# On the Regulation of Quality of Service Provisioning for Next Generation Networks in Spain and the European Union

**Juan Rendón[*] and Johan Zuidweg**
*Department of Information and Communication Technologies*
*Pompeu Fabra University, Barcelona, Spain*
*juan.rendon@upf.edu*

**Abstract:**
The term Next Generation Networks (NGN) practically always refers to an all-IP multi-service core network connecting a variety of fixed and mobile access networks. In order to have a good connection with end-to-end Quality of Service (QoS) levels across NGNs, technical and regulatory aspects have to be considered. In the article we analyze technical and regulatory matters related to the deployment of QoS mechanisms in NGN in Spain as a European Union (EU) member. Based on questions related to the possible regulatory framework in the EU and to the willingness of operators to interconnect, the paper describes four possible scenarios that could be useful to understand the situations that could arise in the future.

**Keywords:** QoS, NGN, Regulation, Spain, EU

Paper to be presented at the 35th Research Conference on Communication, Information and Internet Policy (TPRC 2007), September 28-30, 2007, Arlington, Virginia, USA

---

[*] contact author

## 1. Introduction

The term Next Generation Networks (NGN) can mean different things according to the context it is used in. The most common elements usually understood to be part of NGN are the following: an all-IP core network and a high speed access based on digital subscriber lines including fibre to the home, 3G mobile or unlicensed spectrum (WiFi or WiMAX). It is also assumed that most providers deploy IP Multimedia Subsystem (IMS) as the signalling system for multimedia services.

It is common for service providers to provide Service Level Agreements (SLAs) and guarantee Quality of Service (QoS) to business customers, but few service providers differentiate QoS for the residential market. Service providers will specify the maximum bandwidth a customer can expect on the access network, but without any guarantees on minimum or average throughput, and end-to-end QoS is virtually never offered. QoS is much easier to achieve in the business market where networks are fully managed, than in the residential market where the dominant service consists of broadband connections to the Internet. Though DSL is widespread and fibre to the home is on the horizon in many EU countries, it will be difficult for service providers to differentiate any QoS beyond mere access connection speed until IPv6 becomes the dominant internetwork protocol. IPv6 deployment has not yet reached critical mass despite the many IPv6 related initiatives that exist on the level of EU member states and the EU as a whole.

On the other hand, the 80-20 rule also applies to NGN: around 20% of users account for 80% of today's Internet traffic. This stands in sharp contrast to the flat fee structure that most service providers apply to their residential customers. The result is that "light" users end up paying for "heavy" ones, thus raising the barrier for NGN access for those sectors of the market with modest QoS demands that would most benefit from low cost access. The "network neutrality" debate is related to this issue and from a technical point of view operators are and will be able to prioritize traffic by using available QoS techniques. Hence it is important to know which QoS techniques are being deployed by NGN operators.

A few studies analyze the IP Interconnection regulatory framework. [ERG07] studies the IP interconnection regulatory framework in Europe, whereas [Marcus06-1] describes the Framework for IP Interconnection Regimes in the USA and the UK. On the other hand, [OECD07] describes technical and policy considerations related to traffic prioritisation issues. [Marcus06-2] describes technical and economic aspects of NGN networks.

In the article we analyze technical and regulatory issues related to the deployment of QoS mechanisms in NGN in Spain as a European Union member. Based on questions related to the possible regulatory framework and to the willingness of operators to interconnect, the paper describes four possible scenarios that could be useful to understand the situations that could arise in the future.

The paper is structured as follows. Section 2 describes a few technical aspects of NGN, whereas Section 3 studies some of the QoS mechanisms that have already been deployed and that will be used in NGN. Section 4 gives a brief description of the regulatory framework for Spain (the European Union directives and the specific Spanish regulatory framework) that affects QoS issues in NGN. In Section 5 scenarios related to the possible approval of a regulatory framework that permits QoS interconnection are built and explained. Finally, Section 6 contains the conclusions and recommendations for future directions.

## 2. Next Generation Networks

The term NGN has many definitions in literature and can mean different things depending on the context it is used in. Even so, NGN practically always refers to an all-IP multi-service core network connecting a variety of fixed and mobile access networks that include DSL, fibre to the home, WiFi, WiMAX and 3G cellular. In this section we shall take a closer look at some of the more common and some of the more variable aspects of the NGN.

