Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

NEXT GENERATION NETWORK DEVELOPMENTS AND THEIR IMPLICATIONS FOR THE NEW REGULATORY REGIME

Bornholm, October 2003

EXECUTIVE SUMMARY

This report describes the main factors in the development of next generation networks and their implementation by the traditional telecommunications operators, and the prospective growth in competition between these networks and the public Internet for the carriage of new services. It then goes on to discuss the application of the new regulatory framework to both next generation networks and the Internet. It draws attention to areas where the regulatory framework may have difficulty in addressing the provision of services by independent third parties who are not network operators and who may be located outside national or European jurisdiction.

The main conclusions of the report are that:

1 - There seems to be little clear "vision" about NGNs amongst the telcos, and there does not seem to be a strong economic case for replacing the circuit networks with an IP-based infrastructure although some operators are replacing and restructuring their transit networks with IP or ATM based technology.

2 - Voice communications are starting to migrate away from the PSTN and the migration onto the Internet will probably gather pace.

3 - The main barriers to the growth of voice communications over the Internet relate to ease of use and blocking of the media channels by NATs. It is not clear how quickly these barriers will be overcome but late 2003 – 2004 is the current expectation. Voice quality problems are likely to be overcome soon by the adoption of codecs that are tolerant to packet loss.

4 - If the Internet proves capable of providing adequate quality for real-time communications then it will have a profound impact on the revenues of the telcos and undermine the justification of investment in telco NGNs.

5 - The circuit switched PSTN is likely to remain for a long time but with a reducing traffic load. Its reliability makes it the network of last resort when problems are experienced on the newer networks. Thus the focus of the universal service obligations on the circuit switched PSTN will continue to be appropriate for the foreseeable future.

6 - The separation of service, network and access provision that is being promoted at technical level in NGN standardisation will make the application of the new regulatory framework much more difficult and lead to the increasing offering of services from one location to users anywhere in the world. Regional and national legislation may have difficulty in applying requirements to service providers in this environment.

7 – The development of new services on a competitive and proprietary basis will reduce the interoperability of services and users may increasingly have to subscribe to multiple similar services to obtain the desired capability of communicating with all their correspondents.

8 - If the telcos continue to use the traditional model of a "closed" network for the NGN backbone then the interconnection arrangements needs to support new services may become too complex to administer and the situation may be self defeating and lead to the telcos adopting the Internet model for the backbone.

9 - There is a serious possibility that telcos who have a large share of the Internet access market could degrade the quality of Internet access so that real-time services and applications do not work adequately over the Internet and thereby try to retain voice traffic on the PSTN for longer and improve the prospects for NGNs. Regulators need to give careful consideration to the quality issues for Internet access, eg ADSL contention ratios, and appropriate QoS parameters need to be defined.

10 – The changes in network and service provision will affect terminals, which will increasingly become general purpose processor based platforms offering APIs for use by software downloaded from service providers.

INDEX TABLE

1   INTRODUCTION

The purpose of this report is to highlight some of the main commercial and technical developments involved in next generation networks and to assess how well the new regulatory framework will handle them. The report is written primarily from a technical perspective but also includes a discussion of how the market will develop in broad terms, and thus it includes those economic and commercial issues that will substantially affect the direction of the market. Particular attention is given to the regulatory issues concerning services and interconnection.

2   CURRENT MARKET SITUATION AND DEVELOPMENTS

Overall the market currently lacks direction. After a period of diverse investments, many of which have not been profitable, the top priority for many operators is to manage their debt situations.

In terms of fundamental resources:
- Local physical infrastructure remains expensive;
- Transmission costs has fallen and is falling very rapidly thanks to a combination of absolute costs and coding;
- Switching costs are falling but faster for IP-based switches than for circuit switches;
- Billing costs are falling only slowly.

This situation leaves telcos re-focusing on core business and in particular developing broadband access networks.

There is a great deal of discussion and confusion about how telecommunications networks will develop at a technical level in the next few years. Three years ago everyone was expecting the rapid and near universal adoption of IP technology but since then the whole investment climate has changed and the current situation is much less clear.

Figure 1 shows an expected view of how networks will change. The diagram is best viewed in colour as the colours are significant. The rectangle covering the whole diagram illustrates the dependence on a common IP based transmission platform, the exception being the top left hand corner where circuit switching is still used.
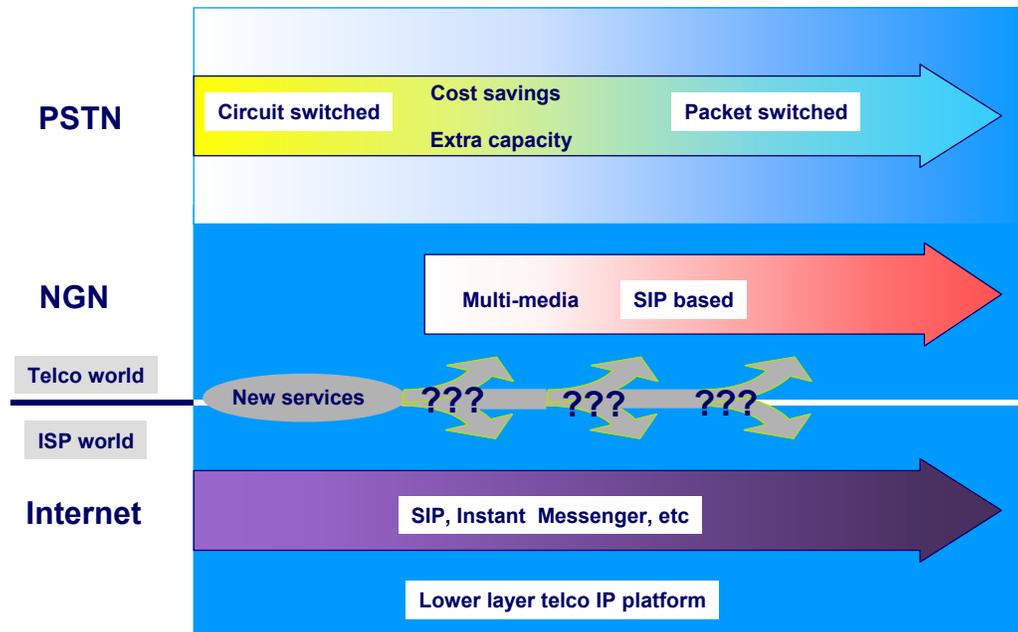

Figure 1: Nearer term network developments

2.1 PSTN

The PSTN/ISDN is largely circuit switched. Public services currently offered on the PSTN using E.164 numbering are likely to continue largely unchanged for the indefinite future because they work well and are universal. In some cases circuit switches are being replaced by soft-switches with arrangements such as are shown in figure 2. A soft switch is a processor that handles call signalling and controls network access and gateways to other networks.
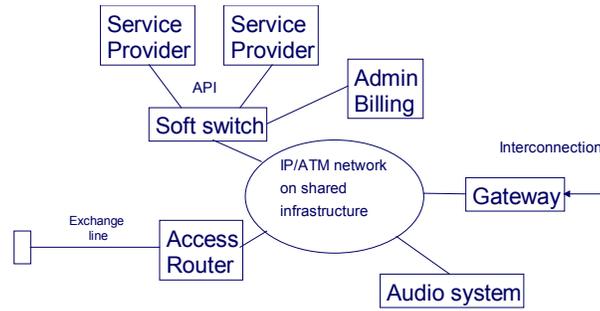
Figure 2: Network architecture for PSTN replacement

The main justification for replacing circuit switches with IP or ATM based switches[1] are cost savings primarily in operational expenditure since the capital expenditure has already been made. This justification will grow gradually if manufacturers fail to supply adequate spares and if the expertise for software modifications is dissipated, but relatively few modifications will be needed and the current circuit switches could remain in use for at least another 10 years, at least at the local level.

There are differing reports on the current scope for justifying replacement based on savings. Telecom Italia has recently announced widespread replacement of its transit and international network based on savings in operational expenditure mostly by reducing the number of switches. Many operators have been unable to justify any change but a growing number of operators are now planning to introduce packet switches (ATM or IP) in their transit network. In addition to reducing the number of overall transit switches, other potential benefits may include more efficient use of transmission capacity, integration of voice traffic with other traffic sources and more cost effective ways of implementing (long distance) leased line services.

Where extra capacity is needed, it is less likely that operators will buy new circuit switches and some manufactures may no longer be able to supply them, so they will buy softswitches instead. Since PSTN/ISDN traffic is static or falling (except for Internet access and some calls to non-geographic numbers) there should not be too much need for additional capacity.

The solution to the growing Internet access traffic is to introduce xDSL eg as ADSL and so remove this growing traffic from the local switches to separate packet infrastructures, eg ATM. Some telcos are now pushing ADSL very actively.

