to Internet data and to VoIP.)

## OSIPTEL should strive for clarity and efficiency in charging arrangements going forward

In the near to intermediate term, we anticipate that CPNP arrangements based on minutes of use will be retained.[1] Termination rates should continue to move downwards, especially for mobile, consistent with cost modeling that recognizes that relatively little of the cost of an NGN is associated with the voice service. (Recommendation 7. In the near to intermediate term, implement per minute charges substantially lower than those in use today.) Termination rates that are closer to real usage based incremental costs, and thus closer to zero, will imply less of an economic shock if a substantially different wholesale arrangement is needed in the future, as is likely to be the case. They also give network operators (and their customers) time to adjust to retail plans that better fit these wholesale arrangements.

In the longer term, and in the interest of investment certainty, OSIPTEL should signal its intent to evolve in the direction of monthly charges rather than usage-based per-minute charges. (Recommendation 6. Initiate a public consultation to discuss a proposed long term direction that charging for IP-based NGN voice interconnection should be based either on CBC or on Bill and Keep.) This might logically build on the CBC arrangements that were recently put in place.

## OSIPTEL can pave the way for IP-based NGN interconnection

Market players do not seem to be ready for IP-based NGN interconnection today, but OSIPTEL can stimulate the kind of discussions – and the creation of a suitable discussion forum – so as to facilitate migration at the right time.

Based on experience in other countries, a huge number of issues will need to be resolved. In the circuit switched world, it may have been appropriate for OSIPTEL to impose a widely recognized solution (Signaling System 7), but it is less appropriate in the NGN case. OSIPTEL should prefer market-led solutions where possible.

Questions over the nature and number of Points of Interconnection (PoI) are likely to arise quickly, based on experience in other countries. This is an obvious place to start. (Recommendation 3. Consult with market players as regards the appropriate number and nature of Points of Interconnection (PoI) for IP-based NGN voice.)

A conventional regulatory proceeding is probably not the appropriate mechanism. In international experience, the most promising example we know of is the IP Working Party in New Zealand (see Section 4.2.2.5), and even that process ultimately stalled.

1 The CBC charging that was recently imposed applies only to the fixed network incumbent, and even there it is an alternative to per-minute termination fees.

The structure of the IPWP's parent organisation, the TCF, is somewhat similar to that of NAP.Peru, but with a more inclusive membership. OSIPTEL should have a seat at the table, but should not run the industry forum.

Such a forum could deal with the many issues that must be resolved. (Recommendation 9. OSIPTEL should indicate its intention, in the event that market players cannot agree on standards for QoS, to establish its own standards on the basis of the MIT QoS white paper.)

OSIPTEL should retain its authority to resolve interconnection disputes, and to review interconnection agreements. (Recommendation 5. Network operators need suitable flexibility, but OSIPTEL should continue to oversee the voice interconnection process.)

## Other recommendations

Independent of the migration to IP-based NGN, it is clear that Internet access is becoming increasingly critical to the Peruvian public. Additional attention to network reliability and robustness is in order. (Recommendation 4. Promote the creation of a second or third NAP.Peru.)

With the migration to NGN, and the increased importance of data transmission over the network, access to spectrum becomes more important. We have not assessed the current state of spectrum management in Peru, but would simply emphasize the need to maintain best practice spectrum management. (Recommendation 16. Peruvian spectrum management in the commercial sector should reflect the use of auctions and secondary markets. Recommendation 17. Peruvian spectrum managers should keep current as regards emerging technologies. Recommendation 18. Peruvian spectrum management should be aware of emerging trends in the public sector, with a move away from permanent assignments without cost.)

## Suggested schedule

| Nbr | Summary | Action | Target Start | Target End | 2009 | 2010 | 2011 | 2012 | 2013 | Later |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Obligations only on market power | None | Now | Indefinite | | | | | | |
| 2 | Inefficiencies in current arrangements | Consultation … | 2010 | 2011 | | | | | | |
| 3 | Number of PoI for NGN | Consultation … | 2011 | 2012 | | | | | | |
| 4 | Second NAP.Peru | Unclear | 2009 | Unclear | | | | | | |
| 5 | OSIPTEL oversees flexible process | None | Now | Indefinite | | | | | | |
| 6 | Long-term direction CBC or Bill and Keep | Consultation | 2011 | 2012 | | | | | | |
| 7 | Lower termination rates, esp. MTRs | OSIPTEL procedure | 2009 | 2013 | | | | | | |
| 8 | Reassess calls to rural and F2M | Consultation … | 2010 | 2012 | | | | | | |
| 9 | IP QoS arrangements | Market player discuss; if no consensus, OSIPTEL could impose | 2011 | 2013 | | | | | | |
| 10 | Retain non-discrimination | None | Now | Indefinite | | | | | | |
| 11 | Ensure suitable licensing category for VoIP | Ministry procedure | 2009 | 2010 | | | | | | |
| 12 | Ensure VoIP service providers can use suitable numbers | OSIPTEL procedure | 2009 | 2010 | | | | | | |
| 13 | Oblige VoIP providers to access emergency services where feasible | OSIPTEL or Ministry procedure | 2010 | 2011 | | | | | | |
| 14 | Surveillance for VoIP | Ministry procedure | 2009 | 2010 | | | | | | |
| 15 | Enable a "working horse" | Consultation | 2009 | 2011 | | | | | | |

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## Recommendations

# 1 Introduction

This is the **Final Report** for a study of **Interconnection in Next Generation Network (NGN)** that WIK-Consult GmbH conducted on behalf of the Peruvian national regulatory authority OSIPTEL.

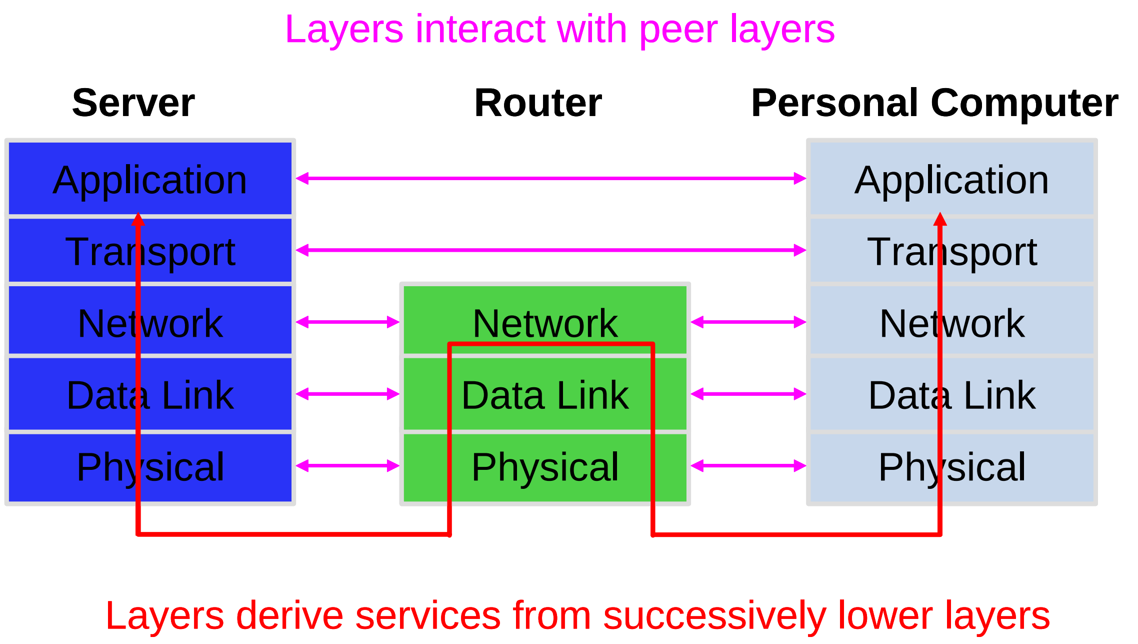
The next section of this Introduction, Section 1.1, provides a general explanation of how the migration to IP in general changes established practice and relationships. Section 1.2 explains how the migration impacts on public policy issues. Section 1.3 identifies specific regulatory issues that OSIPTEL must confront. (Specific recommendations are discussed in Chapter 5.) Section 1.4 outlines the organization of the remainder of this report.

## 1.1 Next Generation networks (NGNs)

There is a movement throughout the world to evolve existing telecommunications networks (and other networks as well) into Next Generation Networks based on packet switching using the *Internet Protocol (IP)*. This migration has profound technical, economic, and public policy implications.

The Internet Protocol family is a layered network protocol suite. Applications in different computers (for example, the browser in the personal computer [PC] on your desk and the web server at www.osiptel.gob.pe) communicate with one another over a comparatively simple substrate of routers that simply forward IP packets from one communications path (*link*) to another, as shown in Figure 1. The applications need not know anything about the physical characteristics of the networks that carry their data; the networks (i.e. the routers) need not know anything about the applications, except for the destination for each packet and any special requirements in regard to the priority with which a particular packet must be carried. This conceptual *layering* of information and capabilities, and the clear separation between applications and transmission facilities, has proven to be of enormous value.

Figure 1: The Internet Protocol (IP) suite




Source: WIK-Consult.

The migration to Internet Protocol (IP) in general, and to IP-based NGNs in particular, thus de-couples the *network* from the *service*. This is an important aspect of the broader phenomenon of convergence. In the past, telephone networks were designed to deliver one service: voice telephony. Cable television was designed to deliver one service: video. Networks were designed to carry only one service, and it was often the case that no other platform (or mix of platforms) could deliver that service.

No more! Today, we are rapidly approaching a world where any platform can deliver any service or combination of services (provided that the transmission platform has enough capacity or *bandwidth*).

This implies complex changes:

- In the entire value chain by means of which services are delivered to end-users.
- In the ability of different service providers (not all of whom are network operators) to compete with one another for the same services. Distinctions of cable versus telecommunications, fixed versus mobile, wired versus wireless all become less relevant.

- In the ability of end-users (or software developers on their behalf) to create new capabilities in the end-user's device (PC), often without the active involvement of the network operator. The emergence of Voice over IP (VoIP) service providers who are not network operators is a conspicuous example.

The migration to Next Generation Networks (NGNs) has additional implications for policymakers:

- In the speed and the character of network access, and thus in the ability to offer bandwidth-hungry services (e.g. video).
- In the ease with which certain public needs can be satisfied, such as:
  - Access to emergency services.
  - Lawful intercept.

This migration presents a wealth of opportunities, but it also poses many challenges for policymakers.

## 1.2 How does the migration to NGN interact with public policy?

Regulation of electronic communications tends to have three primary objectives,[2] all involved in correcting for common deficiencies of pure unregulated markets:

- Addressing distortions of competition, especially those caused by some form of market power.
- Addressing social needs that the free market might not, typically because the social value exceeds the private value to parties that might otherwise invest.
- Allocating scarce resources that are unique to each country.

The migration to NGN changes the game, so to speak, in all three areas.

As regards market power, the migration to NGN has a number of positive effects. It enables *inter-modal* competition, for example between cable television operators and telecommunications network operators. It also makes it possible for application service providers who do not even have a network (for example, the Voice over IP [VoIP] service provider Skype) to compete on the services level with traditional network operators.

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2 The migration also interacts, of course, with many other aspects of the legal system, including for example the maintenance of consumer privacy.

At the same time, it is clear that some market bottlenecks will remain. Last mile wired facilities will continue to be expensive to replicate. The so-called *call termination monopoly* will remain (see Sections 3.1.2 and 5.1). There is also the risk that the migration to NGN might introduce new competitive bottlenecks, especially in the upper layers of the network.[3]

In countries that have well developed regulatory systems to enable network access (e.g. access to unbundled local loops, line sharing, and/or bitstream access), the migration to NGN at the level of the access network implies new challenges to those pro-competitive regimes.[4]

As regards social needs that the market alone might not provide, many such capabilities (not all) are referred to by economists as *public goods*. The benefits to society at large may be substantial, but the benefits to individual companies may not be sufficient to incentivize them to make the necessary investments. A first concern in this regard is with universal access to communications, which is a particularly acute issue in Peru due to exceptionally challenging terrain. Portions of the country have low population density. Mobile voice telephony has been of great benefit to remote areas; however, the question must now be raised whether mobile solutions alone will be the right answer for these areas as networks evolve to NGNs, and as application requirements increase correspondingly. Fixed wireless solutions may also have a role to play in bringing voice and high speed data access to parts of the national territory.

Other social needs that often experience challenges as the communications substrate evolves to an IP base are (1) the ability to call emergency services (police, ambulance, fire), and the ability to automatically provide accurate caller location information when doing so; and (2) the ability to intercept communications traffic (with suitable safeguards for consumer privacy) for legitimate law enforcement and national security purposes.

Finally, the migration poses challenges for telephone numbering and spectrum management. For independent providers of VoIP, for example, should telephone numbers be made available, and if so, what kind of numbers is appropriate? Is it possible to make additional spectrum available to meet the increased bandwidth needs of NGN, and perhaps to support Fixed Wireless Access to remote areas?

All of these are important policy questions, but not all of them are within the scope of our study. Our focus here is on network *interconnection* – the linkage of two independent networks to enable their respective customers to communicate with one

3 See Cullen International and Devoteam Siticom (2003): *"Regulatory implications of the introduction of next generation networks and other new developments in electronic communications"*, final report for the EU Commission, May 16.

4 See Elixmann, D., Ilic, D., Neumann, K.-H. and T. Plückebaum (2008): "*The Economics of Next Generation Access*"; Final Report for ECTA; http://www.ectaportal.com/en/news_item860.html, September (Retrieved on 7 August 2009).

another. We will cover these other regulatory questions only to the extent that they interact with interconnection in an NGN environment.

We have, however, taken a broad approach to the questions posed. We have identified relevant issues in many aspects of Peruvian regulation that are relevant to interconnection, but they are not normally thought of as interconnection. Also, we have taken a fresh look at the regulation of Voice over IP (VoIP) in the Peruvian environment.

## 1.3 What should be done?

In this report, we address a number of key policy questions. The findings and recommendations that respond to these questions appear in Chapter 5 of this report. Section 5.13 provides a full list of our specific recommendations as well as an integrated discussion of how they could be implemented. Annex 2 discusses how these recommendations might be reflected within the Peruvian regulatory framework.

- **Is it necessary to maintain regulation of interconnection in the first place in an NGN environment?** Some have suggested that the migration to NGN will obviate the need for regulation; however, we have concluded in several previous studies that regulation of interconnection of the voice service will continue to be required for the foreseeable future. This finding appears to be fully applicable to Peru. See Section 5.1.

- **What services should be regulated?** Should there be regulation of voice calls, SMS, MMS? Should anything else be regulated? Should there be regulation at wholesale level, retail, or both? See Section 5.4.

- **Should there continue to be call termination payments?** If so, should they be at rates approximating long run incremental cost, or is some other basis appropriate? Is it appropriate (or even possible) to charge on the basis of minutes? See Sections 5.7 and 5.8.

- **How should OSIPTEL compute cost (to the extent that the question is still relevant)?** How should OSIPTEL interpret long run incremental cost in an NGN world? How should costs be allocated in a world where voice constitutes only a tiny fraction of the total burden (and thus arguably of the total cost) of the network? Is risk higher in an NGN, and if so how should this be reflected? If expenditures are higher during migration (due to the need to maintain parallel operation of PSTN and NGN), is this relevant to cost models? See Section 5.7.

- **What special factors relate to the period of migration?** Will the migration result in fewer points of interconnection? If so, is it necessary to cushion the impact of the change on competitors that have not-yet-fully-depreciated investments in interconnect infrastructure? What kinds of consultation mechanisms are appropriate between large, established players versus smaller market entrants? Should there be different interconnection regimes for NGN and for circuit switched PSTN (and mobile PLMN) during the period when the two co-exist? See in particular Sections 4.1.3 and 5.4.7.

## 1.4 Organization of the remainder of this report

Chapter 2 explains the technical milieu in which the evolution to IP-based NGN is taking place. Chapter 3 provides background on the economics of interconnection in the switched network (fixed PSTN and mobile PLMN), the Internet, and now the NGN. Chapter 4 discusses the market evolution to NGN in various countries, the regulatory and public policy responses to those developments, and the likely evolutionary path in Peru. Chapter 5 provides our recommendations and conclusions in regard to regulation and public policy in Peru.

Annex 1 provides an overview of the Peruvian marketplace for electronic communications, to the extent that background on the market environment is necessary for an understanding of this report. Annex 2 explores how the recommendations in Chapter 5 might potentially be given effect within the Peruvian legal and regulatory framework. Annex 3 provides a glossary.

# 2 The Technology of Next Generation Networks

This chapter describes the architecture of Next Generation Networks and the underlying technology to interconnect NGNs. A description of the key points for the interconnection of VoIP operators appears at the end of the chapter.

There is no single universally accepted definition of a Next Generation Network; moreover, the definition is itself evolving over time. Nonetheless, it is reasonable to take as a starting point the definition put forward by the International Telecommunications Union (ITU):

> A Next Generation Network (NGN) is a packet-based network able to provide services including Telecommunication Services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It offers unrestricted access by users to different service providers. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.[5]

## 2.1 Understanding NGN networks

This section includes a description of four key elements of the architecture of NGN networks: NGN access networks, NGN aggregation network, NGN core network, and the NGN service control.

An NGN network is a packet-switched network which provides broadband services and Quality of Service (QoS) capabilities. The architecture of the NGN was defined by the ITU in the recommendations "General Overview of NGN" and "General principles and general reference model for next generation networks". According to the ITU guidelines, in an NGN there is a separation of the NGN service stratum and the NGN transport stratum. This separation permits the provisioning of different types of services through several access networks. The implications of a layered network architecture was already addressed in Section 1.1, and will not be further discussed here.

The basic elements of an NGN network are shown in Figure 2. The network can be viewed as comprising the following three elements or components: the IP core network, the aggregation network, and the subscriber access network.

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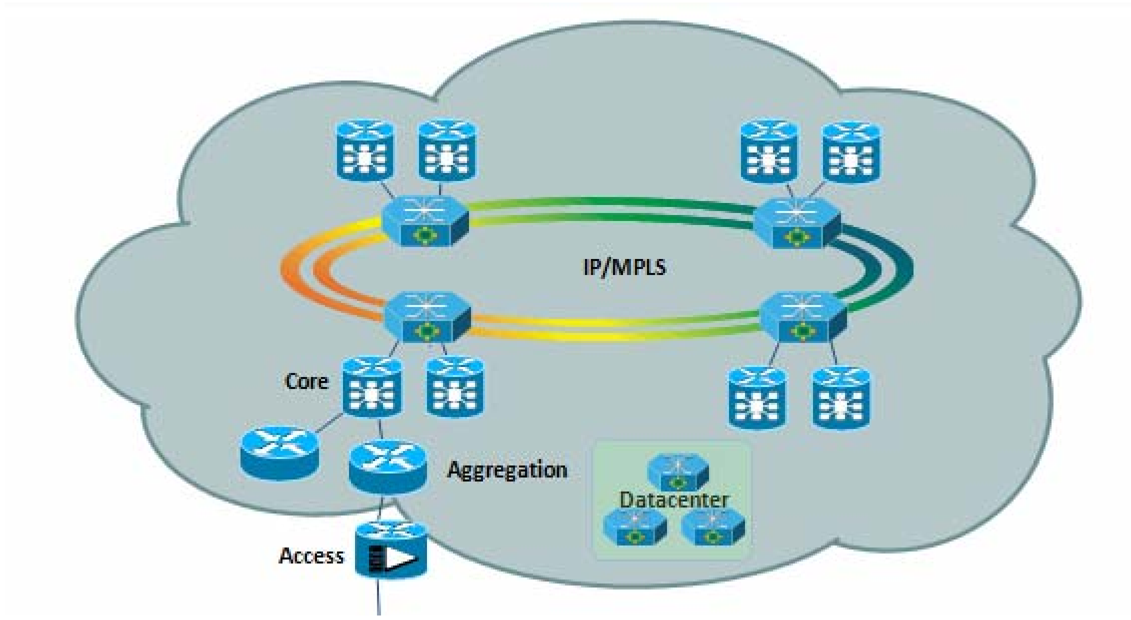
5 See http://www.itu.int/ITU-T/studygroups/com13/ngn2004/working_definition.html (Retrieved on 7 August 2009).

Figure 2: Elements of an NGN network




Source: Wik-Consult.

### 2.1.1 NGN Core network

The infrastructure of the core network is typically deployed on a nationwide basis; it provides the interconnection to other networks and to central services and applications. The core network contains routers (for example Label Edge Routers and Label Switch Routers) connected in a redundant fashion, gateways to other networks, and servers that host services.

### 2.1.2 NGN aggregation network

The NGN aggregation network aggregates the traffic from metro core switches to the backbone network, typically by means of Ethernet switches. The metro core switches can be located at the Main Distribution Frames or at local exchanges. The next section explains several technologies available for the NGN access network.

### 2.1.3 NGN Access network

There are several technologies that can be used as NGN access networks (NGA). The main prerequisite is that they could support IP-based packet-switched broadband services. A few of the possible options of NGA networks are described below:

- xDSL: At least parts of today's copper-based networks can be used to provide users with bandwidths of up to about 25 Mbps for purely copper-based solutions, or somewhat higher for VDSL (which is fiber-based).
- FTTB/H: Fiber technologies deployed up to buildings or apartments enable the provisioning of ultra-high-speed data services with bandwidth availability of 100 Mbps up to the Gb region.
- Cable networks: Cable networks that were initially deployed to offer TV have been used for some time to offer data services. The standard DOCSIS 3.0 enables transmissions of more than 100 Mbps.
- Mobile access: HSDPA (High-Speed Downlink Packet Access) enables in theory the transmission of 14 Mbps and in practice transmissions of around 2 or 3 Mbps. This technology is cell based, i.e. it is a shared use technology limiting the capacity that is available for each user the more users are active in the cell.
- Fixed Wireless access: A range of fixed wireless alternatives could be particularly useful in the Peruvian context as a means of providing high bandwidth broadband access to areas of low teledensity, or where the terrain is inhospitable to wired access.

Several operators in Europe, Asia and North America have already initiated deployment of fiber-based technologies for the access network.

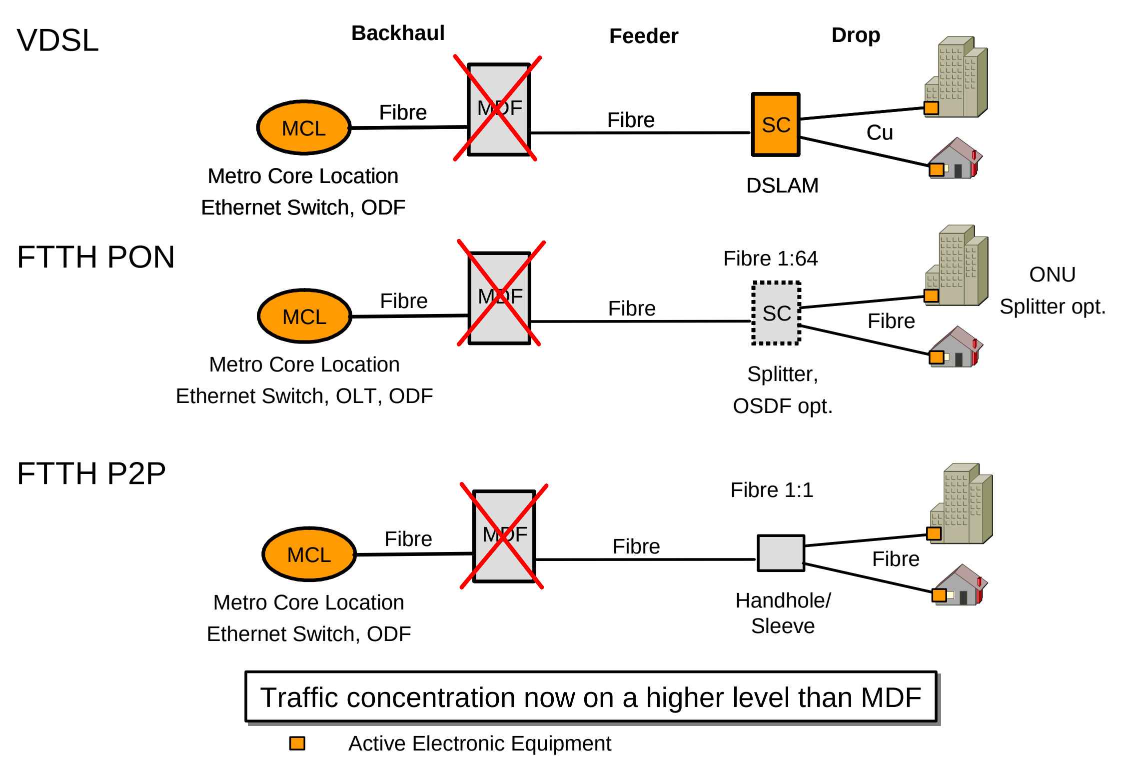
Figure 3 shows the most prominent fixed network possibilities for the subscriber access network that are implemented today around the world:

- Fiber-to-the-Curb/Cabinet (FTTC) and VDSL (Very High Speed Digital Subscriber Line),
- Fiber-to-the-Home (FTTH) PON (Passive Optical Network), and
- FTTH P2P (Point-to-Point) Access Networks.

In the traditional TDM based telephony network the subscriber access network consists of Main Distribution Frames (MDFs) and Street Cabinets (SCs). Due to the deployment of new fiber-based architectures in the local loop, MDFs (MDF functionalities) are no longer necessary. Otherwise stated, in an NGA world the network design of the concentration and perhaps also the backbone network can be optimized. New "nodes" are implemented, so called Metro Core Locations (MCL). It is likely that at least 50 % of all MDF locations are no longer needed.

In the FTTC/VDSL architecture the fiber ends at the Street Cabinet or at a similar location close to the customer premises, and the currently deployed copper-based cable is used with the VDSL technology to arrive at the customer home. The Metro Core location contains the Ethernet switch and the ODF (Optical Distribution Frame). A DSLAM (Digital Subscriber Line Access Multiplexer) is located at the Street Cabinet. For FTTC/VDSL to work, street cabinets need additional power and additional heat dissipation facilities beyond those required for conventional ADSL. Overall, it is worth noting that the available bandwidth is very much dependent on the length of the remaining copper loop. The rule is that the longer the copper loop, the less the bandwidth available to an end-user's home or business site. This dependency is not linear (see Figure 4). VDSL/FTTC can reach up to 50 Mbps, however, in order to achieve this bandwidth the requirement is that the remaining copper part of the network between cabinet and end user is no longer than about 400 to 500 meters.

Figure 3: Different technical solutions for deep fibre deployment in the local loop



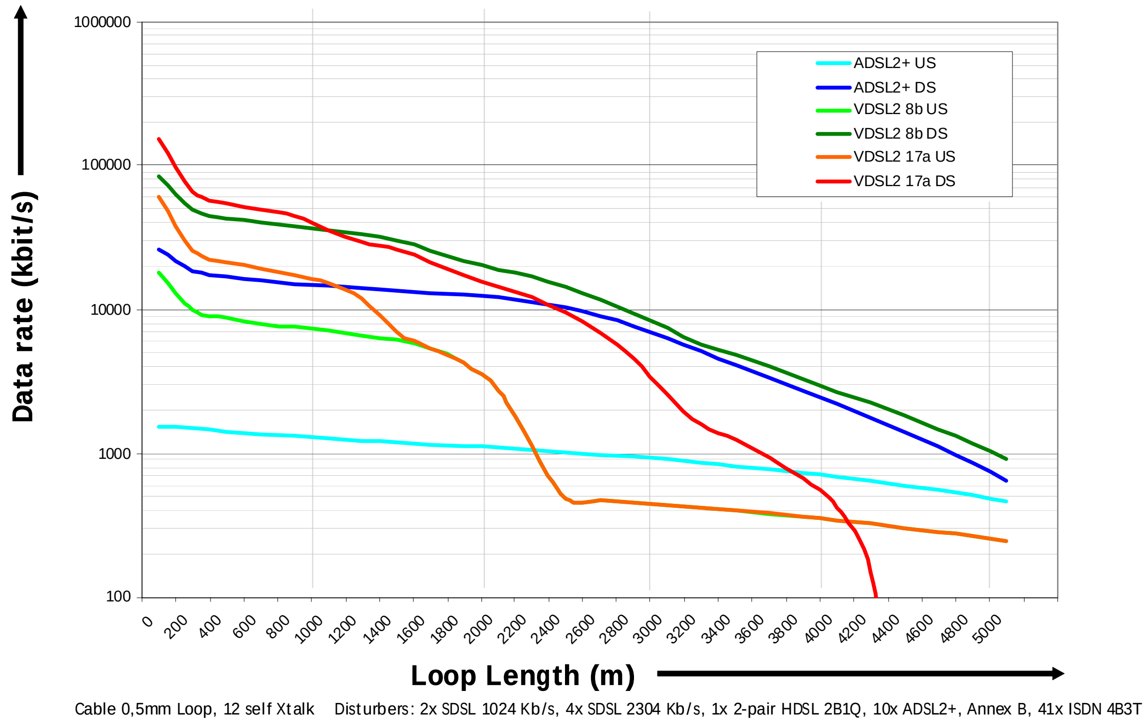

Source: WIK-Consult.

If the fiber infrastructure is deployed between the network operator's point of presence and the building of the end-user, then we refer to it as FTTB; if however the in-house infrastructure is also based on fiber, and in particular if fiber is deployed into the different apartments of a multi-dwelling unit, then we refer to it as FTTH. In either case, we distinguish between *point to point* (P2P, not to be confused with peer to peer) networks (where each end-user is connected with a distinct fiber-based bandwidth), versus *Passive Optical Networks (PON)* where the same signal is transmitted to multiple households or end-users. PON is particularly interesting as a means of sending linear video to multiple users, much as cable television does.

In a typical point to point FTTH implementation, the network operator's point of presence is connected directly to an Ethernet Switch located at the end-user premises (see Figure 3).

In a typical Passive Optical Network (PON), by contrast, the Metro Core Location houses an Ethernet switch, an OLT (Optical Line Terminator) and an ODF (Optical Distribution Frame). Somewhere between the *Metropolitan Core Location (MCL)* and the users (e.g. at a former street cabinet location), a splitter is implemented together with an OSDF (Optical Street Distribution Frame). An ONU (Optical Network Unit) is located at the customer premises. Between the OLT and the ONU, the capacity is shared between all the users. The usual splitting ratios applied today in practice are 1:32 or 1:64. Typical transmission capacity is 1.25 Gbit/s upstream and 2.5 Gbit/s downstream.

Figure 4: Relationship of loop length to available bandwidth for a range of technologies




Source: Wulf, WIK VDSL Conference 21 March 2007.

### 2.1.4 NGN Service control

In NGN networks, the service provider need not necessarily be the operator of the physical network infrastructure. This section describes several elements of the NGN service control and the role of the IMS for the implementation of service control functionalities.

#### 2.1.4.1 Nomadicity and mobility of services

In an NGN environment, a service provider will be able to offer a service independently of the access technology used by the customer. The user will only need access to a broadband network to continue using the service. *Nomadicity* means that the user can stop using the NGN service, transport the customer premises equipment to a different location, and resume use of the NGN seamlessly at the new location. Unlike *mobility*, which implies that the user continues to use the service while the user is in motion, nomadicity does not imply full mobility.

Nomadicity and mobility have different implications. For example, if the end-user wants to place a call to emergency services, it is typically necessary to know the end-user's location without waiting for the user to provide the information himself or herself. Mobility poses well understood challenges to identifying the caller's location. Nomadicity poses more complex challenges to location identification, inasmuch as nomadicity makes it possible for nominally fixed services to be relocated. Independent providers of *Voice over IP (VoIP)* have been struggling with this issue for years.

#### 2.1.4.2 Network security issues

Network security is not just one thing; it consists of many things. Some of the main aspects of network security are:

- **Authentication:** ensuring that a party is who he purports to be;
- **Authorization:** ensuring that the party is permitted to do what he wishes to do;
- **Integrity:** ensuring that the information that a party receives is the same as the information that was sent to him or her; and
- **Confidentiality (privacy):** ensuring that information is not seen by unauthorized third parties.

Availability is closely linked to security. One of the most common network attacks, and thus one of the greatest challenges to network security, consists of *denial of service (DoS)*.

Consumer privacy is closely intertwined with network and computer security, but they are not the same thing.

It is still not clear whether NGNs will be more vulnerable than today's ISP or PSTN networks; however, the ITU, the IETF, the 3GPP-IMS, and ETSI-TISPAN have been steadily improving security standards.

#### 2.1.4.3 Quality of Service

NGNs are intended to provide support for differentiated Quality of Service (QoS). Different applications, notably including real-time bidirectional voice, have different QoS requirements in terms of the mean and variance of packet delay, and the probability of lost packets.

IP-based communications were originally designed for delay-insensitive traffic. Contrary to what many have assumed, the need for differentiated QoS was understood early on.

Differentiated QoS in support of voice services was in production deployment by the US military in the eighties,[6] and differentiated QoS in private networks has been in widespread use for at least ten years.

What has been rare has been differentiated QoS between independently managed IP-based networks. The reasons for this are complex, having to do with transaction costs in implementing interconnection agreements between networks, and the simple lack of perceived benefit on the part of most customers. We return to these points in Section 3.5.

#### 2.1.4.3.1 Overview of QoS techniques

Several different techniques have been developed during the last two decades to guarantee QoS in packet-switched networks. They can be roughly grouped into:

- Reservation of transmission capacity on an end-to-end basis;
- Statistical assurance on a hop-by-hop basis; and
- So-called over-engineering.

End-to-end solutions attempt to ensure QoS over the entire transmission, from one end of the Transport Layer Transmission Control Protocol (TCP) session (or equivalent UDP datagram flow) to the other. The best known attempt at end-to-end control is the Integrated Services Architecture (ISA), which was implemented using the Resource Reservation Protocol (RSVP). This technique consisted of reserving and retaining data transmission capacity along the end-to-end path before the transmission takes place. RSVP was placed in production by a few firms, but it never achieved widespread acceptance by providers or customers. It was too complex and cumbersome.

The Differentiated Services (DiffServ) technique can be used to indicate the desired priority for each packet over each link. It provides statistical guarantees of QoS for each hop; however, it provides no absolute assurance. Moreover, since DiffServ is unaware of the end-to-end path, it provides no assurance at all that the overall performance seen by the end-user will be that which is desired; however, if the links all perform as desired most of the time, then the performance end-to-end will also be as desired most of the time. A still open question is the degree to which performance assurance with DiffServ will exceed that provided by normal Internet transmission with no special performance assurance.

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**6** Using, for example, the ST-II streams protocol.

DiffServ is a signaling protocol. DiffServ itself does not specify how its performance goals should be achieved. Network operators are free to make their own choices. Basically, the network operator controls two parameters: (1) how packets should be prioritized in the queue before being transmitted over the outbound link from a router; and (2) if the outbound queue exceeds available storage in the router, determining which packets should be dropped.

One of the most common options for controlling the link prioritization is the Multiprotocol Label Switching (MPLS) protocol. The routers and switches will read the *Type of Service (ToS)* or *Quality of Service (QoS)* information contained in a packet's Internet Protocol (IP) header and prioritize it accordingly in the outbound transmission queue.

DiffServ and MPLS are relatively straightforward, and have been deployable together for a decade. Use between networks would require prior agreement as to how to interpret quality specifications, and as to what the remuneration model should be and how service delivery should be measured. This has not happened, primarily because of a lack of customer demand.

The truth of the matter is that the Internet provides good QoS most of the time, with or without special arrangements. High-speed interfaces between networks (e.g. more than 155 Mbps) provide suitably low delay most of the time, even as average load on a transmission link approaches 90%; however, delay expands without bound when offered load exceeds 100%. Consequently, all IP-networks need to be designed with some "headroom" to allow for random or unusual peaks in activity.

For a competent designer with good tools and good data, this headroom need not be very large. Not every network operator has tools or skills at that level, so many find it necessary to provide considerable headroom. This is what is meant by over-engineering.

To re-cap, the technology of differentiated IP QoS is reasonably mature, and has been for a decade; nonetheless, many technical, administrative and business questions remain about its implementation between and among networks.

#### 2.1.4.3.2 Integrated Service Model

The IntServ model relies on the Resource Reservation Protocol (RSVP) to signal and reserve the desired QoS for each flow in the network. A flow is defined as an individual, unidirectional data stream between two applications, and is uniquely identified by the 5-tuple (source IP address, source port number, destination IP address, destination port number, and the transport protocol).

Two types of service can be requested via RSVP (assuming all network devices support RSVP along the path from the source to the destination). The first type is a very strict guaranteed service that provides for firm bounds on end-to-end delay and assured bandwidth for traffic that conforms to the reserved specifications. The second type is a controlled load service that provides for a better than best effort and low delay service under light to moderate network loads. It is possible (at least theoretically) to provide the requisite QoS for every flow in the network, provided it is signaled using RSVP and the resources are available.

However, there are several drawbacks to this approach:

- Every device along the path of a packet, including the end systems such as servers and PCs, need to be fully aware of RSVP and capable of signaling the required QoS.
- Reservations in each device along the path are "soft," which means they need to be refreshed periodically, thereby adding to the traffic on the network and increasing the chance that the reservation may time out if refresh packets are lost.
- Maintaining soft-states in each router, combined with admission control at each hop and increased memory requirements to support a large number of reservations, adds to the complexity of each network node along the path.
- Since state information for each reservation needs to be maintained at every router along the path, scalability with hundreds of thousands of flows through a network core becomes an issue.

Fortunately, many of these shortcomings have been remedied by the introduction of "RSVP Refresh Reduction and Reliable Messaging," "RSVP scalability enhancements," Proxy RSVP and many other feature enhancements that make RSVP more scalable and deployable.

Since per-flow QoS is difficult to achieve in an end-to-end network without adding significant complexity, cost, and introducing scalability issues, it naturally leads to thinking about classifying flows into aggregates (classes), and providing appropriate QoS for the aggregates – defined through the DiffServ Model, described here next.

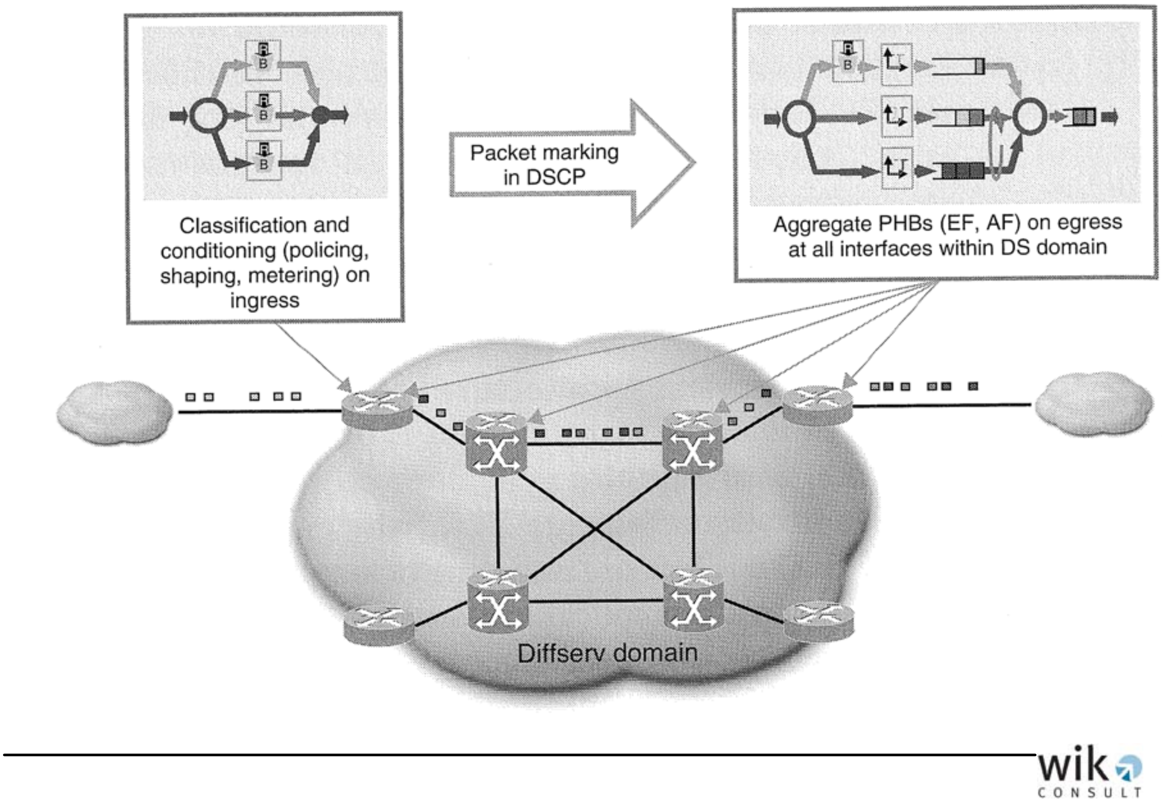
#### 2.1.4.3.3 Differentiated Service (DiffServ) Model

Differentiated Services (DiffServ) is a prioritization technique that classifies traffic according to the priority assigned to every packet. The DiffServ architecture is defined in IETF RFC 2475[7]. Figure 5 shows the main components of a DiffServ-enabled

7 Blake et al., „An Architecture for Differentiated Services“, IETF RFC 2475, December 1998.

network, which is also known as a DiffServ domain: traffic classification and conditioning, DiffServ Code Point (DSCP) marking, and Per-Hop Behaviour (PHB). These components are explained below.

Figure 5: DiffServ Architecture




Source: "Deploying IP and MPLS QoS for Multiservice Networks", p. 148[8]

- **Traffic classification and conditioning:**[9] at the border of the DiffServ domain, a network element (e.g. a router with DiffServ capabilities) classifies customers' traffic into a certain number of traffic classes, which are referred to as "behaviour aggregates" in the Diffserv nomenclature. The Service Level Agreement (SLA) that was signed between the network operator and the end customer specifies how to handle the traffic. This treatment is reflected in the Traffic Conditioning Agreement (TCA). Traffic shaping or traffic policing techniques can be used to condition the traffic so that it meets the requirements described in the TCA.

**8** Evans, J. and Filsfils, C., "Deploying IP and MPLS QoS for Multiservice Networks", The Morgan Kaufmann Series in Networking, Elsevier, 2007.

**9** Ibid.

- **DSCP marking:** The IP header contains a Differentiated Services (DS) 8-bit field. The first 6 bits of this field are named DiffServ Code Point (DSCP) and they are used to identify the traffic class the packet belongs to. The packets can be marked at the edge of the DiffServ domain.

- **Per-Hop Behaviors:** Within the DiffServ domain, routers use queuing control and scheduling mechanisms to forward packets according to the traffic class or behaviour aggregate that is marked in the DSCP field. The Per-Hop Behaviours (PHBs) are the forwarding properties that can be applied to a packet.

DiffServ does not define the specific forwarding techniques that should be implemented at every hop. DiffServ has defined four classes of Per-Hop Behaviours: Expedited Forwarding (EF), Assured Forwarding (AF), Default PHB, and Class Selector PHB.

The Expedited Forwarding PHB is defined in the IETF RFC 3246 and it provides packets with low loss, low delay and low jitter services[10]. The Assured Forwarding (AF) PHB defines four classes that support data packets with certain bandwidth requirements[11]. The intent of the Default PHB, which was defined in the IETF RFC 2474[12], is to support a kind of traffic that can be considered best-effort traffic. Finally, the Class Selector PHB, which is also defined in the IETF RFC 2474, is used to keep backward compatibility with the IP precedence field.

#### 2.1.4.3.4 Different QoS service classes

ITU-T has also delivered work in the area of Quality of Service. The ITU-T has delivered two relevant recommendations,

- Y.1541, which defines the QoS classes that quantify user application needs in terms of IP network performance

- Y.1221, which defines “traffic contracts” that complement the QoS classes by describing flow characteristics/limits.

The two Recommendations together specify the key data for IP network QoS signaling.

Y.1541 defines 6 classes of services (numbered form 0 to 5) with the characteristics shown in Table 3.[13]

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**10** Davie, B. et al., „An Expedited Forwarding PHB (Per-Hop Behavior)”, IETF RFC 3246, March 2002.
**11** Heinanen, J. et al., „Assured Forwarding PHB Group“, IETF RFC 2597, June 1999.
**12** Nichols, K., et al., „Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers”, IETF RFC 2474, December 1998.
**13** In the recommendation the reader may find these characteristics in terms of network performance parameters.

Table 3: Y.1541 performance classes

| QoS Class | Applications (Examples) |
|---|---|
| **0** | Real-Time, Jitter Sensitive, High Interaction (VoIP, VTC) |
| **1** | Real-Time, Jitter Sensitive, Interactive (VoIP, VTC) |
| **2** | Transaction Data, Highly Interactive (Signaling) |
| **3** | Transaction Data, Interactive |
| **4** | Low Loss Only (Short Transactions, Bulk Data, Video Streaming) |
| **5** | Traditional Applications of Default IP Networks |

Source: Neal Seitz, "ITU-T Recs. Y.1541 and Y.1221 – a Basis for IP Network QoS Control and Traffic Management".[14]

These Y.1541 performance classes, Y.1221 transfer capabilities, and DiffServ Per Hop Behaviour could potentially be mapped to one another as shown in Table 4.

Table 4: Potential Y.1221 Contacts and DiffServ PHB Mapping

| Y.1221 transfer capability | Associated DiffServ PHB | IP QoS class | Remarks |
|---|---|---|---|
| **Best Effort (BE)** | Default | QoS Class 5 (Unspecified) | A legacy IP service, when operated on a lightly loaded network, may achieve a good level of IP QoS. |
| **Statistical Bandwidth* (Modified to Limit Delay)** | AF | QoS Classes 2,3,4 | The IPLR objective applies only to the IP packets in the higher priority levels of each AF class; the IPTD objective applies to all packets. |
| **Dedicated Bandwidth (DBW)** | EF | QoS Classes 0 and 1 | – |

Source: Neal Seitz, "ITU-T Recs. Y.1541 and Y.1221 – a Basis for IP Network QoS Control and Traffic Management".[15]

**14** At http://www.itu.int/ITU-T/worksem/qos/presentations/qos_1003_s5p1_pres.ppt, Retrieved on 8 August 2009.

**15** Ibid.

#### 2.1.4.4 The role of the IMS (IP Multimedia Subsystem)

The definition of the IP Multimedia Subsystem was developed initially by the mobile network standards body 3GPP for the provisioning of multimedia services over 3rd generation mobile services[16]. Subsequently ETSI (European Telecommunications Standards Institute) adopted IMS into the NGN specifications developed by the ETSI Telecoms & Internet converged Services & Protocols for Advanced networks (TISPAN). Today, IMS has worked its way into ITU standards recommendations for NGNs.

IMS is an architecture that enables a service provider to control the provisioning of services through its own network (or through the network of another cooperating operator). This functionality fits nicely into the overall design philosophy of the NGN network.

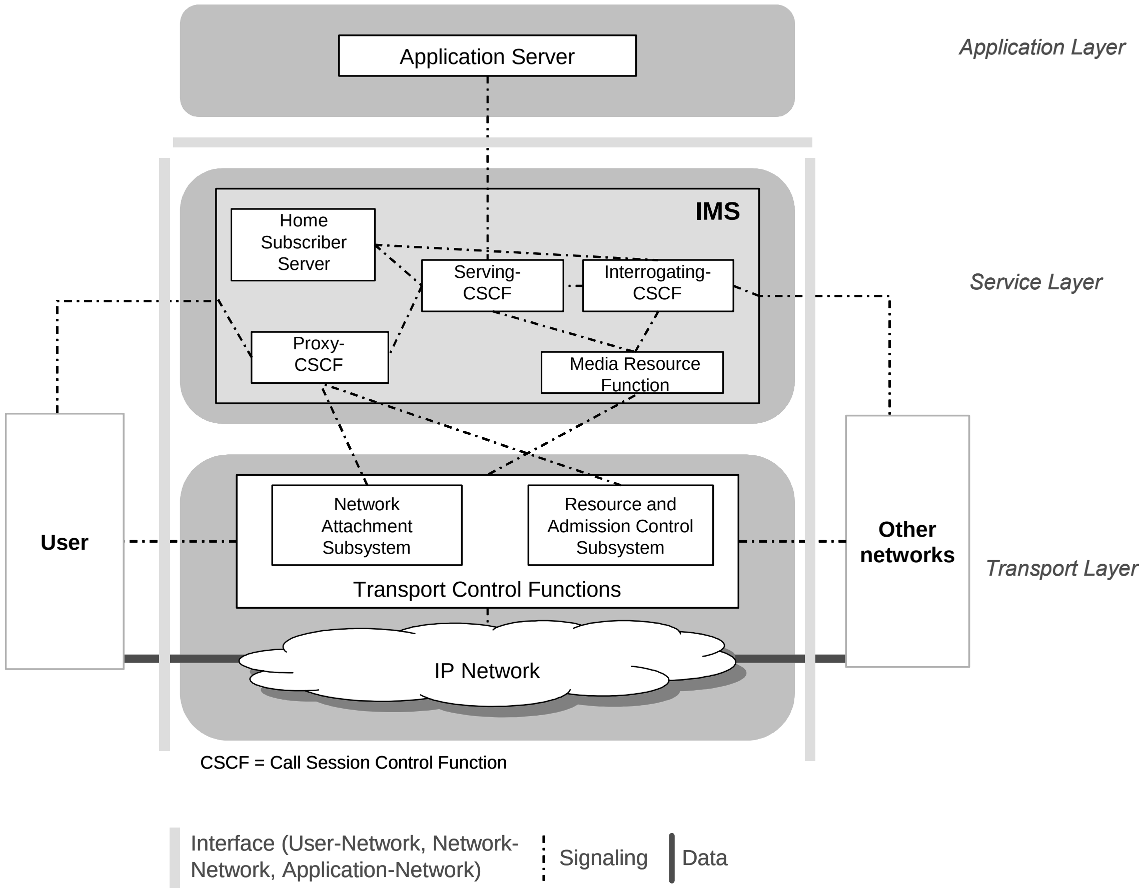
IMS uses the IETF-developed Session Initiation Protocol (SIP) to control the different nodes.

Figure 6 shows the 3-layer IMS-based NGN architecture with the correspondent IMS nodes[17]. The CSCF (Call Session Control Function) and the HSS (Home Subscriber Server) are the primary building blocks of the IMS. The CSCF is in charge of network intelligence and it processes sessions from and to end-users terminals and applications servers. The Proxy-CSCF, Serving-CSCF, and Interrogating-CSCF nodes carry out the CSCF functions. The user information is saved in the HSS, which acts as a master database.

**16** Dieter Elixmann, Antonio Portilla, Klaus Hackbarth, et al., "The Regulation of Next Generation Networks (NGN)", WIK-Consult and Infrapont, study for the Hungarian telecommunications regulator (NHH).

**17** Stephan Jay, Thomas Plückebaum, „Next Generation Core Networks: Access, Interconnection and Competition Policy", WIK Newsletter Nr. 72, September 2008.

Figure 6: 3-layer IMS-based NGN architecture




Source: WIK-Consult.

### 2.1.4.5 Billing and accounting

Network management is a key aspect of any networking system, and billing and accounting constitute critical aspects of network management.

In this section, we will discuss first the *theory* of billing and accounting, as reflected in the activities of standards bodies and industry consortia, and then the *practice* of billing and interconnection in an NGN world. Note, however, that the practice of billing for IP-based NGN interconnection is still in an immature state, because large operators still interconnect their networks using circuit-switched SS-7 technology rather than with IP.

Several different standards organizations and industry fora deal with various aspects of charging and billing architectures for NGN:

- The ITU
- ETSI and 3GPP, in conjunction with the IMS standard (see Section 2.1.4.4)
- The Telecommunication Management Forum (TMF)

The ITU has developed standards for tariffs, charging and billing in its “D” Series of Recommendations. Aspects of interconnection for ATM-based broadband networks are addressed in Recommendation D.224;[18] for interconnection of IP networks in Recommendation D.50;[19] and more concretely for NGN in general in Recommendation D.271.[20] In line with the tendency of the ITU to restrict itself to high-level conceptual standards, Recommendation 271 provides no details about charging and billing in an IMS environment.

García, Rodríguez de Lope and Hackbarth (2008) provide an overview of charging and billing functions in the 3GPP IMS.[21] As the authors explain, two types of charging have been defined: recurrent (*offline*) billing and transaction-based (*online*) billing.

With offline billing, the *Charging Control Function (CCF)* receives accounting information through a defined interface (the Rf reference point), and uses it to create a *Charging Detail Record (CDR)*. The CCF then forwards the CDR to the billing system through the defined Bi interface. *Accounting Request* commands (*ACRs*) contain *attribute-value pairs* (*AVPs*) as required by the IETF *Diameter* protocol.[22] Different IMS components might contribute different ACRs to the CDR; for example, the *Serving Call Session Control Function* (*S-CSCF*) might contain information about the AS contacted, while the *Proxy Call Session Control Function* might contain QoS information.

With online billing, a rather complex *Online Charging System* (*OCS*) draws on other IMS components, such as the aforementioned S-CSCF, the Application Server that is controlling the application in question, or the Media Resource Control Function, which controls resource flows. The *Online Charging System* contains a wide range of elements: (1) the Event Charging System determines the appropriate tariff for an event; (2) the Session Charging Function performs uniform charging according to resource usage; (3) the Rating Functions identify the appropriate price and tariff determinations; and (4) the Correlating Function correlates and integrates this data which comes from so many sources. No special provisions have been made for interconnection billing, but online billing would appear to be appropriate.

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**18** Charging and accounting principles for ATM/B-ISDN, ITU-T Recommendation D.224, 12/1999.
**19** International Internet connection, ITU-T Recommendation D.50, 10/2008.
**20** Charging and accounting principles for NGN, ITU-T Recommendation D.271, 04/2008.
**21** A. García, L. Rodríguez de Lope, K. Hackbarth: 2008, “3GPP towards IMS: Quality of Service and Charging”, 8th WSEAS International Conf. on Distance Learning, Multimedia and Video Technologies, Santander-Spain 2008, ISBN 978-960-474-005-5 / ISSN 1790-5109. Note that both ETSI and 3GPP are involved in IMS.
**22** Diameter is an enhanced version of RADIUS.

Most experts anticipate that, despite all of this preparation and technical analysis, the real challenges that IMS faces reflect a lack of proven business models suitable to an IP-based world.

The Telecommunications Management Forum (TMF) is an industry association focused on transforming business processes, operations and systems for managing and monetizing on-line information, communications and entertainment services.[23] TMF's annual publication (Management World) for 2008 contains a series of useful articles about a range of billing issues relevant to IP-based NGN and IMS.[24] Ian Scales considers benchmarking billing and the outlines the corresponding activities of the TMF in this field.[25] Finegold explores various aspects of real-time billing, which corresponds to ON-Line billing in IMS, from a business and technical point of view.[26] The article explains how the English mobile network operator O2 used the IMS ON-Line billing scheme to build a stronger market position among both retail and wholesale customers. Finally, Lex provides a global perspective on ON-Line billing in conjunction with a range of different billing methods.[27]

In terms of billing and accounting practice in an NGN or IMS setting, García, de Lope and Hackbarth (2008)[28] provides a detailed discussion of technical architecture in billing systems offered by different providers, including Orga Systems, Cognizant Technology Solutions, Converse, and Ixonos.[29]

## 2.2 Technical standards

This section deals with the technical standards that enable NGN and VoIP in general, and IP interconnection in particular. Section 2.2.1 describes interactions among a number of key standards activities, while Sections 2.2.2, 2.2.3, and 2.2.4 describe standards produced by the ITU, 3GPP, ETSI, and IETF.

Standards are important to the extent that they enable *interoperability* among different implementations, and also help to achieve *economies of scale*. These are useful properties. It is important, however, to remember that the existence of a standard is the beginning of the story, not the end. Purported standards can fail to achieve the desired effects, for a number of different reasons, including:

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**23** See http://www.tmforum.org/AbouttheTMForum/730/home.html (Retrieved on 7 August 2009).
**24** Lynd Morley ed., *Management World*, 2008, ISBN: 1-905435-68-1.
**25** Ian Scales, "Peer pressure", in Lynd Morley ed., *Management World*, 2008, pp. 32-36.
**26** E.J. Finegold, "The many faces of billing", in Lynd Morley ed., Management World, 2008, pp. 93-95.
**27** Leslie Lex, "Another next big thing", in Lynd Morley ed., Management World, 2008, pp. 119-121.
**28** A. García, L. Rodríguez de Lope, K. Hackbarth: 2008, "3GPP towards IMS: Quality of Service and Charging", op. cit.
**29** Ibid., pages 2, 6, 43, 92, and 98, respectively.

- Many technical standards are fairly abstract, defining terminology or goals. They do not necessarily provide enough technical detail to ensure interoperability.
- Not every standard is really a standard. This is especially true in the IETF, where a *Requests for Comments (RFC)* document could be purely informational (and a few even represent practical jokes). Even among RFCs that purport to be on the IETF standards track, not every RFC will achieve sufficient acceptance to progress to a true standard.
- A technical standard may allow too many options. The result can be that different, fully compliant implementations are unable to interoperate. Worse, a technical standard may be ambiguous in key details. Interviewees emphasized, for instance, that independent SIP implementations rarely interoperate correctly.[30]
- Even if a standard is sufficiently tight and unambiguous, there is no assurance that it will be implemented by providers of equipment and software, nor that it will be deployed by service providers.

### 2.2.1 A plethora of standards bodies

There are many bodies involved in NGN standardization efforts. They address aspects such as definition, terms of reference, protocols and architectures, depending on the body or forum involved.

The many groups involved in NGN related activities include industry fora, standardization groups, and regulators. In addition, a number of bodies (GSMA, for example) provide documents that in effect explain how standards should be applied, even though they may not think of themselves as standards bodies. From the NGN/VoIP standardization perspective, the most important standards bodies are:

- **ITU-T**: Defines world telecommunication standards. Did the seminal standards work on NGN.
- **3GPP**: The 3rd Generation Partnership Project has developed standards for IMS (IP Multimedia Subsystem), and also works on the interconnection of IP Services. 3GPP is primarily oriented to mobile services.
- **ETSI**: The *TISPAN (Telecommunications and Internet converged Services and Protocols for Advanced Networking)* group of the *European Telecommunication*

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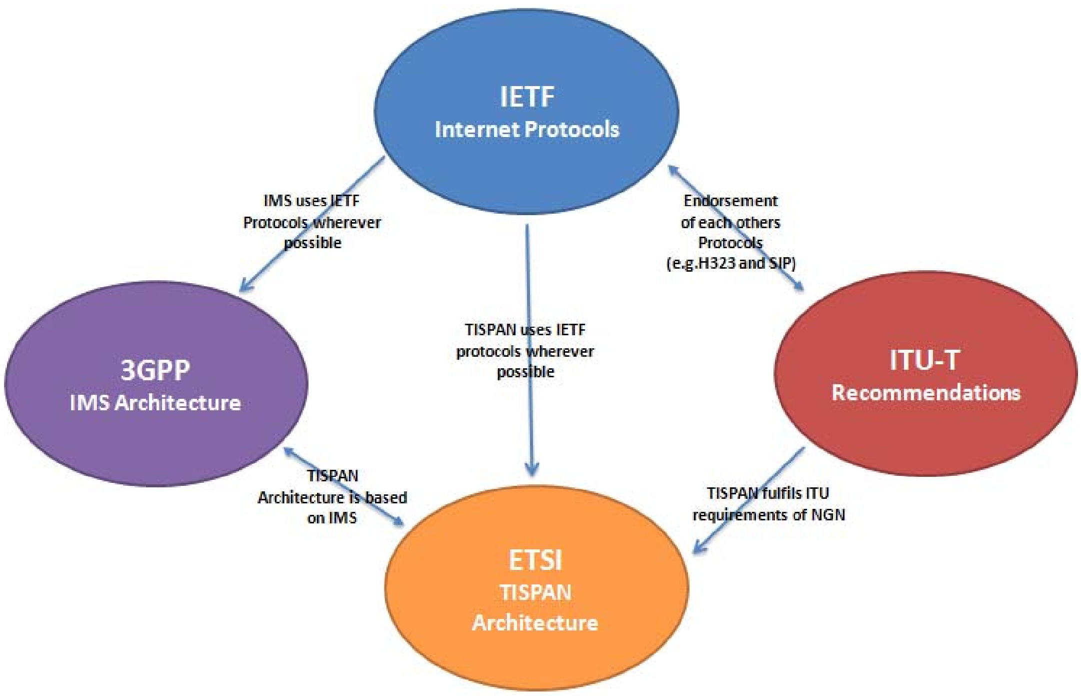
**30** One interviewee observed, for instance, that there are about 150 SIP RFCs, with another 100 progressing through the IETF at present. Developers have no idea what they are supposed to be implementing.

*Standard Institute (ETSI)* a set of standards for an NGN based on the 3GPP's IP Multimedia System (IMS). ETSI IMS is primarily oriented to fixed services.

- **IETF**: The IETF provides building blocks for IMS systems, including SIP and other IP-based protocols.

Figure 7 aims at depicting some of the interactions that exist between these bodies.

Figure 7: Standardization Bodies Interaction




Source: WIK-Consult.

The following sections describe the standardization and related efforts that these bodies have undertaken in the areas of NGN, VoIP and interconnection.

## 2.2.2 ITU

The ITU contributes to the NGN concept mostly in the form of high-level conceptual standards, where the core recommendation is Y.2001. It is then up to other standards bodies and fora, notably ETSI TISPAN[31] and 3GPP, to fill in the necessary protocol details.

ITU has been involved in NGN standardization for many years. A Joint Rapporteur Group on NGN in ITU-T's *Study Group 13 (SG13)* began to explore the concept of a new broadband network with strong service integration in 2003. Work continued under ITU's *NGN Focus Group (FGNGN)* until the end of 2005. The work was progressed further in different ITU Study Groups under the label of the *NGN Global Standards Initiative (NGN-GSI)*. ITU documents about NGN proper have been published in ITU's Recommendations[32] series Y.2000-Y.2899 (see Table 5), a choice that reflects the fact that the NGN is an IP-based network.

Table 5: ITU-T NGN Recommendations

| **Next Generation Networks** | |
|---|---|
| **Y.2000-Y.2099** | Framework and functional architecture models |
| **Y.2100-Y.2199** | Quality of service and performance |
| **Y.2200-Y.2249** | Service aspects: Service capabilities and service architecture |
| **Y.2250-Y.2299** | Service aspects: Interoperability of services and networks in NGN |
| **Y.2300-Y.2399** | Numbering, naming and addressing |
| **Y.2400-Y.2499** | Network management |
| **Y.2500-Y.2599** | Network control architectures and protocols |
| **Y.2700-Y.2799** | Security |
| **Y.2800-Y.2899** | Generalized mobility |

Source: Wikipedia.

From the ITU perspective, an NGN is a packet-based network able to provide Telecommunication Services to users and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent of the underlying transport-related technologies. It enables unfettered access for users to networks and to competing service providers and services of their choice. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.[33]

Thus, an NGN is characterized by:

---

**31** TISPAN is the ETSI core competence centre for fixed networks, and for the migration from circuit-switched networks to packet-switched networks with an architecture that can serve in both. See Section 2.2.3.

**32** An ITU Recommendation can be viewed as a standard.

**33** ITU-T Recommendation Y.2001 (12/2004) - General overview of NGN.

- Logical separation of the transport, control and service layer,
- Differentiated network access,
- An IP transport network in the core,
- Application of open protocols (ITU, ETSI, IETF) to integrate different services, transport and system providers.

In ITU standards, interconnection is viewed as a form of *interworking*. ITU standards recognize both the need for interworking between NGN networks, and the need for interworking between NGNs and pre-existing “legacy” networks. For example, Recommendation Y.1453 describes the interworking between TDM and IP, and thus between the traditional PSTN/ISDN and the emerging NGN.

ITU recommendations on interworking are published in the Series Y.1400-Y.1499. Table 6 provides an overview of the current Recommendations in force.

Table 6: ITU-T Recommendations for Interworking

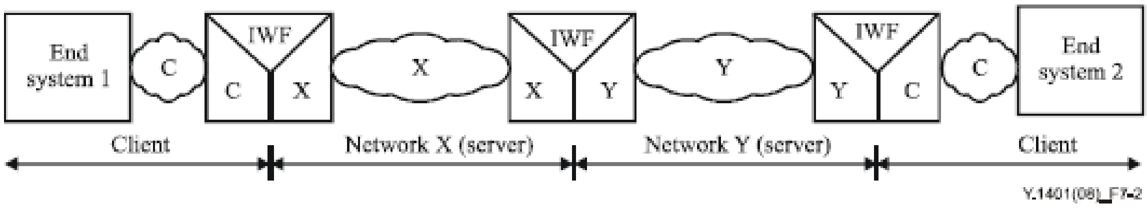
| Number | Title |
|---|---|
| **Y.1401** | Principles of interworking |
| **Y.1402** | General arrangements for interworking between Public Data Networks and the Internet |
| **Y.1411** | ATM-MPLS network interworking - Cell mode user plane interworking |
| **Y.1412** | ATM-MPLS network interworking - Frame mode user plane interworking |
| **Y.1413** | TDM-MPLS network interworking - User plane interworking |
| **Y.1414** | Voice services - MPLS network interworking |
| **Y.1415** | Ethernet-MPLS network interworking - User plane interworking |
| **Y.1416** | Use of virtual trunks for ATM/MPLS client/server control plane interworking |
| **Y.1417** | ATM and frame relay/MPLS control plane interworking: Client-server |
| **Y.1418** | Pseudowire layer network |
| **Y.1451.1** | Functionality and interface specifications for GSTN transport network equipment for Interconnecting GSTN and IP networks |
| **Y.1452** | Voice trunking over IP networks |
| **Y.1453** | TDM-IP interworking - User plane interworking |
| **Y.1454** | Tandem free operation (TFO)-IP network interworking |

Source: ITU.34

**34** See http://www.itu.int/osg/spu/ip/chapter_four.html (Retrieved on 7 August 2009).

Recommendation Y.1401 provides an overview of interworking, but primarily from the perspective of the transport function. For example, Figure 8 shows an example of a generic connection between two end systems over two networks.

Figure 8: Generic connection between two End Systems over two networks




Source: ITU Recommendation Y.1401.

### 2.2.3 3GPP and ETSI TISPAN: the standardization of IMS

The NGN and IMS standards originated independently, but they have largely converged.[35]

In terms of technical standards, NGN standards were developed primarily by the ITU and by ETSI. The IP Multimedia Subsystem (IMS), however, originated with the 3GPP, a standards body focused on mobile networks. IMS was developed primarily in order to provide multimedia services over 3rd generation mobile networks, e.g. UMTS in Europe. IMS first appeared in 3GPP release 5 specifications, finalized in March 2002, but only for mobile access. 3GPP subsequently developed improved versions of IMS in releases 6 (wireless access) and 7 (fixed access).

Later on, the European Telecommunications Standards Institute (ETSI) incorporated IMS into the NGN specifications developed by ETSI *Telecoms & Internet converged Services & Protocols for Advanced Networks (TISPAN)*[36] working group.[37]

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**35** This section of the report draws heavily on our earlier study for the Hungarian NHH, *The Regulation of Next Generation Networks (NGN)*, 10 May 2007.

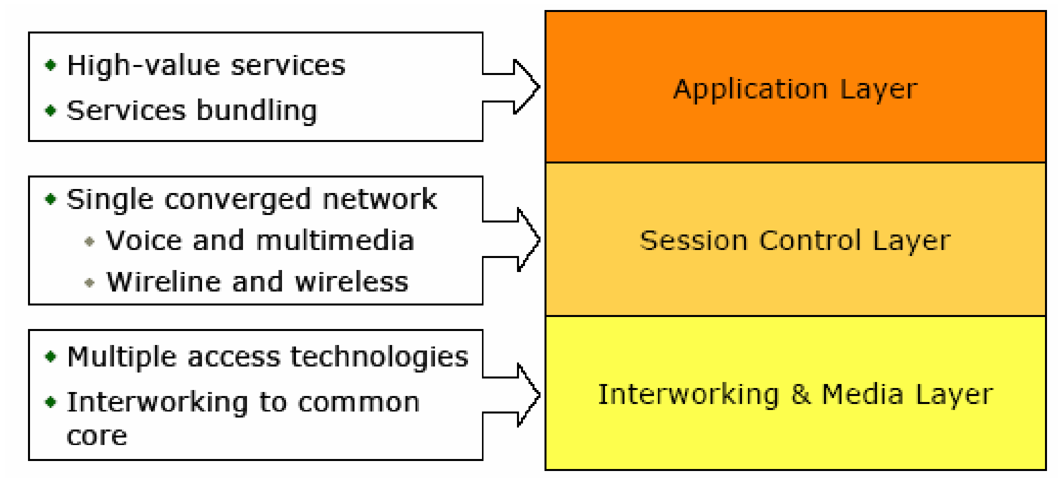
**36** TISPAN is the ETSI core competence centre for fixed networks, and for the migration from circuit-switched networks to packet-switched networks with an architecture that can serve in both. TISPAN is responsible for all aspects of standardisation for present and future converged networks, including NGN and its related service, architectural, and protocol aspects. TISPAN also performs QoS studies, security-related studies, studies on mobility aspects within fixed networks.

**37** For a short review of the general TISPAN activities, see T. Kovacikova, P. Segec, "NGN Standards Activities in ETSI", *Proceedings of the Six International Conference on Networking (ICN07)*, IEEE 2007 [Kovacika-2007].

Current ITU recommendations for NGN are based on IMS (NGN-IMS) as incorporated into ETSI TISPAN. Thus, the IMS standards are going to be incorporated into ITU and ETSI NGN standards, but with minor differences (primarily in the scheme for the provision of QoS.

Like NGN, the IMS is a layered architecture, as shown in Figure 9 below. This similarity of structure facilitated the incorporation of IMS into the NGN standards.

Figure 9: Layered view of the IMS Model




Source: Kinder (2005).[38]

IMS is based on end to end IP services controlled by the SIP protocol. IMS provides the functions of a SIP-based soft-switch, but extends them in order to enable open access to value-added services, applications and content. It thus adds session control functions so as to enable the seamless use of multimedia services from different access technologies, fixed and mobile, thus promoting fixed mobile convergence.