### *2.1 Access and core networks*

In NGN the first important distinction is between access and core networks. Although we assume that all access and core networks that make up the NGN use IP, access networks may have characteristics that are specific to the access medium. For example, GPRS cellular data networks use a Packet Data Protocol (PDP) that adapts data transport to terminal mobility and transmissions on the air interface. The PDP used in GPRS can tunnel IP packets, but also other types of data.

Access network providers usually make their revenue from the nature of the access medium rather than from IP transit. In the case of ADSL, the value added resource is the local loop, in the case of 3G it is the radio spectrum. Although the medium often introduces limitations to the Quality of Service, service providers may provide some QoS within the bounds of their access network. These QoS notions rarely go beyond promising a maximum (and in rare cases a minimum) data speed.

Large operators and Internet Service Providers (ISPs) like Vodafone or Telefónica typically operate both access and core networks. Such operators are in a position to control QoS and offer Service Level Agreements (SLAs) within their entire domains. But smaller service providers may have to rely on the *transit* services offered by other ISPs for interconnection. Section 3.3 below goes deeper into the subject of transit and interconnection.

### *2.2 IPv4 and IPv6*

The NGN concept does not seem to hinge on IPv6, even though all networks are set to migrate to the new IP protocol at some point in the future. Where this point lies is quite uncertain. There was quite a lot of buzz around IPv6 in the first years of the new Millennium, and some thought IPv6 would have supplanted IPv4 entirely by 2010. Today, that seems to be an unlikely prediction.

Most backbone networks now support IPv6, and Microsoft Windows Vista includes IPv6 as one of its standard networking protocols. Yet only very few applications use IPv6 today, and in most cases IPv6 traffic is tunnelled through IPv4. A single reason for the slow acceptance of IPv6 may be difficult to pinpoint, but the slower exhaustion of network addresses and the vast amount of personal computer applications that rely on IPv4 may explain part of it.

IPv4 and IPv6 are incompatible networking technologies, but even so they provide essentially the same service: addressing and routing. IPv6 has been designed primarily to be more than efficient than IPv4, and does not introduce truly new functionality. This means that IPv6 offers essentially the same tools for traffic shaping and managing QoS as IPv4. Section 3.1 will consider these in more detail.

### *2.3 Network or edge based services*

There is a marked difference in the way that “Bell heads” and “Net heads” see the NGN. “Bell heads” are typically telecommunications operators (fixed, mobile or both) with an interest in maintaining control over the “call” or communication session. These operators used to run circuit switched telephony networks with very reliable SS7 signalling networks, in which circuits and calls represented chargeable entities.

As networks migrate to all-IP, telecommunications operators have their hopes on the Internet Multimedia Subsystem (IMS) as the heir of their SS7 signalling infrastructure [KMT05].

The IMS is often drawn as a layer above IP, as in Figure 1. Of course this is only a conceptual view that has to be taken with a grain of salt. In terms of IP networking, a SIP proxy or application server is just another IP host. Virtually all mayor telecommunications operators in Spain, including incumbent Telefónica, are currently evolving their networks to a structure similar to Figure 1.


**Figure 1: Next Generation Networks concept**

Today's SS7 networks are highly redundant and reliable networks that offer "five nines" availability and guaranteed transaction times. Operators will require the SIP traffic in IMS to be equally reliable, which means they will have to shape the traffic carried on the all-IP network to give priority to critical SIP traffic.

"Net heads" are typically ISPs and Application Server Provider (ASPs) that argue strongly against network centric call or session control. They claim that the power of the NGN lies exactly in the open nature of the network where users can plug in any application, and they consider the absence of network centric control as a condition for creating a level playing ground. Net heads are not against SIP, but they consider neither session signalling, nor application servers to be critical layers in the network architecture. These are simply end-to-end applications to which the IP network is completely transparent.

Today the Net head and Bell head visions still compete. Classical voice telephony and free-for-all voice over IP applications live side by side. In Spain, many telecommunications operators are themselves Internet service providers, and as such face the same dilemma even within their own company.

## 3. Quality of service in NGNs

In this section we shall consider in more detail how the NGN may handle Quality of Service, and what problems the structure of the Internet places on universal QoS provisioning.