Where circuit switches are replaced by softswitches, the aim will be to make the PSTN services appear not to be changed. Thus the simplest solution will be to implement the No7 Signalling Protocols over IP with minimum changes. This means using ISUP or BICC or H.323 over IP, but not SIP. Manufacturers already are doing this for transit level switches but few if any have yet developed soft switches with the full capability of local exchange circuit switches, but this is expected to change.

At the international level, there are now several IP based networks that handle international traffic including traffic from incumbents and the entry into the market of these networks has helped to create an active market in international call minutes.

In summary the PSTN/ISDN is likely to stay largely unchanged at the local level with slowly declining traffic volumes and a slow migration to softswitches at the transit level. Changes in the PSTN/ISDN network structure are likely to affect interconnection arrangements and are discussed in chapter 5. The PSTN arrow in figure 1 shows the migration by a gradual change in colour.

---

[1] IP and ATM are not exact equivalents and there are several alternatives ways in which network architecture can be organised.

2.2   NGN

The term "NGN" is used here to describe the telcos' attempt to develop an IP-based platform for future services and includes developments such as the IP Multimedia platform in 3GPP and ETSI TIPHON. Thus it is the initial stage of implementation that is working towards what the ITU-T defines as the longer term goal for the "Next Generation Network (NGN)" and is the culmination of the work initially called the Global Information Infrastructure. In this report we use the term "NGN" to describe the shorter term developments that lead towards the ITU-T "NGN".

The telcos are particularly keen to develop a multi-service platform capable of supporting multi-media services and wish to allow separation between service or application creation and basic transport. The NGN concept continues the telco approach of closed networks where charges are mostly usage based.

SIP is currently the favourite protocol for these developments and work on SIP is being undertaken in 3GPP for its IP Multimedia Platform.

One of the problems with NGN is that few people have clear ideas of what services will be needed. This is one reason why the manufacturers are perusing an "open services environment", as no one is very sure about what to do. In some cases the telcos seem to be wanting to pursue technical competition in service creation, rather than standardisation and they are resisting suggestions of service standardisation in ETSI.

A vital question for NGN is whether in the nearer term it needs to include all or most of the PSTN functionality, or can develop separately and in parallel to the slow migration of the PSTN to IP. This is important because it determines the extent to which the NGN needs to take account of the special features of the PSTN, some of which are required by regulation. If the two will develop separately and in parallel then the NGN will not need to embrace the PSTN, although both will be supported on the same underlying infrastructure. This will simplify greatly the development of the NGN.

Figure 1 shows the NGN arrow growing from nothing to indicate its gradual implementation.

2.3   Corporate VPNs

This is currently the area where telco IP-based services are growing most rapidly. The VPNs provide:
- Internal voice communications
- External PSTN access
- Services exclusive to the customer that relate to their operations
- Internet access.

The needs for corporate and public telephony are similar technically to the provision of public telephony over IP, however the protocol is likely to be QSIG over IP since it will be necessary to provide a smooth transition for services from circuit switching to IP.

There is as yet little information about new NGN services other than ones that relate specifically to corporate operations.

Continued expansion of the VPN market is likely and it is also likely that there will be a demand for interconnection between the VPNs of different organisations. However this interconnection will only be of value where the "services" of both networks are similar at a technical level. This should be achievable for standardised services such as public telephony and its private counterpart. Where new NGN services have been developed such as video-telephony, interconnection between VPNs run by different telcos will be possible only if the "service" is similar at a technical level, which implies standardisation.

2.4   Internet

The public Internet is the third area of development. It is by definition an open services environment but the commercial arrangements are quite different from those of the NGN because the Internet provides a global platform with access paid largely by subscription.

The range of services available on the Internet is increasing and users are able to obtain services, including voice communications, at low or zero marginal price on the Internet that previously they had to pay usage based charges for to

the telcos. Thus the fixed telcos are facing a steady migration of traffic away towards the Internet and also to mobile networks.

The Internet model represents a major threat to the traffic related revenue of the telcos because the marginal costs of using the Internet are low or zero for many users who have already obtained the necessary equipment such as a PC.

Table 1 compares the "closed" telco networks with the "open" Internet. The most important difference is that the telco networks are aware of both the services that they are carrying and the users for whom they are carrying them, and are responding in different ways (eg charging) to this information, whereas the Internet is just transporting packets without this awareness.

Current telco networks closed	Telco NGN networks -closed	Internet - open
• Circuit switched technology • Intelligent network • Dumb terminal • User-user services centrally controlled by provider of transport service • Usage related charges and quality control • Access control for users and interconnection • Interconnection is service related and controlled • Few/no third party services	• ATM/IP based technology • Less intelligent network • More intelligent terminal • User-user services centrally controlled, with much greater scope for third party services run via APIs • Usage related charges and quality control • Access control for users and interconnection • Interconnection may occur at various levels. Above the IP level it is likely to be service related and controlled	• IP based technology • Dumb network • Intelligent terminal • No service creation - services and applications run from edge • User-user services run by users themselves • Client-host services run by independent hosts at edge • Access control for users but otherwise open • Interconnection is open and only at IP level • No usage-related charges and little quality control • Gateways to telco networks have control and charging

Table 1: Comparison of telco networks and the Internet

The distinctions are illustrated in Figure 3, which compares the telco concept of the next generation network with the Internet.
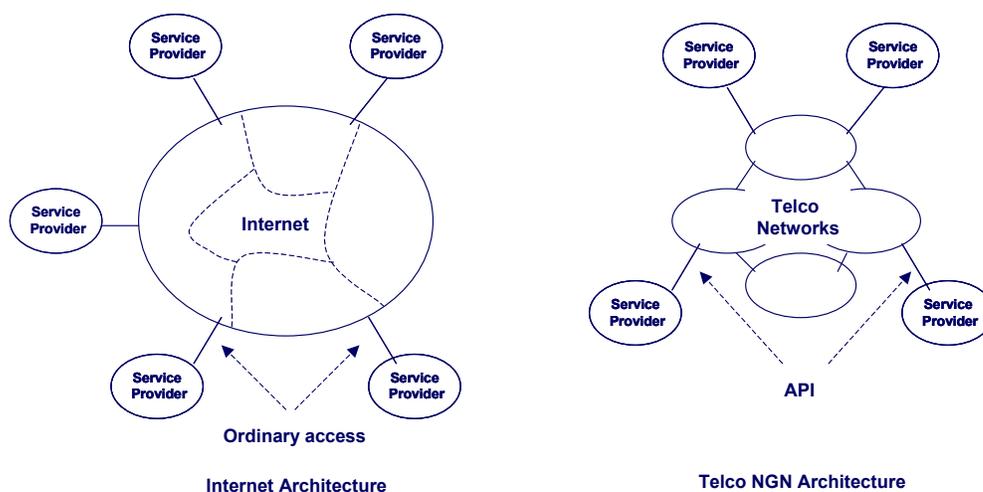
Figure 3: Comparison of telco NGN architecture and the Internet

2.5   Voice traffic

The telcos are heavily involved in the support of the Internet in that they supply the basic transmission facilities and dial-up access and in many cases also have large businesses as ISPs, and therefore the growth of the Internet is not wholly a commercial threat. Their main risk, however, is the loss of revenue from usage based voice traffic, which is typically some three times that for access line rental.

Voice traffic can be subdivided into three categories:
- Repeat calls to same people (family, friends, colleagues). This is the largest category. Some of this traffic is already carried on corporate networks. This category is also the one best suited to new applications on the Internet such as the voice part of the relatively new Instant Messenger services;
- Calls to Government, shops, services, schools. This will be a major application for click to talk services as call centres develop Internet access;
- "Random other calls". These calls are likely to remain served by the PSTN.

