GSR 2009 Discussion Paper

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Coexistence of traditional and IP interconnection

Authors: Natalija Gelvanovska, Head of Networks and Access division, Communications Regulatory Authority of the Republic of Lithuania and John Alden, Senior Telecom Expert and Editor

1 Introduction

One of the basic principles of telecommunications is that the value of a network is not based on the amount of investment dollars sunk into it, but rather on the number of people, homes and businesses it can reach. Interconnection, then, is the key to unlocking nearly unlimited value for consumers and citizens, because it provides a passport to potentially every other network on Earth.

The importance of interconnection cannot be overstated, particularly in the evolving era of Internet Protocol-based (IP-based) networks. After all, the "poster child" of all IP-based networks – the Internet itself – was teethed and weaned on open architectures, common protocols, and massive peering and transit relationships that have eventually spanned the globe. In a basic sense, then, interconnection is the founding ethos of IP-based networks: they exist to interconnect.

The trick, of course, is translating the global to the local – that is, allowing the theoretical ease of IP interconnection to flourish in an environment of privately owned, proprietary networks. Interconnection is, after all, not just a technical arrangement among different network elements. It is also a business arrangement and a regulatory challenge, particularly because of the way IP-based networks are developing out of legacy models.

1.1 New model of IP-based networks

Traditional telecommunication operators are now moving beyond the public switched telephone network (PSTN) into IP-based, full-service networks, which are generally known as *next-generation networks* (NGNs). Telecommunication operators can use these NGNs to deliver a package of voice, data and video offerings, all using the same core network hardware.

Following the PSTN model, many operators want to control the entire network value chain – in other words, they want to build end-to-end networks, including trunking and access elements. This means that many NGNs are deployed with control and service-layer functions that resemble the closed systems of PSTN operations. These types of networks can be referred to as the *closed network* model.

Meanwhile, many Internet service providers (ISPs) are also building broadband, IP-based networks that allow them to compete head-on with telephone operators by offering their own packages of voice (often VoIP), video and data. The ISP model, however, more closely complements and resembles the open Internet, with the "intelligence" and control of the network decentralized and powered by intelligent terminal equipment (i.e. computers, handsets or set-top boxes). This model, which can be termed the *open network model,* can be viewed as simply providing a more powerful, digital on-ramp to the existing (and growing) global Internet.[1]

So what the world is increasingly seeing is an evolutionary stage that features two models:

- The operator-managed, closed network model, which is successor of the legacy, public-switched telephone network (PSTN); and
- The ISP-derived, decentralized, open network model, which is an improvement on the best-effort IP-based network.

1.2 The Era of IP Network Coexistence

Can these different types of networks coexist? Can they interconnect? How will they evolve? The answers to these questions are crucial – precisely because of the value that can be unlocked through interconnection and the resulting ubiquity of information and content. No government wants to strand thousands of people on a legacy network that can carry only voice – but which loses thousands of high-value customers yearly to broadband IP networks. Similarly, regulators want to avoid a perpetual NGN monopoly operated by an incumbent that will not interconnect with, or provide access to, ISPs.

As this chapter will explore, technology gives us the answers to some of those key questions. Different network models can coexist – and most importantly, they can interconnect. As a technical matter, IP-based networks will hold true to their birthright: they still exist to interconnect. But as a business matter – and therefore, as a regulatory matter – the era of IP network evolution and coexistence brings with it some new regulatory challenges. This chapter explains the technical elements that allow interconnection, but it also highlights those regulatory issues – some of which are ongoing and inherent to any kind of interconnection, and some of which are particular to the IP-based transition.

2 How Networks Interconnect

From a regulatory standpoint, the term *interconnection* is probably defined in every country in the world, and there are no significant differences among existing definitions. For higher accuracy, though, it is important to distinguish between interconnection *among* networks and access *to* a network. From the regulatory point of view, interconnection and access serve different purposes and therefore require different regulatory approaches. The purpose of interconnection is to ensure end-to-end service connectivity and to enable end user customers of interconnected operators to establish communications with each other. Access, on the other hand, enables an operator to utilize the facilities of another operator in order to further its own business plans and provide its service to customers[2,3]. This chapter will focus on trends in interconnection regulatory approaches, as opposed to those addressing pure access issues.

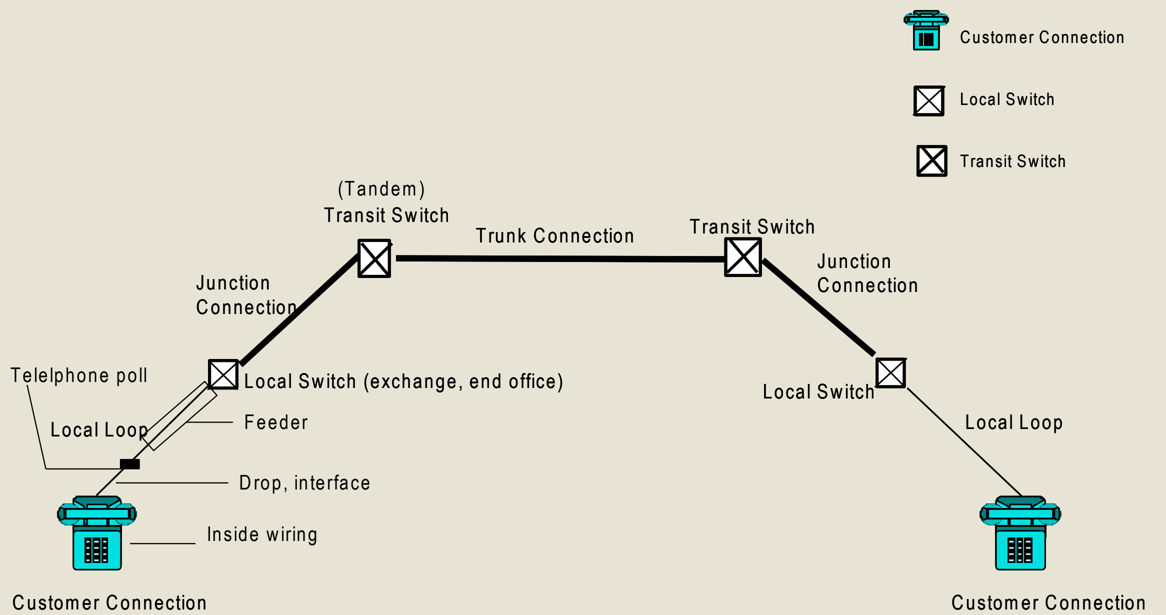
2.1 Technical Aspects of Interconnection

In order to understand the current regulatory issues, it may be best to briefly review some of the technical aspects of interconnection. These vary somewhat, depending on the type of network (i.e., PSTN or NGN).

2.1.1 PSTN interconnection

Interconnection in the PSTN network typically requires the deployment of new, dedicated facilities to connect the two networks. Depending upon the nature and location of the interconnection, these can range from minor network additions to significant investments in new network segments.[4] The interconnection of two fully developed, facilities-based, switched voice networks may involve merely establishing high-capacity, two-way circuits between tandem switching centres, with all of the related termination and processing costs that may entail. But interconnection can occur at a variety of levels across networks, with different facility and management requirements at each level (for example, tandem, end-office, trunk-side or line-side connections (See Figure 1).[5]

Figure 1: Generic PSTN Network Structure



Source: Trends in Telecommunication Reform 2000/2001. Taken from Maev Sullivan's presentation "The Basics of Interconnection" made at the ITU Workshop on Telecommunication Reform (3-5 May 1999).

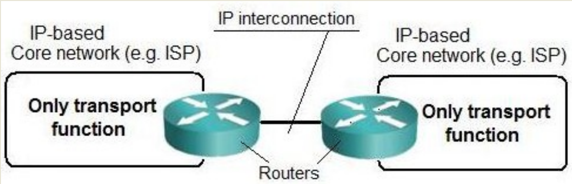
Interconnection between PSTN networks is relatively simple and well established, and normally it does not raise interoperability issues.[6] This is because all legacy telephone networks use the same signalling system (Signalling System Number 7, or SS7), numbering scheme (E.164), media transport (Time Division Multiplexing or TDM) and interfaces (E1/T1 or their multiples).

2.1.2 Interconnection between Best-Effort IP Networks

When describing interconnection between IP networks – or, in other words, describing the existing model of IP interconnection – we naturally point to interconnection arrangements that are taking place in the Internet environment, where IP networks were first introduced and interconnected.

To visualize the interaction between various protocols in packet-switched networks (including IP networks), it is common to refer to a layered model. This allows one to envision the operation of the protocols occurring within each layer, as well as the functions that occur at each layer. The TCP/IP suite of protocols is the most widely implemented among IP networks (See Fig. 2). ISP networks are classical examples of IP networks that are based on the TCP/IP model.[7]

Figure 2: Interconnection between Packet-Switched Networks



At the Network Access Layer, the TCP/IP model does not specify which protocols to use when transmitting over a physical medium; it only describes the handoff from the Internet Layer to the physical network protocols. The OSI Layers 1 and 2 discuss the necessary procedures to access the media and the physical means to send data over a network.