### *3.1 Quality of Service techniques*

The Internet Protocol (IP) itself, whether in version 4 or 6, does not guarantee the delivery of data packets in any order, priority or at any speed. In fact it does not guarantee delivery of data at all. Since the mid 1990s, the Internet community has come up with several techniques adjacent to IP to control QoS. The most important ones are:

- *Over-dimensioning* links and routers is often cheaper than deploying sophisticated QoS techniques, so many networks use this brute-force way of reducing congestion and keeping users happy. Yet over-dimensioning can not be strictly called a QoS technique, as it does not differentiate any traffic nor guarantee any bandwidth to any user in particular.
- *IntServ and the Resource Reservation Protocol (RSVP)* allow an application to reserve router capacity on the path from source to destination host. While IntServ is effective in guaranteeing bandwidth for a given application, it interferes with one of the most important principles of IP: independent routing of individual packets, even if they belong to the same application.
- *Diffserv* uses a field in the IP header to distinguish traffic classes, which allows a router to prioritize packets according to their class. Diffserv does not violate IP principles and scales better than IntServ. On downside, Diffserv cannot always fulfil as “hard” QoS commitments as a reservation protocol like IntServ.
- *Multi Protocol Label Switching (MPLS)* resembles Diffserv to some extent in that it uses labels to classify data traffic. The difference is that MPLS routers manage traffic flows below the network (IP) level. Although MPLS is not part of the IP protocol but rather a new sub-IP protocol, its simplicity and efficiency have made it the most promising QoS technique on the Internet so far.
- *Asynchronous Transfer Mode (ATM)* used to be the great promise until MPLS came along. In principle, ATM is a networking technique that is completely independent from IP. Since ATM uses virtual circuits and very fast switching of small cells, it has built in QoS support. The high cost of ATM equipment and the popularity of IP have caused ATM to be on the retreat, but there are still networks that run IP over ATM, especially ADSL access networks.

Techniques based on traffic labelling, especially MPLS, are most widely used today. Yet we should not entirely discard reservation techniques, which have their use in applications that rely critically on die-hard QoS guarantees. The downside to any technique, be it reservation or traffic labelling, is that it requires all routers on the data path to be willing and able to handle the respective QoS algorithms.

Both IPv4 and IPv6 packet headers can carry the information necessary to control the above techniques. In other words, although IPv6 is more efficient and more adapted to the actual structure of the Internet, IPv6 is not critical for providing QoS.

### *3.2 Traffic evolution*

Traffic on the Internet does not only grow, it also changes. In the 1990’s, e-mail, file transfer and World Wide Web accounted for much of the traffic. Then file-sharing applications took the lead, and caused as much as 65% of all Internet traffic only a few years ago. Recently what is called Web 2.0 and IP telephony are again changing traffic patterns. Telefónica in Spain stated in 2006 that 80% of the traffic in its network was P2P traffic generated by 25% of the users [ElPais06].

The nature of HTTP traffic changes as well. HTTP can no longer be associated exclusively with the World Wide Web, because it has become a general-purpose protocol for many types of applications. At present, HTTP and streaming traffic together already have a larger share than peer-to-peer traffic, and will grow even more as Internet telephony and Web 2.0 portals gain ground. Figure 2 shows the traffic distribution.

New bandwidth hungry applications like Internet television will amplify this trend further. In the future, a few big scale services are likely to account for most Internet traffic. Table 1 shows the type of traffic we believe will be dominant on the NGN for the next five years.

| Application | Protocols | Bandwidth sensitive | Delay or jitter sensitive |
|---|---|---|---|
| e-mail | POP, SMTP | no | no |
| WWW | HTTP | no | no |
| Web 2.0 | HTTP, RTP | yes | no |
| IP Telephony | HTTP, RTP | no | yes |
| IP Television | HTTP, RTP | yes | yes |
| Peer to peer | HTTP | yes | no |
| VPN Traffic | HTTP | yes | yes |

**Table 1: Dominant traffic types on the NGN**

### *3.3 QoS across domains*

It is common for Internet service providers to provide SLAs and guarantee QoS to business customers, but few service providers differentiate QoS for the residential market. Service providers will specify the maximum bandwidth a customer can expect on the access network, but without any guarantees on minimum or average throughput, and they virtually never offer end-to-end QoS.

