Voice-over-packet technology: Options for OPTA

Report for OPTA, Numbers and Registrations Unit

By Stratix Consulting

Schiphol, December 2003

Stratix

Management Summary

Services based on voice-over-packet technology are becoming increasingly popular within the Dutch market, both with consumers and with business users. The Dutch Independent Post and Telecommunications Authority (OPTA) wishes to gain a better understanding of the technology underlying these services, the market players, and the issues and options for the regulator. This report was produced by Stratix Consulting at OPTA's request in order to answer some of their questions related to voice-over-packet based services.

Technology

The increasing performance of voice-over-packet technology can result in a cost efficient alternative for traditional circuit switched voice networks. Public voice-over-packet services, and specifically Voice-over-DSL (VoDSL) and Voice-over-IP (VoIP), allow the current vertical telephony market structure to be split into layers (such as the copper loop, the DSL circuit, and the IP access), with potentially different providers at each layer. Whereas VoDSL services in many respects resemble traditional voice services, VoIP services introduce more complex issues. VoIP services are implemented on top of the IP layer. As a result, these services can be offered by any party with access to the Internet.

VoIP technology allows the signalling and voice part of the signal to be separated. Therefore, for calls between VoIP subscribers the provider only needs to provide the signalling part of the service. This signalling can even be limited to a directory look-up service, as two VoIP endpoints can perform call set-up independently as long as the corresponding IP addresses are known. In order to provide a call between a VoIP device and a PSTN phone connected to the Public Switched Telephone Network, a gateway is needed to interface between these different type of networks.

Market

At this moment there are few fully operational public services on the Dutch market. They are in most cases small players with a small customer base. However, many of the larger players (ISPs, cable operators, and telecom operators) are conducting commercial trials, testing new equipment, or partnering with the existing small players to provide these services on their infrastructure. These are indications that voice-over-packet services may well have a real impact on the market within the next few years.

The main drivers for an increased implementation of VoIP and VoDSL are the growing penetration of broadband access and the shrinking equipment costs. Service providers in the US and Japan have shown significant growth in their subscribers base over the past year. However, except for Japan, the absolute numbers are still modest compared to the PSTN subscribers and revenues.

Regulatory

Voice-over-packet based services create new regulatory uncertainties. While the service itself resembles a telephony service, many of the assumptions implicit in the existing regulation do not always apply to these services. The distinction between fixed and mobile telephony becomes blurred in the case of VoIP, as the service provider may have no knowledge of the underlying physical connection.

In the new European framework, it is up to the regulator to define relevant markets to assess the competitive situation. Whether voice-over-packet services should be defined as part of the same relevant markets as traditional telephony services is as yet unclear.

Scenarios, options and impact analysis

In order to define options for OPTA which make sense regardless of the uncertainties, OPTA and Stratix developed a set of scenarios which reflect these uncertainties. The starting point for the scenario building and analysis was the key question as stated by OPTA: *What are the options for OPTA in the years to come in order to avoid a monopoly situation in the market for voice and underlying services caused by new voice-over-packet technologies?*

The scenarios were projected with a time horizon of 6 years, until the year 2009. This resulted in four scenarios, based on two major drivers: *Price versus quality and features of VoIP services* and *The strategic position of the incumbent.* Each scenario leads to different issues with regard to the key question. In order to address these issues, OPTA and Stratix defined a number of options open to OPTA (in some cases involving changes in the number plan, which the Department of Economic Affairs would need to implement).

Relevant options were found regarding: numbering and number allocation, retail and whole-sale relevant markets, and pricing transparency for end users. All relevant options were analysed in terms of feasibility and impact in the various scenarios with respect to the key question for OPTA. This resulted in a number of "robust" options, meaning options that give the OPTA the greatest chance of achieving her objective and the greatest amount of flexibility to roll with events as they occur.