Routers are the elements of the IP network that are physically interconnected. Therefore, Internet protocol, which operates at this layer, also gives its name to interconnection between those network elements – IP interconnection.

Source: Natalija Gelvanovska

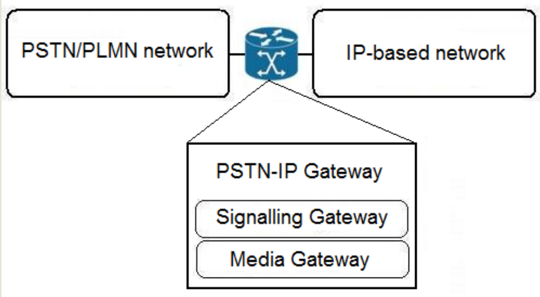
Routers perform just a transport function, so interconnection between those network elements ensures connectivity between two networks, without any reference to the services that may be provided over the point of interconnection. Provision of IP interconnection, therefore, may be considered both "connectivity-oriented" and "service-antagonistic". When negotiating IP interconnection, ISPs consider only transport-specific performance objectives (for example, delay or packet/loss ratio). Service provision and connectivity are fully separated within the TCP/IP model – a separation that is easy to see in practical terms on the Internet. Because different services may be provided over IP-based networks, those networks are not considered service-specific and are usually referred to as *open networks*.

In contrast to open, IP-based networks, PSTN networks have service and transport layers that are closely linked. Here, interconnection is implemented with the idea of providing a particular service, such as voice telephony. PSTN networks, therefore, can be termed "service-specific" because they are designed to provide particular services. Compared with the Internet, independent introduction of third-party services to PSTN end users is difficult, if not impossible; hence, legacy telco networks are usually called *closed networks*.

2.1.3 Interconnection between IP-based and PSTN networks

With the emergence of Voice over IP (VoIP) service, IP-based network providers are now able to compete with telco operators in offering voice services. Because both telco and IP-based networks use different technologies, however, they cannot be interconnected directly. As of today, those networks are interconnected through two intermediate elements that ensure voice and signalling translation: media gateways (MGWs) and signalling gateways (SGWs). Both MGWs and SGWs are usually incorporated into one piece of equipment, often known as simply a gateway. Gateways are owned by one of the interconnected operators -- usually the operator of the IP-based network. The use of gateways has essentially resolved interoperability challenges, making interconnection between telcos and IP-based networks widespread.

Figure 3: Interworking between PSTN and IP-based networks



Legacy telco and IP-based networks cannot communicate directly, as they use different signalling and media transport technologies. Translation between different networks is ensured through:.

A *Media Gateway* that provides translation of audio as a call passes across the boundary between two systems using different encodings. For example, a media gateway on the boundary between the PSTN and an IP network moves digitized audio between the Time Division Multiplexing (TDM) encoding used on a conventional voice circuit and the encoding used on an IP network.

A *Signalling Gateway* which provides translation of signalling operations, e.g., between SS7 and SIP.

Source: adopted from Douglas Comer, Computer Networks and Internets with Internet Applications (fourth edition), Prentice Hall, Upper Saddle River, NJ, 2004.

The most important thing to keep in mind from this and previous sections is that both legacy telco and IP-based networks can be seamlessly and relatively easily interconnected on a technical level. However, in contrast to closed telco networks, IP-based, open networks are designed to accommodate multiple services and applications.

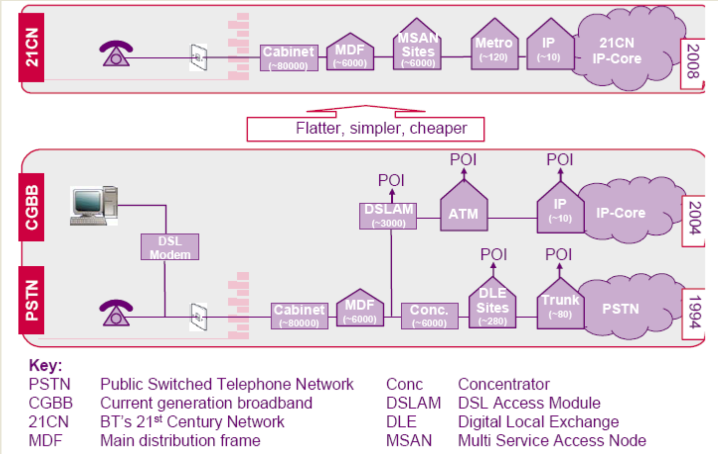
2.2 Migration from the PSTN to IP-Based Networks

Legacy telco networks are converging to the NGN network model. NGNs integrate PSTN and IP-based network services on a uniform platform.[8] Migration requires significant investments, but experts[9] emphasize that it is critical that networks evolve and do not become stagnant, as it is the network that gives operators their competitive advantage. Operators understand that freezing development today would undermine their own futures. They also understand that customers expect increasingly more for less money, and if they stop the clock on NGN migration, they will find themselves uncompetitive in a highly competitive market.

2.2.1 Evolving from Circuit-Switched Telephony to NGNs

Considering that it is not cost-effective to manage different networks for different services, telephone network operators have begun evolving toward the NGN. The main argument behind migration is the possibility of reducing network operation costs. Both fixed and mobile core networks are integrating within a single NGN core network.[10] Therefore, as in the case of plain telco networks, there may be no difference among interconnection principles between mobile and fixed core networks in an NGN. (See Fig. 4).[11]

Figure 4: Comparing Existing Voice and Broadband Networks with BT's "21CN" NGN

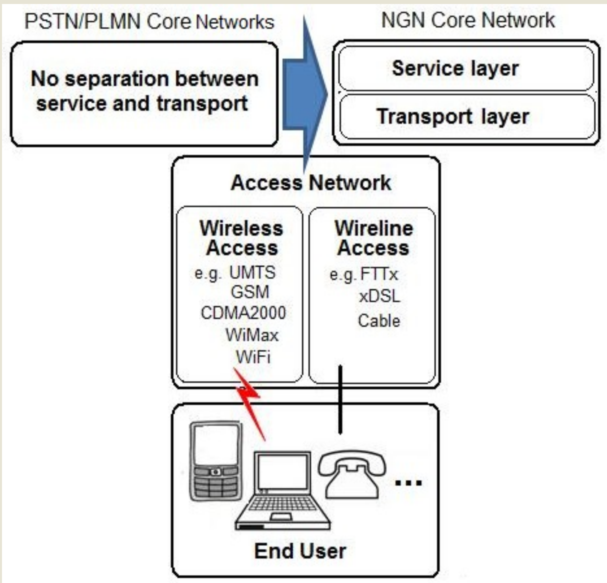


Source: OFCOM ; United Kingdom.

The network of an operator that provides end-to-end services consists of both access and core segments. By contrast, an operator that does not provide service directly to the end user (for example, an Internet transport provider) will have only a core network. Technically, networks are interconnected via network elements in the core part. For instance, in the PSTN, interconnected elements of the core network are transit and local switches.

The NGN model introduces a principal change in the core of the network: separation between transport and service layers (See Figure 5). The idea of separating transport and service functions comes from the world of IP-based networks and is designed to ensure the provision of multiple services over a single infrastructure.

Figure 5: Separation of Layers in NGN Core Networks



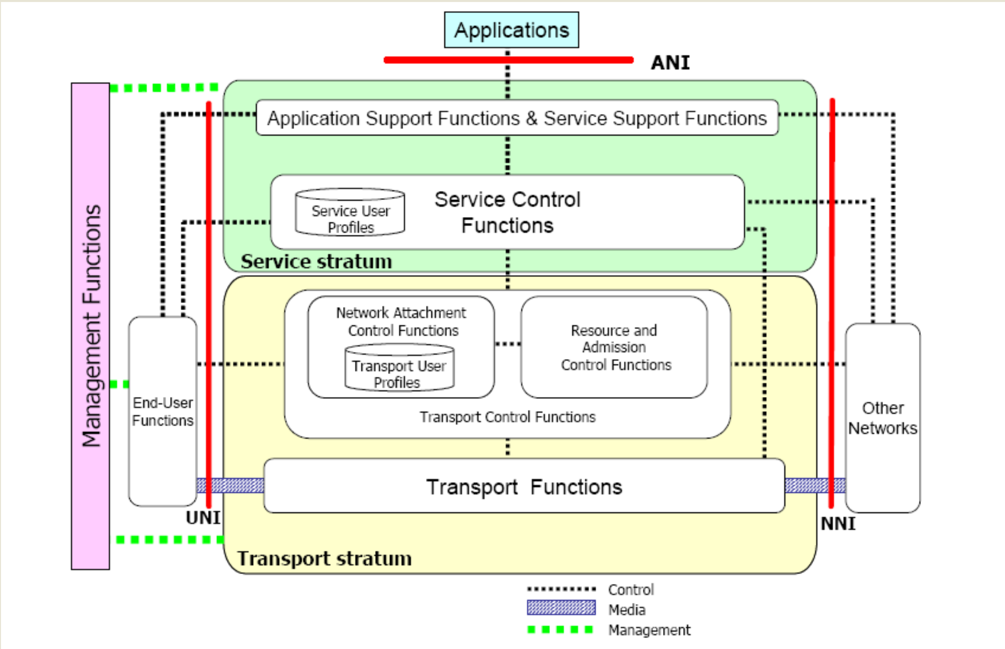
Source: Natalija Gelvanovska

In technical terms, an NGN may be considered as a substitute for the existing telco networks. The migration from PSTN to NGN, however, requires significant changes, both at the core and access segments of the network. Modifications of the core part of the network (see Box 1) are important from a regulatory standpoint, because they have a direct impact on the implementation of interconnection.