Figure 4 shows where voice traffic that has hitherto been carried on the fixed PSTN is migrating. The migrations are:
- Slow but accelerating substitution by mobile networks. An increasing number of customers no longer bother to have fixed lines and rely wholly on mobiles;
- Substitution of some short non-urgent calls by text messaging using either email or SMS;
- A slow substitutionary migration of traffic to the public Internet and corporate VPNs. This traffic is mainly frequent calls between the same small group of people (eg teams at work or distant family members) and calls to organisations where "click-to-talk" is provided from their web pages.
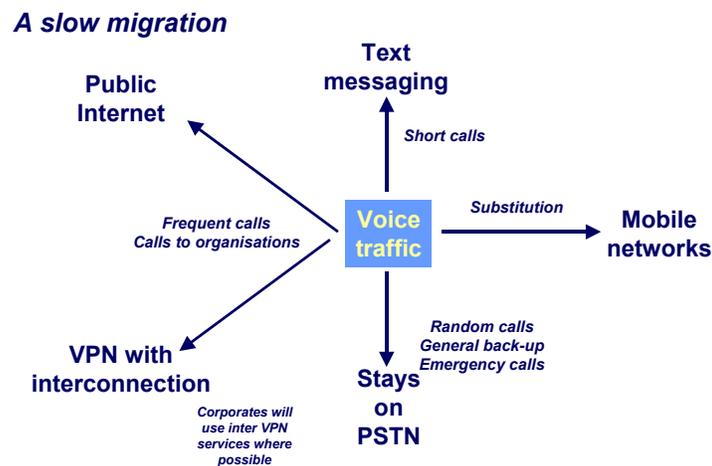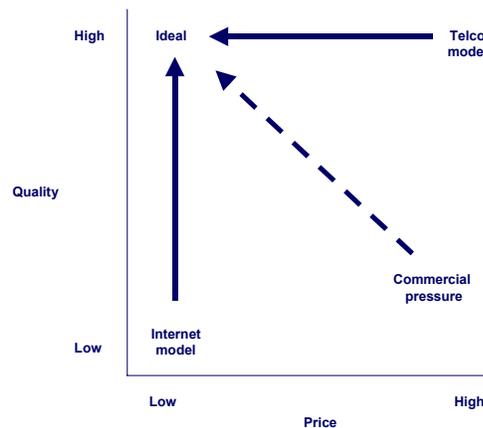

Figure 4: Migration of voice traffic

Figure 5 shows the differences in market pressure between the telcos and the Internet. The main issue for the telcos is price, the main issue for the Internet world is quality.

Figure 5: Market pressures

Three main issues are slowing the migration of voice traffic to the public Internet:
- Transmission quality
- Ease of use
- Blocking by NATs and firewalls.

At present most of the codecs used in VoIP were designed for circuit switched applications and are badly affected by the packet loss that occurs on congested IP-based networks, however new codecs designed to tolerate packet loss are becoming available and are expected to provide adequate quality even over the Internet.

Ease of use will then remain the critical factor. Voice communications over the Internet at present depend on services such as Instant Messenger to overcome the problem of dynamic assignment of IP addresses. This creates two problems:
- There are different proprietary solutions (eg Microsoft, AOL and Yahoo) which results in users having to register with multiple systems, which is not popular. (Interestingly this is the same problem that will be created by the competition in services that the telcos now seem to favour.);
- The call set-up arrangements of Instant messaging is not as quite simple as making an ordinary telephone call.

Dynamic assignment of IP addresses is likely to remain common for the next few years although it might reduce if there is rapid adoption of IPv6, but this seems unlikely.

The ease of use needs to be improved by better software but Microsoft is planning to introduce better user interfaces as part of Windows during the next two years.

In most cases, voice communications over the Internet are blocked by firewalls and Network Address Translators (NATs). Some of the causes of blocking are can be solved by changing the policy of the relevant IT Departments, but voice communications cannot currently traverse NATs because the NAT cannot be made to translate IP addresses and port numbers for the media streams as well as the signalling. There are various activities that aim to solve this problem and substantial progress is expected during 2003.

Other developments that facilitate the migration of voice to the Internet are:
- The growing popularity of broadband Internet access with always-on capabilities. Ironically this means that if telcos accelerate the roll-out of broadband access they may facilitate the loss of some voice traffic revenue.
- Growth in the use of LANs in the home, whether wireless LANs or hardwired ones. LANs are being sold in some DIY stores in some countries.

The main development that is likely to deter the migration of voice to the Internet is the introduction of flat rate tariffs by the telcos. Such tariffs are becoming more common, whether for the whole day or just for off-peak times, and they remove the cost saving incentive of using the Internet. Users seem to like flat rate tariffs because they are less vulnerable to unexpectedly high bills. Flat rate tariffs also help the telcos to reduce their costs in handling customer complaints.

The overall conclusion is that voice traffic, which has limited potential growth capability within Europe, will continue to migrate away from the fixed networks to mobile networks and to VPNs and the Internet. The migration to the Internet is likely to gather pace from late 2003 as the problems of traversing NATs are solved and new facilities in PC operating systems make PC based voice communications more user friendly.

This migration of voice traffic is unlikely to reduce the demand for fixed access including access to the PSTN greatly as most smaller premises will require Internet access via ADSL or newer technologies and most users will wish to continue to have access to public telephony both for any-any connectivity and for use when other forms of communication fail.

3   COMPETITION BETWEEN NGN AND THE INTERNET

3.1   NGN Developments

Whilst there is a clear case for migrating private and corporate networks to an IP platform to provide integrated voice and data, there is not a clear economic case for doing so for public networks. Several operators have undertaken studies of the economic benefits of replacing circuit switched networks with IP based NGNs but have found that the benefits do not outweigh the costs but other operators such as Telcom Italia are embarking on replacement programmes.

The fundamental problem for fixed network operators is that traffic levels are flat or decreasing slightly for almost all traffic other than dial-up Internet traffic. The strategy of removing Internet access traffic as early as possible onto a separate network platform and leaving the circuit switched network in place therefore seems increasingly attractive and is likely to remain attractive until the maintenance costs of the circuit switches and concentrators becomes too high. This problem may occur earlier than "necessary" since many manufacturers have ceased, perhaps prematurely, manufacturing spares for this technology. Notwithstanding this, it is unlikely that a clear case will emerge for replacing circuit switches within the next 4-5 years. IP based infrastructure will therefore be rolled-out in parallel as an overlay network to serve:
- New developments
- Areas where high population growth cannot be served by the existing switches
- Customers who specifically need NGNs.

Two of the hopes of the telcos are that:
- Users will want to continue to have "guaranteed quality"
- Service providers will pay to host services on the new telco NGN platforms.

It is not clear whether these hopes will come to fruition. Adequate quality for a high proportion of cases may prove sufficient for most customers, and innovators of new services may prefer to use the Internet and gain global reach to prospective customers at the price of basic access rather than enter special arrangements with telcos whose history of helping third party service development in the IN era was disappointing.

Within ETSI the support of TIPHON has reduced significantly and there are few signs that manufacturers are implementing the standards yet[2].

3.2   Internet Developments

The critical question for the Internet is whether quality will continue to increase or whether it is currently at its peak, due to excessive "dot-com" investments, and will deteriorate in the future. The trend for increasing dependence on the Internet suggests that people will if necessary be willing to pay more overall for Internet access and so quality can be sustained or improved. In practice it seems that a large proportion of the costs are in the access arrangements and several countries are seeing quite high levels of demand for ADSL access which indicates willingness to pay more for better quality. The fact that most of the bottlenecks are in the access means that it should be possible to achieve a fairly direct relationship between subscription levels and quality, giving the right economic signals to the market.

One of the main methods to improve Internet quality is to segregate traffic of different types (packet length and delay sensitivity) onto different virtual networks so that they queue separately for routers and some priority can be given to delay sensitive traffic. Techniques for such segregation have been developed (eg diffserv) and may be introduced in the future.

---

[2] Most examples of the use of TIPHON standards relate to the OSP protocol for billing and clearing house services, which was developed outside TIPHON and presented to ETSI for re-publication.

3.3 Hybrid developments

There is a great deal of activity in hybrid PSTN-Internet services mostly from smaller new entrant operators. The main businesses established so far are Internet based services for PSTN break-out that enable users with Internet access to make long distance and international phone calls at reduced rates, especially into countries with high termination rates.

A group of operators called VisionNG are establishing a service for users with laptops to have both incoming and outgoing calls from Internet connections. They will be allocated numbers from the global code +878 10. Some of the technology developed is a spin-off from TIPHON.

Other potential developments are linkages between ISPs and local exchanges so that Internet users on dial-up access can be warned on incoming telephone calls and either clear to receive them or receive them on their Internet access.

In general the hybrid developments are either specialist services or short term bypass services that will decline when better Internet access is available for more people.

3.4 Parallel operation

Possibly the most likely outcome is that both the Internet and telco NGN platforms develop in parallel but with the NGN platforms for the PSTN developing slowly. It is not at all clear how quickly the Internet will take traffic from the PSTN because it is not clear how rapidly the ease of use and NATs problems of voice over the Internet will be solved. It is also unclear how rapidly new NGN services will develop (see next section).

Computer based systems for voice over the Internet are unlikely to reach the levels of reliability of the PSTN for a long time and many customers may choose to retain their traditional PSTN connections for use when the PC or LAN crashes, even when they use the Internet for most of their voice traffic. This combination could be the "best of both worlds".

One serious possibility is that telcos who have a large share of the Internet access market could degrade the quality of Internet access so that real-time services and applications do not work adequately over the Internet and therefore try to retain voice traffic on the PSTN for longer and improve the prospects for NGNs.