Residential customers have been accepting this, as they have been using the Internet mostly for web access, peer-to-peer file sharing, and free or very low cost voice or video over IP communications which they don't expect to have the same quality as switched telephony. But the advent of IP television and personalized streaming applications like Sling Media's Slingbox™ or Sony's LocationFree™ may change users' QoS demands.

A single ISP offering triple play services usually controls QoS for its streaming services, for example in the case of Telefónica's Imagenio IP television and video on demand service. But streaming applications like Slingbox™ or LocationFree™ may require cross-domain QoS.

Over the years Internet has evolved to a collection of interconnected Autonomous Systems (AS) without any central control. An AS can be seen as an administrative domain that manages routing strategies, QoS and everything else related to IP within the domain. An AS usually deploys the Open Shortest Path First (OSPF) or a similar routing protocol. AS interconnect through the Border Gateway Protocol (BGP), which allows routing information to propagate from one AS to another.

The BGP does not by default propagate QoS parameters, but it can be extended to do so. Cisco has devised a solution for propagating QoS through BGP that requires the use of its proprietary Express Routing. The European project MESCAL (Management of End-to-end Quality of Service Across the Internet at Large) has been proposing a more general, standardized solution [MESCAL].

Although it is technically possible to provide QoS across IP networks interconnected via the Border Gateway Protocol (BGP), current *peering* and *transit* agreements do not usually cater for this. These interconnection agreements are illustrated in Figure 2.

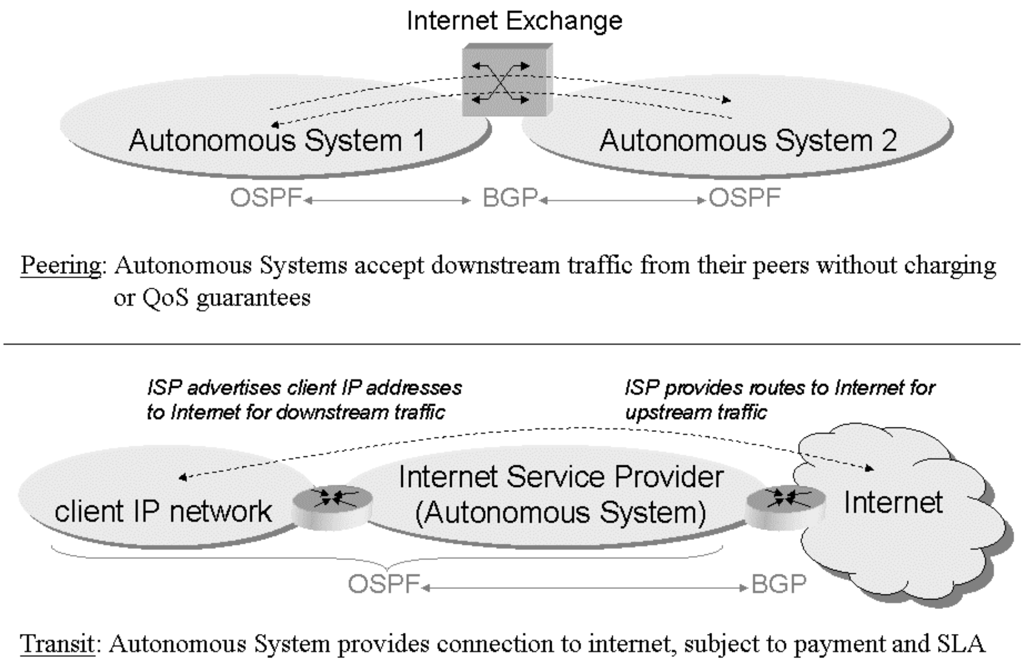


**Figure 2: Peering vs. Transit**

In a *peering* agreement shown in the upper half of figure2, two networks that manage their own IP addresses and routes (called Autonomous Systems or AS) agree to exchange IP traffic on a best-effort delivery and no-pay basis.

In a *transit* agreement shown in the lower half of figure 3, an ISP (normally an AS) provides access to the Internet for both upstream and downstream traffic. This type of service is normally subject to pay. The client network usually has to commit to a minimum volume of traffic, while the ISP guarantees a certain Quality of Service, measured in connection speed (Mb/s).

Only the transit agreement involves some measure of Quality of Service, though a very rudimentary one. Moreover, the ISP can only guarantee data rates within its own network, not across the Internet.