Box 1: The ITU-T NGN R1 Functional Architecture

The ITU-T's functional architectural framework for NGNs is defined in ITU recommendation Y.2011, as shown in the figure below.

There is a separation between control and transport layers (or *stratum* in ITU-T terminology), as well as between *Network Attachment Control Functions* (NACFs) and *Resource and Admission Control Functions* (RACFs) that lie at the interface between the *Service Control Functions* (SCFs) and the *Transport Functions*.



UNI – User Network Interface, ANI – Application Network Interface, NNI – Network Network Interface.

For interconnection with other networks, the NNI interface should be used. However interconnection between NGNs and other networks is far from being mature. For instance, recommendations for signalling for the NNI and UNI were issued in March 2007 and February 2008, respectively. Hence, the specifications for basic communications of session-oriented services have been developed only recently.

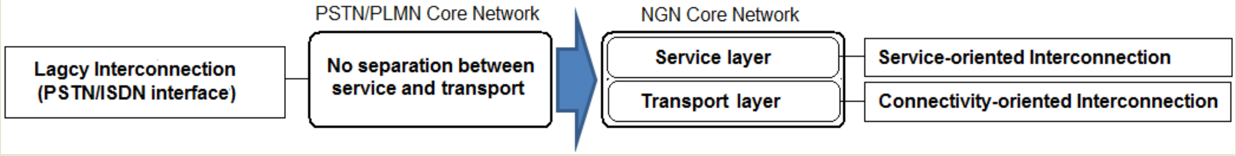
Source: ITU-T recommendation Y.2011, Takumi Ohb, Koji Tanida, Standardization Trends in ITU-T NGN UNI and NNI Signalling, NTT Technical Review, Vol. 7 No. 2 Feb. 2009, https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr200902gls.pdf&mode=show_pdf

Splitting the core network's functions results in a split of interconnection into *service-oriented interconnection* and *connectivity-oriented interconnection* (See Box 2). So migration to the NGN model will have numerous implications for traditional PSTN interconnection, such as:

- Different services may require different service-oriented interconnections while, once obtained, connectivity may remain the same for numerous services;
- Service-oriented interconnection and connectivity-oriented interconnection may take place at different physical locations;
- Service control functions will be centralized in the NGN, so there will be fewer service-oriented interconnection points compared with connectivity-oriented interconnection points.

Overall, the number of *points of interconnection* (PoIs) in an NGN will be reduced compared with the number of PoIs in a PSTN network.

Box 2: Differences in Implementation of Interconnection, PSTN vs. NGN



Legacy telco networks are interconnected through standard E1/T1 interfaces. Signalling and connectivity are combined within one interconnection link, which connects two elements of respective core networks.

Changes in implementation of interconnection are related to changes in the core network. A feature of NGN core network architecture is the separation of the main functional layers: transport and service. Consequently, interconnection in an NGN is going to be split into two separate interconnection services: service-oriented and connectivity-oriented. Below are presented definitions of both interconnection services as they are defined by ETSI TS 181 005: “Service and Capability Requirements.”

Service-oriented Interconnection (SoIx)	The physical and logical linking of NGN domains that allows carriers and service providers to offer services over NGN <...> with control, signalling (i.e. session-based), which provides defined levels of interoperability. This does apply for carrier-grade voice and/or multimedia services over IP interconnection. The level of interoperability depends e.g., on services, Quality of Service, security.
Connectivity-oriented Interconnection (CoIx)	The physical and logical linking of carriers and service providers based on simple IP connectivity, irrespective of the levels of interoperability. For example, an IP interconnection of this type is not aware of the specific end-to-end service and, as a consequence, service-specific network performance, QoS and security requirements are not necessarily assured. This definition does not exclude that some services may provide a defined level of interoperability. However, only SoIx fully satisfies NGN interoperability requirements.

Source: Natalija Gelvanovska; ETSI TISPAN, NGN Interconnection, ETSI Workshop on NGN Interconnection, June, 2008 at: http://portal.etsi.org/docbox/Workshop/2008/200806_NGN_INTERCONNECTION/

3 Interconnection in the Internet

With a greater understanding of network layers, as well as the core and access segments of IP-based networks, we can examine more closely how IP networks are interconnected in the current business and regulatory environments. Moreover, we can also analyze how interconnection bridges the gaps between different models of IP-based networks (that is, open vs. closed networks).

When describing interconnection between IP networks, we naturally point to the interconnection arrangements currently in place in the Internet environment. This is where IP networks were first introduced and interconnected, and where service and network provision have historically been independent of each other. Understanding the nature of interconnection between ISPs in today’s market may help to understand how interconnection arrangements will look in the future. Understanding the weaknesses and constraints of existing interconnection models also may help to prevent future interconnection arrangements from replicating those shortcomings.

The key principle is that technical interoperability of IP-based networks does not represent a serious obstacle in the Internet. This is mainly due to a unified IP protocol, which is globally implemented among Internet participants. So interconnection as a technical task does not present significant difficulties for ISPs. The technical aspects of IP-based interoperability, then, allow freedom to negotiate the business arrangements that comprise interconnection. This freedom has been amplified, in most cases, by loose or completely absent rules governing termination and payment arrangements. The strong *ex ante* regulations that almost universally characterize PSTN interconnection have not been applied to IP interconnection, particularly in the international setting. Indeed, developing countries often stress that the established model of commercial relationships between ISPs has had a negative impact on the development of their telecommunication markets. Therefore, it is crucially important for regulators to understand the underlying logic of the Internet interconnection environment.

3.1 Commercial Arrangements among ISPs

Today, ISPs are normally grouped into three tiers of carriers. In this hierarchy, relationships between ISPs depend on their interconnection arrangements, which often have formed naturally in the unregulated Internet environment. In this model, ISPs of the first (upper) tier are interconnected with each other via shared-cost peering only. The second-tier ISPs are interconnected both via peering and transit arrangements, and the third-tier ISPs solely purchase (upstream) transit services from the upper-tier ISPs. The logic behind this model is that ISPs on the same tier enjoy (or potentially enjoy) approximately equal value from interconnection with each other. ISPs lying on different tiers, however, would not benefit equally from interconnection, because of differences in the size and scope of their networks. So interconnection between different tiers usually involves transit payments, paid by the smaller network operator to the larger one. Table 1 provides a brief comparison of peering and transit arrangements.

Table 1: Peering and Transit Arrangements

Characteristic	Peering	Transit
Type of relationships	Barter	Consumer & provider
Type of traffic	Obligation to carry traffic for each other and for each other's respective customers	Obligation to carry all types of traffic
Provides access to	Interconnected ISPs customers	Entire Internet
Payment arrangements	No exchange of money between parties; Every party covers part of interconnection cost;	A party that purchases transit covers all costs of both transit and interconnection
Willingness to engage	In case both parties perceive an approximately equal exchange of value	In all cases when peering is not possible.

Source: Natalija Gelvanovska

3.1.1 Transit

Transit arrangements represent a consumer-provider relationship between interconnected parties, in contrast to equal barter in the case of peering. Basically, a consumer ISP pays for traffic to be routed through the network of a provider ISP. There is no cost distribution among interconnecting parties; the consumer ISP covers all the interconnection costs. Transit is analogous to the connectivity provided by an ISP to an end user, i.e. providing the ability to communicate with the rest of the Internet.

3.1.2 Peering

Compared with transit payments, peering is a bit more complicated. First of all, two main types of peering arrangements stand out:

- *Shared-cost* or *settlement-free peering* arrangements (also known as "sender keeps all" or "bill and keep" arrangements), in which two directly interconnected ISPs agree to exchange traffic at no charge; and
- *Paid peering* arrangements, which include all other peering deals that involve payments from one ISP to another.[12]

Each ISP will use its own specific criteria to form its peering policy, in order to set the value of each potential peering arrangement and to decide which ISPs to peer with (normally on shared-cost basis). Some examples of peering policies as well as applied peering criteria may be found in Table 2 below. It should be noted that there are no legal obligations to disclose (or even to have) such policies.