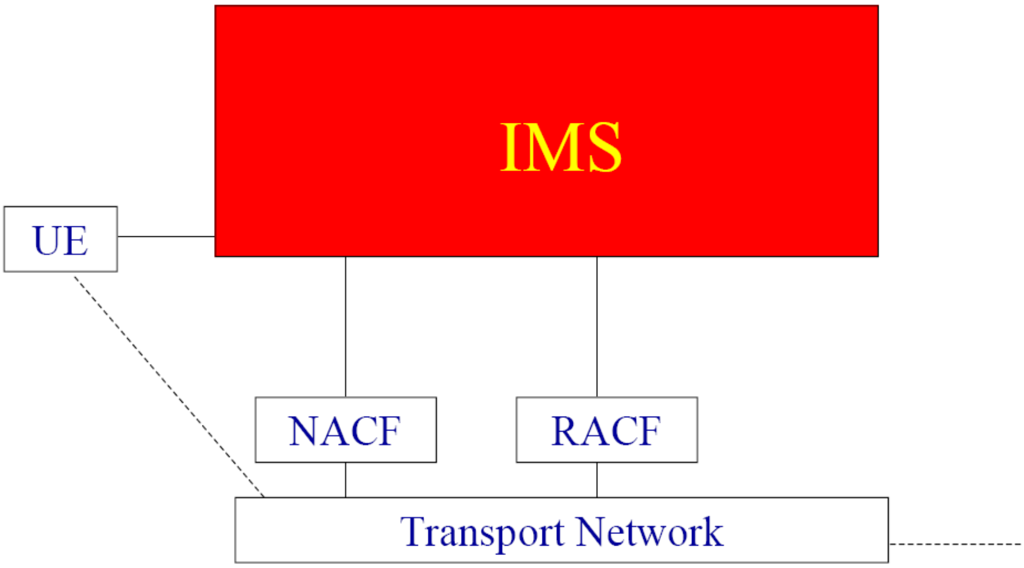
The internal architectural structure of IMS comprises three major elements, as shown in Figure 10 below:

- The IMS core,
- The Network Attachment Subsystem (NASS) which provides the Network Attachment Control Functions (NACF), including authentication and authorization of the user, and

38 Kinder, N. (2005): "IMS IP Multimedia Subsystem", Sonus Networks.

- The Resource and Admission Control Subsystem (RACS) which provides the Resource Attachment Control Functions (RACF), including resource management and admission control based on the user's profile and the resources currently available.

Figure 10: Functional elements of IMS




Source: Knight (2006).[39]

Interconnection issues of the IMS-TISPAN architecture are addressed in Section 2.3.3.2.

### 2.2.4 IETF

The Internet Engineering Task Force (IETF) develops and promotes Internet standards. It deals in particular with the standards development of the TCP/IP and Internet Protocol suite.

Most of its specifications are focused mainly on single protocols rather than tightly-interlocked systems or architectures. This has allowed its protocols to be used in many

39 Knight, D. (2006): "IMS based NGN Architecture and its application", presentation at the ITU-T Workshop "NGN and its Transport Networks", Kobe, 20-21 April; www.itu.int/ITU-T/worksem/ngn/200604/presentation/s2_knight.pdf, visited 9 August 2009.

different systems, and its standards are routinely re-used by bodies which create full-fledged architectures such as 3GPP IMS.

As highlighted in the previous section, there is a significant volume of work from the IETF that has been incorporated into standardization efforts by the 3GPP, ETSI and ITU. For example IP, TCP and SIP are part of the NGN architecture and BGP is part of the interconnection solution.

The IETF SPEERMINT (Session PEERing for Multimedia INTerconnect) Working Group is developing which focuses on architectures that will identify, signal, and route delay-sensitive (real-time) communication sessions.[40] SPEERMINT focuses on how to identify and route real-time sessions (such as VoIP calls) at the session layer, but it does not necessarily cover the exchange of packet-routing data or media sessions.

Note that the term "peering" is used to refer to the interconnection between application layer entities such as SIP servers as opposed to interconnection at the IP network layer; however, in order to achieve real-time Session PEERing, both signaling and media flows must be taken into consideration.

More specifically, SPEERMINT focuses on real-time session routing architectures and their associated use cases. Deliverables here include the specification of the various types of application flows, such as signaling and media flows, in such networks, and includes both trunking and peer-to-peer flows.

The focus is based on the premise that these delay-sensitive (real-time) communication sessions use the SIP signaling protocol to enable peering between two or more administrative domains over IP networks. Where these domains peer, the establishment of trust, security, and a resistance to abuse and attack are all important considerations.

At the time of this writing, it is premature to assess the impact that SPEERMINT will have on the industry.

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40 D. Malas and D. Meyer, “Session Peering for Multimedia Interconnect (SPEERMINT) Terminology”, IETF RFC 5486, March 2009, available http://www.ietf.org/rfc/rfc5486.txt (visited 8 August 2009).

## 2.3 Interconnection of NGNs

This section responds to the following requirements from the procurement document:

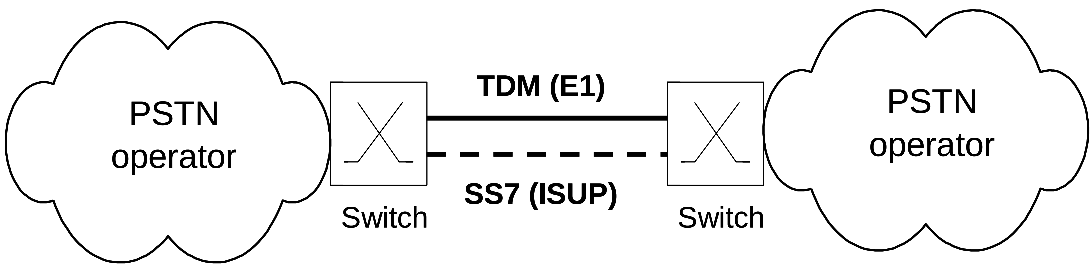
- Detailed technical description of interconnection for packet-switching networks based on Internet Protocol IP, considering connectivity and ensuring end-to-end traffic exchange as well as exchange and advertising of routing information between different operators' networks, also taking into account the cases of a peer to peer relationship (peering) and interconnection with traffic exchanges (IXPs) and NAPs, among others.

- Detailed technical description of interconnection for Next Generation Networks (NGN) and IMS ("IP Multimedia Subsystem") system, considering a description of the components, functional levels, and signaling protocols between networks among others.

### 2.3.1 Circuit-switched network interconnection

Even though many network operators in many countries are moving to deploy new NGNs, it is clear that the existing circuit switched networks (fixed *Public Switched Telephone Networks (PSTN)* and mobile *Public Land Mobile Networks (PLMN)* using the *Signaling System 7 (SS7)* signaling protocol) will still be used for quite some time. Thus, interconnection will continue taking place through circuit switched SS7 interfaces for years to come. Figure 11 shows the interconnection interfaces of PSTN operators: For the transmission of voice TDM (E1) interfaces are used, whereas SS7 (ISUP) interfaces are necessary for signaling transmission.

Figure 11: PSTN interconnection




Source: WIK-Consult.

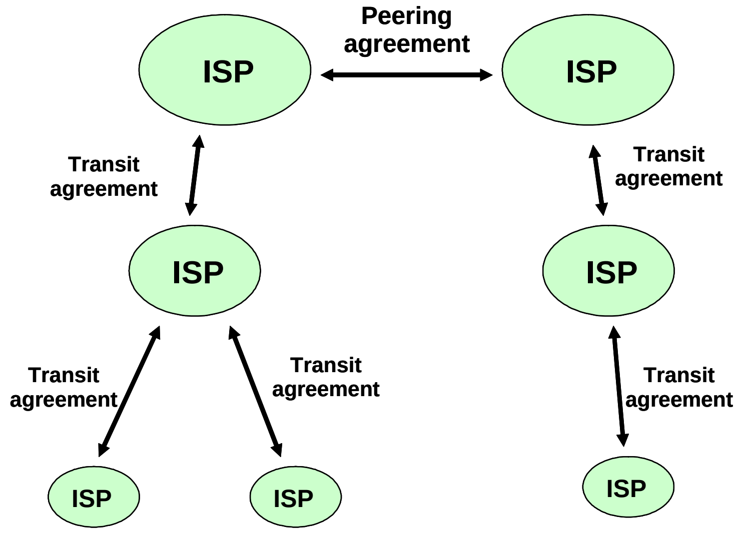
### 2.3.2 IP-based packet-switched interconnection

This section describes the technology with which IP interconnection is performed (transit and peering agreements and the physical interconnection for peering). It should be understood in conjunction with Section 3.2, which describes the economics of IP interconnection and seeks to clarify the incentive structures under which IP-based network operators choose to interconnect (or choose not to interconnect). Section 2.3.2.1 explains briefly the difference between peering and transit, whereas Section 2.3.2.2 discusses the physical transmission mechanisms used to implement peering.

#### 2.3.2.1 Transit and Peering Agreements

Between two IP-based networks there are generally two types of interconnection agreements: peering and transit. In a peering agreement both ISPs agree to carry the IP traffic for one another, and for their respective customers. A transit agreement implies, by contrast, that an ISP will carry its transit customer's traffic to customers of other ISPs. Figure 12 shows how a combination of peering and transit agreements contributes to a richly interconnected Internet.

Figure 12: Peering and transit agreements




Source: WIK-Consult.

### 2.3.2.2 Peering: Physical Interconnection

Peering occurs through (1) private arrangements, or through (2) connections at “public” peering points.[41]

- The great majority of traffic exchange is through private arrangements between large market players, often implemented with nothing more than a high capacity (SONET or SDH) private line interconnecting their respective networks. The details of these arrangements are often treated as business secrets.

- “Public” peering points probably account for a far smaller volume of traffic interchange, but it is likely that a far greater number of (small) interconnections occur there.

An Internet Exchange Point (IXP) can be used for public peering interconnection. An IXP is a place where several network operators exchange traffic with one another by means of a physical port. A layer 2 access technology is used for the exchange of traffic (Ethernet or ATM). At an IXP, network operators make bilateral (private peering) and multilateral agreements (public peering). The network topology of an IXP is a shared fabric that consists of routers and switches. Figure 13 shows the network topology of DE-CIX, the by far biggest IXP in Germany.

The Border Gateway Protocol (BGP4) is used to implement peering interconnection between or among ISPs, irrespective of whether the peering is public or private. Routing for a singly homed transit customer ISP is often implemented using simpler routing protocols, or even with the use of a simple default route.

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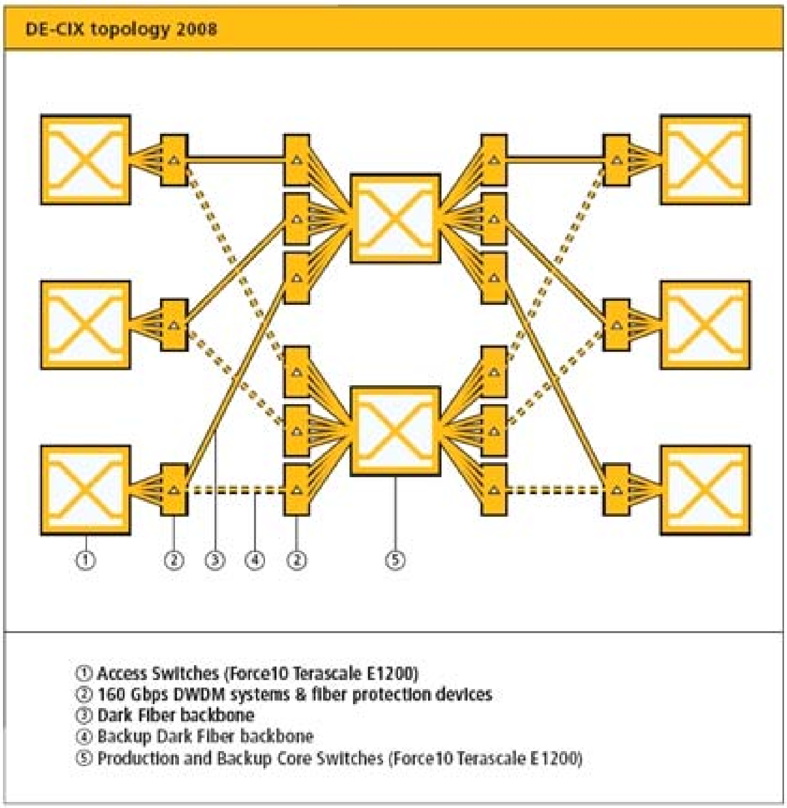
**41** For more details see e.g. Elixmann, D., Hackbarth, K., Scanlan. M. et al. (2002): “*The Economics of IP networks – Market, technical and public policy issues relating to Internet traffic exchange”*, Report prepared on behalf of the EU Commission (DG Info Soc), Brussels.

Figure 13: Network Topology of the IXP DE-CIX




Source: DE-CIX webpage.[42]

## 2.3.3 Interconnection of NGNs

### 2.3.3.1 Overview of NGN interconnection

Today, most NGNs have been implemented by existing network operators that continue to operate circuit switched (PSTN/PLMN) infrastructure in parallel with the NGN. Interconnection to other networks is typically implemented using existing circuit switched PSTN/SS7 arrangements rather than at the IP packet level, for a number of reasons:

- The interconnected network is not yet an NGN;
- Portions of one's own network have not yet converted to NGN;

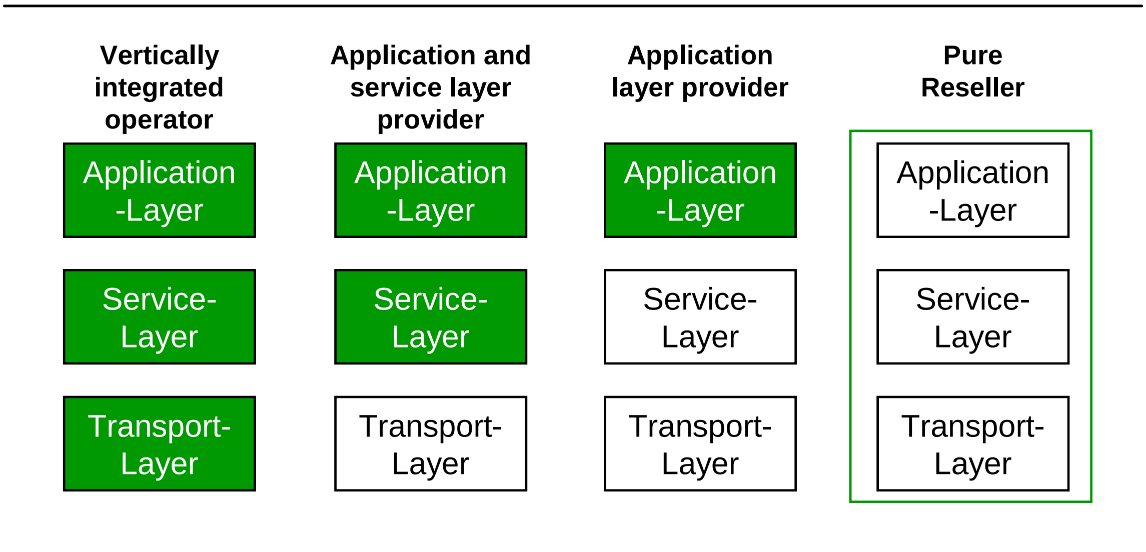
42 DEC-CIX webpage. Available at http://www.de-cix.net/content/network/topology.html (Retrieved on 7 August 2009).

- The network operator may not wish to risk relinquishing lucrative call termination fees, and to lose the competitive benefits of termination fees.

Historically, voice interconnection was viewed as a single form of interconnection. In an NGN, however, the application, the service and the network are no longer the same. NGN networks can be viewed as consisting of three layers (application layer, service layer, and transport layer). Interconnection has ramifications at all three layers.

There can also be very different levels of integration among different NGN market participants, as shown in Figure 14. A market participant might be fully integrated, providing the application, the service, and the underlying transport; it might provide only the application; it might provide only the underlying transmission; or almost any combination of application, service layer (IMS), and transmission. Or it might be a reseller, selling some combination of these provided by others. Again, these scenarios have technical, economic and policy implications for interconnection.

Figure 14: Variants of vertical responsibility sharing in the NGN[43]




Source: WIK-Consult.

For a discussion of technical standards associated with NGN interconnection, see Section 2.2, especially Section 2.2.3.

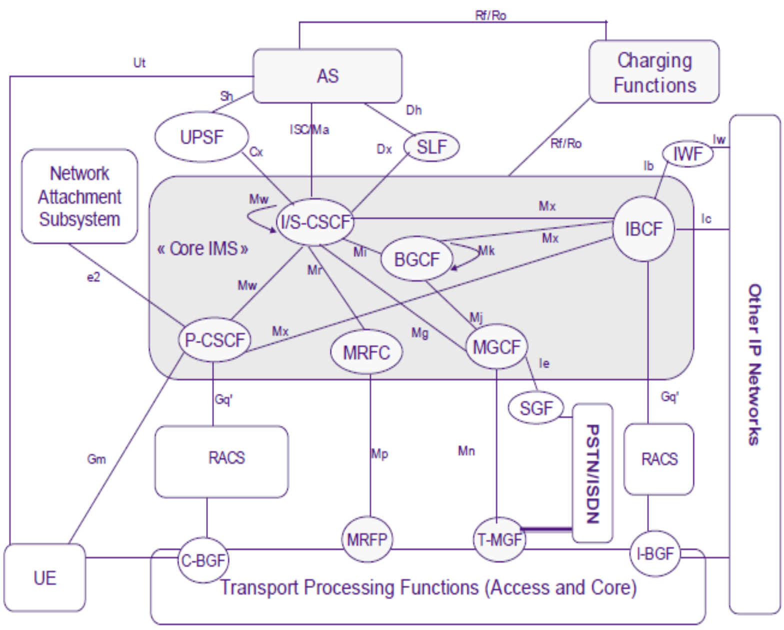
43 Stephan, Jay, Thomas Plückebaum, „Next Generation Core Networks: Access, Interconnection and Competition Policy“, WIK Newsletter Nr. 72, September 2008.

### 2.3.3.2 Interconnection and the IMS

No special provisions have been made for interconnection billing, but online billing would appear to be appropriate.

IMS-TISPAN architecture is best explained in terms of functional blocks and corresponding reference points. These reference points are either internally between functional blocks of the IMS, or situated externally between IMS and another end system or another network (see Figure 15). Note that interconnection reference points (Iw and Ic) are defined only in the control plane, while the interconnection on the transport plane under the Interconnect Border Gateway Function (I-BGF) function is provided at the IP level and hence is covered instead by the relevant IETF standards.

Figure 15: Functional architecture of IMS-TISPAN




Source: ETSI.[44]

Figure 16 shows more in detail the elements of the IMS-TISPAN functional architecture that are directly involved in the interworking function. The *Interconnect Border Control Function* (*IBCF*) is in charge of providing the interconnection between two operator

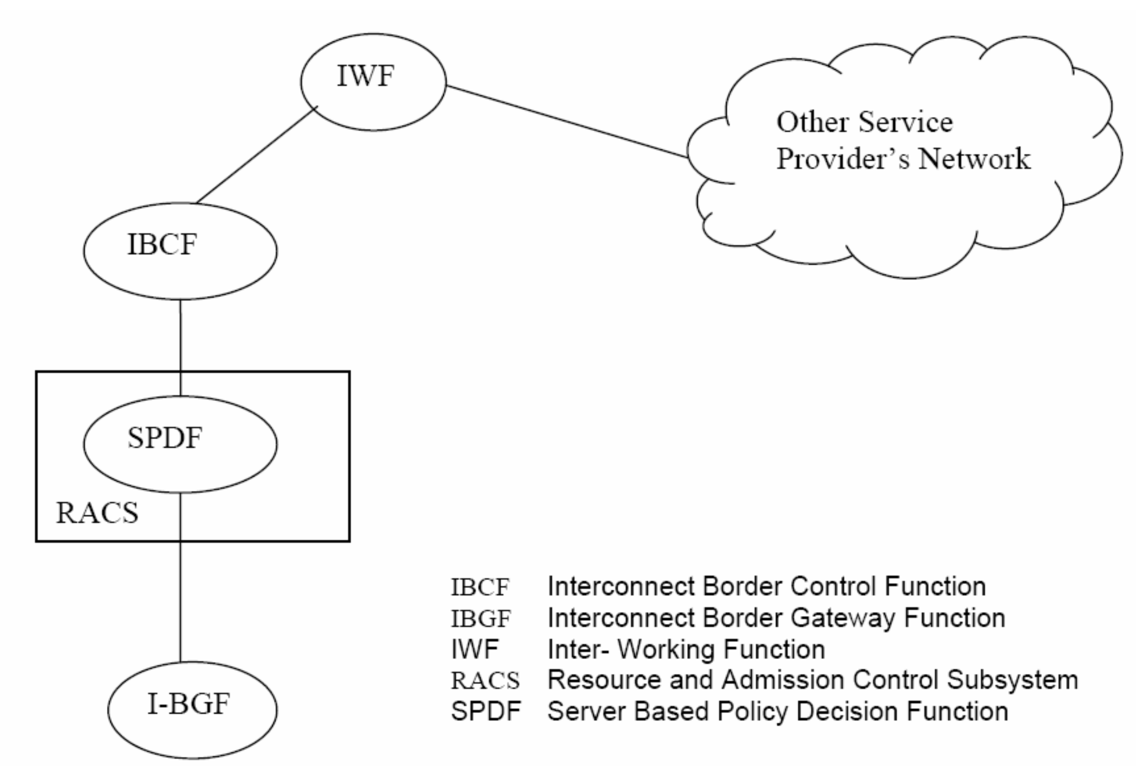
**44** ETSI Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) (2008): IP Multimedia Subsystem (IMS); Functional architecture, ETSI ES 282 007 V2.0.0 (2008-03).

domains. Among other functions, it provides communication between IPv6 and IPv4 IMS/SIP applications, network topology hiding, and control of transport plane functions[45]. The *Interconnect Border Gateway Function* (*I-BGF*) is in charge of several security functions: it provides firewalls to protect the IMS core, uses *Network Address and Port Translations* (*NAPT*), and controls access by packet filtering[46]. The Interworking Function (IWF) provides signaling protocol conversion between the SIP version used inside the IMS and the signaling protocols used by other operators. With the Resource and Admission Control Subsystem (RACS), applications can manage the resource reservation. For example, the *Server Based Policy Decision* (*SPDF*) function of the RACS can handle media path reservation and call admission control.

**45** M. Poikselkä, G. Mayer, "The IMS, IP Multimedia Concepts and Services", Third Edition, Wiley, 2009.

**46** "IMS Tispan Architecture", White paper available at the Telecommunication Engineering Centre of the Government of India. http://www.tec.gov.in/technology%20updates/White%20paper%20on%20IMS%20TISPAN%20Architecture.pdf. Retrieved on 21 August 2009.

Figure 16: TISPAN Interworking



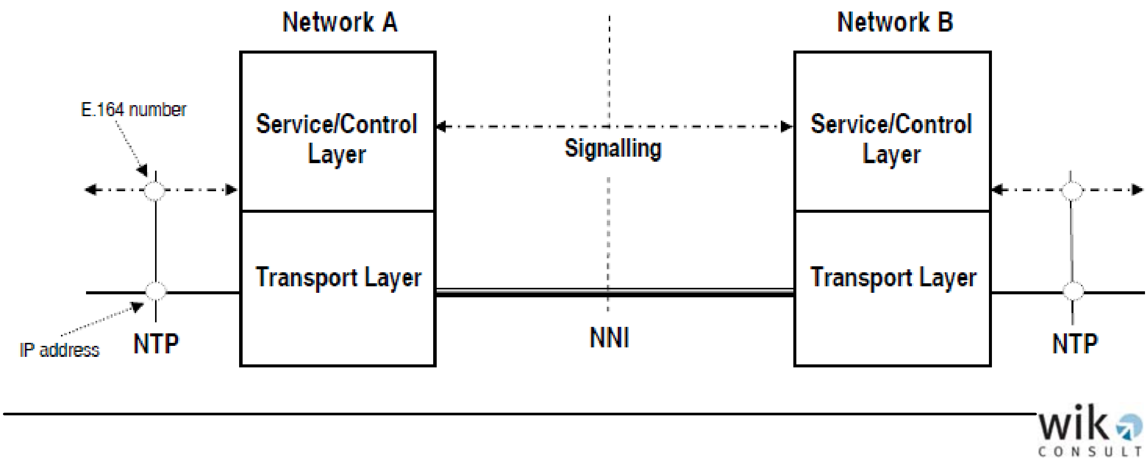

Source: IMS Tispan Architecture.[47]

Much as with ITU Interconnection, the ETSI documents for Interconnection currently provide only a generic high-level description. Detailed specifications of Interconnection Border Control Functions (IBCF) which would enable interconnection of the IMS core with other networks have not yet been specified.[48] Nonetheless, it is worthwhile to consider the implications of IP addressing on IMS interconnection.

The functions (IBCF, IBGF, IWF and SPDF) and the Subsystem (RACS) are elements that are used to perform the interconnection. In TISPAN the service and the transport layers can be used for the NGN interconnection (see Figure 17). As explained below, there are different types of interconnections.

47 Ibid.
48 See Kovacikova, P. Segec, "NGN Standards Activities in ETSI", Proceedings of the Sixth International Conference on Networking (ICN07) published by the IEEE 2007.

Figure 17: Reference scheme for Interconnection

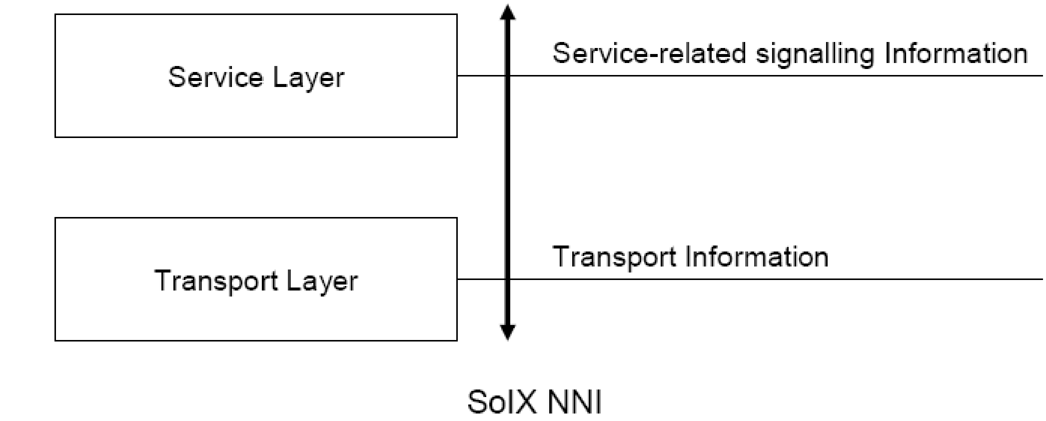



Source: ETSI.[49]

The TISPAN NGN interconnection types that have been proposed are Service-oriented Interconnection (SoIX) and Connectivity-oriented Interconnection (CoIX). The SoIX interconnection type is characterized by the presence of two types of information exchanged: service-related signaling information, which enables the identification of end-to-end services that have been requested, and transport information that carries the bearer traffic (see Figure 18).

49 ETSI Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN) (2009): Interconnection and Routing requirements related to Numbering and Naming for NGNs; NAR Interconnect ETSI TS 184 006 V2.1.1 (2008-09).

Figure 18: Service-oriented Interconnection (SoIX)

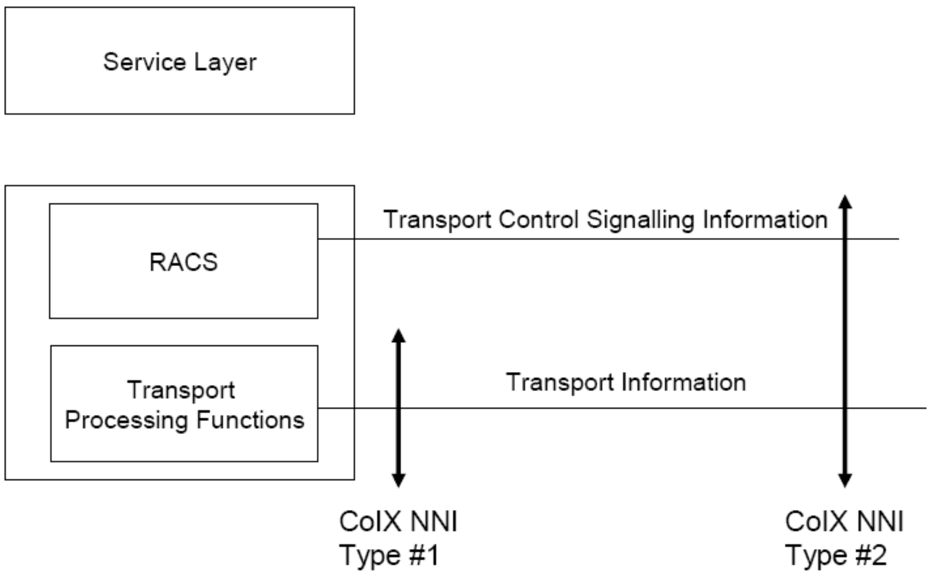



Source: NGN Functional Architecture, ETSI-TISPAN, 2009[50]

On the other hand, the CoIX Interconnection is characterized by the absence of service-related signaling. There is no end-to-end service awareness in CoIX interconnection. Figure 19 shows two types of CoIX interconnections: in CoIX #1 only transport information (bearer traffic) is exchanged, whereas in CoIX #2 transport information and transport control signaling information are exchanged.

**50** ETSI Telecommunications and Internet converged Services and Protocols for Advanced Networking (TISPAN); NGN Functional Architecture, ETSI ES 282 001 V3.3.0 (2009-02).

Figure 19: Connectivity-oriented Interconnection (CoIX)

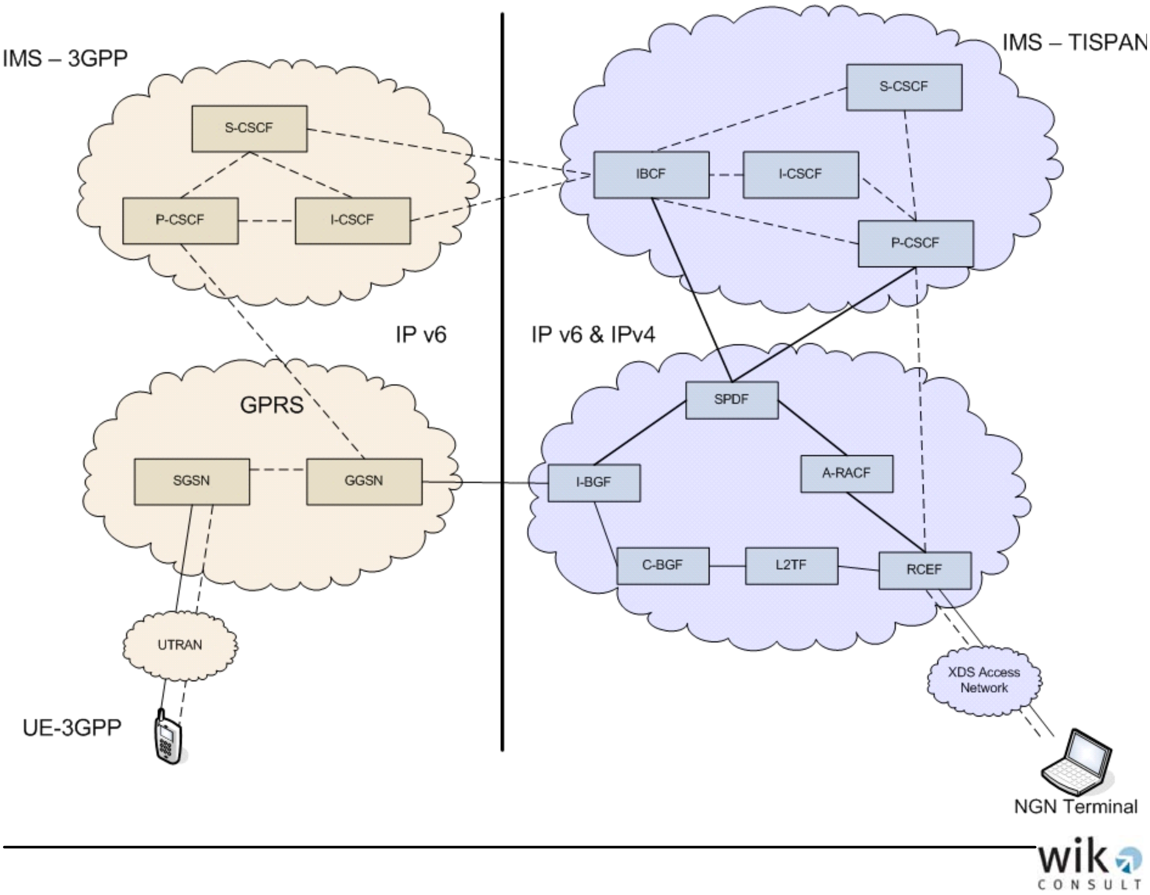



Source: NGN Functional Architecture, ETSI-TISPAN, 2009[51]

In ETSI TISPAN, the interconnection scheme between the IMS 3GPP and the TISPAN IMS is done in both planes, both control and transport, by means of the Interconnection Border Control Function (I-BCF) in the control plane and the Interconnection Border Gateway Function (I-BGF) in the transport plane. TISPAN defines these elements in order to enable NGN IMS operators to apply control mechanisms at entry to their respective networks, and to enable users to enjoy seamless roaming (including fixed-mobile roaming). Figure 20 shows an example of interconnection between fixed and mobile networks when the IMS is used in a scenario considered by ETSI/TISPAN.

**51** Ibid.

Figure 20: Fixed and mobile interoperability under ETSI TISPAN




Source: Moro and Fernandez (2005).[52]

Note that the 3GPP IMS operates only under IP version 6, while NGN IMS supports both versions 6 and 4. Should IPv4-IPv6 translation be necessary, it is the job of the I-BGF.

Provision of QoS (defined in terms of bandwidth, delay or packet loss) could be a problem in the interconnection between the ETSI NGN IMS and 3GPP IMS. 3GPP IMS defines separate QoS traffic classes that are handled according to operator requirements. This means that 3GPP provides a *relative* QoS. The ETSI TISPAN IMS has two approaches for QoS control, one is a *Guaranteed QoS* (and thus absolute), the other is a *Relative QoS*. Conflicts might arise when a user in the NGN world subscribed to a service with Guaranteed QoS connects to a user/server/service in the 3GPP IMS world with relative QoS. The user might not receive the expected QoS.

52 See Moro, D., Jular, A. and S. Fernández (2005): *"Estudio de la interconexión entre redes fijas y móviles en el plano de control mediante los estándares IMS de 3GPP y NGN de TISPAN"*, in: Journal Comunicaciones de Telefonica I+D, nº 37, pp 111-118.

2.3.3.3 NGN Interconnection Solutions

Several IMS architectures that are being deployed by telecommunications equipment manufacturers like Alcatel-Lucent[53], Nokia-Siemens[54] and Huawei[55] comply with the TISPAN standards.

On the other hand, the IMS Forum is an industry association in charge of the interoperability and certification of NGN and IMS application and services. There are on-going efforts promoted by the NGN Forum and by the IMS Forum[56] for the creation of test that will help for the interoperability of NGN networks. For example, a few issues that are being studied by the technical working groups of the NGN Forum and the IMS Forum are Interface Compliance testing, IMS/NGN control plane interoperability, and multi-domain scenarios covering user-to-network and network-to-network IMS interoperability[57].

Another body that has defined technical solutions for the interconnection of network operators is the GSM Association (GSMA). Section 2.5.3 describes the network architectures proposed by the GSMA.

## 2.4 Interconnection of VoIP

This section responds to the following requirements from the procurement document:

- Discussion of the protocols and techniques used to implement VoIP
- Detailed technical description of interconnection for voice communications networks (Voice over IP), functional description of the components, levels, and protocols, among others.
- Study on the functionality of interconnection for voice communications over Internet Protocol (VoIP) and in a multiservice NGN environment with emphasis on emulation of events needed for proper implementation of service pricing and billing, especially for telephone traffic, so as to effectively replicate the functions of traditional systems.

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**53** See Alcatel-Lucent End-to-end IMS solution, 2008. Available at http://www.alcatel-lucent.com/wps/portal/solution/detail?LMSG_CABINET=Solution_Product_Catalog&LMSG_CONTENT_FILE=Solutions/Solution2_Detail_000044.xml#tabAnchor4, Retrieved on 21 August 2009.

**54** See Nokia Siemens White paper about the IP Multimedia Subsystem, December 2008. Available at http://www.nokiasiemensnetworks.com/NR/rdonlyres/6998BB1C-C68C-450D-BBE1-5F5D7C282A0D/0/IMSwhitepaper.pdf, Retrieved on 21 August 2009.

**55** http://www.huawei.com/core_network/products/ims.do, Retrieved on 21 August 2009.

**56** http://www.imsforum.org, Retrieved on 21 August 2009.

**57** Press Release about the IMS NGN 8 Plugfest: http://www.imsforum.org/press-releases, Retrieved on 21 August 2009.

Whereas there is an extensive history of interconnection between PSTN networks, commercial IP-based VoIP/VoIP and VoIP/PSTN interconnection began only in the 1990s with the initial deployment of commercial VoIP networks. For voice operators that have a large number of VoIP users, a direct IP-based VoIP-VoIP interconnection[58] (referred to as *VoIP peering*) would seem to be the technically preferred means of achieving interconnection. With that in mind, standardization bodies such as the IETF and the ITU-T have been proposing mechanisms for the interconnection of VoIP and circuit switched networks; however, the reality today is that a great deal of VoIP interconnection is implemented by first converting the call to traditional circuit switched TDM and then using conventional TDM/SS7 interconnection.

As noted previously, IP interconnection agreements implemented in support of voice traffic in an ideal world would ensure the QoS of the IP data on an end-to-end basis. This is rarely done, but a number of researchers have sketched out possible scenarios. In one possible scenario,[59] the customer would typically subscribe (explicitly or implicitly) to a Service Level Agreement (SLA) agreement with his or her VoIP service provider. If the Internet Service Provider (ISP) were not the same as the VoIP service provider, as is the case for example with Skype VoIP software, then there would be two Service Level Agreements (see Figure 21), one with the VoIP service provider and the other with the ISP. For the interconnection of VoIP traffic, there would need to be Service Peering Agreements between the VoIP service providers. The Service Peering Agreements would be done on a wholesale basis (between VoIP service providers), whereas the Service Level Agreements would be done on a retail basis (between the VoIP service provider [or ISP] and its customer).

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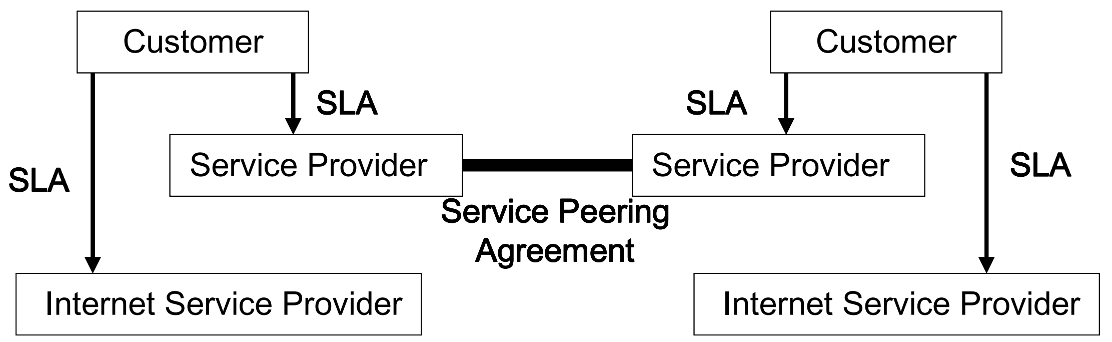
**58** That is, without translation into circuit switched SS-7.

**59** Anastasius Gavras, "Potentials of P2P-SIP Architecture in Telecommunications", Eurescom study P1755, August 2008.

Figure 21: Service Level and Service Peering Agreements in VoIP networks




Source: Anastasius Gavras, Eurescom.[60]

Section 2.4.1 describes VoIP communication protocols. Section 2.4.2 explains how VoIP is implemented for use over the Internet, while Section 2.4.3 explains how VoIP is implemented in an NGN. Section 2.4.4 discusses regulatory and public policy issues associated with VoIP, whether over the Internet or in an NGN setting.

### 2.4.1 Voice over IP (VoIP) protocols

There has been substantial evolution over the years of communication protocols, with their associated network architectures, that could be used for the deployment of VoIP services. Some are formal standards, others are de facto standards, and still others are proprietary solutions. The following could be said to have been the most relevant:

- The ITU-T H.323 protocol standard.
- IETF Session Initiation Protocol (SIP), which also forms the core of the IMS.
- Media Gateway Control Protocol (MGCP), and ITU-T H.248 MEGACO (Media Gateway Control Protocol).
- Proprietary solutions, including Skype and Cisco's Skinny Call Control Protocol (SCCP).
- Open source solutions, notably Asterisk and IAX2.

60 Ibid.

Table 7 provides a comparison among these VoIP protocols. The reader may find it convenient to refer back to the table while reviewing the protocol descriptions in this section of the report.

Table 7: Comparison of VoIP protocols

| | H.323 | SIP | MGCP | H.248 MEGACO |
|---|---|---|---|---|
| **Scope** | Designed to support calls | Designed to support sessions between points.<br>Inspired by HTTP | Designed to control Media Gateway | Designed to control Media Gateway |
| **Standard Body** | ITU-T | IETF | IETF | ITU-T (based on earlier IETF work) |
| **Architecture** | Distributed | Distributed<br>Peer-to-peer | Centralized | Centralized |
| **Reliability** | Alternate gatekeepers, alternate endpoints | Redundant Architecture possible | Redundant Media Gateway and Media Gateway Controller | Redundant Media Gateway and Media Gateway Controller |
| **Signaling Transport** | TCP/UDP | TCP/UDP | MGCP - UDP<br>MeGaCo - TCP/UDP | TCP/UDP |
| **Control** | Gatekeeper | Soft switch<br>Proxy | Call Agent<br>Media Control Gateway Soft switch | Call Agent<br>Media Control Gateway Soft switch |
| **End Point Types** | Gateway, Terminal | User Agent | Media Gateway | Media Gateway |
| **"Media" Transport** | RTP/RTCP/SRTP | RTP/RTCP/SRTP | RTP/RTCP/SRTP | RTP/RTCP/SRTP |
| **User Addressing** | E.164 dialed digits, generic H.323 ID, URL, transport address, email address, party number, mobile UIM, and ISUP number | URI-style addresses. | NA | NA |
| **Status** | Mainly deployed in Enterprise networks | Protocol of choice for SP deployments | Protocol of choice for managing MG | Protocol of choice for managing MG |

Source: Elaboration: WIK-Consult, partly based on information retrieved from "H.323 versus SIP: A comparison". Available at http://www.packetizer.com/ipmc/h323_vs_sip/ (Visited on 30 August 2009)

Note that MGCP and H.248 MEGACO are both realizations of the IETF's Media Gateway Control Protocol architecture,[61] but they are not mutually compatible or interoperable.

61 See N. Greene, M. Ramalho, and B. Rosen, "Media Gateway Control Protocol Architecture and Requirements", IETF, RFC 2805, April 2000.

For the interconnection between a packet-switched VoIP system and a circuit-switched system, a media gateway is necessary. For the translation of payload information, a media gateway translates VoIP data packets into circuit-switched signals, and vice versa. For the translation of signaling information, a node with the function of a Signaling Gateway is employed. On the other hand, the softswitch can be used for the interconnection of a PSTN network with a VoIP network.

#### 2.4.1.1 The H.323 protocol standard

The ITU-T has standardized the H.323 system to enable the provision of real-time audio, video and data communications over packet switched (IP) networks. When the standard was initially conceived in 1996, it was fairly narrowly focused on voice capabilities over local area networks (LANs), but it has been progressively broadened to incorporate a wider range of multimedia services over a wider range of networks.

The H.323 architecture defines four types of components: gatekeepers, terminals, gateways, and the Multipoint Control Unit (MCU).

The gatekeeper is in charge of offering call control services to registered H.323 endpoints, and it is the central point of the calls. The gatekeeper functions are the following ones: bandwidth control, zone management, call-control signaling, address translation, call authorization, call management, and bandwidth management.

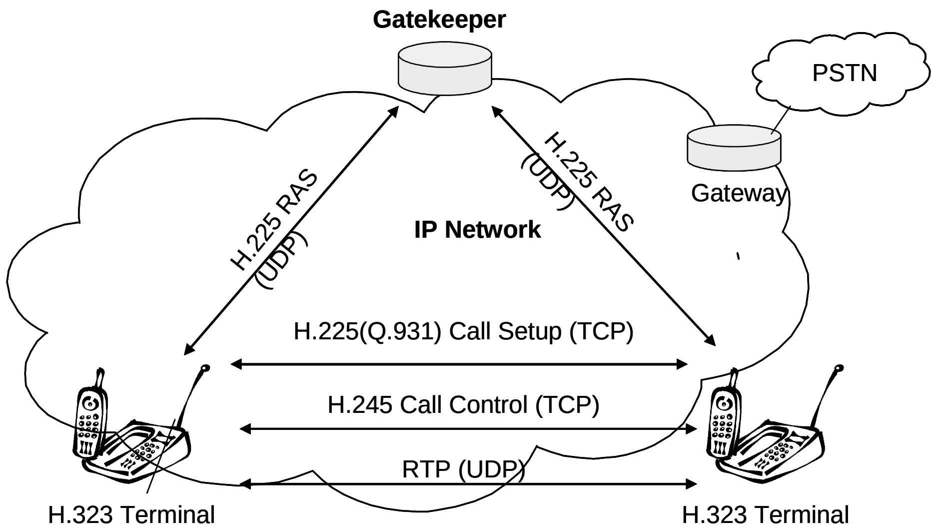
A personal computer or an H.323 terminal can have the functions of terminals. For the interworking with other terminals, the H.323 terminal needs the following components:

- The H.245 protocol, necessary for the negotiation of channel usage and capabilities.
- Q.931 protocol for call setup and signaling.
- The Registration/Admission/Status (RAS) protocol for the communication with the gatekeeper.
- The RTP/RTCP protocol for audio and video packets.

A gateway is necessary for the interconnection between H.323 and non-H.323 networks. The H.323 gateway uses the H.225 protocol for registration, admission, and status (RAS) with the gatekeeper, the H.245 control signaling protocol for exchanging capabilities, and the H.225 call signaling protocol for call setup and release. The Multipoint Control Unit provides support for conferences of three or more H.323 terminals.

Figure 22 depicts a basic scenario of an H.323 network. The H.323 terminals exchange VoIP packets directly by using the RTP/UDP protocols. A Gatekeeper is needed to control the Gateways, and the H.225 and H.245 protocols are used for controlling the call.

Figure 22: Basic nodes and protocols of an H.323 system




Source: Cisco (2006), Understanding H.323 Gatekeepers.

### 2.4.1.2 The SIP Architecture

The Session Initiation Protocol (SIP) was defined by the IETF for the signaling and session management functions of a packet telephony network. IETF RFC 3261 contains the definition of SIP[62]. SIP can be used to establish, maintain, and terminate calls. It is a peer-to-peer protocol used by User Agent Servers (UASs) and User Agent Clients (UACs). In a transaction, a SIP end point takes the role of a UAC or of a UAS.

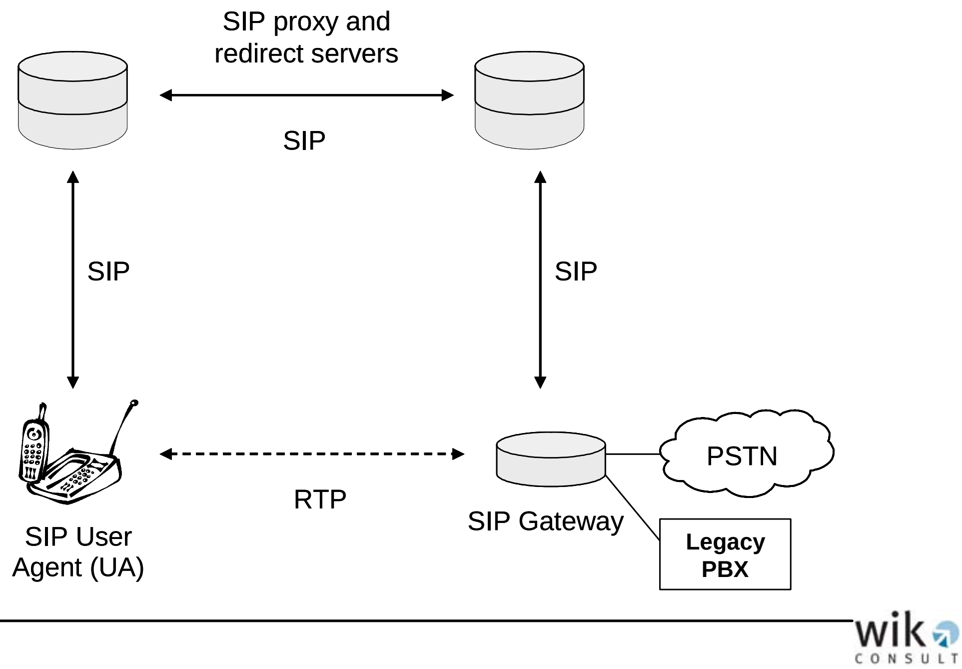
A phone or a gateway can play the role of a SIP client. An end-user terminal is a SIP phone, and for the translation functions between SIP terminals and different terminal types the gateways are employed. The proxy servers, the redirect servers, and the registrar servers are SIP servers. The proxy server receives SIP messages and forwards them to another SIP server. The proxy servers are used for authentication, reliable request retransmission, network access control, routing and security. The function of the redirect server is to provide the client with information about the next hop

62 IETF, SIP: Session Initiation Protocol, RFC 3261, June 2002.

that can be taken by a message. The registrar server is in charge of the registration function.

Figure 23 shows the basic SIP architecture, which consists of two basic elements: the SIP clients and the SIP servers.

Figure 23: SIP Architecture




Source: Cisco, Overview of the Session Initiation Protocol.

SIP works with the RTP/RTCP and the Session Description Protocol (SDP), a protocol necessary to negotiate the participant capabilities, the codification type, etc. SIP follows an end-to-end oriented signaling technique (the logic is stored in the SIP end-user's device).

### 2.4.1.3 Media Gateway Control Protocol and Megaco

The Media Gateway Control Protocol (MGCP) is a VoIP signaling and call control protocol defined in the IETF RFC 3435[63]. This protocol has the capability of interoperating with the circuit-switched PSTN network. MGCP uses the RTP and SDP protocols. With the MGCP protocol the Media Gateways can be controlled by the Media Gateway Controllers.

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**63** IETF, Media Gateway Control Protocol (MGCP), version 1.0, RFC 3435, January 2003.

Another protocol that is used for the communication between a Media Gateway and a Media Gateway Controller is Megaco. Megaco is a result of the cooperation between the ITU-T Study Group 16 and the IETF Megaco Working Group. The ITU-T Recommendation is H.248.1 and the IETF standard is RFC 3525[64]. As previously noted, MGCP and Megaco are both realizations of the same underlying protocol architecture, but they are not mutually compatible or interoperable.

#### 2.4.1.4 Proprietary VoIP systems

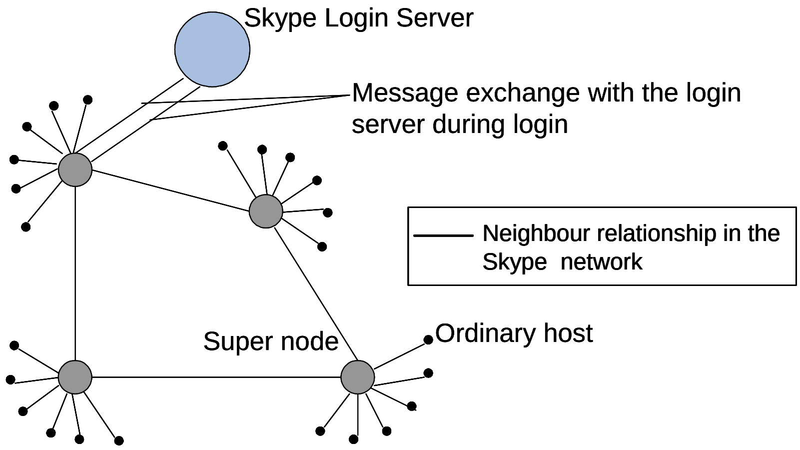
There are any number of proprietary solutions. This section discusses two of them: Skype in Section 2.4.1.4.1, and Cisco's Skinny Call Control Protocol (SCCP) in Section 2.4.1.4.2.

##### 2.4.1.4.1 The Skype architecture

Skype is a widely deployed VoIP solution that is based on a proprietary architecture. The architectural design is comprised of three basic nodes: a Skype login server, a super node, and an ordinary host. The only central component in the Skype network is the Skype login server. Any computer where a user has installed the Skype application can be an ordinary host or a super node. Skype uses codecs with a bandwidth of 32 Kbps. TCP is used for signaling, while UDP and TCP are used for media traffic[65]. A Media Gateway is used to interconnect with a circuit switched PSTN network.

**64** IETF, Gateway Control Protocol version 1, RFC 3525, June 2003.
**65** Arora, Prateek, VoIP: Skype architecture & complete call setup, seminar 2.

Figure 24: A Skype peer-to-peer system




Source: Baset and Schulzrinne (2004), An analysis of the Skype peer-to-peer Internet Telephony Protocol.

### 2.4.1.4.2 Cisco's Skinny Call Control Protocol (SCCP)

The Cisco Skinny Call Control Protocol (SCCP) is a proprietary protocol. The protocol provides communication between a network terminal and a (Cisco) Call Manager. A number of companies have implemented SCCP, and an open source implementation is available. It is used in a number of devices, including Cisco 7900 series IP phones.[66]

### 2.4.1.5 VoIP open source standards: IAX2

In contrast to H.323 and SIP, which are respectively official ITU and IETF standards, the Inter-Asterisk eXchange protocol version 2 (IAX2) was defined as part of a community effort.[67] Asterisk is an open source PBX server, and IAX2 is the Inter-Asterisk protocol used by Asterisk[68]. IAX2 enables connections between servers and clients; it transmits the payload and the signaling information on the same UDP data stream, which helps to enhance its performance.

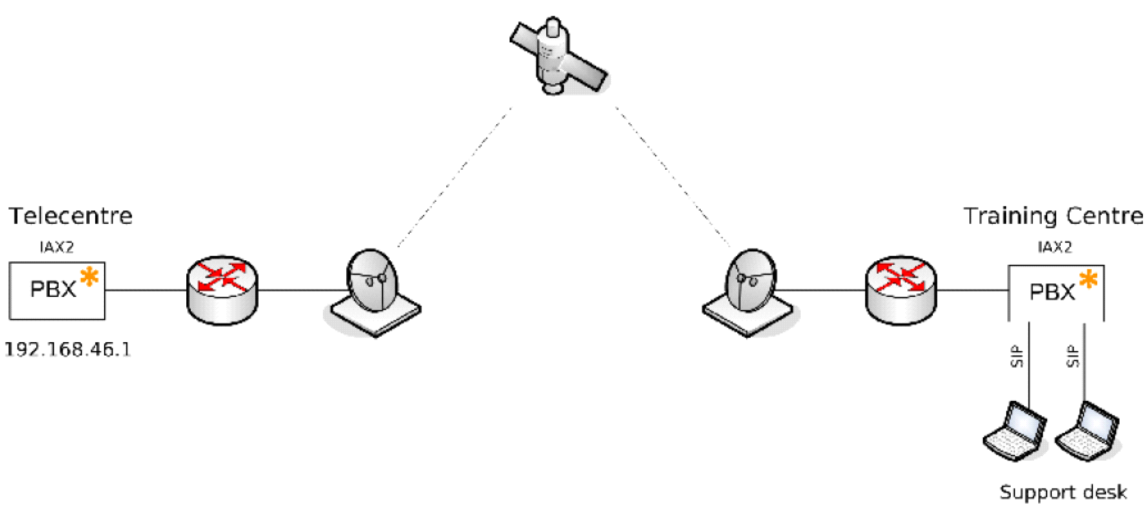
66 Cisco, Skinny Call Control Protocol, (http://www.cisco.com/en/US/tech/tk652/tk701/tk589/tsd_technology_support_sub-protocol_home.html) Retrieved on 7 August 2009.

67 The IETF RFC 5456 (February 2009) provides information about IAX2, but this RFC does not specify an Internet standard.

68 Escudero-Pascual, Alberto und Berthilson, Louise (2006) – VoIP-4D Primer. Building Voice infrastructure in developing regions.

IAX2 is suited for private VoIP networks with low-budget limitations. With the Asterisk software a computer can be converted into a telephone exchange and IAX2 is the protocol used to transmit VoIP traffic. Figure 25 shows an example of a Telecentre that is linked to a Training Centre by means of an Internet VSAT satellite link. A satellite border router is needed for the connection to the Internet. The Telecentre and the Training Centre use PBXs with Asterisk and IAX2.

Figure 25: Example of VoIP interconnection between two PBXs with IAX2



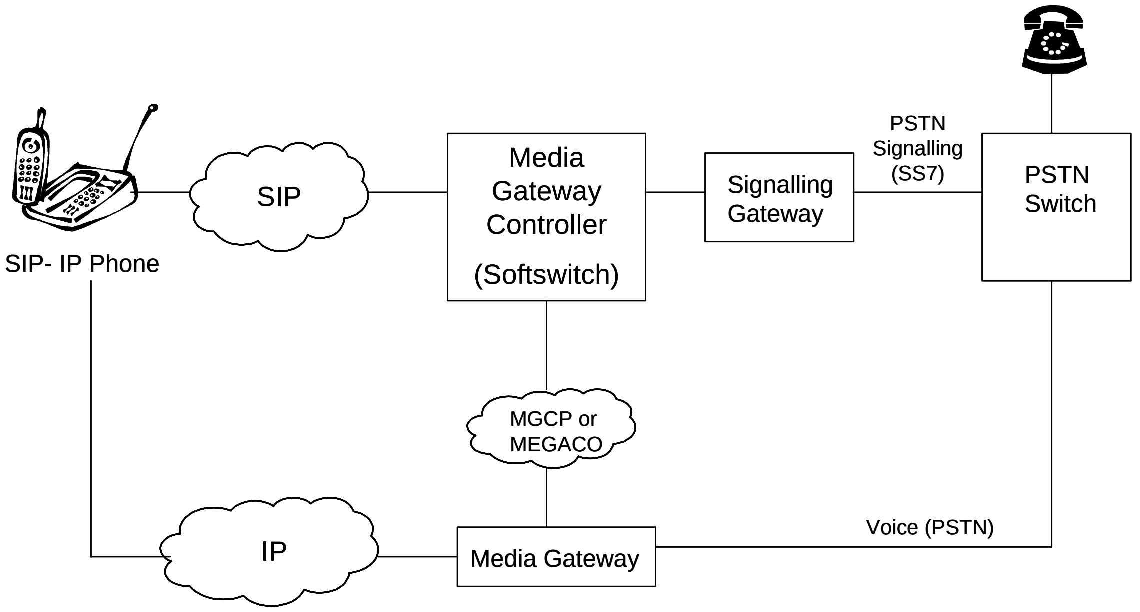

Source: Escudero-Pascual, Alberto und Berthilson, Louise (2006) – VoIP-4D Primer.

## 2.4.2 Equipment to implement Voice over IP (VoIP)

The equipment to implement IP-based voice is largely the same, whether deployed for use in the Internet or in an NGN. Figure 26 depicts the architecture of a typical VoIP implementation in the Internet; Section 2.4.2.2 shows a largely parallel of IP-based voice deployment in an NGN.

The major functional components in widespread use are the Softswitch, the media gateway, the Session Border Controller, and the terminal (e.g. the IP phone). One often speaks of Signaling Gateways as a distinct component (and we list it here for completeness), but the Signaling Gateway function is often implemented within the Softswitch.

Figure 26: Architecture of a typical VoIP deployment in the Internet




Source: Chang, Ming-Feng (2008), Course on Internet Telephony.

With that background established, Section 2.4.2.1 briefly describes the equipment used in a typical Internet or NGN deployment of VoIP, while 2.4.2.2 explains the need for a database to indicate which network operator is responsible for a given telephone number.

#### 2.4.2.1 The equipment typically used to implement VoIP over the Internet

The major components of a typical VoIP deployment are:

- **Softswitch:** The softswitch function is the essential element within an NGN to initiate a telephone call. It manages and controls call set-up by means of signaling protocols (call control). Moreover, the call server communicates with the media gateways to ensure proper physical call set-up (media gateway control), and it also controls messages being stored on media, message or application servers (service control).

- **Signaling Gateway:** Signaling Gateways convert the SS7 protocols into the signaling protocols used in the IP network. The Signaling Gateway is often implemented as part of the Softswitch.

- **Media Gateway:** Media gateways are physically located at the interface between different networks. Thus, they are located at the interface between the PSTN/ISDN and a packet-switching network, or alternatively at the interface between packet-switching networks that are supported by different protocols. Media gateways convert media information flows of one network into those of the other network based on the specific requirements of the destination network.

- **Session Border Controller:** In interconnecting VoIP services, a Session Border Controller can meet several distinct functions. It can provide a means of ensuring security and/or privacy; it can serve as a locus of control. Perhaps, most important, it can perform protocol translation. In interconnecting different VoIP services, there is often a need for conversion from one CODEC[69] to another, or from one VoIP signaling protocol standard[70] to another.

- **Terminal:** Today, VoIP is most frequently implemented to provide voice services to conventional telephone terminal devices; however, it is increasingly common for the terminal to itself be an IP-capable telephone or PBX.

#### 2.4.2.2 Identifying the service provider responsible for a number: carrier ENUM

Inside VoIP networks, it is possible for a VoIP operator to set up a phone call by using aliases that are matched to the current location (in terms of IP address) of the called party. The VoIP operator therefore needs a database with tables that contain the current IP addresses of VoIP users.

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**69** A CODEC is a coder-decoder device that encodes, in this instance, analog voice into a digital signal. Many different CODEC standards are in use today.

**70** For example, conversion among SIP, H.323, and MGCP.

VoIP operators need blocks of telephone numbers for the interconnection with fixed and mobile operators, just as does any other voice provider. Traditional voice providers usually have large blocks of numbers, where it is well known which provider is responsible for which numbers; however, once number portability is mandated, this association is no longer reliable. Often, this problem is solved by means of a number portability database.

For VoIP service providers, many of the traditional number portability solutions tend to be awkward, inappropriate or unavailable. A popular solution is to instead map the E.164[71] telephone number to the IP-based resource identification information of the VoIP service provider that serves that phone number. *ENUM* is an IETF standard that is used for the mapping from an E.164 telephone number to an (Internet) service (identified by means of a *Universal Resource Identifier (URI)*). For PSTN-to-VoIP calls, a Domain Name Server (DNS) is used for looking up the E.164 number locating the responsible service provider.

### 2.4.3 Implementing VoIP in an NGN

Figure 27 depicts a typical implementation of voice services within an NGN network. Key devices in a typical implementation include the *Softswitch*, the *Media Gateway*, and the *Session Border Controller*, as described in Section 2.4.2.[72] The protocol names that appear above each of the dotted lines in Figure 27 represent the voice-related signaling and control protocols that might typically be implemented in such a deployment.

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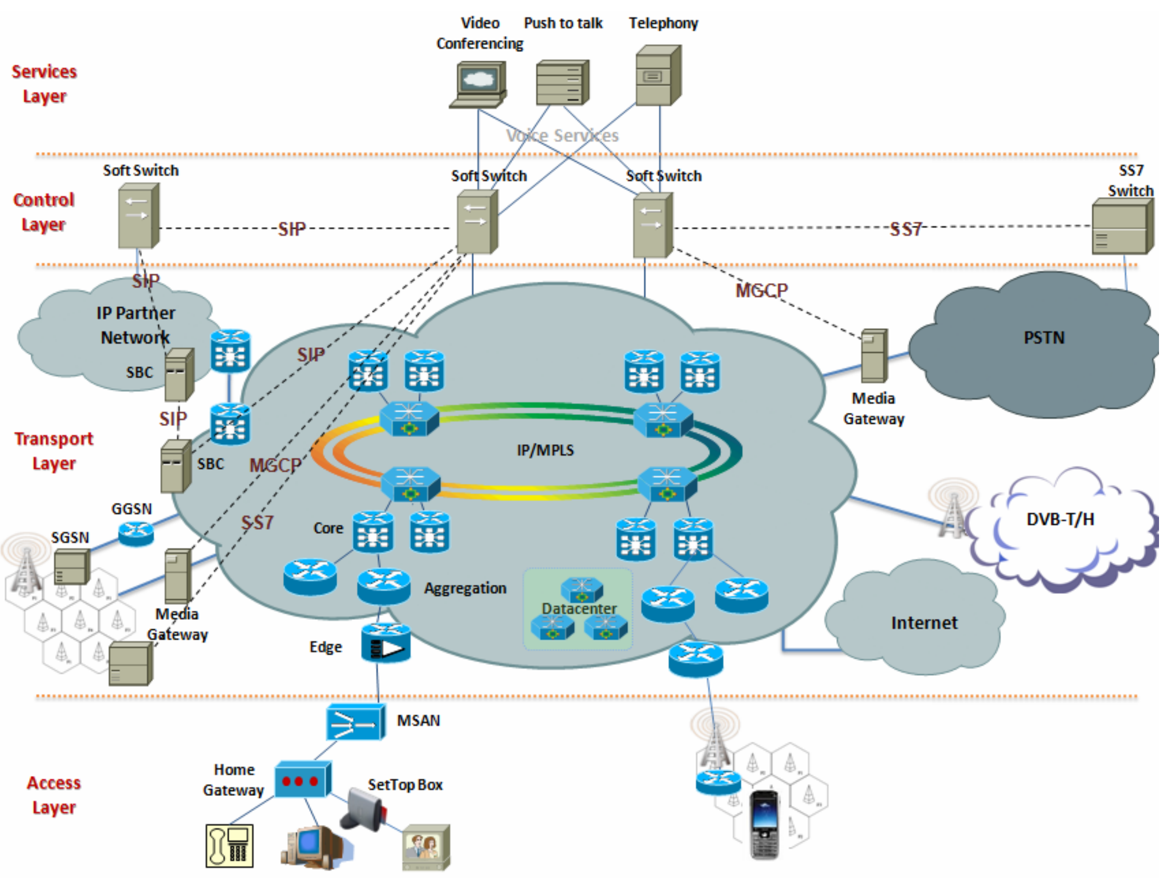
**71** E.164 is the ITU standard that identifies which country has been assigned which country code. It thus represents a high level directory to the worldwide telephone system.

**72** The following discussion of these components draws on earlier work by the authors, notably on *The Regulation of Next Generation Networks (NGN)*, 10 May 2007, a study for the Hungarian NHH, available at: http://www.nhh.hu/dokumentum.php?cid=15910.

Figure 27: Architecture of a typical VoIP deployment in an NGN




Source: WIK-Consult.

## 2.4.4 Regulatory and policy challenges associated with the migration to NGN

A 2008 study for the European Commission identified any number of regulatory challenges associated with the evolution to VoIP, and found that different European Member States were implementing significantly different regulatory solutions to those challenges.[73] These issues are driven by the move from circuit switched voice to IP-based voice, irrespective of whether the voice service is implemented over the Internet or over an NGN. These considerations are thus fully relevant to Peru today, with or without a comprehensive migration to NGNs.

73 Dieter Elixmann, J. Scott Marcus, and Christian Wernick, "The Regulation of Voice over IP (VoIP) in Europe", WIK-Consult study for the European Commission, February 2008. See also J. Scott Marcus, Dieter Elixmann, et al., "The Future of IP Interconnection: Technical, Economic, and Public Policy Aspects", WIK-Consult study for the European Commission, January 2008.

A number of the findings of the study for the European Commission are equally applicable to Peru:

- Independent VoIP service providers (those without a network of their own) need to be able to provide their customers with the kind of phone numbers that their customers demand. For Europe, these are geographic numbers.
- For purposes of number portability, VoIP service providers should be granted insofar as possible the same rights as traditional voice service providers, and should be subject insofar as possible to the same obligations (see Section 2.4.4.1).
- Obligations to connect to emergency services (police, fire, ambulance) should be similar for conventional telephones and for VoIP voice services; however, there are real problems that cannot be ignored, especially in the case of nomadic VoIP services (which can move from one fixed location to another). See Section 2.4.4.2.
- Inconsistencies from one Member State to the next in the procedures used to require lawful intercept (wiretapping), and to transfer the results to the authorities, can impose needless costs and inefficiencies on VoIP service providers.

#### 2.4.4.1 Number Portability

For the consumer, it is valuable to keep the phone number when switching from one telephony service provider to another. One common way to implement number portability is to use a central number portability database. This database is used to identify the call routing information of the ported number.

Any country that mandates number portability should consider operational procedures to ensure reasonable expeditious transfer times.

#### 2.4.4.2 Access to Emergency Services

Access to emergency services has posed problems for independent VoIP service providers since the inception of the service, especially for VoIP users whose access is *nomadic* (i.e., whose location might change from time to time). It has been less problematic for IP-based service providers whose end-users are *not* free to move around nomadically.

Access to emergency services is not necessarily an interconnection issue; however, it can interact with interconnection. For this reason, and also in response to requests from

OSIPTEL, we have provided recommendations concerning access to emergency services in Section 5.11.3.

## 2.5 The evolution of IP Interconnection: case studies and scenarios

The three case studies described below address the interconnection of operators that provide voice or quality-assured data services over IP.

Operators (TDM voice operators, VoIP operators, Internet Service Providers) need to exchange different types of traffic (TDM voice, VoIP traffic, IP data traffic, video, and so on). There are different ways of performing the interconnection. IP interconnection has existed for decades, but only recently have concrete, operational examples emerged where operators would interconnect to exchange real-time voice or data with QoS assurance. This section explains how these operators have achieved interconnection.

The first case study explains interconnection between network operators by means of MPLS-VPN techniques. Nowadays, multinational enterprises that have branches in different regions (using multiple Internet Service Providers) can deliver high-quality services to their end-users provided that their ISPs interconnect with one another using inter-provider MPLS-VPN services. Data-oriented *Virtual Private Networks (VPNs)* can provide assured QoS across more than one interconnected IP-based network.