4 NGN SERVICES

The telcos and their suppliers who are supporting NGN developments, whether fixed or mobile, are planning to promote technical competition in the development of new services rather than the standardisation of new services. Figure 6 shows the architecture planned. This approach applies to both mobile (eg 3GPP IP Multimedia) and fixed networks (eg TIPHON).
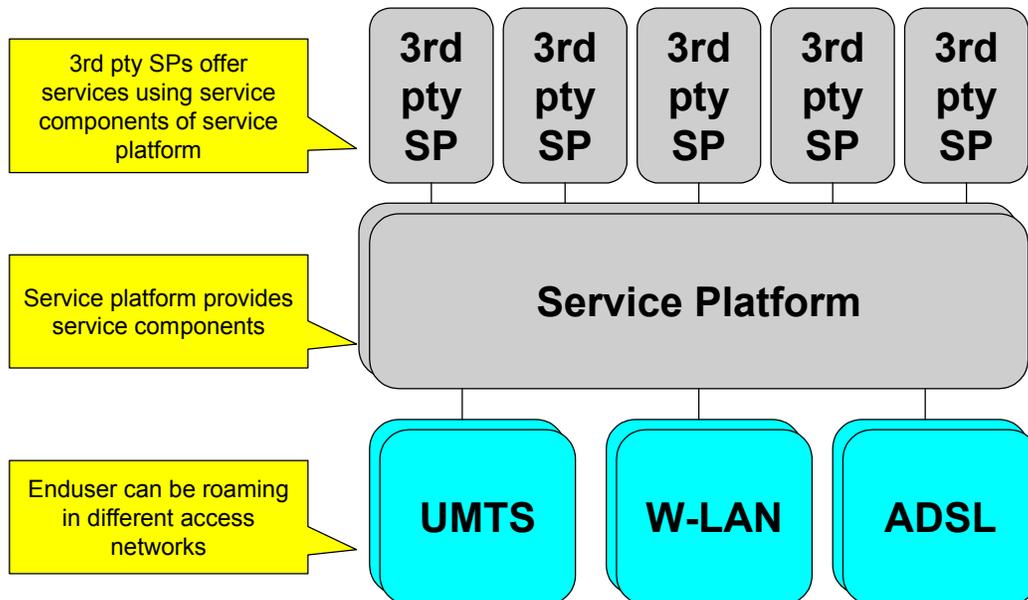

Figure 6: Architecture of NGNs

The intention of the development work is that the network operators will be able to provide a general purpose service platform for the creation of innovative services by themselves and third parties, and that the service platforms and third party service providers will be able to charge customers on a usage basis. Various forms of access will be possible and the diagram shows examples of common forms.

The service providers will innovate in service creation and place contracts with service platforms for connectivity. This approach raises several issues:

- Network operators were unwilling to promote third party service creation in the ISDN-IN era and have not yet demonstrated in practice a willingness not to favour their own vertically integrated services;
- Service providers, in many cases, will have to negotiate connectivity agreements with the platforms of many different operators if they are to have wide coverage for their services and to have usage based billing;
- Where new client-client services are provided, communications will only be possible between the customers of the same service provider unless different service providers cooperate to offer the same technical service.

It is far from clear how these developments will work out. There is a huge advantage in having a standardised service with standardised UNI and NNI interfaces for public services and also for any "private services" that could be interconnected on VPNs. The standardised UNI interface creates a large independent terminal market, and the standardised NNI provides easy any-any interconnectivity between the customers of different service providers and facilitates the development of comparable Reference Interconnection Offers. Standardisation of these interfaces does not inhibit the development of new features that exist wholly within a terminal or wholly within a network.

The success of competitive service innovation compared to the standardisation route will depend on:

- The extent to which better technical characteristics in a particular service influence the choice of service provider when most customers take many or all services from the same provider;
- The extent to which customers find that the loss of an any-any capability is a disadvantage when communications are possible only between customers of the same service provider. In other words, how well do the informal groups whose communications account for probably the majority of each persons communications map to the choice of service provider?
- The effect of competition from similar services on the Internet which may not have the same constraints.

Figure 7 shows some of the possible developments for new services and their dependence on the main key issues.
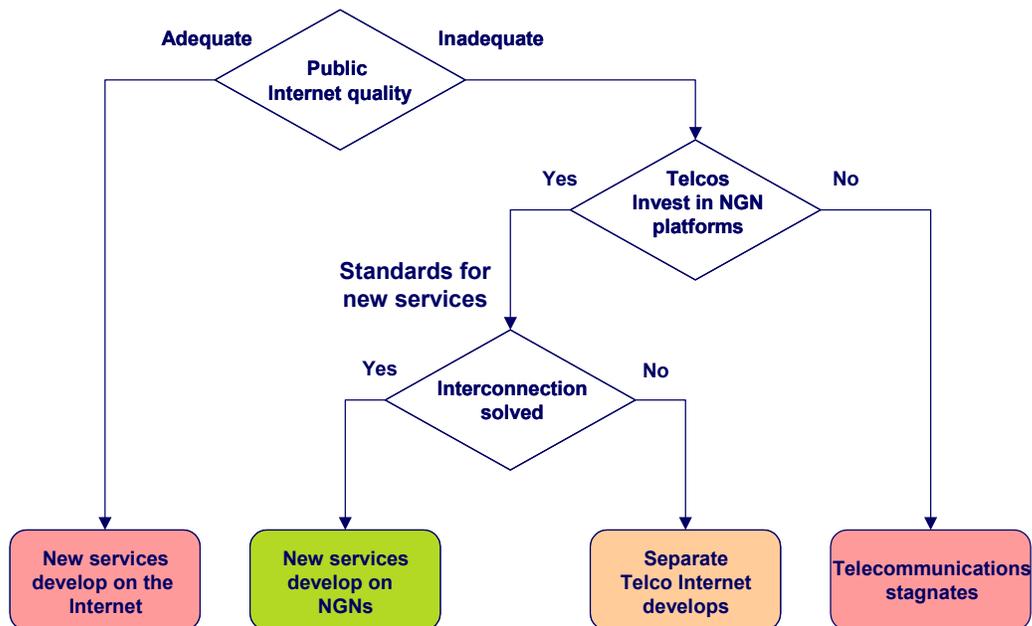
Figure 7: Possible developments

Probably the main issue is whether the public Internet satisfies the quality requirements for new services. If it proves adequate for new services, then service innovation is likely to take place on the Internet and the market for those services could develop as shown in figure 8.
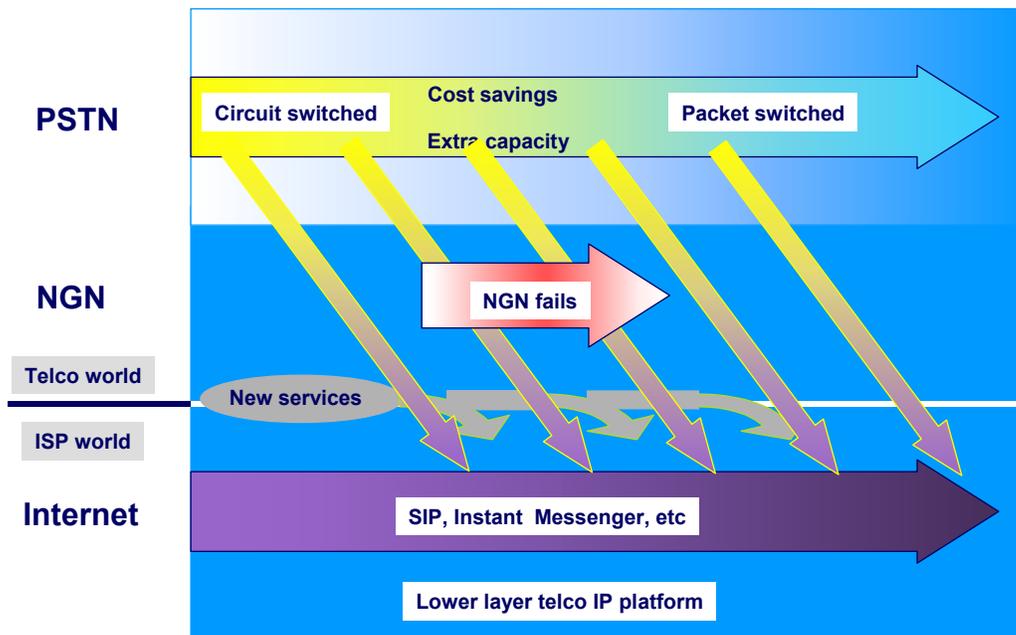
Figure 8: Market development if the quality on the Internet is adequate for new services

However, if the public Internet does not provide sufficient quality for most new services, then the telcos will have more incentive to invest in NGN platforms. If the new services start to develop on the NGN platforms then the main issues will be coverage and interconnectivity. If they are solved then the current telco NGN model will prevail. If they are not solved then the telcos may have to offer an open platform of higher quality than the public Internet, ie an "Internet Mark 2" with higher access charges and higher charges for attaching service but without usage based charging to simplify interconnectivity.