Figure 2: Some Peering Policies

ISP	Peering policy	Peering criteria*
AT&T	http://www.corp.att.com/peering/	Location and number of PoIs; Interconnection bandwidth; Type of traffic (on-net); Amount of traffic (in Gbps).
TeliaSonera International Carrier	http://www.teliasoneraic.com/tsicWeb/tsic/faqlist/begin.do	Amount of traffic (in Gbps); Location and number of PoIs; requirement to operate a particular number of IP backbone nodes; the prospective peer shall not be a customer of TeliaSonera's existing peers**.
France Telecom	http://vision.opentransit.net/docs/peering_policy/	Amount of traffic (in Gbps); Location and number of PoIs; France Telecom will not enter into peering relationship with customers of existing peering partners.
Interoute	http://www.interoute.com/files/peering_policy_000.pdf	Number of PoIs; having a network operations center (NOC) operating on a 24/7/365 basis; Significance of traffic volumes; the prospective peer is not an IP customer of Interoute and has not been an IP customer within the previous six months.

All of the presented criteria apply for international settlement-free peering. For an exact and full list of applied peering criteria refer to appropriate operator peering policies.

Source: Natalija Gelvanovska

Physical interconnection for peering is usually organized in two ways:

- *Public peering* (multi-party interconnection): public peering is interconnection between more than two ISPs at a specialized facility that is specifically designed to enable large-scale peering. Such facilities are known by various names, including "telco-hotels," "network access points" or "Internet exchange points" (IXPs). The facility's operator provides physical security, climate control, a "house" network, and electric power that is backed-up to ensure that there is no disruption in service. Space is then leased to ISPs, which in turn install routers and other networking gear in order to obtain physical interconnection. Many of the IXPs today can have hundreds of interconnected ISPs, and some span multiple buildings and collocation facilities across a city.[13]

- *Private peering:* Private peering represents a direct interconnection between two ISPs via dedicated circuits that are not shared by any other parties. Because private peering requires dedicated resources for interconnection with a single ISP, the value gained from interconnection with any one ISP has to be sufficient to justify the costs of interconnecting with it. Most of the traffic on the

Internet, especially traffic between the largest networks, occurs via private peering. But large, "backbone" ISPs are often unwilling to provide private peering to smaller ISPs.

Public peering provides an opportunity for ISPs to decrease interconnection costs by interconnecting with many other ISPs through a single port. In the beginning of their presence in the market, especially small ISPs may find that IXPs provide an excellent way for interconnection, while bigger ISPs may utilize IXPs as a way to aggregate a large number of small interconnection partners. However, larger ISPs are not usually willing to participate in IXPs. Regulators may want to consider promoting or supporting IXPs as "incubators" for ISP market competition and growth in Internet bandwidth.

3.2 Confronting Traffic Imbalances

The openness of the Internet is an attractive and fertile environment for the development of new services. It is also a competitive environment, and it fascinates the regulatory community, which often faces a lack of openness on the part of incumbent telephone network operators. Interconnection relationships within the Internet are historically unregulated, and the absence of regulation is often given as a reason for the success of the Internet.

From the perspective of smaller countries on the remote ends of narrow backbone pipes, however, the relative "success" of the Internet is an assertion that they might question. With the growing importance of the Internet, it is inevitable that various parties will question whether the contracts and mechanisms that have sustained interconnection in the Internet to date will be sufficient to sustain stable interconnection in the future, and whether the "hands off" regulatory approach remains the right one.[14]

The fact that interconnection decisions are based exclusively on bilateral business logic has important implications for the developing world, where local ISPs might only have a handful of customers, and may have a significant part of the local content hosted outside the country. Because network coverage and volume of traffic are considered basic peering criteria, many ISPs in developing countries cannot meet the established peering criteria of international carriers and obtain international Internet connectivity under peering arrangements. So, in the global Internet hierarchy a developing country usually finds itself on Tier 3.

Viewed from a solely commercial point of view, both Tier 1 and Tier 2 market players may see no business incentive to conclude peering agreements with an ISP of a developing country. In fact, Internet backbone providers argue that peering relationships in that case would not make sense, pointing out that it would not be an equal exchange of value. For example, a backbone network would provide connectivity to multiple continents, while a small ISP might only extend to a single town or city.[15]

To address economic imbalances in peering/transit arrangements, regulators may want to focus on both international and national measures[16]. At the international level, many network operators indicate that imbalances in peering are structural and largely unavoidable. For example, they point to the low level of demand in the Least Developed Countries and Small Island Developing States. Low demand tends to push up unit costs, and some of these countries and regions are not well served by undersea cables, making them rely on high-priced satellite access.

There is also a nagging suspicion, however, that the international bandwidth market is not as competitive as might be expected, especially since the consolidation of recent years, and in addition, that regulators may lack the appropriate means and information to perform *ex post* competition analyses.[17] Lack of real data and available cost models also hinder any academic contribution to the efficiency of this process.[18] Experts argue, however, that without any kind of cost distribution among ISPs, the Internet market cannot be considered as a long-term, sustainable or open competitive market that is capable of supporting a wide diversity of players both large and small.[19] Many developing-country ISPs consider, therefore, that International Internet Connectivity (IIC) problems, as they are termed, can only be resolved if ISPs in other countries agree to share the costs of the international link capacity according to the level of traffic exchanged between the ISPs concerned. This would mirror the principle applied in traditional interconnection in the PSTN world, where operators usually agree to share the costs of the interconnection link capacity (through international settlements payments) according to the level and balance of traffic exchanged.

While international issues are still debated, a lot may yet be done on a national (or regional) level in order to avoid over-paying for international bandwidth. Activities that may be undertaken on the national level for this purpose may include:[20]

- **The liberalization of access to international gateway (IGW) facilities** -- High access prices for IIC are also related to the liberalization of access to IGW facilities within developing countries. The lack of access to international capacity raises prices for Internet access services within a country. High prices suppress demand and incentives to invest in additional capacity.
- **The need to foster creation of IXPs** -- If developing countries had a greater ability to exchange traffic at a national or regional level, they would not be paying for expensive international bandwidth for their connections. Similarly, if these countries had more outgoing traffic and more regional carriers, these carriers would be able to peer with their international counterparts and lower the costs of international bandwidth.
- **Development of national capacity for ICT** -- Development of national capacity for ICT is an important factor that may significantly affect development of local content and applications. So there is a pressing need to develop human capital -- particularly inter-networking skills.[21]
- **Increase transparency of conditions (policies), on which ISPs/IXPs are willing to interconnect** -- It is commonly understood that the traditional telephony interconnection model reduced bargaining costs. Some analysts believe that if it were possible to identify a “best practice” or “common practice” in Internet interconnection, it might similarly help to reduce bargaining costs. Experts argue that industry could overcome problems related to lack of transparency in a more flexible way than might be achieved via regulatory constraints.

4 Emerging Models of Interconnection within an All-IP Environment

In addressing interconnection issues within an all-IP environment, some may question whether such discussions are premature. Certainly, all-IP environments are still far away from becoming reality, particularly in the developing countries. While migration towards IP-based networks in developed countries is relatively well highlighted, it may be useful to take a brief look also at the evolution of IP-based networks in developing countries.

As IP-based networks evolve, different models of interconnection between them are being shaped both at national and international levels. This section will show that activities on the international level are developing in a generally more organized fashion. By contrast, only a few regulators are actively defining the future interconnection landscapes in their countries. A closer look at international interconnection models being created may help regulators to understand how operators see interconnection within all-IP environments. After exploring those issues, this section then draws some conclusions about the likely future trend of interconnection in evolving IP-based networks.

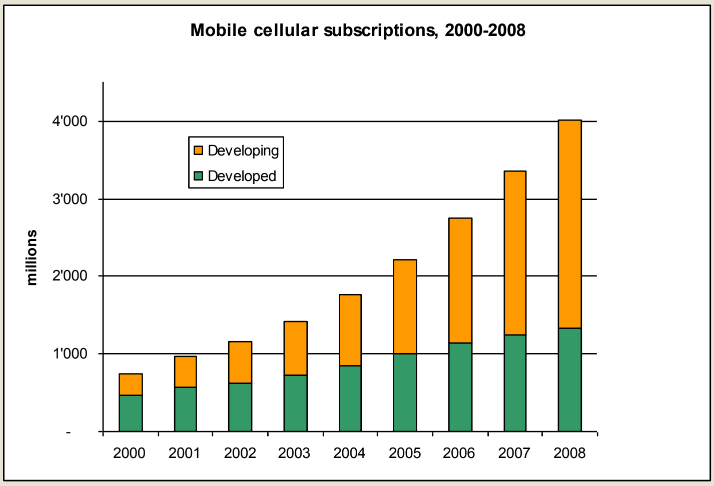
4.1 Is Now the Right Time for Discussion?

Indeed, in 2007, when regulators of European countries were asked whether interconnection with IP-based networks was a relevant regulatory concern, the majority replied that it did not affect their respective markets, and in fact, only a few countries considered IP interconnection to be a relevant problem.[22] The same survey showed that contrary to regulators, market players considered IP interconnection a relevant issue. Differences in stakeholder assessments of the situation may not only indicate a lack of interaction between regulators and market players, it may also indicate that regulators are not always aware of relevant market issues. ITU-D Study Group 1 agreed to look at the issues arising from the interconnection of NGNs[23].