The second case study describes how VoIP peering services are provided by the company XConnect. Usually VoIP operators interconnect with each other – due to regulatory obligations in many cases – through TDM/SS7 interfaces. To overcome this situation, XConnect uses a multilateral peering model that enables VoIP operators to interconnect directly.

The third case study describes the Inter-Service Provider IP Backbone Architectures defined by the GSM Association: the GPRS Roaming eXchange (GRX) and the IP Packet eXchange (IPX). The GRX network enables the interconnection between GSM and 3G Mobile Network Operators. The IPX, on the other hand, expands the GRX functionalities and offers end-to-end QoS between Service Providers.

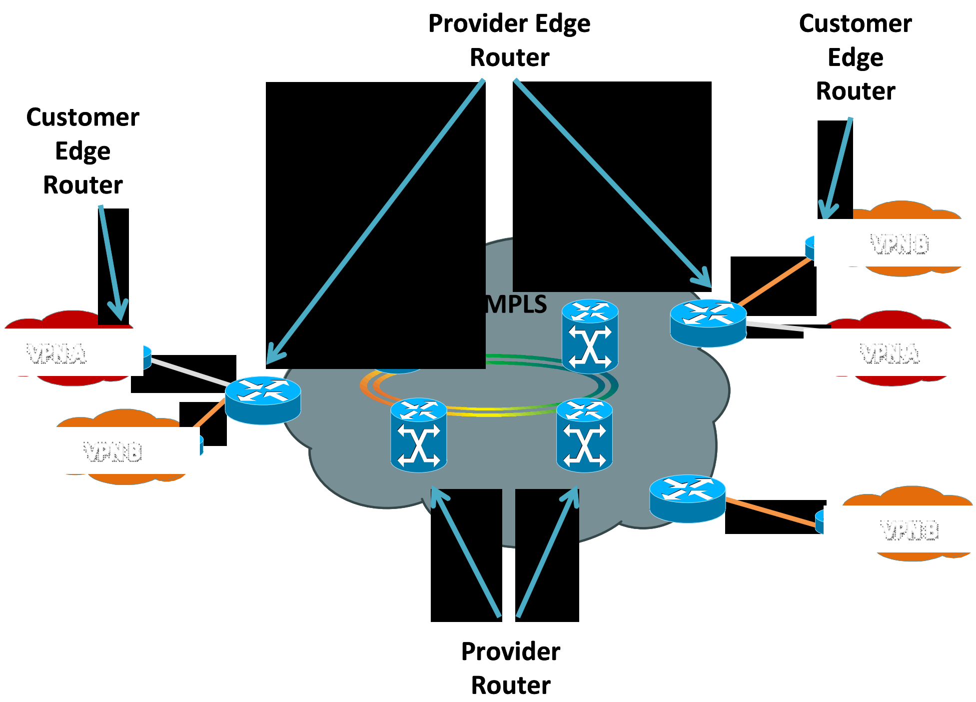
### 2.5.1 QoS-assured IP data interconnection using MPLS-VPN

Multinational enterprises that use multiple ISPs can deliver high-quality services to their customers provided that their ISPs interconnect with one another by means of the inter-provider Multi-Protocol Label Switching-Virtual Private Network (MPLS-VPN) services.

Many operators around the globe have implemented MPLS-VPN. For example, KPN has interconnected with Sprint to deliver high data services to its customer in the US.[74] Prior to this agreement, they had already signed interconnections agreements with SingTel and Telefonica.[75] Global Crossing has also been using MPLS-VPN with differentiated QoS treatment for quite some time.[76]

The underlying technology used to perform this type of interconnection is MPLS-VPN. MPLS-VPNs, which are defined in the IETF RFC 4364, provide a Layer 3 VPN functionality as depicted in Figure 28. MPLS and Border Gateway Protocol version 4 (BGPv4) are the standard base technologies for this architecture

Figure 28: MPLS-VPN Architecture



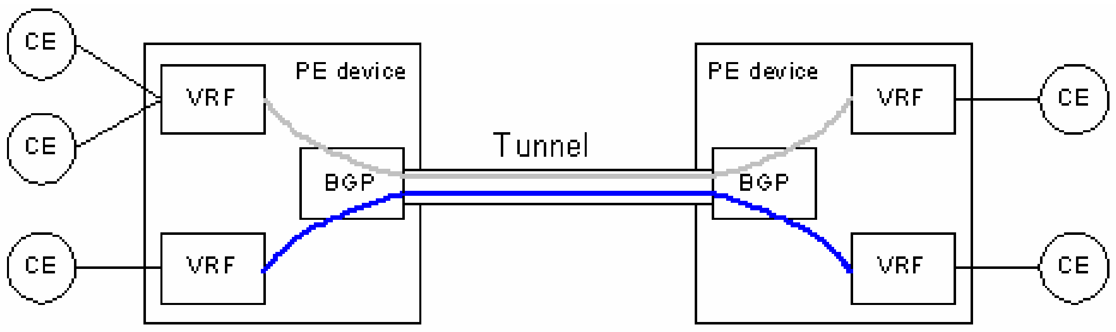

Source: WIK-Consult.

A mesh of MPLS Label Switched Paths (LSPs) between the Provider Edge (PE) routers is established. A VPN identifier is broadcasted by a PE device to all the other PE devices by means of a form of BGP (see Figure 29). The PE devices are in charging of

74 http://www.lightreading.com/document.asp?doc_id=146977 (Retrieved on 7 August 2009).
75 http://www.lightreading.com/document.asp?doc_id=146977 (Retrieved on 7 August 2009).
76 http://www.globalcrossing.com/news/2004/october/Release_iMPLS_CB_10-19-04_final.pdf (Retrieved on 7 August 2009).

constructing a map of the VPNs and destination labels. There are several ways of implementing the interconnection between Autonomous Systems (AS). The IETF RFC 4364 defines the three following cases: VPN Routing and Forwarding Tables (VRF)-to-VRF connections at the Autonomous System Border Routers (ASBR), External BGP (EBGP) redistribution of labeled VPN-IPv4 routes from AS to neighboring AS, and Multi-hop EBGP redistribution of labeled VPN-IPv4 routes between source and destination Ases, with EBGP redistribution of labeled IPv4 routes from AS to neighboring AS.

Figure 29: MPLS Label Switched Paths




Source: Data Connection.[77]

## 2.5.2 XConnect and VoIP peering

XConnect is a company that provides voice operators with VoIP peering services. The company has its headquarters in the UK and has offices in Europe, USA and Asia.

The business case of XConnect is based on the fact that there is a growing number of VoIP users in the world: new IP-based operators usually offer VoIP services and established voice operators are migrating their TDM infrastructure to VoIP. Moreover, several Cable operators are deploying SIP-based solutions, and mobile operators have been working on the IMS platform as part of the 3GPP project. In many cases, the interconnection between the VoIP operators is done through a TDM carrier which uses SS7 for signaling. XConnect offers a VoIP Peering solution that enables VoIP operators to interconnect directly, which brings the following benefits:

- Improvement of the call quality;

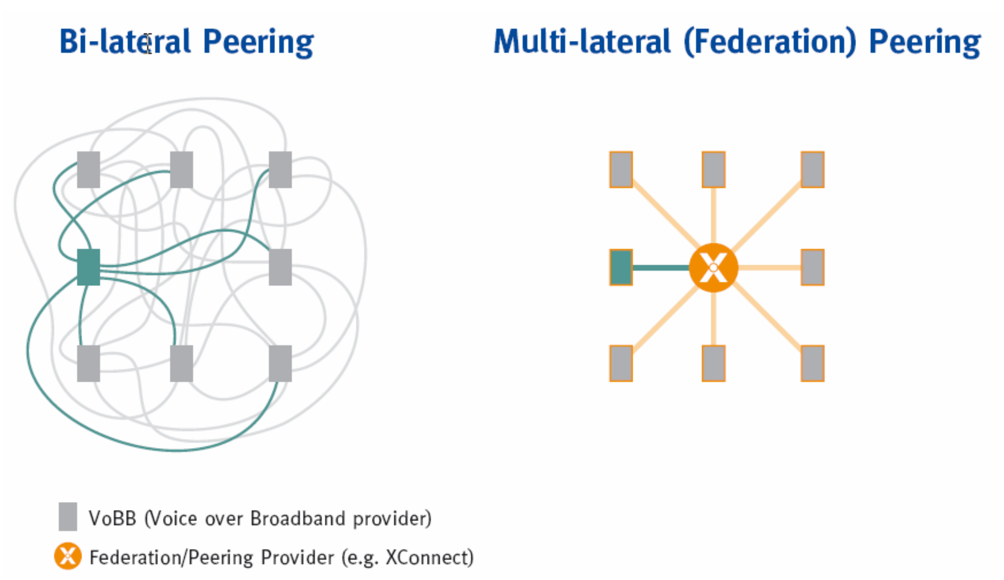
77 See http://www.dataconnection.com/solutions/layer3.htm, visited on 9 August 2009.

- Transparent call features (wideband codecs);
- A cheaper interconnection (VoIP interconnection equipment is cheaper, and there are no transit fees).

Nowadays, several voice operators follow a bilateral peering model for the interconnection with other operators. This system works well in a context with established technical standards, simple rules for call routing, and a limited number of participants[78]. However, in a VoIP environment operators that have different VoIP systems may have an interoperability problem (e.g., due to different VoIP codecs). In addition, each VoIP operator must exchange telephone numbers with all the other operators on a daily basis.

A multilateral peering model can overcome these problems. XConnect proposes the use of a Federation managed by a neutral operator (see Figure 30 below). The use of the federated approach creates a central management of the following functions: the interoperability issues will be solved because the protocols used for the calls between the peered providers will be normalized, and there is a central mechanism for exchanging numbering data.

Figure 30: Bi-lateral and Multi-lateral Peering




Source: XConnect, „Bridging the VoIP Islands“, White Paper, available at http://www.xconnect.net.

78 XConnect, „Bridging the VoIP Islands“, White Paper, available at www.xconnect.net (Retrieved on 7 August 2009).

The following issues should be addressed to implement Multilateral Peering:

- Media Handling: Codec compatibility.
- Discovery/Location (ENUM Directory management): Analysis of dialed numbers and determination of routing information.
- Peering Policy Management: A service provider has the possibility of choosing the service providers with whom it will peer.
- Signaling Interoperability: The peering service providers is in charge of translating and normalizing the different signaling protocols or variants used by operators (e.g., SIP, H.323, and MGCP).
- Security: The peering provider must prevent SPIT (SPAM over Internet Telephony) by identifying suspicious calling patterns.

XConnect is a provider of Federation and VoIP peering solutions. The IETF SPEERMINT working group defines the role of Federation in a VoIP peering model[79]. XConnect has participated in the set up of VoIP Federations in the Netherlands, Korea, and Brazil.

### 2.5.3 The GRX and IPX architectures of the GSMA

The GSM Association (GSMA) includes operators that work with the GSM family of technologies as well as manufacturers that provide the necessary equipment (hardware, software, handsets, etc.). Among other functions, the GSMA is in charge of proposing technical and commercial solutions for the interconnection between operators.

For the interconnection between operators, the GSMA has defined Inter-Service Provider IP Backbone Architectures. These architectures enable the interconnection between Service Providers according to commercial agreements and established inter-operable service definitions[80]. A Service Provider can be a Mobile Network Operator (MNO), ad Fixed Network Operator (FNO), an Internet Service Provider (ISP), or an Application Service Provider (ASP). The architecture contains a private IP backbone network, where all the information is carried by using IP-based protocols. For the interconnection with selected Servide Provider partners, a Service Provider only needs one connection with the Inter-Service Provider IP Backbone.

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79 Information about the IETF SPEERMINT working group is available at http://www.ietf.org/html.charters/speermint-charter.html (Retrieved on 7 August 2009).

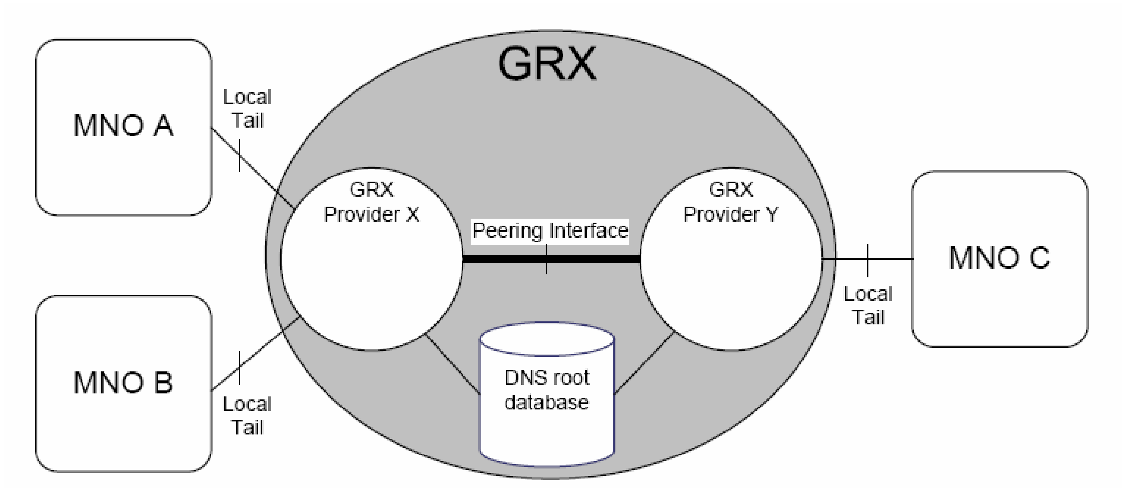
80 GSM Association, „Inter-Service Provider IP Backbone Guidelines", IR.34, June 19, 2008.

The Inter-Service Provider IP Backbone Architectures that have been defined are the GPRS Roaming eXchange (GRX) and the IP Packet eXchange (IPX).

### 2.5.3.1 The GRX

The GRX network provides connectivity between GSM and 3G Mobile Network Operators whenever there is a bilateral agreement between the operators. Figure 31 depicts the high-level architecture of the GRX.

Figure 31: GRX Architecture




Source: GSM Associacion, "Inter-Service Provider IP Backbone Guidelines", IR.34, June 19, 2008.

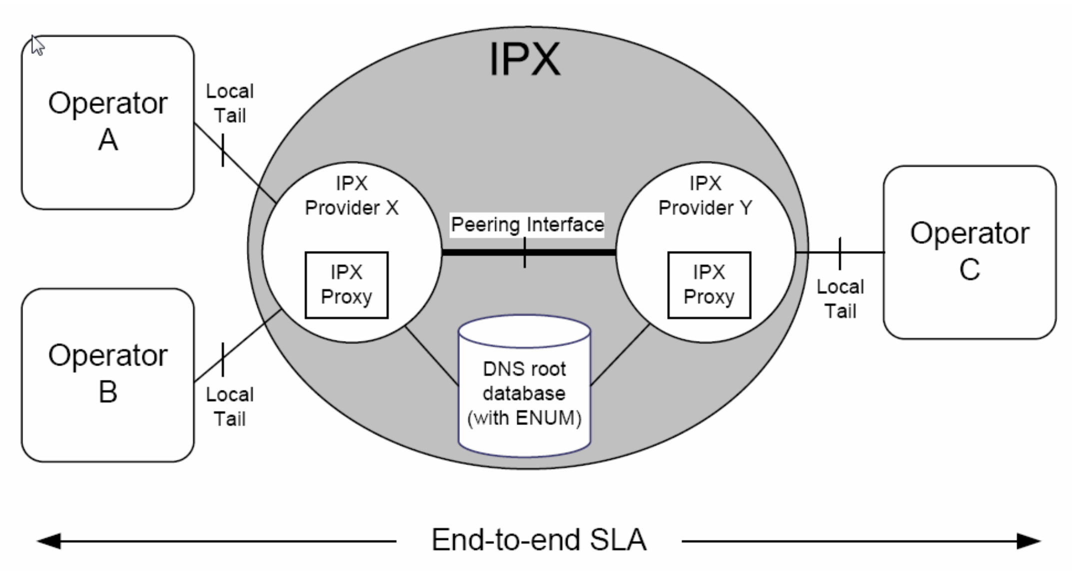
The Mobile Network Operators, the Service Providers, are connected to the GRX through a local tail. The GRX is formed from separate GRX Providers which are operated by qualified parties. The interconnection between GRX Providers is done through peering interfaces. The peering interface can be a common peering point or a direct connection between the GRX Providers. In any case, a Service Level Agreement (SLA) should be signed between the GRX Providers. The domain name resolution function is supported by a common DNS root database that can be used by all GRX Providers.

The GRX is separated from the public Internet. The GRX should have BGP-4 routing capabilities. The GRX provides mobile operators with interconnection services "on a bilateral basis with no guarantees of QoS end-to-end"[81].

### 2.5.3.2 The IPX

The IPX architecture is based on the GRX architecture and it includes the following functionalities: connectivity between any type of Service Provider (MNO, FNO, ISP or ASP, and end-to-end QoS for interworking and roaming. Figure 32 shows the IPX model.

Figure 32: IPX Architecture




Source: GSM Associacion, "Inter-Service Provider IP Backbone Guidelines", IR.34, June 19, 2008.

The IPX consists of separate and competing IPX Providers that can be operated by qualified parties. The support of end-to-end QoS in the IPX model requires that the IPX Providers involved in the transport of a service sign end-to-end Service Level Agreements. As in the GRX model, the IPX uses a DNS root database. The IPX introduces ENUM functionalities for the translation of a telephone number to a Uniform Resource Identifier (URI) at the common DNS root database.

**81** GSM Associacion, "Inter-Service Provider IP Backbone Guidelines", IR.34, June 19, 2008.

The IPX can include proxy elements for the interworking of specified IP services; they also enable the cascading interconnect billing and the multilateral interconnect model. Some features required from IPX proxies are the following[82]:

- Session-based accounting including CDR generation
- Implementation of Black and White lists in a multilateral mode
- Security functions (e.g., access control)
- IPv4/IPv6 translation
- Media protocol conversion/transcoding
- Signaling protocol conversion
- Destination address look-up

The IPX has the following three connectivity options: the transport-only connectivity option, the bilateral service transit connectivity option, and the multilateral service hub connectivity option.

The transport-only connectivity option is a bilateral agreement between two Service Providers that use the IPX transport layer with guaranteed QoS end-to-end. This is a model without service awareness and the IPX is used to transport a protocol between two Service Providers.

The Bilateral Service Transit Connectivity Option is a service awareness transport model for bilateral agreements between two Service Providers. The IPX proxy function can be used and there is a guaranteed end-to-end QoS. There can be service-based interconnect charging and cascade billing.

The Multilateral Service Hub Connectivity Option provides Service Providers with end-to-end QoS and service-based interconnect charging. A hubbing/multilateral connectivity is where traffic from one Service Provider is routed to any of several interworking partners by means of a single agreement with the IPX provider.

As the IPX is in charge of the interconnection between Service Providers that will offer end-to-end services, it has to support the corresponding functions so that the customer of Service Provider “1” can establish a session with the customer of a Service Provider “2”. Examples of services that are supported by the IPX are IP voice telephony, IP video telephony, Push-to-tal over Cellular (PoC), Instant Messaging (e.g., text messages), Presence (status of a user: online, offline, busy, etc.), and video share (whilst

**82** GSM Associacion, “Inter-Service Provider IP Backbone Guidelines”, IR.34, June 19, 2008.

maintaining a voice call, a user can share video). If two Service Providers decide to use non-standardized services, the IPX could provide the transport as a “bit-pipe” function with end-to-end QoS support.

The GRX is being used today by hundreds of mobile operators around the world. On the other hand, the IPX is an emerging platform that will be provided in the future by IPX Providers that want to offer enhanced services that require end-to-end Quality of Service.

## 2.6 Chapter Summary

This chapter focuses on the description of NGN technology and standards and on the interconnection of NGN and VoIP operators.

- **Architecture of NGN Networks:** The NGN architecture includes the NGN access network, the NGN aggregation network, the NGN core network, and the NGN service control layer. Several technologies can be used for the access network: xDSL, FTTx, cable networks, mobile access (HSDPA), or Fixed Wireless Access. Nowadays, the most widely implemented Next Generation fixed access technologies are FTTC/VDSL, FTTH PON and FTTH P2P. The NGN aggregation network aggregates traffic from metro core switches to the backbone network. The NGN core network is an IP network that is deployed on a geographically widespread basis and that provides the interconnection to other networks and to central services and applications. The NGN service control layer is in charge of controlling elements such as nomadicity and mobility of services, network security issues, and Quality of Service. NGN operators have the possibility of deploying several QoS techniques. The IMS is an architecture that can be used by service providers and network operators to control the provisioning of services in an NGN network.

- **Technical Standards:** Several bodies have been involved in the definition of NGN standards. The ITU-T has defined several functionalities of NGN networks in the Y-Series Recommendations, which also include recommendations for interworking. The 3GPP group worked on the standardization of the IMS architecture. An IMS architecture was also defined by the TISPAN standard group of ETSI. The IETF is in charge of developing Internet standards. Several protocol defined by the IETF are used in the architectures developed by other standardization bodies.

- **Interconnection of NGNs:** Whereas in a circuit-switched environment the interconnection is done by means of the SS7 signaling system, the interconnection in an IP NGN environment is in principle done by using an IP-based protocol. IP interconnection today is implemented under transit and peering agreements between ISPs. Internet Exchange Points (IXPs) can be used for public peering interconnection. Large network operators use the Border Gateway Protocol (BGPv4) to route traffic among themselves. The IMS can be used for the interconnection of NGN networks at the level of the control plane.

- **Interconnection of VoIP networks:** A VoIP operator has several possibilities at the moment of choosing the VoIP technique that it will implement. The best known non-proprietary VoIP systems are H.323, SIP, and MGCP/Megaco. There are proprietary VoIP architectures such as the Skype architecture and proprietary protocols such as the Cisco Skinny Client Control Protocol. For the interconnection between a VoIP network and a circuit-switched network, it is necessary to install equipment with the functions of Media Gateway and Signaling Gateway. On the other hand, a softswitch architecture can be used to control the Media Gateways and the Signaling Gateways. ENUM is an IETF standard used for the mapping of PSTN E.164 telephone numbers to IP-based resource identification information of the VoIP service provider that serves that phone number. Number portability and access to emergency services are issues that should be addressed at the moment of interconnecting VoIP networks.

- **Case studies of IP Interconnection:** The report includes three case studies about the interconnection of operators that provide voice or quality-assured data services over IP. In the first case study, the interconnection between operators by means of the MPLS-VNP technique is explained. The second case study describes the VoIP peering services provided by the company XConnect. Finally, the third case study addresses the GRX and IPX Inter-Service Provider IP Backbone Architectures defined by the GSM Association.

# 3 The economic and policy challenges of IP interconnection and Voice over IP

This chapter analyses global developments from the perspective of economics and policy in the switched telephony world (PSTN/PLMN) (Section 3.1), the Internet (Section 3.2), and the emerging NGN environment (Section 3.3). It also includes a discussion of the economics and policy challenges of Network Neutrality (Section 3.5). Section 3.6 provides a chapter summary.

## 3.1 The switched telephony world

Telecommunications economics has been dominated from its birth in the Nineteenth Century by the arrangements used to interconnect *voice services*. This is still the case today, even though events are rapidly out-pacing this rather narrow view. Voice services still represent the bulk of revenues for most communications network operators, even though voice represents a declining fraction of network traffic.

These trends must be viewed as somewhat anomalous. Voice will represent a negligible proportion of the *cost* of NGNs going forward, but might nonetheless represent the bulk of the network operators' *revenues*.

In understanding the economics of the voice service, and for that matter of any other network services, it is helpful to distinguish between the *retail level* (facing consumers and other end-users) and the *wholesale level* (between network operators).

### 3.1.1 Retail voice services

An extensive literature exists comparing the merits of different retail arrangements. Our view is that, under proper wholesale regulation and in a competitive marketplace, it is not necessary to regulate retail arrangements at all. Consequently, we think that it is not necessary for regulators to try to determine the optimal retail pricing arrangements; these are best left to the voice service providers, who will tend to be motivated to address their respective customers' needs.

At the retail level, voice services have often been offered on a *Calling Party Pays (CPP)* basis. Under CPP, the party that places the call pays the total cost of the call; the party that receives the call pays nothing. If all calling patterns were balanced, this arrangement would be as good as any; however, it is clear that not all calling patterns are balanced. In an unbalanced world, the rationality of CPP rests on a tacit assumption that the party that places the call derives the primary benefit from the call, and that it is appropriate to attribute the cost causation solely to the caller. This assumption has increasingly been challenged in the literature, as economists recognize that there must be benefits (economic surplus) to the call recipient as well; otherwise, he or she would simply hang up the phone.[83]

In recent years, *flat rate* plans have become increasingly common. In a typical flat rate plan, the subscriber pays a monthly fee for unlimited use of the service. There are no usage-based fees at all.

A common variant of the flat rate plan is sometimes referred to as a *bucket of minutes*. The subscriber pays a flat rate in order to use his or her mobile phone up to a certain number of minutes per month. Minutes beyond the "bucket" are charged at a high or even punitive per-minute rate, so as to effectively force the end-user to upgrade to a larger bucket.[84]

"Buckets" plans vary greatly as to which minutes are counted. Some count call minutes only on weekdays, or only during certain hours, or only *off-net* calls (calls to or from customers of other networks).

Consumers tend to greatly prefer flat rate plans (including "buckets" plans) over CPP arrangements. In a number of instances, once a disruptive player has offered a flat rate plan, they gained market share rapidly and forced CPP players to respond in kind. Examples in the U.S. include AT&T Wireless's Digital OneRate mobile plan, and America OnLine's unlimited dial-up Internet access for $19.95 U.S. per month.[85] Odlyzko has argued that the consumer preference for flat rate is strong to the point where flat rate will ultimately win out over metered plan whenever the usage-based costs are sufficiently low.[86]

Retail plans can be either *pre-paid* (where the consumer occasionally makes a payment to maintain a balance and then uses services that are charged against that balance) or post-paid (where there is a standard billing arrangement, and services are in principle billed periodically to the end-user). Pre-paid arrangements are usually CPP.

It is increasingly common for voice to be packaged as part of a bundle with some combination of SMS, MMS, data services, and even video. Consumers tend to view this

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**83** Jeon, Laffont and Tirole refer to this as the principle of *receiver sovereignty*. See Jeon, Doh-Shin/ Laffont, Jean-Jacques/ Tirole, Jean (2000) On the "Receiver-Pays" Principle, in the *RAND Journal of Economics*, Vol. 35, pp. 85-110.

**84** The literature also speaks of Receiving Party Pays (RPP). Under RPP, a mobile customer pays per-minute fees whether he or she is placing or receiving the call. RPP used to be common in the United States ten years ago. Today, RPP retail arrangements are quite rare.

**85** See for example J. Scott Marcus, "Call Termination Fees: The U.S. in global perspective", presented at the 4th ZEW Conference on the Economics of Information and Communication Technologies, Mannheim, Germany, July 2004. Available at: ftp://ftp.zew.de/pub/zew-docs/div/IKT04/Paper_Marcus_Parallel_Session.pdf (Retrieved on 7 August 2009).

**86** Odlyzko, Andrew (2001): Internet Pricing and the History of Communications, AT&T Labs – Research, available at: http://www.dtc.umn.edu/~odlyzko/doc/history.communications1b.pdf (Retrieved on 7 August 2009).

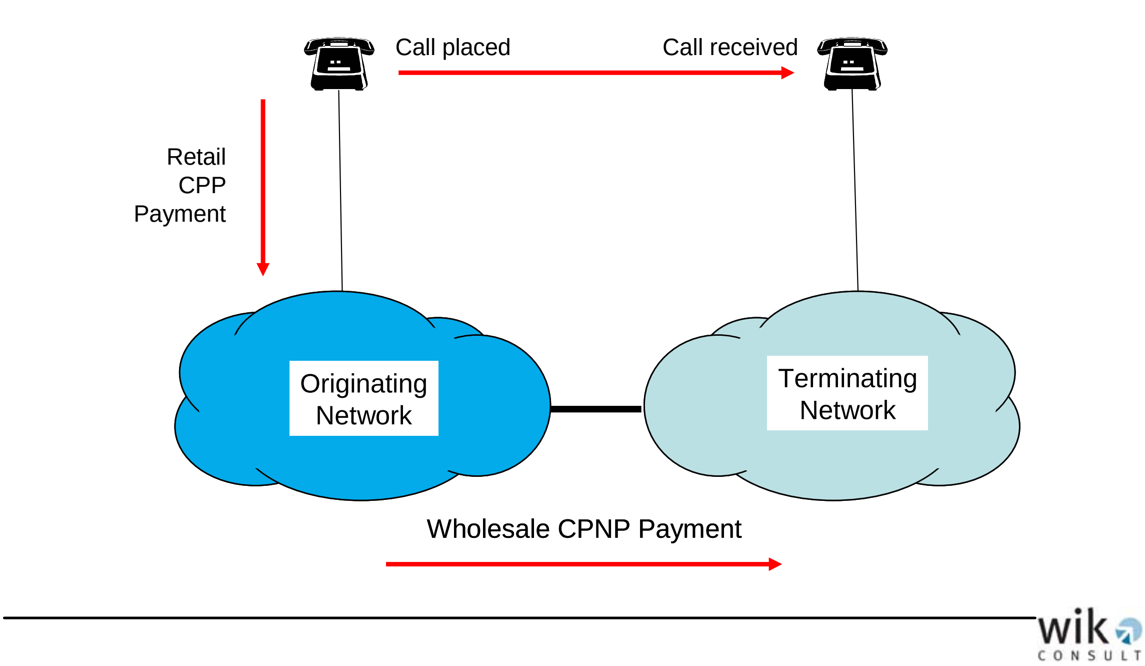
as a benefit overall, even though bundling tends to make it more difficult for them to switch from one service provider to another.

When a consumer purchases a bundle, it tends to be impractical to pay equal attention to all of the components of the bundle. Partly as a result, components of the bundle that seem less critical – SMS, for example, of mobile roaming services – often receive less attention than they arguably deserve. This tendency explains in part prices for these ancillary services that are often greatly in excess of cost, more so than could otherwise be easily explained in an otherwise competitive market.

### 3.1.2 Wholesale voice services

Wholesale voice services are usually associated with per-minute payments from the network operator whose customer placed the call to the network operator whose customer received the call (see Figure 33). This system is referred to as Calling Party's Network Pays (CPNP). CPNP is often (*not* always) found together with CPP, as shown in Figure 33, but they should not be confused. They are not the same thing at all; one is at retail level, between service provider and end-user, while the other is at wholesale level, between two network operators.

Figure 33: Calling Party's Network Pays (CPNP) payment arrangements




Source: WIK-Consult.

If the world consisted solely of CPP retail arrangements (as was once largely the case), then only network operators whose customers place calls would receive retail revenues. CPNP tries to correct for this by ensuring that the costs of the terminating network are recovered through wholesale payments.

CPNP at the international level can benefit developing countries like Peru. Consumers in developing countries have less disposable income than those in developed countries, and therefore place fewer calls (in a CPP environment) than consumers in developed countries. There thus tends to be an asymmetry between calls placed and calls received in developed countries. CPNP, with termination fees set to true costs, would tend to correct for this. At the same time, we would caution that termination fees that were set *in excess of true costs* would transfer revenue to the developing country but would also represent an economic distortion.

Wholesale CPNP prices have complex characteristics, some of them problematic. Network operators tend to be motivated to set CPNP call termination levels far in excess of real cost. Normal market forces do not adequately constrain these prices, because *they are ultimately paid by a different network operator's customers*. As a result, wholesale prices will tend (in the absence of regulation) to be well in excess of competitive or cost-based levels. The market power that leads to these high wholesale prices is referred to as the *termination monopoly*. It is a consequence of the ability of only a single network operator to complete a call (or an SMS or MMS) to a single telephone number.

Historically, there has been a tendency to regulate fixed termination rates, especially to the incumbent, but not to regulate mobile termination rates (MTRs); consequently, in many countries this is a far greater problem for the mobile network than the fixed. It also tends to transfer revenue from the fixed network to the mobile, potentially distorting the development of both.

These high wholesale prices represent a real cost to the network operator that has to pay them; consequently, they tend to be reflected directly in high usage-based (e.g. per-minute) retail prices for voice calls. Where prices are high, consumption tends to be low, and vice versa – this is known as *demand elasticity*. High per-minute costs for calls to mobile phones leads to fewer calls being placed.

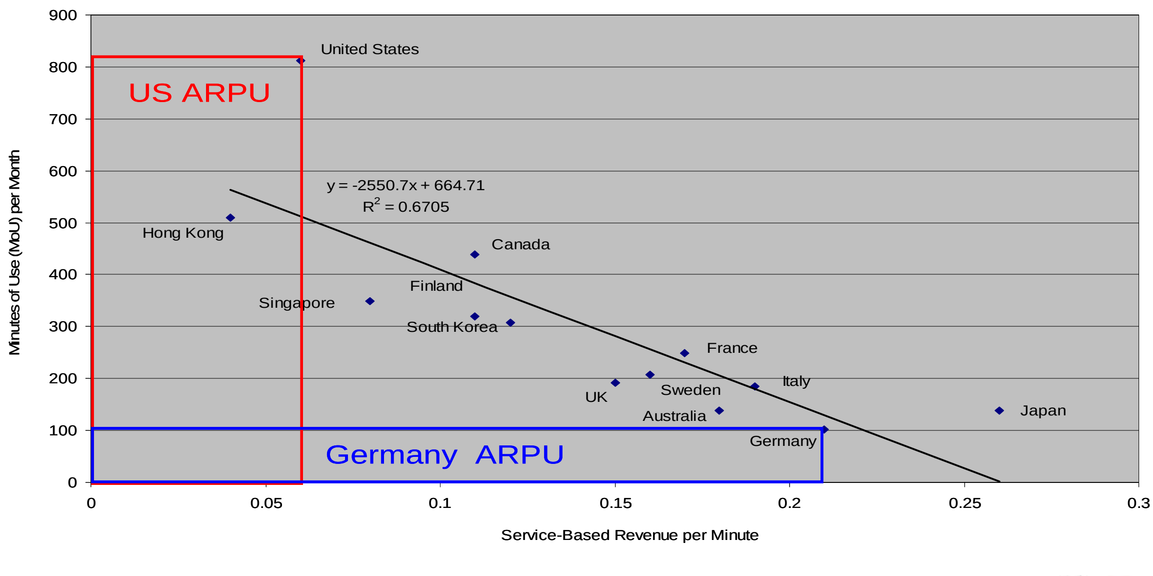
To the extent that fewer mobile and fixed-to-mobile voice calls are placed (due to inflated retail prices), this represents a *loss of consumer welfare*. It is analogous to the *deadweight social loss* that is experienced when a monopolist intentionally limits supply in order to drive up prices.

Figure 34 is based on Merrill-Lynch data, as reflected in a recent report by the US FCC.[87] *Service-based revenue* is simply all of the revenue generated by the company for the provision of mobile services, including both retail revenue and wholesale termination revenue; however, it does not include equipment revenue, and thus does not reflect either the cost of handsets or the level of handset subsidies.

The monthly *Minutes of Use* reflect all billable minutes, whether billable at wholesale (through CPNP termination rates) or at retail. For CPNP countries, calls received on the same network on which they were placed generate neither retail nor wholesale revenue, and are consequently not counted; consequently, one must be careful when comparing figures between CPNP countries and non-CPNP countries (see below).[88]

*Service-based Revenue per Minute* is the Service-based Revenue normalized by dividing it by the Minutes of Use. It thus represents something of a normalized measure of retail price.[89]

Figure 34: Service-based Revenue per Minute versus Monthly Minutes of Use




Source: WIK-Consult.[90]

**87** FCC (2009): *Annual Report and Analysis of Competitive Market Conditions With Respect to Commercial Mobile Services* (13th CMRS Report), Washington, DC, WT Docket No. 08-27, released 16 January 2009.

**88** Merrill-Lynch has estimated that this introduces a disparity of perhaps 20% in comparing CPNP countries to Bill and Keep countries. We conjecture that the disparity is probably closer to 12%, inasmuch as it relates only to (1) calls received (2) mobile-to-mobile (3) from the same mobile network, i.e. on-net.

**89** Again, one must bear in mind that the Service-based Revenue includes wholesale termination payments in CPNP countries, but not in non-CPNP countries.

What is abundantly clear in Figure 34 is that countries with high prices (expressed as high Service-based Revenue per Minute of Use) tend to have low Minutes of Use per month, and vice versa.

At the same time, the countries with the highest unit prices do not necessarily have the highest revenue per month, expressed as the Average Revenue per User (ARPU). The service-based ARPU is simply the area under the rectangle of Minutes and Revenue per Minute. The United States has low unit prices, but high usage and high ARPU; conversely, Germany has high unit prices, but low usage and low ARPU. Germany's rectangle is long, but low – it does not enclose much area.

Relatively high termination rates tend to lead to high retail prices, because the termination rate sets an effective floor on the retail price that a network operator can set for calls to the network with the high termination rates. High retail prices lead to low usage. High termination rates and the associated high retail prices also tend to lead to relatively high penetration for mobile phones. The high retail prices tend to motivate operators to subsidize handsets heavily, and to charge little or nothing initially and per month, in order to put mobile phones into the hands of even customers who may not place many calls. The mobile operator can still profit substantially from the termination fees associated with the calls that the user receives. For a developing country like Peru, this is an important positive aspect that must be kept in mind.

And where is Peru on this continuum? According to Merrill-Lynch data, mobile Service-based Revenue per Minute of Use averaged $0.08 USD in 3Q2008.[91] This is similar to Colombia and Mexico, and lower than Argentina, Brazil and Chile. In international comparative terms, mobile prices in Peru were historically rather high, but now rank with the best in the region.[92] Meanwhile, usage in 2007 (both originating and terminating minutes, but counting call termination to on-net mobile) was 91 Minutes of Use per month per subscriber. This is slightly lower than Argentina, Brazil and Venezuela, and significantly lower than Chile, Colombia and Mexico. Usage is thus fairly low in comparison with other countries in the region. As a check, we would note that OSIPTEL data for 2008 show just under 50 originating mobile minutes per month per subscriber.[93]

Some countries (the US, Canada, Hong Kong and Singapore) use an alternative set of wholesale arrangements known as Bill and Keep. Bill and Keep countries tend to have mobile termination rates that are either very low or zero. These arrangements are very

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**90** Based on Merrill-Lynch *Interactive Global Wireless Matrix* 4Q07 data, as reported in the US FCC's 13th CMRS Competition Report, document DA 09-54, 16 January 2009.

**91** At http://www.cwes01.com/10323/24789/Interactive_Global_Wireless_Matrix.xls, visited 9 May 2009.

**92** See also Figure 56: Comparative retail price per mobile Minute of Use in Annex 1.

**93** WIK computations/estimates based on these OSIPTEL data for June 2006, June 2008 and September 2008 are 45.3 minutes, 49.6 minutes and 49.8 minutes, respectively.

complex, especially in the US[94] (where they tend to be poorly understood, even by the experts), but they have arguably achieved great results in the countries concerned.

For developing countries, we have suggested elsewhere that a different approach might be preferable. India has implemented arrangements that are conventional CPNP in form, but the level of termination fees for both fixed and mobile has been fixed at roughly $0.005 US per minute. This resulted in low retail prices (with heavy reliance on flat rate plans) and high usage per month. At the same time, India has enjoyed an explosion of penetration. In the near to medium term, this is a more promising model for developing countries.[95]

A third approach is the use of Capacity Based Charging (CBC). With CBC, the maximum interconnection capacity utilization is booked in advance and paid for with monthly or one-time fees; there are then no further charges (e.g. on a per-minute basis) for usage within the specified capacity limit. CBC generally follows efficiency criteria more closely than per-minute charges. What distinguishes CBC from per minute charges is the closer tracking of network costs, and the possibility for risk sharing between the dominant network operator and the competitors.[96] These advantages hold true just as much for NGN as they do for traditional networks. Given that Peru has just imposed CBC on TdP,[97] it becomes a natural and obvious candidate for NGN interconnection arrangements in Peru going forward. We return to this discussion in Sections 5.7 and 5.8.

## 3.2 The Internet, and Voice over IP (VoIP)

The firms that provide connectivity to the Internet are referred to as *Internet Service Providers (ISPs)*. ISPs, including the large backbone ISPs, have interconnected to one another by two primary means: *peering* and *transit*. For our purposes:

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**94** The termination fees for local calls in the US must be "reciprocal", i.e. the same in both directions, whether operators are fixed or mobile. In addition, fixed incumbents are limited to cost-based termination fees. Substantial asymmetry between fixed and mobile is thus prevented. In consequence, most mobile operators prefer not to charge termination fees to one another. See J. Scott Marcus "Call Termination Fees: The U.S. in global perspective", presented at the 4th ZEW Conference on the Economics of Information and Communication Technologies, Mannheim, Germany, July 2004. Available at: ftp://ftp.zew.de/pub/zew-docs/div/IKT04/Paper_Marcus_Parallel_Session.pdf (Retrieved on 7 August 2009).

**95** J. Scott Marcus (2007): Interconnection in an IP-based NGN Environment, GSR Discussion Paper, Presented at the ITU Global Symposium for Regulators, Dubai, 2007. The paper appears in *Trends in Telecommunications Reform 2007: The Road to Next Generation Networks (NGN)*, ITU, 2007.

**96** Ingo Vogelsang with Ralph-Georg Wöhrl, "Determining interconnect charges based on network capacity utilized", K.-H. Neumann, S. Strube Martins and U. Stumpf (eds.), *Price Regulation*, Bad Honnef: WIK Proceedings, 2002, pp. 95-129.

**97** See OSIPTEL, *Revisión del Cargo de Interconexión Tope por Terminación de Llamadas en la Red del Servicio de Telefonía Fija Local* , Nº 00001-2006-CD-GPR/IX, 29 September 2008.

- *Peering* is a relationship where two ISPs agree to exchange traffic destined for their respective customers (or customers of their customers), but not for third parties. Peering is often, but not always, done without charge to either party.

- *Transit* is a relationship where one ISP pays another to deliver its traffic to third parties, usually to all or substantially all destinations on the Internet.[98]

The distinction between peering and transit is a technical distinction, not an economic one. It implies a different structure of the Internet routing tables.[99] The difference in charging arrangements are an economic consequence, not a defining characteristic.

Publicly available information on peering and transit arrangements is limited, but there is reason to think that these interconnection arrangements may be becoming more complex over time. Historically, the great majority of peering was free of charge, and the great majority of transit provided full global connectivity. Today, some have argued that *paid peering* (i.e. for a fee) and *partial transit* (i.e. with less than global connectivity) are becoming increasingly common.[100] Note that paid peering and partial transit fall within the scope of peering and transit, respectively, as previously defined.

One also occasionally encounters *mutual transit*, where two providers each provider transit to one another, possibly without a fee.

Neither peering nor transit alone would yield a very workable system. If all $N$ ISPs were obliged to interconnect by means of peering, roughly $N^2/2$ interconnections would be required, which would be technically and administratively completely intractable. A more hierarchical arrangement is necessary. On the other hand, a system composed solely of transit would, by definition, have to have a single root (and thus a single point of failure) in order to achieve full global reachability. For many reasons, this too would be unworkable. Peering and transit together offer a system that generally works well, and that scales to enable an Internet comprised of thousands of independent ISPs.

Most countries have left peering and transit arrangements to be determined by the market.[101] This has usually led to satisfactory outcomes; however, some ISPs and some national governments have complained that these unregulated commercial arrangements unfairly disadvantage ISPs in developing countries, and unfairly favor

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**98** For comprehensive definitions of peering and transit, see Report of the NRIC V Interoperability Focus Group, "Service Provider Interconnection for Internet Protocol Best Effort Service", page 7, available at http://www.nric.org/fg/fg4/ISP_Interconnection.doc (Retrieved on 7 August 2009).

**99** Cf. Gao, Lixin (2000): On inferring autonomous system relationships in the Internet, in *Proceedings of the IEEE Global Internet Symposium*, 2000.

**100** D. Clark, P. Faratin, S. Bauer, W. Lehr, P. Gilmore, and A. Berger, "The Growing Complexity of Internet Interconnection", in *Communications & Strategies* Number 72, 4th quarter 2008.

**101** There have been occasional exceptions. The Australian incumbent declined to peer with any of its domestic competitors. The Australian Competition and Consumer Commission (ACCC) ultimately forced Telstra to peer with domestic competitors in 1998.

ISPs in the United States. The authors of this report do not subscribe to this view; we generally advocate leaving Internet interconnection arrangements as they are for now.

Interconnection of IP-based voice requires a bit more than raw IP interconnectivity. First, there is the need to locate an IP-based server that corresponds to a particular E.164 telephone number; second, there are often protocol conversions required.

In the IP world, services are identified primarily by means of IP addresses, or more generally by means of Universal Resource Identifiers (URIs). The URLs that point to a web page are an example of a URI. There is no inherent correspondence between a phone number and a URI (and the problem is further complicated by number portability); consequently, some form of database lookup is required.

To address this problem, the IETF[102] developed a communications protocol known as ENUM.[103] ENUM uses the technology of the *Domain Name System (DNS)* to map a phone number to one or more URIs corresponding to service that cater to that phone number. Typically, the URI would point to a media gateway (a translator from circuit switched voice to IP-based voice) operated by the *IP Telephony Service Provider (ITSP)* that serves the customer who has that number.

The world of Voice over IP (VoIP) is characterized by competing communication standards (e.g. SIP, H.323, and so on) and competing voice encoding schemes (implemented by different codecs). Interconnecting IP voice consequently often entails protocol translation between these different communication protocols and different voice encoding schemes. This translation is sometimes implemented by devices known as *Session Border Controllers (SBCs)*.

The technology for IP-based interconnection of IP voice is mature enough to deploy: Competitive *Internet Telephone Service Providers (ITSPs)* often interconnect by means of IP (see, for instance, Section 2.5.2). To date, however, it is quite rare for fixed incumbents (or large mobile operators) to interconnect by means of IP; instead, nearly all VoIP interconnection to fixed incumbents is achieved by first transforming the call to circuit switched voice, and then interconnecting at a circuit level.

The GSM Association has defined an IP interconnection mechanism known as the IPX (see Section 2.5.3). The IPX could provide a highly capable IP voice interconnection suitable for IP voice, or for QoS-assured data. How the IPX will be used remains to be seen. Mobile operators have rarely if ever interconnected their inherent voice services by means of IP.

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**102** The *Internet Engineering Task Force (IETF)* is the primary standards body for the Internet.

**103** ENUM is not an acronym. The name does not stand for anything at all. It is perhaps suggestive of *electronic numbering*.

Our contention is that technical considerations play at most a secondary role here. Fixed incumbents and large mobile operators decline to connect using IP for a number of reasons (see Section 3.4). Perhaps the most significant of these reasons is that they fear that interconnecting on an IP basis (absent arrangements like the IPX) might eventually oblige them to stop collecting wholesale call termination revenues. Surrendering call termination revenues would likely also lead to more intense retail price competition.[104]

## 3.3 The world of the Next Generation Network (NGN)

This section considers evolving developments in regard to NGN interconnection. It responds to the following requirements in the procurement document:

- Detailed description, based on international experience, of the main difficulties encountered by operators in the NGN interconnection process, considering a detailed explanation of the types of interconnection agreements for those operators and the processes developed until settlement in NGN interconnection matters.

- Analysis of NGN interconnection considering international regulation as well as recommendations from standardization bodies, taking into account considerations and practical examples as well as a description of basic-interconnection packages, among others.

To date, the question of IP-based NGN interconnection has received considerable attention at the international level. Noteworthy are various studies that the ITU has conducted,[105] in addition to various studies conducted by the European Regulators' Group, the German BNetzA, and the European Commission. Nonetheless, there is nothing that one can point to today as representing a clear consensus, or a detailed example of best practice.

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**104** See Section 5.1.4 of J. Scott Marcus, Dieter Elixmann, Kenneth R. Carter, and senior experts Scott Bradner, Klaus Hackbarth, Bruno Jullien, Gabriele Kulenkampff, Karl-Heinz Neumann, Antonio Portilla, Patrick Rey, and Ingo Vogelsang, *The Future of IP Interconnection: Technical, Economic, and Public Policy Aspects*, March 2008, a study prepared for the European Commission, available at: http://ec.europa.eu/information_society/policy/ecomm/doc/library/ext_studies/future_ip_intercon/ip_intercon_study_final.pdf, visited on 8 August 2009.

**105** See "Interconnection in an NGN Environment", a background paper commissioned for the ITU New Initiatives Programme workshop on "What rules for IP-enabled Next Generation Networks?" held on 23-24 March 2006 at ITU Headquarters, Geneva. Available at: http://www.itu.int/osg/spu/ngn/documents/Papers/Marcus-060323-Fin-v2.1.pdf, Retrieved on 7 August 2009. Also available as WIK Discussion Paper 274 (see http://www.wik.org/content_e/diskus/274.htm, Retrieved on 7 August 2009). See also "Interconnection in an IP-based NGN environment", a chapter in ITU's *Global Trends 2007*, presented at the ITU Global Symposium for Regulators, Dubai, 6 Feb 2007, available at: http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR07/discussion_papers/JScott_Marcus_Interconnection_IP-based.pdf, Retrieved on 7 August 2009.

A number of questions have featured prominently in the various explorations of interconnection in an NGN world. Among them are:

- Given that interconnection regulation has not been required for the Internet, is interconnection regulation necessary at all in an IP-based NGN world?
- If interconnection regulation is required, is it relevant to only certain services? If so, which ones? Is it sufficient to apply controls to wholesale prices, or would it be necessary to also intervene in regard to retail arrangements?
- What is the proper level of wholesale payments between network operators?
- What transitional arrangements are appropriate?
    - Will the number of Points of Interconnection be reduced, and if so what are the implications?
    - Will the cost structure of the network change, and if so what are the implications?

Our expectation is that interconnection regulation will continue to be required, at least for the voice service (and SMS and MMS). As long as only a single operator can complete calls to a single phone number, the termination monopoly will persist.

Viewed from a different angle, the regulator should not take too much comfort from the fact that regulation has not been generally necessary in the Internet world. When an incumbent with market power converts its network from circuit switched technology to IP-based technology, the technical migration will not in and of itself do anything to eliminate whatever market power the incumbent previously possessed.

Most of the world uses CPNP for wholesale interconnection arrangements, as does Peru. With that in mind, we will frame this discussion in terms of the CPNP environment.

As we have seen in Section 3.1.2, the use of CPNP rests on a number of tacit assumptions. Among these are:

- That there is a fundamental and easily discerned difference between placing and receiving a call.
- That the network exists primarily to carry voice.
- That the retail service party is the same as the wholesale network operator.
- That the wholesale payment approximates the cost of call termination.

All of these assumptions are subject to considerable doubt in an IP-based world. We sketch out the concerns here, then expand on them later in this section. First, the relationship between call origination and termination in an IP world is largely arbitrary, and easily reversed or arbitraged. Second, voice becomes a relatively minor component of the cost of the network. Third, the appearance of independent third party voice operators (Skype, Vonage, SIPgate, and corresponding Peruvian VoIP operators) calls into question the assumption that the service provider and the network operator are one and the same. Finally, experience throughout the world suggests that termination fees are often well in excess of the real cost of termination, and that in the best of circumstances the cost of termination is variable over a wide range depending on the assumptions that go into the cost model.

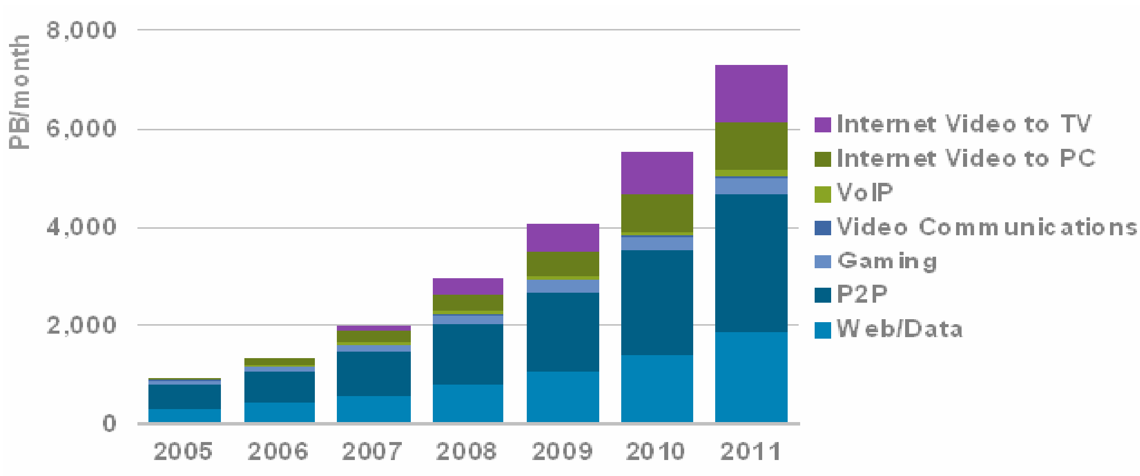
We consider these four factors in turn.

First, we note that the direction of telephone calls has long been subject to arbitrage. Years ago, it cost far more to call the US from Europe than to call Europe from the US. As a result, so called re-file schemes came into being where a European would call a service in the US that would hang up, would dial the desired number in the US on the caller's behalf, and would then call the European back, bridging the calls together and thus providing the caller with the more favorable rate from the US to Europe. Re-file schemes are not problematic; rather, they provide a "correction" to an economic distortion. They served, in this case, to correct for inflated regulated retail prices from Europe to the United States. Re-file is not new, but it is enormously easier in the Internet world.

Aside from this, it was never clear in the first place that it was appropriate to allocate all of the charges to the party placing the call, as explained in Section 3.1.1.

Second, it is abundantly clear that voice traffic will represent only a small fraction of the traffic of future networks. To the extent that this is so, it naturally calls into question the practice under CPNP of recovering the cost of the network from a single service that is largely irrelevant to network cost. Voice require a nominal 64 Kbps in each direction in the circuit switched world. With IP, there is some additional overhead (e.g. packet headers), but this inefficiency is overwhelmed by (1) the ease with which IP voice can be compressed, and (2) the avoidance of traffic when the network is silent (which is almost always more than 50% of the time, since it is rare for both parties to a conversation to speak at once. Voice can be carried effectively in as little as 8-11 Kbps. Compared to typical voice or video traffic, this is negligible. Even if all voice traffic were to move to VoIP, the contribution to network traffic would be minimal. To illustrate this point, consider a credible survey by Cisco Systems, as depicted in Figure 35. As always, the data need to be interpreted with some care, but the point is clear.

Figure 35: Total Internet traffic, by application




Source: Cisco Systems.

The appearance of third party VoIP providers puts the whole CPNP model into doubt. CPNP uses a wholesale payment between network operators to "correct" for a perceived asymmetry in retail payments. This assumes that the service provider and the network operator are one and the same, or are at least closely linked. If they are independent and unrelated parties, the payment model breaks down in ways that cannot readily be fixed.

Finally, there is the question of the appropriateness of the level of termination fees (see also Section 5.7). There is a wide range of possible interpretations of termination costs. Different regulatory authorities might employ quite different assumptions as to how much of the cost of the network can appropriately be allocated to each service that uses the network. There are real, substantive questions as to how to deal with shared and common costs. For a variety of reasons, there has been an interest in adjusting downward the interpretation of termination costs in an NGN environment. This is particularly visible in recent publications from the European Commission and the European Regulators' Group (ERG).[106]

For all of these reasons (and more), there a growing perception that CPNP arrangements may have outlived their usefulness, and there has been interest (most notably in the aforementioned ERG report) in adopting a US-style interconnection model. There is as yet, however, no overall consensus on how to proceed.

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**106** J. Scott Marcus, "IP-Based NGNs and Interconnection: The Debate in Europe", *Communications & Strategies*, Number 72, 4th quarter 2008.

## 3.4 New ideas for QoS-aware IP-based interconnection

The prevailing arrangements of the Internet, based as they are primarily on peering and transit (see Section 2.3.2.1 and Section 3.2), have shown themselves to be effective and versatile. Nonetheless, efforts to extend these arrangements to address Quality of Service (QoS) and to cover a wider set of network operators have failed to catch fire. The reasons for this are relevant to Peru, and indeed to any country where networks are evolving to Next Generation Networks:

- **Scale:** Bilateral peering arrangements will tend to be acceptable to both network operators only when the networks are of similar scale, or more precisely when both networks can be expected to be subject to similar cost drivers for carrying their respective traffic.

- **Traffic balance:** Where traffic is significantly asymmetric, cost drivers are likely to also be asymmetric.

- **Monitoring and management:** There are many practical challenges in determining whether each network operator has in fact delivered the QoS that it committed to deliver.

- **Financial arrangements:** There has been no agreement as to how financial arrangements should work. In particular, there has been enormous reluctance on the part of network operators to accept financial penalties for failing to meet quality standards.

The requirement for similar scale is to a significant degree a requirement that the volume of traffic that each network receives and must deliver, multiplied by the average as-the-crow-flies distance that that traffic must be carried (i.e. the *bit-Kilometer* product[107]) be similar. The reason for this focus on rough parity in cost drivers is that the various network operators are ultimately competing for the same end-user customers. No network will want, through its own interconnection practices, to cede an advantage to a competitor.

Relatively little data on peering is available publicly today, but ten years ago the four or five largest ISP backbones in the world typically had about fifty US-based peer networks. Obviously, not all of these networks were the same size as the largest backbones; nonetheless, the bit-Kilometer products were felt to be sufficiently similar. The tests that backbone ISPs would typically apply in determining this to be the case included:

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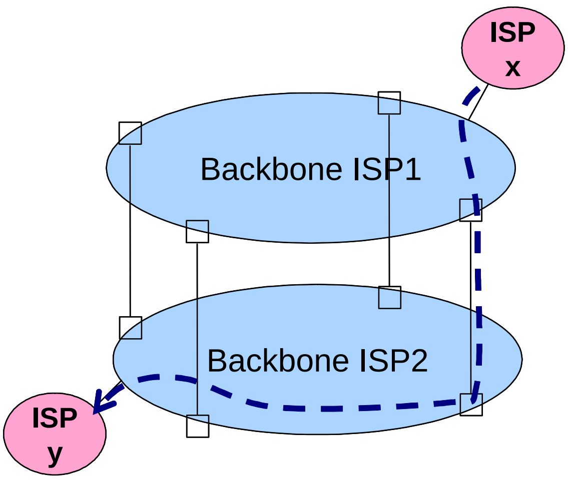
**107** See J. Scott Marcus, *Designing Wide Area Networks and Internetworks: A Practical Guide*, Addison Wesley, 1999, Chapter 14.

- Multiple points of interconnection, including points on opposite sides of the United States;
- Sufficient bandwidth interconnecting those points within each network; and
- Rough symmetry of traffic between the two networks.

To understand why these preconditions usually resulted in rough bit-Kilometer parity, it is necessary to understand *shortest exit routing* (also referred to as *hot potato routing*). NRIC V, an industry advisory body to the US FCC, explained it[108] this way:

> Consider two ISPs which span the same geographic area, and which are interconnected in multiple locations. [Figure 36] shows an example of two backbone ISPs, which are interconnected in four locations.

Figure 36: Shortest exit routing




Source: NRIC V, Service Provider Interconnection for Internet Protocol Best Effort Service, 2001

> Consider a packet originating in service provider ISPx (served by Backbone ISP1), for a destination in service provider ISPy (served by Backbone ISP2). ISPx forwards the packet to its backbone service provider, which is ISP1. ISP1 then does a normal route lookup, and finds that the destination is served by Backbone ISP2. ISP1 then forwards the packet to ISP2. With shortest exit routing, ISP1 will use the closest

**108** NRIC V, *Service Provider Interconnection for Internet Protocol Best Effort Service*, December 2001, available at http://www.nric.org/pubs/, Retrieved on 7 August 2009.

> connection to ISP2, as illustrated in figure 1. ISP2 then forwards the packet on to ISPy.
>
> In this example, the ISP whose customer is originating the packet (ISP1) needs to forward the packet for only a short distance. The ISP whose customer is receiving the packet needs to forward the packet for a greater distance. This is a common occurrence when shortest exit routing is used.
>
> If both ISPs use shortest exit routing, the paths that the packets take will not be the same in both directions, even between the same two end points.

Shortest exit routing is neither good nor bad *per se*, but it has significant technical and business implications. In particular, it implies that traffic that a network *receives* over a peering interface will, on average, be carried further (and thus imply greater cost drivers) than traffic that a network *transmits* over the peering interface. It is for this reason that some network operators refuse to peer with networks that transmit far more traffic than they receive (as will tend to be the case, for example, with networks that cater to web server farms).

*Telecom New Zealand (TNZ)*, the New Zealand incumbent network operator, recently proposed a set of technical and business arrangements that represent a fresh perspective on these issues, and that could represent a useful set of foundations for QoS-aware peering.[109] Key elements of their approach are:

- Division of New Zealand into 29 interconnection areas;
- Willingness to interconnect with any network operator of any size (without settlement payments for IP traffic) to interchange data with TNZ customers within that interconnection area, provided that the access-seeking network operator has made arrangements to get its traffic to or from the interconnection area;
- Availability of IP traffic transit arrangements from TNZ at reasonable wholesale prices to get the traffic to the desired interconnection area;
- A fair process for achieving physical interconnection within an IP interconnection area if desired;
- Two classes of services offering performance better than “best efforts”; but
- No specific penalties or payments if traffic is delivered with quality less than that committed.

**109** Telecom New Zealand Limited, *Discussion Paper: IP Interconnection*, 1 September 2008, cited with permission.

These arrangements collectively have some interesting properties. At both a technical and an economic level, there is reason to think that these arrangements are likely to prove workable.

Economists will recognize strong parallels to the COBAK (Central Office Bill And Keep) approach to PSTN interconnection put forward by Patrick DeGraba.[110] With COBAK, DeGraba proposed that there should be no call termination fees within a Central Office, but that the access seeker should take responsibility for getting the traffic to and from the Central Office, either by paying for a transit service or by building out to the Central Office. The access seeker should be free to make its own build-or-buy decision between building out versus paying transit.

Economists will also see parallels to Vogelsang (2006), which proposed the use of Bill and Keep at a local level, but *Capacity Based Charging (CBC)* for transit to the Central Office (Main Distribution Frame).[111]

At a technical level, the arrangements are reminiscent of peering agreements operating at continental scale between the largest backbones. Large U.S.-based Internet backbones tended historically to maintain separate interconnection arrangements for Europe, Asia, and North America. An Internet backbone that qualified for European peering would not gain peering access to the North American customers unless it also met criteria for North American peering. As one example, Europe, Asia and North America had distinct Autonomous System Numbers (ASNs) for UUNet and for GTE Internetworking. The technical underpinnings for such a system are straightforward and well understood.

So a system of this type is clearly workable. With that said, the key point is that it potentially addresses at least the first two key concerns about peering arrangements listed above, and possibly the rest as well.

First, it largely solves the problem of large networks refusing to peer with small ones. It is no longer necessary that an access-seeking network have a bit-Kilometer product comparable to that of an incumbent network; rather, the access-seeking network needs only to have a bit-Kilometer product comparable to that of an incumbent network *within the interconnection area*. This is in practice a much weaker constraint – so much so that TNZ is willing to peer on this basis with all access seekers without limitation.

Second it largely or completely eliminates concerns regarding traffic balance. Recall that traffic balance has been a concern largely because, under shortest exit routing, it implied asymmetries in the bit-Kilometer product and thus in the underlying cost drivers.

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**110** DeGraba, Patrick. (2000): *Bill and Keep at the Central Office as the Efficient Interconnection Regime*, in: OPP Working Paper Series, No. 33, FCC, Washington, D.C, 2000.

**111** Vogelsang, Ingo (2006): *Abrechnungssysteme und Zusammenschaltungsregime aus ökonomischer Sicht*, Study for the Bundesnetzagentur, Boston, 2006.

The TNZ system, however, is not shortest exit / hot potato; rather, it reflects *cold potato* routing. The sending network carries traffic to the interconnection point closest to the destination, not just to the interconnection point closest to the sender. Given that most technologies in the core of a network are symmetric in their traffic carrying capacity,[112] there is no longer a reason to prefer sending traffic over receiving it.

TNZ is looking to extend this model to support two classes of services beyond best efforts traffic: one suitable for real time bidirectional IP voice, the other suitable for delay-sensitive IP data. They do not, however, propose to introduce penalty payments of any form. This approach runs counter to what most experts have expected. To date, most economists have assumed that IP QoS would be supported only if network operators agreed on higher payments,[113] and on economic penalties for failure to meet targets. That assumption, however, has always begged the question: If traffic-based QoS-based payments are really essential to the system, why are they not already necessary for best efforts traffic? Phrased differently, why would it not be possible to apply the techniques already used for best efforts traffic to the interconnection of higher QoS traffic?

The insight that prompted this TNZ approach is the same one that underlies conventional best efforts peering. By definition, peering traffic between networks A and B comprises traffic between customers of network A and those of network B, Both will be motivated to ensure that their respective customers receive the performance that they expect and insist on, and conversely neither will be motivated to degrade the QoS if in doing so they risk making their own customers unhappy. Under suitable assumptions, this analysis should hold.[114] Indeed, it is perhaps surprising that QoS-aware interconnection without explicit compensation has not been attempted to date.[115]

Even in the absence of payment mechanisms or penalties, it may still be appropriate to have measurement and monitoring tools. A Russian proverb of which U.S. President Ronald Reagan was fond is apposite: “Trust, but verify.”

As regards monitoring, another relatively recent development may be useful. In 2005 – 2006, an industry Quality of Service (QoS) Working Group, hosted at MIT in the U.S., developed a comprehensive white paper on QoS. The MIT White Paper establishes targets for delay, jitter and packet loss for a service capable of supporting high quality IP voice, and also puts forward an overall methodology for measuring adherence to the

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**112** xDSL being an obvious exception at the edge of the network.

**113** See for example Laffont, Jean-Jacques/ Marcus, J. Scott/ Rey, Patrick/ Tirole, Jean (2003): “Internet Interconnection and the Off-Net-Cost Pricing Principle”, in: *RAND Journal of Economics*, Vol. 34, pp. 370-390. An exception is Vogelsang (2006), who suggests a Bill and Keep arrangement with contractual commitments on QoS.

**114** See however Crémer, Jacques/ Rey, Patrick/ Tirole, Jean (2000) : “Connectivity in the Commercial Internet”, in: *Journal of Industrial Economics*, Vol. 48, pp. 433-472.

**115** Moreover, this idea has been toyed with for a long time.

targets.[116] We would inject a word of caution at this point: substantial work would be needed to reduce the MIT White Paper to practice. Nonetheless, this is a solid and workmanlike document that could provide a good foundation to a QoS measurement methodology.

Having discussed at length what the TNZ document covers, it is important to note what it specifically does not address. The TNZ document provides a comprehensive and probably workable approach to IP-based interconnection suitable for carrying bidirectional IP voice traffic (and also delay-sensitive IP data traffic). It does not discuss the voice service itself, and specifically does not commit to link this service to the inherent voice services carried by TNZ. Whether they would be linked, and whether there would be fees akin to conventional termination fees associated with that linkage, is presumably a distinct topic for negotiation.

Nonetheless, the TNZ approach should be viewed as a promising step forward. By decomposing the IP-based voice interconnection problem (with QoS assurance) into two pieces, and offering a practical methodology to deal with the first of the two, they may well have brought the problem as a whole substantially closer to solution.[117]

## 3.5 The network neutrality debate as networks evolve to Internet Protocol

This section considers Network Neutrality in the context of the migration to IP-based NGNs. It responds to the following requirement in the procurement document:

- Description of potential quality problems and possible solutions within the interconnection framework for NGN, considering factors that operators need to take into account to interconnect their networks (quality parameters and indicators, service level agreements ) as well as factors that are subject to supervision by the regulatory authority aiming at maintaining the quality of services provided. A proposal of a set of quality indicators based on the description provided.

In switched networks, interconnection quality has rarely been an issue. Either a voice circuit connection can be supported, or it cannot. The call can be refused, but once initiated, the quality will be satisfactory.

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**116** MIT QoS WG, "Inter-provider Quality of Service", White paper draft 1.1, 17 November 2006, available at: http://cfp.mit.edu/publications/CFP_Papers/Interprovider%20QoS%20MIT_CFP_WP_9_14_06.pdf, Retrieved on 7 August 2009.

**117** Through the first quarter of 2009, all indications were that the TNZ approach would achieve a consensus among New Zealand network operators. Recent reports indicate that this consensus has broken down for reasons largely unrelated to the quality of the proposal.

Internet Protocol was designed to support packet-based communication among delay-tolerant applications such as email. It was not designed for delay-sensitive applications, such as real-time bidirectional voice (which depends on delay rarely exceeding about 150 milliseconds round trip time). Later enhancements were introduced into the IP protocol family in the eighties and nineties to provide assurance of Quality of Service (QoS) on a statistical basis in order to support delay-sensitive traffic such as voice, and these are widely implemented *within* networks; however, they have rarely been implemented *between* networks.

The reasons for the lack of deployment have nothing to do with the technology, which has been sufficiently mature (more or less) for at least ten years. The reasons are primarily economic, and are typical of new capabilities in an environment characterized by strong network externalities and high transaction costs.[118]

In recent years, there have been concerns (primarily in the United States) that network operators might intentionally provide less-than-adequate QoS to their customers. This has been a particular concern where a broadband ISP might favor affiliated applications, content, or devices over unaffiliated ones. The reason that this has emerged in the US is that the market for broadband services has consolidated such that very few Americans have more than two realistic choices for broadband providers; consequently, the broadband ISPs have at least duopoly market power, if not an outright monopoly. Under these circumstances, one could reasonably expect that they would find it profitable to exercise *economic foreclosure*, which is to say that they would attempt to project their market power into upstream or downstream market segments that would otherwise be competitive.

The Obama Administration has indicated a strong interest in promoting law or regulation to prevent this kind of anticompetitive discrimination. In the US, this may be the appropriate response.