5   INTERCONNECTION

Figure 9 shows a general diagram of interconnection between the different types of players:
- PSTN providers
- VPN providers
- Internet service providers (ISPs) who provide access to the Internet
- Internet backbone providers
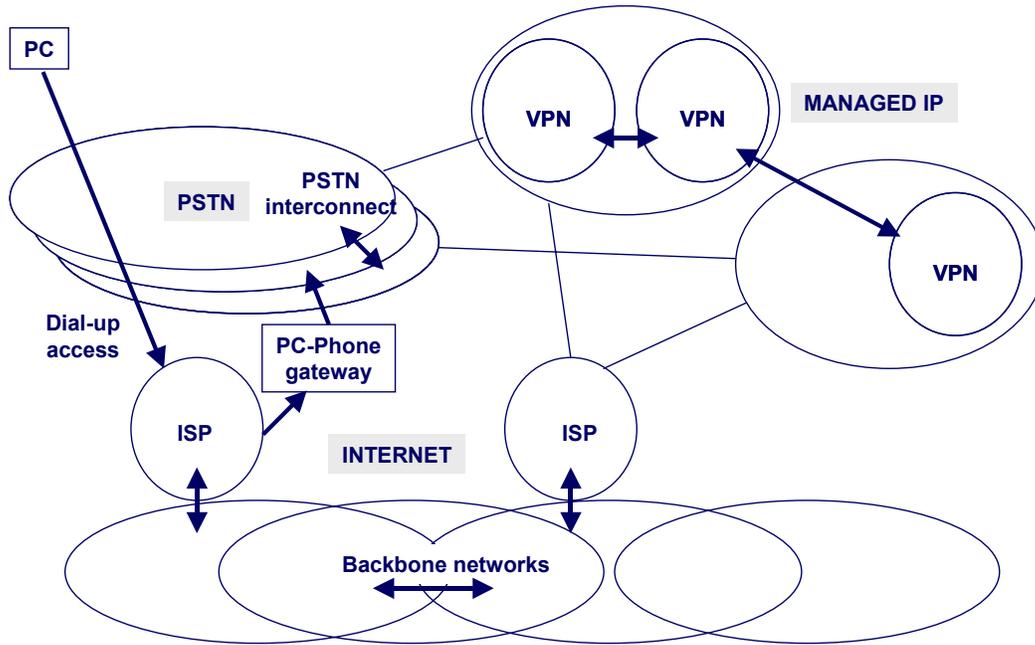
Figure 9: Interconnection

Although the diagram shows PSTN, VPN and Internet as separate networks, they are likely all to use the same transmission infrastructure and many incumbent operators are active in all three markets. The lower layer infrastructures are partitioned into:
- PSTN
- Managed IP with other protocols eg SIP
- Public Internet

Figure 10 shows the different interconnection scenarios at a technical level. There are two types of interconnection:

- Service level, where the interconnection supports specific services only together with time and usage related billing (note: capacity rather than usage related billing is being introduced in Spain);
- Network level, where the interconnection is open at the service level and peering or very simple capacity related billing applies.

Service layer Service level interconnection	Service control (closed)			User defined (open)
Network layer Network level interconnection	Circuit switched	Managed IP	ATM	IP (Internet)
	Telco NGN world			Internet world

Figure 10: Interconnection types

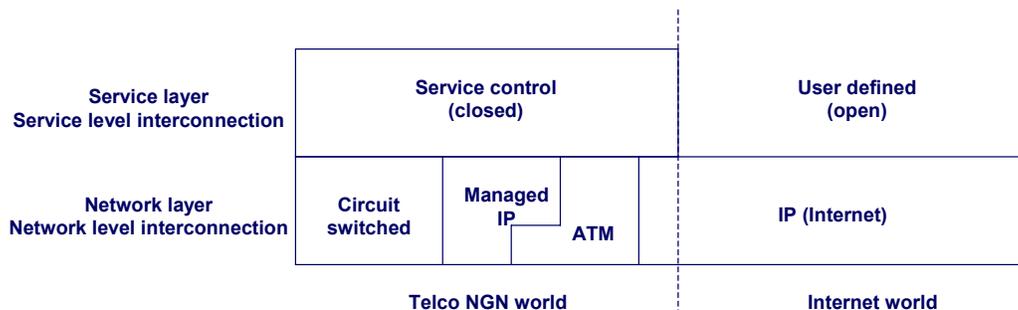Network level IP-based interconnection already exists between ISPs and the Internet backbone and within the Internet backbone. This will continue to grow with the Internet but is unlikely to change much.

Interconnection to support PSTN voice is currently circuit switched. Where IP or the Internet is used for PSTN access via a gateway, the connection of the gateway to the PSTN is circuit switched. Where telcos introduce IP or ATM to replace circuit switched technology, they are unlikely to move to IP or ATM based interconnection until a significant number of other operators will interconnect using the same technology. Thus IP interconnection is likely to lag behind the migration of the PSTN to IP, but the traditional E1 (2 Mbit/s) interconnection interfaces for telephony are now beginning to be supplemented by high capacity interconnection interfaces e.g. STM-1 (TDM or ATM based). The introduction of packet switched systems in the transit network may also affect the number and topology of available POI (points-of - interconnect).

Where IP is used for the support of corporate VPNs, which are growing rapidly, there will be an increasing incentive to interconnect the VPN infrastructures directly at the IP level to avoid passing traffic to the PSTN. The traffic quality will benefit from avoiding multiple changes in technology. This form of interconnection has not started yet but could grow rapidly. Telcos with VPN platforms could decide to introduce a form of peering to reduce or remove the costs of interconnection billing.

6   POLICY ISSUES AND THE NEW REGULATORY FRAMEWORK

6.1   Introduction

The development of NGNs and the migration in technology towards IP, with their increasing separation of the roles of:
- service provider
- service platform provider (core network operator)
- access network operator.

is coinciding with the change to the new regulatory framework. Regulators are therefore having to re-assess their roles and decide how to handle the greater flexibility of the new framework.

The separation of roles in the developing NGN mirrors the separation of roles that already exists in the Internet. The difference is that in the telco model it is expected that there will be interconnection contracts that relate to specific services between the different parties. Figure 11 compares and contrasts the relationships in the two cases. Red shading denotes that a service specific relationship is the norm. Orange shading denotes the possibility of a service specific relationship. No shading denotes a general purpose relationship not linked to any specific service or application.
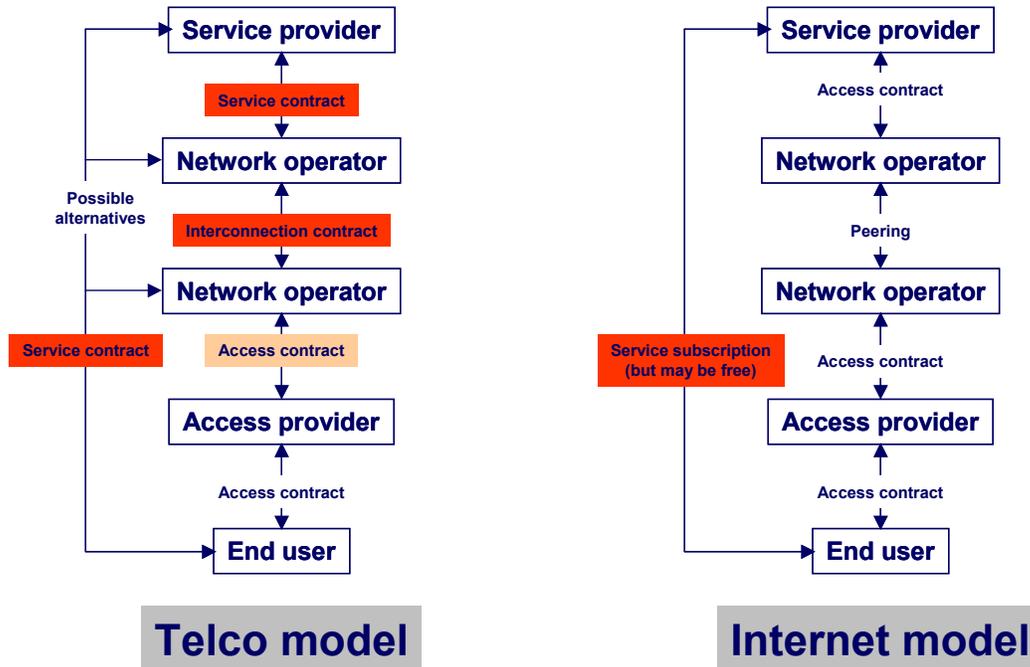
Figure 11: Comparison of relationships in the telco and Internet models

The new framework does not introduce an abrupt change to the regulations concerning interconnection and universal service but provides flexibility for a longer term movement from regulation to competition and gives more scope for not imposing regulatory obligations on operators and service providers who do not have significant market power. However, the new framework still recognizes the capability for NRAs to impose, when appropriate, obligations to any undertaking providing electronic communication services, on grounds of the general policy objectives listed in article 8 of the framework directive (see Annex 1).