Migration toward all-IP networks is a common concern for operators worldwide and especially for operators in developing countries. Beginning in 2007, IP-based network expansion in developing countries has been notably visible, as reflected in international media and press releases. A significant number of developing countries are in the initial phase of NGN migration, upgrading existing networks and and deploying new access networks and IP-MPLS backbone infrastructures. Some developing countries (for example, Albania, Moldova and Serbia) are today in the final phase of migration toward NGN, in which they are replacing legacy TDM switches. Annex 1 looks at NGN deployment status and/or major initiatives announced in 2008-2009 in developing countries.

There are a few reasons why deployment of IP-based networks is gaining momentum in developing countries. First of all, developing countries do not experience recession as severely as do developed countries.[24] Also, their telecommunication markets are usually still growing. [25] For example, the number of mobile subscriptions in developing countries is increasing drastically in contrast to the saturation that can be observed in developed countries (See Figure 6). For instance, in Vietnam the number of mobile subscribers in the second quarter of 2009 grew 86 per cent, compared with the same period of 2008[26]. In Indonesia, that number grew 46 per cent, and in India, 52 per cent.[27] As the number of subscribers continues to grow, networks are getting upgrades. So it is not surprising that in developing countries mobile operators are executing much more aggressive expansions than fixed operators in recession-stymied developed regions.\

Figure 6: Growth of Mobile Phone Subscriptions (in Billions)



Source: "ITU World Telecommunication/ICT Indicators database.

More evidence of the take up of IP-based networks is provided by the emergence of leading Developing countries telecommunication equipment makers. Huawei, ZTE and others have entered the global stage over the past five years. Together, the Chinese equipment makers have driven down the costs of network equipment, while offering significant discounts. These developments indicate that while the global vendor community is struggling, some developing countries equipment-makers are still growing.[28, 29] As the adoption of IP-based networks in developing countries gains momentum, the question of whether migration to IP-based interconnection is only relevant to developed countries can be answered with a resounding "no."

4.2 International and National IP Interconnection Approaches

There are two aspects to the development of IP interconnection approaches: national and international. At the national level, regulators are definitely taking the leading role today. However, different countries are taking different approaches at different times, with no harmonization among their varying actions. Some countries are forbearing from engaging in any activities in this area right now. In contrast to the national level, meanwhile, activities at the international level are much better organized and are led by a number of industry groups.

4.2.1 The International level

Several industry groups are attempting to define the landscape for future IP-based interconnection at the international level, among them are the GSM Association (GSMA), the IP Internetworking Alliance (IPIA), the i3 Forum, and the Fixed-Mobile Convergence Alliance (FMCA). Table 3 gives an overview of these groups, which are managing projects for international IP interconnection.

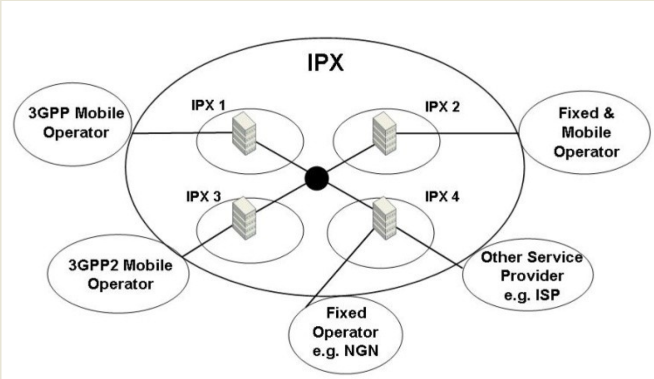
Table 3: Main industry groups working on international IP-interconnection approaches

Organization	Activities
The GSM Association (GSMA) was formally created as the "GSM MoU Association" in 1995. It represents the interests of the worldwide mobile communications industry. Spanning 219 countries, the GSMA unites nearly 800 of the world's mobile operators, as well as more than 200 companies in the broader mobile ecosystem, including handset makers, software companies, equipment providers, Internet companies, and media and entertainment organizations.	Created GPRS Roaming Exchange (GRX), as well as a new "IP eXchange" (IPX).
The IP Interworking Alliance (IPIA), established under GSMA, has been formed with the mission of supporting the development of global interoperability of IP Services.	Supports GSMA's IPX. Certifies IPX providers.
The i3 Forum was founded in Q3 2007 by eight major international operators, and it now includes 28 such carriers. It makes use of existing standards (from e.g., ITU-T, ETSI TISPAN, IETF, 3GPP) for specifying how to achieve IP-based international interconnections.	Developing collaborative recommendations for an industry-wide transition of voice and related services to Internet Protocol (IP)
The Fixed Mobile Convergence Alliance (FMCA) was formed in 2004 and incorporated as a not-for-profit trade association. It promotes the acceleration and adoption of convergence technologies by encouraging consistency across product and equipment standards. FMCA includes both operators and a significant number of equipment makers. It works in the areas of interoperability and interconnection between members to enable global roaming and access to convergent services.	In general encourages and supports interoperability and interconnection between members. Undertakes and supports trials to test and validate prioritized convergent solutions.

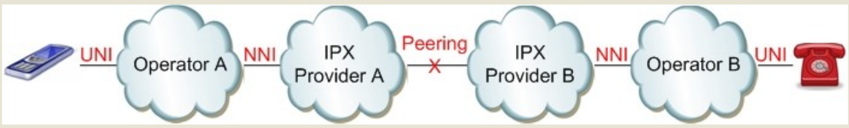
Source: GSMA, IPIA, i3 Forum, FMCA

Probably the best-known project for international IP interconnection up to now is the "IP eXchange" (IPX) operated by the GSMA. The IPX is promoted as a private global IP backbone, open to any telecommunications company adhering to the required standards. It is intended to provide fixed and mobile service providers a technical and commercial platform for the performance-based exchange of IP-based services. The IPX is a successor to the international GPRS roaming exchange (GRX), also run by GSMA. Since the year 2000, GSM operators have been using the GRX network to route IP-based commercial roaming traffic between visited and home operators. The GRX has mainly involved 2.5G and 3G data roaming. It is a private IP network (separate from the Internet) consisting of multiple GRX carriers connected to each other via peering points. The GRX, however, is limited only to the GSM operator community. By contrast, the GSMA IPX is intended to exchange all types of IP traffic, and to interconnect with all types of networks and application providers (See Fig. 7).

Figure 7: The GSMA IPX



Contrary to its predecessor, the GRX, GSMA's IPX will interconnect all types of networks and providers, supporting both bilateral and multilateral interconnection. As with the GRX, though, the IXP will remain fully separate from the public Internet. The IPX represents a performance-oriented, IP-based interconnection model.



X is a peering point where IPX Provider A and IPX Provider B exchange traffic. Contrary to the widespread practice among Tier 1 ISPs, peering within the IPX is an example of paid peering. The IPX transports services according to a common charging principle. A cascade payment method between interconnected operators is foreseen for use within IPX. The cascading responsibility in an IPX means each party is responsible for the performance of the next party in the transit chain. Because all participants make this commitment, the financial benefits of providing the service are cascaded through the value chain, enabling all ISPs involved to receive a commercial return for their participation.

Interconnect Relationship	IPX Interworking Service	End to End QoS	Cascade Billing	Single Contract/ Connection
Internet		✗	✗	✗
Bilateral	Transport Only	✓	Termination billing takes place directly between Service Providers	Single contract with IPX provider but multiple contracts with connecting Service Providers
Bilateral	Service Transit	✓	✓	Single contract with IPX provider but multiple contracts with connecting Service Providers
Multilateral	Service Hub	✓	✓	✓

Source: based on GSMA

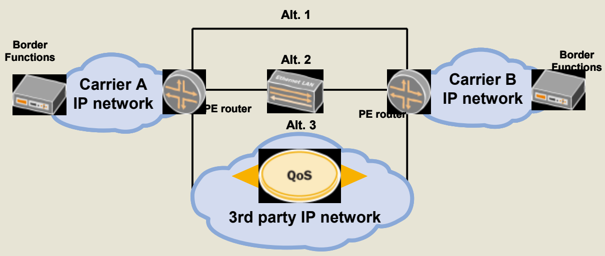
Interconnection to the IPX will be delivered through certified IPX providers. IPX service providers can choose the service they want and the service providers they want to interconnect with.

The IPX model offers both bilateral and multilateral interconnection. Bilateral denotes the traditional model of two operators collectively writing an interconnection contract prior to setting up a connection between each other. Multilateral, on the other hand, means that the IPX provider takes care of handling both the contract and connectivity set-up on behalf of the operators. Setting up bilateral interconnection contracts and connections with numerous operators can be a major burden. Therefore, the multilateral option, which allows an operator to open multiple connections by making a single contract and single technical connection with the IPX provider, makes interconnection deployment easier and faster.

In contrast to GSMA, which advocates the multilateral approach, i3 Forum is focusing mainly on bilateral interconnection. Currently, i3 Forum's objective is to ensure international VoIP connectivity; however, that model should include interconnection of other IP-based services in the future. In June 2008, the Forum delivered its first set of recommendations on implementing international interconnectivity.[30] In those recommendations, i3 Forum supported applying the existing Calling Party Pays (CPP) mechanism for international interconnection settlements.[31] It also foresaw two interconnection models: Private and Public (See Fig. 8).