### 4. - Regulatory Framework in Spain and in the EU for the Interconnection

Interconnection is one of the main aspects that characterizes the effectiveness of a network. In the beginning, telephone networks interconnected voice switches to reach a growing number of users. Then, data networks started to interconnect data switches and routers. The main data network in the world is the Internet, and precisely one of its main features is the capacity to interconnect in an easy way new networks and nodes. The interconnection is necessary to provide universal connectivity on the Internet [Econ05].

With the telecommunications liberalization process of the past decades the interconnection between networks was considered a key issue to foster the competition. One of the policies that was promoted was the Local Loop unbundling, which enabled a rapid entrance of new operators into the telecommunications arena.

There are two types of regulation directives that apply to the telecommunications sector in the EU. The first one is the general competition law and the second one consists on the “sector-specific” rules valid for the electronic communications sector [Walden05]. The objective of the sector-specific rules is to promote competition. The Articles 81 and 82 of the EC Treaty prohibit anti-competitive agreements and the abuse of dominance by a company that has a dominant position in a particular market.

The Interconnection Directive was approved in 1997 and it defines the conditions for establishing an interconnection agreement between operators. In 2002 the EC approved a Directives’ package for the Electronic Communications sector that came into effect in 2003. The Access Directive and the Framework Directive belong to this package. The Framework Directive is necessary to understand the market analysis process, whereas the Access Directive defines the access obligations of operators.

These Directives, which are valid nowadays, enable Telecommunications undertakings to have the type of agreements that suits them best, but they do not force any company to provision a specific QoS level.

Currently, the Regulatory Framework is being reviewed and the EC is working on a draft of the EU Regulatory Framework for Electronic Communications networks and services [EC06]. The Network Neutrality debate was originated in the USA and a few undertakings in Europe tried to consider some aspects of this debate in the EU. Section 6.4 of the draft is about the Network Neutrality subject and defines the following:

"In Europe the regulatory framework allows operators to offer different services to different customer groups, but does not allow those who are in a dominant position to *discriminate* between customers in similar circumstances. However, there is a risk that, in some situations, the Quality of Service could degrade to unacceptably low levels. It is therefore proposed to give NRAs the power to set minimum quality levels for network transmission services in an NGN environment based on technical standards identified at EU level".

This section means that a set of minimum QoS levels can be defined for the interconnection between NGNs.

At the moment of dealing with NGN interconnection issues, there are two levels that should be considered: the interconnection with the Core Network and the Interconnection with the Access Network [Nicholls06].

In Spain the NRA, the Comisión del Mercado de las Telecomunicaciones (CMT), launched a public consultation in May 2007 about Next Generation Access Networks [CMT07]. Among other matters, the CMT wanted to gather contributions about the specific regulation suited for Next Generation Access Networks.

## 5. Scenarios

In this section a set of scenarios are constructed to understand that possible situations that could arise in the future. The two questions that are the drivers for the definition of the four scenarios are the following:

1. *Does the regulatory framework request interconnection with QoS agreements?*

If the answer is positive, the regulatory framework request the interconnection with QoS agreements between two operators (as long as the NRA defines the minimum set of QoS levels). If the answer is negative, the regulatory framework does not forbid the interconnection.

2. *Do the operators want to interconnect?*

If the answer is positive, both operators want to interconnect. If the answer is negative, one of the operators or none of them wants to interconnect.

As the new EU Regulatory Framework could be valid since 2010 approximately, the analysis carried out for these scenarios is valid for the year 2015. Figure 3 shows the four scenarios and a description of each scenario appears below.

**Does the Regulatory framework request interconnection with QoS levels? YES**

- The law is very clear

**Do both operators want to interconnect? NO**

| Scenario 1:<br>**CONFLICT**<br>- Judiciary problems | Scenario 2:<br>**IDEAL SCENARIO**<br>- Technological changes will be demanded by the companies<br>- QoS is demanded by the users and can easily be satisfied. |
|---|---|
| Scenario 3:<br>**INERTIA**<br>- Worst case | Scenario 4:<br>- Even though the law does not specify anything, the operators can interconnect. |

**Do both operators want to interconnect? YES**

**Does the Regulatory framework request interconnection with QoS levels? NO**

- But the law does not forbid the interconnection

**Figure 3. Scenarios**

<u>Scenario 1: CONFLICT</u>

The first scenario represents a situation where the Regulatory Framework permits an interconnection with QoS levels and at least one of the operators does not want to interconnect. This situation leads to a conflict status because the operator that wants to interconnect will probably file suit against the operator that does not want the interconnection.