The authors of this report are of the opinion that a better approach, in countries where it is feasible, would be to ensure more competition in the underlying broadband markets, thus nipping this problem in the bud. A regulatory approach is likely to have difficulty distinguishing between healthy price and quality discrimination – which, in the absence of market power, would tend to enhance societal welfare – and anticompetitive discrimination, which is likely to negatively impact consumer welfare and overall societal welfare.[119]

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**118** See e.g. J.H. Rohlfs (2001): *Bandwagon Effects in High-Technology Industries*, MIT Press Cambridge (Mass.), and J. Scott Marcus (2004): “Evolving Core Capabilities of the Internet”, *Journal on Telecommunications and High Technology Law*, 2004, available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=921903, Retrieved on 7 August 2009.

**119** J. Scott Marcus (2008): Network Neutrality; The Roots of the Debate in the United States”, in *Intereconomics*, Volume 43, Number 1, January/February 2008. See also Kenneth R. Carter, J. Scott Marcus, and Christian Wernick, *Network Neutrality: Implications for Europe*, WIK Discussion Paper 314, December 2008, available at: http://www.wik.org/content/diskus/Diskus_314.pdf, Retrieved on 7 August 2009.

This view is bolstered by the observation that the Network Neutrality debate has been at most a minor annoyance in Europe. European regulation has led to a broadband marketplace that is, in our view, far more robustly competitive than that of the United States (despite the relative lack of cable television as a competitor). Moreover, European regulators have a far better palette of options for dealing with abuse should it arise.[120]

We provide recommendations on Network Neutrality in Section 5.10.2.

## 3.6 Chapter Summary

The economics of interconnection in switched networks has been dominated by the analysis of voice telephony. Retail arrangements today tend to be either *Calling Party Pays (CPP)*, where the party that places the call pays per minute, and the receiving party pays nothing; or else some form of *flat rate*, where the user pays a fixed monthly fee for all calls (up to some maximum number of minutes).

Wholesale arrangements are typically based on *Calling Party's Network Pays (CPNP)*, where the network of the party that placed the call (the *originating network*) makes a wholesale payment to the network of the party that received the call (the *terminating network*). CPNP suffers from the defect that the terminating network possesses a form of market power (the *terminating monopoly*) that enables it to charge fees at wholesale that are well in excess of true usage-based marginal cost. Regulation can mitigate this problem, but regulators rarely force network operators to charge a termination fee that is sufficiently low.

Inflated termination fees are usually associated with inflated retail prices; with a tendency to exclude calls to off-net mobile operators from flat rate retail plans; and from a substantial reduction in the number of calls placed. On the positive side, they tend to encourage mobile penetration (possibly at the cost of fixed penetration), which is an important benefit in a country like Peru.

IP-based Internet interconnection is based primarily on forms of *peering* and of *transit*. Voluntary commercial arrangements usually work satisfactorily; very few countries have found it necessary to regulate IP interconnection.

Experience throughout the world is the conversion of the network core from switched telephony to an IP-based NGN does not automatically result in evolution of interconnection arrangements from circuit switched SS7 to IP-based interconnection. Small VoIP service providers tend to prefer IP-based interconnection to one another, as

**120** Ibid.

do some cable television operators, but most fixed and mobile operators remain with traditional interconnection long after they convert their respective core networks.

For IP interconnection, certain applications (primarily real time two way voice) would benefit from strong assurances of the quality with which the IP data is to be delivered. The technology to assure Quality of Service (QoS) has existed for a decade, and is widely implemented *within* networks, but very rarely *between* networks. Voice is likely to represent only a small fraction of the traffic of most IP-based networks; thus, if QoS were used primarily for voice, QoS assurance would have relatively little impact on cost.

Efforts have been under way in New Zealand to establish interconnection among all market players that can support a level of QoS suitable for IP-based voice. Telecom New Zealand (TNZ), the incumbent, would offer IP interconnection free of charge within each of 29 service areas (local peering). This is a novel and promising approach. It is potentially relevant to Peru.

The issue of Network Neutrality takes on particular urgency as voice telephony migrates to an IP basis. There are concerns that network operators with market power might intentionally favor affiliated traffic over unaffiliated traffic (e.g. traffic to competing VoIP service providers). Given that communications markets in Peru are fairly concentrated, this could be a significant concern.

# 4 The migration to NGN

This section reviews the migration path being taken by market players in various countries, and reviews in some depth the particular regulatory measures that should be considered while the migration from circuit switched networks to IP-based NGN networks is under way. It seeks to respond to the following requirement in the procurement document:

- Operators' migration schemes to a NGN networks, considering steps that operators should follow until achieving the final interconnection using NGN (preparation, critical points in the network and migration procedures to be considered, recommended tests), so that migration does not affect the quality of service provided to end users, nor does it affect interconnection relationships with non-NGN networks.

## 4.1 Global experience

This section reviews NGN build-out plans and experience in a range of developed countries around the world. Section 4.1.1 addresses different technical approaches to NGN migration, while Section 4.1.2 describes the different routes that have been concretely followed in different countries. Section 4.1.3 explores the challenges that are unique to the transition period to NGN.

### 4.1.1 Different technical routes to NGN

In many countries, market participants are migrating their traditional networks to "new" NGN networks. This relates both to architecture and topology of the network. From a technical perspective, one can distinguish among a range of different cases based primarily on the specific market participants that are deploying new technologies:

- Telecommunications network operators;
- Cable operators;
- Mobile carriers; or
- Internet Service Providers (ISPs).

Basically, three cases can be distinguished indicating the main focus of the activities among telecommunications network operators to date:

- Case I: Focus on activities in the local loop, i.e. deployment of deep fibre: FTTC/VDSL technology, deployment of FTTB/H technology; migration to

NGN/IMS technology “later” (in the short-/mid-/long-term); usual prerequisite: deployment of fibre in the core and concentration network already finalized. Developments in Germany, and in many other European Member States, generally follow this pattern.

- Case II: Focus on activities in the core/concentration network; deployment of fibre in the core and concentration network, migration to IP as the unique transport protocol; focus on activities in the local loop “later”. Developments with BT in the UK, and with Telecom Italia in Italy generally follow this pattern.

- Case III: Focus on activities both in the local loop and in the concentration/core network. KPN in the Netherlands follow this pattern.

We consider the relative merits of these approaches, and the factors that motivated different operators to prefer one over the other, in Section 4.1.2.11 (after having reviewed developments in a range of countries around the world).

#### 4.1.1.1 Different market players, different strategies

The migration to NGN is not solely the province of traditional telecommunications market players. Other market players often follow a somewhat different evolutionary path, inasmuch as they do not have legacy telecommunications infrastructure to deal with. Often, their evolution is less centralized, more strongly Internet-oriented, and more oriented toward distributed intelligence and control. We see this trend in various sectors:

- **Incumbent with voice services:** The migration to NGN is motivated by the desire to reduce operating expense by integrating voice and data operations, and to offer new services. Different network operators have migrated in different ways, depending on a range of factors (see Section 4.1.1.2).

- **Cable operators:** Traditional cable networks are point-to-multipoint cable networks optimized for providing broadcasting services. The traditional cable networks are based to a large degree on copper-coaxial infrastructure. Over the past decade, cable networks all over the world have been upgraded to enable two-way communications and to provide broadband IP based services. One requirement is to replace at least a portion of the copper coaxial infrastructure between head ends and the end users with fibre, and thus to bring fibre closer to the end user (*Hybrid Fibre Coax (HFC)* infrastructures). Another requirement is to enlarge the frequency range to higher frequencies (e.g. up to 862 Hertz in Germany). With these changes, cable becomes an effective platform for triple play (voice, video and data over a single physical interface).

- **Mobile network operators:** Higher bandwidth has become available thanks to new technologies: e.g. the migration from GSM/GPRS/EDGE to UMTS/HSPA technologies with LTE looming on the horizon. Likewise, there has been a steady growth of usable capacity in the CDMA world. Thus, technical progress in mobile networks has mainly been focused in the access network. However, in order to be able to provide these higher bandwidths and "Mobile Internet" solutions, mobile operators need to also deploy "better" infrastructure, usually based on fibre, to access the base stations. Backhaul bandwidth is key.

  Many network operators, in particular the telecommunications incumbents, are operating both a mobile and a fixed line network. Historically, these networks rest on different physical and logical facilities. Yet, in the mid- and long term perspective the mobile backbone network and the fixed-line backbone network are likely to be merged into a single multi-service network platform, i.e. into an IMS based infrastructure.

  There is still debate over the degree to which mobile infrastructure represents an economic *substitute* for fixed broadband to the home. For reasons of cost and scalability, it is more likely an economic *complement* in densely settled areas.

- **Internet Service Providers (ISPs):** ISPs are also achieving network-related technical progress. Technical enhancements include increased emphasis on network reliability, security and robustness. Typically, these networks already make internal provision for differentiated Quality of Service (QoS). One might also hope for increased reliance over time on the next version of the Internet Protocol (IPv6), and for deployment of QoS capabilities between ISPs, but deployment experience continues to lag.

#### 4.1.1.2 Migration strategies for an incumbent with voice services

The evolution to an NGN varies greatly depending on the scope and the strategy of the deployment. It therefore has a significant impact on the overall cost reductions that the operator could expect.

As previously noted, NGN migration is approached somewhat differently in different sectors. This section of the report focuses on the alternative migration paths for a fixed incumbent network operator with voice services.

In this context, one can identify four principal migration scenarios:

- Transit replacement (Section 4.1.1.2.1);
- Transit and aggregation replacement (Section 4.1.1.2.2);

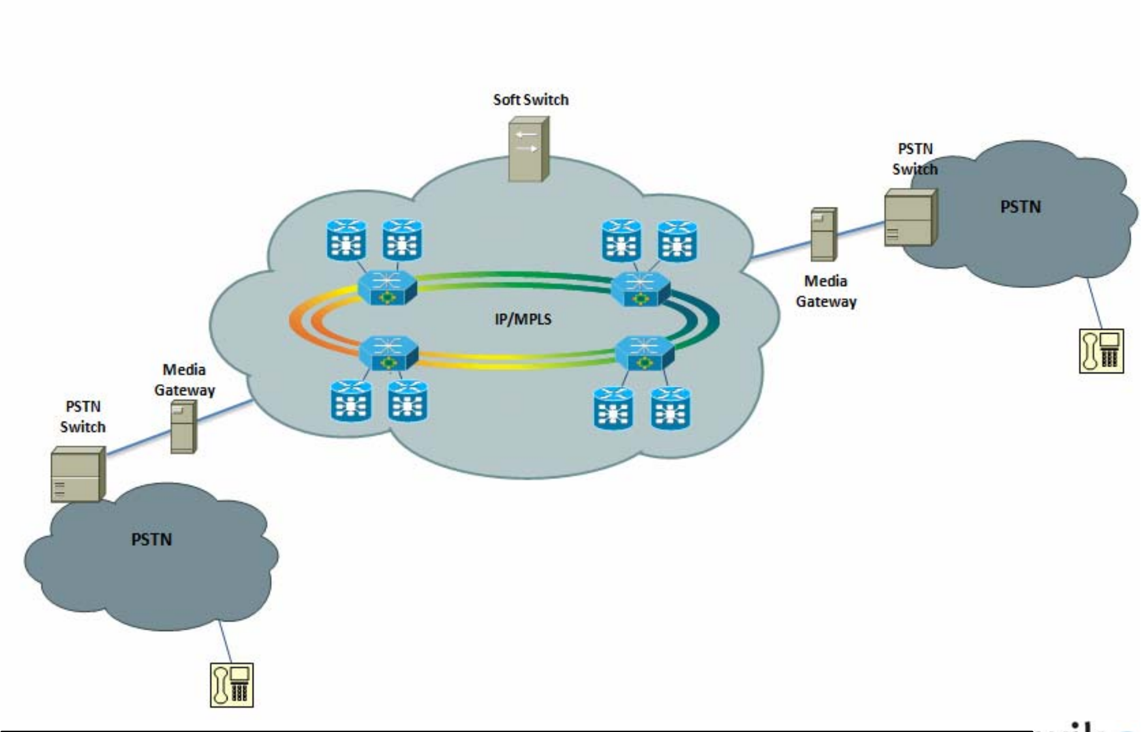
- Overlay network (Section 4.1.1.2.3); and
- Full replacement (Section 4.1.1.2.4).

The remainder of this section of the report considers those four alternatives in turn. It concludes by comparing and contrasting them in terms of advantages and disadvantages for the network operator (Section 4.1.1.2.5).

#### 4.1.1.2.1 Transit replacement

In this scenario, NGN technology is used in the core of the network and replaces the transit part of the PSTN network, as shown in Figure 37. The scope could be national and/or international.

Figure 37: Transit replacement migration




Source: WIK-Consult.

In this scenario, Media Gateways need to be installed to enable interconnectivity between the IP network and the PSTN. These media Gateway are managed by Soft Switches through the MGCP protocol.

This solution has comparatively low complexity. The objective is cost reduction for national and/or international calls. The routers deployed to the core of the network tend to have price/performance characteristics that are greatly superior to those of the switches that they replace; consequently, there tends to be a net savings in operating expense, even when the costs of transition (including the deployment of media gateways) are considered.

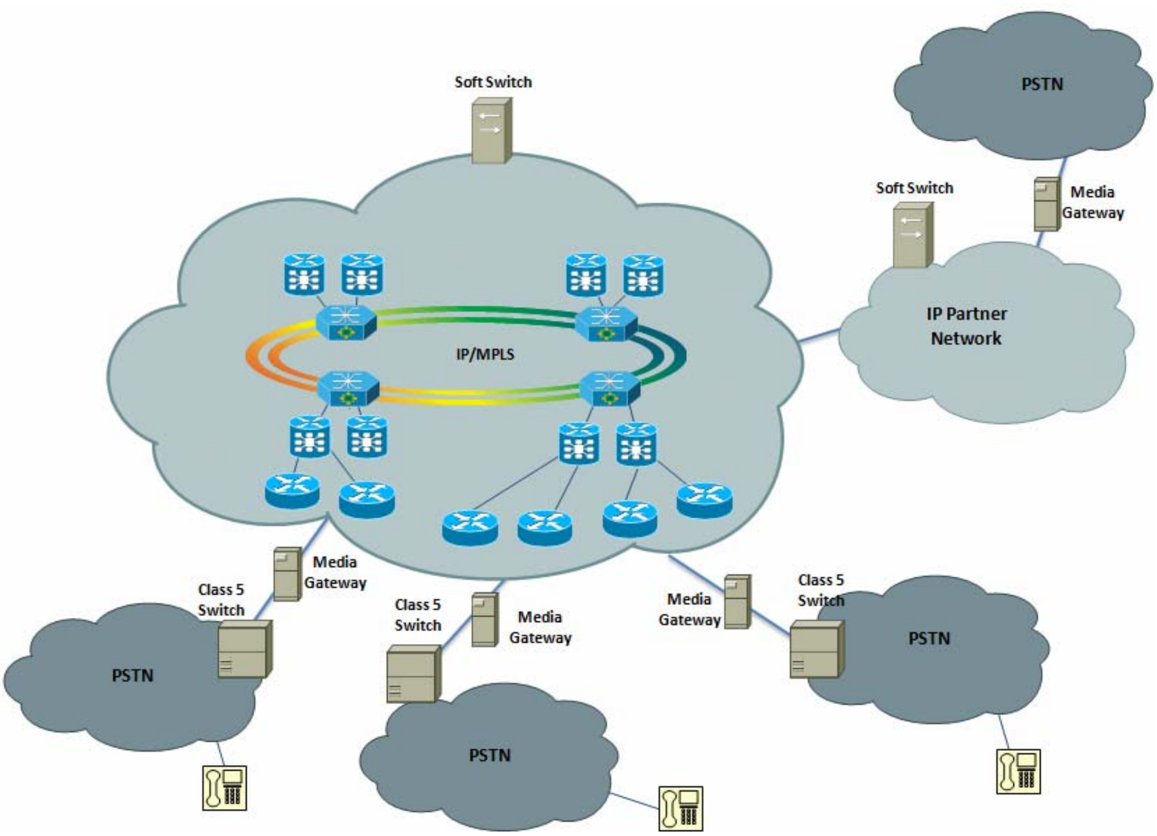
#### 4.1.1.2.2 Transit and aggregation replacement

In this scenario, the network operator aims at offloading the PSTN traffic into a NGN infrastructure while retaining the traditional access network. It is similar in concept to the Transit Replacement described in Section 4.1.1.2.1, but NGN technology is deployed closer to the edge of the network.

This is the solution that was implemented by Telecom Italia in 2002. A number of incumbent operators are implementing this migration model.

As in the previous scenario, In this scenario, Media Gateways enable interconnectivity between the IP network and the PSTN.

Figure 38: Migration by transit and aggregation replacement




Source: WIK-Consult.

This NGN network could interconnect to another network at the IP level, in which case Soft Switches would provide the voice signaling support.

The advantages and disadvantages are analogous to those of transit-only replacement, except that more infrastructure is replaced. The cost is thus higher, but savings could be correspondingly greater.

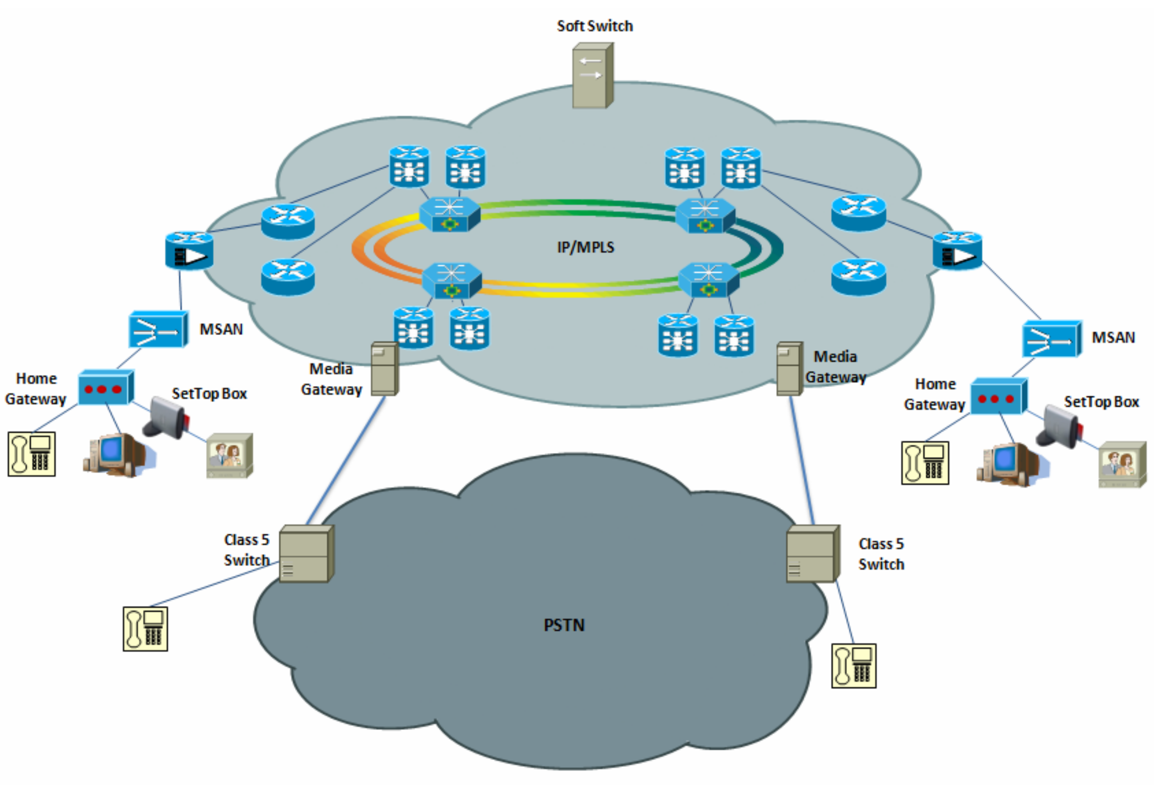
One could thus envision a natural evolutionary path, where an operator initially replaces the transit in the core, then the aggregation network, and subsequently the access network and the end-user devices at the edge of the network (thus progressing through the Overlay Network or Full Replacement scenarios described in Sections 4.1.1.2.3 and 4.1.1.2.4, respectively). In practice, the migration is usually more complex.

#### 4.1.1.2.3 Overlay Network

In this scenario, the operator deploys a parallel IP-based NGN network that provides its own set of services through its own set of access technologies. The IP-based network is not dependent on the PSTN. This solution is particularly compelling for traditional operators who need to develop value-added services while continuing to protect the PSTN revenue stream.

In this case, the NGN overlay network provides new value-added services, while the PSTN continues to provide basic voice services. The two networks interconnect by means of Media Gateways in order to provide interoperability.

Figure 39: Overlay migration




Source: WIK-Consult.

If the NGN overlay network has a sufficiently geographic deployment, it could be used to offload some or all of the transit traffic from the PSTN. Thus, this approach could evolve into the Transit Replacement strategy, or for that matter into the Transit and Aggregation Replacement strategy.

The immediate thrust of the Overlay Network strategy is to generate new revenues by offering new services. It is not primarily a cost reduction strategy, although it can be combined with other strategies that reduce costs.

#### 4.1.1.2.4 Full replacement

In this scenario, the network operator seeks to provide a fully integrated IP-based access to the subscriber. This solution allows for the end-to-end IP services delivery (provided that the user has IP-enabled devices). Ideally, the last mile access to the customer would be IP-based as well, and would connect to an IP-based telephone device at the customer premises.

This is a very complex proposition. For that reason, this solution is not yet common. Few network operators have taken this path.

With Full Replacement, a network operator would replace its local PSTN switches by Soft Switches. In practice, customers depend on a wide range of capabilities as part of the voice service. To satisfy these customer needs, not only the traditional voice services need to be preserved, but also value-added services such as 800 numbers, voice messaging, call waiting, and so on.

This solution potential offers the best economies of scale and scope that could be achieved through NGN migration. It is thus the desired end state; however, it is also the migration approach with highest cost and highest complexity.

#### 4.1.1.2.5 Comparison of different migration strategies for incumbents with voice services

The costs and benefits of each migration strategy were discussed in each of the preceding sections. Sums up the results.

Table 8: Strengths and weaknesses of incumbent voice operator migration strategies

| Strategy | Section | Cost | Complexity | Benefits | Limitations |
|---|---|---|---|---|---|
| Transit replacement | 4.1.1.2.1 | Fairly low | Fairly low | Cost savings, with least investment. | Provides no new services. |
| Transit and aggregation replacement | 4.1.1.2.2 | Moderate | Fairly low | Greater cost savings, with greater investment. | Provides no new services. |
| Overlay network | 4.1.1.2.3 | Fairly high | Moderate | Enables new services. | Does not (by itself) reduce costs. |
| Full replacement | 4.1.1.2.4 | Very high | Extremely high | Enables new services, and achieves maximum cost savings. | Greatest investment, and greatest complexity. |

### 4.1.2 Different paths in different countries

This section provides a summary of Next Generation Network evolution in a number of countries: The United Kingdom (Section 4.1.2.1), the Netherlands (Section 4.1.2.2), Germany (Section 4.1.2.3), Finland (Section 4.1.2.4), France (Section 4.1.2.5), Italy (Section 4.1.2.6), South Korea (Section 4.1.2.7), Australia (Section 4.1.2.8), Singapore (Section 4.1.2.9), and the United States (Section 4.1.2.10). Note that the approach to NGN cost modeling in different countries is covered not here, but rather in Section 5.7.10.

Section 4.1.2.11 then provides a comparative summary of the results, and seeks to explain why network operators (especially incumbents) in certain countries preferred one approach to NGN roll-out over another. In particular, we conclude that NGN incumbents that were far more likely to focus on NGN access if they were under strong last mile competitive threat. In the absence of such a threat, they would tend to focus first on NGN core upgrades as a means of trying to reduce or conserve operating expense (OPEX).

A common theme that has just emerged in nearly all of these countries is government funding for the roll-out of broadband to households, both to raise available broadband speed and as a means of achieving universal service for broadband. Government funding for broadband has taken on particular urgency as a response to the financial crisis of 2008-2009. Given that there is a need to stimulate employment, there is a recognition that broadband build-out provides a way to do so that is likely to provide long term benefits to the broader economy.

At the same time, there are enormous differences among these broadband stimulus programs. Even in Europe, there are quite substantial differences from on Member State to the next, and no clear consensus yet as to what fraction of the population and the national territory should be covered, at what speed, with what technologies (e.g. fixed or wireless), and how quickly.[121]

#### 4.1.2.1 The United Kingdom (UK)

As to the migration to NGN in Great Britain, several separate elements can be distinguished.

Element no. 1 is characterized by British Telecom (BT) announcing its intent to migrate its entire network to an IP-based Next Generation Network, the 21st Century Network (21CN)[122]. This announcement was made in 2004. The 21CN was envisaged to be a single IP and DWDM-based network that will carry both voice and data[123]. In most respects, the technology that they intend to use (Dense Wave Division Multiplexing [DWDM], DiffServ, MPLS traffic engineering, and VoIP) is straightforward, mature and unadventurous. At another level, the initiative was rightly seen from the first as breathtaking, primarily for its scope. A rapid roll-out was envisioned for 21CN, coupled with a complete replacement of BT's PSTN operations in the UK. The actual pace of deployment has been notably more mellow. BT hopes that the 21CN evolution will enable them to (1) transform the customer experience, (2) accelerate time-to-market for new services, and (3) eliminate about a billion British pounds per year in operating expense.

Element no. 2 is characterized by a specific reorganization of activities within BT. This reorganization mirrors facets of the regulation of the British incumbent operator. Indeed, the UK regulatory discussion entails an element that so far is nearly unique in European regulation (although the European Commission has proposed to make it a standard regulatory remedy): a set of agreements or undertakings between BT and Ofcom to largely separate BT's wholesale operations from its customer-facing retail operations, and to ensure that BT cannot discriminate against its wholesale customers (who are

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**121** Cf. Viviane Reding (European Commissioner, Information Society and Media), “Digital Europe – Europe's Fast Track to Economic Recovery”, a speech delivered 9 July 2009: “The French government, with its plan France Numérique 2012, is pursuing the objective to equip all French households with an internet connection of at least 512 Kbit/s by the end of 2012. In the UK, Lord Carter told us, in his ambitious Digital Britain report, that the government sets the objective to serve all British households by broadband networks of at least 2 Mbit/s by the end of 2012, eased by the creation of a Next Generation Fund. In Germany, the federal government, in its Breitbandstrategie, calls for connections of 50 Mbit/s to serve 75% of the population by 2014. Finland has even committed to a universal broadband service at 100 Mbit/s. These are examples of countries who got their priorities right. They all have recognised the need for boosting the digital economy.”

**122** BT’s plans are extensively documented in various public documents, starting with their web site, at http://www.btplc.com/21CN/index.htm, Retrieved on 7 August 2009.

**123** See: http://www.btglobalservices.com/business/global/en/business/business_innovations/issue_02/century_network.html, Retrieved on 7 August 2009.

also its retail competitors)[124]. This is discussed in detail in Section 4.2.2.1.3 of this report.

Element no. 3 consists of BT announcing in July 2008 its plans to invest £1.5bn in Next Generation Access networks over five years, of which £1bn was incremental to planned investment. Their announcement promised delivery of download speeds up to 40Mb/s to 10m homes by 2010. BT has stated that the deployment will involve a mix of fiber-to-the-home and fiber-to-the-cabinet solutions. This investment was identified as contingent on certain regulatory decisions, such as the rate of return on capital and rules on network access for BT's competitors.

Element no 4 relates to the report "Digital Britain", with an interim report published by the British government in January 2009 and final report in June 2009.[125] This report contains more than 20 recommendations with regard to the future of society and economy in the context of the proceeding digitization of every day life. The focus of several of these strategic recommendations is on broadband (access) infrastructures, like e.g.:

- Establishment of a working group headed by the government to develop measures for the maximization of commercial broadband roll-out.
- Removal of barriers of access to ducts and comparable "primary" infrastructures.
- Requiring users of fixed lines to pay 50 pence per month to fund deployment of next generation broadband (of whatever technology, under a reverse auction mechanism) to areas where commercial deployment is not occurring.
- Preparation of a universal service obligation, which ought to comprise bandwidths of up to 2 Mbit/s by 2012, as well as an analysis of financing options.
- Substantial liberalization of spectrum management.

In light of this report, there is currently a broad public debate about the costs of a national fiber roll-out and options for operating models. Parallel to this, BT underlines that regulatory conditions have to be favorable in order to make the business case for the respective investments viable. In March 2009, the UK regulator Ofcom has

**124** See: http://www.ofcom.org.uk/media/news/2005/06/nr_20050623, Retrieved on 7 August 2009, and: http://www.ofcom.org.uk/consult/condocs/telecoms_p2/statement/main.pdf, Retrieved on 7 August 2009,
See also: Ofcom, 2005a.

**125** See Department for Culture, Media and Sport and Department for Business, Enterprise and Regulatory Reform (2009): „Digital Britain- The Interim Report"; January.

announced that providers of wholesale 'super-fast' broadband services, principally BT, will be free to set prices without any regulatory intervention.[126]

Much of the impetus for NGN interconnection in the UK has shifted to the *NGNuk*. NGNuk is an independent NGN industry body that enables discussion, research, and where possible agreement on the direction for NGNs in the UK. It is part of a constellation of industry bodies with somewhat overlapping functions, including Consult 21 and the NICC

NGNuk has drafted a series of document on end-to-end service requirements, interconnection service requirements, and charging principles and mechanisms.[127] The documents are interesting, but they are very preliminary. It is also important to bear in mind that they represent the views of a body comprised of network operators and service providers whose interests are not necessarily fully aligned with those of the general public.

#### 4.1.2.2 The Netherlands

The migration to NGN in the Netherlands can be viewed as comprising two distinct phases.

Phase 1 saw the incumbent (KPN) announcing its intention to migrate to an ALL-IP network. Although this migration covered both access/concentration and core network aspects, the main public discussion in the Netherlands rested on the former. The crucial point was in particular the envisaged rapid phasing out of existing access arrangements in favor of FTTC/VDSL deployments. The migration was to be funded in large part by revenues generated by selling central offices (Main Distribution Frame locations) that would no longer be needed. Much of the discussion in the Netherlands has centered on this drastic proposed reduction in the number of access locations, and on its implications in terms of stranded investment (see Section 4.1.3.1) on the part of alternative operators. KPN's current (TDM based) network infrastructure in the Netherlands consists of about 28,000 street cabinets and about 1,350 Main Distribution Frames (MDFs). KPN's All-IP network was to consist of five distinct network layers: the access network (local loop), the metro access network, the metro core network, the backbone, and the IP-Edge network.

The original network deployment plan comprised the following features: the existing copper loop between the cabinet and the Main Distribution Frame (MDF) would be

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**126** See UK government, "Digital Britain: Final Report", June 2009; Ofcom, "Delivering super-fast broadband in the UK: Setting the right policy framework", 23 September 2008; and Primetrica GlobalComms Database, March 3 2009.

**127** See http://www.ngnuk.org.uk/122.html, Retrieved on 7 August 2009, and http://www.ngnuk.org.uk/75.html, Retrieved on 7 August 2009.

replaced or overbuilt by fibre. The number of street cabinets would remain constant at about 28,000, but street cabinets would now contain new devices, NG-DSLAMs, that would provide voice, video and data in an integrated way (thus becoming Multi-Service Access Nodes [MSANs]). The street cabinets would be linked to presumably fewer than 200 Metro Core Locations (MCLs) placed at former MDF locations. The remaining roughly 1,150 MDF locations would no longer be needed. KPN intended to close down the former MDF locations and to sell the real estate in order to fund the transition.

Much of this planned deployment was, however, put on hold. First, a cost modeling study performed by Analysys on behalf of OPTA (the Dutch regulator) called into question whether competitors could survive solely on the basis of unbundled local sub-loops at the level of the street cabinets once the MDFs were gone. Second, OPTA was concerned that competition in the fixed network could be severely impacted if the not-yet-fully-depreciated investments that competitors had made in accessing KPN facilities were abruptly rendered ineffective (i.e., if competitors' investments were "stranded", as described in Section 4.1.3.1). These concerns led to regulatory delays.

In parallel with KPN's All-IP plan, many local and regional ventures in the Netherlands were initiating the deployment of fiber optic infrastructure up to the building or even to the home (FTTB/H). Although in each case usually one or more local entities were involved there was one player, called Reggefiber, which was active in many of these ventures.

Phase 2 in the Netherlands is characterized by KPN purchasing a 41% stake in Reggefiber in late 2008 (with a call option on a majority stake). This represents a substantial change in direction, with increased emphasis on FTTB/FTTH. The joint venture will e.g. roll out fiber in Amsterdam and Almere (100,000 and 40,000 connections). The joint venture meanwhile has gained approval by the Dutch cartel office. An essential factor for the activities of this joint venture is the regulatory certainty OPTA gave by its decisions (end of 2008), i.e. the draft policy rules regarding the regulation of unbundled fiber access.[128]

KPN describes its approach to FTTB/H as "cautious".[129] The main goals of this strategy are regaining lines from cable operators, raising ARPU, and raising customer life time value.

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**128** See Bos, R. (2009): „Access pricing: a key element in effective NGN Access regulation", presentation at the WIK NGAN Conference, Berlin, March 24.

**129** See Huigen, J. (2009): „Fiber to the home in The Netherlands", presentation at the WIK NGAN Conference, Berlin, March 24.

#### 4.1.2.3 Germany

The NGN migration plans of the incumbent Deutsche Telekom in Germany comprise both access/concentration and core network aspects. It is, however, fair to state that with respect to the timeline the former is oriented towards the short and medium term whereas the latter is focusing on the middle and longer term.

Indeed, the German discussion in the past years has centered on the question of access arrangements in a future NGN based on FTTC/VDSL deployment. In Germany, rather short average loop length to the customer (below 400 m) makes VDSL a very workable technical proposition. Interconnection has also featured prominently in the German discussion. These access arrangements enable a drastic reduction in the number of Points of Interconnection (PoIs).

DTAG's current network consists of about 7,900 Main Distribution Frames (MDFs) which are entirely accessible on the basis of fiber, and about 290,000 street cabinets. This corresponds to approximately 40 cabinets per MDF. In Germany, the average number of access lines per cabinet is less than 200. DTAG's biggest competitors currently have access to about 3,000 MDFs, representing a coverage of 70 to 80% of the German population.

In 2005, DTAG announced plans to deploy fiber between the MDF and the street cabinet (FTTC), and to install VDSL solutions. Geographically, the company wanted to focus these deployments on densely populated areas. As of end of 2008, DTAG has deployed FTTC/VDSL infrastructure in about 40 cities, and ADSL 2+ infrastructure in about 1,000 cities. The goal of DTAG’s VDSL plan is to deploy the respective fiber infrastructure in 50 towns and cities. Thus, DTAG claims that overall 20 mill. households (slightly more than half of the overall number of households in Germany) will have DSL based high-speed broadband access. The overall investment budget for the VDSL/FTTC fiber deployment is 3 billion Euro.

The crucial point with regard to this deployment is, however, the following: DTAG committed to make those investments only if the German government were to provide a "regulatory holiday" from the obligations to which DTAG would otherwise be subject to offer wholesale services to competitors at regulated prices based on the new VDSL capabilities. DTAG has argued that its investment warrants protection from regulation because "new products" like IPTV are offered over VDSL. These developments are discussed in Section 4.2.2.2 of this report.

Regarding its core network, DTAG aims at migrating all of today’s (sub-)networks to a generic IMS (IP Multimedia Subsystem) platform. DTAG is, however, very reluctant to publish actual information on this migration plan.

Several other market participants in Germany have migrated (in some cases already all of) their network infrastructure to IP. Examples are the German subsidiaries of the incumbents in Spain (Telefónica) and the UK (BT).

In the past several local and regional ventures in Germany have initiated projects focusing on the deployment of FTTB/H infrastructure. From a geographical perspective, these ventures not only concentrate on the big metropols in Germany (e.g. Hamburg, Munich, Cologne), but also on medium and small sized cities and counties.

From a regulatory perspective there are several crucial issues which are hotly debated in Germany today: (1) deciding on the (wholesale) prices for access to VDSL infrastructure; (2) laying the (competition policy and regulatory) foundations for a cooperation between network operators (incumbent and competitors) that are willing to deploy FTTB/H infrastructure; (3) shaping an "open access" regime for access to fiber.

As in many other countries, also the government in Germany has launched a stimulus package where one particular focus is on broadband infrastructure deployment. The respective targets of the stimulus program are (as of February 2009):

- Gaps in the current broadband penetration are to be eliminated and broadband access should be made available nationwide by the end of 2010.
- A total of 75 percent of households are to have Internet access with transmission rates of at least 50Mbps by 2014. This level of high-speed broadband access is to be rolled out nationwide as quickly as possible.

#### 4.1.2.4 Finland

The migration to NGN in Finland currently concentrates on access network migration. The Finnish government passed a far-reaching national broadband project in December 2008. It applies a two stage approach. All private permanent residences and business users should have access to broadband connections with downstream rates of at least 1 Mbit/s by the end of 2010. This transfer rate will be classified as a universal service obligation. By the end of 2015, fiber or cable networks enabling speeds of 100 Mbit/s are designated to be rolled-out in such a manner that 99% of the population will have be no further than two kilometers from a point at which they can interconnect to these networks. End-users will have to pay for their connections to the network; however, this enables the end-user to make a rational decision between fixed and wireless last mile access.

Up to one third of the cost of broadband roll-out will be provided by the central government if market solutions are lacking.[130] Between 2010 and 2015 a sum of up to 66 million EUR is designated for this task. The refunding of this sum is supposed to happen by auction revenues and compensatory payment revenues of telecommunications operators in the timeframe between 2010 and 2015. In addition to furthering supply, financial incentives for end-users are also planned. End-users who install and operate broadband access are supposed to receive tax advantages.

#### 4.1.2.5 France

The French government launched its plan “France Numérique 2012” in October 2008. It is part of this plan to assign the right to each French household to have access to broadband Internet with transfer rates of at least 512 kbit/s for a maximum monthly fee of 35 EUR.

#### 4.1.2.6 Italy

NGN and NGA roll-out in Italy is driven by two companies, the incumbent Telecom Italia (TI) and its largest competitor Fastweb (a subsidiary of the Swiss incumbent Swisscom).

Telecom Italia quietly converted its core network to an IP-based NGN some years ago.

TI announced its plans for the Next Generation Access Network (“NGN 2”) in March 2007. Its main elements are:

- Implementation of an All-IP network;
- Deployment of deep fiber in the local loop with a mix of technologies, comprising FTTCab and FTTB solutions (especially in main cities);
- Installation of VDSL2 technology aiming at a coverage of up to 65% of the population;
- A total project Capex of around 6.5 billion EUR.[131]

Fastweb’s network comprises about 26,500 km, covering 45% of the Italian population, which represents about 10 million homes (by the end of 2007). The network passes

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**130** As with any scheme where government finances network deployment, this scheme runs the risk of distorting commercial incentives. It might, for instance, serve to inhibit build-out that might otherwise have taken place on a purely commercial basis.

**131** See Elixmann, D., Ilic, D., Neumann, K.-H. and T. Plückebaum (2008): “*The Economics of Next Generation Access*”; Final Report for ECTA.

about 2 million homes via FTTH technology and the remaining 8 million via metallic local loop unbundling. Fastweb has invested 4 billion Euros since 1999 and it has about 1.3 million customers (as of the end of 2007).

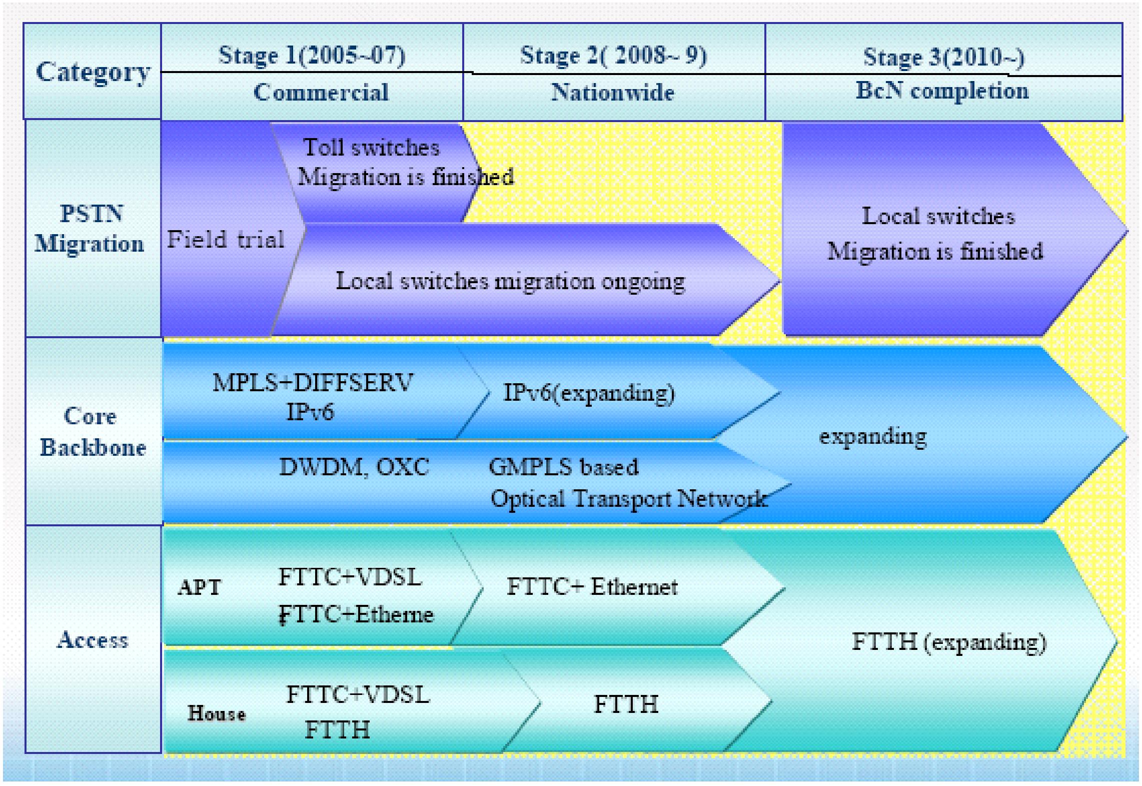
TI and Fastweb signed an agreement in June 2008 that provides for reciprocal access to ducts in order to enable them to deploy NGN infrastructure more rapidly. The agreement is said to be open to all interested operators. The two companies agreed to cooperate with regard to:

- The planning of civil infrastructure necessary for the deployment of fiber optic networks (encompassing e.g. empty ducts along the streets) with the objective of avoiding infrastructure duplication;
- The reciprocal exchange of usage rights for civil infrastructure; and
- The study of, and experimentation with, innovative techniques regarding civil infrastructures, e.g. the utilization of newest generation micro tubes for the deployment of optical fiber.

#### 4.1.2.7 South Korea

Migration to NGN technology in South Korea is embedded in far reaching and ambitious governmental actions promoting information society technology. Already in 2005 Korea Telecom (KT) has initiated its “Octave Project” (see Figure 40).

Figure 40: Planned evolution of KT's network infrastructure over time: Octave Project roadmap (as of 2005)




Source: KT Co., June 2005.

The figure shows the planned different stages of network evolution in the access and core part of KT's network. An important part of the Korean policies related to information society technologies is the "BcN" (Broadband converged Network). The current "u-Korea masterplan" (Establishment Phase (2006 ~ 2010) underlines that ubiquitous social infrastructure through improvement of networks such as BcN should be built.[132]

In February 2009, the South Korean government decided to invest in fixed broadband infrastructure allowing data transfer rates in the area of 1 Gbit/s by 2012. These high transmission speeds will be limited to metropolitan areas in the foreseeable future. However, customers in the remaining parts of the country should have access to transfer rates in a range between 50 Mbit/s and 100 Mbit/s in any case by 2012.

132 See http://www.ipc.go.kr/ipceng/policy/enews_view.jsp?num=2146, Retrieved on 7 August 2009.

### 4.1.2.8 Australia

The Australian Government issued a call for tender to construct a next generation network in Australia in 2008. This NGN is supposed to be built mainly on VDSL technology and is intended to enable downlink speeds of 12 Mbit/s for a 98% share of Australian households. An important precondition, which has been emphasized in the call for tender, is the willingness of the operator to provide these activities in a structurally separated manner.

After the call for tender had been closed, the incumbent Telstra was excluded from the further evaluation procedure because they failed to submit sufficient information on how they would address the requirements of small and medium sized enterprises. In April 2009, the Australian experts group evaluating the bids came to the conclusion that the bids submitted by the other consortia were not sufficient. This is why, on 7 April 2009, the Australian Government decided not to offer the contract out to a single private entity. Rather, the focus will be on realizing its national broadband project by means of a public-private partnership. It will be the largest national infrastructure project in the Australian history.

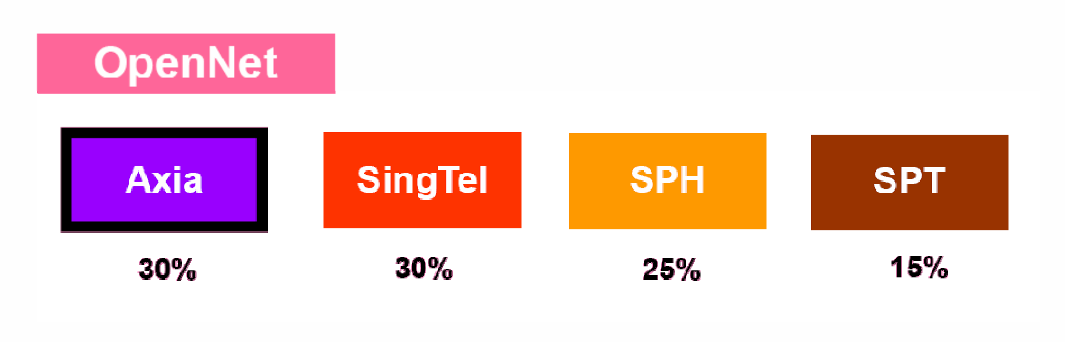
Using FTTN- or FTTP-technology, the government is willing to spend 43 bn. AUD ($ 31.17 bn.) in deploying aerial fiber. This venture aims at reaching 90% of Australian households and it is supposed to be finished in 2018. These actions are coupled with an announcement by the government that it aims at launching a comprehensive review of the country’s telecom regulations. In particular, it can be expected that the government will take on a more aggressive regulation of the incumbent Telstra, in order to promote greater competition in the country’s information and telecommunication’s sector. The critical issue is “separation”. Just recently (see Primetrica GlobalComms Database, April 14, 2009) it was reported that Telstra may consider a voluntary separation of its retail and wholesale operations in a bid to improve its relationship with the government.

### 4.1.2.9 Singapore

In Singapore, the government set up a call for tender to construct a high bit broadband infrastructure, too. This call for tender particularly requires a layered model. A “NetCo” is designated to roll out the “passive” duct and fiber components of the network infrastructure. A “ServCo” is to run the infrastructure, while several “SalesCos” are designated to provide services on the infrastructure. A detailed specification of instructions with regard to the separation of NetCo and ServCo takes centre stage in the call for tender.

In September 2008 the consortium OpenNet was awarded the NetCo contract (see Figure 41). 50% of households have to be covered by 2012. Full coverage has to be achieved by 2015 (Universal Service Obligation). Singapore will grant financial support for the roll-out of the NetCo infrastructure equaling up to 750 mill. S$ (about 375 mill. EUR). It deserves to be stated that the incumbent in Singapore, Singapore Telecom, is part of the winning consortium, although it is not the leader.

Figure 41: Composition of the consortium Open-Net




Axia = Axia NetMedia Corporation (leader of the consortium)
SingTel = Singapore Telecommunications Pte
SPH = Singapore Press Holdings
SPT = Singapore Power Telecommunications Pte

Source: Khoong, Hock Yun Khoong: Blazing the Trail – Singapore's Next Generation Broadband Network, presentation in the context of the FTTH Council Europe Conference, Kopenhagen, February 11, 2009.

Singapore will also grant financial support for the ServCo equaling up to 250 mill. S$ (125 mill. EUR). The entire build of the broadband network infrastructure is expected to cost around S$3b.

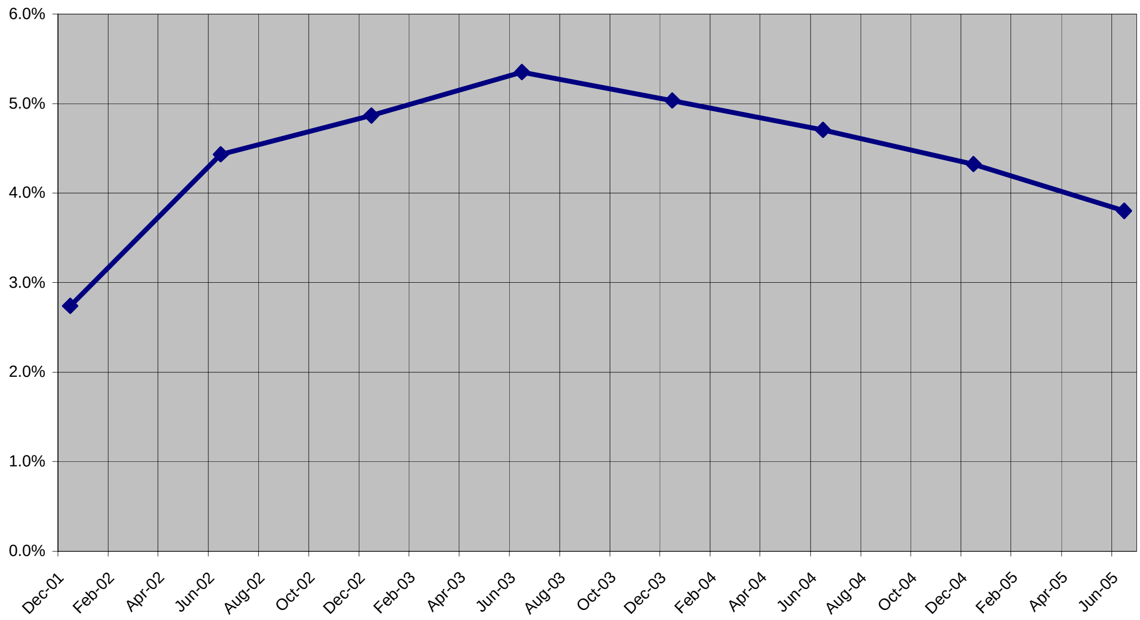
The decision on the winning ServCo consortium has been made on 6 April 2009: The Infocomm Development Authority selected the StarHub "Nucleus Connect" bid as the winner. As StarHub is the main competitor of Singapore Telecom and the latter is part of the winning NetCo consortium the decision on the ServCo is remarkable because it implicitly implements a very radical structural separation in the market: the incumbent and a competitor are forced to work closely in deploying and operating a communications network.

4.1.2.10 USA

The “American Recovery and Reinvestment Act of 2009“ was passed in February 2009 (shortly after President Obama’s inauguration) against the backdrop of the financial crisis. It is an economic package with a volume of a total of 787 Billion USD (consisting of extraordinary expenditures and tax cuts). 7 Billion USD are supposed to be spent for the improvement of access to broadband in rural, unserved and underserved areas. Network operators that accept money under these programs must agree to provide service on a non-discriminatory basis, consistent with FCC principles that attempt to enforce Network Neutrality.

The regulatory situation in the U.S. has been characterized by a significant relaxation or withdrawal of unbundling and access requirements for fiber and DSL incumbents in recent years.[133] As a consequence, competition in DSL is less developed. Competitors provide less than 3% of all xDSL connections.

Figure 42: Market Shares of competitors (CLECs) in the US xDSL market

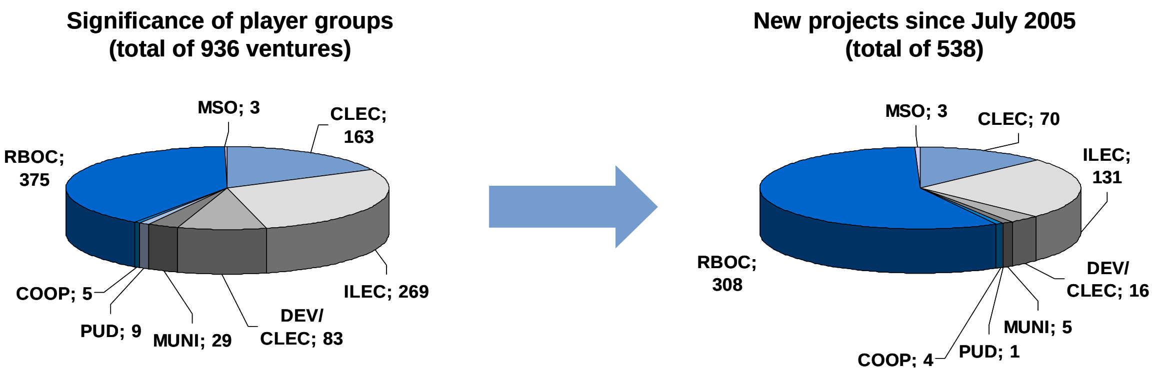



Source: FCC reports on the basis of information provided by network operators (Form 477).

133 See J. Scott Marcus, "Network Neutrality: The Roots of the Debate in the United States", *Intereconomics*, Volume 43, Number 1, January 2008. See: http://www.springerlink.com/content/g37k162urx11/?p=1a363b658dfb4d95accaecba21b38d5f&pi=0, Retrieved on 7 August 2009.

The market structure for fiber access in the U.S. is characterized by a multitude of local or regional network operators (See Figure 43). They are frequently operated in form of “Public Private Partnerships“. An example of this kind of operator is the Utah Telecommunication Open Infrastructure Agency (UTOPIA), which is backed by 14 urban und rural communities. UTOPIA rolls out fiber infrastructure and offers wholesale products to service operators such as AT&T. Local incumbents such as Qwest dislike this type of arrangement and refuse to cooperate. The economic success of approaches like UTOPIA is thus endangered by incumbents’ behavior.[134]

Figure 43: FTTx-projects in the U.S. by type of operator




RBOC – Regional Bell Operating Companies
CLEC – Competitive Local Exchange Carrier
ILEC – Incumbent Local Exchange Carrier (non-RBOC Incumbents)
MUNI – Municipalities
COOP – Cooperatives
PUD – Public Utility District
MSO – Multiple System Operator

Source: Analysis WIK-Consult, August 2006.

Moreover, a “Broadband Technology Opportunity Program“ for furthering attractive applications has been announced in the context of the “American Recovery and Reinvestment Act 2009“. The National Telecommunications and Information Administration (NTIA) has been commissioned to substantiate this task. Moreover, the NTIA is ought to improve mapping and monitoring of broadband development and support federal states’ reporting following to the „Broadband Data Improvement Act“, which had been already signed by Obama’s predecessor President Bush. Both activities have been recently combined under the term “Broadband Grant Program“. In March 2009, the NTIA started hearings in order to substantiate these measures.[135]

**134** UTOPIA has also reportedly experienced financial difficulties due to the financial crisis in the US.
**135** See http://www.ntia.doc.gov/frnotices/2009/broadbandmeetings_090224.pdf, Retrieved on 7 August 2009.

#### 4.1.2.11 Assessment of different migration scenarios in different countries

In Section 4.1.1, we explained that some network operators have migrated to Next Generation Access while changing relatively little in the network core (Case I); others have upgraded the network core to IP while doing relatively little to the network access (Case II); and still others have upgraded both access and core more or less simultaneously (Case III). Which network operators have followed which path, and why?

British Telecom (BT) was among the first network operators in the world to announce a transition to NGN. They were motivated primarily by a desire to reduce costs, especially in regard to Operational Support Systems (OSS). Migration to NGN would provide a simpler and more manageable network. As a secondary consideration, they also felt that migration to an NGN core would enable them to more quickly implement new application services.

They were not under strong pressure to upgrade IP-based data access. At the time, there had been only minimal take-up of Local Loop Unbundling or Shared Access; thus, competitors were not positioned to offer broadband data access superior to that offered by BT itself. Cable in the UK has the highest ARPU (Average monthly Revenue Per User) among cable operators in Europe, but coverage is very spotty. Taking all of this together, BT was under only minimal competition for high speed data access, and saw no business case for making strong investments in the access network.

Thus, BT saw cost avoidance gains in upgrading the core, but saw no compelling business case in upgrading the access network.

Similar considerations must have influenced Telecom Italia to follow a similar course. They quietly upgraded the network core to an IP-based NGN to reduce operating expense. There is essentially no cable television in Italy, and thus no competition from cable-based broadband services. There are fiber deployments in Milan, but Telecom Italia was otherwise not under competitive pressure to make expensive upgrades to its access network. Again, they followed a Case I (upgrade just the core network) approach.

Deutsche Telekom (DT), by contrast, was competing against a number of nimble opponents. Germany has had an aggressive Local Loop Unbundling program for years, thanks to which the German competitors were well positioned to offer high speed broadband. The German cable industry got off to a slow start in broadband for a variety of reasons,[136] but cable passes some 70% of German homes and serves video to some 55% of German households. DT implemented a VDSL-based Next Generation

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**136** J. Scott Marcus and Peter Stamm, “Kabelinternet in Deutschland” (German only), a study on behalf of the Deutscher Kabelverband, 24 November 2006, available at: http://www.deutscherkabelverband.de/web/cms/upload/pdf/06-12-14_Studie_Kabelinternet_in_Deutschland.pdf, visited on 8 August 2009.

Access (NGA) strategy (Case II), with little done to the core network, because it saw a significant potential competitive threat to its network access business.

Finally, KPN (Netherlands) responded aggressively by upgrading core and access networks more-or-less simultaneously (Case III). On the one hand, KPN was under tremendous competitive pressure, both from the toughest cable broadband competition in Europe and from effective LLU-based competitors. At the same time, they felt that the best way to finance the migration was by reducing the number of buildings required for the network, and selling of the buildings and/or the underlying land. This plan required a comprehensive upgrade of both the access and the core networks.

To summarize, network operators will tend to prefer Case I if they are under only limited competitive pressure in regard to high speed broadband access. Cases II or III will be preferred if there are strong competitive pressures to upgrade the access network.

This is best illustrated by Table 9, which immediately follows. The competitive environment, as it relates to last mile access, plays a large role in the choice of access-first versus core-first deployment.

Table 9: NGN evolution in different countries

| Country | Section | Case | Competitive environment | Policy challenges | Results |
|---|---|---|---|---|---|
| UK | 4.1.2.1 | I | Limited last mile competion. Cable covers less than half of the country. Fixed competition was ineffective, but is gaining. | The incumbent is subject to functional separation. Proposed abandonment of MDFs would have burdened telephony competitors with stranded investments. Need for regulatory certainty in a fast changing environment. | Steady progress on core migration. Access migration has been slow to date. Digital Britain proposes to charge consumers 50 pence/month to support broadband to lower density areas. |
| Netherlands | 4.1.2.2 | III | Very substnatial last mile competion. Ubiquitous cable coverage, strong telephony competitors. | Proposed abandonment of MDFs would have crippled telephony competitors. Sub-loop unbundling was shown not to be viable. | Instead of the planned deployment, we are seeing FTTB/FTTH thru a partnership. |
| Germany | 4.1.2.3 | II | Moderate last mile competion.Widespread cable coverage (but with limited effectiveness), moderately strong telephony competitors. Substantial LLU. Steady loss of incumbent market share. | Incumbent refused to deploy NGN access without a promise that it would be exempt from regulation. This was acceptable to the German government, but not to the European Commission. Many questions remain unanswered. | The incumbent is deploying VDSL to roughly half of German households. Competitors have also been rolling out high speed access in metropolitan areas. The German government has committed to providing 100% broadband availability by the end of 2010, and 75% at 50 Mbps by 2014. |
| Finland | 4.1.2.4 | II | Moderate last mile competion. Many incumbents collectively serve 65% of broadband demand using DSL. | Government to ensure 100% access to 1 Mbps broadband by the end of 2010. By 2015, 100% should be within 2 km of a 100 Mbps point of presence. | Too soon to say. |
| France | 4.1.2.5 | II | Heavy competition in Paris and other metropolitan areas, where extensive sewers facilitate FTTB/FTTH. | Infrastructure sharing within buildings, applicability of LLU to GPON have posed challenges. | France has an excellent roll-out of FTTB/FTTH. |

| Country | Section | Case | Competitive environment | Policy challenges | Results |
|---|---|---|---|---|---|
| Italy | 4.1.2.6 | I | Cable is absent in Italy. The incumbent was subject to only limited competition in the past, but is under increasing pressure from FASTWEB. | The changes to the core network had minimal regulatory impact (technological neutrality), since they were largely invisible to customers. The incumbent is subject to a form of functional separation. | Telecom Italia quietly converted its core network to an IP-based NGN some years ago. FASTWEB has been deploying FTTH for years, and is present in about half of Italy. The incumbent has been deploying fibre access since 2007. |
| Australia | 4.1.2.8 | II | A highly concentrated market, where the incumbent has bottlenecks for the fixed network, back-haul, mobile, cable television, mobile, and video content. | Government intends to provide $43 billion AU to fund aerial FTTH to 90% of Australians in the next eight years. Separation of the incumbent is under discussion. | Too soon to say. |
| USA | 4.1.2.10 | II | An increasingly concentrated market; however, ubiquitous cable competes with the telephone incumbent in almost every part of the country. | Penetration is lower than one would expect in a country with the fundamental advantages of the US. Choice is limited. Anticompetitive behavior is feared (e.g. net neutrality) and is sometimes present. A $7 billion invesment in broadband has been committed to rural, unserved or underserved areas. | The US has achieved a moderately high level of broadband, and substantial fibre deployment; however many problems remain, and commercial forces are not likely to suffice to cover remaining areas. |

### 4.1.3 Policy challenges during migration

A number of issues have emerged that are *specific to the transition period itself*. This section deals with those challenges.

Even if network operators are involved in more or less ambitious NGN deployment activities, it can be taken for granted that “old” (i.e. TDM based PSTN) networks and “new” (i.e IP based NGN/IMS networks) will co-exist for quite some time in each country. Otherwise stated, there will be a migration period where the old world will be transferred into the new world. To shape this migration period efficiently and to set the appropriate incentives for competition as well as innovation and investment will be one of the most important tasks on the agenda of regulatory and competition policy.

From the perspective of NGN interconnection, we think the following issues are likely to be the most important ones during the migration period:

- Phasing out of “old” points of interconnection (POIs), coupled with the introduction of new POIs (Section 4.1.3.1),
- Costs and cost structures of a regime where “old” and “new” networks co-exist; implications for the regulation of interconnection rates (Section 4.1.3.2),
- Setting incentive compatible termination rates (Section 4.1.3.3),
- How to minimize the risk that the transition somehow stalls (Section 4.1.3.4), and
- Interoperability testing during the transition period (Section 4.1.3.5).

At the end of this section, Section 4.1.3.6 provides a summary of the challenges, their root causes, the remedies that are generally appropriate, and the relevant recommendation for Peru.

#### 4.1.3.1 Change in the number and nature of points of interconnection

A TDM world is based on principles of traffic exchange which are very different from those in an IP-based world. Both the technical and the economic characteristics of traffic exchange in an IP-based world show that a much lower number of physical exchange points is needed in an IP-based world than in a TDM world.[137]

Regulation should therefore proactively anticipate a period where many of the current interconnection points of the PSTN could be phased out.

Such a phasing out process carries the risk of “stranded investment”. Stranded investment refers to the risk that (competitive) network operators that have deployed network transmission and switching facilities for purposes of voice interconnection might experience a substantial economic loss, and thus a competitive disadvantage, if the number and location of interconnection points were to change. One could also envision scenarios where the incumbent intentionally phases out PoI abruptly or without warning

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**137** This is true in general, but the degree to which it is applicable to Peru is less clear. Market player interviewees did not identify a possible reduction in PoI as a concern. The regulatory obligation on TdP to maintain a PoI in each Department was felt to prevent a reduction in PoI; on the other hand, a number of interviewees felt that the current number of required PoI is too high. See Section 5.4.7.

in order to harm competitors. The regulator's attempts to enable competition could thus be undermined by changes in the number and locations of PoI.

Thus, regulation must seek a balance between supporting technical change and innovation (which might speak for a quick phasing out of interconnection points that are no longer needed) and avoiding harm to competition (which might speak for a slower and more gradual phasing out process, so as to give market participants more time to write off equipment that is no longer needed for interconnection).

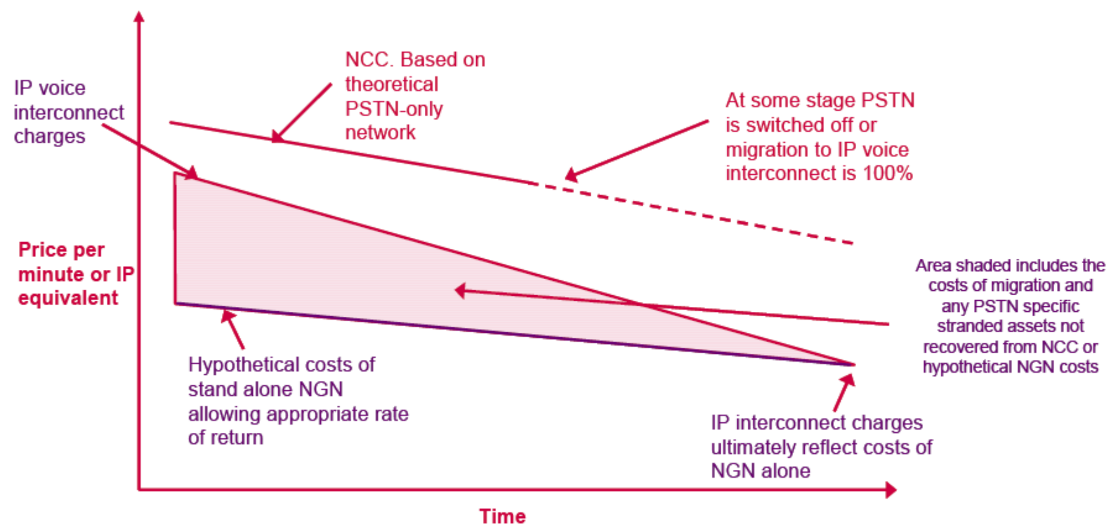
Regulators in the UK and in the Netherlands have generally attempted to get the market players themselves to negotiate the pace at which points of interconnection would be shut down, and to ensure that competitors received timely notification of any planned changes in the number and location of incumbent PoI.

#### 4.1.3.2 Changes in cost structure

Given the cost structure of the old PSTN world it is highly likely that co-existence of two networks (old TDM, new IP) for at least some time might increase the respective cost level. In the end, however, it can be taken for granted that an All-IP network has a significant lower cost level. Thus, the issue at stake for regulation is: how to move from here to there?

A conceptual view on this has been suggested by the British NRA.

Figure 44: 'Holistic' approach to narrowband voice interconnect cost recovery




Source: Ofcom, Further Consultation, Figure 5, page 13.

Thus, Oftel (now OFCOM) proposed that interconnect charges follow a glide path. In particular, they do not intend to introduce a regime of artificial distinctions in regulated prices, (e.g. distinct prices for “old-to-old” interconnection and “new-to-new” interconnection), but rather to follow an approach where a single price is set for interconnection irrespective of the technology used. In particular, this reduces the risk of problematic arbitrage.

Today, regulators all over the world know today how to estimate long run incremental costs of a telephony network. They know the network elements involved in interconnection, and they can calculate the respective efficient cost levels by virtue of sophisticated bottom-up cost models. The migration does not change this basic process; however, due regard must be paid to a range of new considerations, as explained in Section 5.7.

One could imagine modeling the network during each stage of the transition from PSTN to NGN; however, we think that this is a bad idea, for reasons sketched out in Section 5.7.10.4. Instead, the model should reflect the anticipated end state of an efficient network when the transition is complete – after all, this is a *long run* incremental cost model. With the current state and the end state of the network firmly in hand, the transition can be addressed by means of a suitable glide path for regulatory cost.[138]

Traffic exchange in an IP world rests on different network elements and economic principles. In a best effort Internet world, there is no need to sub-divide traffic into different service classes. It might, however, very well be the case that network operators in a country have an incentive to introduce a specific service class for voice traffic and to market this arrangement as a specific “service” (call this “Voice over NGN”, rather than “Voice over Internet”). The idea behind such an approach is to keep the minute based regime known from the era of TDM traffic also in an IP-based NGN world. Such an approach is “Bellhead” minded and bears inherently a “walled garden” behavior, i.e. to subdivide the market for voice services into “quality based voice” offered by a specific class of network operators (the “haves”) and “non-quality based voice” offered by the rest of market participants (service providers, who do not belong to the “club”, i.e. the “have nots”). To prepare itself for such a foreseeable market structure, and to find an appropriate position regarding foreclosure tendencies, is an additional item of regulatory policy during the migration period.

**138** Doing so ignores the possibility that operating expense actually *increases* during the migration period as a result of the need to maintain both old and new networks in parallel; however, from a regulatory cost modeling perspective, that is the correct way to deal with things.

#### 4.1.3.3 Risk of arbitrage

Given that there are different network operators in a market, it is highly likely that their specific deployment plans differ. Thus, even if network operators have the same size and service scope, it might very well be that their costs of network operation vary according to their different respective NGN deployment schedules. At first sight, one might therefore be inclined to accept different termination rates for traffic.

This is, however, not an efficient approach. The reason is that such an arrangement with different termination rates in a given market bears inherently the risk of arbitrage.

A possibly even greater concern exists among the voice offerings within a single operator, especially the incumbent. Suppose termination fees were to be substantially different for voice calls to the NGN versus voice calls to traditional PSTN. This would likely invite arbitrage on a massive scale, and would likely “tip” the market one way or another based on regulatory rather than economic considerations. With this in mind, we are of the view that it is probably better to use a single “blended” rate for termination, thus maintaining technological neutrality between NGN and PSTN call termination.

#### 4.1.3.4 Risk that arrangements never evolve beyond current arrangements

There is a non-trivial risk that arrangements will, for any of a number of possible reasons, never evolve (or at least be slow to evolve) in the direction that technological and economic considerations suggest is desirable. Some possible failure modes involve inappropriate regulation; others involve “sins of omission”, i.e. the failure to regulate when regulation is needed.