These powers are mainly recognised in the Authorisation Directive (article 6, see Annex 1) and in the Universal Service Directive (Articles 20 to 31) where a number of specific conditions that can be attached to general authorisations are listed. Additionally, Access Directive's article 5 considers the possibility to impose specific access and interconnection conditions on any undertaking, in particular (but not exclusively) to the extent that is necessary to ensure end-to-end connectivity to end users.

The new framework is primarily concerned with the provision of "electronic communications services". This approach fits readily to the traditional style of telco service, but, if the analysis provided in this report is correct, there will be a migration of traffic from the traditional telco infrastructures, which provide both the requested services and the appropriate transport capacities, to the Internet where little more than transmission capacity is offered and there may be no third party service provided at all, since instead users can run their own applications end-end over the Internet (ie create their own self provided services). In some cases, these applications may be run purely user-user without any third party, but in practice at present, because of the problem of dynamic assignment of IP addresses, most applications are dependent on some common function for discovering the current IP address/port number combination of the desired correspondent. These common functions are run from the edge of the networks without the detailed knowledge of the network operator.

In regulatory terms, the self provision of services should not be a problem as users will naturally look after their own interests. The self provision of services may be an area where there will be increasing issues of competition law issues in terms of the equipment or software that they use and the potential leveraging of market power from consumer hardware or software products (e.g. operating systems such as Windows) to provide end-user applications that substitute for conventional telecommunication services provision.

As an example, the absence of explicit payment for some key functions that are attached to the edge of the Internet such as Instant Messenger Services may create special problems. Instant Messenger Services are not standardised and so, in principle, are not interoperable. They consist of specific "free" downloaded client software and some central functions operated by Microsoft and other providers (eg Yahoo and AOL). Both the client software and the central functions are provided without any explicit charge, which means in effect that they are bundled with other services or goods or cross

subsidised. For example Microsoft's Instant Messenger service is provided free and cross subsidised, we presume, from Microsoft software sales.

Microsoft is developing its Instant Messenger Service steadily and it may become the enabler of the majority of voice based real-time communications over the Internet with volumes that eventually are comparable with those on the fixed telephone networks of the telcos. Thus it would attain significant market power but there would be no "market" in the traditional sense since there is no explicit payment for the service.

In this case, although the concept of market power (see Framework Directive Article 14.2 reproduced in Annex 1) would still be applicable, there could be difficulties in identifying the relevant market and the corresponding measures to be taken, because in this case the offer involves a combination of user software and centralized addressing capabilities that, together with transmission capacity obtained by end-users from third parties, act as a substitute of a conventional telco service.

In spite of all the difficulties related to the nature of the services provided over the Internet, NRAs are clearly entitled to intervene with the aim of achieving the general policy objectives. This intervention may come from ex ante regulation, through obligations imposed to all the undertakings, or through specific obligations to those operators having SMP in a given market. The other way is the application of ex post competition regulation when an abuse of dominant position has been identified.

Another aspect of the Internet is that services, whether paid for or not, can be provided from anywhere in the world and so services to users in Europe may be provided from outside European jurisdiction. This could open a number of concerns, both of economic or competition nature (e.g. related to the possibility to declare that a provider has SMP, although this provider's infrastructure is located outside Europe) but also on horizontal issues like lawful interception or data protection. Under these situations, it would be logical for the NRAs to focus on the geographical area where services are offered or provided rather than on the location of the service provider's equipment.

In general the primary issues that regulators are facing are:

- Does the legal structure of the requirements handle adequately the way in which services will be provided?
- Will the approach to competition in the technical characteristics of services produce the degree of interoperability that is required to be promoted by the Directives and that is in the interests of users?
- Will the approach to competition in the technical characteristics of services produce adequate interoperability and economies of scale in the terminal market?
- How does the concept of universal service apply when the market is structured with separate service providers, and core and access network operators, and when it can no longer be assumed that all services can be reached by all access networks?
- How is the concept of significant market power to be applied in this new market structure?
- How will the technology changes and the migration of traffic away from the PSTN change the cost basis for many of the determinations made by regulators?

Oftel has already considered some of these issues and published its views in a document "Imposing access obligations under the new EU Directives" (See http://www.oftel.gov.uk/publications/ind_guidelines/acce0902.htm) but this document does not cover all the issues considered in this report.

The figure 12 is used in the subsequent analysis and discussion.

```
                    ┌─────────────────┐
                    │ Service Provider│
                    │      SP-1       │
                    └────────┬────────┘
                             │
                             │
┌─────────────────┐ ┌────────┴────────┐ ┌─────────────────┐
│ Service Platform│ │ Service Platform│ │ Service Platform│
│    (network)    ├─┤    (network)    ├─┤    (network)    │
│        A        │ │        B        │ │        C        │
└─────────────────┘ └─────────────────┘ └────────┬────────┘
                                                  │
                                        ┌─────────┴───────┐
                                        │  Access network │
                                        │       AN-1      │
                                        └─────────┬───────┘
                                                  │
                                          ---- ┼ ----   NTP
                                                  │
                                        ┌─────────┴───────┐  Terminal
                                        │                 │  equipment
                                        └─────────────────┘
```
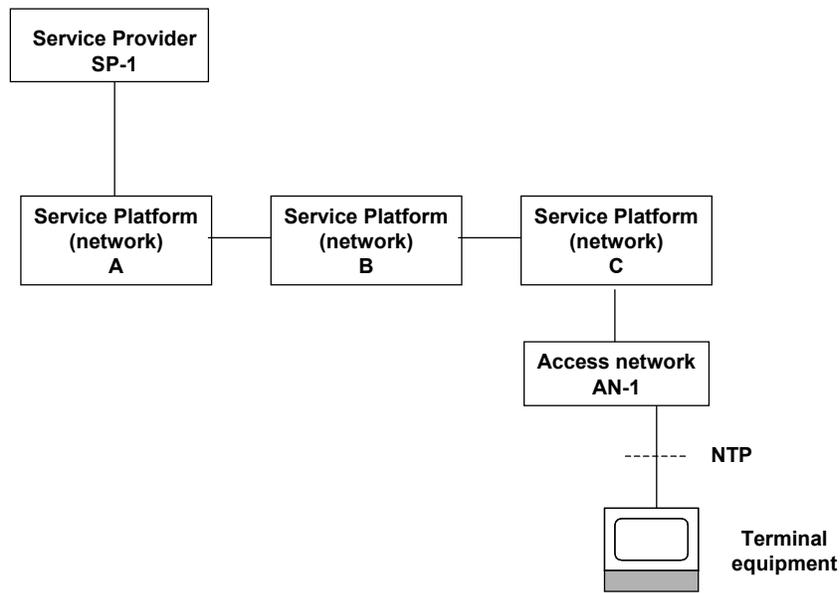
Figure 12: Service provision over interconnected networks

6.2   Structure of service provision and requirements

The structure of service provision is shown in figure 12. The service provider may not run a network at all but may simply run a computer system that controls the service via an API. The service provider may be located anywhere in the world and be remote from the network platforms on which access to the service is provided. The access network operator may be separate from the provider of the service platform.

In the case of telco networks, the provider of the service platform may know something about the services provided over the API.

In the case of the Internet, the Internet backbone provider is likely to know nothing of the services carried.

In both cases the access network provider may know nothing about the services provided.

The service provider may not be in the same country as the NTP and may be wholly outside the jurisdiction of the Member State concerned or even outside the EU and so outside any equivalent legislation.

In conclusion, the structure of service provision has changed substantially. Regulations aimed at the provision of electronic communications services may not address all aspects of the way in which service provision occurs on telco NGNs or the Internet, since the platform that conveys the messages may not control the service. The following issues are identified:

Issue 1: Undertakings located wholly outside Europe may achieve significant market power in the provision of electronic communications services within Europe, yet be outside European jurisdiction. This may be a problem in principle with the national or regional legislation when services are provided globally.

Issue 2: Undertakings located wholly within one Member State may achieve significant market power in the provision of electronic services within another Member State, yet because the Directives are transposed into national legislation and do not themselves have the status of European law the NRA in the Member State where the services are provided may have no direct control over the undertaking that provides the service. Article 21 of the Framework Directive provides for cooperation between NRAs but it s not clear whether this will resolve all the relevant legal issues.

Issue 3: The decoupling of services from networks and access is more complete on the Internet than it may be on NGNs, therefore if any NRAs find ways to exercise controls on services on NGNs they may not find equivalent ways on the Internet and so the implementations of the directives will not be technologically neutral.