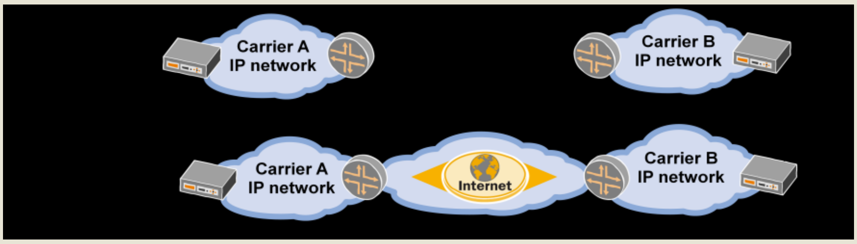
Figure 8: i3 Forum's International IP Interconnection Models: Private and Public

Private-oriented interconnection:



"Alt. 1," "alt. 2" and "alt. 3" are different alternatives for transport. This interconnection can replace existing TDM-based interconnection and, as a result, can guarantee the highest level of quality, in terms of voice call quality, service quality, network availability and network security.

Public-oriented interconnection:



Different transport alternatives are: Layer 1 / Layer 2 direct interconnection sharing data and VoIP traffic (Alt. 1), and interconnection via the public Internet, or non-direct interconnection (Alt. 2).

Source: i3 Forum

The public-oriented interconnection model is implemented using the public Internet as a transport medium, allowing lower costs, but providing less-reliable interconnection. The absence of multilateral interconnection, however, may be a weakness of i3 Forum's model, because it may be more complex to obtain global connectivity than it would be using the IPX solution.

Among the drawbacks of the IPX solution, on the other hand, may be the relative difficulty in introducing new services, which may be complicated by the need for standardization and agreement among all IPX participants. Another aspect is interconnection pricing at an IPX, which may not be regulated or even made public. Thus, it may be difficult to judge whether those prices would be fair or sustainable for smaller operators and/or service providers. Would these models lead to a replication of the current IIC scenario in the Internet – this time in IPX interconnection? With regard to mobile take up, these issues should be of particular interest for developing countries.

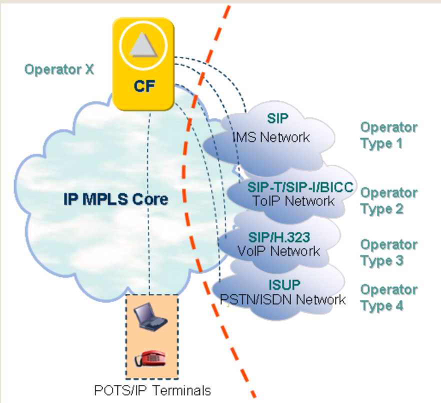
4.2.2 The National Level

While the IP-interconnection approach on the international level is increasingly clear, the creation of national IP interconnection frameworks looks totally different. For many regulators in both developed and developing countries, IP interconnection is associated with numerous regulatory concerns, with no clear blueprint for how to address them. Therefore, it is also not clear how a future approach for interconnection between IP-based networks should work. The innovative thinker Michael J. Gelb once said that "the best way to forecast the future is to create it." It looks like some countries are definitely following that motto and are actively defining their future interconnection landscapes.

Summarizing national experiences from countries such as Germany, Ireland,[32] New Zealand,[33] and the United Kingdom in defining interconnection between IP-based networks, the following issues were recognized to be core concerns in developing national IP-interconnection frameworks: technical interoperability, points of interconnection and interconnection charging.

Technical interoperability issues: As different IP-based networks evolve, from the technical perspective there still would be different IP interconnection scenarios. In order to ensure technical interoperability between different IP-based networks, a number of interfaces should be supported in every network. In order to ensure that interconnection will continue in an all-IP environment, regulators in collaboration with market players should establish which interfaces should be supported at a national level. India's Telecom Regulatory Authority of India (TRAI) report of Next Generation Network Expert Committee[34] (NGN-eCO) looked at interconnection between different IP-based networks and made such recommendations, in order to ensure interconnectivity. As an example, different IP networks may use different signalling systems; hence different signalling interfaces should be supported (See Figure 9).

Figure 9: Interconnection between NGNs and Different Types of IP-Based Networks



CF – Control Function; SIP – Session Initiation Protocol signalling protocol used in IP-based networks defined by IETF, ToIP – Telephony over IP (PSTN emulation); BICC – Bearer Independent call control; ISUP – ISDN User Part, protocol of Signalling System Nr.7; H.323 signalling protocol used in IP-based networks defined in ITU-T

Source: Report of Next Generation Network Expert Committee (NGN-eCO), Telecom Regulatory Authority of India

Points of Interconnection (PoIs): At the national level, bilateral interconnection has commonly been maintained between network operators. As networks migrate to IP-based architectures, the number of PoIs decreases and geographical locations for PoIs may also change. Normally, regulators still stick to the bilateral model of interconnection and propose to solve the problem of PoI rearrangement through increased transparency obligations and financial compensations. But some regulators are challenging the bilateral interconnection model in principle, arguing that it has numerous imperfections such as high interconnection costs and port charges, delays in provision of interconnection, and high operating expenses for managing inter-operator settlements. Those regulators propose to borrow the interconnect exchange model from the Internet and apply it for interconnection between emerging IP-based networks. Introduction of the interconnect exchange model could be reasonably considered by regulators, as it may facilitate interconnection through making it easier and less expensive.

Interconnection charging: The question of how to impose interconnection charges remains mostly unresolved at national levels. Regulators admit that all-IP networks may require multiple charging options, based on QoS, bandwidth, call duration, time and type of day, per service, etc. Different charging mechanisms may be applied depending on the service in question. In the current environment, many regulators consider that in the short-term existing billing mechanisms for existing services should continue. For the long term, however, regulators agree that cost-based interconnection charges should apply, and mechanisms based on QoS and bandwidth may prevail.

Comparing activities at the international and national levels, it is apparent that regulators usually forbear from any consistent action to introduce mandatory IP-interconnection frameworks. Moreover, there is no harmonization among existing national approaches. At the international level, though, migration toward IP-based interconnection is well organized. Also, workable IP-interconnection platforms are being introduced and tested.

4.3 National Interconnection Models in Evolving IP-Based Networks

From a technical perspective, national IP interconnection practices could more or less mirror international interconnection approaches. Regulators might find it useful to incorporate the technical expertise developed at the international level. Some international models, such as interconnection at IXPs, may be reasonably considered as a possible approach for interconnection between IP-based networks at the national level. International experience suggests that interconnection through the public Internet should remain as a cheaper alternative than interconnection through closed platforms like IPX.

While looking for possible interconnection products, existing international interconnection practices may be used once again. Thus national interconnection frameworks may include at least such interconnection products as:[35]

- Transport connectivity, which includes providing guaranteed QoS at the transport level and enables a connection between two or more interconnected operators without service awareness; and
- Service connectivity, which enables a bilateral connection between the interconnected parties using the transport layer and service layers, with guaranteed QoS end-to-end and service awareness.

An assessment of present and future changes in traditional approaches to the regulation of interconnection indicates that the traditional interconnection environment is being strongly influenced by the IP-interconnection approach of the Internet. It is doubtful, however, that the application of existing Internet interconnection approaches would be sufficient to sustain stable interconnection in the future. Meanwhile, the existing model of Internet interconnection is changing, and new forms of interconnection settlements are evolving. The impact of co-existence on both interconnection models is summarized in Table 4.

Table 4: The Impact of Co-existence on Interconnection models

Feature	PSTN-IC	Trends	Internet-IC
Organizational and regulatory feature			
Ex-ante regulation	Ex-ante prices/ interconnection obligations	In PSTN: Consistent regulatory decisions leading to lower termination rates, and also a trend towards possible introduction of zero termination rates (settlement – free peering); In the Internet: Spread of interconnection settlements based on Route Announcements.	None
Contractual relations	(Bill and Keep where applicable) Transit and Termination		(Settlement free) peering, Transit
Charging principle	Principle of initiation (mutuality)	In PSTN: In the long-term possible rejection of principle of initiation;	One pays all (one-sidedness)
	Cost sharing principle for inter-connection capacity (PoI)	In PSTN: Associated facilities tend to remain of critical importance. Cost sharing principle is remaining. In the Internet: Consistent pressure toward possible introduction of cost sharing principle of IIC. Principle of one-sidedness may not be applicable in the future;	
Main pricing factor	Distance	In PSTN: change of pricing factor from distance to quality.	Quality
Main billing factor	Time	In PSTN: Consistent trend towards change of billing factor from time-based to capacity-based.	Volume
Partners	Any-to-any Coequal	Both types of relationships co-exist at the moment. In PSTN: Some trends may be noted towards Hierarchical model (i.e. operators of international connectivity differentiate themselves, i.e. IPX providers)	Classes (tiers 1-3); Hierarchical
Technical features			
QoS	Fixed quality	In PSTN: more flexible QoS approach. In the Internet: more QoS oriented approach (i.e. Internet Backbone providers implement QoS measures between their networks).	QoS parameters at best
Standardization	Physical (technology)	In PSTN: development of plain telephony networks is saturating main principles of IP-based networks.	Logical (protocols)
Conveyance	Constant link		Packages
Routing	Constant ways		Random
Levels	Several network levels		One network level
Number of PoPs	Depending on level		At least 1

Source: Author

5 Pressure on Regulatory Practices

The future interconnection regulatory framework is definitely going beyond the regulation of voice interconnection. Emergence of IP-based networks and the co-existence of telco and Internet environments put pressure on existing regulatory practices. There are indications that the established interconnection regulatory regimes may not be sufficiently flexible, and they may not be able to solve problems in the market effectively. Some changes in interconnection practices already have taken place naturally (such as implementation of capacity-based interconnection), and more changes will be required in the future. It also seems clear that most of the changes in interconnection regulatory models are following Internet interconnection approaches.