Experience in other countries strongly suggests that large telecommunications firms benefit from current interconnection and call termination arrangements, and will therefore do whatever they can to preserve them. This is not only a matter of maintaining termination revenues, which have been variously estimated as being between 15% and 30% of a mobile operator’s revenues. Current termination rates also enforce usage-based retail prices at levels well in excess of cost, prevent small “challengers” from undercutting larger operators on price, and facilitate on-net off-net price discrimination that tends to weaken competitive pressures. For both fixed and mobile operators, termination fees play a complex and important role in their profitability. (And for somewhat analogous reasons, while we are very much of the view that termination rates in nearly all countries are too high today, there is a credible argument that overall social welfare might best be served by leaving just a little “fat” in these arrangements, especially in a developing country where coverage is not yet complete.)

Given this dynamic, existing incumbents and large mobile operators are unlikely to voluntarily migrate to a regime that puts their termination revenues at risk. If enabling IP-based interconnection for the traditional voice service implies lower termination rates, or no termination payments at all, then incumbents and large mobile operators will simply choose not to evolve their interconnection arrangements (or they will evolve them in a way that seeks to preserve current business models as much as possible).

We should add that we know of no instance where a regulator has directed a network operator to change their voice interconnection arrangements from circuit switched PSTN/SS7 to IP-based interconnection.

This would seem to imply that the better solution is to adopt an interconnection regime that is appropriate for NGN before the migration to NGN takes place, and to apply it in a way that is competitively and technologically neutral between the circuit switched world of PSTN/PLMN and the IP-based world of NGN.

#### 4.1.3.5 Interoperability testing during the transition period

This section deals with technical aspects of testing the migration from legacy networks to NGN.

##### 4.1.3.5.1 Introduction

The concept of service Integration has been considered since the end of the 1980s under the concept of ISDN, and later on under the concept of BA-ISDN networks. The corresponding standards provided an attribute value scheme which allowed, on the one hand, to map existing services and, on the other hand, to create new ones under a limited set of unified User Network Interfaces (UNI), Network Node Interfaces (NNI) and Interconnection Interfaces between different networks (INI). On the contrary, the NGN concept, as defined from the ITU, inverted the paradigm of a service integrated network into a network integrated platform for service provisioning. With this approach the service provisioning is independent from the underlying platform.

In the migration path from legacy networks (mainly PSTN/ISDN networks) to an NGN, legacy services must be provided from the NGN. From this follows that an NGN has to provide at least Legacy Service Simulation (LSS) and, under stronger requirements, even Legacy Service Emulation (LSE). Note that Legacy Service Simulation means that the NGN provides a service similar to the legacy one, while in Legacy Service Emulation the NGN provides exactly the same legacy service[139]. In the LSS service the UNI can be different from the legacy UNI, whereas in the LSE the UNI must be the

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**139** Lim Shue Ping, Migration Scenarios to NGN, ITU-T Workshop on “Next Generation Networks“, 2006.

same. An example of a LSS service is a connection between two VoIP phones connected to an NGN, whereas a 64 Kbps bearer service connection between an ISDN terminal connected to an NGN and another terminal connected to a PSTN network is an example of LSE; Table 10 shows additional examples of LSE and LSS services.

Table 10: Example of LSE and LSS for the telephone service

| OT | ON | DT | DN | QoS | |
|---|---|---|---|---|---|
| legacy phone | NGN | Legacy phone | PSTN | G.711 | LSE |
| legacy phone | NGN | Legacy phone | PSTN | G.729 | LSS |
| VoIP phone | NGN | Legacy phone | PSTN | G.711 | LSS |
| VoIP phone | NGN | Legacy phone | PSTN | G.729 | LSS |

The ITU definition of NGN considers that the NGN transport layer is packet-based in praxis, and it can work with IPv4 or IPv6. There might be different transport layers, e.g. there can be an IP network that provides a guaranteed QoS (as IMS-TSPAN), or a MPLS-DiffServ improved best-effort Internet that instead of using the QoS concept uses the Quality of Experience of the users (QoE)[140] concept. Hence there is a broad definition of NGN which covers mainly both the ITU/ETSI and the IETF world[141]. This implies a larger number of UNI, NNI and INI interfaces where the last is also named Gateways. Note that PSTN/ISDN emulation and simulation is completely covered in the IMS-TISPAN standard[142], while the migration from current best effort internet to a QoS-enabled Internet might provide at best PSTN/ISDN service simulation. Regarding ITU, NGN basic principles for testing have been already specified[143].

The change from a circuit-switched connection in the PSTN/ISDN network to a virtual connection in the NGN poses questions of security and privacy. This is caused by the packet nature of the transport stratum which requires additional means for maintaining the security and privacy inherent in circuit-switching transport.

**140** Kalevi Kilkki, Quality of Experience in Communications Ecosystem, Journal of Universal Computer Science, vol. 14, no. 5 (2008).

**141** ERG Consultation Document on Regulatory Principles of IP-IC/NGN Core (ERG (08) 26rev1, 2008.

**142** Richard Brennan, ETSI TISPAN Vision on Convergence, FMCA Convergence & Customer Experience 2008.

**143** ITU-Q.3905, Methods of testing and model network architecture for NGN technical means testing as applied to public telecommunication Networks, 2006.

#### 4.1.3.5.2 Testing principles

The main tests which should be provided in an NGN environment are[144]:

- functional tests
  - single vendor mode
  - multi vendor mode
- performance test
  - interface
  - end-to-end
- reliability tests
- conformance test
- security test

For regulatory issues the performance tests are of special interest because they have to prove the fulfillment of performance parameters like Grade of Service (GoS), QoS and QoE. Performance tests must be provided not only in the implementation phase of the NGN, but also under real life network operation. In contrast, functional and conformance tests must be provided with the help of testing equipment before implementing the network. Test-beds are also used. Reliability tests and security tests are provided mainly in the implementation phase of the network.

It must be pointed out that due to the high number of interfaces and the heterogeneity of the different types of connections, performance and QoS/QoE tests based on interfaces are not sufficient. Real-time services like VoIP tests based on the end-to-end connection should be provided. As long as the connection is inside one network (Intranet), a performance test is not problematic. But for the case of a connection through different networks, the performance of an end-to end connection must be evaluated by using the values resulting from the involved Intranet connections and the involved INIs.

#### 4.1.3.5.3 Testing equipment

NGN testing requires special equipment for the different types of tests to be performed. This equipment must be able to test the different stratums (transport, control and services), the corresponding interfaces, and also end-to-end services. Due to the

144 See for more details, Yaghoiubi Waskasi et. al. NGN test strategy, evolution next generation Networks in a realistic environment, First ITU-T Kaleidoscope Academic Conference 2008.

introduction of triple play services, different test equipments are already in the market: test equipment for performance test of interfaces[145], test equipment for testing the QoS (QoE) based on both interfaces but also on end-to-end connections[146], and different types of test equipments for field test[147]. Some test centers with corresponding test-beds have also been implemented.[148]

#### 4.1.3.6 Summary of challenges and recommended responses

Table 11 summarizes the various regulatory challenges associated with migration to NGN that have been discussed in this chapter. It provides the root cause of the problem, the remedy that is generally applicable, and a pointer to the specific recommendation for Peru.

Table 11: Regulatory challenges, recommended responses

| Challenge | Section | Cause | Remedy | Recommendation |
|---|---|---|---|---|
| Changes in points of interconnection (POIs) | 4.1.3.1 | NGN technology does not require as many PoI. Risk of stranded investment by small competitors. | Consultations among industry players, with regulatory observers, have been effective. | See Section 5.4.7. |
| Changes in cost structures | 4.1.3.2 | Costs are likely to increase, e.g. due to parallel operation, before they decline. | Adhere to LRIC principles in modeling the current network, and the future NGN. Do not try to model a blended network; instead, use a glide path to deal with the transition period. | See Section 5.7. |
| Arbitrage between termination rates | 4.1.3.3 | If rates are different, economic distortions are likely to result. | Implement single fixed and mobile rates, irrespecive of technology. | See Section 5.8.2. |
| Risk that the transition stalls | 4.1.3.4 | Interests of network operators are not aligned. Some benefit more from current arrangements. | Adopt interconnection arrangements that move in the direction of the long term solution. Do not force migration at this time. | See Sections 5.1, 5.2, and 5.8.1. |
| Interoperability testing during the transition period | 4.1.3.5 | Migration to IP introduces challenges in maintaining QoS, privacy and security. | Network operators should carefully test interoperability, especially during the initial transition period. | See Section 4.1.3.5. |

**145** CSA Convergent Service Analyzer, Anacise Testnology Corp.
**146** NGN Quality Testing TiQoS Platform, VIERLING Communications GmbH.
**147** NGN Product Solutions Guide, Livingstone 2006/2007.
**148** Cisco Service Provider Test and Validation Services, Cisco 2008.

## 4.2 NGN and VoIP regulatory developments

Section 4.2.1 deals with regulation of VoIP; Section 4.2.2 deals with regulation (and relevant consultative bodies and mechanisms) for the regulation of IP-based Next Generation Networks.

### 4.2.1 VoIP regulation

The regulation of VoIP has been an active topic in Europe since 2004, when the European Commission issued its public consultation on VoIP.[149] Subsequent assessments by the European Regulators' Group (ERG)[150] have sought to harmonize regulation among the European Member States. A WIK-Cullen study in 2008[151] sought to identify commonalities and differences between the European Member States in the regulation of VoIP. Meanwhile, the United States has pursued a course sometimes similar to that of Europe, and sometimes notably divergent.

#### 4.2.1.1 Telephone numbers

Access to geographic numbers in the United States is straightforward, but VoIP service providers have access only if they are also network operators. Non-facilities-based VoIP service providers typically obtain numbers through the intermediation of a competitive carrier (CLEC) such as Level 3. Numbering has been a fairly minor issue in the United States, largely because termination rates for geographic, non-geographic and mobile numbers are not markedly different from one another. This is largely a result of efficient U.S. voice telephony interconnection arrangements, which preclude large asymmetries in the wholesale price for terminating a voice telephone call. Geographic numbers are only loosely tied to a geographic area, or for that matter to the United States.

In Europe, the WIK-Cullen study found that rules regarding the ability of VoIP service providers to obtain geographic versus non-geographic numbers were highly diverse and confusing. They also found that National Regulatory Authorities (NRAs) did not consistently provide timely response to requests for numbers, even though they were

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**149** European Commission, "The treatment of Voice over Internet Protocol (VoIP) under the EU Regulatory Framework", Commission Staff Working Document, Brussels, 2004.

**150** ERG, "ERG Common Statement for VoIP Regulatory Approaches", ERG (05)12, Brussels (2005); ERG, "Report on "VoIP and Consumer Issues", ERG (06) 39, Brussels (2006); and ERG, "Common Position on VoIP (Draft) of the ERG – High Level Policy Task Force on VoIP", ERG (07) 56 Rev1, Brussels (2007).

**151** See Dieter Elixmann, Christian Wernick, J. Scott Marcus, with the support of Cullen International, *The Regulation of Voice over IP (VoIP) in Europe*, available at: http://ec.europa.eu/information_society/policy/ecomm/doc/library/ext_studies/voip_f_f_master_19mar08_fin_vers.pdf, Retrieved on 7 August 2009.

required to by the Authorization Directive. Rules regarding number portability were also diverse.

The UK, for example, is unusually liberal in its policies toward geographic telephone numbers. UK numbers are not strongly tied to a particular geographic area, nor for that matter to the UK. This has been a boon to providers of "nomadic" VoIP service – services that can be utilized from a location other than the user's home location. The UK also provides for non-geographic numbers, but in the UK (as elsewhere in Europe) there is negligible demand for non-geographic numbers for standard consumer VoIP services.

In regard to the use of telephone numbers by IP-based voice services, Germany has made geographic numbers available, but only where the user has a relationship (for example, a residence or a business) to the geographic area in question. As in the UK, non-geographic numbers are available, but consumer demand is negligible.

#### 4.2.1.2 Access to emergency services (police, fire, and ambulance)

Implementing VoIP access to emergency services is a huge challenge, because the location of the caller may not be reliably known, especially in the case of nomadic services (where the user can fluidly change the location from which the service is provided). It is particularly problematic in Europe in view of the very different emergency systems from one Member State to the next. Emergency systems in Europe differ with respect to the actual number of emergency numbers, the regional organization of PSAPs (Public Safety Answering Points), and the way in which routing to the "correct" PSAP is organized.

If the customer's location cannot be reliably determined through automated means, it is impossible to complete an emergency call to the proper emergency response unit, and it is also impossible to reliably report the user's whereabouts. Technical solutions are improving over time, but gaps are likely to remain for a long time to come.

The United States attempted to solve this problem by simply requiring all VoIP service providers to quickly provide a service as reliable as that of the wired network. In doing so, they simply ignored the fact that it is technically infeasible to do so (and for that matter, the fixed and mobile telephone networks have their own problems with location determination). By failing to pay proper attention to the need for consumer education, and by imposing unrealistic obligations in unrealistic time frames, the U.S. FCC substantially harmed competitive entry, to the benefit of incumbents.[152]

**152** J. Scott Marcus, "Voice over IP (VoIP) and Access to Emergency Services: A Comparison between the U.S. and the UK", *IEEE Communications Magazine*, August 2006, available at http://www.comsoc.org/livepubs/ci1/public/2006/aug/cireg.html, Retrieved on 7 August 2009.

In the UK, Ofcom implemented a measured and appropriate response.[153] Nonetheless, it is worth noting that there are quite substantial differences from one European Member State to the next as regards which VoIP service providers are obliged to provide access to emergency services, and how the access should be implemented.

The European Commission proposed on 13 November 2007 to require providers of VoIP services to conventional national or international phone numbers to provide access to emergency services.

#### 4.2.1.3 Lawful intercept (wiretapping)

Inconsistencies in the implementation of lawful intercept (wiretapping for law enforcement and for national security) are probably just as significant, but they have not been fully studied because information is not readily publicly available. The WIK-Cullen study found that European Member States seemed to be reasonably well harmonized in terms of the technology used, but in terms of the many procedures employed (for initiating an intercept, for example, and for conveying data to authorities) there seemed to be substantial differences. To the extent that procedures are different from one country to the next, this implies costs and diseconomies of scale on VoIP service providers, and thus effective barriers to competitive entry.

### 4.2.2 NGN core and access regulation

This section reviews regulatory developments, and the processes and consultative bodies that have enabled them, in the United Kingdom (UK) (Section 4.2.2.1), Germany (Section 4.2.2.2), the European Union (Section 4.2.2.3), the United States (Section 4.2.2.4), and New Zealand (Section 4.2.2.5).

#### 4.2.2.1 The United Kingdom (UK)

In many respects, regulatory proceedings in the UK were the first to deal with issues of Next Generation Networks. BT's ambitious plans necessitated a comprehensive response on Ofcom's part.

In 2004, British Telecom (BT) announced its intent to migrate its entire network to an IP-based Next Generation Network, the 21$^{st}$ Century Network (21CN).[154] The 21CN is a

**153** Ibid.

**154** BT's plans are extensively documented in various public documents, starting with their web site, at http://www.btplc.com/21CN/index.htm, Retrieved on 7 August 2009.

single IP and DWDM-based network that will carry both voice and data.[155] In most respects, the technology that they intend to use (Dense Wave Division Multiplexing [DWDM], DiffServ, MPLS traffic engineering, and VoIP) is straightforward, mature and unadventurous.

#### 4.2.2.1.1 Interconnection

Ofcom has conducted a number of public consultations on the significance of the migration to NGN, and on the impact of that migration on regulation in general and on interconnection in particular. Key themes of these consultations have been access and interconnection arrangements; changes in BT's Weighted Average Cost of Capital (WACC); and joint planning between BT and its competitors during the migration. The documents provide a wealth of enlightened and informed analysis; at the same time, relatively little has concretely been implemented to date. To a point, that is as should be: it would have been premature to attempt to design in detail a regulatory regime today for an environment that was still to a significant degree speculative.

Instead, Ofcom has focused on putting in place processes and mechanisms for moving the regulatory environment forward over time, as the migration to 21CN progresses. The focus to date has thus been on *process* rather than on *outcome*.

Taken as a whole, the interconnection discussion in the UK has been surprisingly "retro", largely focused on narrowband voice interconnection in the context of traditional Calling Party's Network Pays (CPNP) arrangements.

#### 4.2.2.1.2 Consultation mechanisms

To date, three major industry fora have been driving the process. The first is *Consult21*, a forum created by BT to facilitate open cooperative discussions with its wholesale customers on the migration of its existing SMP products, and to begin to consider future SMP products as 21CN matures. Consult21 appears to be working reasonably well. As one illustration, a competitor remarked that BT's openness and transparency in these consultations had been extremely helpful, and that this kind of open dialogue is key to sustained viability and investment.[156]

The second is the *Network Interoperability Consultative Committee (NICC).* The NICC is responsible for technical standardization of interconnect interfaces within the UK, drawing on the work of other standards bodies (e.g. ETSI, ITU-T, and the IETF). The

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**155** See http://www.btglobalservices.com/business/global/en/business/business_innovations/issue_02/century_network.html, Retrieved on 7 August 2009.

**156** Remarks of Steve Hewson (MCI) at WIK's "NGN and Emerging Markets" workshop, 5 December 2005.

NICC previously functioned as an advisor to Ofcom, but was transformed by Ofcom in June 2008 into an independent standardization body.

A third industry body sponsored by Ofcom is NGNuk. NGNuk mission is "… to act as a co-ordination forum in which key investors in NGN infrastructure and services will discuss, research, consider and, where possible, agree the direction for NGNs in the UK". NGNuk has produced some possibly useful work on NGN interconnection.[157] NGNuk has also done quite considerable work on commercial arrangements.

These arrangements were crafted with much thought and great care, but how well they will work over time remains to be seen. First, the creation of three independent industry consultation bodies creates numerous opportunities for duplication, "turf wars", and confusion as to roles and responsibilities. Second, the substantial focus of NGNuk on commercial charging arrangements may prove to be problematic. NGNuk is comprised of network operators. On some matters, the network operators are unlikely to find common ground; however, where their interests are aligned, it may well be in commercial arrangements that favor network operators at the expense of consumers.

#### 4.2.2.1.3 Functional Separation

The UK regulatory discussion entails an element that so far is nearly unique in European regulation (although the European Commission has recently proposed to make it a standard regulatory remedy): a set of agreements or undertakings between BT and Ofcom to largely separate BT's wholesale operations from its customer-facing retail operations, and to ensure that BT cannot discriminate against its wholesale customers (who are also its retail competitors).[158] BT made legally enforceable commitments[159] to provide a range of access services to competitors on a nondiscriminatory *equivalence of input* basis. Ofcom defines *equivalence of input (EoI)* as "…a requirement for BT to make available the same SMP products and services to others as it makes available to itself, at the same price, and using the same systems and processes." EoI obligations would be applicable "… when the cost is proportionate,

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**157** "NGNuk End-to-End Services Requirements Scope for Interconnected Next Generation Network Interconnections", Draft 2.1, 11 April 2007; and "Interconnect Services Requirements Scope for Next Generation Networks", Draft 2.1, 13 July 2007.

**158** See http://www.ofcom.org.uk/media/news/2005/06/nr_20050623, Retrieved on 7 August 2009, and http://www.ofcom.org.uk/consult/condocs/telecoms_p2/statement/main.pdf, Retrieved on 7 August 2009. See also Ofcom's *Final statements on the Strategic Review of Telecommunications, and undertakings in lieu of a reference under the Enterprise Act 2002* (Strategic Review), 22 September 2005.

**159** BT offered undertakings in lieu of a reference by Ofcom under the Enterprise Act. The undertakings are thus pursuant to competition law, and operate in a parallel and complementary fashion to Ofcom's *ex ante* sector-specific regulation. See http://www.ofcom.org.uk/consult/condocs/sec155/sec155.pdf, Retrieved on 7 August 2009. BT's commitments appear as Annex A to Ofcom's *Strategic Review*.

and in particular [to] all new wholesale SMP products, processes and systems, and therefore to all new SMP products delivered over 21CN."[160]

BT has not been broken up, but a substantial "Chinese Wall" has been established between BT's Openreach access services division and the rest of BT. Openreach has a separate management team with substantial autonomy, and some 30,000 employees who have their own uniforms and their own branding. Notably, their bonus plans are based on Openreach objectives, and are decoupled from the price of BT group stock. An Equality of Access Board monitors Openreach's compliance with its commitments to provide equality of access.[161]

From a public policy perspective, this is a promising but still unproven approach. To the extent that Functional Separation is effective, the provision of wholesale services on a nondiscriminatory basis should be self-enforcing, thus easing the burden on the regulator and also providing BT with greater flexibility to respond to market demands. Many feel that it is a promising way to side-step a range of regulatory issues as the network evolves to an NGN.

At the same time, many open questions remain as to how effective these arrangements will prove to be over time.

#### 4.2.2.2 Germany

Germany launched a public consultation process early on as regards IP-based NGN interconnection.[162] The report produced a comprehensive report exploring the issues, but did not reach definitive conclusions. Given that commercial interests among the market players conflict strongly, it is perhaps no surprise that it proved impossible to forge a consensus.

The German NGN discussion has centered on the question of access arrangements in a future NGN based on FTTC/VDSL deployment. In Germany, rather short average loop length to the customer (below 400 m) makes VDSL a very workable technical proposition. Interconnection has also featured prominently in the German discussion. These access arrangements enable a drastic reduction in the number of Points of Interconnection (PoIs).

In 2005, DTAG announced plans to deploy fibre between the MDF and the street cabinet (FTTC), and to install VDSL solutions. Geographically, the company will focus

**160** Ofcom, Next Generation Networks: Further consultation (hereinafter Further Consultation), 30 June 2005, section 1.21.
**161** See http://www.openreach.co.uk/orpg/aboutus/aregulatedbusiness.do, Retrieved on 7 August 2009.
**162** See German Federal Network Agency (BNetzA), "Final Report of the Project Group: Framework Conditions for the Interconnection of IP-Based Networks", 15 December 2006, available at: http://www.bundesnetzagentur.de/media/archive/8370.pdf, Retrieved on 7 August 2009.

these deployments on densely populated areas. DTAG has committed to make these investments, however, only if the German government provides a “regulatory holiday” from the obligations to which DTAG would otherwise be subject to offer wholesale services to competitors at regulated prices based on these new VDSL capabilities. DTAG has argued that its investment warrants protection from regulation because “new products” like IPTV are offered over VDSL. This lobbying has been successful in Germany[163], but has had no traction with the European Commission. The proposal is dead at the European level.[164]

To date, the German regulator (BNetzA) has not imposed unbundling obligations on DTAG VDSL deployments;[165] they did, however, impose the obligation to make ducts available from the central office to the street cabinet.

This is a complicated game, which will likely take two or three years to play out. As of now, there is no effective competitive access to DTAG’s VDSL infrastructure; however, German competitors are discussing the conditions under which there might be a viable business case for deploying their own FTTC/VDSL infrastructure. Moreover, at least one netwwork operator (NetCologne, the regional netwwork operator active in Cologne) has initiated a far-reaching FTTB deployment. NetCologne’s business case rests on savings in ULL fees that they would otherwise have paid to DTAG for access to the local loop. They fees will be eliminated once NetCologne’s FTTB network is complete.

#### 4.2.2.3 European Union

The European Commission proposed a package of changes to the European regulatory framework on 13 November 2007. The European Parliament has passed a version of these changes, but as of this date (August 2009) the Council has not reached final agreement with the European Parliament; consequently, they are not in force.

The proposed changes address a number of the topics addressed in this report. In particular, the package does not implement comprehensive Network Neutrality regulation; instead, it imposes more modest regulatory protections to ensure that consumers must be informed to the extent that network operators disfavor or block access to certain content or applications, and to prevent network operators from erecting barriers to switching providers if consumers are dissatisfied.

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**163** A specific clause has been added to the telecommunications law which can be applied to grant a regulatory holiday to DTAG.

**164** The Commission has launched an infringement procedure against Germany the outcome of which is still pending.

**165** Currently, there are, however, bilateral negotiations between DTAG and competitors about (in particular the price of) access to DTAG’s VDSL infrastructure.

The Commission recently implemented changes to interconnection regulations that require consistency between fixed and mobile, and among European Member States. The new rules require a much more aggressive imposition on price controls on call termination. Only “avoided costs” (costs that would not have been present had the service not been provided) associated with a particular voice service can be recovered through the termination charge. The new rules are expected to lower mobile termination rates from present levels in excess of €0.08 to new levels of €0.015 - € 0.03 by 2012.

The European Regulators’ Group (ERG) has repeatedly studied interconnection as networks evolve toward IP-based NGNs, and they continue to do so. It is perhaps noteworthy that the ERG has not been able to reach closure as to whether Bill and Keep arrangements should be preferred over traditional CPNP (albeit with lower termination rates than those that pertain today).

#### 4.2.2.4 The United States

It is rare to hear NGN discussed as such in the United States; however, the evolution of the access network as fiber migrates closer to the end-user is not much different from that in Europe or Japan. Consequently, it raises the same issues.

The regulatory response, however, has been completely different. The United States FCC has withdrawn nearly all regulatory obligations on network access as regards not only fiber, but also wired copper broadband Internet access.[166] A previously effective program of shared access has been withdrawn. The only remaining remedy relevant to broadband access is Local Loop Unbundling (LLU) for copper lines (not for fiber); unfortunately, as European experience has richly demonstrated, that is not enough to maintain a robust ladder of investment.

The FCC has claimed that the wholesale market for DSL and cable modem Internet access services was effective, and would remain so in the absence of regulation.[167] The FCC’s own data flatly contradict this view, which show third party (CLEC) DSL declining to 3.1% of all DSL lines as of December 2006. The third party access provided by cable operators is negligible.

The U.S. is blessed with extensive cable television infrastructure, and the cable operators were heavily engaged in broadband access before the telephone incumbents;

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**166** See Marcus, J. Scott, “Is the U.S. Dancing to a Different Drummer?”, *Communications & Strategies*, no. 60, 4th quarter 2005. Available at: http://www.idate.fr/fic/revue_telech/132/CS60%20MARCUS.pdf, Retrieved on 7 August 2009. Also available in *intermedia* (the journal of the International Institute of Communications), vol. 34, no.3, July/August 2006.

**167** See FCC, *In the Matters of Appropriate Framework for Broadband Access to the Internet over Wireline Facilities*…), document FCC 05-150, released September 23, especially paragraph 75.

in consequence, the withdrawal of regulation has resulted, not in monopoly, but in a series of non-geographically overlapping duopolies.

The results must be viewed as mixed at best. The U.S. has seen strong investment in fibre access by incumbents, and steady improvements in cable plant, but negligible investment (or disinvestment) on the part of competitors. Broadband penetration and the price/performance of offers are reasonable, but probably nowhere near what might have been expected given the ubiquity of cable television and the enormous head start that the U.S. once had.

As regards interconnection, the US FCC has sought since 2001 to evolve the entire set of interconnection arrangements, both for circuit-switched and for packet-switched interconnection, to Bill and Keep arrangements.[168] They have been seeking consensus among network operators – which, for reasons that should be obvious to the reader, has not been forthcoming.

#### 4.2.2.5 New Zealand

Telecom New Zealand (TNZ), the incumbent, is subject to a form of operational separation. One of the undertakings that was agreed as part of the separation is that they would seek to work with industry to define standards for IP interconnection in support of real time voice and in support of Virtual Private Networks (VPNs) suitable for delay-sensitive data.

This work was carried out by the Telecommunications Carriers' Forum (TCF), a working group of New Zealand network operators. The TCF created an IP Working Party (IPWP) comprised of representatives of significant New Zealand market players.

In the first quarter of 2009, the IPWP appeared to be making effective progress, and to have been close to achieving consensus. New Zealand is a small and somewhat self-contained market, where all the market players know one another well. The IPWP is small and for the most part collegial. These characteristics contributed to good initial results.

More recently, indications are that the process has broken down, reportedly for reasons unrelated to the quality of TNZ's proposals. This experience is perhaps a sobering reminder of the difficulty in reaching negotiated arrangements when the commercial interests of many of the parties are likely to be diametrically opposed.

**168** FCC, *In the Matter of developing a Unified Intercarrier Compensation Regime*, CC Docket 01-92, released April 27, 2001.

### 4.2.2.6 Summary of regulatory initiatives

A summary of the NGN regulatory initiatives discussed in the previous sections appears in Table 12. (Note that European Union, which appears in the table, is not a country but rather a treaty organization comprised of twelve Member States.)

Table 12: NGN regulatory proceedings in various countries and in the EU

| Country | Section | Issue | Proceeding | Results |
|---|---|---|---|---|
| UK | 4.2.2.1 | Interconnection | Extensive proceedings, substantial use of industry fora. Difficulties in achieving consensus. | Rather traditional approach remains in place. |
| | | Separation | Functional separation of BT implemented. | Apparently positive overall. Has enabled some relaxation of access regulation. |
| | | Access | New initiative to charge every fixed network user 50p per month to fund deployment of NGA to underserved areas. | For funding for NGA, too soon to say. Functional separation may possibly have slowed NGA deployment. |
| Germany | 4.2.2.2 | Interconnection | A series of industry panels to study NGN interconnection. | No consensus reached, thus no change from traditional arrangements. |
| | | Access | Incumbent demanded and received exemption from access regulation to incent NGA deployment. | Long-standing lawsuit by the European Commission contests the "regulatory holiday" exemption. |
| European Union (EU)<br><br>(group of countries) | 4.2.2.3 | Interconnection | Multiple ERG studies of NGN interconnection, limited consensus. European Commission has imposed quite strict cost orientation. | Arrangements remain traditional in form, but MTRs are likely to drop to € 0.015-0.03 by 2012. |
| | | Separation | European Commission has sought to provide all Member States with authority to impose functional separation if needed. | This will like be approved, with safeguards, by the end of 2009. |
| | | Access | Commission recently issued a new public consultation on NGN access. | Existing rules appear to be quite effective overall. For the new rules, too soon to say. |
| US | 4.2.2.4 | Interconnection | Proceeding active since 2001. | No consensus reached. |
| | | Access | Massive deregulation. | Collapse of competition, emergence of geographic duopolies. |
| New Zealand | 4.2.2.5 | Interconnection | Industry forum sought to define QoS-capable IP interconnection. | A strong start, followed by failure to achieve consensus. |
| | | Separation | Operational separation of TNZ is in place. | Apparently effective, but it is early to judge. |
| | | Access | Government is seeking to fund NGN access to 75% of population. | Too soon to say. |

It is worth noting that industry consultations regarding interconnection, whether for current or for future networks, have been particularly prone to deadlock. We surmise that the interests of industry players will rarely be perfectly aligned, and may also not be aligned with those of consumers. Given the high economic stakes involved, and the lack of consensus, it is perhaps not surprising that so many of these consultative groups have deadlocked without reaching definitive results.

## 4.3 Likely developments in Peru

This section describes likely evolutionary developments in Peru. Section 4.3.1 quickly summarizes key input from our interviews with market players. Section 4.3.2 discusses the status of VoIP in Peru. Section 4.3.3 discusses IP interconnection in Peru today, with particular emphasis on NAP.Peru. Section 4.3.4 deals with likely *evolutionary scenarios* for the migration to NGN in Peru. These scenarios inform the discussion of possible *interconnection scenarios* that appears in Section 4.3.5, based on the network evolution that is occurring and that is likely to occur. Finally, Section 4.3.6 discusses technological and economic implications of the scenarios; however, a detailed discussion of regulatory implications is deferred to Chapter 5.

### 4.3.1 Current and likely future network evolution

Interviews with major market players indicated the following present and likely future market developments:

- **Telefonica del Peru** sees no business case for upgrading the access network to next generation fiber-based access for the moment. They also see no business case for a comprehensive or rapid evolution of the core network to NGN; however, they will upgrade individual components of the fixed network on an opportunistic basis if they see an opportunity to reduce costs by doing so.

- **Telmex Peru** has a modern fixed network that internally operates as an IP-based NGN. They provide substantial support for broadband access; however, they are deployed in only a small fraction of the Peruvian national territory. There is no compelling business case to upgrade to fiber-based Next Generation Access (NGA).

- **Telefonica Moviles** has a mobile network that reflects a broad mix of technologies; however the clear move is toward GSM and UMTS. Within the GSM/GPRS/EDGE network, the deployment of an IP-based core is far advanced.

- **Claro** has not yet been interviewed. The Claro network is based on a single GSM/UMTS technology, and we conjecture that the core is already mostly or entirely IP-based.
- **Rural operators** seem to be quite diverse. Some appear to be based on circuit-switched technology, with no plans or prospects of upgrading to IP-based technology; others were based from the first on IP-based technology.

### 4.3.2 Voice over IP in Peru today

Many Peruvian market players have either trial or production deployments of Voice over IP today, either as an IP-accessible customer service or as a means of delivering their traditional voice services. This section is based on the information obtained from the interviews with the market players.

- **Telefonica del Peru** does not have plans to offer VoIP services for the moment.
- **Telmex Peru** has an IP network with softswitches. Their internal VoIP service is based on the SIP protocol. MPLS is used to provide QoS.
- **Telefonica Moviles** operates two IP core networks: one IP core network for voice traffic, which is critical, and another IP core network for data traffic, which is not critical. They do not offer VoIP as a distinct service.
- **PeruSat** is an independent VoIP provider. They have an IP network that uses a softswitch. They have 7 PoIs: 4 in coastal cities, and 3 in other cities. They use MPLS over Telefonica's national long-distance network.
- **Gilat-Spacenet Rural** has a VSAT network with analog telephony. It would be difficult for them to move all the current clients to an IP platform, but the new platform will be based on IP; for the moment they have a field trial with SIP.

### 4.3.3 IP interconnection in Peru today

In explaining IP-based interconnection, it is necessary to distinguish between IP-based *data* interconnection (including services such as Skype) and IP-based interconnection of *telephony services*.

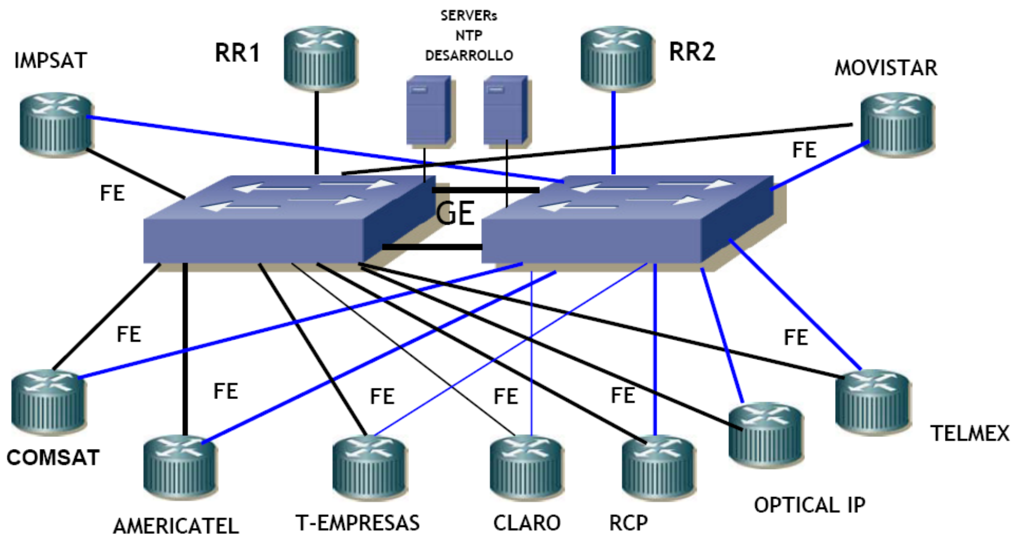
#### 4.3.3.1 IP data interconnection

NAP.Peru is the main IP data interconnection facility in Peru. The only form of peering offered is Multilateral Free Settlement Peering, i.e. any-to-any peering. The members are:

- América Móvil Perú - (Claro)
- Americatel Perú
- Comsat Perú
- Global Crossing
- Infoductos y Telecomunicaciones del Perú
- Optical IP
- Telefónica del Perú
- Telefónica Móviles
- Telmex Perú

The physical infrastructure of the Peruvian NAP consists of a level 2 switching NAP. In the center of the NAP there are 2 switches, which are connected in a star topology to the routers of all the members of the NAP (see Figure 45). Each operator has a number of Autonomous System. Each exchanges traffic with other operators by means of the Border Gateway Protocol (BGP-4).

Figure 45: Architecture of the Peruvian NAP




Source: "Análisis de la Situación del NAP a nivel EE.UU. y Latinoamérica", DN Consultores, January 2007.

### 4.3.3.2 IP interconnection of telephony services

In Peru – as in every other country that we have studied – for two network operators to implement IP data interconnection does not necessarily imply that they will choose to interconnect their inherent voice capabilities using IP.

In our experience, small VoIP operators are usually happy to interconnect with one another at the IP level (see, for instance, Section 2.5.2). Cable operators are often happy to interconnect their IP-based voice services to one another at the IP level (as appears to be happening in the United States and in the Netherlands). We know of no instance, however, where a large incumbent fixed operator or a large mobile operator has agreed to interconnect its inherent voice service with competitors at the IP level.[169]

The reasons for this are not entirely clear, but we conjecture that this is due to some combination of the following:

169 Customers can, of course, run independent third party VoIP offerings over IP access services provided by these network operators. That is quite a different matter from being able to connect to a conventional circuit switched telephone connected to an incumbent's circuit-switched network.

- Network operators receive call termination payments for conventional switched interconnection that are probably well in excess of real usage-based marginal cost. These payments help to sustain profitable retail arrangements, and to weaken price-based competition. Migration to IP-based interconnection might undermine the basis for these call termination payments.

- The business and regulatory models for using IP-based interconnection to interconnect their respective inherent voice services have never been established in sufficient detail.

- As a closely related matter, *Operational Support Systems (OSS)* and corresponding operational procedures have not yet been developed. This is not solely or even primarily a matter of technology; rather, it is not always clear how things should be managed in the first place. If the voice quality between two operators is poor, how can responsibility be unambiguously established? Are financial penalties appropriate, and if so what should they be? How should disputes be adjudicated? What possibilities exist for gaming the system? None of these questions are trivial.

- If two network operators were to agree to interconnect using IP-based interconnection, they would still need to interconnect to all other network operators (at least initially) using circuit-switched interconnection. The immediate effect of the change, then, would likely be to *increase* operational complexity, which would typically imply increased operational costs for the network operator.

Several of our market player interviewees identified an additional problem that would have been sufficient to explain the lack of IP-based interconnection, but was probably not the dominant reason in most cases:

- Current OSIPTEL rules do not permit interconnection on other than a circuit-switched basis.

In the case, however, of interconnection among different members of the same corporate family – for example, among the various Telmex enterprises, or among various Telefonica enterprises – it is indeed possible that the lack of regulatory support for IP-based interconnection is the most noteworthy impediment.

Our impression is that few if any countries have explicit, detailed rules today that explicitly permit IP-based interconnection, but that it is comparably unusual to have a rule that effectively *prohibits* interconnection using any technology other than circuit-switched SS-7 (as is effectively the case in Peru). In Germany, for example, the RIO does not envision any interconnection other than that based on E-1 circuits and SS-7; nonetheless, there is no prohibition on interconnecting outside of the regulatory regime, and there is no rule that forbids voice interconnection without the use of SS-7; thus, one could interconnect on an IP basis, or one could connect under private contract using SS-7/ E-1 gateways. Our understanding is that this is typical for the Member States of the European Union, where *technological neutrality* is the order of the day.

### 4.3.4 Likely scenarios of network evolution in Peru

Factoring in what the market players have told us, we can delineate a number of likely evolutionary scenarios. Among them, the most likely evolutionary scenarios are:

- **Scenario 1:** Telefonica Moviles, Claro and Telmex Peru complete the transformation of their core networks to an IP basis over the next few years (to the extent that the transformation is not already complete), but Telefonica del Peru continues to be primarily circuit-switched in its core network. Fixed broadband continues to grow, but the fixed network still reaches only a small fraction of Peruvians, and migration to fiber-based IP access occurs only in limited (high disposable income) areas of Lima and other coastal cities.

- **Scenario 2:** Telefonica Moviles, Claro and Telmex Peru complete the transformation of their core networks to an IP basis over the next few years (to the extent that the transformation is not already complete). Telefonica del Peru accelerates the migration of its core network and soon joins them. Fixed broadband continues to grow, but the fixed network still reaches only a small fraction of Peruvians, and migration to fiber-based IP access occurs only in limited (high disposable income) areas of Lima and other coastal cities.

- **Scenario 3:** Telefonica Moviles, Claro and Telmex Peru complete the transformation of their core networks to an IP basis over the next few years (to the extent that the transformation is not already complete). Telefonica del Peru accelerates the migration of its core network and soon joins them. Fixed broadband continues to grow. Increased take-up of new services (such as IP-based video) stimulates faster-than-expected demand for high bandwidth fiber-based next generation network access, but primarily in limited (high disposable income) areas of Lima and other coastal cities.

Schematically, we can distinguish among these scenarios as shown in Table 13.

Table 13: Evolutionary scenarios for migration to IP-based NGN in Peru

| | Core Network | Access Network |
|---|---|---|
| **Evolutionary Scenario 1** | Telefonica Moviles, Claro and Telmex Peru complete the migration quickly to an IP NGN core, TdP upgrades only opportunistically and sporadically. | High speed broadband deploys in coastal metropolitan areas, but migration to fiber-based NGA is rare. |
| **Evolutionary Scenario 2** | Telefonica Moviles, Claro, Telmex Peru, and TdP all complete the migration quickly to an IP NGN core quickly. | High speed broadband deploys in coastal metropolitan areas, but migration to fiber-based NGA is rare. |
| **Evolutionary Scenario 3** | Telefonica Moviles, Claro, Telmex Peru, and TdP all complete the migration quickly to an IP NGN core quickly. | High speed broadband deploys in coastal metropolitan areas, accom-panied by significant migration to fiber-based NGA in those same areas. |

These evolutionary developments are striking. The migration of core networks to IP is already well advanced in Peru (except in the case of Telefonica del Peru); the evolution of the access network to fiber-based IP, clearly less so. This is understandable when one considers that the evolution of the core network is motivated primarily as a means of reducing operational expense (OPEX) and of achieving economies of scale and scope. The evolution of the access network is expensive, and is motivated instead by the desire to provide new services and to bring them more rapidly to market. Market players see the benefits of cost savings in the core network, but do not find the business case for upgrading the access network in Peru to be as compelling.

We do not take issue with their judgment.

The UK and Italy have also experienced core-first migration to NGN. This contrasts strongly with Germany and many other countries that have upgraded the access network first.

Just now, a number of countries are responding to the global financial crisis by providing economic stimulus funding to build out fiber-based ultra-fast broadband access networks. *In the case of Peru, this may not be the right answer.* It may well be that any broadband stimulus funding would be better spent achieving a more widespread deployment of conventional (copper-based) or (fixed) wireless broadband, and a wider footprint beyond the coastal areas of Peru. It could also mean incentivizing fixed wireless broadband access or 2.5/3G in rural areas, where spectrum should be plentiful.

This judgment reflects many distinct considerations. First, we observe that next generation access is quite expensive to deploy.[170] Second, we note that existing fixed network infrastructure reaches only a limited fraction of the population, and that long distance back-haul (which is a necessary prerequisite to ultra-high speed broadband) is lacking in many areas of Peru; thus, the economics are particularly challenging in Peru. Third, penetration of conventional broadband (2 Mbps and less) in Peru is still limited. Fourth, disposable income in many parts of Peru is insufficient to support large new consumer expenditures for new services over next generation broadband.[171] Finally, the equipment to implement next generation access is declining in price, and experience is growing as to how to implement next generation access in a cost-effective manner. For all of these reasons, we think that using public funds to achieve greater penetration of broadband at conventional speeds (2 Mbps and less) is likely to provide a substantially better balance between cost and benefits *at this time* than using public funds to upgrade to ultra-high speed fiber-based next generation access. Public funding for next generation access could be reconsidered at a later date.

The question of next generation access deployment is not specifically an interconnection question, but interconnection arrangements are closely linked to questions of universal access and universal service. Beyond that, these questions have a great deal to say about how NGN will roll out in the years to come.

### 4.3.5 Likely interconnection scenarios in Peru

As previously noted, we consider it likely that Peru will (absent policy intervention to the contrary) follow roughly the same path that we have observed in other countries. Notably, IP interconnection for *data* will not necessarily imply interconnection of the *inherent voice service* of a fixed incumbent or of a large mobile operator.

The following interconnection scenarios are not mutually exclusive. In fact, it is nearly inevitable that some mix of them will continue to coexist concurrently, as is already the case.

- **Scenario 1: circuit switched / SS-7 interconnection.** Interconnection today is implemented using classic circuit switched techniques, incorporating the use of Signaling System 7. Even after core networks migrate to IP-based NGNs, traditional interconnection arrangements will continue to be in widespread use (and this is indeed already the case). Even if IP-based interconnection were to become widespread in Peru, circuit switched interconnection would probably persist for many years for international interconnection.

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**170** Elixmann, D., Ilic, D., Neumann, K.-H. und Th. Plückebaum (2008): "*The Economics of Next Generation Access*"; Final Report for ECTA.

**171** Market player interviewees said that it would be of interest only in certain neighbourhoods in Lima.

- **Scenario 2: “best efforts” IP-based interconnection.** IP-based interconnection could be implemented using a mix of IP transit and IP “best efforts” (i.e. with no special provisions for IP Quality of Service) peering.
- **Scenario 3: QoS-aware IP-based interconnection.** IP-based interconnection could be implemented using IP peering that preserves the IP QoS requested by the transmitting device. Operational experience with this form of interconnection continues to be extremely limited.

### 4.3.6 Technical and economic properties of the different interconnection scenarios

In this section, we consider technical and administrative requirements of the different interconnection scenarios.

#### 4.3.6.1 Scenario 1: circuit switched SS-7

Inasmuch as OSIPTEL and market players are already familiar with technical arrangements, they need not be discussed further in this report.

#### 4.3.6.2 Scenario 2: “best efforts” IP-based interconnection

IP-based transit service is normally governed by commercial arrangements. Unless specific problems have been identified, we would assume that there is no need to address requirements in this report.

IP-based best efforts peering is currently implemented at the Peru NAP (see Section 4.3.3.1). All major fixed and mobile operators are present. Market players appear to be satisfied with these arrangements.

Under current circumstances, there is no obvious justification for public policy intervention; however, there are a number of possible future developments that bear watching. These include:

- Even if the Peru NAP is used only for data and not for voice services, these data services are becoming increasingly critical to Peruvian society over time. A single point of interconnection is inherently vulnerable to malicious disruption or to natural disasters. In the interest of robustness and resiliency, there is a strong argument that two or three locations would be preferable.
- To the extent that presence at the Peru NAP confers a substantial competitive advantage, and that some network operators were excluded, it could in principle

raise concerns that the current members were operating as a form of cartel. If excluded network operators were to complain to OSIPTEL, OSIPTEL might want to consider whether any exclusions were anticompetitive. We have seen nothing to suggest that this is in fact a problem in Peru, and we note that regulatory intervention in the peering process has only rarely been required.

- If the IP data interconnection were to be used for voice service for which consumers expected robustness comparable to that of the existing voice network,[172] this would also imply an increased need for interconnection robustness and resiliency.

- Increasing data traffic will put increasing demands on Peru NAP. We have not assessed the degree to which the current design is scalable. At some point, larger market players may prefer to directly interconnect to one another (*private peering*) rather than the interconnect to each other at Peru NAP. They might continue to interconnect with smaller players at Peru NAP.

- New demands for high quality real time voice services, and perhaps for other services, may lead market players to demand that Peru NAP or a successor implement support for IP QoS. At that point, this interconnection scenario would merge into Scenario 3 (as described in the next section).

#### 4.3.6.3 Scenario 3: QoS-aware IP-based interconnection

As previously noted, the basic technology for IP-based QoS has largely been a settled matter for more than ten years; however, very few implementations exist between or *among* service providers. Business models are for the most part unresolved, and operational support procedures and management systems have not been defined.

With that in mind, we do not propose that Peru proceed to hurriedly implement QoS-aware IP interconnection. There is much to be said for waiting for countries with more pressing requirements to implement first, and thus to provide the world with the operational experience that is currently lacking.

Nonetheless, the problem has been studied extensively for years. We think it is possible to distinguish between promising practices, versus those that are not likely to work out. With all of that in mind, this section of the report offers guidance on the techniques and methodologies for IP-based interconnection that are most likely to prove workable. Many of these points are addressed more comprehensively in Chapter 5, which provides overall policy and regulatory guidance.

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**172** This is arguably not the case for services such as Skype, but is the case for some other VoIP services.

- **How requirements are specified:** Technical requirements are complex, and the underlying technology continues to evolve. In general, it is preferable for market players to mutually agree technical standards, rather than for the regulator to specify them ex ante. Nonetheless, the regulator must be prepared to step in, otherwise impasse is likely. Either the regulator can establish a default position, from which the parties can deviate by mutual agreement; or the regulator commits to arbitrate if the parties cannot reach agreement. The subsequent bullets can thus be viewed as candidates for the default position.

- **Routing between IP-based service providers:** The standards exterior routing protocol for IPv4 addresses in the Internet is BGP-4, as defined in IETF Request for Comments (RFC) document RFC 4271, "A Border Gateway Protocol 4 (BGP-4)" and successor documents.

- **General approach to IP-based interconnection:** The approach recently put forward by Telecom New Zealand (and discussed earlier in Section 3.4) is the most promising that we have seen. We nonetheless suggest that OSIPTEL not implement until there is operational experience.

- **Business model for providing QoS:** Most of the economic literature assumes that different levels of payment would be required for different levels of QoS. TNZ proposes to offer different levels of QoS without explicit payment. There is merit in the idea, but it is not yet clear what side-effects might result. Again, we suggest that OSIPTEL not implement until there is operational experience.

- **Number of Points of Interconnection:** At least two or three are required for resiliency and robustness. With a TNZ-style approach, more PoI make it progressively easier for large players to interconnect with very small ones; on the other hand, more PoI effectively imply higher barriers to entry. We think that one per Department (i.e. 24) is definitely too many, but it is not immediately clear how one would arrive at the optimal number of PoIs.

- **Classes of service:** Absent agreement to the contrary, there should be at least one class of service in addition to best efforts service, and that class should be suitable for real time bidirectional voice. Quality standards (in terms of delay, jitter and loss) should by default be derived from the MIT QoS Working Group report.[173] An additional class for delay-sensitive data traffic could be considered if market players identify a strong market demand.

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**173** *Inter-provider Quality of Service*, White paper draft 1.1, 17 November 2006, available at: http://cfp.mit.edu/publications/CFP_Papers/Interprovider%20QoS%20MIT_CFP_WP_9_14_06.pdf, Retrieved on 7 August 2009.

- **Monitoring of QoS:** The need to monitor whether the interconnected network has actually delivered the committed QoS in terms of delay, jitter and loss poses devilishly complex practical problems. In practice, PING measurements are simple, and widely used by service providers, but these measurements have well-known limitations. The MIT QoS Working Group[174] proposes monitoring using one-way measurements as developed by the IETF's IPPM (IP Performance Measurement Working Group). The choice between operationally simple PING measurements, versus IPPM measurements that are more accurate but also more complex, is not clear-cut.

## 4.4 Chapter Summary

This Chapter focuses on the migration to NGN thereby addressing different issues.

First, different technical routes to NGN are highlighted and an overview of patterns of network evolution across different countries is given. Apparently, the most prominent role on the agenda of network operators and regulators alike is played by the migration towards Next Generation *Access* Network infrastructures. Core network migration is also underway (or at least envisaged) in many countries, however, the competition policy and regulatory concerns of access network migration seem to be more challenging. Moreover, the Chapter focuses on the driving forces of the different migration scenarios across countries. In addition, policy challenges during the migration phase are analyzed. We perceive the following issues to be the most important ones: (a) the change in the number and nature of points of interconnection, (b) the apparent changes in the cost structure brought about by NGN, (c) the possibility of setting different termination rates for traffic in view of the risk of arbitrage, (d) the risk that arrangements never evolve beyond current arrangements, and (e) interoperability testing during the transition period.

Second, regulatory developments regarding VoIP, the NGN core and the NGN access infrastructure are addressed.

Third, this Chapter focuses on likely developments in Peru.

**174** Ibid.

# 5 Implications for regulation and policy in Peru

This chapter provides overall regulatory and policy recommendations for Peru that flow from the migration of fixed and mobile networks from a circuit switched basis to IP-based NGNs.

Consistent with our terms of reference, our focus is on network interconnection in an NGN environment. That implies that our primary emphasis is on the core network, and only secondarily on the access network.

Our research and our interviews have identified any number of apparently important issues on related topics, including universal service / universal access, and wholesale and retail pricing arrangements for the current circuit switched network (PSTN and PLMN). Even though these issues are well outside of the remit of the current study, we have identified them and provided preliminary impressions where we felt it appropriate to do so. These sections could perhaps be useful to OSIPTEL in identifying needs for future research.

Section 5.1 distinguishes among the various findings and recommendations that we are making in this report. Some are appropriate for immediate implementation, while others may be more suitable for eventual consultation among groups of industry stakeholders. With that in mind, Section 0 discusses the degree to which OSIPTEL should focus on process versus outcome in regard to these questions that are less ripe today, and begins to consider what the characteristics of a successful consultation would be. Section 5.3 discusses different evolutionary and interconnection scenarios, and considers the role of OSIPTEL (and the Ministry) in regard to these developments. Section 5.4 considers what the role of interconnection regulation is, and what should be regulated. Section 5.4.7 discusses the number of Points of Interconnection, while Section 5.6 discusses the different physical interconnection possibilities, including the possible evolution of NAP.Peru. Section 5.7 discusses cost modeling, and explains the changes implicit in the migration to NGN. Section 5.8 discusses the appropriate *structure* and the appropriate *level* of interconnection payments (e.g. call termination rates) in the near, intermediate and long terms. Section 5.9 discusses universal service and universal access in the context of interconnection. Section 5.10 considers IP-based Quality of Service (QoS) and the closely related issue of network neutrality. Section 5.11 provides recommendations as regards Voice over IP (VoIP) services, including licensing and authorization, numbering, access to emergency services, and lawful intercept. Finally, Section 5.12 explores the relevance of spectrum management policy as Peru evolves to IP-based NGNs.

Section 5.13 is a crucial “capstone” section. It organizes and summarizes the Recommendations, and attempts to present a reasonable sequence for implementing the Recommendations.

A detailed assessment of those aspects of specific current Ministry and OSIPTEL regulations that are ripe for revision as a result of the migration to NGN appears in Annex 2 to this report.

## 5.1 Different kinds of findings and recommendations

Formulation of specific recommendations for OSIPTEL in regard to NGN interconnection poses a number of distinctive challenges. It is particularly important to get the *phasing* and *timing* right for any public policy initiatives that OSIPTEL might wish to launch.

As we have seen in Section 4.3, the market is in a very uneven state, and market players do not yet appear to be clamoring for IP-based NGN interconnection; nonetheless, many of the larger market players are well along in migrating their core networks to IP, and a number of the newer rural operators have been IP-based from the first. In this environment, there are risks of doing *too much*; there are also risks associated with doing *too little*. The premature imposition of rigid or heavy-handed regulation might have the unwanted effect of freezing the market in its current state. Conversely, the failure to establish a clear and coherent regulatory and policy direction could equally well have the effect of chilling investment, and thus inhibiting the natural and healthy evolution of the Peruvian telecommunications environment. Our recommendations seek to cautiously navigate between these two extremes.

Our findings fall into a number of distinct categories:

- Some identify needs to modernize the Peruvian regulatory environment to address IP-based products and services that have recently emerged in the Peruvian marketplace, notably including Voice over IP (VoIP).
- Some relate to apparent problems that we have identified in the Peruvian regulatory system that probably have been present for some time, some of which are not necessarily closely linked to the migration to IP.
- Still others relate to problems that are likely to emerge with the future migration to IP-based interconnection.

Our recommendations necessarily treat these three categories of findings very differently.

As regards IP-based services, especially VoIP services, regulatory policy has been studied intensely since roughly 2004. Notions of regulatory best practice are now reasonably well established in Europe[175] and, to a lesser extent, in the United States. In these instances, we can provide concrete recommendations that OSIPTEL can profitably implement today.

For apparent regulatory problems that are independent of the migration to IP, we have identified corrections where we could. In a couple of noteworthy instances, either the exact dimensions of the problem were not clear, or else the most appropriate solution was not evident. Since these matters were clearly outside of the scope of our study, we have attempted instead to identify them either for future studies or for future industry consultations.

As regards regulatory policy for IP-based voice interconnection, we have followed a similar line of reasoning. This is not happening yet in Peru, it is rare in the world, and there is no clearly established sense of global best practice. Here our approach has been:

- To identify concrete recommendations that could be implemented today where appropriate;
- To put forward proposed principles that could guide OSIPTEL's going forward in those areas where immediate implementation would be premature; and
- To focus otherwise on the *process* whereby OSIPTEL could solicit feedback from market players on the guiding principles, and could move forward with concrete implementation when the time is right.

Schematically, we thus have an approach, and an implicit sequence of tasks, as depicted in Table 14. The rightmost column ("Relevant recommendations") serves as a cross-reference to the concrete Recommendations that we have made (see Table 17 on page 223). In machine-readable versions of this report, the entries in the rightmost column serve as clickable hot links that can be used to jump to the recommendation in question.

**175** WIK studied this for the European Commission in 2008. See Dieter Elixmann, Christian Wernick, J. Scott Marcus, with the support of Cullen International, *The Regulation of Voice over IP (VoIP) in Europe*, available at: http://ec.europa.eu/information_society/policy/ecomm/doc/library/ext_studies/voip_f_f_master_19mar08_fin_vers.pdf, visited on 8 August 2009.

Table 14: Suggested approach to public policy challenges association with the evolution to NGN

| Challenge | Suggested approach | Relevant recommendations |
|---|---|---|
| Modernization of regulation for current IP-based services | Implement appropriate policy updates today. | Recommendation 4<br>Recommendation 10<br>Recommendation 11<br>Recommendation 12<br>Recommendation 13<br>Recommendation 14 |
| Apparent problems in the current regulatory environment | 1. Implement corrections where appropriate;<br>2. otherwise, identify the topic for further study. | Recommendation 2<br>Recommendation 7<br>Recommendation 8 |
| IP-based NGN voice interconnection | 1. Identify regulatory changes that could be implemented today;<br>2. propose guiding principles for other aspects;<br>3. focus otherwise on the process whereby OSIPTEL could solicit feedback from market players on the guiding principles, and could move forward with concrete implementation when the time is right. | Recommendation 1<br>Recommendation 3<br>Recommendation 5<br>Recommendation 6<br>Recommendation 7<br>Recommendation 9<br>Recommendation 10 |

Note that some of our Recommendations are highly relevant to more than one challenge. For example, "Recommendation 10. Retain non-discrimination provisions." is equally applicable to today's IP-based services in general, and to tomorrow's IP-based voice interconnection.[176]

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**176** Three of our Recommendations (Recommendation 16, Recommendation 17, and Recommendation 18) express general principles with respect to spectrum management. They do not appear in this table because they are not linked to concrete, recommended actions.

## 5.2 Should OSIPTEL focus on *process* or on *outcome*?

It is appropriate for regulators (and regulatory consultants) to operate with a certain degree of professional humility. One can never predict with certainty what will happen in the marketplace, nor can one predict with certainty the effects of one's own actions.

The same could be said for market players. There is much to be said for the benefits of competitive markets, and market players will be better positioned than public policymakers to make certain judgments; still, market players also get it wrong from time to time. Moreover, market players may have incentives to be less than fully honest in conveying what they know to regulators and to other public policymakers.

IP-based NGN voice interconnection is clearly a case where one cannot predict with certainty today which regulatory approaches will work, and which will fail. We have strong intuitions about what is likely to work, but they have not been tested adequately in the real marketplace.

We therefore recommend that OSIPTEL not attempt to "drive beyond its headlights" (not attempt to navigate in a way that depends on assumptions about parts of the road ahead that cannot yet be clearly seen). We have therefore taken the approach of emphasizing *how OSIPTEL should procedurally go about reaching conclusions* for those areas where it would be premature to impose specific regulation today. In other words, we feel that OSIPTEL should focus on *process* rather than *outcome* in those areas at this time.

By establishing a clear set of regulatory principles today, and by identifying the process that will eventually be followed, we think that OSIPTEL can create an appropriate level of regulatory certainty without locking the industry into premature regulation that might later prove to have been inappropriate.

The specific form of consultative processes can be crucial. Consultative processes for British Telecom's migration to NGN were carefully orchestrated in the UK, and they appear to have greatly aided the transition. Processes in New Zealand also appear to be effective. Consultations on NGN interconnection in Germany were implemented with considerable care, but nonetheless led to interminable deadlock.

A noteworthy difference is that in the cases where consultations appear to have been effective, the regulator not only has had a seat at the table in negotiations among market players, but has also been perceived to have the authority (and the will!) to ultimately impose a solution if the parties cannot agree. The same was likely true of the negotiations that led to the creation of NAP.Peru – the negotiation was entirely voluntary, but the market parties likely felt that a failure to reach agreement would risk having OSIPTEL impose a solution that might well be less to their liking.

## 5.3 A choice among migration scenarios?

In Section 4.1.2, we discussed the network evolutionary paths that have been taken in various countries around the world. In Sections 4.3.1 and 4.3.4, we discussed current developments in Peru as regards NGN evolution and their likely implications for the character of network interconnection going forward.

Based on what we have heard, we anticipate that the NGN core will be upgraded to IP fairly quickly in Peru; however, the access network is unlikely to be upgraded to fiber-based Next Generation Access for quite some time. Market players see the merit in driving down operating cost by migrating the network core to NGN, but they do not seem to see a sound business case for large investments in upgrading the access network to high speed fiber (see Section 4.3.4). We have no reason to disagree with them.

To a first order, we do not see the need to treat the slower evolution to Next Generation Access as a market failure. It is probably a legitimate market outcome.

There is perhaps a stronger case for promoting a basic (i.e. copper-based) broadband roll-out to a larger fraction of the Peruvian population, and in achieving broadband penetration beyond the coastal regions of Peru. Inasmuch as this is a universal service question rather than an interconnection question, it is well beyond the scope of this study.

A second question that arises in regard to the likely evolution of interconnection in Peru has to do with the transition from circuit-switched interconnection with SS-7 to packet-based IP interconnection, with or without support for QoS (see Section 4.3.5). IP interconnection for data is already well established, but we do not expect (based on international experience) that Peru's major fixed and mobile market players will offer IP-based interconnection as a means of interconnecting with their inherent voice services.

One could perhaps argue that the failure to migrate to IP-based interconnection is a market failure; however, we know of no regulator in the world that has seen fit to mandate such a migration, and we think it would be premature if not inappropriate for OSIPTEL to do so at this time. We would also note that, while there may be some efficiency loss in interconnecting IP-based networks with circuit-switched SS-7 technology, there is no obvious anticompetitive implication.

With all of that in mind, we think that the appropriate near to middle term policy for OSIPTEL would be to ensure that there are no impediments to a migration of voice services to IP-based interconnection when market players are ready to do so. Such a policy could include enabling network operators who wish to do so to establish mutually agreeable arrangements for IP interconnection in support of voice.

It might also include ongoing efforts to continue to bring down termination rates to levels approaching real usage-based marginal costs associated solely with the voice service (see Section 5.8.2). Network operators may be resisting migration because they may fear that termination rates would be low or zero under an IP-based interconnection regime. By lowering current termination rates to levels more in keeping with real costs, the amount of revenue possibly at risk for the network operators is reduced.

We are making no specific recommendation in this section, because we believe that a wait-and-see approach is appropriate at this time in regard to the evolution of Peruvian networks.

## 5.4 Regulation of interconnection

This section of the report responds to the following requirements from the procurement document:

- Policy recommendations to consider when regulating NGN interconnection and requirements for public interconnection tender.
- Development of models to identify potential barriers to the entry of new operators to the market, taking into account incentives for competition among operators due to interconnection procedures.

This section continues with a discussion of potential barriers to entry (5.4.1), moves on to behavioral incentives (5.4.2) and the expected performance during migration to NGN, including the potentially resulting market power problems (5.4.3). Section 5.4.4 addresses issues of service aggregation, classification and bundling. Section 5.4.5 delves into the question of what should be regulated, while 5.4.6 addresses how regulation should be implemented.

### 5.4.1 Potential barriers to entry

Barriers to entry refer to (cost) advantages that an incumbent holds over potential entrants. Such barriers can be structural or legal/regulatory. Some economists also identify behavioral barriers (e.g., caused by the threat of predatory pricing), but such strategies can only work if one of the other barriers is already present. Given this rough classification, there can be further categorization of structural barriers by properties such as absolute cost advantages, the presence of sunk costs in combination with economies of scale, capacity constraints, or large financial requirements; however, such categorization does not lead to “models for identifying potential barriers to entry”. Rather, such barriers have to be identified in empirical processes based on knowledge about the technology, cost properties, financial market conditions (for structural barriers) and the legal and regulatory constraints (legal/regulatory barriers).

In some cases, the potential barriers in the NGN can be extrapolated from existing knowledge about entry barriers that were found in the past in the PSTN, mobile networks and backbone networks for the Internet.

Since this report is not concerned with NGA, we spend only a few words on this area, even though most of the potential barriers arise in the NGN access network rather than in the NGN core network (to the extent that NGA's are actually implemented). Very generally, duplication of fibre-based NGA's is harder than conventional broadband access so that NGA's are associated with heightened barriers to entry. This also holds for wholesale access via ULL, because the number of access points increases as the relevant points are closer to the users. The entry-enabling solution for this case could be to replace ULL with some form of bitstream access. This lowers the entry barriers but also reduces the entrants' ability to differentiate their offerings from those of the incumbent. Under ADSL++, this would not necessarily be a problem; however, if ULL has not been deemed feasible for the PSTN it will be less feasible under NGA.

Barriers to entry associated with the NGN could actually diminish, because the incumbent would have to convert its network, while *de novo* entrants could start immediately on basis of NGN. They would therefore not incur additional adjustment costs. This would reduce advantages the incumbent would otherwise have.

Entry barriers could also lessen for nation-wide competitors through a reduction in the number of PoI. Counter-acting this could be the potential elimination of (single and double tandem) network levels. An elimination of network levels would force potential entrants to build out their networks to the remaining PoI. This only pays if the scale of entry (more customers, more traffic) is increased along with the scope of entry (deeper network). Entry barriers of this kind could arise particularly for competitors with limited regional coverage.

In an NGN environment, switches will probably lose their status as entry barriers; however, as long as TdP maintains a circuit-switched network, conversion from IP to circuit-switched interconnection will probably have to continue (all new entrants would use IP, while the incumbent may stay with the old technology for some time).

Closely related to barriers to entry, which solely refer to *de novo* entrants, are new investment requirements and the danger of stranded investments imposed on existing competitors by the incumbent's move to NGN. Such competitors may have to abandon existing PoI and change their network architecture along with that of the incumbent. While the incumbent is also faced with such stranding issues, the incumbent migrates voluntarily and most probably replaces older equipment than that of the competitors. Thus, existing competitors could be weakened by structural changes required for the switch to NGN. However, as indicated in Section 5.5 and expressed in Recommendations 2 and 3, it is not clear at this time, which changes in the incumbent's network architecture and in the number and location of PoI will occur. Given the widespread consequences, it is paramount that such fundamental decisions are well prepared and discussed in the open so that competitors and potential entrants can make their investment decisions with some assurance about the PoI.

### 5.4.2 Incentives faced by market players in a process of migration to NGN networks

The process of migration to NGN networks and coexistence of the Public Switched Telephone Network (PSTN) with IP telephony services leads to specific incentives faced by market players.

There appears to be one incentive common to all market players in the process of migration to NGN networks. It is to improve their relationship with their own customers by providing uninterrupted and trouble-free service at a quality that keeps their customers happy. This overriding incentive is one reason for the use of overlay networks enabling parallel systems during the migration period. It is to some extent counter-balanced by cost considerations caused by having duplicate networks. This is a particular concern of radical network conversions like the one BT is currently undergoing in the UK. It may be less of a concern under the more gradual replacement approaches that are, for example, pursued in the U.S., where the change to NGN core networks happens almost unnoticed by the public. This last fact also hints at an incentive for network operators in general to keep their own plans out of the public eye, unless they have to reveal them (for example, in order to be able to raise cash from financial markets or in order to satisfy regulatory requirements for openness or in order to promote new services). An exception to this tendency towards secrecy can be preemptive announcements of technological advances meant to intimidate rivals. There is no indication of such announcements in Peru so far.

Incumbents may also have incentives to move ahead with aggressive plans for NGN conversion in order to preempt similar investment by (new) competitors. This holds particularly for NGA, although the incumbent often has a natural head start that entrants may be unable to overcome. With that head start in mind, the incumbent may want to wait and learn from the experience of other countries with new (access and core network) technologies and then follow more aggressively after the winning technology has been revealed.

To the extent that the incumbent waits, the entrants could forge ahead with investments that could improve their market positions through improved services and lower costs. Generally, the competitors have the advantage that they start out with a more modern network than the incumbent and that they face much less of a cannibalization problem, due to their much smaller market shares with the old technology.

Generally, network operators also have an incentive not to fall behind new technological developments employed by others. The incumbent, like TdP in Peru, can be an exception in this case, but that will only hold if the competitors cannot convert their technological lead into market successes.

### 5.4.3 Performance aspects of the market in a process of migration to NGN networks

Given the uncertainties associated with the actual moves of the players in the Peruvian market, we can only characterize the main performance tradeoffs involved in the process of migration to NGN networks and IP telephony. Keeping in mind that at the end of the migration process the overall network costs should be lower and the scope of services greatly enhanced, the end stage should have performance vastly improved. There are some dangers, though. For example, potential quality deteriorations could go along with QoS differentiation, as high quality for some classes of users might be accompanied by low quality for others. This might be a necessary consequence of the quality differentiation scheme (e.g., prioritizing) or a deliberate strategy for boosting demand for high-quality services at the expense of the best-effort Internet. Performance problems could also arise from potential market power enhancements due to NGA; however, we do not see these performance dangers as very likely to materialize. Also, performance degradations could be counter-acted by regulation once they become imminent. With this bright final outlook, the question is whether performance is going to improve steadily during migration or whether there will instead be performance deterioration along the way.