6.3   Interoperability of services

The support of technological competition rather than standardisation in the development of new electronic services will lead to a situation where the customers of SP-1 may not be able to communicate for the new service with the customers of SP-2. This situation is already developing with proprietary Instant Messenger services with the disutility for the customer of having to subscribe to several different but similar services to communicate with all their wanted correspondents. Thus the lack of standardisation in new services is not promoting the interoperability of services that is called for in Article 5.1 of the access and interconnection directive:

"1. National regulatory authorities shall, acting in pursuit of the objectives set out in Article 8 of Directive 2002/21/EC (Framework Directive), encourage and where appropriate ensure, in accordance with the provisions of this Directive, adequate access and interconnection, and interoperability of services, exercising their responsibility in a way that promotes efficiency, sustainable competition, and gives the maximum benefit to end-users."

Issue 4: The approach of technological competition in new services will make the interoperability of services more difficult to achieve.

There is no simple solution to this situation, since there is little consensus on the new services that are needed. This means that regulators will have to observe the market and when necessary try to force service providers with significant market power to publish their specifications, but this will be a very difficult task.

Even where there are standards that can support the interoperability of services, service providers may decide not to interconnect their services. The access and interconnection directive, however, contains powers to require interconnection in these circumstances.

The Framework Directive clearly says that Member States shall encourage the use of standards, and that there may be situations where the implementation of standards listed in the Official Journal may be made compulsory, to ensure interoperability and to improve freedom of choice for users (see Article 17).

6.4   Interoperability with terminal equipment

The R&TTE Directive Article 4.2 requires the publication of information about the interface at the network termination point " in sufficient detail to permit the design of telecommunications terminal equipment capable of utilising all services provided through the corresponding interface". (See Annex 1 for full text)

This requirement applies to the access network since the access network provides the network termination point. Whilst AN-1 may provide and specify its own interfaces at the lower layers, it may not be in a position to specify the upper layers of the interface and the protocol used by the service. In the case of the Internet, any service may be provided at the network termination point. In the case of telco networks where the service platform is provided by the same operator as the network access there may be more knowledge about the service. Thus the application of this part of the R&TTE Directive appears to be a problem because of the separation of access, networks and services.

The main concern behind the requirement for the publication of information, however, is the possibility of access networks with significant market power also dominating the terminal market. This problem can also arise where the access network operator and the service provider are separate. A service provider may wish to dominate the market for compatible software to be loaded into terminals and thus may keep the details of the service protocol confidential. If the service provider is separate from the access provider then the service provider appears to escape the requirements of the R&TTE Directive.

Issue 5: The requirement in the R&TTE Directive for the publication of interface specifications does not fit clearly the separation of services from networks and access

In the longer term there may be a significant change in the nature of terminal equipment with terminal equipment becoming a less intelligent general purpose platform with its own API that can be used by service specfic non-standardised software downloaded from service providers.

6.5   Universal service

The aim of the universal service directive is to ensure the availability of connection to the public telephone network for access to publicly available telephone services including the capability of functional Internet access. The Internet access is dial-up access and excludes broadband, however there is flexibility to revise the scope after a formal review.

The general approach to universal service is compatible with the expected market developments, especially the continued operation of the PSTN in parallel with the Internet and possibly the telco NGNs. The new services provided on the Internet and telco NGNs are outside the scope of the requirements. Since the PSTN is expected to continue in parallel with new developments and remain universal, emergency organisations can continue to use it as the primary method for the public to contact them.

At some stage it may be appropriate to add broadband access to the scope of the requirements.

6.6   Significant market power

The application of many of the requirements in the new Directives depends on the existence of significant market power. Article 14.2 states that:

"2. An undertaking shall be deemed to have significant market power if, either individually or jointly with others, it enjoys a position equivalent to dominance, that is to say a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers and ultimately consumers."

Apart from the problem of defining the threshold of "*to an appreciable extent* ", there will be difficulties in deciding how to apply this criterion when services are provided in the way shown in figure 10.

The way in which NGN will lead to multi-service networks replacing single purpose networks will make it more difficult to define the relevant markets as the analysis of the substitution effect on the supply side may be quite complex to evaluate.

6.7   Cost based determinations

The migration of voice traffic away from the circuit switched telco networks will change the basis on which their costs are shared and therefore regulators may need to revise determinations based on costs such as the interconnection price determinations.

The introduction of multi-service networks will also make cost allocation more difficult.

6.8   Support of law enforcement

Various provision for lawful interception and access are implemented through contacts between network operators and law enforcement agencies and are based on the assumption that the operator is the service provider. The increasing separation of roles will lead to a need for these arrangements to be reviewed and revised.

6.9   Support of emergency communications

The current generation of networks supports priority access to emergency services and some networks support priority communications between emergency services. Studies (eg EMTEL work in ETSI) have been initiated recently on the support and further enhancement of these facilities in future networks. Requirements, for example, for forwarding user information to emergency services will be affected by the separation of networks and service providers.

7   CONCLUSIONS

The overall conclusions are as follows:

1 - There seems to be little clear "vision" about NGNs amongst the telcos, and there does not seem to be a strong economic case for replacing the circuit networks with an IP-based infrastructure although some operators are replacing and restructuring their transit networks with IP or ATM based technology.

2 - Voice communications are starting to migrate away from the PSTN and the migration onto the Internet will probably gather pace.

3 - The main barriers to the growth of voice communications over the Internet relate to ease of use and blocking of the media channels by NATs. It is not clear how quickly these barriers will be overcome but late 2003 – 2004 is the current expectation. Voice quality problems are likely to be overcome soon by the adoption of codecs that are tolerant to packet loss.

4 - If the Internet proves capable of providing adequate quality for real-time communications then it will have a profound impact on the revenues of the telcos and undermine the justification of investment in telco NGNs.

5 - The circuit switched PSTN is likely to remain for a long time but with a reducing traffic load. Its reliability makes it the network of last resort when problems are experienced on the newer networks. Thus the focus of the universal service obligations on the circuit switched PSTN will continue to be appropriate for the foreseeable future.

6 - The separation of service, network and access provision that is being promoted at technical level in NGN standardisation will make the application of the new regulatory framework much more difficult and lead to the increasing offering of services from one location to users anywhere in the world. Regional and national legislation may have difficulty in applying requirements to service providers in this environment.

7 – The development of new services on a competitive and proprietary basis will reduce the interoperability of services and users may increasingly have to subscribe to multiple similar services to obtain the desired capability of communicating with all their correspondents.

8 - If the telcos continue to use the traditional model of a "closed" network for the NGN backbone then the interconnection arrangements needs to support new services may become too complex to administer and the situation may be self defeating and lead to the telcos adopting the Internet model for the backbone.

9 - There is a serious possibility that telcos who have a large share of the Internet access market could degrade the quality of Internet access so that real-time services and applications do not work adequately over the Internet and thereby try to retain voice traffic on the PSTN for longer and improve the prospects for NGNs. Regulators need to give careful consideration to the quality issues for Internet access, eg ADSL contention ratios, and appropriate QoS parameters need to be defined.

10 – The changes in network and service provision will affect terminals, which will increasingly become general purpose processor based platforms offering APIs for use by software downloaded from service providers.

ANNEX A: RELEVANT EXTRACTS FROM THE NEW FRAMEWORK DIRECTIVES

FRAMEWORK DIRECTIVE

Article 8 Policy objectives and regulatory principles

1. Member States shall ensure that in carrying out the regulatory tasks specified in this Directive and the Specific Directives, the national regulatory authorities take all reasonable measures which are aimed at achieving the objectives set out in paragraphs 2, 3 and 4. Such measures shall be proportionate to those objectives.

Member States shall ensure that in carrying out the regulatory tasks specified in this Directive and the Specific Directives, in particular those designed to ensure effective competition, national regulatory authorities take the utmost account of the desirability of making regulations technologically neutral.

National regulatory authorities may contribute within their competencies to ensuring the implementation of policies aimed at the promotion of cultural and linguistic diversity, as well as media pluralism.

2. The national regulatory authorities shall promote competition in the provision of electronic communications networks, electronic communications services and associated facilities and services by inter alia:

(a) ensuring that users, including disabled users, derive maximum benefit in terms of choice, price, and quality;

(b) ensuring that there is no distortion or restriction of competition in the electronic communications sector;

(c) encouraging efficient investment in infrastructure, and promoting innovation; and

(d) encouraging efficient use and ensuring the effective management of radio frequencies and numbering resources.

3. The national regulatory authorities shall contribute to the development of the internal market by inter alia:

(a) removing remaining obstacles to the provision of electronic communications networks, associated facilities and services and electronic communications services at European level;

(b) encouraging the establishment and development of trans-European networks and the interoperability of pan-European services, and end-to-end connectivity;

(c) ensuring that, in similar circumstances, there is no discrimination in the treatment of undertakings providing electronic communications networks and services;

(d) cooperating with each other and with the Commission in a transparent manner to ensure the development of consistent regulatory practice and the consistent application of this Directive and the Specific Directives.