The co-existence of substantially different network environments, however, raises challenges for regulators. The question of whether the contracts and mechanisms that have sustained interconnection in the Internet to date will be sufficient to sustain stable interconnection in the future, and whether the "hands off" regulatory approach remains the right approach, has become critical and remains open for discussion and further exploration. Existing opinions still differ. Some of the potential regulatory issues are explored in the final subsections of this chapter.

5.1 Symmetric or Asymmetric Regulation

Regulators face the need to decide whether interconnection regulatory regimes may be applied symmetrically, on all operators, or asymmetrically, on particular operators – such as incumbents or those deemed to hold significant market power. Meanwhile, a growing number of interconnection disputes are between network operators that are not subject to interconnection obligations. Especially in the countries that maintain an asymmetric approach to interconnection regulation, such disputes indicate a potential need to update the interconnection regulatory regime. Where the regulator is not able to intervene effectively and ensure interconnection where it is needed, there is a risk that some retail offerings may not reach end users.

Most developing countries historically have maintained symmetrical interconnection regulatory regimes. Countries that maintain asymmetric regulatory regimes may find it challenging to introduce significant changes to the interconnection environment that will apply symmetrically to all market players – such as changes in charging settlements or the introduction reciprocity obligations.

5.2 Transparency of Interconnection Terms and Conditions

Transparency is a part of every regulatory regime and an obligation to ensure, at a minimum, that terms and conditions for interconnection are publicly available.[36] Yet, information about modifications and changes in network architectures has traditionally been recognized as confidential. Therefore, there have been no regulatory requirements in many jurisdictions for disclosing and publishing such information.

Some significant changes in the existing PSTN core will be required before the PSTN can be fully replaced by the NGN. These changes will significantly affect already-interconnected operators. Considering that alternative providers arguably depend on wholesale products, protection of their interests and those of end users will require extended transparency obligations.

National Internet infrastructure provides substantial benefits for society, so its secure and robust operation is a high priority. Studies indicate that public availability and transparency of terms of connection to

IXPs encourage interconnection between ISPs and enhance the reliability of the national Internet infrastructure.

5.3 Separating Transport and Service Interconnection

A distinguishing characteristic of NGNs, which has been highlighted in numerous studies, is the decoupling of networks and services. This separation will be mirrored in interconnection --that is, interconnection of services will be performed separately from transport interconnection. Therefore, interconnection service and the technical implementation of interconnection will definitely be modified in the future.

Required technical measures – such as measures to ensure QoS – are mature enough and are in place, so it is a matter of consensus between market players what new interconnection services may be and how technically they may be implemented. The role of regulators may be limited to the creation of an open forum for discussion and co-ordination.

5.4 Capacity-Based Charges

In legacy interconnection models, the billing system is time-based. A capacity-based interconnection modality, however, allows operators to request a specific capacity for interconnection. They can then pay a flat-rate charge that reflects the fixed-cost nature of the interconnection capacity.[37] Migration toward capacity-based interconnection, even in the legacy PSTN environment, represents quite a visible trend both in the developed and developing countries.

The introduction of capacity-based interconnection may be explained as an outcome of migration to the capacity-based IP interconnection environment. But it can be also explained as an outcome of retail flat-rate (or similar) telephony offerings. Provision of capacity-based interconnection is therefore essential, because it allows alternative market players to introduce competitive offerings.

Several countries (for example, Poland, Spain, Colombia, and Portugal) have directed incumbents to provide capacity-based interconnection since the first retail flat-rate offering was introduced. The experience of countries where capacity-based interconnection is available shows that a significant portion of interconnection traffic is transferred using a capacity-based approach.

The OECD concludes that “the shift by last mile operators away from time based charging, in many cases for telephony as well, would argue in favour of using Internet charging practices for interconnect.”[38]

5.5 Consistent Rate Regulation

Consistent regulatory decisions leading to lower termination rates represent a worldwide trend. Experts agree that lower termination rates stimulate usage on the retail level. Some experts argue that low termination rates are good for the developing countries.[39] However, some regulators may consider the possibility of eliminating termination rates entirely.

Peering has fascinated the regulatory community for number of years. Discussing which charging model for interconnection may prevail in the future, regulators usually name peering.[40] They argue that the implementation of interconnection charging models existing in the Internet may contribute to the development of competition within traditional telecommunication environments. In certain circumstances, peering may make economic sense for telephony operators, as well, and regulatory intervention may not be required.[41]

5.6 Reliability and Robustness

While networks are converging to a single, IP-based infrastructure, the importance of IP interconnection is rising quickly and will continue to rise significantly in the future. The ongoing migration of circuit-switched traffic to IP-based networks is contributing to an increase in the volume of traffic being routed through IP interconnections and in the number of IP-based interconnections. An increasingly large proportion of the traffic sent between operators will be handled by border routers. Traditional, national legacy infrastructure is being replaced by IP infrastructure, which was not created to meet standards of national critical infrastructure.

In the transition to IP infrastructure, the consequences of a disruption or interruption in interconnection functions could be serious. The transition also affects diversity in the technology used. Security and robustness of the IP interconnection function is a new challenge brought by migration to IP-based networking. There are strong indications that ensuring the reliability and robustness of IP interconnection may become routine regulatory duties.[42]

5.7 QoS and Network Neutrality

The European Regulatory Group (ERG) has noted that QoS potentially may become a new dimension in interconnection regulatory frameworks. QoS could be an important focus for regulators, because it could lead to new forms of discrimination between a larger operator's services and those provided by interconnecting competitors.

The concept of network-based control seems to be the main difference between the public Internet approach and the managed NGN approach. NGNs offer the possibility of providing detailed service control and security from within the network, so that network operators are aware of both the services they are carrying and the users for whom they are carrying them. Operators can respond in different ways to this information. In managed IP networks, operators are able to control the content going through the network. In turn, this may have negative implications for the content of third party providers if their traffic is discriminated against in relation to that of an integrated or interconnected operator. Such discrimination is related to the "network neutrality" issue and could potentially be manifested either in purposeful degradation of service quality or in total blocking of particular services.

Network neutrality is being defined in more general terms as an environment in which the network is free of restrictions on content, sites, access devices or platforms, and where the QoS/QoE (Quality of Experience) of one communication is not unreasonably degraded by another. The first country which faced network neutrality problems was the United States, where in the beginning of 2008 two ISPs were recognized as blocking Internet services. However, the practical implications of network neutrality may be classified more as content blocking issues than interconnection issues. In the context of interconnection, degradation of QoS at the point of interconnection is the potential threat.

Regulators facing NGN deployments in their countries commonly apply the principle that at least the same (or equivalent) QoS level should be offered in an NGN environment as in the PSTN environment. Some regulators consider defining QoS parameters (such as jitter, latency, packet loss, etc.) for regulated wholesale interconnection services as one of the policy principles that should be integrated into existing interconnection regulatory frameworks. This, however, does not mean that other operators should not be able to provide services at other QoS levels.

A high QoS level may come at a price. For instance, a control platform must be provided for VoIP offerings with incorporated QoS mechanisms both for closed and open NGNs. The fixed costs of closed networks are assumed to be higher (because of incorporated extensive features, including advanced QoS mechanisms and reliability parameters) than in open networks. In the latter, the costs of implementing QoS depend on particular mechanisms, as well as on the ratio between "best-effort" traffic and real-time services. By contrast, VoIP service providers usually do not implement any QoS techniques. Therefore, NGNs will still co-exist with cheaper and less-secure Internet facilities. While NGNs maintain high QoS from the start of operation, interconnected operators may not be implementing QoS mechanisms from the very beginning. In such cases, high QoS requirements could become a barrier for operators seeking interconnection and a method for incumbents to refuse to grant it.

6 Conclusions

It seems clear that the telecommunication industry is evolving toward a future in which IP-based networks (NGNs) gradually replace circuit-switched networks, both for fixed and mobile (3G and 4G) services. Even as they do, however, there remains a strong incentive for regulators to see networks interconnect, in order to maximize value and reach as many customers as possible. The separation of transport and service functions not only enables seamless interconnectivity, it provides maximum flexibility to drive services over multiple networks. In short, IP offers up a future of more interconnection rather than less.