The expected market performance will depend on the scenario chosen by the market participants, which in turn depends on the aggressiveness with which the market players (the incumbent in particular) pursue NGN and NGA deployment. Performance during migration may suffer from cost increases, due to overlay networks, early retirement of infrastructure and from migration costs imposed on rivals. Conversely, in the absence of overlay networks, consumer satisfaction may suffer. Generally, we would expect that migration performance reductions will be more severe initially the more aggressively the move towards NGN/NGA is pursued. On the other hand, a later and slower migration would impose lower adjustment costs because (a) of better planning and execution and (b) the availability of more (foreign and domestic) experience. The cost of a slower migration strategy lies in the postponement of the ultimate benefits from NGN/NGA.

Of particular policy concern for market performance are potentially anti-competitive strategies of the players. Anticompetitive strategies refer to actions undertaken by operators with market power (incumbent) or in the pursuit of market power (entrants) that would not be profitable but for their anticompetitive effects. This does not mean that directly profitable strategies could not have anticompetitive effects as well. It may actually be difficult or impossible to differentiate between such strategies, both of which we will call “anticompetitive” in this characterization.

Anticompetitive effects can be expected from secrecy of the incumbent about its intentions as regards the deployment of NGN. This secrecy results in a delayed adjustment of competitors, and subjects them to potential stranding of investments that they incur based on the incumbent’s current network. It may also prevent competitors from making timely complementary investments to those of the incumbent. Both have the effect of raising rivals’ costs. Secrecy can however have a legitimate justification in protecting technical and organization innovations from imitation.

Aggressive NGA investment on the part of the incumbent can also prevent other competitors from investing in similar access networks or in close substitutes. At the same time, the incumbent usually faces substantial risks, due to the large financial outlays and uncertainty regarding the take-up rate by consumers.

As a dominant network operator in the fixed-net market and a major operator in the mobile market, Telefonica could potentially use fixed-mobile bundling or, in a future NGN world, fixed-mobile integration in order to disadvantage both fixed-network and mobile rivals. Since fixed-mobile integration may mean desirable new services, the anti-competitive consequences may have to be weighed against the consumer benefits from new products.

Currently, the fixed incumbent (TdP) enjoys a very strong dominant position in long-distance telephony, telephone access and fixed broadband access. In addition it also owns the dominant mobile provider so that potential competition from fixed-mobile substitution will be limited. Without any move toward NGN/NGA, the market power of the incumbent is unlikely to diminish in the foreseeable future.

How is this going to change under the evolutionary scenarios described in Section 4.3.4 above? It is unlikely that Evolutionary Scenario 1 constitutes an anticompetitive strategy by TdP. At the same time, it is a low-risk strategy that should keep TdP financially sound. The greatest dangers for TdP under this strategy could come from fixed-mobile substitution (which would also prominently involve Telefonica Moviles) and from VoIP provided by other fixed-network providers. However, given the overwhelming market position of TdP in the ADSL market, TdP would continue to benefit from VoIP as the broadband access provider: The demand for broadband access would be shifted outward. Thus, the slow migration to NGN and provisioning of IP telephony services may actually have little effect on TdP’s market power. This does not mean that TdP could not increase its market power after successfully concluding the migration.

Under Evolutionary Scenario 2, TdP would assume some investment risk that could expose it financially if the traffic associated with a profitable NGN conversion of the core network does not materialize. TdP's success would therefore depend on substantial growth either from its own customers or through the provision of services to competing operators. It is likely that this necessity may lead TdP to aggressively competitive behavior that, for some time, will benefit consumers in the form of lower prices, but could well weaken TdP's competitors and therefore strengthen TdP's market power. Scenario 2 in particular will also mean that TdP will effectively move from circuit-switched to VoIP telephone services, making the incumbent more competitive with alternative providers.

Evolutionary Scenario 3 is one further step up in terms of TdP's risk-taking. If successful, it could enhance TdP's market power in the high-speed broadband market. The extent of this potential market power increase would depend on the closeness of substitution between fiber-based broadband or ADSL++ and slower speed access available from both mobile and fixed network competitors. Because of the high risk, the incumbent is likely to want to combine network services with content provision so that the network neutrality issues described in Section 3.5 will become relevant.

Aggressive strategies of investment in transmission capacity and/or access by competitors could influence both the incumbent's strategies and its market power.

Under Evolutionary Scenario 1, aggressive transmission investment could provide the competitors with the ability to provide better services than the incumbent. At the same time, they would have to increase their market shares in order to utilize the new capacities. This would lead to tense competitive interaction among one another and with the incumbent. Although the incumbent's network has higher operating costs, the incumbent could well be very competitive in this battle because its network will be much more depreciated, while the competitors are dealing with new networks that will have to show some profit. To the extent that the new network costs are sunk the competitors can, however, credibly commit to aggressive market behavior. This may prevent the incumbent from a forceful response. Once the incumbent has recognized the competitors' investment strategy, the incumbent may switch to Evolutionary Scenario 2 and, as a quick follower, catch up with and perhaps overtake the competitors. Thus, a diverse set of outcomes appears to be possible. It is generally impossible for the regulator to second-guess the risk-taking engaged in by the market participants in such situations. In our view, the regulator should therefore not interfere, unless predatory or foreclosure strategies are used by the incumbent.

An aggressive transmission investment strategy on the part of the competitors in Evolutionary Scenario 2 could well lead to overall excess capacity, which may imply lower prices for consumers for some time, possibly accompanied by less investment. It could with some low probability also lead to more aggressive NGA investment in an attempt to boost core network utilization.

Aggressive investment in new access technologies by competitors is not very likely, but remains a possibility. In Germany, for example, Net Cologne is investing in FTTH/FTTB access ahead of the incumbent, Deutsche Telekom. Such investments can occur in situations where the incumbent does not have a head-start and where local conditions may favor a competitor. It may also occur with respect to new technologies, such as PowerLine, DOCSIS 3.0 or mobile broadband. Such NGA investments by competitors may induce the incumbent to move towards Evolutionary Scenario 3 if it fears being preempted.

### 5.4.4 Service aggregation and classification of services

To the extent that services are being established in spontaneous markets, their aggregation and classification follows from market properties. Operators try to offer new (or repackaged) services to their customers. This leads to new markets if they are successful. These services may then be categorized by means of market definitions (based on substitutability) and vertical relationships (based largely on complementarity).

Services can also be influenced by regulatory decisions about unbundling, about the provision of essential inputs and about pricing (e.g., rebalancing of access and usage charges). Even in these cases, the best criteria for service aggregation would be by substitutability and classification by complementarity.

Such classification can have important policy consequences if laws and regulatory rules are linked to service definition. A famous distinction in a related context has been the one between telecommunication and information services in the US. Information services are much less regulated by the FCC than telecommunication services. The classification of broadband Internet access over cable as an information service therefore had the consequence that no unbundling and no severe access obligations were imposed on cable TV operators offering broadband services. In contrast, DSL had been classified as a telecommunication service and was therefore subject to line sharing and other obligations by ISPs. These (and other) regulations were later abolished along with a redefinition of DSL as an information service. In our view, this example shows that there is a problem with regulation that is based on definitions of service categories rather than on the underlying market conditions. In that sense, the EU communications framework is an approach that is more likely to lead to technological neutrality on the part of the regulators.

Aggregation by network operators is often done in the form of bundling or tying. Tying is a form of *pure* bundling, where the purchase of one item also obliges the buyer to purchase another item along with it. For example, it was once that case that the purchase of an IBM punchcard machine obligated the buyer to purchase the punchcards from IBM as well. Analogously, Xerox obligated the buyer or renter of a copying machine to also buy the copy paper from Xerox. Pure bundling can, however, be asymmetric so that one could get the paper without having to buy or rent the copier.

In contrast, the offer of convergent services usually represents *mixed* bundling, under which both items can be purchased together but can also be purchased separately. With mixed bundling, there might also be technical or transactional reasons that encourage the joint purchase of two products, even though they may also be available separately. For example, when one purchases a car, it typically comes with tires and a radio. Analogously, convergent services are offered as triple or quadruple play, but one can also restrict the purchase to telephony or to TV or to high-speed Internet and purchase the other services from a different supplier.

The main concern with tying is that it may enable a supplier to leverage market power from one service (where the supplier has market power) to the other services (where the supplier would not otherwise have market power).

Convergent services can have a similar effect to tying if price discounts for the bundle are such that the customers would be foolish not to buy the bundle but instead to buy services separately. The question then is if the leverage of monopoly power is possible and incentive-compatible in this case. It is possible only if the provision of one of the services is associated with monopoly power and cannot at reasonable costs be duplicated by rivals. For example, if (1) the converged service bundle consists of telephony, Internet access and video, and if (2) video can only be provided by the incumbent, then a deeply discounted bundle of the three services would disadvantage rivals who can only supply telephone and Internet services.

Tying is often dealt with, not by means of *ex ante* (in advance) regulation, but rather through *ex post* application of competition law. There is no simple, bright line test for anticompetitive tying, but the factors that should prompt concern are linkage of purchase or rental between (1) a product where the supplier has market power and (2) a product or service where the supplier would otherwise not have market power, (3) under conditions where significant barriers have been erected to purchase or rental of the otherwise competitive product from a competing supplier.

### 5.4.5 What exactly should be regulated?

A number of threshold questions need to be addressed at the outset. Why do we regulate in the first place? Why has there been a tendency to regulate interconnection? Which entities should be subject to interconnection regulation?

It is widely accepted that regulation is appropriate in order to achieve socially desirable outcomes that free markets alone generally would not achieve; in other words, regulation addresses a range of potential market failures.[177] Most regulation can be characterized as falling into one of three categories:

- Responses to market power that would otherwise disadvantage end-users or inhibit competitive entry.
- Initiatives to deliver societally useful capabilities for which private benefits would not be sufficient to motivate commercial parties (for example, *public goods*).
- Allocation of resources that must be managed nationally (spectrum, numbers).

The migration to NGN does little to change this picture. Market power still exists, and must still be addressed. Necessary capabilities that the market alone probably would not provide (including access to emergency services, and lawful intercept) may be implemented differently in an NGN, but they are just as necessary as in today's networks. Spectrum and numbers are no less important for an NGN, at least in the near to medium term, than they are for today's networks.

The guiding principles of a market-power-based regulation requirement in a NGN context should generally be the same as in traditional telecommunications markets. The most logical approach to the regulation requirement has been established by the European Commission in its communications framework. The approach here is first to define markets, based on competition policy principles. Second, a three-criteria test is applied, which specifies if there are high and non-transitory barriers to entry, if effective competition is unlikely to evolve within a set time horizon and if competition policy is unable to solve the resulting market failures. Third, if the three criteria are fulfilled a dominant firm will tend to exist in this market, which has to be regulated with a choice of remedies from a prespecified set. Emerging new markets, for which the three-criteria test cannot yet be determined, will be temporarily exempt from regulation.

If one applies this framework to the Peruvian incumbent in an NGN context, an initial threshold question is whether the three-criteria test can be applied. Will NGN create new (wholesale) markets? While some old markets, those for termination in particular, will be modified, it is unlikely that new ones will be created. A regulatory exemption for "emerging new markets" (regulatory holidays) will therefore hardly be justified, unless the incumbent's market power is actually reduced. We have also argued that call termination will remain an essential facility (which always fulfils the three-criteria test). So, termination regulation should continue in an NGN regime, and this also holds for operators other than the incumbent.

Regulation can also be based on externalities (that may or may not be associated with market power). The case in point here is an obligation for operators to offer voice

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**177** This section expands on the discussion that appeared in the Introduction, in Section 1.2.

interconnection with each other (directly or indirectly). Such an obligation should remain in the NGN environment (Recommendation 5 of the report). The regulation should also include oversight over the number and location of interconnection points to the extent that the market participants cannot reach an agreement. This is necessary because the market players have made their infrastructure investments based on the current number and location of PoI so that any change can lead to stranded investments and suboptimal network architectures (see Section 4.1.3.1).

The development in many countries shows that the business model of (preselection and call-by-call based) long-distance network operators in fixed networks becomes less and less viable as mobile calling and VoIP have developed into superior substitutes. Although the regulatory requirements for call-by-call and preselection should remain on the books, it is important that OSIPTEL develop the prerequisites for other forms of competition. One of them is facilitating VoIP as a direct substitute for current long-distance services. This is expressed in recommendations 11-15 of this report. Another regulatory option is to facilitate integrated fixed-net offerings by competitors with their own long-distance networks but with no or only locally restricted access networks. While this can in principle be done through the requirement of local loop unbundling (ULL), we favor bitstream access or ADSL resale. ULL has been very successful in aiding full-scale competition in a number of rich countries, but it is a complicated and resource-intensive remedy. Additionally, problems emerge here in connection with the spread of fiber-based NGA, because this can lead to the closure of MDFs, where the competitors would collocate their equipment. However, any NGA development in Peru would most likely be of the ADSL++ variety so that current MDFs would not be affected.

Generally, experience in many countries has shown that there is no reason to restrict access of new competitors to the market. Thus, when spectrum licensing is not involved, new operators should be permitted to enter the market at their own pace, with their chosen lawful products and in the areas of their choice.

### 5.4.6 What interconnection regulation is needful, and how should it be applied?

Historically, interconnection regulation has been a response to market power.

In the circuit-switched world of the fixed PSTN and mobile PLMN, interconnection obligations have generally been required. In the IP-based world of the Internet, unregulated commercial arrangements have functioned to the satisfaction of many stakeholders (not all). As existing networks take on characteristics of the Internet, will regulation continue to be required?

This is not a trivial question. Some experts have suggested that the migration to IP will obviate the need for interconnection regulation;[178] we are, however, firmly of the view that this is wrong in the case of providers of voice services. As long as only a single network operator can complete voice calls (and SMS and MMS) to a single E.164 telephone number, the call termination monopoly is likely to persist.[179] As long as this unilateral market power remains, it is difficult to see any basis for the withdrawal of interconnection regulation. The migration to IP-based voice does not, in and of itself, reduce or eliminate the market power of a network operator that previously possessed market power.

If interconnection regulation is a response to market power, then it should be applied only to operators that possess market power; conversely, there is no need to apply interconnection regulation to network operators who do not possess market power. NGN network operators will tend to possess market power for one of three reasons:

- Because they possess market power in the access network (e.g. last mile);
- Because of the termination monopoly; or
- Because of network externalities[180] (the effect of having a very large number of customers).

Nearly all network operators that terminate telephone calls to E.164 telephone numbers possess terminating monopoly power,[181] and should therefore be subject to interconnection obligations and to limitations of the termination fees that they are allowed to charge. Even small network operators possess terminating monopoly power.[182] Even if call *origination* is fully competitive, call *termination* will tend to be subject to market power.

In recent years, there has been interest in migrating from *ex ante* (in advance) regulatory rules to a less intrusive *ex post* (after the fact) application of competition law

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**178** See, for example Reynolds, Paul/ Mitchell, Bridger/ Paterson, Paul/ Dodd, Moya/ Jung, Astrid/ Waters, Peter/ Nicholls, Rob/ Ball, Elise (2007): *Economic Study on IP Interworking: White Paper Prepared for the GSM Association*, London, 2007. Factors that might weaken the termination monopoly include multi-homing, termination arbitrage and termination bypass through call reversals.

**179** See WIK's study for the European Commission, Marcus et al., *The Future of IP Interconnection: Technical, Economic, and Public Policy Aspects*, March 2008.

**180** See Katz, Michael L./ Shapiro, Carl (1985): "Network Externalities, Competition, and Compatibility", in: *The American Economic Review*, Vol. 75, pp. 424-440; Farrell, Joseph / Saloner, Garth (1985): "Standardization, Compatibility, and Innovation", in: *The RAND Journal of Economics*, Vol. 16, pp. 70-83; and Crémer, Jacques/ Rey, Patrick/ Tirole, Jean (2000) : "Connectivity in the Commercial Internet", in: *Journal of Industrial Economics*, Vol. 48, pp. 433-472.

**181** Independent VoIP operators (without a network of their own) may possibly represent an exception. In principle, one would expect that they, too, should possess terminating monopoly power, but we have seen no evidence that they actually exercise it. Perhaps they are constrained by countervailing bargaining power.

**182** In fact, economic theory tells us that small operators are motivated to charge higher termination fees than large ones.

to deal with occasional violations. At this point in time, withdrawal of *ex ante* regulation of *data* interconnection seems to be workable; however, withdrawal of *ex ante* regulation of *voice* call termination is not. If voice call termination were not regulated *ex ante*, competitors would never be able to achieve market entry.[183] Voice call termination must therefore be regulated *ex ante*.

Having said all of this, it is important to bear in mind that remedies for market power should be narrowly focused and carefully crafted so as to be no more intrusive than is necessary to address the likely competitive harm. Typically, the regulator would impose similar remedies on similarly situated firms that possess similar market power; however, not all firms are similarly situated. For example, nearly all firms that offer voice telephony termination have market power, but it might be inappropriate to impose a stringent remedy on a small operator, because their scale of operations might simply be to low to efficiently carry the burden.

One could also consider what the appropriate level of aggregation is for the determination of interconnection charges – should one distinguish among signaling, switching, and transport, for example? What distinguishes termination as a bottleneck is the unique access to the receiving party. The bottleneck begins where the choice ends. That is usually the Point of Interconnection (PoI) closest to the receiving party. The termination charge (if any) needs to compensate for network usage from that point on.

An alternative operator that needs to use additional network elements to reach that PoI should in principle be obliged to pay for them, whether aggregated or not. In today's world, this is represented by single or double tandem charges. In an NGN, this will require re-thinking, because there are no tandems *per se*. If these transit costs are small, it may be appropriate to lump them in with the average cost of termination. If they are larger, then it might be more appropriate to offer transit as a function of the distance that the data is carried, or the area to which it is carried, as Telecom New Zealand is doing (see Section 3.4). There is no settled best practice for this as regards NGN voice services, but it is not unusual for large-scale wholesale Internet interconnection arrangements to have some basic charging arrangements to reflect the transit of large volumes of data across an ocean.

Some countries implement interconnection obligations by means of a Reference Interconnection Offer (RIO). There are both costs and benefits to this approach, but possibly more benefits, as summarized in Table 15. An RIO can increase market transparency and lower barriers to entry. It can also serve as a tool to assure non-discrimination. If there are several or many requests for interconnection, an RIO can

**183** J. Scott Marcus and Justus Haucap, "Why Regulate? Lessons from New Zealand", *IEEE Communications Magazine*, November 2005, available at: http://www.comsoc.org/ci1/Public/2005/nov/ (click on "Regulatory and Policy", Retrieved on 7 August 2009).

provide economies of scale (thus accelerating the provision of access, effectively reducing transaction costs for access seekers and thus enhancing competition); on the other hand, differences between access seekers might be great enough to warrant different treatment. One could argue that individual negotiations lead to better outcomes (inasmuch as an RIO could lead to "free rider" problems and inefficiencies); however, this concern is ameliorated somewhat to the extent that the parties are permitted to mutually agree to terms other than those in the RIO.

Table 15: Advantages and disadvantages of an RIO

| Advantages | Disadvantages |
|---|---|
| Increases market transparency | Might force identical treatment where it is not warranted |
| Lowers barriers to entry, accelerates entry | May lead to outcomes less efficient than those of free negotiation, including free rider problems |
| Lowers transaction costs for competitors | |

Given that IP-based interconnection would require complex interactions with the incumbent, an RIO might represent an efficient way to express a default outcome. Otherwise, the decision to require an RIO (or not) is not an NGN question.

The termination monopoly has been studied primarily in regard to voice services, but in principle it is just as applicable to SMS and MMS messaging.

Technical standards that might be referenced in Peru are discussed in Annex 2. Standards for IP Quality of Service (QoS), especially in terms of mean and variance of packet delay, and of packet loss, are discussed in Section 5.10.1.

**Recommendation 1. Apply regulation only to those entities that possess market power.**

As networks evolve to IP-based NGNs, interconnection regulation should be applied only to those entities that possess market power due to the call termination monopoly. Specifically, network operators that provide voice call termination to E.164 telephone numbers should be subject to regulation. Voice service providers that do not possess a network, however, should not be subject to interconnection regulation.

### 5.4.7 Infrastructure sharing

Infrastructure sharing is not specifically an NGN issue, but it comes up frequently in conjunction with the migration to NGN.

Infrastructure sharing has been implemented in a wide range of circumstances, for a wide variety of reasons. Sometimes it is compulsory, sometimes voluntary. An obligation may be based on market power, but it could just as well be based on some notion of societal efficiency; for example, an electric utility firm might be obliged to carry telecommunications fiber on its poles, even though the firm has no telecommunications market power (and may not even operate in that market).

No instance comes to mind where an infrastructure sharing obligation was imposed by a developed country on an entity that was not substantially dependent on public authorization to conduct business (for example, a municipal franchise, or the right to run wires across public rights of way).Thus, the obligation is something of a quid pro quo.

In the US, mobile companies often choose to rent space on towers provided by third parties who offer space to multiple operators. In Germany, two mobile operators chose to share their tower capacity, but the agreement does not extend to their competitors. In the US, cable television operators are required to provide “pole attachment” at cost-based prices to telephone network operators. France just enacted rules that encourage the first network operator to wire a building for fibre access to make the building fibre available to competitors, but permits them to deny access to competitors who do not return the favor in buildings in which the competitor is the first mover.

The principles for infrastructure sharing do not change in an NGN environment, but the specific issues of concern and the detailed components to be shared might be different. For NGN access, this is clearly the case. Within a multi-family dwelling, for example, there is a strong argument that FTTH fiber should somehow be shared.

For NGN interconnection, which is the thrust of this report, there will be presumably also be differences; however, given that most NGN interconnection today is done using traditional circuit switched SS-7 interconnection, there is no concrete experience that would make it possible to identify established best practice.

## 5.5 The number of Points of Interconnection (PoI)

We distinguish between the current circuit-switched fixed and mobile environment (Section 5.5.1) and the future IP-based NGN environment (Section 5.5.2).

### 5.5.1 Number of PoI in circuit-switched networks today

Before proceeding to Points of Interconnection (PoI) in an NGN environment, it is necessary to make some points about current arrangements for interconnection of circuit switched networks in Peru, even if these are arguably outside of the terms of reference for this study.

Current arrangements in Peru, as we understand them, are based on a Point of Interconnection (PoI) in each of the 24 Departments. Calls handed off from the originating network operator to the terminating network operator, and destined to terminate on a telephone number within that Department, are terminated at an appropriate wholesale termination rate. Calls handed off in a Department other than that of the terminating telephone number are subject to substantial transit charges.

Only Telefonica del Peru is subject to an explicit regulatory requirement to maintain PoIs in all 24 Departments. Other operators are not compelled to do so, but nonetheless may find it advantageous to maintain a substantial number of PoI (at least to Telefonica del Peru) in order to avoid transit charges.

These arrangements seem reasonable at first glance; however, nearly every interviewee complained that they imposed inefficiencies of one kind or another.

To begin with, the number of PoI may be too high, even in the current circuit-switched environment. Very few operators (other than Telefonica del Peru) require physical presence in all 24 Departments. The effective need to build out to multiple PoI in order to obtain more favorable pricing represents a significant barrier to entry for smaller network operators.

Even for the largest mobile operators, these arrangements appear to be inefficient. A large Peruvian mobile operator need not have, on purely functional grounds, more than three or four tandem switch locations capable of voice call interconnection. Large mobile operators connect to one another in just a few locations, but find it necessary to connect to Telefonica del Peru at a large number of PoI in order to avoid high transit charges. Even so, the large mobile operators report that they are repeatedly back-hauling significant volumes of voice calls solely in order to reduce transit payments. Interviewees spoke of voice calls crossing roughly the same ground two or three times before being delivered to their final destination.

This seems to us to be different from what we observe in other countries. Mobile operators in other countries typically accept calls at any PoI, because in reality they do not know where the customer happens to be physically located at the instant in time when the call is originated.[184]

From the perspective of small competitive or rural operator operating in a small part of the national territory, on the other hand, there may also be advantages associated with the relatively large number of PoIs. A fairly large number of PoI implies that the distance that traffic has to be back-hauled to reach the nearest PoI will tend not to be very great.

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**184** Mobile operators often deliberately agree on hot-potato routing.

It is possible that the number of PoI is appropriate for the current environment, but that inefficiencies or rigidities in wholesale and retail pricing are getting in the way.

That all of this is a major issue may be a function of the challenging topography of Peru. In many developed countries, the back-haul networks used for transit have been upgraded to fiber optics. With the advent of Dense Wave Division Multiplexing (DWDM), these fiber optic offer enormous capacity at reasonable cost. The cost of transit thus becomes very small as a fraction of total cost. In such countries, the economic significance of the distance that traffic has to be back-hauled has declined substantially over time. Indeed, there is a tendency to “postalize” prices, i.e. to charge a single price for calls to any point in the national territory.[185]

In Peru, this same technological and economic evolution has happened in the populous coastal regions; however, back-haul to mountainous and interior regions still depends on expensive copper-based alternatives. For that matter, portions of the national territory can be reached only by satellite. Thus, the cost of transit remains high as a fraction of total cost for many parts of the national territory. Thus, the number of PoI, and also the wholesale and retail pricing arrangements associated with their use, have significant economic impact.

We did not develop a comprehensive understanding of what is happening in regard to circuit-switched interconnection. These aspects of the *current* system did not seem to be within the scope of our study. We would also note that the information from interviewees and from OSIPTEL itself did not fully explain what we were hearing. All considered, however, we think that further study of these issues would be warranted.

**Recommendation 2. Initiate a public consultation to identify any inefficiencies in current circuit-switched interconnection arrangements.**

OSIPTEL should initiate a public consultation, soliciting input from stakeholders and market players (large and small, fixed and mobile, urban and rural), in order to identify any inefficiencies in current circuit-switched interconnection arrangements. Market players should be asked whether the number of PoIs is appropriate; whether there are any inefficiencies imposed on wholesale and/or retail pricing arrangements as a result of the delivery of call traffic to the PoI associated with the geographic telephone number; and what reforms might best address any shortcomings identified.

**185** Typically, there is one price for the fixed network, and another for the mobile network.

### 5.5.2 Number of PoI for future IP-based NGN interconnection

This section considers the number of Points of Interconnection that should be chosen for IP-based NGN voice interconnection. Whether IP-based data interconnection would be implemented at the same PoI, or at NAP.Peru, or at some other PoI is a question we return to in Section 5.6.

As previously noted, we are aware of no instance in the world where an incumbent or a large mobile operator is offering IP-based interconnection to its inherent voice services today. The closest that we are aware of is the "local peering" that is offered by Telecom New Zealand (see Section 3.4). That system is somewhat analogous to the Peruvian system, inasmuch as data would typically be carried to the PoI closest to the termination PoI before being handed off, and would then be subject to no IP-based *traffic* charges at all. (Whether there might still be some form of voice termination fee, independent of IP traffic charges, is a matter that the New Zealanders have not yet come to grips with.)

A crucial difference between Peruvian arrangements and New Zealand arrangements is that the interconnecting network operators in New Zealand are free to negotiate whatever they choose. This kind of solution, based on private negotiations and property-like rights, is often attributed to Coase.[186] The negotiating parties are arguably much better situated than the regulator to identify and to rectify inefficiencies.

In a Coasian system, it is important that rights be clearly defined at the outset. It is important that the initial or default position – the Reference Offer in this case – be *fair*, but it may be less important for the initial position to be *efficient*. Assuming that the differences in bargaining power are not prohibitively great, the parties ought to be able to negotiate their way to a more efficient outcome. To the extent that the initial position is inefficient, it makes it that much easier for the negotiating parties to arrive at an agreement that benefits them both (a *Pareto improvement*, or more colloquially a win-win outcome).

In Peru, only Telefonica del Peru is subject to an explicit obligation to provide a PoI in each of the 24 Departments; however, our understanding is that the cost of transit creates strong economic incentives for other network operators to appear at a large number of PoI. In Section 5.5.1, we recommended that OSIPTEL initiate a consultation to identify any inefficiencies or rigidities as regards the number of PoIs and the charging arrangements associated with them.

As regards the initial or nominal number of PoI, we would note that most countries that have migrated to IP-based NGNs have experienced a substantial reduction in the number of Central Offices, usually accompanied by a substantial reduction in the

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**186** Ronald Coase, "The Federal Communications Commission", 1959.

number of PoIs.[187] Peruvian market players whom we interviewed, however, did not anticipate a reduction in PoIs, due at least in part to the need to maintain presence in multiple Departments. This reinforces the notion that the continued effective obligation to maintain a large number of mandated PoIs would create inefficiencies in an IP-based NGN environment.

In general, having more PoI makes it possible to have smaller local areas for interconnection. This makes it possible for transit payment arrangements to more closely approximate distance-based circuit costs, and may also make it possible for networks with a greater overall disparity in size to interconnect on a roughly equal basis (as envisioned in the Telecom New Zealand "local peering" arrangements.

A larger number of PoI also reduces the distance that a small operator (doing business in only one Department, for example) has to back-haul traffic before handing it off.

On the other hand, having more PoI implies that more interconnection infrastructure is required for operators that do business in multiple departments – more circuits (for more distance), more equipment, or both. More PoI consequently tends to imply higher barriers to competitive entry for medium-sized to large competitors.

In light of these various considerations, we propose (1) that OSIPTEL conduct a public consultation regarding the number of PoIs required for IP-based NGN voice interconnection; (2) that OSIPTEL consider a number of PoIs considerably less than 24; (3) that the parties should have some latitude to negotiate the number and location of PoI, and (4) that OSIPTEL should consider whether some of these ideas could perhaps be applied to interconnection on a circuit switched SS-7 basis today.

**Recommendation 3. Consult with market players as regards the appropriate number and nature of Points of Interconnection (PoI) for IP-based NGN voice.**

OSIPTEL should consult with market players as regards the appropriate number and nature of Points of Interconnection (PoI) for IP-based NGN voice. Is it necessary to maintain the current system of one PoI per Department when voice interconnection is based on IP? To what extent can the nature and location of PoI be left to the market players themselves? Are there rigidities or inefficiencies in wholesale or retail pricing that would need to be addressed as Peruvian network interconnection evolves to an IP basis? This consultation might profitably be combined with the consultation that we have recommended regarding interconnection in today's circuit-switched environment.

187 In a number of countries, including the UK and the Netherlands, regulators have required the incumbent to keep PoIs open longer than otherwise necessary so as not to strand competitors' investments.

## 5.6 The nature of a Point of Interconnection (PoI)

In this section, it is necessary to distinguish between IP-based *voice* interconnection and IP-based *data* interconnection.

In Peru, data interconnection is implemented at a single location: NAP.Peru. Voice interconnection, by contrast is implemented in each of multiple Departments. In an NGN world with IP-based voice interconnection, the data interconnection might be implemented over the same PoI as the voice, or it might remain distinct (as it is today). It is also possible, or perhaps likely, that different pairs of network operators would reach different decisions as to whether to merge the IP-based voice and data interconnections or to keep them distinct.

For the market players, considerations of technology and of cost do not appear to compel that the voice and data PoI be merged, nor that they remain distinct. From a regulatory perspective, we see no strong grounds for preferring one approach over the other. Consequently, we assume that both are likely to exist, and that there is no need for OSIPTEL to try to drive the decision in one direction or the other.

### 5.6.1 IP-based NGN data interconnection

In most of the world, the discussion of Internet interconnection focuses on so-called *public peering points* similar to NAP.Peru. It is important to note that public peering has always co-existed with so-called *private peering* – direct interconnections between two ISPs, often consisting simply of a circuit from one to the other.

A common pattern is that large or backbone ISPs use private peering to reach their largest competitors – essentially, any competing ISP for which there is enough peering traffic to keep a circuit fairly fully loaded. They then use public peering to reach a large number of small competitors – a single shared circuit can provide access to all of the competitors that are present at the NAP.

It is thus important to remember that the NAP is not the only way for IP-based network operators to interconnect. It is only part of the story, and it is not inherently better or worse than private peering.

Market players are usually better positioned than regulators to identify the most appropriate technology to use for private or for public peering. To a first order, we do not think that OSIPTEL needs to be establishing standards for IP interconnection media.

Again, assuming that NAP.Peru is run in a fair and non-discriminatory fashion, there should be no call for OSIPTEL to intervene. We would note that there are scenarios where a network operator might choose to degrade the quality of interconnection (or equivalently not to upgrade capacity as demand rose), but this has been rare in practice and probably does not require *ex ante* regulatory measures.

The only area where we see a possible basis for public policy intervention has to do with the fact that there is only one NAP.Peru. It could be useful to explore with the market players what would happen in the event of a massive failure. How would traffic be re-routed? What would the likely consequences be in terms of packet loss and delay during the outage? There might be an argument for ensuring that a second or third NAP is available for purposes of robustness and resiliency.

**Recommendation 4. Promote the creation of a second or third NAP.Peru.**

In the interest of robustness of critical infrastructure, OSIPTEL might wish to promote the creation of a second or third NAP.Peru.

### 5.6.2 IP-based NGN voice interconnection

The technologies available for IP-based voice interconnection and data interconnection are much the same. A pair of routers operated by two network operators could be linked (at the Data Link Layer [Level 2] of the OSI Reference Model for Interconnection) by means of a circuit, or by means of a switching fabric. Quality of Service (QoS), to the extent required, could be implemented either by the routers (at Level 3) or by the underlying Level 2 interconnection medium.

For IP-based voice interconnection, as for IP-based data interconnection, there is a strong argument that the network operators themselves are better positioned to identify good technical solutions than is OSIPTEL.

At the same time, there is probably a role for OSIPTEL to play. Voice interconnection will tend to be associated with termination market power. Consequently, the risk of anticompetitive behavior is larger for voice than for data.

International best practice is not a settled matter. For now, we consider it appropriate that OSIPTEL carry forward its current practices into the world of IP-based voice interconnection.

**Recommendation 5. Network operators need suitable flexibility, but OSIPTEL should continue to oversee the voice interconnection process.**

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| Network operators need suitable flexibility, but OSIPTEL should continue to oversee the voice interconnection process. Specifically: (1) Network operators that are presently subject to an obligation to interconnect their voice services should continue to be so obliged. (2) Network operators should be encouraged to agree voice interconnection arrangements among themselves. (3) Such agreements should be provided to OSIPTEL. (4) OSIPTEL should retain the right to establish voice interconnection arrangements if the parties cannot agree, and the right to intervene if a voice interconnection arrangement appears to be anticompetitive. |

## 5.7 Analysis of network costs in Peru

Section 5.7.1 provides a working definition of cost. Section 5.7.2 expands on that discussion in the context of the *Long Run Incremental Cost (LRIC)* methodology. Section 5.7.3 considers the changes in approach that might be appropriate when approaching LRIC cost modeling from the perspective of an NGN. Section 5.7.4 then addresses more directly the specific challenges of LRIC cost modeling in the context of determining the capex of an NGN. Section 5.7.5 deals with the determination of opex, Section 5.7.6 with the allocation of costs to services and capacities demanded, Section 5.7.7 with the special topic of how uncertainty and risk is to be taken into consideration in the specification of the WACC, and Section 5.7.8 with how to differentiate incremental and common costs. Finally Section 5.7.9 provides an example of how the costs for telephony delivered over an NGN could be traced to the various network elements of an NGN that are used in its provision.

### 5.7.1 Definition of cost

When arguing about cost, misunderstanding and confusion can easily crop up. One should avoid identifying a cost solely because it has to be "allocated" to an activity or service without giving due regard to what the cause of that cost is. We therefore start the discussion with a very brief review of how cost is defined in general, and then deal with the relevant issues relating to the cost of NGN from this vantage point.

As will become apparent, most of the regulatory issues that are approached in terms of the cost of a service are actually issues of cost *recovery*, i.e. issues of pricing. The regulatory authority on the one hand, and the (regulated) operator on the other, may use different criteria regarding how the costs of services are to be recovered. With that in mind, the focus in the ensuing discussion is on how costs arise, how they are measured and – only then – how they are to be allocated to the various services to be provided now and in the future.

According to the standard definition, cost corresponds to "the value of the goods and services consumed in the production of some output, usually another good or service". From a regulatory point of view, if for example prices of the output are regulated due to market power, an additional requirement is that the production should be efficient, meaning that the consumption of goods and services should be at the minimum level necessary to generate the output. Also, if the *Long Run Incremental Cost (LRIC)* standard is applied, the goods and services to be counted as consumed in the process should be all those that – over the long run – are caused by this production.

Given the great capital intensity with which telecommunications services are produced, the goods and services consumed according to the above definition are primarily the capital items (network elements) that make up the network and that are being consumed over their useful lives, plus the corresponding operating and maintenance services. At the root of most issues concerning the costing of network service lies the fact that these capital items have a lifetime extending over a number of periods (years), providing services over these periods (possibly in varying volumes). Therefore, the following discussion will also primarily dwell on the costs caused by the investment in these capital items.

### 5.7.2 The determination of costs following the LRIC standard

The following discussion is in terms of a bottom-up modeling approach to the costing of telecommunications services. We know from the record that OSIPTEL has used this approach and considers it to be the most complete and reliable methodology for the determination of costs that reflect the provision of service by an efficient network.[188] For the purpose of the present discussion, we will therefore summarize here only briefly WIK's methodology to bottom-up cost modeling to assure a common understanding of the framework within which the issues of costing are going to be discussed.

The LRIC modeling process as WIK implements it can best be understood on the basis of Figure 46 below. The schematic modeling process shown in Figure 46 would in its generality apply to any kind of network to be modeled, i.e. an NGN as well as a traditional PSTN or a mobile network. As shown in the figure, the modeling process consists of two separate steps, the first being the planning of the relevant network and representing it on the computer, the second being the determination of the costs of the services of interest that are provided by this network.

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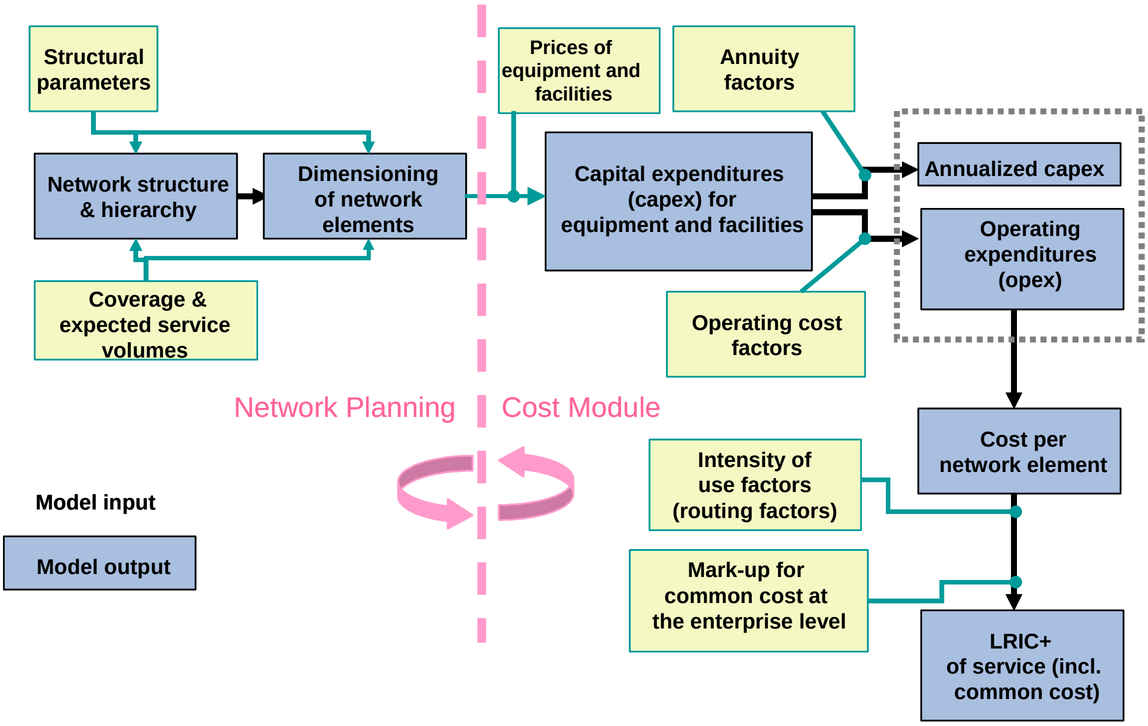
**188** See OSIPTEL: “Modelos de Costos – Facilidades Esenciales – Experiencia Peruana”, Presentation, February 2007.

Figure 46: Schematic view of the modeling process for WIK's network cost models




Source: WIK-Consult.

The structural parameters that the modeling process starts with are the population of the territory in question, information about the portion of the territory covered, penetration in the areas covered, average demand by subscribers during the busy hour and the distribution of that demand among the various services. Given this information, engineering know-how is applied to plan the network that efficiently delivers services demanded to subscribers and also provides interconnection services to other networks. From the network structure thus established, the list of required network elements and corresponding facilities and equipment (e.g. number of base station locations, number of switches, lengths of leased lines of various capacities) are derived. This then provides the information to carry out the cost calculation. For the cost calculation, the following information is required:

- prices of the facilities and equipment,
- the value of the *Weighted Average Cost of Capital (WACC)*,
- the lengths of the economic lives of facilities and equipment,

- the expected growth rates of the various services,
- the mark-ups to determine operating expenses as a function of the replacement values of facilities and equipment,
- the matrix of the intensity of use factors (also known as routing matrix) by which the costs of the various network elements are assigned to the various services (actually a result of the network design), and
- the mark-ups for common cost at the enterprise level.

The cost of each service consists of three components:

- the user cost of capital (depreciation, cost of money), referred to as annualised capex;
- the cost of operating and maintaining the network, referred to as opex, and
- common cost at the enterprise level.

Annualized capex of each facility or piece of equipment is determined using the annuity approach that integrates depreciation and cost of money as well as expected changes in the prices of these inputs and the expected growth in output (an extension of the so-called "tilted" annuity approach).

Opex is determined on the basis of a mark-up on the values of the network elements where these values are at replacement prices. The reason for this approach is that this cost component is very difficult to model explicitly and there exist so far no such models that are able to do so, further because the approach we use has been empirically validated by actual data from operators.

Common cost at the enterprise level is added to network costs as a mark-up; it is also based on evidence from operators' cost records. Note that no common costs are calculated at the level of the network because any cost component of a network element that does not vary with volume – usually only over a certain volume range – is rolled into the network cost for the various services.

The model determines costs according to the LRIC cost standard, which implies that whenever there is joint use of resources, the costs of these resources are assigned to services according to the principle of cost causation. This is implemented by determining the costs of network elements and assigning shares of these costs to the various services according to the intensity with which they use the network elements. Whenever such network elements are also used by services not modeled (for example whenever there is shared use of facilities by different networks), this is taken into account by including the applicable share of the costs only. Being bottom-up, the WIK model may nevertheless incorporate elements of the existing network to which the model is to be applied, for example by taking a scorched-node perspective with respect to the locations of nodes.

There are several important aspects that have made the approach so successful when applied to traditional networks and services. These are:

- Relatively sure expectations regarding types and volumes of the various services;
- Information about best industry practice regarding network design and implementation; and
- Knowledge of world market prices for the different types of network equipment and facilities

The first two points collectively make it possible to plan the right size and structure of the relevant network and to dimension the different network elements such that the services are provided in a technically efficient way, while the third assures that the costing process reflects proper levels of input prices, rather than inflated levels.

The approach should in general not be different when applied to a network according to the NGN philosophy. All the tasks shown in Figure 46 need to be accomplished and – for costing purposes – it makes no difference whether the network elements consist of concentrators, local and tandem switches or of media gateways, access routers or core routers, as long as they are part of a network that is efficient in terms of what it is supposed to accomplish. What will be different is the quality of information available to actually design the network and carry out the costing exercise. This applies in particular to the reliability of the forecasts of the volumes and composition of the demand to fill the network. NGNs will in general allow for much higher capacities than traditional networks, and the extent to which the relevant volumes of demand for services can be expected to be forthcoming will have an immense influence on what the cost of an NGN is.

### 5.7.3 What is different when determining the cost of NGN

Before going into specifics, a few aspects of NGNs should be mentioned that have implications for the measurement and determination of the costs of services delivered over them, in particular regarding NGNs in developing countries and issues of interconnection relating to NGNs in those countries:

(a) Once mature, NGNs are expected to deliver services at lower cost per "unit of service" than the traditional networks. There is, however, considerable uncertainty when and to what extent this will happen.

(b) It is frequently asserted that NGNs have higher up-front costs than those of traditional networks (where this applies, however, primarily to NGN access networks).

(c) While traditional voice services will use only a small fraction of the capacity of an NGN, they are likely to continue to be responsible for a large, if not the largest, share of revenue. In contrast, Internet and television services use a huge amount of capacity but contribute at most about the same as voice services do to overall revenue. This observation holds for a typical European country; in a country like Peru, the imbalance might well be even greater.

(d) It might well be that the trend towards NGNs in developing countries is driven more by the motive of cost saving than by the prospects provided by new business cases. This holds in particular for the mobile operators who in these countries by far serve the largest share of total customers.[189]

What are the messages from the above observations? The promise of (a) is that costs and therefore prices of all services will eventually come down, but that this promise depends on NGN becoming mature, meaning in particular that sufficient volumes of demand are forthcoming to fill the capacities installed. Point (b) makes this more explicit by pointing out that an NGN requires substantial up-front investment that might not yet be justified by current demand, such that the prospects of cost recovery are uncertain. We will enlarge on this below. Point (c) contains the implicit threat that making prices of traditional services cost-based (in the sense that they are based on the cost of the share of capacity actually used) might result in a drastic decrease of revenues to network operators – a decrease that would not readily be compensated by revenues from Internet and television services that use the lion’s share of that capacity. If (d) is a correct characterization, it throws a telling spotlight on the situation in developing countries, in that it implies that the migration to NGN in developing countries serves primarily to drive costs down.

We return to point (b) which is graphically depicted in Figure 47. We see two curves representing the costs of a PSTN and an NGN, respectively, rising as a function of the total volume of services. The curve for the PSTN starts at a lower level than that of the NGN, but it rises more steeply, so that it crosses that of the NGN at a certain level of volume. This will have implications for cost recovery that we will develop later. We assume that the picture represents the cost situation at the current period. What is then worth pointing out is that this picture represents a "static" perspective, a view of cost causation and recovery that takes for granted what will be happening in the future. As regards the PSTN, we can assume this perspective to be relatively precise; as regards the NGN this can probably not be assumed.

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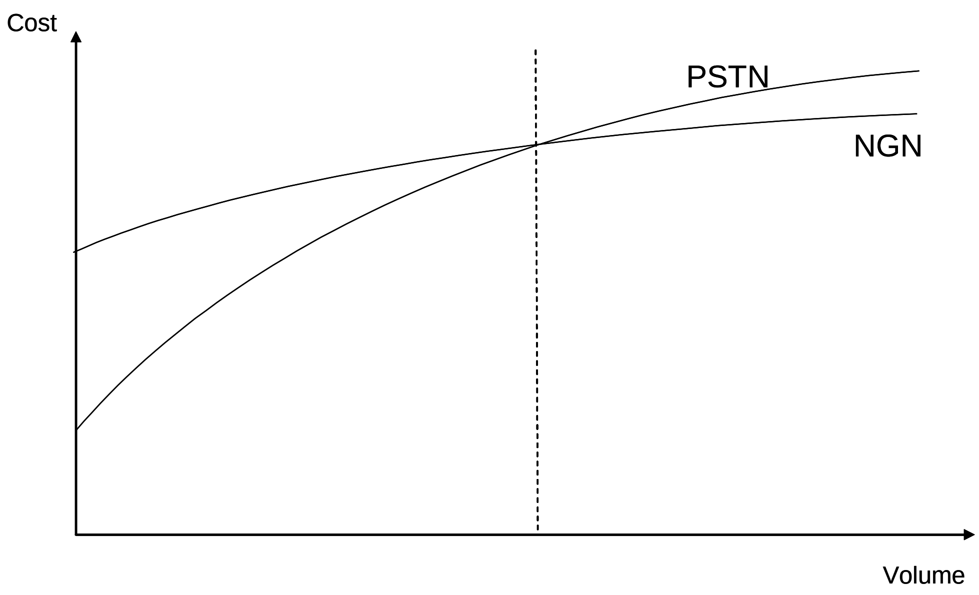
**189** See Tim Kelly: “Next-Generation Networks (NGN): Market and Regulatory Trends”, Presentation, 10-11 September 2007. See also Section 4.3.6 and 5.1.

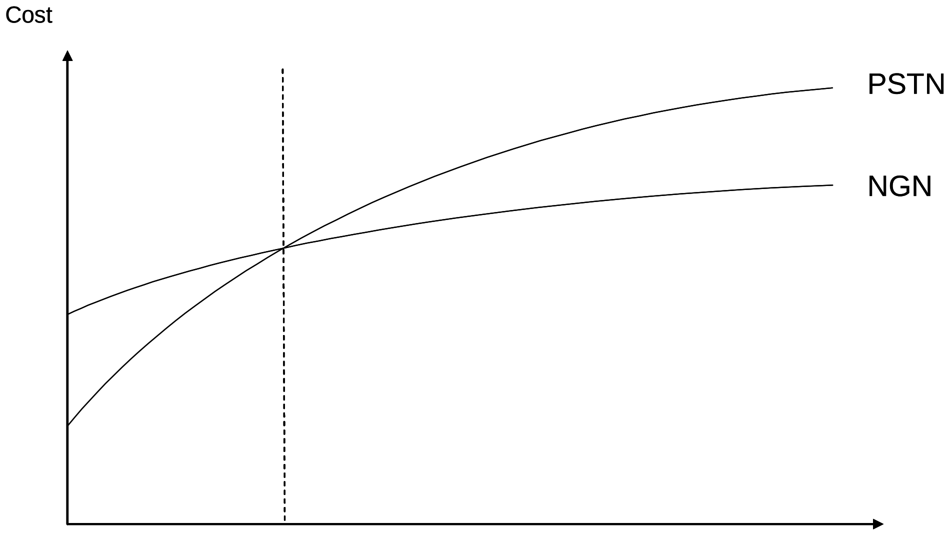
Figure 47: Comparison of costs of a PSTN and an NGN




Source: WIK-Consult.

Given the large up-front investment that will have to be amortized over many years, the cost to be assigned to the current period depends on the share of that up-front cost that can be expected to be recovered from future business. If the volume of this business is expected to be high, the share to be assigned to the current period will be low and vice versa. Further, depending on whether the NGN cost curve starts at a higher or lower point on the vertical axis, the point of intersection with the PSTN cost curve will be more to the right or to the left. Figure 48 represents a perspective on the current cost of the NGN that reflects a more optimistic view regarding future service volumes and the prospect of future cost recovery. This little exercise in comparative statics is not meant to diminish the pedagogical value of such graphical devices, but to alert the reader that they always contain hidden assumptions that, if made explicit, may provide a different slant on the intended message. Here, the added insight is that the current level of the cost of the NGN relative to that of the PSTN will depend largely on expectations of future developments, a point that will be given more attention further below.

Figure 48: Comparison of costs of a PSTN and an NGN with more optimistic expectations future service volumes




Source: WIK-Consult.

The general message from the four points listed above is that the chain of reasoning from the demand for a given output to the size and structure of the network required to fulfill this demand is not as clear-cut as it used to be for traditional networks. More precisely, it would appear that in practice the decision process leading to NGN deployment is generally not from projecting the development of future demand for services (voice, Internet, television) forward to the network required to best deliver those volumes. It seems to be much more that operators all over the world (including the Peruvian incumbent) see the need to move towards NGN without yet being assured that the requisite volumes of demand for services would actually be forthcoming. Still, to discuss issues of the level, allocation and recovery of the cost of NGN, it is necessary that some vision of future demand underpins the analysis, even if that vision is vague. The simplest way of incorporating this vagueness into the analysis is to let rather pessimistic expectations be the basis for the cost determination exercise.

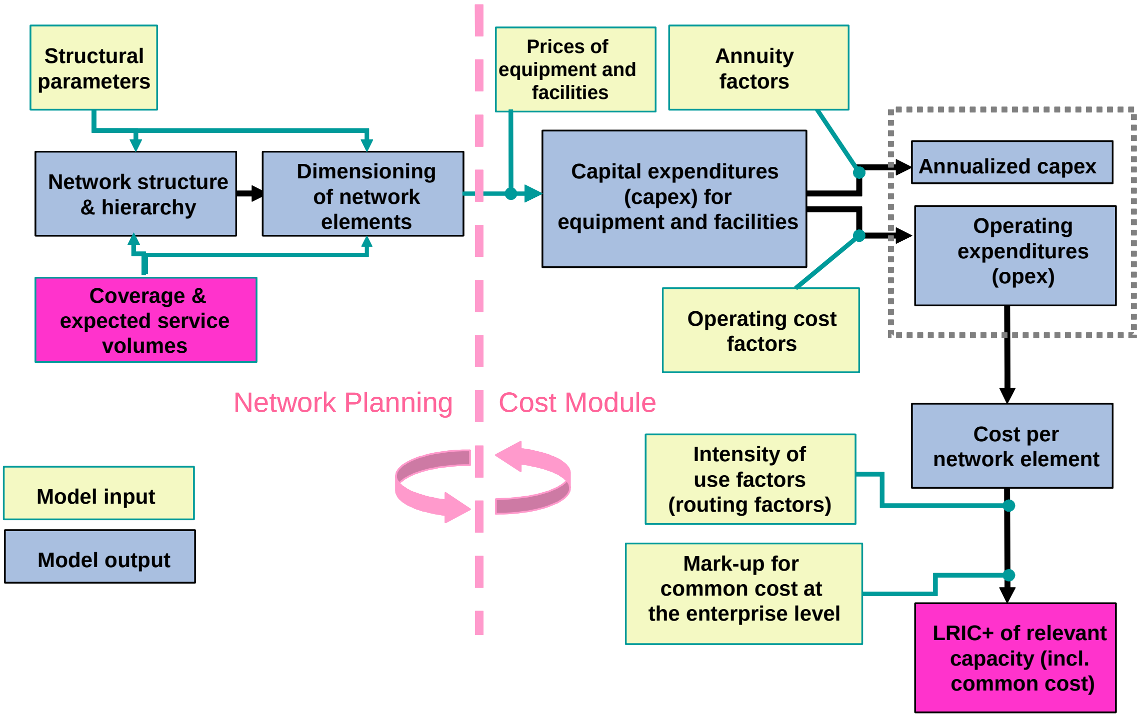
In the following section, we will develop our arguments by applying the tools of bottom-up cost modeling that we briefly presented in Section 5.7.2. We will, however, take into consideration the vagueness regarding demand that we identified. It will be seen that depending on the degree of pessimism or optimism underlying the forecast of future services, the assignment of the cost of the NGN to the current period will be higher or lower, and that the difference may be quite substantial. Assuming that initial NGN capacity will be oversized compared to the volume of traditional and new services currently demanded, it is argued that it would make sense to express costs independently of actual usage, i.e. not in terms of minutes but in terms of capacity made available per period of time. This should in particular be the case if it turns out that the total cost of the NGN is lower than that of the traditional network. This would have implications for the prices of services as these would then also have to be expressed in terms of capacity used instead of minutes. The proviso would be that these prices, in particular of wholesale services used by other, smaller operators, are at most as high as current ones for the bundle of services actually demanded. To assure this, it would be advisable to install a bifurcated price structure in which the old regime is maintained in parallel with a new one for some time. Section 5.8.1 will pick up this discussion in some detail.

### 5.7.4 Applying bottom-up cost methodology to NGN

The point of departure is Figure 46, which gives a schematic view of the bottom-up cost modeling process. It is reproduced here as Figure 49, but with two modifications. First, the background of the box "Coverage & expected service volumes" (on the left side) is colored in pink to emphasize that the uncertainty about demand is the main source of the added complexity. Second, the box reserved for showing the result of the modeling exercise (in the lower right corner) is changed in that, besides its background also being colored in pink, the text now reflects the fact that the cost determined will not be for a (unit of a) particular service, but instead for the share of network capacity reserved for a particular user (where that user may be an end user or another operator requiring some wholesale service), or may even be for the total capacity of the network if the focus is on a comparison with the total cost of the traditional network (as suggested by the discussion in the preceding subsection). As regards the boundary of the network, it could vary. In the mobile case it would include the access network, as the transition to 3G (NGN) technology clearly involves access as an integral part of the new network (for example, 2G technology base stations are replaced by 3G technology nodes B). In the case of the fixed network, issues of costs in the access network (NGA) may be considered separately from those in the core NGN. What will be assured, however, is that the network elements responsible for (the equivalent of) local, single tandem or double tandem interconnection will be included. That we do not explicitly dwell on aspects of the type or boundary of the network means that "Structural parameters" (in the box in the upper left corner of Figure 49) are not considered to be an issue for the present discussion. It is assumed that the engineering knowledge is available to design and implement the network according to best industry practice.

An important point is that the cost to be determined is the cost for the current period, the period for which, say, interconnection charges are to be determined. From the discussion surrounding Figure 47 and Figure 48 we know, however, that this will also involve considerations of the shares of cost, in particular capex, that are to be charged to future periods.

Figure 49: Slightly modified schematic view of the modeling process for WIK's network cost models




Source: WIK-Consult.

It is obvious that the great uncertainty regarding the volumes of services to be provided by the network – as indicated by giving the corresponding box in Figure 49 a pink background – will greatly affect all the following derivations. Let us nevertheless assume that despite this uncertainty, a network is put in place and that the size and structure of the network is at a minimum scale, even though this may not yet be justified by current levels of demand. This means that in the figure the boxes "Network structure & hierarchy", "Dimensioning of network elements" and "Capital expenditures (capex) for equipment and facilities" could all be filled in. What would still be left open is most prominently "Annualized capex", i.e. the portions of total capital expenditures to be allocated to the current period, "Operating expenditures (opex)", and the "LRIC+ of relevant capacity (incl. common cost)", In the “LRIC+” box, the LRIC before common cost would be the item of interest. The focus on annualized capex confirms what we indicated earlier, i.e. that the allocation of capital expenditures is one of the sticking points, and the focus on the LRIC of the relevant capacity puts into relief that whatever the portion of the total cost of the network allocated to the current period might be, there remains the issue of the distribution of this cost across the various uses.

In this section, we are dealing with the question of annualized capex to be charged to the current period while the questions regarding opex as well as the allocation of the annual cost to the various services will be addressed in Sections 5.7.5 and 5.7.6.

One approach not uncommon in cost accounting generally and in telecommunications in particular is the use of linear depreciation. In terms of expressing annualized capex in an annuity, which is the appropriate approach in bottom-up cost modeling, this translates into

(1) $$I = \frac{A}{(1+i)} + \frac{A}{(1+i)^2} + \ldots + \frac{A}{(1+i)^{n-1}} + \frac{A}{(1+i)^n},$$

where

*A* = the amortization to be recovered during each of the periods *t*, *t* = 1, ..., *n*, which are to be regarded as the amounts of annualized capex, the variable to be determined,

*I* = the amount of investment (of a particular piece of equipment or in a stylized approach, of the total investment in NGN),

*n* = the number of years of useful life of the investment, and

*i* = the relevant rate of interest (cost of money[190]).

From equation (1) the amount of annualized capex in the current period, *A*, can be determined since *I*, *n* and *i* are parameters with given values.

Note that this formula derives annualized capex for each of the periods *t* of *n* irrespective of the actual demand for the network in question. This means that if currently demand is still low – and possibly not enough to fill capacity – but higher demand is expected in future periods, a *unit* of service this period is to carry a higher share of capex than a *unit* of service during later periods when volumes are higher. If costs so determined serve as basis for regulated prices, this means that current revenues derived from such prices are used to cross subsidize future services. This follows simply from the fact that a constant share of the cost of the investment (i.e. the *A* for each *t* in equation [1]) will be distributed over a larger and larger volume of future services and thus leads to future per-unit costs and prices that are lower than current ones. The question arises whether this does not unjustifiably burden current users with relatively high prices, in particular if these users are still predominantly demanding traditional services for which NGN actually was not put in place.

Suppose now that a projection of demand has been made and a corresponding projection of the volumes of services for the purpose of cost assignment. Amounts of

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**190** We resist calling *i* the cost of capital since this term, strictly speaking, includes depreciation.

amortization during the periods $t$ of $n$ could then be scaled to stay in relation to these projections, and instead of (1) the following equation for the recovery of capex would obtain:

(2) $$I = \frac{A_1}{(1+i)} + \frac{A_2}{(1+i)^2} + \ldots + \frac{A_{n-1}}{(1+i)^{n-1}} + \frac{A_n}{(1+i)^n}\,.$$

Note that the $A_t$ in equation (2) have in each period $t$ an individual value reflecting the differing volumes of services being carried by the network during the different periods. Although the normal annuity formula cannot be used to derive them, it is intuitively clear that their values can easily be determined by iterative methods such that the amortization of the investment $I$ is ascertained and at the same time the values of the $A_t$ stand in a relation to each other that corresponds to the expected development of future business. Determining the amounts of annualized capex this way corresponds to the principle of economic depreciation.

It is further illuminating to assume that future development of the relevant services can be expressed in an average growth rate over the relevant number of periods so that volumes of services, and therefore also the $A_t$ in (2), stand in a given relationship to each other, i.e. that $A_{t+1} = A_t * (1+g)$ where $g$ stand for the average growth rate. In equation (2) we can then express all future $A_t$ in terms of $A_1$, the amortization of the current period, as shown in equation (3):

(3) $$I = A_1 \frac{1}{(1+i)} + A_1 * \frac{(1+g)}{(1+i)^2} + \ldots + A_1 * \frac{(1+g)^{n-2}}{(1+g)^{n-1}} + A_1 * \frac{(1+g)^{n-1}}{(1+i)^n}\,.$$

By slightly adjusting the usual annuity formula, equation (3) can be transformed to show capex of the current period, i.e. for $t = 1$, to be equal to

(4) $$A_1 = k*I$$

where

(5) $$k = \frac{(i-g)}{(1-q^n)}$$

with $q = (1 + g)/(1 + i)$. Note that (5) differs from the usual annuity formula $k = i/(1 - q^n)$ with $q = 1/(1 + i)$ only by the parameter $g$ appearing both in the numerator of (5) and in the definition of $q$. If g = 0 then (5) reverts to the usual form of the formula.[191]

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**191** For an application of the usual formula, see inter alia OSIPTEL: "Modelos de Costos – Facilidades Esenciales – Experiencia Peruana", Presentation, February 2007, slide 44.

It follows from (4) and (5) that the amount of capex to be allocated to the current period depends on how optimistic or pessimistic expectations of future developments are. Optimistic expectations would translate into a large value of the average expected growth rate *g*, and pessimistic expectations into a low value of *g*. If *g* is large then *k* in (5) is relatively small and according to (4) the amount of amortization for period 1 is also relatively small, and conversely if *g* is small. In the extreme, if no future growth is expected, *g* would be zero and we would have again the case of linear depreciation.

To give a numerical example, assume that $i$ = 15% and $n$ = 8 and let *g* be either 20%, 10% and 0% where the different percentages stand for optimistic, pessimistic and very pessimistic scenarios. Capex assigned to the current period would in the pessimistic scenario be about 50% and in the very pessimistic scenario about 115% higher than in the optimistic one.

In addition to the issue of the share of NGN cost to be charged *to the current period*, there is the issue of the shares of this cost to be allocated *to the various uses* that are made of the network during the current period. The first question of interest in this context concerns the current position of the modeled network on the NGN cost curve according to Figure 47 or Figure 48. Is this position at a point where total NGN cost is still higher or already lower than the cost of the traditional network? Let us treat the second case first. In this case, the recognition that total NGN cost is already lower than total PSTN cost goes hand in hand with the knowledge that the NGN has a capacity that is far beyond that required to meet current demand both for traditional services and for new services. This implies that the marginal cost of a greater or lesser use of NGN capacity by any service, in particular a traditional service like voice, or, more concretely, interconnection for voice services, say the additional minute conveyed, is near zero – also from a long-run perspective – so that this marginal use appears to be inappropriate as the unit in which to express the cost of usage. What comes closest to the marginal unit that may be demanded, either by an end user or a demander of wholesale services, would be the average capacity used by such a user during the high load period for all of her/his services contracted. While when adding up all such usages the resulting total would be less than the total capacity of the network, allocating costs proportionally to these usages might come closest to obeying the principle of cost causation. When costs determined this way are used to set prices on a flat rate basis, users would on average pay less than before. While it would not be possible to disaggregate this price into the components paid for voice on the one hand and for Internet, data and television on the other, this would be of little interest as long as users in fact pay in total less. What will probably be a problem, however, is that there are users with a predominant use of traditional services who pay more than they did before, while there are other users with the converse usage pattern who would obtain the benefit of a disproportionate share of the savings. The network operator might choose to solve this through the design of pricing packages that respond to the different demand patterns. Typically, it would make sense to retain the pricing package that had been in effect before (based on the relevant costs calculated according to the LRIC standard from a traditional network) as one of the pricing options.

In case total NGN cost is still higher than the cost of the traditional network, costs of the NGN services should also be expressed in terms of the average capacity used. In this respect, there would be no difference between the two cases as again the capacity placed at the disposal of the user would in most cases be higher than that required. In this case, too, there would be no pressure on capacity during the high load period that could be used as a signal for cost assignment. As in the first case, flat rate price packages derived in a similar way could be offered to those users whose demand pattern would give them an overall better deal. More so than in the first case, however, the option of having services priced according to the old regime should continue to be offered as this would allow each user to select him/herself into the price category most appropriate to his/her profile of demand. As time passes and demand of new services grows beyond what was forecast according to a pessimistic scenario (which would presumably be the reason that NGN costs still surpass PSTN costs) so that costs and therefore prices of relevant service bundles decrease, more and more of those demanding services of all types would migrate to flat rate price regimes, so that the old regime could eventually be phased out.

The above has been a conceptual discussion with, however, empirical relevance. Witness to this is the increasing trend towards flat rates at the retail level. From the discussion also follows a rationale for flat rates at the wholesale level. The technical problems of defining relevant service packages and calculating their costs, if regulated wholesale flat rates are to be based on such costs, are not insurmountable. One approach would involve, first, assuming a demand that is sufficient to fill the NGN in question. Second, it would involve observing what actual service packages consist of, what are the characteristics and composition of the most frequent packages, and what are their relative volumes. This information could be used to put together the composition of the total demand which by assumption (consistent with our approach throughout this section) is great enough to fill the NGN of minimum capacity. Once this information is available one can, following the procedure outlined in Section 5.7.2, proceed to design and implement on the computer the relevant NGN with all the necessary network elements and to determine the costs of the various service bundles. The cost for each bundle so determined should be lower than appropriate for the actual current network since by assumption the latter is oversized and current service bundles would have to be burdened with the cost of some empty capacity. But the relationship among the costs of the various bundles from the hypothetically filled network could be used to calculate the factors by which to scale the costs of the bundles currently delivered in such a way that, when the resulting cost figures are multiplied through with the corresponding volumes and these amounts are added up, the result corresponds to the total cost of the current network.

### 5.7.5 Opex

The determination of capex according to economic depreciation, as discussed in the preceding section, is the main vehicle to assure the allocation of network cost to the various periods in a way which is free of cross subsidization over time. Opex should, however, be allocated with the same objective in mind. Assume for this that the amount of opex for each of the years of useful life of the asset could be estimated. Then it is also possible to determine the present value of all these amounts and consider this as an investment into the asset in addition to the actual payment for the asset itself. This perspective is justified by the fact that installing the relevant facility or equipment implies a commitment to maintain it adequately throughout its useful life. The determination of the amounts to be amortized of the present value of opex in the current period should then follow the same procedure as for capex, i.e. according to the approach of the preceding section as expressed in equations (3) through (5) where the parameter $I$ , would be replaced by $I_{opex}$ , i.e. the investment in opex as just described.

In our introductory discussion on cost determination according to the LRIC standard in Section 5.7.2, we pointed out that this cost component is very difficult to model explicitly and that there exist so far no models that are able to do so. It is therefore determined on the basis of a mark-up on the values of the network elements where the mark-ups are obtained from the cost accounting records of the operator. If we then define the mark-up on the investment as $m$ then the amount of opex in each year would be equal to $m*I$ and the present value of all amounts of opex, using the usual annuity formula, would equal:

(6) $I_{opex} = m*I * i/(1-q^n)$ ,

where here $q = 1/(1+i)$. Applying then to the right side of (6) the amortization rule expressed in equations (4) and (5) leads to

(7) $A_{1,opex} = k*m*I* i/(1-q^n)$ .

Since from (5) it follows that $k < i/(1-q^n)$ as long as there is growth, i.e. $g > 0$, it also follows that the amount of opex to be recovered from current services is less than is actually spent currently to maintain and operate the corresponding piece of equipment. Only in the case that $g = 0$ would $A_{1,opex} = m*I$ be true as then $k = i/(1-q^n)$. The justification for the lower amount of opex currently recovered is – as for capex – that the equipment was installed mostly to cater to future demand which will be larger than current demand, and the revenue from this greater demand should also cover the corresponding part of opex being currently incurred.

There is a caveat, however, to be taken into consideration. The amount of opex for a piece of equipment, estimated to be equal to $m$ times the investment value of the equipment, is a rather rough approximation to the actual amount, given – as we have pointed out – that the specific modeling of the activities that cause opex is difficult to do. For traditional networks, the value of $m$ can quite reliably be determined on the basis of data from the cost accounting records of the operators. For NGNs, however, the relevant cost accounting records will probably not be long enough yet to really provide correspondingly reliable information. From this follows that the determination of opex on the basis of the relation $m*I$ will be an approximation with a considerable margin of error. It would then not seem appropriate to submit the amount derived this way to an investment/present value transformation as expressed by equations (6) and (7).

It appears that the lesson to be drawn from the above analysis is to ascertain that the amount of opex, as a mark-up on the value of the invested assets, should be considerably lower than for the traditional networks, not only because the opex caused by NGNs will in general be lower than that of traditional networks but also because of the fact, to the extent it is relevant, that a large part of the assets are put in place to serve future and not for current demand.