On the other hand, if there are operators from the competition that agree to interconnect the situation could be easily solved. But if there are no alternatives, then the operator that wants the interconnection would be trapped without other option than filing suit.

Moreover, the users satisfaction would be the same due to the fact that the user will not perceive any QoS improvement.

Scenario 2: IDEAL SCENARIO

In this case the regulatory framework permits the interconnection with QoS levels and both operators want to interconnect. The user satisfaction will improve because the user could get an end-to-end QoS.

Operators will of course improve their network so that they can compete in terms of QoS.

Scenario 3: INERTIA

This situation is basically the one that is perceived by the users nowadays: Most operators do not have an interconnection with QoS levels and QoS interconnection between operators is not mandatory.

If this is the case, the Spanish and the EU networking market could probably lag behind the networking markets in other regions of the world.

Scenario 4:

In this situation the regulatory framework does not request the interconnection with QoS levels and if both operators agree they will interconnect. Probably this scenario is similar to the IDEAL SCENARIO (number 4). Even though there is no regulatory framework defined, the regulators will probably supervise that there are no unfair treatments with third operators that want to interconnect.

On the other hand, this scenario can be considered in some aspects similar to a deregulated market where undertakings consider the interconnection with QoS levels a good deal in order to offer users an end-to-end QoS.

## 6. Conclusions

Technical and regulatory issues related to the provisioning of QoS in NGNs were described in the paper. A NGN network can be defined as an all-IP core network that has different types of access networks, e.g., DSL, fibre to the home, WiFi, 3G cellular and WiMAX. There are several techniques that can be used for the provisioning of Quality of Service in NGNs, but so far it is not clear whether these techniques can satisfy the demand for bandwidth hungry traffic generated by users.

In Spain and in the EU the current telecommunications law permits that operators interconnect if they come to an agreement, but it does not specify a minimum set of QoS levels that should be satisfied. In the current Review of the EU Electronic Communications law it has been proposed that NRA had the power to establish a minimum set of QoS levels for the transmission in NGNs. In order to understand in more detail the consequences of this proposal, four scenarios were constructed in the paper. It was found out that if two NGN operators want to interconnect they would do it, regardless of the existence of the proposed law. This situation could lead to an improvement of the QoS perceived by end users.

## References


[CMT07] CMT, "Consulta Pública sobre Redes de Acceso de Nueva Generación", May 10, 2007.

[EC06] European Commission, "Communication from the Commission to the Council, the European Parliament, The European Economic and Social Committee and the Committee of the Regions on the Review of the EU Regulatory Framework for electronic communications networks and services", COM(226) 334 final, Brussels, June 28, 2006.

[Econ05] N. Economides, “The Economics of the Internet Backbone”, Handbook of Telecommunications Economics, Volume 2, Elsevier, 2005.

[ElPais06] “Hay que pagar por usar Internet?”, *El Pais*, Spain, September 10, 2006.

[ERG07] ERG (European Regulators Group), “Final Report on IP interconnection”, ERG (07) 09, 2007.

[KMT05] K. Knightson, N. Morita, T. Towle, "NGN Architecture: Generic Principles, Functional Architecture, and Implementation", IEEE Communications Magazine, October 2005.

[Marcus06-1] S. Marcus, “Framework for Interconnection of IP-Based Networks-Accounting Systems and Interconnection Regime in the USA and the UK”, Study for the Federal Network Agency, German, WIK Consult, March 6, 2006

[Marcus06-2] S. Marcus, “Interconnection in an NGN Environment”, ITU/02, March 2006.

[MESCAL] http://www.mescal.org

[Nicholls06] R. Nicholls, "Interconnection of next generation networks - A regulatory perspective", International Telecommunications Society (ITS), ITS 2006, June 2006, Beijing, China

[OECD07] OECD, “Internet Traffic Prioritisation: An Overview”, Committee for Information, Computer and Communications Policy, OECD DSTI/ICCP/TISP(2006)4/Final, April 6, 2007.

[Walden05] I. Walden and J. Angel, “Telecommunications Law and Regulation”, Second Edition, Oxford University Press, 2005