It also seems clear, however, that IP networks will coexist with older legacy networks, including 2G mobile and PSTN networks. That means that the need for legacy interconnection regulations will not dissolve – indeed, the complex interconnection environment may well call for greater oversight. Certainly, governments will have to closely examine whether a "hands-off" approach to IP interconnection is optimal, particularly with regard to development of NGNs by incumbents and other carriers that may try to leverage their market power into dominance in the markets for services and applications. And as always, regulators will have to look to safeguard competition, which has in the past been a frequent victim of efforts to use interconnection as weapon to stave off new market entrants.

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[1] In December 2006 report commissioned by the German regulatory agency, a "Project Group" focusing on interconnection of IP-based networks used the term "Next Generation Internet" or "NGI" to refer to "the further development of independent IP network domains of ISPs and Internet transport providers into multi-service networks." (See Berg, Achim, et al., "Framework Conditions for the Interconnection of IP-Based Networks," Final Report of the Project Group, 15 December 2006 [translated from German]). This term does not appear to have been adopted universally, so in this chapter, this model will be referred to more generally as the "open network model," to distinguish it from the more proprietary or controlled "closed network model" of NGN.

[2] ITU Trends in Telecommunication Reform 2007, p.103.

[3] E.g., regulation of unbundling access to the local loop (or last mile) is a classical form of access regulation.

[4] ITU Trends in Telecommunication Reform 2000/2001 on Interconnection Regulation, Chapter 4

[5] Line-side denotes the customer side of a switch, usually to end office switch.

[6] When referring to "telco networks", this generally relates to fixed and mobile networks. Encompassing mobile networks in this chapter is not to deny differences between fixed and mobile networks, e.g. with regard to the differences in access network

[7] Internet Service Provider is usually defined as a provider of Internet access service to the end user (see definition from European Internet Exchange Association at: http://www.euro-ix.net/glossary/). However for the sake of simplicity in this chapter the term ISP includes all the IP-based network providers which form the Internet and therefore provides Internet access to each other. For instance, Internet transport providers provide Internet access for Internet Access Providers.

[8] ITU Trends in Telecommunication Reform 2007, p. 63

[9] Laura Howard, A challenging time is a time of opportunity for telecoms, TotalTele.com, March, 2009

[10] Martin Sauter, "Evolution of Mobile Networks: Impact and Possibilities for Future Services", Oxford University CPD Future Technology Conference, April, 2009

[11] T. Koshimizu, „Interconnection between NGN and mobile networks", NTT DOCOMO , ETSI Workshop on NGN Interconnection, June, 2008 at: http://portal.etsi.org/docbox/Workshop/2008/200806_NGN_INTERCONNECTION/

[12] Example of paid peering (nevertheless being outside the Internet environment) may be GRX/IPX peering platform which was created by GSMA (GRX – GPRS Roaming Exchange).

[13] Mark A. Sportack, IP addressing fundamentals, Cisco Press, 2002, p.230.

[14] P. Faratin, D. Clark, P. Gilmore, S. Bauer, A. Berger and W. Lehr, "The Growing Complexity of Internet Interconnections", Communications & Strategies, No. 72, p. 51, 4th Quarter 2008, at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1374285

[15] Ed Rushton, "Internet Interconnection", Cable&Wireless, available at: http://ec.europa.eu/information_society/activities/internationalrel/global_issues/itu/index_en.htm

[16] See 2008 edition of Trends in Telecommunications Reform

[17] Emanuele Giovannetti, "Market Power and Agglomeration in Internet Connectivity", Department of Applied Economics, University of Cambridge, ITU Joint Rapporteur Group Meeting On IIC and traffic Flow Methodology, 28-30 April 2003, Brussels.

[18] See note 12

[19] Geoff Huston, "Where's the Money? - Internet Interconnection and Financial Settlements," The ISP Column, Internet Society (January 2005), at http://ispcolumn.isoc.org/2005-01/interconns.pdf

[20] Source: Trends in Telecommunication Reform 2008, p.135; P. Faratin, D. Clark, P. Gilmore, S. Bauer, A. Berger and W. Lehr, "The Growing Complexity of Internet Interconnections", Communications & Strategies, No. 72, p. 51, 4th Quarter 2008, at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1374285; Daniel Roseman, "The Digital Divide and the Competitive Behaviour of Internet Backbone Providers A Way Forward", Roseman Associates International Trade and Communications Consultants; Emanuele Giovannetti, "Market Power and Agglomeration in Internet Connectivity", Department of Applied Economics, University of Cambridge, ITU Joint Rapporteur Group Meeting On IIC and traffic Flow Methodology, 28-30 April 2003, Brussels; "International Internet Interconnectivity: Are poor countries subsidizing the rich?", ITU News, Nr. 3, April 2005; "Occasional curiosity or Regular Routine? Evaluating reliability of the Internet infrastructure", ENISA Quarterly Review, Vol. 5, No 3, September, 2009.

[21] Role of international organizations may be critically valuable there. It may help to create an enabling environment for ICT development, build capacity of key institutions, etc. It may be helpful to assess experience of common project of UNDP and the Government of Uzbekistan: "Assisting the Government of Uzbekistan in the formulation and implementation of information and communication technologies for development policy". More information about the ICT Policy Project may be found here: http://www.undp.uz/en/projects/project.php?id=24;

[22] ERG (07) 09, Document on IP interconnection, 2007, 13 p., available at: http://erg.ec.europa.eu/doc/publications/consult_ip_interconnection/report_ip_ic_interconn.pdf;

[23] ITU-D Study Group 1, Draft interim report on Question 6-2/1 (Regulatory impact of next generation networks on interconnection, Doc. 1/207-E, 2009;

[24] see also the GSR09 Discussion paper on impact of economical recession on telecom market, at: http://www.itu.int/ITU-D/treg/Events/Seminars/GSR/GSR09/papers.html ;

[25] Laura Howard, A challenging time is a time of opportunity for telecoms, TotalTele.com, March, 2009;

[26] "Mobile Marvels", A special report on telecom in emerging markets, The Economist , September, 2009. http://www.economist.com/specialreports/displaystory.cfm?story_id=14483896

[27] "Mobile Marvels", A special report on telecom in emerging markets, The Economist , September, 2009. http://www.economist.com/specialreports/displaystory.cfm?story_id=14483896

[28] "Up, up and Huawei", A special report on telecom in emerging markets, The Economist , September, 2009

[29] http://www.totaltele.com/view.aspx?C=0&ID=450049

[30] http://www.i3forum.org/library

[31] "Solutions for implementing IP-based interconnections for the international wholesale industry", i3 Forum, ETSI Workshop on NGN Interconnection of Services Standardization, Sophia Antipolis, 2008.

[32] http://www.comreg.ie/_fileupload/publications/NGN_OVUM_Report_2007.pdf

[33] http://www.comcom.govt.nz/IndustryRegulation/Telecommunications/Inquiries,ReviewsandStudies/ContentFiles/Documents/NGN%20Discussion%20Paper_Final%20_241208.pdf;

[34] http://www.trai.gov.in/NGN.asp

[35] Extracted and adopted from GSMA framework IPX interconnection agreement

[36] More extensive transparency regulation may include obligations to publish operational characteristics of interconnection service delivery, e.g. average time for service delivery, average time for fault repair and etc. Such characteristics are usually named key performance indicators (KPI) and are dedicated to define an actual quality of interconnection service delivery

[37] http://www.ictregulationtoolkit.org/en/Section.2095.html

[38] Convergence and Next Generation Networks: Background Report, Working Party on Communication Infrastructure and Service Policy, DSTI/ICCP/CISP(2007)2/REV1 , OECD, p. 27.

[39] http://internetthought.blogspot.com/2009/07/low-mobile-termination-costs-are-good.html

[40] See ERG Draft Common Position on Next Generation Networks Future Charging Mechanisms and Long Term Termination Issues, launched in October 2009, available at: http://erg.ec.europa.eu/doc/publications/2009/erg_09_34_draft_cp_ngn_future_charging_mechanisms_final.pdf.

[41] On the one hand peering sometimes became an outcome of regulatory intervention. For instance, the Commerce Commission of New Zealand successfully imposes peering on local level and is arguing that such form of commercial arrangement creates a long-term benefit for end consumers[41]. On the other hand US experience has demonstrated inability to impose peering. Nevertheless such interconnection arrangements developed naturally and are applied partially in the US as a result of market outcome.

[42] "Occasional curiosity or Regular Routine? Evaluating reliability of the Internet infrastructure", ENISA Quarterly Review, Vol. 5, No 3, September, 2009; Threats to Security in the exchange of the traffic between Internet service providers, The Swedish Post and Telecom Agency, available at: http://www.pts.se/upload/Documents/EN/Threats_to_security_in_the_exchange_of_traffic_between_Internet_service_providers.pdf.