### 5.7.6 Allocation of costs to services

In addition to the issue of the share of NGN cost to be charged *to the current period*, there is the issue of the shares of this cost to be allocated *to the various uses* that are made of the network during the current period. The first question of interest in this context concerns the current position of the modeled network on the NGN cost curve according to Figure 47 or Figure 48, i.e. whether this position is at a point where total NGN cost is still higher or already lower than the cost of the traditional network. Let us treat the second case first. In this case, the recognition that total NGN cost is already lower than total PSTN cost goes hand in hand with the knowledge that the NGN has a capacity that is far beyond that required to meet current demand both for traditional services and for new services. This implies that the marginal cost of a greater or lesser use of NGN capacity by any service, in particular a traditional service like voice, or, more concretely, interconnection for voice services is near zero – also from a long-run perspective. This again implies that the marginal use, say the additional minute conveyed, appears to be inappropriate as the unit in which to express the cost of usage. What comes closest to the marginal unit that may be demanded, either by an end user or a demander of wholesale services, would be the average capacity used by such a user during the high load period for all of her/his services contracted. While when adding up all such usages the resulting total would be less than the total capacity of the network, allocating costs proportionally to these usages might come closest to obeying the principle of cost causation. When costs determined this way are used to set prices on a flat rate basis (we anticipate here our discussion on pricing in Section 5.8), users would on average pay less than before. While it would not be possible to disaggregate this price on the basis of cost causation into the components paid for voice on the one hand and for Internet, data and television on the other, this would be of little interest as long as users in fact pay in total less. What will probably be a problem, however, is that there are users with a predominant use of traditional services who pay more than they did before, while there are other users with the converse usage pattern who would obtain the benefit of a disproportionate share of the savings. The network operator might choose to solve this through the design of pricing packages that respond to the different demand patterns. Typically, it would make sense to retain the pricing package that had been in effect before (based on the relevant costs calculated according to the LRIC standard from a traditional network) as one of the pricing options.

In case total NGN cost is still higher than the cost of the traditional network, costs of the NGN services should also be expressed in terms of the average capacity used. In this respect, there would be no difference between the two cases as again the capacity placed at the disposal of the user would in most cases be higher than what he needs. In this case, too, there would be no pressure on capacity during the high load period that could be used as a signal for cost allocation to different services. As in the first case, flat rate price packages derived in a similar way could be offered to those users whose demand pattern would give them an overall better deal. More so than in the first case, however, the option of having services priced according to the old regime should continue to be offered as this would allow each user to select him/herself into the price category most appropriate to his/her profile of demand. As time passes and demand of new services grows beyond what was forecast according to a pessimistic scenario (which would presumably be the reason that NGN costs still surpass PSTN costs) so that costs and therefore prices of relevant service bundles decrease, more and more of those users demanding services of all types would migrate to flat rate price regimes, so that the old regime could eventually be phased out. Wherever prices, say for interconnection, are regulated, this development could be assisted by the regulator by mandating that from an initially relatively high level, prices are to decrease following a glide path (see Section 5.8.2).

The above discussion on cost has been at a conceptual level with, however, empirical relevance. While one observes already an increasing trend towards flat rates at the retail level, there follows also from the discussion a rationale for flat rates at the wholesale level. The technical problems of defining relevant service packages and calculating their costs, if regulated wholesale flat rates are to be based on such costs, are not insurmountable. One approach would involve, first, assuming a demand that is sufficient to fill the NGN in question. Second, it would involve observing what actual service packages consist of, what are the characteristics and composition of the most frequent packages, and what are their relative volumes. This information could be used to put together the composition of the total demand which by assumption (consistent with our approach throughout this section) would be great enough to fill the NGN of minimum capacity. Once this information is available one can, following the procedure outlined in Section 5.7.2, proceed to design and implement on the computer the relevant NGN with all the necessary network elements and to determine the costs of the various service bundles. The cost for each bundle so determined should be lower than appropriate for the actual current network since by assumption the latter is oversized and current service bundles would have to be burdened with the cost of some empty capacity. But the relationship among the costs of the various bundles from the hypothetically filled network could be used to calculate the factors by which to scale the costs of the bundles currently delivered in such a way that, when the resulting cost figures are multiplied through with the corresponding volumes and these amounts are added up, the result corresponds to the total cost of the current network.

Summarizing the analysis in the present and the preceding two sections, it has essentially been shown that:

- The cost of services currently delivered by an NGN depend very much on expectations regarding the development of future demand and the opportunities of amortization of investment from the corresponding business, and this dependence is more pronounced than was previously the case for services delivered over traditional telecommunications networks;
- The incremental unit in which such a cost should appropriately be expressed is not anything small like a minute of use, a call attempt or a bit or byte, but should rather be the capacity that enables the delivery of a bundle of services demanded by a typical user, including both end users and other network operators requiring wholesale services; and
- Consequently there is a strong argument that prices for wholesale services should be on a flat rate basis.

This last insight serves to bolster Recommendation 6, which argues that OSIPTEL's long term direction for wholesale charges for IP-based NGN voice interconnection should be based either on Capacity Based Charging (CBC) or on Bill and Keep, but not on the number of call minutes. See Section 5.8.1.

### 5.7.7 Accounting for uncertainty in the WACC

In Section 5.7.4, we discussed the determination of the annual cost of capex as a function of the expectations regarding the future development of demand for the services of the NGN. With the help of equations (3) through (5), repeated below:

(3) $$I = A_1 \frac{1}{(1+i)} + A_1 * \frac{(1+g)}{(1+i)^2} + \ldots + A_1 * \frac{(1+g)^{n-2}}{(1+i)^{n-1}} + A_1 * \frac{(1+g)^{n-1}}{(1+i)^n} \ ,$$

(4) $A_1 = k*I$ , and

(5) $$k = \frac{(i-g)}{(1-q^n)} \ ,$$

we showed that the share of the invested capital, including the return of capital, to be charged to the current period depends also on the value of $g$ which is the expected average growth rate of the services to be provided by the NGN over the life times of its facilities and equipments. We also pointed out that a large degree of uncertainty concerning the amount of future NGN business could be expressed by assigning a smaller value to the expected average growth rate. This would have the effect of increasing the cost to be charged to the current period, and thus also increase the cost of current services, relative to a situation with a smaller degree of uncertainty.

It should be noted that arguing in terms of more or less optimistic expectations that express themselves in a higher or lower value of $g$ is formally equivalent to changing the value of the WACC that is used in the annuity formula. This can be shown as follows. Below we repeat equation (3) in a slightly different form:

(3') $$I = \frac{A_1}{(1+g)} * \left[\left(\frac{1+g}{1+i}\right) + \left(\frac{1+g}{1+i}\right)^2 + \ldots + \left(\frac{1+g}{1+i}\right)^{n-1} + \left(\frac{1+g}{1+i}\right)^n\right]$$

By pulling $A_1$ in (3) before the brackets and dividing it by $(1+g)$ and compensating for the latter change by multiplying through with $(1+g)$ within the brackets, we get an expression determining the amounts of amortization for the various periods in the form of $(1+g)^t / (1+i)^t$ where $t$ stands for the individual periods. It is immediately clear that the two parameters $g$ (the average expected growth rate) and $i$ (the WACC) have an impact that in form are completely alike, although the impact will be in different directions.

Suppose that it is expected that the average growth rate of services to fill the network will in the future be a particular $g$ but that one should make allowance for the uncertainty by using a smaller growth rate, say $g - \Delta g$ (where $\Delta g$ is a positive number). If, however, this is to be expressed not by decreasing the value of $g$ but by increasing the value of $i$, it can be shown with a few algebraic steps that $\Delta i$, that is the increase in $i$, relates to the $\Delta g$ as follows:

(8) $$\Delta i = \Delta g * (1+i) / (1+g-\Delta g) .$$

In equation (5),one would then retain the initial value of $g$ but have increased the value of $i$ by the value of $\Delta i$ as shown in (8). The effect would be the same as if one had decreased $g$ by $\Delta g$. This shows the formal equivalence of expressing uncertainty and risk by either decreasing the expected average growth rate or by increasing the WACC.

The above discussion, which as it stands is theoretical and formal, has the following quite practical implications. Suppose the normal annuity formula, as expressed in equation (1), is used to determine capex of a network that will in future years be filled with a greater and greater volume of services. In other words $g$ is set equal to zero in determining capex for the current year while it actually has a positive expected value. Referring back to the discussion leading to equation (4), realizing that the practice discussed here amounts to setting $\Delta g$ equal to $g$, we see by referring to (8) that this practice is tantamount to an increase in $i$ by $\Delta g (1+i)$. If for example $i$ were equal to 12 % and $g$ equal to 10 %, the practice would lead to an increase in the WACC by 11.2 percentage points, or from 12 % to 23.2 %.

Furthermore, interested parties may claim that not only linear depreciation should be used, which as we have seen would corresponds to setting $g$ equal to zero, but that in addition the value of $i$, the WACC, be increased above the normally accepted level to account for the added uncertainty and risk. This would be the same as arguing that growth might not only be lower than was initially assumed to justify the investment, but that growth might even be negative. This can be made clearer by extending the example used in the preceding paragraph. From the example we saw that when setting $g$ in the annuity formula equal to zero when its value actually is 10 %, i.e. prescribing $\Delta g = g$, this is the same as increasing the value of the WACC from 12 % to 23.2 %. If, in addition to the use of linear depreciation, the value of the WACC is also increased, all in the name of accounting for risk, this is the same as if $\Delta g > g$, i.e. that one should count with negative growth.

The following conclusion can be drawn from the above discussion. Uncertainty and the risk that comes with it can be accounted for by increasing the value of the WACC or by allowing for a lower average growth rate in the determination of capex. It is a "must" that the values of *both* of these parameters should be taken into consideration in this determination. When instead of economic depreciation – as proposed here – linear depreciation is used, which in regulatory practice is apparently still too often the case, this always implies a higher value of the WACC whenever there will be growth in the volumes of services being provided by the asset in question.

### 5.7.8 Incremental and common cost

When network costs are determined according to the principle of *Long-Run Incremental Cost*, all network components are considered variable – since the perspective is that of the long run – and therefore all network components are considered to be dependent on the volume of services being provided currently and in the future. This means that all costs of these network components will in effect be *incremental* costs to the services for which the components were put in place. This principle is embodied in the approach of *Total Element Long Run Incremental Cost (TELRIC)* which is commonly applied in costing approaches by regulatory authorities. In TELRIC, the total cost of a network element, even if this costs includes some volume-independent cost component, is allocated to the various services that are produced by it in proportion to the volumes of these services.[192]

**192** The European Commission has initiated a discussion whereby "true" incremental cost should be the basis for the setting of prices for interconnection services. The difference between this "true" approach and the one we propose in the text consists in how economies of scale and scope are distributed over the various services. In the approach we propose, and which we consider the correct one, all services using a network element benefit proportionately from the economies realised at the level of that element. In pure LRIC approach, it is assumed that the termination service is added as the “last” marginal service which will bear only costs of network elements to the extent that equipment has to be added because of the addition of this service.

As an example, consider the tower of a base station in a mobile network. It carries electronic equipment to establish and maintain communication links with users of various services, say voice and data. One may consider the electronic equipment as incremental, varying directly with volumes of voice and data, and the tower as fixed. But consider that growth occurs and after a while the network needs to be reconfigured somewhat and another tower is added to accommodate that growth. It becomes apparent that the tower is not fixed in the sense of not being volume dependent but that it is rather also incremental to services. The reconfiguration is due to both the growth in voice and data so that the new total cost of the network element should again be allocated to be the two services in relation to their volumes. Actually, the only difference between towers and other types of equipment is that their numbers increase stepwise and not continuously in relation to volume. This stepwise dependence on volume, however, does not make the relevant cost any less incremental than that of electronic components.

It is at the level of the company as a whole that common cost arises. Functions like legal, accounting and general management can in general not be traced to individual services and therefore their costs can not directly be associated with any of them. In their case it is regulatory practice to allocate the relevant cost by adding a mark-up to the LRIC of the various services.[193]

### 5.7.9 Costs for voice provided through an NGN

We conclude the discussion of cost by tracing the costs of the network elements that are involved in the delivery of voice services, in particular the termination of voice calls, in an NGN. Figure 50 depicts the NGN multi-service architecture. The figure is color-coded for easy identification of the network elements that are used for the various services, i.e. the grey elements are voice-specific, the dark blue elements are video-specific, the red elements are data-specific, and the light blue elements are common to all.

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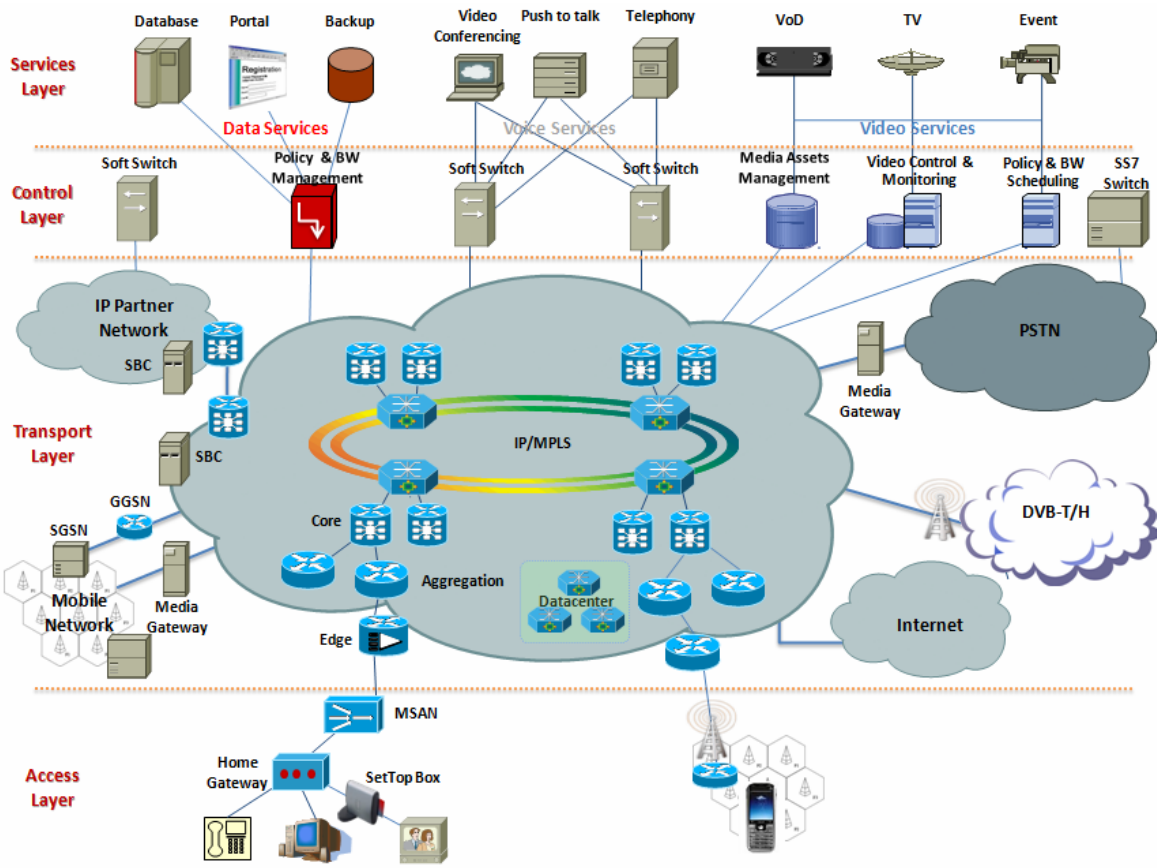
**193** The fact that this type of cost is common does not mean that it is a fixed cost. The size of the functions giving rise to common cost also always increase when the total size of the company increases, and since we expect companies to grow, and since we are taking a long-run perspective, we must in principle consider common cost also as incremental, however, as incremental to the total operations of the company. The latter aspect makes them common for the purpose of cost allocation.

Figure 50: NGN multiservice architecture




Source: WIK-Consult.

As can be seen, there are specific network elements that are exclusively used for voice in the control layer (soft switches), in the services layer (e.g. specialized equipment for telephony, video conferences and "push to talk"), and also at the border of the transport layer (session border controllers [SBCs] and media gateways [MGWs]) performing functions when packets of traffic move between two different NGNs or between an NGN and a traditional PSTN. Most functions in the transport layer and all functions in the access layer serve all types of services (voice, data, TV, mobile). As examples, we look at three types of termination of a voice call coming in from another network, (a) a basic call being terminated via the MSAN, (b) a call using functions in the NGN's services layer being terminated via the MSAN, and (c) a call being terminated on the mobile access network where in this case we may consider the NGN actually to be an 3G mobile network:

(a) The call may come in over an MGW or and SBC, be transported to the MSAN to which the receiving partner is connected and terminated there. Being a basic service, no functions of the services layer is implicated. In this case, the voice specific network elements would be either the MGW or the SBC at the border of the transport layer plus the soft switches in the control layer. All other network elements that are used would also be used by other services. This holds in particular for all access network elements and for the network elements in the actual transport network.

(b) The call may be similar to the one considered under (a) with the exception that advanced service functions are used (such as voice forwarding) which use network elements of the services layer.

(c) The call may be one like under (a) and (b) but be terminated on the access network consisting of radio base stations.

For all three types of termination, the costs would consist of the costs of network elements providing the various transport, control, services and access functions. There are network elements in all four layers that are dedicated to telephony. Call termination (interconnection), as an example of a telephony service, would have to bear part of these network elements' costs, together with all other telephony services, and be allocated a corresponding share on the basis of routing factors. Call termination would also bear part of the costs of the other network elements in the transport layer and the access layer, together with all other telephony services and all other services that use these network elements, and be allocated the corresponding share again on the basis of routing factors. These costs may differ substantially depending on whether part of the access network is volume-dependent as opposed to being subscriber-dedicated. In the former case the cost of the access network would also have to be allocated to services, and correspondingly part of it would be included in the cost of termination, in the latter case not. The 3G mobile network is a case where the access network in form of nodes-B is volume dependent and where its cost needs to be factored into the costs of termination (as it has also been in the case of 2G networks).

All of the above will hold if costs are actually determined for services and not, as we have argued above to be more appropriate, for a measure of capacity demanded by users. In the case of cost determination for capacity demanded, the corresponding costs would be traced in a similar fashion, only for shares of capacity used by demanders and not by services.

### 5.7.10 Examples of NGN cost modeling by national regulatory authorities

In this section, we present examples of approaches by regulatory authorities in three European countries to cost modeling in the context of migration of these networks from conventional fixed PSTN to NGN, or from 2G to 3G mobile networks. The description of these approaches makes it clear that no fast and hard rules have so far emerged as to how such modeling should be handled. This should not be surprising inasmuch as the process of migration is a very complex one that will be different from one case to the next. Nevertheless, the examples reported below are instructive, as we will point out in the concluding observations at the end of the section.

Sections 5.7.10.1, 5.7.10.2, and 5.7.10.3 describe cost modeling in the UK (see also Section 4.2.2.1), Austria, and Norway, respectively. Section 5.7.10.4 provides our concluding remarks on these different approaches.

#### 5.7.10.1 UK

In its statement on mobile call termination of March 2007,[194] the British regulatory Authority Ofcom explains its approach as follows:

> (A)s summarized in paragraph 9.11 of the September 2006 Consultation, Ofcom has concluded that the level of the charge control(s) to be applied to MNOs with 2G and 3G networks should be determined with reference to a blended 2G/3G benchmark …. This will be based on an average of 2G and 3G cost benchmarks, weighted according to the respective volumes of terminated voice minutes in each year. These component 2G and 3G cost benchmarks for an MNO with both 2G and 3G networks can be constructed so as to take into account reasonable assumptions around the migration of traffic between these networks and the potential cost savings arising due to a degree of asset sharing. Ofcom considers that the use of combined 2G and 3G benchmarks in this way is the most appropriate option for modeling the costs of an average efficient 2G/3G operator, since it enables Ofcom to take into account any differences in the costs of termination on 2G and 3G networks.

The 2G and 3G cost benchmarks are derived from separate models, each calculating the cost of a stand-alone network, which however take into account economies of scale and scope when it is reasonable to assume that the two networks jointly use towers and other facilities.

**194** Ofcom, Mobile call termination - Statement , 27 March 2007.

### 5.7.10.2 Austria

In a decision of April 2009, the Austrian regulatory authority Telekom-Control-Kommission (TCK) set rates for the termination of calls on mobile networks in Austria.[195] The rates will have to decrease from currently existing individual levels for the four operators to a single rate that is based on the costs incurred by the operator that appeared to be the most efficient. The decreases will take place along a glide path leading to levels that are from 26% to 50% lower than current rates by 2011. The operator found to be the most efficient is Hutchison 3G Austria, which operates (as the name indicates) a comprehensive 3G mobile network.

It appears that TCK applied the LRIC principle in its strict sense, i.e. it set prices according to the cost of the operator that is the most efficient and is thus able to discipline the pricing behavior of the other operators. The costs of the other operators still mainly operating 2G networks were also established; however, since those costs were higher than those of the 3G operator, they were not taken into consideration.

The report by the group of experts retained by TCK to carry out the costing exercise has not been published. It appears, however, that the costs were not established on the basis of bottom-up cost models, but rather were derived from actual costs as found in the cost accounting records of the operators.

A noteworthy aspect of this process is that the TKC did not try to mimic the process of migration from a heretofore 2G network to a 3G network, and to derive from that process the cost of a network providing services during such a process. The TKC considers such costs to be irrelevant from a competition perspective, since only prices based on the cost of the most efficient operator could prevail in the market.

The new single rate for termination will be enforced within the period from 2009 to 2011 following a relatively steep glide path.

We regard the Austrian approach as reasonable, but it is not clear that it would be appropriate in every country. First, one needs to have a disruptive competitor with efficient technology; otherwise, in an oligopolistic environment, operators might have a tendency to report the highest costs that they can justify, and the more efficient operators might moreover might have a perverse incentive to operate more costly and inefficient networks than would otherwise be the case. Second, the most efficient operator needs to cover the whole national territory (to the same degree that less efficient operator do). If the first is not fulfilled, there will be a tendency to estimate costs *higher* than they should be; if the second is not fulfilled, the tendency will be to estimate costs *lower* than they should be.

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**195** Telekom-Control-Kommission, Entwurf einer Vollziehungshandlung, Vienna, 20 April 2009.

### 5.7.10.3 Norway

The Norwegian regulatory authority Post-og Teletilsynet (NPT) published a consultative document in June 2009 outlining the modeling of the LRIC of fixed network services.[196] For this, NPT has chosen to develop a model that can consider both conventional PSTN and next-generation IP-based services. It states that the "definition of modern equipment is a complex issue. Operators around the world are at different stages (from initial plans to fully deployed) of deploying next-generation, IP-based networks. Conversely, a significant proportion of customers are still served through conventional PSTN networks. Therefore in the timeframe being considered, both approaches may be considered reasonable". Thus, two functionally separate core network models are defined, one based on an understanding of the incumbent's current network, the other based on an entirely next-generation architecture.

To reflect the migration from the existing to the next-generation technology, two approaches are considered:

(1) Construct two stand-alone models of the core network – one of the current network, and one of a full core NGN. Derive current interconnection rates from the current network cost model. Determine the corresponding rate for a future period from the full core NGN model. Apply a glide path from the higher current rate to the lower future rate.

(2) For the other approach, the NGN is supposed to be phased in directly by applying upgrades over time to the existing architecture. This would be a slow process in a mobile network but could be much faster in a fixed deployment, with perhaps around 100 core and distribution nodes in which to conduct upgrades. For this approach, a series of migration profiles would be included in the model. It is clear that the rate at which the incumbent and the other operators migrate from the one to the other core technology is a critical factor. There is a detailed description of the model for the incumbent’s fixed network and how upgrades may replace conventional equipment. However, it is also stated that it is unclear, now and for the foreseeable future, when this migration will happen.

The difference between the two approaches is captured in the following table:

**196** Post-og Teletilsynet, Conceptual approach for the LRIC model for fixed networks, Draft model specification, 19 June 2009.

Table 16: The Norwegian regulator is considering two different approaches to cost modeling

| Approach (1) | Approach (2) |
| --- | --- |
| Allows users to easily test the cost implications of the rate of migration. | May better capture some of the migration costs. |
| Simpler approach may allow more scenarios or range over which scenarios will work. | More complex approach may limit the number of scenarios that can be validated. |

Although this is not explicitly stated (given that this is a consultative document), the report leaves the impression that the NPT has a tendency to favor the first approach. The second comment under "Approach (2)" makes it clear that the modeling of a gradual migration from a conventional PSTN to an NGN is a complex undertaking which can only be done for a limited number of scenarios which necessarily need to be specified given the concrete situation of the existing network.

#### 5.7.10.4 Concluding observations on the examples

Note the three distinct treatments of the costs of 3G or NGN networks relative to those of 2G or conventional fixed technology. In the Austrian approach, the costs of operators that still operate mostly 2G networks are discarded and only the cost of the 3G network is used; however, the new 3G cost-based level of the termination charge will be reached via a glide path that starts from current rates which were based on 2G costs. The UK approach consists of a blending of the costs modeled for services delivered over 2G and 3G networks where the blending occurs according to relative shares of services carried by the two networks. Approach (1) proposed by the Norwegian regulatory authority NTP would consider explicitly both the costs from bottom-up cost models for (present) conventional and for (future) NGN networks. It would determine the rates for termination according to a glide path taking as starting point the present (supposedly higher) cost arrived at on the basis of conventional technology.

Only the second approach by NPT considers a step-by-step phasing in of new technology into the old existing one. While this approach, if successfully implemented, might provide a better understanding of the actual path of costs incurred by the incumbent, it is questionable whether the approach is in agreement with the LRIC principle. According to the LRIC principle, the cost of an actual or potential new entrant using the most modern technology should be the basis of regulated prices. Aside from that, the regulatory authority will not necessarily have either the knowledge or the data to model the migration (or to challenge a model put forward by a network operator).

We view the first of the two approaches put forward by the Norwegians as the most promising and most straightforward for Peru. A bottom-up cost model based on sound LRIC principles (specifically including the most efficient network architecture) provides the most appropriate long term target in estimating cost.[197] The information requirements for such a model are well understood. The migration to NGN requires minor refinements to the process, as explained throughout this chapter, but it does not change the basic approach to cost modeling.

We would also note that trying to analyze a blend of two significantly different network architectures in a single model adds greatly to the complexity of the task, and potentially adds uncertainty to the result as well. We think it is greatly preferable to model the beginning and ending states, before and after the transition, and to reflect any intermediate states through a glide path, much as the Norwegians have done.

## 5.8 The structure and level of termination payments

This section considers the basis for interconnection payments. In line with the discussion in the previous section, we place particular emphasis on the interconnection of voice services, SMS and MMS. The section responds to procurement document requirements to address:

- Development of a regulation model, considering economic and engineering factors, for NGN interconnection costs between operators. This model should provide the unit value of adequate compensation mechanisms: by capacity and by time, among others.

Section 5.8.1 deals with the structure of interconnection payments; Section 5.8.2 with the level of payments (assuming a structure based on Minutes of Use, as exists today); and Section 5.8.3 with interconnection payments during the period of migration.

### 5.8.1 The *structure* of interconnection payments

The traditional pricing for interconnection in the PSTN has been per-minute of use and based on forward-looking long run average incremental costs (LRAIC) plus a markup for common costs (LRAIC+) (see also Section 5.7). This pricing mechanism was instrumental and quite successful in bringing competition to fixed telephone networks formerly totally dominated by incumbents; however, it has shown its limits in dealing

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**197** There will presumably be a consultation process where market parties can comment on the approach taken. If any network operator were to argue that its actual cost is, or will be, lower than that generated by the model, that could be a very significant input to the analysis. To that extent, the approach used in Austria can be taken into account, within creating a dependency on having a kind of market player that does not necessarily exist in Peru.

with unregulated infrastructure providers, who can offer flat rates and thereby out-compete firms that depend on a large fraction of inputs that they pay for on a per-minute basis. Also, the incumbent is constantly in danger of being accused of price squeezes because she has a natural tendency to follow more short-run costs (which largely vanish) in her retail pricing decisions. The traditional LRAIC+ interconnection pricing imposes a certain rigidity on the end-user pricing both of incumbents and alternative providers. This has, for example, handicapped the fixed-line operators in Austria in their competition against mobile operators, who now totally dominate the voice segment. Similar handicaps are evident in competition with VoIP.

While per-minute pricing may have its merits for telephone calls that require a pre-specified bandwidth and are measured by duration, they are not a useful unit of measurement for consumption when it comes to other communications services that vary in their bandwidth requirements and are best counted by bandwidth requirements and/or by the data flow. In light of the diminishing importance of voice in network utilization (if not in revenues), a different type of pricing system needs to be established. Three options are worth considering: Bit-based charging, Capacity Based Charging (CBC) and *bill and keep (B&K)*.

Bit-based charging at the end-user level is currently at the experimentation stage in the U.S. and may have some future for restricting over-use of networks. This may be of interest for network operators in Peru and may have some relevance for network neutrality, but is currently not applicable to interconnection pricing.

In Section 3.1.2, we explained that Capacity Based Charging (CBC) is an arrangement where the maximum interconnection capacity utilization is booked in advance and paid for with monthly or one-time fees. There are then no further charges (e.g. on a per-minute basis) for usage within the specified capacity limit. CBC generally follows efficiency criteria more closely than per-minute charges. What distinguishes CBC from per minute charges is the closer tracking of network costs, and the possibility for risk sharing between the dominant network operator and the competitors.[198] These advantages hold true just as much for NGN as they do for traditional networks. Given that Peru has just imposed support for CBC on TdP,[199] it becomes a natural and obvious candidate for NGN interconnection arrangements in Peru going forward.

CBC is currently used only in very few countries (other than Peru). Spain has introduced CBC in response to flat-rated end-user charges of the incumbent. It has had some good experience with it and may have seen less fixed-mobile substitution as a result. In principle, CBC can mimic most of the network costs quite well, and can

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**198** Ingo Vogelsang with Ralph-Georg Wöhrl, “Determining interconnect charges based on network capacity utilized”, K.-H. Neumann, S. Strube Martins and U. Stumpf (eds.), *Price Regulation*, Bad Honnef: WIK Proceedings, 2002, pp. 95-129.

**199** See OSIPTEL, *Revisión del Cargo de Interconexión Tope por Terminación de Llamadas en la Red del Servicio de Telefonía Fija Local* , Nº 00001-2006-CD-GPR/IX, 29 September 2008.

therefore lead to better capacity utilization; however, just like per-minute pricing that deviates from perfect peak-load pricing, CBC has to be made practical and tends, as a consequence, to be less perfect than the theoretical ideal. Rather than pricing actual peak capacity utilization in all parts of the network, CBC is typically simplified by specifying limiting capacities or maximum capacity utilization at certain links. Since specifying actual capacity utilization requires good measurement capabilities, it may be easier to price the capacity of the links, whether fully utilized or not. This would be quite similar to broadband end-user pricing by the speed of the connection. Another aspect is the derivation of prices from costs. As discussed in Section 5.7.4, the relevant costs can come from analytical cost models, where they would require adjustments for the fact that the links would not be fully utilized, even at peak.

The literature on CBC emphasizes long-term contracts as a way to introduce risk sharing between incumbent and alternative providers into interconnection pricing.[200] This would generally favor large over small alternative network operators, and is not a prerequisite for CBC. Thus, CBC can be priced *ex ante*, but without contracts, meaning that the purchasing networks pay as they use. Under link-based pricing, there are implicit or explicit long-term contracts, because the links cannot usually be changed at short notice. One way to deal with additional risks imposed on entrants by CBC would be the availability of contract options or, initially, of an option between CBC and the traditional regime (as is the case in Peru). The latter is also the case for Spain, where CBC has been gaining ground over time because it resulted in distinctly lower average costs of origination and termination. The option, however, can result in selection problems that have to be considered at the design phase.

In implementing CBC, one would have to carefully weigh the various costs associated with transition. Given that CBC has already been implemented in Peru, this becomes a somewhat lesser concern, but nonetheless significant. Peru has imposed an obligation on TdP to make interconnection available on a CBC basis, as an alternative to per-minute termination charges; however, no CBC obligation is in place for other fixed network operators, nor for any mobile operator (nor for any mobile operator, including Telefonica). If OSTIPTEL were to implement CBC as a *replacement* for per-minute charges, it would be necessary to deal with the termination monopoly power of these network operators as well, most likely by imposing CBC termination arrangements on them.

In addition it would be necessary to re-visit the cost models currently in place for CBC. For the foreseeable future, voice service in the access network is likely to continue to be implemented primarily on a circuit-switched basis that is dedicated to a single subscriber (even though the line may be shared for DSL data). The cost modeling

**200** Such long-term contracts could also be viewed as an alternative to infrastructure sharing for new and risky investments.

procedure in the current implementation assumes, however, a circuit-switched network between the “remote unit and central header”, and the “central header and central Tandem”. In an NGN, one or both of these would be replaced by an IP-based core. This does not change the principles of determining CBC charges, but many details would need to be carefully reviewed. Capacity modeling in the IP segments would need to be based, not on the Erlang-B formula, but rather on queuing theory.[201] Traffic routing would also likely change, and the hierarchy of the network might well become flatter. If voice interconnection were done with IP-based circuits rather than circuit-switched SS-7 circuits, that would also need to be appropriately reflected. Any or all of these changes would result in changes in the rolling up and allocation of costs.[202]

A hybrid between per-minute (or bit-based) pricing and CBC would be discriminatory two-part tariffs, where the variable fee would reflect minutes or bits and the fixed fee the capacity utilized (speed of links). Such two-part tariffs could soften any measurement problems regarding capacity utilization. They would be “discriminatory” in the sense that the fixed fee would increase in the size of the interconnection user, but that is precisely what makes this approach acceptable. A “non-discriminatory” two-part tariff with the same fixed fee for all interconnecting parties would favor large over small alternative providers and thereby increase market concentration.

Bill and Keep (B&K) reflects a totally different philosophy than the preceding approaches in that it requires each network to pay its own network costs, but not those of the other networks. The idea of B&K is usually restricted to reciprocal termination charges. In its strongest form, B&K is based on the philosophy that networks should recover their costs from their own final customers, not from those of other, competing networks. This clearly assumes that receiving parties are substantial beneficiaries of incoming calls. Although this probably holds for low-income countries, it is not clear that the solution for them is that end-users should have to pay for incoming calls (whether on a usage basis or in their monthly fees). Weaker versions of B&K rely on the fact that the traffic between networks is roughly balanced, and that there are strong call-back effects. In those cases, the transaction cost savings and cost-reducing incentives of B&K outweigh the gains from cashing in on terminations.

The big advantages of B&K include the simplicity and the ability to do away with complicated interconnection price regulation. The approach would also lead to approximate competitive neutrality between telephony, VoIP and mobile voice

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**201** For example, one could model capacity requirements in the core of the network during the busy hour using the Pollaczek-Khinchine formula for an M/G/1 queuing system, and allowing a little extra “headroom” to accommodate the bursty nature of IP-based traffic. Appropriate modeling techniques are described in various references, including J. Scott Marcus, *Designing Wide Area Networks and Internetworks: A Practical Guide*, Addison Wesley, 1999.

**202** It is likely that the overall costs per E-1 would be found to be lower in an IP-based NGN, due to data compression, silence suppression, and lower unit costs for equipment; however, other aspects might drive costs up, including substantially higher protocol overhead.

communications. Its potential drawback comes from its lack of investment incentives for alternative providers. This will partially depend on the way in which origination is treated, and whether this is part of the B&K arrangement or not. While origination could also be included in B&K, that could mean that customers would receive two bills for a single call, one from the long-distance provider and one by the local (origination) provider.

Any move to a new interconnection payment system would require extensive preparation and possibly a glide path (e.g. to B&K) or an intermediate hybrid (2-part tariffs to CBC). A more comprehensive adoption of CBC would likely require imposition on all of the significant fixed and mobile operators who are not subject to CBC today, in addition to moderate changes to the cost model.

Given that CBC is well suited to NGN, there is an obvious argument that it should be retained and expanded. Arrangements based on per-minute pricing are ill-suited to NGNs going forward. If there is to be wholesale charging at all, it should be linked to longer term capacity, not to highly granular consumption of bits, calls or minutes. Meanwhile, it would be premature to rule out more radical solutions, such as Bill and Keep. Section 5.7 arrives at similar conclusions through a different but related thought process.

**Recommendation 6. Initiate a public consultation to discuss a proposed long term direction that charging for IP-based NGN voice interconnection should be based either on CBC or on Bill and Keep.**

OSIPTEL should indicate, through a public consultation process (possibly merged with consultations advocated in other of our recommendations) that it intends its long term direction for charging for IP-based NGN voice interconnection to be based either on Capacity Based Charging (CBC) or on Bill and Keep. Establishing a long term direction can help to maintain regulatory predictability and clarity, and a framework for investment. OSIPTEL should solicit the views of stakeholders.

### 5.8.2 The *level* of interconnection payments

Even though CBC is in place, per-minute termination fees are important in Peru today, and we assume that they will continue to be important for years to come. Per-minute termination fees are in place as an alternative to CBC for TdP, and are the only arrangement available for other fixed and mobile networks at present.

As explained in Section 5.7, technological improvements, including the migration to NGN in the core network, are likely to continue to drive unit costs downward in the coming years. This will have consequences for the level of charges.

Even without any immediate technical change, a second look at current interconnection charges is warranted. In Europe, the question of termination payments as networks evolve to NGNs has been hotly debated in recent years.[203] There has been fairly widespread acceptance of the proposition that existing mobile termination rates in Europe have been set at inefficiently high levels, and that it would be appropriate to reduce them even in the absence of a migration to NGN. High MTRs tend to inflate retail usage-based prices, and thus to depress usage of the service (i.e. fewer mobile calls are made, and their duration is short).They also distort the evolution of fixed and mobile services by forcing users of the former to subsidize the latter.

The move to NGN makes this need more urgent, and also raises the question of whether non-zero termination rates are even sustainable in the long term in an IP-based NGN world.

Our preliminary research suggests that Peruvian Mobile Termination Rates (MTRs) were at quite high levels a few years ago ($0.20 US in 2004), but that they are dropping into the range of about $0.09 in 2009. We would view this as a positive development, but efficient levels might nonetheless be much lower.

At the same time, MTRs in excess of cost may help stimulate mobile penetration, which is a positive benefit in a country like Peru. We think that MTRs need to be lower than they currently are, but there may be merit in keeping them slightly above usage-based incremental cost in order to encourage mobile penetration.[204] We discuss this point further in Section 5.9.1. Termination rates slightly in excess of cost may also encourage mobile operators to offer inexpensive pre-paid plans with subsidized handsets, thus making mobile service available even to those with very limited disposable income.

If mobile operators had sufficient market power, the lowering of MTRs might not in and of itself be sufficient to enhance consumer welfare. The mobile operators might not pass their wholesale savings on to consumers in the form of lower retail prices. In the case of Peru, this is not a major concern. MTRs and retail prices have generally moved downward in lock step over the past several years, thus demonstrating that the three mobile operators do not have sufficient market power to keep retail prices artificially inflated. In Figure 51, the wholesale MTR payment is shown to track closely with the Service Based Revenue per Minute of Use in Peru over the period 2006 – 2008.[205]

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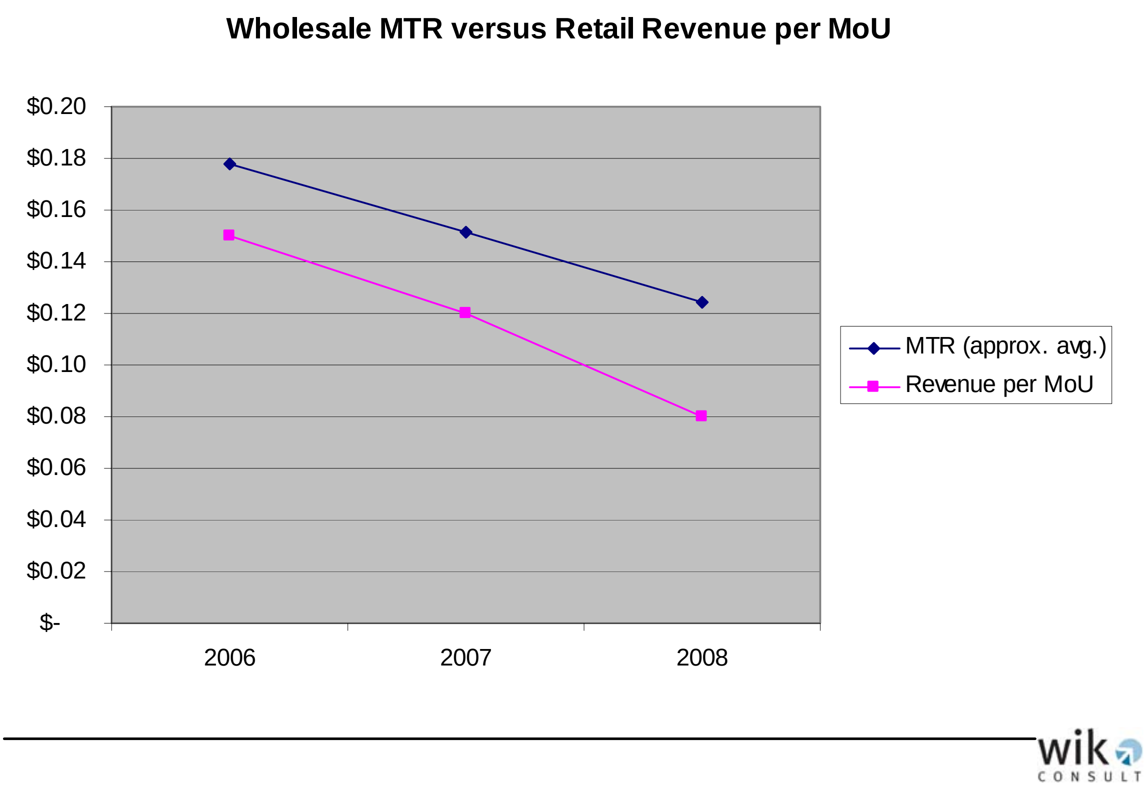
**203** See J. Scott Marcus (2009): “IP-Based NGNs and Interconnection: The Debate in Europe”, op. cit.

**204** They could perhaps still be much lower than they are today. India, for example, has achieved excellent results with fixed and mobile termination rates both pegged to about $0.005 US per minute.

**205** One should nonetheless expect handset subsidies to decline, and the monthly fee to increase somewhat as MTRs decline (the “waterbed effect”). Nonetheless, the overall effect will be toward lower retail prices.

Figure 51: Wholesale MTR versus retail service-based revenue per MoU




Source: WIK-Consult, based on data from OSIPTEL and from the Merrill-Lynch Wireless Matrix.[206]

Adoption of lower termination rates in the near to intermediate term serves to pave the way, and to reduce the ultimate shock, of the long term migration to CBC or Bill and Keep that is probably inevitable.

**Recommendation 7. In the near to intermediate term, implement per minute charges substantially lower than those in use today.**

In the near to intermediate term, OSIPTEL should maintain the *structure* of voice interconnection charges, which are based on CPNP arrangements per minute of use. Per minute charges should be substantially lower than those in use today, and more in line with the true usage-based cost associated with the voice service; however, they should not be zero.

**206** At http://www.cwes01.com/10323/24789/Interactive_Global_Wireless_Matrix.xls, visited 9 May 2009.

### 5.8.3 Interconnection payments during the period of migration

The preceding two sections have focused on two aspects of prices for interconnection, first, that in an NGN environment they should either be based on CBC or be abandoned altogether in favor of Bill and Keep, and, second, that as long as either of these options could not yet be implemented, their levels on a per-minute basis, particularly for mobile termination, should substantially be decreased to better correspond with the cost of this service and therefore direct demand in a more optimal direction. Here we point out what has already been implicit in this discussion, that during the period during which networks are successively migrated to an NGN environment, two charging systems, the old one on a per-minute basis and a new one on a CBC basis (assuming that for some time Bill and Keep will not be a regulatory option) may well exist side by side. Their simultaneous offer during this period would help to achieve two things, that demanders of interconnection services with high volumes could benefit from the cost advantage provided by CBC based on NGN cost, while demanders with a traditional service portfolio would have the assurance of still being able to rely on the old pricing regime with its advantages of a lower risk exposure.

In the end the level for interconnection payments should correspond to the cost as afforded by an NGN. Provided the expectations regarding the demand for NGN services become true, these costs should be substantially lower than current levels. Regulators in Europe interpret LRIC always to be based on the least-cost technology that is currently available even if a particular network operator has not (yet) implemented it. As a result, NGN costing could actually precede NGN implementation if a network operator does not pursue the least-cost route. This would suggest that interconnection prices based on such costing become available as an option even before all operators have actually completed the migration. This also implies that NGN cost models need to be developed at an early stage both for the purpose of network planning by network operators and for the purpose of interconnection pricing by the regulator.

It is, however, not suggested that prices be immediately based on costs that would be realized in a mature NGN exhibiting all the economies of scale and scope that now and in the future could be realized. This may cause drawbacks in the form of unwarranted meltdown of operators' revenues and consequent financial difficulties and therefore disruptions in the process of NGN deployment. When therefore the regulator carries out cost calculations on which to base prices, it would be appropriate, as discussed in Section 5.7, to take into account the uncertainty and risk involved in now erecting an NGN implying that initially the calculated cost level may not be that much lower than the current one and that the low levels would only emerge as over time the uncertainty regarding demand vanishes. This would suggest a gliding path for interconnection prices towards levels of a mature NGN, as suggested in OFCOM’s ‘holistic approach’ that we discussed in Section 4.1.4.2 above. Such a gliding path would be appropriate both for CBC and for the retained option of per-minute prices.

## 5.9 Interconnection, Universal Service and Universal Access

In all countries, there are subtle linkages between interconnection payments and the achievement of *universal service* and/or *universal access*.[207] These are not quite the same thing. The objective of *universal service* is to ensure that end-users can use critical electronic communication services, e.g. a voice telephone service, at home. The more modest objective of *universal access* is that end-users have reasonable access to critical electronic communication services (for example, that they are able to place or receive telephone calls, but not necessarily at home). Access to a telephone or to the Internet in a community school or library could satisfy requirements for universal access, but not for universal service.

Section 5.9.1 deals with the linkage to termination rates (especially mobile termination rates), while Section 5.9.2 discusses the rather unique retail pricing arrangements that apply to rural network operators in Peru.

### 5.9.1 Universal service and Call Termination Rates

In some countries, interconnection payments explicitly fund voice telephone access. This model has largely been abandoned in recent years, but a more subtle variant remains. Call termination fees that are well in excess of cost mean that mobile network operators are highly motivated to ensure that large numbers of people possess mobile handsets, even if they themselves place few calls.[208] Mobile operators are thus motivated to subsidize handsets, and to offer pre-paid plans with low or zero initial and monthly payments.

These arrangements have the positive effect of getting mobile phones into the hands of large numbers of people.

They have the negative effect, as noted earlier, of increasing the price per minute of calls (especially calls to off-net mobile phones), and thus of depressing use.

In a developing country such as Peru, the stimulus to mobile adoption is important and positive. If pursued by means of high mobile termination charges, though, it can

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**207** Cf. ITU, *World Telecommunication Development Report 2002: Reinventing Telecoms: Executive Summary*, 2002: "It is important to distinguish between *Universal Service* and *Universal Access*. Universal Service refers to a high level of ICT penetration at the household level and is more suitable for high and upper middleincome countries. Universal Access refers to a high level of ICT availability. This can be provided via homes, work, schools and public access locations and this measure is more appropriate for lower-middle and low income developing nations."

**208** High termination charges can also be used to increase the on-net/off-net price differences and thereby increase the switching costs for user groups ("calling clubs"). See T.S. Gabrielsen and S. Vagstad, "Why is on-net traffic cheaper than off-net traffic? Access markup as a collusive device", *European Economic Review* 52, 2008, pp. 99-115.

negatively affect fixed-line penetration and can lead to severe end-user price distortions.

Mobile termination rates (MTRs) in Peru are probably too high today, but there is thus a credible argument that they should not go to zero in the medium term, and analogously there is an argument that Capacity Based Charging (CBC) might possibly be preferable to a migration to Bill and Keep in the medium term. As long as mobile penetration is substantially short of complete, the stimulus to adoption is valuable and should (at least to some degree) be maintained.

### 5.9.2 The pricing of calls to rural operators and fixed-to-mobile calls

Retail arrangements for calls to and from rural operators are, in our experience at least, unique. The urban customer pays a fee set by the rural operator, irrespective of whether the urban customer placed or received the call.

Analogously, the called network sets the retail charge for calls from fixed to mobile (F2M), provide an “origination fee” to the originating network to compensate for the call origination and for billing and administration. Economic inefficiencies in retail arrangements for calls to mobile probably have greater impact than those in calls to rural operators, but we did not study them in as much depth.

The retail price for calls to or from rural operators can be quite high – interviewees spoke of prices in the neighborhood of one to two PEN (Peru Nuevo Soles, about US $0.25 each) per minute.

As mobile telephony penetrates deeper and deeper into the interior, these prices are no longer competitive. We have some sympathy with the rural operators (who complain that they are being pushed deeper and deeper into the jungle), but there is a clear economic efficiency argument that services that are effectively propped up by this somewhat artificial mechanism should be phased out as more efficient alternatives become available. Thus, it is altogether appropriate that consumers bear the cost of these calls, rather than having them (for example) paid for out of general government revenues.

Even so, we were very much struck by a comment from Telefonica del Peru that they were effectively forced to charge prices that were much too high for access to these rural telephones. We frequently hear incumbents complaining that regulated prices are too low, but rarely hear complaints that they are too high!

We suspect that this concern is related to (but not the same as) a subtle phenomenon known to economists as *double marginalization*. With double marginalization, two firms in vertically related market segments both take mark-ups. If the firms are prohibited from coordinating their respective pricing behavior, the combined mark-ups may be too high; in fact, the end price to the consumer can be substantially *higher than the monopoly price*. Prices that are high to this level depress use dramatically, to the point where the firms could actually *make more money by charging less*.

In the past, these arrangements may have been sustainable; however, the emergence of mobile service in portions of the interior is putting rural payment arrangements under severe pressure.

We have not studied this matter in detail. We suspect that the concern is a real one, but it is well outside of the remit of this study. There is an economic literature that looks at double marginalization in regard to call termination rates, and that generally advocates enabling the two network operators to coordinate their respective pricing (which would reduce prices to monopoly levels, not necessarily to levels that maximize consumer welfare).[209] This case is somewhat distinct, in that the conventional operator whose customer is placing a call to a mobile network has no control at all over the retail price. Nonetheless, we suspect that the appropriate answer in this case involves somehow reducing the rigidity of current retail payment arrangements.

**Recommendation 8. Initiate a public consultation to solicit input on possible improvements to rural service arrangements and fixed-to-mobile calls.**

OSIPTEL or the Ministry should initiate a public consultation with market players in order to better understand the effects of retail payment arrangements, especially in regard calls to rural operators and to fixed-to-mobile calls. It is important to understand how these arrangements are evolving over time, to identify any problems or challenges with retail and wholesale pricing arrangements, and to solicit input on possible improvements.

**209** Julian Wright, "Access pricing under competition: An application to cellular networks", 29 December 2000; and Michael Carter and Julian Wright, "Interconnection in network industries", in *Review of Industrial Organization* 14: 1-25, 1999.

## 5.10 Quality of Service (QoS) and network neutrality in Peru

Section 5.10.1 considers IP QoS in general. Section 5.10.2 provides recommendations in regard to Network Neutrality, which is closely linked to notions of IP QoS.

### 5.10.1 Quality of Service (QoS)

As an initial consideration, is it necessary for OSIPTEL to concern itself with QoS at all? Could this perhaps be left to the market?

In the case of IP data services, the regulator should leave matters to the market unless there is a specific market failure that must be addressed. In countries with competitive telecommunications markets, commercial motivations are sufficient to ensure adequate QoS for data. If the regulator intervenes to mandate a minimum QoS, the regulator risks excluding from the market low quality services that are also low priced, and that some consumers might want.

The Peruvian market is highly concentrated, particularly on the fixed network side. A pure *laissez-faire* market-based approach might be inappropriate for Peru.

For IP as a means of carrying voice, particularly at such time as the large fixed and mobile operators might be offering interconnection to their inherent voice services by means of IP, quality assurance is likely to be essential. As previously noted, nearly all network operators have terminating monopoly power in regard to voice, especially the large fixed and mobile operators. It would clearly be inappropriate to impose an interconnection obligation, but then not to back it up with assurances that the quality of the interconnection meets reasonable expectations.

There are different ways in which such an obligation could be implemented. One could, for example, establish an obligation at the level of the voice carried by the network, as perceived by end-users. We take a different line here, because we think that it is important to be able to distinguish which of the network operators is responsible for less-than-desired voice quality.

First, will network operators agree to exchange data for their inherent voice services by means of IP in the first place? We assume that this decision would need to be voluntary – most regulators would consider it inappropriate to tell network operators that they were obliged to use IP-based voice interconnection instead of circuit switched SS-7 interconnection.

If market players are interested in achieving IP-based interconnection, but are unable to reach closure (which has happened in other countries), we would suggest that a local peering model similar to that of Telecom New Zealand (see Section 3.4) be introduced into the discussion as a possible means of breaking the deadlock.

Once incumbent fixed network operators or large mobile operators have agreed to interchange real-time bidirectional (or multi-directional) voice by means of IP, we think that it will be necessary to establish IP QoS standards.[210] Implementation experience *between* network operators today is limited to non-existent, but the work done by the QoS Working Group under sponsorship of MIT is likely to prove to be workable.[211]

The MIT white paper on “Inter-provider Quality of Service” defines one additional QoS class in addition to best efforts. The class is a Low Latency class, suitable for bi-directional IP-based real time voice.

The MIT group define one-way IP packet delay, one-way IP packet delay variation, and packet loss ratio in accordance with IETF RFCs 2679, 3393, and 2680, respectively.[212] The MIT group provides useful rigorous bounds on how compute these metrics – for example, how often measurement probes should be sent on average, and how frequently statistics must be aggregated.

The MIT white paper proposes the following Service Level Agreement targets (as long as geographic limits do not preclude their achievement):

- **Delay:** 100 msec (One Way Delay in IPPM terms)
- **Delay Variance:** 50 msec
- **Loss Ratio:** 1 x 10-3 (One Way Packet Loss in IPPM terms)

The MIT QoS QG white paper goes on to allocate these end-to-end values to multiple networks that collectively might form the path between pairs of end-users. This allocation is extremely important; however, the discussion in the MIT white paper is lengthy, and the various permutations are complex. Rather than reproducing the discussion here, we would encourage the reader who wants more detail to consult the MIT white paper itself.

**Recommendation 9. OSIPTEL should indicate its intention, in the event that market players cannot agree on standards for QoS, to establish its own standards on the basis of the MIT QoS white paper.**

OSIPTEL should consult with market players, indicating that at such time as IP-based NGN voice interconnection is available, if market players are unable to agree on standards for Quality of Service, OSIPTEL will establish its own standards on the basis of the MIT QoS white paper.

**210** We think that target standards and measurements would be necessary whether there are financial incentives and/or penalties or not.

**211** *Inter-provider Quality of Service*, White paper draft 1.1, 17 November 2006, op. cit.

**212** Standards of the *Internet Engineering Task Force (IETF)* are generally in the form of numbered *Request for Comments (RFC)* documents. Not every RFC, however, is a standard.

### 5.10.2 Network Neutrality

As noted in Section 5.1 above, it is appropriate to consider what Peru should do to ensure adequate IP service quality in terms of packet delay, jitter and loss. This section responds to the following requirement:

- Determination of appropriate processes for pricing, billing, and monitoring the quality of services to end users.

Background on Quality of Service in IP-based networks appears in Sections 2.1.4.3, 3.4, and 3.5.

As noted in Section 3.5, lack of competition in the market for broadband Internet access in the United States has led to concerns that broadband network operators might favor affiliated content, applications and devices over those from competitors. This so-called *Network Neutrality* debate is a complex and far-ranging debate, but in our view it is largely a manifestation of market power.

Network Neutrality has been far less of an issue in Europe, because broadband markets are far more robustly competitive (despite a dearth of cable television), and because the European regulatory system is far more adept at dealing at any abuses that might occur.[213]

Peruvian markets, and especially the markets for fixed broadband IP-based access, are highly concentrated in our view. Peruvian telecommunications regulation has prevented deviations from Network Neutrality to date. Based on the degree of concentration for fixed broadband access in Peru, we think that it would be unwise to deregulate at this time.

Current nondiscrimination rules should be maintained. We see no need to modernize them to ensure that they work as intended in an IP-based environment. They do not address every conceivable deviation from Network Neutrality, but they appear to address those deviations that are clearly anticompetitive.

**Recommendation 10. Retain non-discrimination provisions.**

| OSIPTEL should retain the non-discrimination provisions that exist in its present rules. |
|---|

**213** J. Scott Marcus (2008): Network Neutrality; The Roots of the Debate in the United States", in *Intereconomics*, Volume 43, Number 1, January/February 2008. See also Kenneth R. Carter, J. Scott Marcus, and Christian Wernick, *Network Neutrality: Implications for Europe*, WIK Discussion Paper 314, December 2008, available at: http://www.wik.org/content/diskus/Diskus_314.pdf, Retrieved on 7 August 2009.

## 5.11 Regulatory policy and provision of Voice over IP (VoIP)

In the various countries where the migration to NGN (and to VoIP) is more advanced than in Peru, a range of regulatory issues that are important but somewhat tangential to NGN migration have been discussed. This section considers issues that have arisen, identifies international best practice to the extent that it is possible to do so at this time, and considers the potential application of international best practice to Peru.

Specific issues addressed include (1) licensing and authorization, (2) numbering, (3) access to emergency services, (4) lawful intercept, and (5) the apparent lack in Peru of “working horse” providers.

### 5.11.1 Licensing and authorization

In many countries, restrictive licensing regimes can serve as an effective barrier to market entry.[214] We do not perceive this as a problem *per se* in Peru; prospective VoIP providers can easily obtain any necessary certifications to operate as providers as value added services.

A concern is that this authorization to provide value added services is probably not sufficient, in and of itself, to enable a VoIP-based business. The obligations and the prerogatives associated with value added services authorization may not be the right ones for an independent VoIP services provider. It is not clear, for example, whether such an authorization would enable a service provider to obtain telephone numbers, or to achieve interconnection with traditional voice service providers. Our understanding is that few of the VoIP service providers in Peru have access to telephone numbers.

There are two potential ways to address this problem, and we recommend that OSIPTEL support both. The first is to ensure that some licensing category meets the full set of needs of independent VoIP service providers. The second is to ensure that one or more players in the Peruvian marketplace have the ability and the incentive to provide the necessary capabilities to VoIP service providers at a reasonable price (as is the case in many countries). We discuss the first more fully in Annex 2; the second, in Section 5.11.5.

**214** It is for this reason that the European Union’s *Authorisation Directive* serves primarily to *limit* the discretion of National Regulatory Authorities in imposing obligations as a condition of obtaining a license ot offer an electronic communications service.

**Recommendation 11. Ensure that some suitable licensing category is available to third-party VoIP service providers.**

OSIPTEL or the Ministry should ensure that some suitable licensing category is suitable for independent (non-network-based) VoIP service providers, including appropriate rights and obligations for telephone numbers, interconnection, access to emergency services, and lawful intercept.

### 5.11.2 Numbering

In principle, the migration of the network core to NGN does not require changes to the numbering plan.

A number of countries have considered or implemented special number ranges for VoIP services provided by firms that are not conventional network operators, or that are not operating in that role when they provide the VoIP service. The special number ranges are not linked to the location of the VoIP device, i.e. they are *non-geographic*.

In a recent WIK study on behalf of the European Commission, we found that there was little or no consumer take-up of these special non-geographic numbers.[215] European market players were emphatic in saying that consumers insisted on standard geographic numbers. Previous consultations by the European Commission and by the European Regulators' Group (ERG) had also found that it is essential that VoIP service providers be able to offer standard geographic numbers.

These concerns are closely linked to the nature of retail (and indirectly to wholesale) charges. In Europe, as in Peru, the number prefix of the called telephone number is a signal to the consumer as to what the call is likely to cost. A non-geographic number (1) implies that *the call will cost more*, and perhaps even more importantly (2) *introduces uncertainty* as to the cost of the call. European experience suggests that consumer preferences *adjust very slowly* to changes in these aspects of the numbering plan, and their linkage to cost.

Some have argued for non-geographic number ranges for VoIP devices because the devices are *nomadic* (i.e. end-user can transport them to a different location); others have argued for special number ranges to denote the lack of guaranteed QoS for VoIP devices. We do not consider either of these arguments to be compelling, and would instead recommend that OSIPTEL (following the European recommendations) permit the assignment of geographic numbers to VoIP telephony services.

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**215** J. Scott Marcus, Dieter Elixmann, Christian Wernick, and the support of Cullen International, *The Regulation of Voice over IP (VoIP) in Europe*, a study prepared for the European Commission, 19 March 2008, available at: http://ec.europa.eu/information_society/policy/ecomm/doc/library/ext_studies/voip_f_f_master_19mar08_fin_vers.pdf, Retrieved on 7 August 2009.

**Recommendation 12. Ensure that VoIP service providers have access to suitable telephone numbers.**

OSIPTEL or the Ministry should ensure that third-party VoIP service providers have access to the telephone numbers that they need to enable viable business models, whether geographic or non-geographic. The “signals” that these numbers implicitly provide to callers as regards retail pricing need to be carefully considered.

Some countries (e.g. the U.S. and the UK) place few or no restrictions on the use of their numbers. They raise no objections if their numbers are used outside of their own geographic boundaries. By contrast, other countries (notably Germany) require that the end-user demonstrate some specific connection to the geographic location associated with a number. Many countries consider the use of their numbers outside of the national borders to be a technical infraction, but enforcement is rare. International best practice in this regard cannot be said to be a settled matter. We tend to prefer the more liberal US/UK approach because it is more hospitable to competitive entry, but we recognize that there are those who would take issue with the US/UK approach.

### 5.11.3 Access to emergency services

The migration of a core network to IP does not in and of itself imply changes in the nature of access to emergency services (police, fire, and emergency medical assistance); however, the introduction of nomadic VoIP devices has raised substantial issues in every country where it has appeared.

The problem is that the geographic location of a nomadic VoIP device cannot be rigorously determined. This is not only a problem for the dispatcher, who does not know the right address to which to send help; rather, it also means that it is not possible to ensure that the call is routed to the most appropriate dispatcher in the first place.

Most countries that have looked at this problem have concluded that VoIP service providers should make reasonable efforts to complete calls to emergency services.[216] We think that this is the appropriate resolution for Peru as well.

Regulations should provide for a reasonable transitional implementation period. Regulations should also recognize that location identification for nomadic VoIP devices will at best be good, but cannot be expected to be perfect.[217] (Location identification for conventional fixed and mobile devices is also imperfect.) Consumer education will

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**216** See *The Regulation of Voice over IP (VoIP) in Europe*, op. cit.
**217** Some countries have done a much better job than others. See “Voice over IP (VoIP) and Access to Emergency Services: A Comparison between the U.S. and the UK”, *IEEE Communications Magazine*, August 2006, available at http://www.comsoc.org/livepubs/ci1/public/2006/aug/cireg.html, Retrieved on 7 August 2009.

necessarily play a role in any realistic solution. Heavy-handed regulation (as has arguably been implemented in the U.S.) can negatively impact competitive entry.

**Recommendation 13. Ensure that providers of voice telephony services (including VoIP) to Peruvian numbers provide access to emergency services.**

OSIPTEL or the Ministry should ensure that voice telephony services (including VoIP-based services) that enable calls to be placed to Peruvian telephone numbers are also capable of reaching emergency services (police, fire, and medical services) using a simple, easily remembered national number. These calls should be free of charge. Insofar as the service is reasonably capable of doing so, it should connect to the geographically most appropriate (e.g. closest) emergency service, and should reliably report the caller’s location. Consumers should be educated as to any limitations of the service in reaching emergency services or in reporting their location. Service providers should be given appropriate transition periods to implement the necessary capabilities.

### 5.11.4 Lawful intercept

Most countries permit some degree of surveillance of telephone calls in support of law enforcement and national security. A number of countries have expanded their rules in recent years to included providers of broadband Internet access, and of VoIP.

As with emergency services, it is important that rules not be overly intrusive, so as to avoid imposing unreasonable burdens (and thus unreasonable barriers to competitive entry). To the extent that rules are reasonably consistent with those of other countries, and also administrative procedures (how information is requested, where it must be routed and in what format), this reduces costs for multi-national operators.

Surveillance programs should be subject to independent oversight, in order to ensure that citizens and residents are subject to surveillance only to the extent that there is a reasonable basis for suspicion.

We have not attempted to provide detailed recommendations for Peru. Information on surveillance programs is invariably closely held, and can only be studied with appropriate authorizations.

**Recommendation 14. Ensure that surveillance can be applied to Internet data and to VoIP.**

Ensure that surveillance can be applied to Internet data traffic and to VoIP, subject to suitable oversight procedures, and to the extent that doing so is implementable at reasonable cost.

### 5.11.5 Enabling some network operator to provide needed services to VoIP service providers

In our study of regulation of VoIP on behalf of the European Commission, we found that the presence of “working horses” – organizations that offered a range of wholesale services to independent VoIP service providers – substantially expanded the VoIP marketplace, and partly corrected for lack of economies of scale on the part of small VoIP service providers. The absence of such an organization is a striking characteristic of the Peruvian marketplace.

The “working horse” is often a large competitor to the fixed incumbent network operator (e.g. Level 3 in the U.S.). It already implements a full range of capabilities for its own customers, and is therefore well placed to offer the same capabilities to independent VoIP operators (even though they may compete with it for end customers). Services that the “working horse” might offer could include:

- Provision of telephone numbers
- Interconnection to the voice services of other network operators
- Access to emergency services
- Lawful intercept

We had previously observed (in Section 5.5.1) that the number of PoI in Peru may serve as an impediment to entry of small competitors. To the extent that a “working horse” was providing interconnection, the lack of scale economies would be largely addressed, since the working horse would have the scale economies that individual providers lack. Similar arguments apply to access to emergency services and lawful intercept.

The emergence of one or more “working horses” would thus, in and of itself, address multiple problems in the current system.

In the U.S. and in many European countries, “working horse” providers have emerged spontaneously. It is not clear why this is not the case in Peru, but we suspect that rigidities and ambiguities in the Peruvian regulatory structure may in effect have prevented emergence of one or more “working horses”.

**Recommendation 15. Address any impediments to the emergence of a VoIP "working horse" in Peru.**

OSIPTEL should consult with market players to determine the reasons why no VoIP “working horse” has emerged in the Peruvian marketplace, and should seek to address any regulatory impediments to the emergence of a “working horse”.

## 5.12 Spectrum management

The migration to NGN does not directly imply changes in spectrum management; however, the deployment of Next Generation Access (NGA) has implications, particularly when one considers the need to deploy high speed IP-based access throughout the national territory, i.e. universal access and universal service.

Given Peru's challenging geography, it is particularly important that suitable spectrum be available to support mobile data services and fixed wireless access, especially to remote areas in the Andes and in the interior.

The recommendations that follow are generally applicable. We have not assessed the degree to which they are already met in Peru.

As regards commercial exclusively licensed spectrum, international best practice is clear cut. Spectrum should be treated as much as possible as a property right, spectrum assignments should have as few restrictions as possible (consistent with avoidance of harmful interference), and market mechanisms (auctions, leasing, trading) should be used as much as possible.[218]

**Recommendation 16. Peruvian spectrum management in the commercial sector should reflect the use of auctions and secondary markets.**

Peruvian spectrum management in the commercial sector should continue to reflect international best practice, including the move to market mechanisms (auctions and secondary markets).

In parallel with these spectrum management innovations, technical advances have permitted more efficient use (e.g. the migration of television from analogue to digital). At the same time, sharing of spectrum has become increasingly feasible. There are many forms of sharing: license-exempt use (referred to in the US as unlicensed); spectrum overlay; and spectrum underlay. In the medium term, new technologies that dynamically adapt to spectrum use (Cognitive Radio [CR] in conjunction with Software Defined Radio [SDR]) may offer substantially enhanced spectrum sharing capabilities.[219]

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**218** See Lorenz Nett, Mark Scanlan, Ulrich Stumpf, J. Scott Marcus, Martin Cave and Gerard Pogorel, *Towards More Flexible Spectrum Regulation*, a WIK study for the German BNetzA. Available at: http://www.bundesnetzagentur.de/media/archive/4745.pdf, Retrieved on 7 August 2009. The ITU published a condensed version under the title *Towards More Flexible Spectrum Regulation and its relevance for the German market* for their workshop on "The Regulatory Environment for Future Mobile Multimedia Services", Mainz, Germany, June 22-23 2006, available at: http://www.itu.int/osg/spu/ni/multimobile/papers/MMS_flexiblespectrumstudy_060606.pdf, Retrieved on 7 August 2009.

**219** See John Burns, Paul Hansell, J. Scott Marcus, Michael Marcus, Phillipa Marks, Frédéric Pujol, and Mark Redman, *Study on Legal, Economic, & Technical Aspects of 'Collective Use' of Spectrum in the European Community*, a study on behalf of the European Commission, November 2006, available at: http://ec.europa.eu/information_society/policy/ecomm/radio_spectrum/_document_storage/studies/cus/cus_rep_fin.pdf.

**Recommendation 17. Peruvian spectrum managers should keep current as regards emerging technologies.**

Peruvian spectrum managers should continue to keep current as regards emerging technologies, including Software Defined Radio (SDR) and Cognitive Radio (CR).

Finally, we note that spectrum management in the public sector (including defense, aeronautical and maritime transport, and emergency services) has been a largely neglected area, even though the public sector uses 40-50% of the most desirable spectrum. There is a strong argument to be made that traditional approaches to management of public sector spectrum promote inefficiency. Assignments have usually been made with no time limits, at no cost, and with few requirements for formal justification. The UK has attempted to use market-inspired mechanisms to improve the efficiency of spectrum management in the public sector – a promising approach, but difficult to implement. For Peru, we would instead recommend an approach modeled on that of the Netherlands, which requires public sector users such as defense to periodically re-justify their spectrum assignments.[220]

Current policy in the Netherlands is established through the Radio Spectrum Policy Memorandum of 2005 (published by the Ministry of Economic Affairs). Spectrum is allocated to public agencies according to the following principles:

- No more spectrum is assigned than is needed.
- Where spectrum is not continuously in use, third party access should be permitted where practically feasible.
- Assignments to public interest tasks must be supported by a needs justification plan, which is to be submitted every three years to the Ministry of Economic Affairs for review. Future growth or reductions in frequency requirements and sharing possibilities must be identified. Justification plans are assessed in terms of the effectiveness and efficiency of frequency use. Requirements must be clearly linked to the public agency's formal charter – for example, the Ministry of Defense could not justify a free public assignment of spectrum to enable it to conduct driving lessons for the public. The Ministry of Economic Affairs can dig deeper into claims that it finds unpersuasive, and can conduct measurements.[221]

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**220** See John Burns, J. Scott Marcus, Phillipa Marks, and Frédéric Pujol, *Optimising the Public Sector's Use of the Radio Spectrum in the European Union*, a study on behalf of the European Commission, completed November 2008, publication forthcoming shortly.