4. The national regulatory authorities shall promote the interests of the citizens of the European Union by inter alia:

(a) ensuring all citizens have access to a universal service specified in Directive 2002/22/EC (Universal Service Directive);

(b) ensuring a high level of protection for consumers in their dealings with suppliers, in particular by ensuring the availability of simple and inexpensive dispute resolution procedures carried out by a body that is independent of the parties involved;

(c) contributing to ensuring a high level of protection of personal data and privacy;

(d) promoting the provision of clear information, in particular requiring transparency of tariffs and conditions for using publicly available electronic communications services;

(e) addressing the needs of specific social groups, in particular disabled users; and

(f) ensuring that the integrity and security of public communications networks are maintained.

Article 14 Undertakings with significant market power

1. Where the Specific Directives require national regulatory authorities to determine whether operators have significant market power in accordance with the procedure referred to in Article 16, paragraphs 2 and 3 of this Article shall apply.

2. An undertaking shall be deemed to have significant market power if, either individually or jointly with others, it enjoys a position equivalent to dominance, that is to say a position of economic strength affording it the power to behave to an appreciable extent independently of competitors, customers and ultimately consumers.

In particular, national regulatory authorities shall, when assessing whether two or more undertakings are in a joint dominant position in a market, act in accordance with Community law and take into the utmost account the guidelines on market analysis and the assessment of significant market power published by the Commission pursuant to Article 15. Criteria to be used in making such an assessment are set out in Annex II.

3. Where an undertaking has significant market power on a specific market, it may also be deemed to have significant market power on a closely related market, where the links between the two markets are such as to allow the market power held in one market to be leveraged into the other market, thereby strengthening the market power of the undertaking.

Article 17 Standarisation

1. The Commission, acting in accordance with the procedure referred to in Article 22(2), shall draw up and publish in the Official Journal of the European Communities a list of standards and/or specifications to serve as a basis for encouraging the harmonised provision of electronic communications networks, electronic communications services and associated facilities and services. Where necessary, the Commission may, acting in accordance with the procedure referred to in Article 22(2) and following consultation of the Committee established by Directive 98/34/EC, request that standards be drawn up by the European standards organisations (European Committee for Standardisation (CEN), European Committee for Electrotechnical Standardisation (CENELEC), and European Telecommunications Standards Institute (ETSI)).

2. Member States shall encourage the use of the standards and/or specifications referred to in paragraph 1, for the provision of services, technical interfaces and/or network functions, to the extent strictly necessary to ensure interoperability of services and to improve freedom of choice for users.

As long as standards and/or specifications have not been published in accordance with paragraph 1, Member States shall encourage the implementation of standards and/or specifications adopted by the European standards organisations.

In the absence of such standards and/or specifications, Member States shall encourage the implementation of international standards or recommendations adopted by the International Telecommunication Union (ITU), the International Organisation for Standardisation (ISO) or the International Electrotechnical Commission (IEC).

Where international standards exist, Member States shall encourage the European standards organisations to use them, or the relevant parts of them, as a basis for the standards they develop, except where such international standards or relevant parts would be ineffective.

3. If the standards and/or specifications referred to in paragraph 1 have not been adequately implemented so that interoperability of services in one or more Member States cannot be ensured, the implementation of such standards and/or specifications may be made compulsory under the procedure laid down in paragraph 4, to the extent strictly necessary to ensure such interoperability and to improve freedom of choice for users.

4. Where the Commission intends to make the implementation of certain standards and/or specifications compulsory, it shall publish a notice in the Official Journal of the European Communities and invite public comment by all parties concerned. The Commission, acting in accordance with the procedure referred to in Article 22(3), shall make implementation of the relevant standards compulsory by making reference to them as compulsory standards in the list of standards and/or specifications published in the Official Journal of the European Communities.

5. Where the Commission considers that standards and/or specifications referred to in paragraph 1 no longer contribute to the provision of harmonised electronic communications services, or that they no longer meet consumers' needs or are hampering technological development, it shall, acting in accordance with the procedure referred to in Article 22(2), remove them from the list of standards and/or specifications referred to in paragraph 1.

6. Where the Commission considers that standards and/or specifications referred to in paragraph 4 no longer contribute to the provision of harmonised electronic communications services, or that they no longer meet consumers' needs or are hampering technological development, it shall, acting in accordance with the procedure referred to in Article 22(3), remove them from this list of standards and/or specifications referred to in paragraph 1.

7. This Article does not apply in respect of any of the essential requirements, interface specifications or harmonised standards to which the provisions of Directive 1999/5/EC apply.

ACCESS AND INTERCONNECTION DIRECTIVE

Article 5 Powers and responsibilities of the national regulatory authorities with regard to access and interconnection

1. National regulatory authorities shall, acting in pursuit of the objectives set out in Article 8 of Directive 2002/21/EC (Framework Directive), encourage and where appropriate ensure, in accordance with the provisions of this Directive, adequate access and interconnection, and interoperability of services, exercising their responsibility in a way that promotes efficiency, sustainable competition, and gives the maximum benefit to end-users.

In particular, without prejudice to measures that may be taken regarding undertakings with significant market power in accordance with Article 8, national regulatory authorities shall be able to impose:

(a) to the extent that is necessary to ensure end-to-end connectivity, obligations on undertakings that control access to end-users, including in justified cases the obligation to interconnect their networks where this is not already the case;

(b) to the extent that is necessary to ensure accessibility for end-users to digital radio and television broadcasting services specified by the Member State, obligations on operators to provide access to the other facilities referred to in Annex I, Part II on fair, reasonable and non-discriminatory terms.

2. When imposing obligations on an operator to provide access in accordance with Article 12, national regulatory authorities may lay down technical or operational conditions to be met by the provider and/or beneficiaries of such access, in accordance with Community law, where necessary to ensure normal operation of the network. Conditions that refer to implementation of specific technical standards or specifications shall respect Article 17 of Directive 2002/21/EC (Framework Directive).

3. Obligations and conditions imposed in accordance with paragraphs 1 and 2 shall be objective, transparent, proportionate and non-discriminatory, and shall be implemented in accordance with the procedures referred to in Articles 6 and 7 of Directive 2002/21/EC (Framework Directive).

4. With regard to access and interconnection, Member States shall ensure that the national regulatory authority is empowered to intervene at its own initiative where justified or, in the absence of agreement between undertakings, at the request of either of the parties involved, in order to secure the policy objectives of Article 8 of Directive 2002/21/EC (Framework Directive), in accordance with the provisions of this Directive and the procedures referred to in Articles 6 and 7, 20 and 21 of Directive 2002/21/EC (Framework Directive).

AUTHORISATION DIRECTIVE

Article 6 Conditions attached to the general authorisation and to the rights of use for radio frequencies and for numbers, and specific obligations

1. The general authorisation for the provision of electronic communications networks or services and the rights of use for radio frequencies and rights of use for numbers may be subject only to the conditions listed respectively in parts A, B and C of the Annex. Such conditions shall be objectively justified in relation to the network or service concerned, non-discriminatory, proportionate and transparent.

2. Specific obligations which may be imposed on providers of electronic communications networks and services under Articles 5(1), 5(2), 6 and 8 of Directive 2002/19/EC (Access Directive) and Articles 16, 17, 18 and 19 of Directive 2002/22/EC (Universal Service Directive) or on those designated to provide universal service under the said Directive shall be legally separate from the rights and obligations under the general authorisation. In order to achieve transparency for undertakings, the criteria and procedures for imposing such specific obligations on individual undertakings shall be referred to in the general authorisation.

3. The general authorisation shall only contain conditions which are specific for that sector and are set out in Part A of the Annex and shall not duplicate conditions which are applicable to undertakings by virtue of other national legislation.

4. Member States shall not duplicate the conditions of the general authorisation where they grant the right of use for radio frequencies or numbers.

R&TTE DIRECTIVE

Article 4 Notification and publication of interface specifications

1. Member States shall notify the interfaces which they have regulated to the Commission insofar as the said interfaces have not been notified under the provisions of Directive 98/34/EC. After consulting the committee in accordance with the procedure set out in Article 15, the Commission shall establish the equivalence between notified interfaces and assign an equipment class identifier, details of which shall be published in the *Official Journal of the European Communities*.

2. Each Member State shall notify to the Commission the types of interface offered in that State by operators of public telecommunications networks. Member States shall ensure that such operators publish accurate and adequate technical specifications of such interfaces before services provided through those interfaces are made publicly available, and regularly publish any updated specifications. The specifications shall be in sufficient detail to permit the design of telecommunications terminal equipment capable of utilising all services provided through the corresponding interface. The specifications shall include, inter alia, all the information necessary to allow manufacturers to carry out, at their choice, the relevant tests for the essential requirements applicable to the telecommunications terminal equipment. Member States shall ensure that those specifications are made readily available by the operators."