**221** See John Burns, J. Scott Marcus, Phillipa Marks, and Frédéric Pujol, *Optimising the Public Sector's Use of the Radio Spectrum in the European Union*, op. cit., publication forthcoming shortly. These practices are written up in Section 3.1 of the Annex to the report.

The process in the Netherlands appears to be performing well. The three year justification cycle seems to represent a reasonable compromise between efficiency and administrative burden. The Ministry of Economic Affairs appears to be accepted by commercial users and by government, including the military, as a “fair broker”.

**Recommendation 18. Peruvian spectrum management should be aware of emerging trends in the public sector, with a move away from permanent assignments without cost.**

Peruvian spectrum management should be aware of emerging trends in the public sector (defense, emergency services, and transport), with a move away from permanent assignments without cost, and a move toward periodic rejustification (or possibly the use of market-inspired mechanisms).

## 5.13 How to implement the recommendations

Based on the discussion earlier in this chapter, this section of the report considers the implementation sequence for regulation of NGN interconnection in Peru.

In the course of the interviews that we conducted under OSIPTEL auspices, we saw few indications that market players are hungry for IP-based interconnection today (even though several of the major networks in Peru have already transitioned in varying degrees to IP-based core networks); however, a number of interviewees indicated that at least one reason why they had not considered IP-based interconnection was that they felt that the current Peruvian regulatory framework did not allow it.

As we have previously noted, we do not see any compelling public interest that would argue that OSIPTEL should mandate IP-based interconnection of NGN services. IP data interconnection is already working satisfactorily. Circuit switched voice interconnection may be less technically efficient than IP-based voice interconnection, but we do not see an argument that the consumer benefits of IP-based voice interconnection should override the economic and technical judgments of network operators, who apparently are not motivated to make the leap just yet.

Nonetheless, there is a great deal that can be done *today* to evolve interconnection arrangements in ways that make sense for Peruvian end-users and market players, and that selectively smooth the way to an eventual migration to IP-based NGN interconnection for voice and data.

Detailed regulation should be done as much as possible in a collaborative process with market players – who will often be better positioned than the regulator to recognize certain technological developments and market trends. We return to this point in Section 5.13.4.

The specific list of recommendations that we have made in this report appears in Table 17, with page numbers to the right.

For challenges specific to the migration period, Table 11 (in Section 4.1.3.6) identified root causes and relevant Recommendations.

Table 14 in Section 5.1 explains which of the Recommendations can be viewed as falling into each of three distinct categories:

- Modernization of regulation for current IP-based services
- Apparent problems in the current regulatory environment
- IP-based NGN voice interconnection

Finally, Table 18 provides a suggested sequence of implementation for Recommendations 1 through 15.

Table 17: List of recommendations

Table 18: Suggested time frame in which to implement each Recommendation

| Nbr | Summary | Action | Target Start | Target End | 2009 | 2010 | 2011 | 2012 | 2013 | Later |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Obligations only on market power | None | Now | Indefinite | | | | | | |
| 2 | Inefficiencies in current arrangements | Consultation … | 2010 | 2011 | | | | | | |
| 3 | Number of PoI for NGN | Consultation … | 2011 | 2012 | | | | | | |
| 4 | Second NAP.Peru | Unclear | 2009 | Unclear | | | | | | |
| 5 | OSIPTEL oversees flexible process | None | Now | Indefinite | | | | | | |
| 6 | Long-term direction CBC or Bill and Keep | Consultation | 2011 | 2012 | | | | | | |
| 7 | Lower termination rates, esp. MTRs | OSIPTEL procedure | 2009 | 2013 | | | | | | |
| 8 | Reassess calls to rural and F2M | Consultation … | 2010 | 2012 | | | | | | |
| 9 | IP QoS arrangements | Market player discuss; if no consensus, OSIPTEL could impose | 2011 | 2013 | | | | | | |
| 10 | Retain non-discrimination | None | Now | Indefinite | | | | | | |
| 11 | Ensure suitable licensing category for VoIP | Ministry procedure | 2009 | 2010 | | | | | | |
| 12 | Ensure VoIP service providers can use suitable numbers | OSIPTEL procedure | 2009 | 2010 | | | | | | |
| 13 | Oblige VoIP providers to access emergency services where feasible | OSIPTEL or Ministry procedure | 2010 | 2011 | | | | | | |
| 14 | Surveillance for VoIP | Ministry procedure | 2009 | 2010 | | | | | | |
| 15 | Enable a "working horse" | Consultation | 2009 | 2011 | | | | | | |

The “Nbr” column of Table 18 contains the Recommendation number. If the “Action” contains “Consultation …”, it means that the suggested time frame is meant to include follow-up actions, possibly including a suitable proceeding on the part of OSIPTEL or the Ministry.

### 5.13.1 Review existing regulations and mitigate impediments to migration to NGN

The first step is to ensure that interconnection regulation applies to those parties, and *only* to those parties, where regulation is unambiguously necessary. (Recommendation 1. Apply regulation only to those entities that possess market power.) This seems to already be the case.

Peruvian regulation is applied to the *service*, not to the *technology*; consequently, existing regulation will automatically apply to NGNs, in general. In some cases, no action is necessary. (Recommendation 10. Retain non-discrimination provisions.) There are however exceptions (for example, explicit references to Signaling System 7), and also instances where regulation should not be carried forward without review and possible change. These are reflected in other recommendations.

The study identified a number of areas where Peruvian regulation appears to be problematic or rigid in ways that could interfere with the migration to NGN. In those instances, we are recommending that OSIPTEL conduct a public consultation in order to properly explore the issue and to solicit input from stakeholders, and implement any necessary corrective actions. (Recommendation 2. Initiate a public consultation to identify any inefficiencies in current circuit-switched interconnection arrangements. Recommendation 8. Initiate a public consultation to solicit input on possible improvements to rural service arrangements and fixed-to-mobile calls.)

### 5.13.2 Provide a proper framework for Voice over IP (VoIP)

The existing regulatory framework is ambiguous as regards VoIP service providers who are not network operators. Licensing as a provider of value added services does not, for example, necessarily provide access to telephone numbers, nor does it necessarily confer rights to interconnection. This could be resolved either by altering the Ministry's licensing rules, or by enabling third parties to provide needed capabilities. We advocate both. (Recommendation 11. Ensure that some suitable licensing category is available to third-party VoIP service providers. Recommendation 15. Address any impediments to the emergence of a VoIP "working horse" in Peru.) VoIP service providers should have access to the kind of telephone numbers that their customers expect and demand. (Recommendation 12. Ensure that VoIP service providers have access to suitable telephone numbers.)

VoIP service providers should be subject to obligations comparable to those of fixed and mobile operators, to the extent that it is reasonably feasible for them to meet the obligations. (Recommendation 13. Ensure that providers of voice telephony services (including VoIP) to Peruvian numbers provide access to emergency services. Recommendation 14. Ensure that surveillance can be applied to Internet data and to VoIP.)

### 5.13.3 OSIPTEL should strive for clarity and efficiency in charging arrangements going forward

In the near to intermediate term, CPNP arrangements based on minutes of use should be retained. Termination rates should continue to move downwards, consistent with cost modeling that recognizes that relatively little of the cost of an NGN is associated with the voice service. (Recommendation 7. In the near to intermediate term, implement per minute charges substantially lower than those in use today.) Termination rates that are closer to real usage based incremental costs, and thus closer to zero, will imply less of an economic shock if a substantially different wholesale arrangement is needed in the future, as is likely to be the case. They also give network operators (and their customers) time to adjust to retail plans that better fit these wholesale arrangements.

In the longer term, and in the interest of investment certainty, OSIPTEL should signal its intent to evolve in the direction of monthly charges rather than usage-based per-minute charges. (Recommendation 6. Initiate a public consultation to discuss a proposed long term direction that charging for IP-based NGN voice interconnection should be based either on CBC or on Bill and Keep.)

### 5.13.4 OSIPTEL can pave the way for IP-based NGN interconnection

Market players do not seem to be ready for IP-based NGN interconnection today, but OSIPTEL can stimulate the kind of discussions – and the creation of a suitable discussion forum – so as to facilitate migration at the right time.

Based on experience in other countries, a huge number of issues will need to be resolved. In the circuit switched world, it may have been appropriate for OSIPTEL to impose a widely recognized solution (Signaling System 7), but it is less appropriate in the NGN case. OSIPTEL should prefer market-led solutions where possible.

Questions over the nature and number of Points of Interconnection (PoI) are likely to arise quickly, based on experience in other countries. This is an obvious place to start. (Recommendation 3. Consult with market players as regards the appropriate number and nature of Points of Interconnection (PoI) for IP-based NGN voice.)

A conventional regulatory proceeding is probably not the appropriate mechanism. In international experience, the most promising example we know of is the IP Working Party in New Zealand (see Section 4.2.2.5). The structure of the IPWP's parent organization, the TCF, is somewhat similar to that of NAP.Peru, but with a more inclusive membership. OSIPTEL should have a seat at the table, but should not run the industry forum.

The forum could then deal with the many issues that must be resolved. (Recommendation 9. OSIPTEL should indicate its intention, in the event that market players cannot agree on standards for QoS, to establish its own standards on the basis of the MIT QoS white paper.) It could also be useful as a means whereby the Peruvian incumbent could keep competitors informed in a timely fashion of plans relevant to their interconnection (e.g. changes in PoI) as it evolves its network to an NGN.

OSIPTEL should retain its authority to resolve interconnection disputes, and to review interconnection agreements. (Recommendation 5. Network operators need suitable flexibility, but OSIPTEL should continue to oversee the voice interconnection process.)

### 5.13.5 Other recommendations

Independent of the migration to IP-based NGN, it is clear that Internet access is becoming increasingly critical to the Peruvian public. Additional attention to network reliability and robustness is in order. (Recommendation 4. Promote the creation of a second or third NAP.Peru.)

With the migration to NGN, and the increased importance of data transmission over the network, access to spectrum becomes more important. We have not assessed the current state of spectrum management in Peru, but would simply emphasize the need to maintain best practice spectrum management. (Recommendation 16. Peruvian spectrum management in the commercial sector should reflect the use of auctions and secondary markets. Recommendation 17. Peruvian spectrum managers should keep current as regards emerging technologies. Recommendation 18. Peruvian spectrum management should be aware of emerging trends in the public sector, with a move away from permanent assignments without cost.)

# Annex 1: The specifics of the Peruvian environment

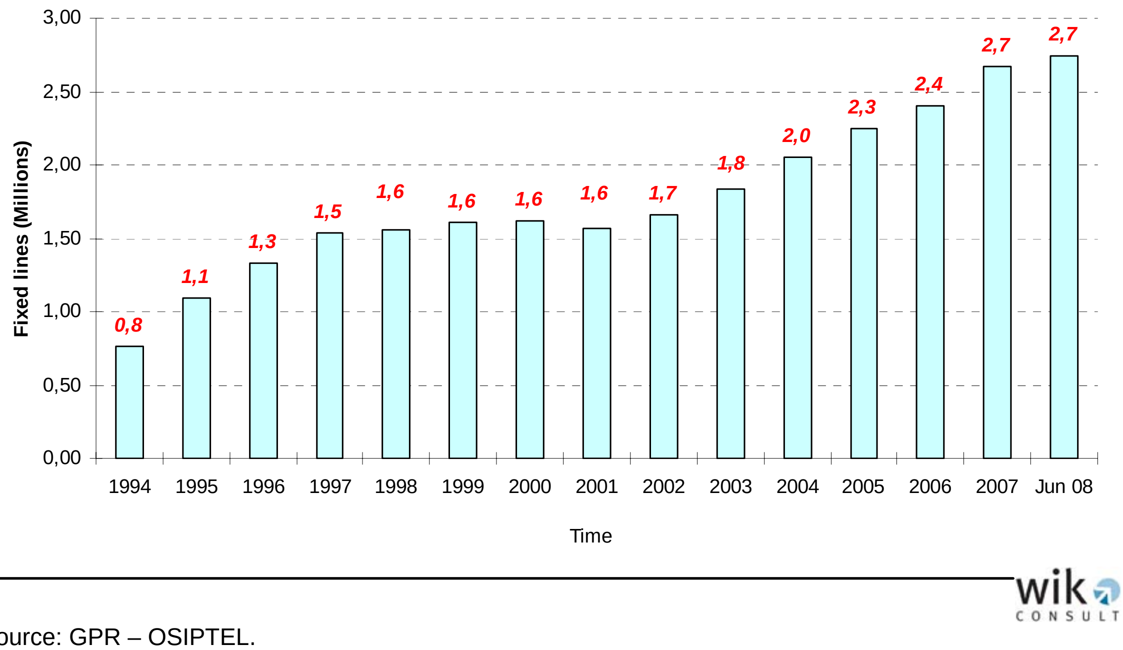
This section provides a description of the fixed telephony, mobile telephony, long-distance telephony and data services markets in Peru.

## The Peruvian fixed telephony environment

### The Peruvian local telephony market

The number of fixed local telephony lines has increased over the last years, reaching a total of 2.74 millions of lines in June 2008 (see Figure 52). On a national level, as of June 2008 the penetration rate of local fixed telephony is of 9.8 lines per 100 inhabitants.

Figure 52: Number of Fixed telephony lines (1994 – June 2008)

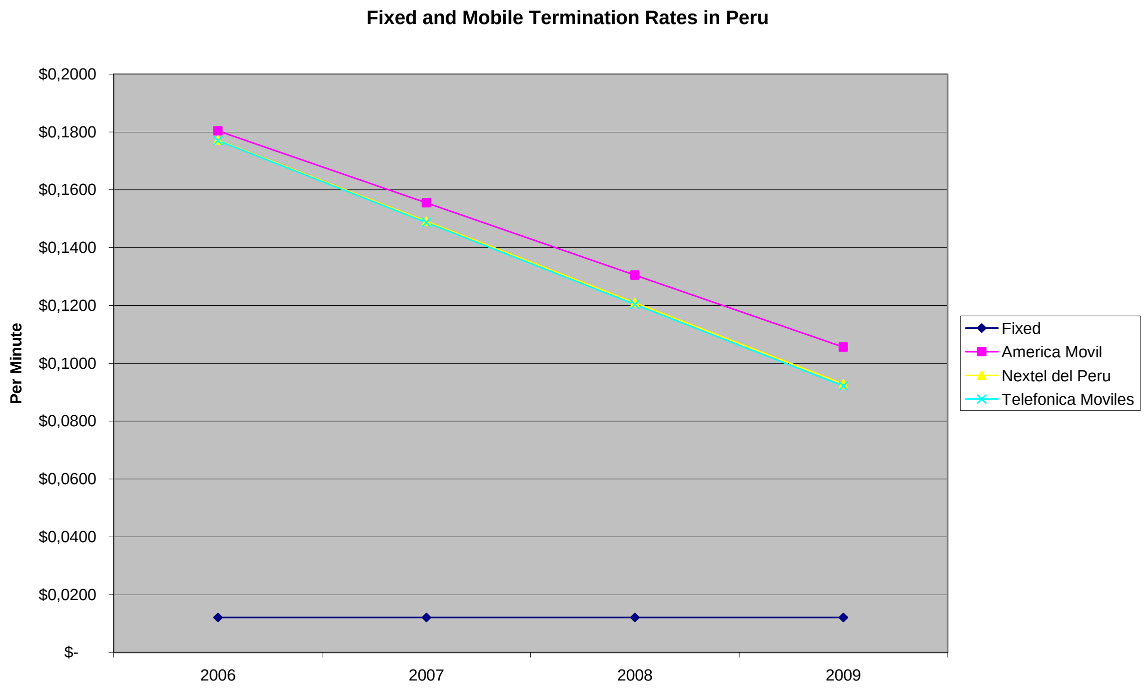



Source: GPR – OSIPTEL.

## Interconnection issues

In March 2003, OSIPTEL established the interconnection ceiling charge for the local fixed network at $0.01208 US per minute[222]. The interconnection charges are periodically in accordance with a resolution of OSIPTEL of 2005. Figure 53 shows the maximum charges for local fixed and mobile interconnection.

Figure 53: Wholesale Fixed and Mobile Termination Rates in Peru




Source: OSIPTEL.

**222** Resolucion N° 018-2003-CD/OSIPTEL (March 21, 2003).

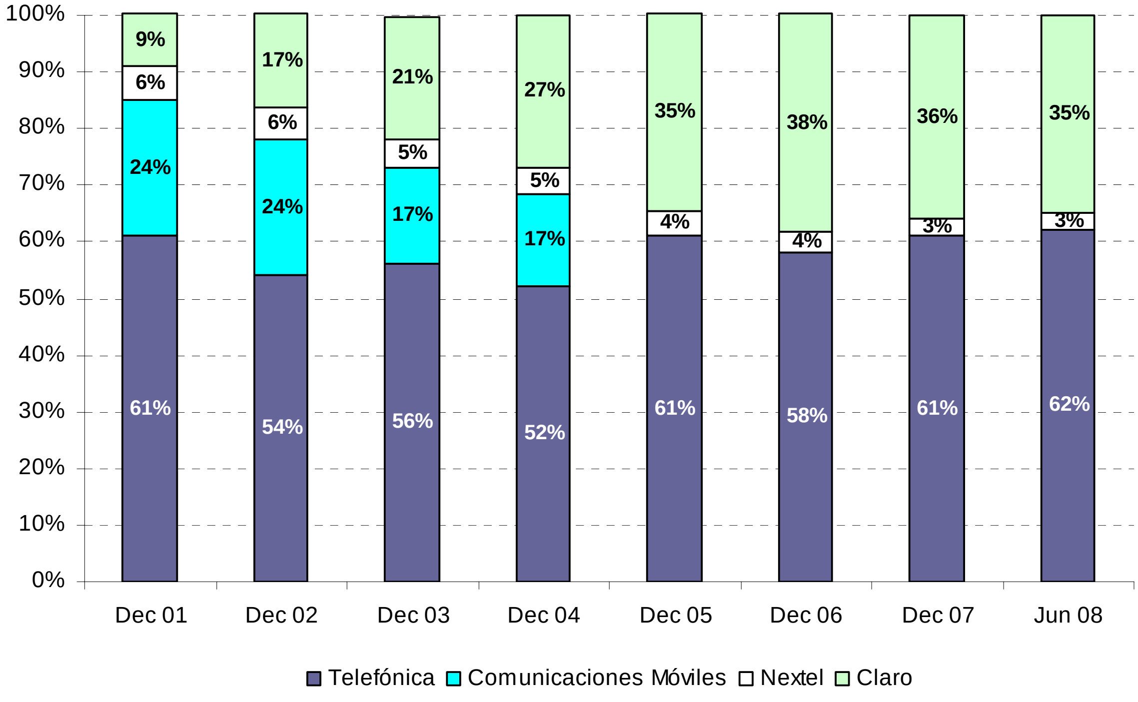
## The Peruvian mobile telephony environment

### The Peruvian mobile telephony market

In the second quarter of 2008, there were 18.6 millions lines (i.e. active mobile users) in Peru. In June 2008, the penetration rate of mobiles lines (i.e. the number of active mobile users divided by the total size of the population) was 65.5%.

Figure 54 shows the market share of the three significant mobile operators: Telefónica Moviles (Telefónica and Comunicaciones Móviles), Nextel, and Claro (América Móviles). As of June 2008, Telefónica Móviles had a 62% share of the mobile market, followed by Claro with 35%, and Nextel with 3%.

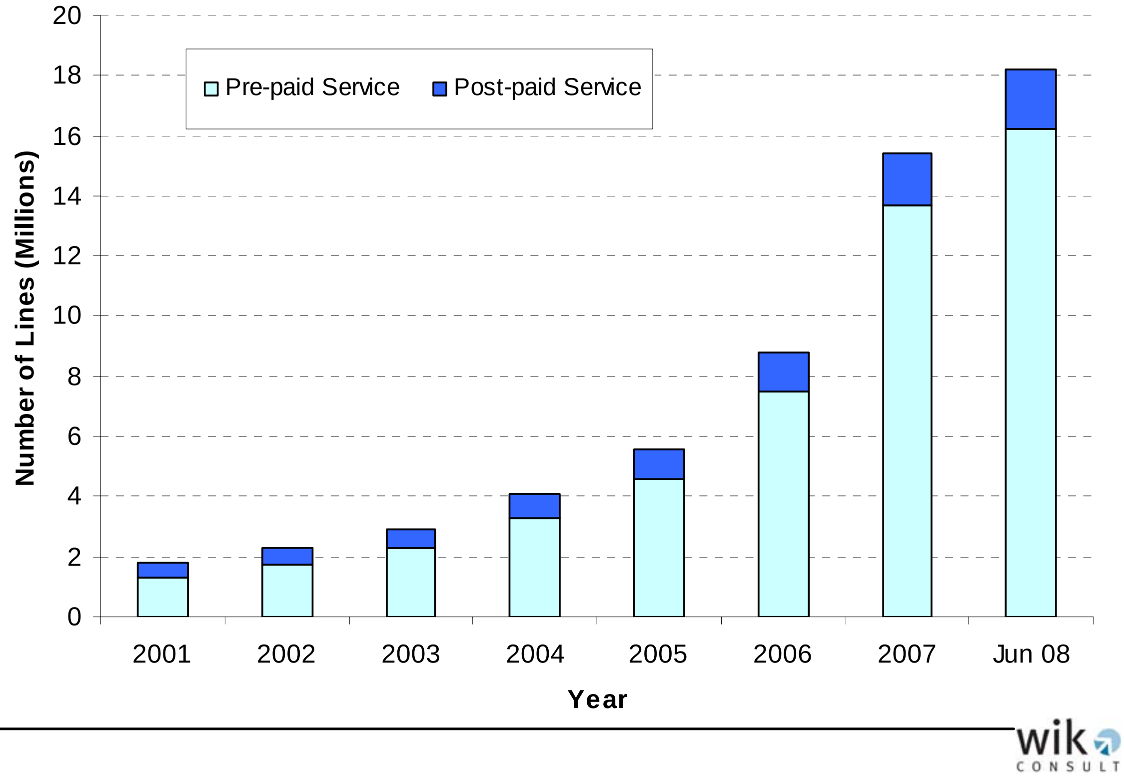
Figure 54: Market share, number of lines (2001 – June 2008)




Source: GPR – OSIPTEL.

Figure 55 shows the evolution in the number of mobile lines.

Figure 55: Number of mobile lines (2001 – 2008)




Source: GPR – OSIPTEL.

## Interconnection issues

In 2005, OSIPTEL published a plan for the reduction of mobile termination charges. The glide path approved has 4 steps which begin in 2006 and end in 2009.[223] It defines slightly different interconnection rates for each of the three mobile operators. Figure 53 shows these mobile termination rates.

**223** OSIPTEL, Resolución N° 070-2005-CD/OSIPTEL, November 21, 2005.

## Retail prices

Comparing Peru to other countries in the region in terms of retail price for mobile services is complex. A number of approaches are available, none of them fully satisfactory. One can, in principle, (1) simply review operator tariffs in each country, and compare the lowest in each; (2) estimate the aggregate cost of a predetermined “market basket” of calls in each country; or (3) use a normalized proxy for retail price.

The inherent limitation with the first two methods is that one does not know how many users sign up for each retail plan of a mobile operator, or what their respective usage patterns are, or what introductory offers might have been available to them. As a result, estimate errors can be large. Most of the data that appear in Figure 56 are based on the lowest retail tariff visible on each operator’s web site, as determined by OSIPTEL.

The World Bank and ITU routinely use the second method, based on a low usage market basket developed by the OECD.[224] We reviewed their data, but (due to the distortions previously noted) we do not think that their market basket estimates shed useful light on retail prices in the region.

The third approach is, in our view, the most reliable. All revenues associated with mobile usage are divided by all revenue-generating minutes in order to yield a normalized *Service-Based Revenue per Minute of Use*. Merrill-Lynch provides a good source of such data in their Quarterly Wireless Matrix reports. This approach avoids the pitfalls of the first two methods, inasmuch as all of those factors are already reflected in the total minutes. Unfortunately, it suffers from anomalies of its own – notably, there is no way to distinguish originating minutes and associated retail revenues from terminating minutes and associated wholesale revenues. Once again, we have provided these data in Figure 56.

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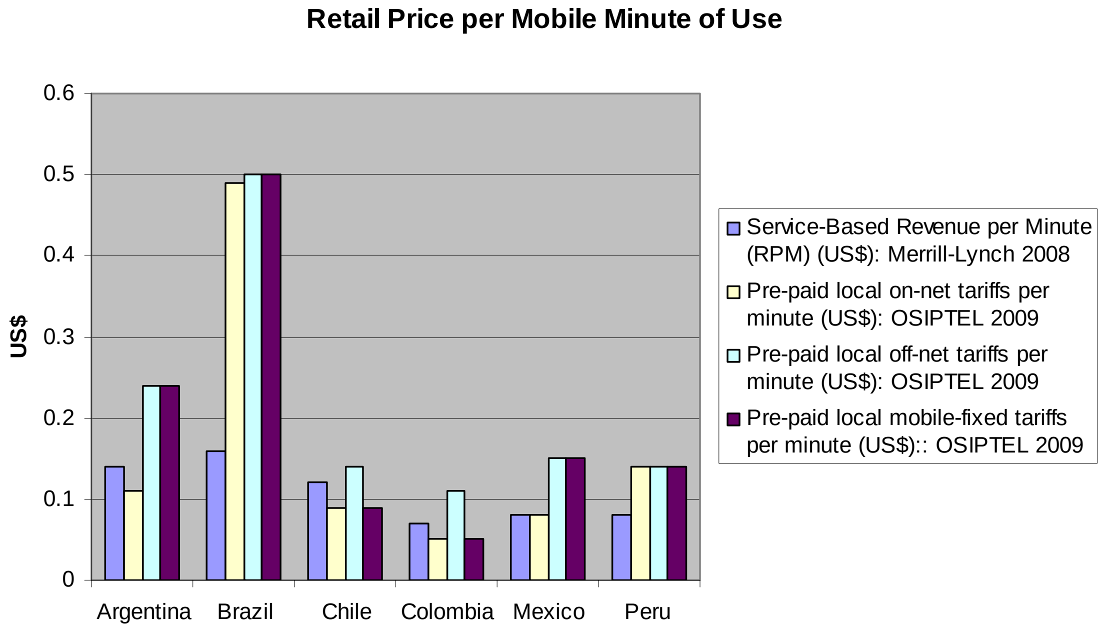
**224** See http://go.worldbank.org/5RZ90VCFH0 and select Peru, Retrieved on 7 August 2009.

Figure 56: Comparative retail price per mobile Minute of Use




Source: WIK, based on data provided by OSIPTEL (2009), and on the Merrill-Lynch Wireless Matrix.[225]

The Merrill-Lynch data thus serve as a cross-check on the OSIPTEL estimates, and vice versa. In most cases, the correspondence is reasonable; however, we suspect that the OSIPTEL estimates may be high for Brazil.

Retail prices in Peru may have been high in the recent past, but they appear to be mid-range or moderate today.

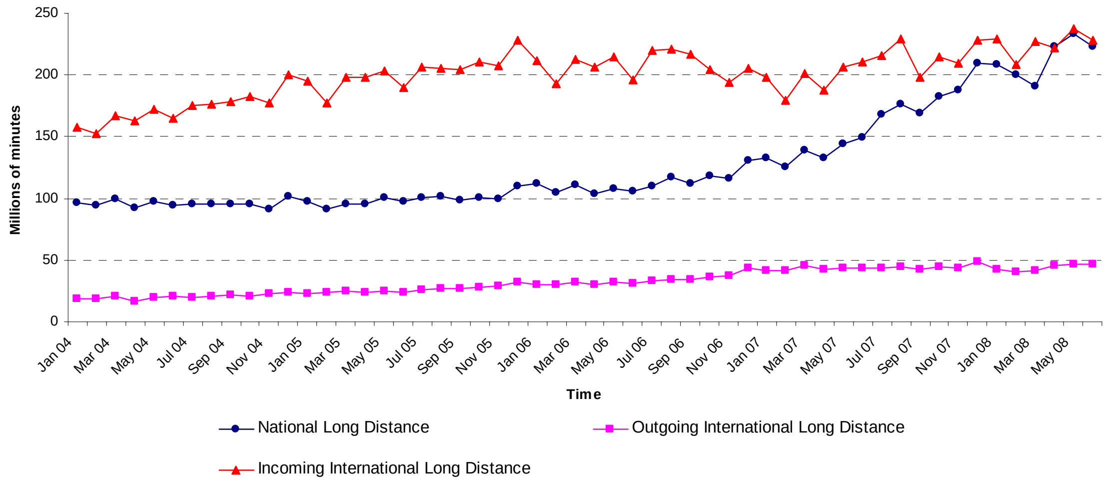
**225** At http://www.cwes01.com/10323/24789/Interactive_Global_Wireless_Matrix.xls, Retrieved on 9 May 2009.

### The Peruvian long-distance market

The long distance telephony market is the most competitive sector of all the telecommunications services provided in Peru. In 2002, the long distance market segment was opened up to competition. Competition increased dramatically.

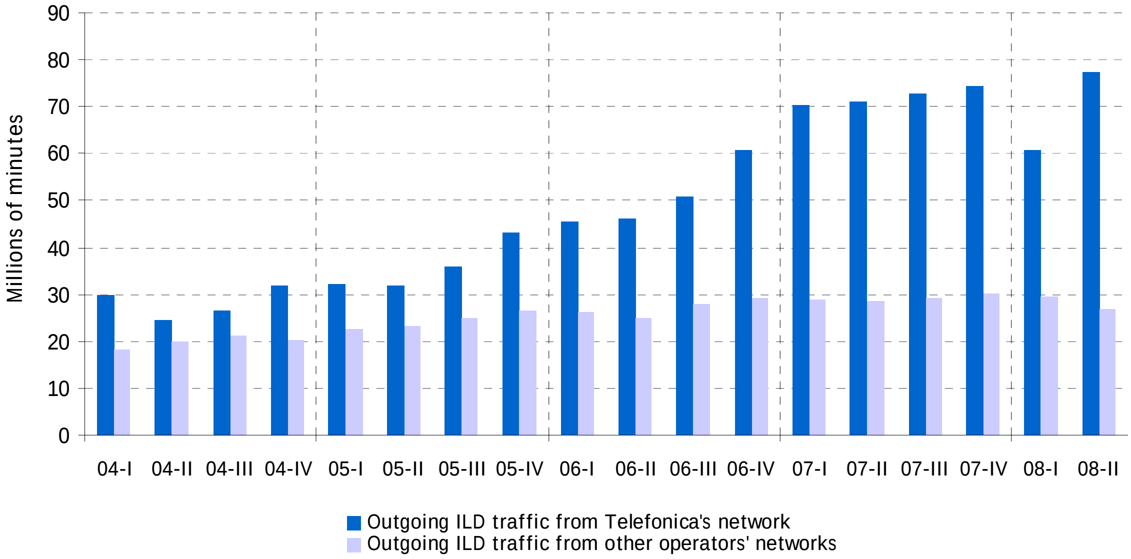
Figure 57 depicts the evolution of the national long-distance traffic.

Figure 57: Evolution of the long-distance traffic (January 2004 – June 2008)




Source: GPR – OSIPTEL.

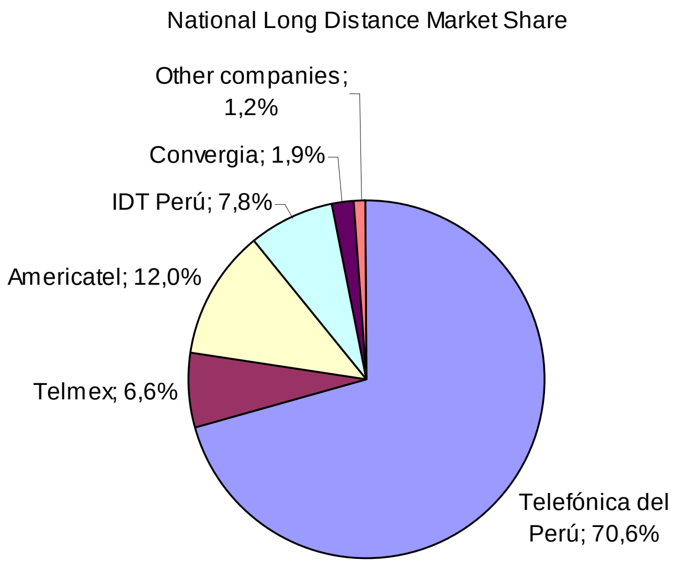
Figure 58: Evolution of the outgoing international long-distance traffic originated at the fixed local network (2004 I – 2008 II)




Source: GPR – OSIPTEL.

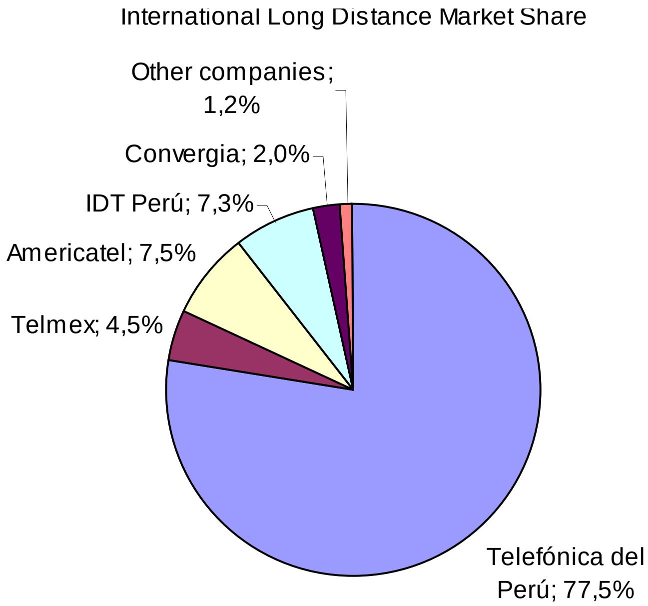
Figure 59 shows the share in the national long distance market.

Figure 59: National Long Distance Market Share, Residential Users (Volume of traffic, December 2008)




Source: GPR – OSIPTEL.

Figure 60: International Long Distance Market Share, Residential Users (Volume of traffic, December 2008)

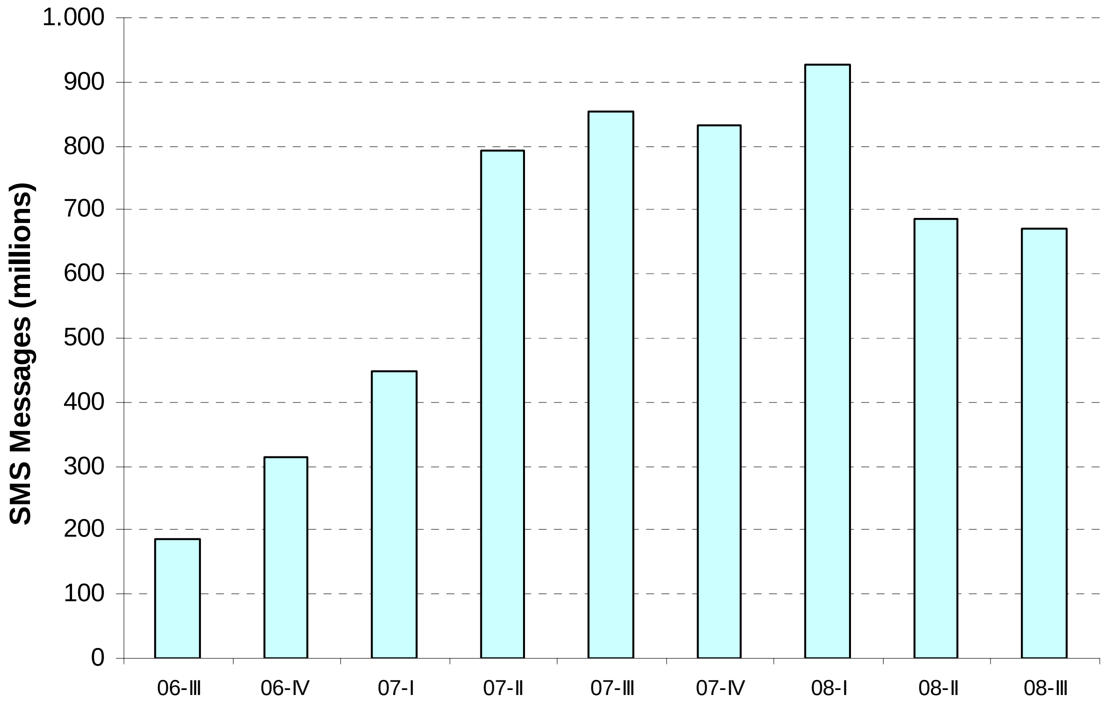



Source: GPR – OSIPTEL.

## The Peruvian market for fixed and mobile data services

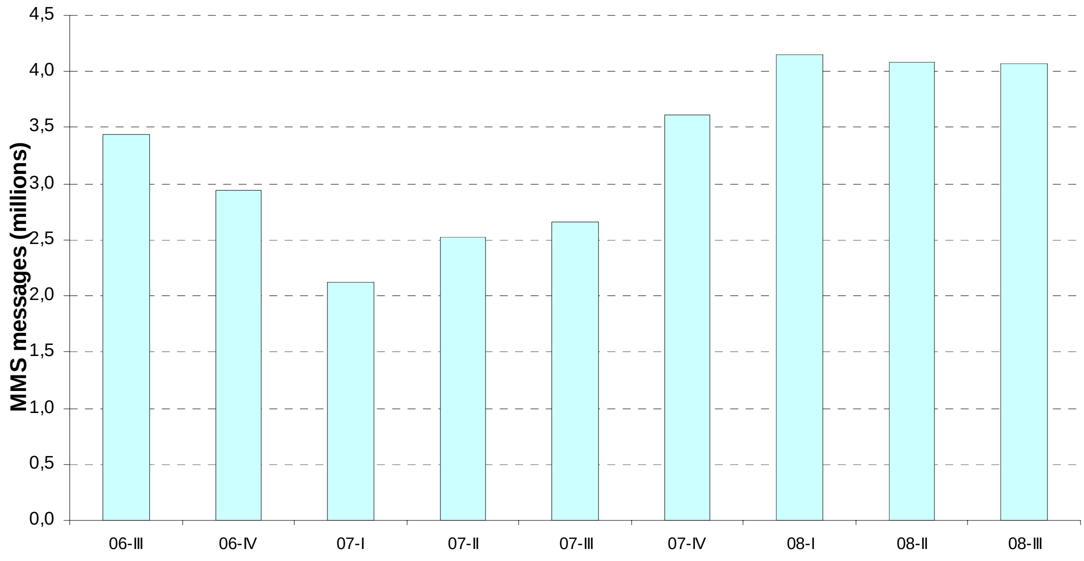
### The Peruvian data services market

Figure 61: Evolution of the number text messages (SMS), in millions (2006 III – 2008 III)



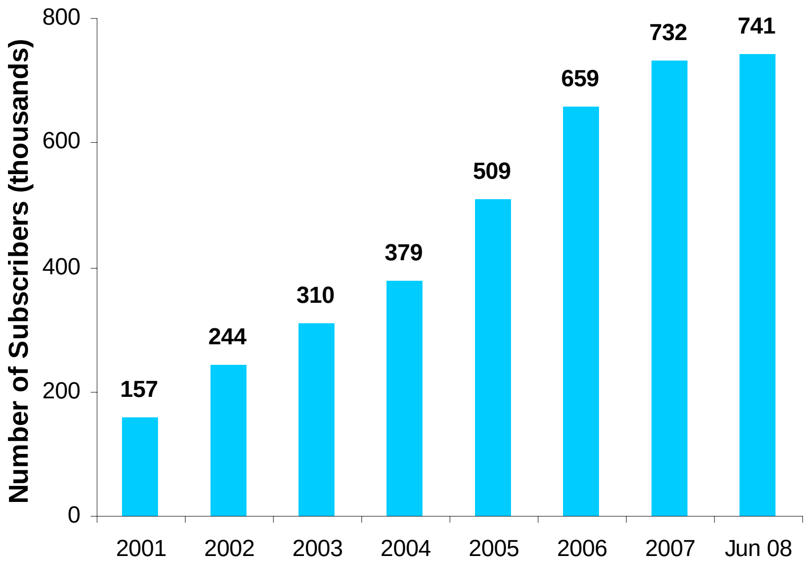

Source: GPR – OSIPTEL.

Figure 62: Evolution of the number of multimedia messages (MMS), in millions (2006 III – 2008 III)



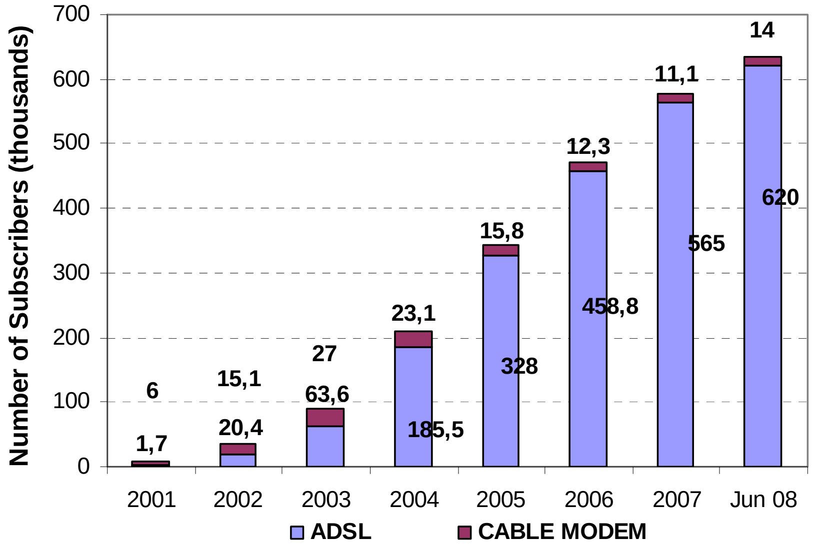

Source: GPR – OSIPTEL.

Figure 63: Number of accesses to the Internet and growing rate (2001 – June 2008)



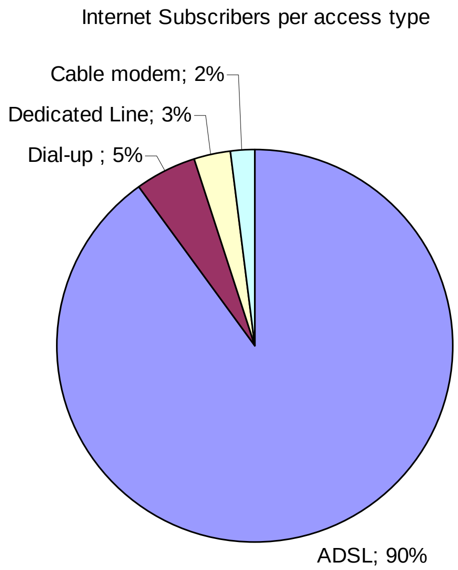

Source: GPR – OSIPTEL. It includes fixed dial-up, dedicated wired and wireless links, ADSL and cable modem subscribers.

Figure 64: ADSL and Cable Modem evolution (2001 – June 2008)




Source: GPR – OSIPTEL.

Figure 65: Internet Subscribes per access type, Residential Market, December 2008




Source: GPR – OSIPTEL.

In the ADSL market, Telefónica del Perú has a 99.97% market share, followed by Telmex Perú with 0.02% market share.

## Annex 2: Interconnection Legislation in Peru

This annex describes the elements of Peruvian law or regulation that would need to be amended to implement the recommendations that appear in this report.

The two public agencies with primary responsibility for telecommunications issues in Peru are OSIPTEL and the Ministry of Transport and Communications (MTC). The Ministry is responsible for the obligation to have Points of Interconnection in all the departments; the obligation to use the SS7 signaling system; and the numbering plan. OSIPTEL is responsible for most aspects of interconnection pursuant to the “Texto Unico Ordenado de las Normas de Interconexión” as amended.

The annex discusses each of the numbered recommendations that appear in this report. The recommendations for which a text change can be identified are discussed in numerical order, by recommendation number. Other recommendations are listed at the end of this annex.

**Recommendation 1. Apply regulation only to those entities that possess market power.**

As networks evolve to IP-based NGNs, interconnection regulation should be applied only to those entities that possess market power due to the call termination monopoly. Specifically, network operators that provide voice call termination to E.164 telephone numbers should be subject to regulation. Voice service providers that do not possess a network, however, should not be subject to interconnection regulation.

The current regulation (the Texto Único Ordenado de las Normas de Interconexión, Articles 4 and 5 of the Resolución N° 001-98-CD/OSIPTEL) already implements this function correctly, for the most part. Interconnection obligations flow from terminating calls to the voice network, which is to say that network operators that possess termination monopoly power are subject to regulation. Network operators who do not provide voice services are not subject to the obligation.

Also, voice service providers that do not operate a network can be licensed as providers of value added services, which does not subject them to interconnection regulations. Again, this is appropriate because it appears that they are not able to exercise termination monopoly power.

These regulations do not deal with (1) last mile market power, or with (2) the market power associated with network externalities. The former is an issue for network access, rather than for network interconnection. The latter could conceivably become an issue in the future, but we do not perceive the need to deal with it at this time.

The declaration of potential bottlenecks as essential facilities is a key aspect of regulatory safeguards of competition. Annex II of the “Texto Único Ordenado de Interconexión (TUO)” identifies the following Essential Facilities: Termination calls, Switching, Transport, Signaling and Ancillary Services. The technological implementation of these capabilities is different in an NGN than in a circuit switched network, but the risk that a bottleneck will be exploited remains.

We fully expect that termination will remain an essential facility for the foreseeable future. This situation will only change to the extent that users can be reached over several networks, among which the caller (or calling network) can choose. Call termination is a “bundled” interconnection service that is provided from the PoI to the receiving party and that includes some signaling services. The structural composition of termination services changes with the network level at which the transfer from one network to the other occurs and with the location of the PoI. Thus, while not changing the nature of the termination essential facility, NGN may change the scope of the termination service. The general rule is that only those parts of termination represent an essential facility that cannot reasonably be duplicated by the originating network operator. Thus, in the PSTN, the single and double tandem parts may not be essential facilities so that only the local part of termination would represent an essential facility. This characterization would depend on user densities and could therefore differ in different regions of the country. The move to NGN would probably lead to a more standardized termination essential facility. Also, under IP-interconnection the current conversion of calls from IP to traditional circuit-switched TDM would no longer be necessary. Mobile network termination would likely be best in the hot-potato variety because only the terminating network knows where the user can currently be located.

Under a move to fiber-based NGAs, which themselves clearly will represent essential facilities, backhaul services tend to become or remain essential facilities as well. The backhaul may extend in two directions, towards the customers under fiber-based access and further into the network under the closure of old PoI’s.

As long as circuit switching continues to be used, switching is likely to remain hard to duplicate in remote areas and therefore an essential facility. The move to IP switching, however, may remove that regulatory requirement because of the lower costs of IP routers.

Transport is probably no longer an essential facility, although there may be some need for continued regulation of leased lines. This is unlikely to change much under a move to NGN.

“Upper layer” bottlenecks have been mentioned as a potential bottleneck in an NGN environment. However, to the best of our knowledge no jurisdiction anywhere has pursued this issue to the extent that it would have led to regulatory decisions. This is therefore nothing OSIPTEL would need to worry about at this time.

Generally, network operators have to provide access for competitors to infrastructure that provides an essential facility. The EU uses a somewhat weaker criterion by requiring access regulation if the hypothetical market for infrastructure is dominated by an operator and if three other criteria are met. In the case of new infrastructure, the question arises if regulation should go further by obliging the builder of the infrastructure to share it (i.e., the ownership) with competing operators. Since such sharing is a very strong regulatory requirement, it should be imposed only for essential facilities, if at all. We would generally advise against such a sharing obligation because it is very hard to administer, since it requires decisions about who should receive which infrastructure shares and at what price.

With regard to sharing there is a very different and often more urgent question, which is whether competitors should be permitted to share new infrastructure voluntarily. This would allow competitors to build a duplicate infrastructure in near-essential-facility cases, where a substantial market share is required for its viability. This may also require some active involvement of the regulator in those cases where the competitors involved have a hard time reaching an agreement or where they leave out some competitor who would like to join. The agreement may also involve the incumbent so that it would pose severe competition policy issues.

**Recommendation 2. Initiate a public consultation to identify any inefficiencies in current circuit-switched interconnection arrangements.**

OSIPTEL should initiate a public consultation, soliciting input from stakeholders and market players (large and small, fixed and mobile, urban and rural), in order to identify any inefficiencies in current circuit-switched interconnection arrangements. Market players should be asked whether the number of PoIs is appropriate; whether there are any inefficiencies imposed on wholesale and/or retail pricing arrangements as a result of the delivery of call traffic to the PoI associated with the geographic telephone number; and what reforms might best address any shortcomings identified.

The obligation to maintain at least PoI in each Department pertains to Telefonica del Peru. It is relevant to fixed operators (whether local or long distance), but not to mobile operators and not to pure Internet service providers.

The governing rule is in the Ministry of Transport and Communications's "Lineamientos de Apertura (D.S. 020-98-MTC)": "*Lineamiento 39. Los operadores establecidos deberán definir por lo menos un punto de interconexión en cada área local, tanto en la interconexión local-local como en la de larga distancia-local y larga distancia-larga distancia. Los puntos de interconexión adicionales estarán sujetos a negociación*." This rule enables parties to negotiate additional points of interconnection, but does not permit them to have fewer points of interconnection.

See also Chapter II, Subchapter III ("De los Contratos de Interconexión") of the "Texto Único Ordenado de Interconexión", which describes the procedure to establish an interconnection agreement between two operators. Chapter IV ("Mandato de Interconexión") describes the mandates of interconnection, which are enacted by OSIPTEL when two operators do not agree on the technical or economic aspects of the interconnection.

Rules regarding wholesale and retail payments are probably just as critical as the interconnection obligations to an understanding of these aspects of the system.

**Recommendation 3. Consult with market players as regards the appropriate number and nature of Points of Interconnection (PoI) for IP-based NGN voice.**

OSIPTEL should consult with market players as regards the appropriate number and nature of Points of Interconnection (PoI) for IP-based NGN voice. Is it necessary to maintain the current system of one PoI per Department when voice interconnection is based on IP? To what extent can the nature and location of PoI be left to the market players themselves? Are there rigidities or inefficiencies in wholesale or retail pricing that would need to be addressed as Peruvian network interconnection evolves to an IP basis? This consultation might profitably be combined with the consultation that we have recommended regarding interconnection in today's circuit-switched environment.

This could be in the form of a standard OSIPTEL exploratory regulatory consultation, where there is no immediate intention of issuing a rule.

**Recommendation 4. Promote the creation of a second or third NAP.Peru.**

In the interest of robustness of critical infrastructure, OSIPTEL might wish to promote the creation of a second or third NAP.Peru.

NAP.Peru is a private organization. It is not currently subject to any specific regulations.

We suggest that OSIPTEL senior management simply indicate to NAP.Peru their interest in a second or third Internet exchange point. The market players who are NAP.Peru members might very well recognize that greater robustness and redundancy is in their own interest.

**Recommendation 5. Network operators need suitable flexibility, but OSIPTEL should continue to oversee the voice interconnection process.**

Network operators need suitable flexibility, but OSIPTEL should continue to oversee the voice interconnection process. Specifically: (1) Network operators that are presently subject to an obligation to interconnect their voice services should continue to be so obliged. (2) Network operators should be encouraged to agree voice interconnection arrangements among themselves. (3) Such agreements should be provided to OSIPTEL. (4) OSIPTEL should retain the right to establish voice interconnection arrangements if the parties cannot agree, and the right to intervene if a voice interconnection arrangement appears to be anticompetitive.

The mechanisms described above are largely those that already exist in the current regulations; however, it would be necessary to make them more technologically neutral.

For example, the "Plan Técnico Fundamental de Señalización", Resolución Suprema N° 011-2003-MTC", enacted by the Ministry of Transport and Communications, requires the use of the SS7 system for interconnection signaling. Network operators should be given the opportunity to substitute some mutually agreeable alternative.

The current text reads: *Section 5.1- "SEÑALIZACIÓN ENTRE CENTRALES: (…) El sistema de señalización empleado entre centrales de redes de diferentes concesionarios debe ser el tipo de señalización red – red. Para tal fin, se define el sistema de señalización de canal común N° 7 norma nacional.*

The text could be changed to: *SEÑALIZACIÓN ENTRE CENTRALES: (…) El sistema de señalización empleado entre centrales de redes de diferentes concesionarios debe ser el tipo de señalización red – red. Para tal fin, se define el sistema de señalización de canal común N° 7 norma nacional,* ***a menos que los operadores acuerden entre sí otro sistema de señalización****.*

This change would effectively render much of the following text inoperative in the event that two network operators mutually agree on a different interconnection signaling protocol.

Retaining the current text has the effect of protecting competitive operators, who always can fall back to the familiar signaling mechanisms.

**Recommendation 6. Initiate a public consultation to discuss a proposed long term direction that charging for IP-based NGN voice interconnection should be based either on CBC or on Bill and Keep.**

OSIPTEL should indicate, through a public consultation process (possibly merged with consultations advocated in other of our recommendations) that it intends its long term direction for charging for IP-based NGN voice interconnection to be based either on Capacity Based Charging (CBC) or on Bill and Keep. Establishing a long term direction can help to maintain regulatory predictability and clarity, and a framework for investment. OSIPTEL should solicit the views of stakeholders.

The consultation would be exploratory. It signals OSIPTEL's long term direction to network operators, and thus creates more regulatory certainty and a better climate for investment.

The legislation about structure of termination payments appears in the following documents:

- Determination of the charge: Guidelines -"Lineamientos"- of the Ministry and the TUO, Art. 13-17).
- Payment Modality: TUO, Art. 23. a) Per Time/Volumen of information: "Por tiempo de ocupación de las comunicaciones debidamente completadas y/o volumen de informacion", b) Periodic Fixed Charges: "Cargos fijos periódicos".
- For the determination of the value: The rules ("normas") enacted by OSIPTEL.

Note that the current rules already envision the possibility of Periodic Fixed Charges. They do not limit how those charges could be determined. It would thus appear that OSIPTEL could implement either CBC or a rigid Bill and Keep (fixed charge of zero) without amendment of the TUO.

**Recommendation 7. In the near to intermediate term, implement per minute charges substantially lower than those in use today.**

In the near to intermediate term, OSIPTEL should maintain the *structure* of voice interconnection charges, which are based on CPNP arrangements per minute of use. Per minute charges should be substantially lower than those in use today, and more in line with the true usage-based cost associated with the voice service; however, they should not be zero.

OSIPTEL is already engaged in computing mobile termination rates for the next few years. OSIPTEL should bear in mind the considerations that appear in 5.7 in assessing what termination rates would be acceptable for the next few years.

**Recommendation 8. Initiate a public consultation to solicit input on possible improvements to rural service arrangements.**

OSIPTEL or the Ministry should initiate a public consultation with market players in order to better understand how universal access / rural service arrangements are evolving over time, to identify any problems or challenges with retail and wholesale pricing arrangements, and to solicit input on possible improvements.

We identified a number of possible problems, but we do not have enough information to assess them fully, and we do not have solutions to put forward. Most interviewees found current arrangements to be problematic. We think that OSIPTEL needs to conduct an exploratory proceeding to get a better handle about how the current arrangements are working in practice, and what problems (if any) they are causing.

The legislation about rural service arrangements appears in the following documents:

- Legislation about rural telephony appears in Chapter III of the “Texto Único Ordenado de Interconexión”, which describes the norms regarding the interconexion of telephony lines in rural areas. Chapter IV-B contains information about communications to and from rural areas.
- The rules (“normas”) enacted by OSIPTEL.
- “Lineamientos para servicios rurales”, 2008.

**Recommendation 9. OSIPTEL should indicate its intention, in the event that market players cannot agree on standards for QoS, to establish its own standards on the basis of the MIT QoS white paper.**

OSIPTEL should consult with market players, indicating that at such time as IP-based NGN voice interconnection is available, if market players are unable to agree on standards for Quality of Service, OSIPTEL will establish its own standards on the basis of the MIT QoS white paper.

This could be done promptly, in order to establish a clear direction, or it could wait until there are concrete movements in the market toward IP-based interconnection (with QoS). It might be better in this case to wait, since the shape of the problem might become clearer over time.

The legislation about Quality of Service appears in the following documents:

- TUO, Art. 32-33, it does not contain interconnection parameters.
- For the quality of service of the end-users: “Resolución 040 del Consejo Directivo de 2005 de OSIPTEL”.

**Recommendation 10. Retain non-discrimination provisions.**

OSIPTEL should retain the non-discrimination provisions that exist in its present rules.

No change is required, so far as we can see. Current rules are general, and they are sufficient.

The legislation about network neutrality appears in the following documents:

- TUO, Art. 7-10
- Norma de Calidad de Servicio, Resolución 040 del Consejo de 2005 de OSIPTEL, parte de Internet, parte 7

**Recommendation 11. Ensure that some suitable licensing category is available to third-party VoIP service providers.**

OSIPTEL or the Ministry should ensure that some suitable licensing category is suitable for independent (non-network-based) VoIP service providers, including appropriate rights and obligations for telephone numbers, interconnection, access to emergency services, and lawful intercept.

This is a matter for the Ministry, not for OSIPTEL.

**Recommendation 12. Ensure that VoIP service providers have access to suitable telephone numbers.**

OSIPTEL or the Ministry should ensure that third-party VoIP service providers have access to the telephone numbers that they need to enable viable business models, whether geographic or non-geographic. The “signals” that these numbers implicitly provide to callers as regards retail pricing need to be carefully considered.

This is a matter for the Ministry, not for OSIPTEL.

The relevant rules appear in the Ministry of Transport and Communications’s “Plan Técnico Fundamental de Numeración”.

**Recommendation 13. Ensure that providers of voice telephony services (including VoIP) to Peruvian numbers provide access to emergency services.**

OSIPTEL or the Ministry should ensure that voice telephony services (including VoIP-based services) that enable calls to be placed to Peruvian telephone numbers are also capable of reaching emergency services (police, fire, and medical services) using a simple, easily remembered national number. These calls should be free of charge. Insofar as the service is reasonably capable of doing so, it should connect to the geographically most appropriate (e.g. closest) emergency service, and should reliably report the caller's location. Consumers should be educated as to any limitations of the service in reaching emergency services or in reporting their location. Service providers should be given appropriate transition periods to implement the necessary capabilities.

We have not identified the relevant law or regulation.

**Recommendation 14. Ensure that surveillance can be applied to Internet data and to VoIP.**

Ensure that surveillance can be applied to Internet data traffic and to VoIP, subject to suitable oversight procedures, and to the extent that doing so is implementable at reasonable cost.

We have not identified the relevant law or regulation.

**Recommendation 15. Address any impediments to the emergence of a VoIP "working horse" in Peru.**

OSIPTEL should consult with market players to determine the reasons why no VoIP "working horse" has emerged in the Peruvian marketplace, and should seek to address any regulatory impediments to the emergence of a "working horse".

This would, once again, be an exploratory proceeding to identify possible regulatory or market barriers to the emergence of one or more network operators that could perform these functions on behalf of smaller market players, thus facilitating market entry.

**Recommendation 16. Peruvian spectrum management in the commercial sector should reflect the use of auctions and secondary markets**

Peruvian spectrum management in the commercial sector should continue to reflect international best practice, including the move to market mechanisms (auctions and secondary markets).

This is a general recommendation to follow international best practice. We are not promoting any specific actions at this time.

**Recommendation 17. Peruvian spectrum managers should keep current as regards emerging technologies.**

Peruvian spectrum managers should continue to keep current as regards emerging technologies, including Software Defined Radio (SDR) and Cognitive Radio (CR).

This is a general recommendation to follow international best practice. We are not promoting any specific actions at this time.

**Recommendation 18. Peruvian spectrum management should be aware of emerging trends in the public sector, with a move away from permanent assignments without cost.**

Peruvian spectrum management should be aware of emerging trends in the public sector (defense, emergency services, and transport), with a move away from permanent assignments without cost, and a move toward periodic rejustification (or possibly the use of market-inspired mechanisms).

This is a general recommendation to follow international best practice. We are not promoting any specific actions at this time.

## Annex 3: Glossary

### A

**Access**: Access enables an operator to utilize the facilities of another operator in the furtherance of its own business and in the service of its own customers.

**ARPU:** Average Revenue per User (often expressed in US dollars per month).

**AS** (Autonomous System): An independently managed IP-based network with its own IP routing policy.

**ASN** (Autonomous System Number): a unique numeric identifier for an AS.

### B

**Bandwidth**: The capacity of a channel to carry information, typically expressed in bits per second.

**BGP4** (Border Gateway Protocol v4): the inter-domain routing protocol used by the Internet.

**Bill and Keep**: agreements to interconnect and to exchange traffic without payment, a system sometimes referred to as Sender Keeps All.

### C

**CBC** (Capacity Based Charging): A wholesale pricing regime reflecting the maximum capacity required.

**CDMA** (Code Division Multiple Access): A set of standards for mobile communications. CDMA is used in the United States and a number of other countries.

**Client-server**: an asymmetric technical implementation involving to computers whose functions are not the same. The software running on the customer's Personal Computer (PC) (often just a web browser) might be the *client* of software running on a *server* platform of the service provider. A single server can support a great many clients.

**CODEC** (coder decoder): An encoding or decoding device that enables the digitization and digital transmission of analogue information (such as voice).

**CPNP** (Calling Party's Network Pays): an interconnection regime where the network of the party who placed the call (the originating network) makes a payment to the network of the party that received the call (the terminating network).

**CPP** (Calling Party Pays): The most common retail payment arrangement. In a CPP system, the party that places the call pays a usage-based price for the call. The recipient typically pays nothing.

**CPS** (Carrier Pre-Selection): A set of arrangements where the end-user selects a default telephone service provider (other than the network operator that connects the end-user to the Public Telephone Network) for all calls.

**CS** (Carrier Selection): A set of arrangements where the end-user explicitly selects a telephone service provider (other than the network operator that connects the end-user to the Public Telephone Network) on a call-by-call basis, typically by dialing a designated prefix.

## D

**DiffServ** (Differentiated Services): a IP-based data communications protocol which enables hop-by-hop traffic management, whereby selected packets can be marked as having application requirements other than best efforts.

**DNS** (Domain Name System): the system of databases which associates various sorts of information with domain names in order to translate hostnames to IP addresses for Internet access. It also stores other information such as the list of mail exchange servers that accept

**DWDM** (Dense Wave Division Multiplexing): See WDM.

## E

**EBC** (Element Based Charging): A wholesale pricing regime reflecting the network elements used.

**Elasticity**: The response of demand to price. An increase in prices generally leads to lower demand, other things being equal.

**ENUM**: A mature IETF standards-based mechanism, drawing on the technology of the DNS, which can be used to map a telephone number to a ranked list of (Internet) services.

**ETSI TISPAN** (ETSI Telecoms & Internet converged Services & Protocols for Advanced Networks)

## F

**FTTB**: Fiber-To-The-Building.

**FTTC:** Fiber-To-The-Cabinet or Fiber-To-The-Curb.

**FTTH**: Fiber-To-The-Home.

**FTTN**: Fiber-To-The-Node.

**FTTP**: Fiber-To-The-Premises.

**FTTx**: A generic acronym that could for example represent FTTB, FTTC, or FTTH.

## G

**Gbps** (Gigabit per second): one billion bits per second.

**GSM** (Global Système Mobile or Groupe Speciale Mobile): A set of standards for second generation (2G) mobile communications.

## H

**IETF** (Internet Engineering Task Force): the protocol engineering arm of the Internet. The IETF was formally established by the IAB in 1986.

**IMS** (IP Multimedia System or Integrated Multimedia System): a standards-based platform, based on IP and SIP protocols, that seeks to employ common, reusable modules for commonly used functions.

**Interconnection**: Interconnection enables an operator to establish and maintain communications between its customers and the customers of another operator.

**IP** (Internet Protocol): The Internet Protocol is a data communications standard that allows computers to communicate with one another over digital networks. Together with the TCP protocol, IP forms the basis of the Internet.

**IPTV** (television over IP): IPTV is the distribution of video programming (one way) by means of the Internet Protocol.

**IPv4** (Internet Protocol, version 4): IPv4 is the current protocol for transmitting Internet Protocol datagrams over the Internet, using a 32-bit address system.

**IPv6** (Internet Protocol, version 6): IPv6 is the emerging protocol for transmitting Internet Protocol datagrams over the Internet, using a 128-bit address system.

**ISP** (Internet Service Provider): An ISP is a firm that enables other organizations to connect to the global Internet.

**ITU** (the International Telecommunications Union): a United Nations agency for information and communication technologies whose mission is to facilitate global communications.

## J

**Jitter**: Variability of delay.

## K

**Kbps** (kilobit per second): One thousand bits per second.

## L

**Latency**: Delay.

**LLU** (Local Loop Unbundling): a regulatory requirement mandating certain telecommunications operators to wholesale to competitors the connections from their telephone exchange's central office to the customer's premises.

## M

**Mbps** (Megabit per second): one million bits per second.

**MDF** (Main Distribution Frame): A signal distribution frame for connecting equipment (inside plant) to cables and subscriber carrier equipment (outside plant). The MDF is a termination point within the local telephone exchange.

**Media Gateway Control Protocol** (MGCP, also known as H.248 and Megaco): A standard data communications protocol for handling VoIP Media Gateways, including signaling and session management.

**MoU** (minute of use): A minute of use, e.g. for voice telephony.

**MPLS** (Multi Protocol Label Switching): A data communications protocol developed by the Internet Engineering Task Force (IETF). It was originally designed to reduce the complexity and thus to improve the performance of routers in ISP backbones, and also to support traffic engineering.

## N

**NAP** (Network Access Point): A “public” peering point.

**NASS** (Network Attachment Subsystem): provides the Network Attachment Control Functions (NACF), including authentication and authorization of the user.

**Net Neutrality or Network Neutrality**: A proposed regulatory principle the seeks to limit anticompetitive discrimination by network operators and service providers.

**Network Externality or Network Effect:** Where network effects are present, the value of a network to its users is greater as the number of participants in the network increases.

**NGN** (Next Generation Network): The ITU defines a Next Generation Network as “… a packet-based network able to provide services including Telecommunication Services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It offers unrestricted access by users to different service providers. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.”

**NRIC** (the Network Reliability and Interoperability Council): The NRIC is an industry advisory council to the U.S. regulatory authority, the FCC.

## O

**optical-electrical-optical** (O-E-O) conversion: Conversion of an optical signal to an electrical signal and back again.

**OSI Reference Model**: A layered data communications protocol model.

**OSS** (Operations Support System): A system to support network operations or management.

## P

**Peer to peer (P2P)** – a system where the users typically have a symmetric relationship with one another.

**Peering**: the arrangement whereby ISPs exchange traffic for their respective customers (and for customers of their respective customers), but not for third parties. Peering is a substantially *symmetric* form of network interconnection.

**PLMN** (Public Land Mobile Network): circuit-switched mobile telephone network.

**PoI** (points of interconnection): A point at which networks meet for purpose of interconnection.

**Propagation delay**: The time that it takes for light or electricity to reach its destination in a network. This is a function of the distance that the signal must travel, and the speed of light in the medium employed (typically wire or fiber).

**PSTN** (Public Switched Telephone Network): circuit-switched fixed telephone network.

## Q

**QoS** (Quality of Service): In an IP-based environment, QoS often denotes measures of delay, variability of delay, and the probability of packet loss.

**Queuing**: The need for one packet of data to wait for another in order to gain access to a shared facility. These delays can be analyzed using a branch of mathematics known as *queuing theory*.

## R

**RACS** (Resource and Admission Control Subsystem): The RACS provides the Resource Attachment Control Functions (RACF), including resource management and admission control based on the user's profile and the resources currently available.

**RPP** (Receiving Party Pays): A retail billing arrangement in which the receiving party pays for the call, typically on a basis reflecting the call duration. The calling party typically also pays.

**RSVP** (Resource ReSerVation Protocol): a data communications protocol designed to reserve resources across the Internet so as to assure end-to-end QoS for applications that require such assurances. RSVP is the key component of the Integrated Services Architecture (ISA).

## S

**Street Cabinet**: a cable distribution system located close to customer premises.

**SIP** (Session Initiation Protocol): an application-layer data communications control protocol for creating, modifying, and terminating sessions with one or more participants. It can be used to create two-party, multiparty, or multicast sessions that include Internet telephone calls, multimedia distribution, and multimedia conferences. SIP is designed to be independent of the underlying transport layer; it can run on TCP, UDP, or SCTP. It is widely used as a signaling protocol for Voice over IP, along with H.323 and others.

**SLA** (Service Level Agreement): a contract between a customers and his or her service provider, or between service providers, which reflects the common understanding about the level of service to be provided.

## T

**TCP/IP Reference Model**: The layered data communications protocol model used by the Internet.

**Teledensity**: The level of deployment and adoption of communications networks in a given geographic area.

**Tier 1 ISP**: A large, well-connected Internet Service Providers that has no significant need for a transit provider. Tier 1 ISPs are richly connected to one another by peering.

**Transmission Control Protocol** (TCP): A data communications protocol used to assure reliable delivery of data in an IP network.

## U - V

**VoD** (Video on Demand): Video on Demand enables end-users to select and watch video content over a network.

**VoIP** (Voice over IP): A set of data communications protocols and technologies to enable voice to be sent over individual IP-based networks or over the Internet.

**VoIP Peering**: The agreement between VoIP providers to interconnect, either physically or virtually, to exchange voice traffic.

**VPN**: A virtual private network.

## W - Z

**Wi-Fi** (Wireless Fidelity): Wi-Fi is an IEEE standard adopted in 1999 for short-range wireless digital connectivity. It is by far the most widely adopted WLAN standard and includes the 802.11b, 802.11a, 802.11g standards.

**WAN**: A Wide Area Network.

**WDM** (Wave(length) Division Multiplexing): A technology that effectively increases the capacity of fiber optic systems by using different wavelengths (colors) of laser light to carry different signals.

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