The following options were identified as "robust":

Number allocation:
Service Neutral: OPTA allows the use of geographic numbers for any service, including voice-over-packet services, as long as the providers makes a 'best effort' to ensure that the numbers are used chiefly in the area defined by the area code;
Full flexibility: OPTA allows the use of geographic numbers for any service, regardless of location;

Number capacity:
Issue smaller number blocks: OPTA issues smaller blocks of numbers to prevent, or at least delay a shortage of numbers;

Defining relevant markets for purposes of encouraging competition:
One market for voice: OPTA treats all voice services as a single relevant market, regardless of whether they are fixed, mobile or 'nomadic';
Mobile and fixed markets: OPTA treats mobile and fixed voice services as separate relevant markets, and defines VoIP and other nomadic services as belonging to one or the other;

Tariff transparency for end-users:
Depository of rates: OPTA mandates that all providers either maintain a register of rates to all destinations on a web site in a downloadable format, or provide this information through a central register;

Some of these options can be implemented relatively easily, others require hard choices and need further analysis in terms of impact and feasibility.

Conclusions and recommendations

It is clear that voice-over-packet technology has the potential to create radical changes in the telecommunications arena, and it is necessary for the regulator to choose whether to attempt to fit the new services into existing frameworks, or to redefine some of the current regulatory parameters.

The changes caused by the new technology may create new issues for the regulator, but also new opportunities.

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1. Introduction

1.1. Background

With the increasing popularity of voice-over-packet services, and specifically Voice over IP, the Dutch post and telecommunications regulator OPTA is asked on a regular basis to allocate numbers from the telephony number plan for these services. As this is very much a new and immature market, there are several areas of uncertainty which make it difficult to decide how to deal with such requests. Therefore OPTA initiated this study, based on the following general questions concerning voice-over-packet services:

1. Which voice services based on voice-over-packet technology are currently being offered?
2. What are the possible ways to implement voice-over-packet services?
3. To which markets belong the various voice-over-packet services, and to what extent do these new developing services offer a substitute for traditional telephony?
4. What are the expected developments in the voice-over-packet market?
5. What are the possible adaptations in the current number plan to facilitate voice-over-packet services and what is the consequent impact of each of these adaptations?

This study is meant to address these areas by describing the current situation and trends, the issues raised through these new services, and the uncertainties for the future. The report includes scenarios based on these uncertainties, and attempts to find robust options for OPTA which will facilitate these new services without creating future problems.

Specific areas addressed in the study are:

- Available “voice-over-packet” technology options, players in the market and the services they offer, and the legal environment;
- Scenarios for future development of the voice-over-packet services market;
- Impact analysis of options for the regulator in general, and specifically for the management of the telephony number plan

1.2. Situation

Voice-over-packet technology has been available for some years, without making a serious impact on the market for public telephony. However, there are reasons to believe this may change in the near future. Some of the signs that indicate this are:

- Equipment for these services has become cheaper. For example, end-user equipment to connect a single analogue telephone to a VoIP service through a broadband connection has come down from several hundred Euro to around one hundred Euro;
- Flat-rate broadband access is becoming more widespread, enabling access to the service at a cost and level of quality which were not feasible using dial-up services;

- Service providers in the US and Japan have managed to expand their user base quite rapidly in recent months, although total numbers are still relatively low in comparison to the total market for voice services.

The effect of new services based on voice-over-packet technology, and specifically Voice over DSL (VoDSL) and Voice over IP (VoIP), is more than just having a new technology to provide telephony service. Currently, telephony is a vertical market, where the copper loop, the subscription, and the actual phone service are usually delivered (at least for the local access part) through a single company. Although local loop unbundling has enabled alternative operators to offer the telephony service without building a local loop, the geographic coverage needed to provide such a service has been a major deterrent for any serious competition in the local access part of the telephony service in the consumer and small and medium enterprise markets.

Voice-over-packet services, and specifically VoDSL and VoIP, allows the vertical market structure to be split into layers, with potentially different providers at each layer. Figure 1 illustrates some of the parties that may be involved in telephony services using these technologies:

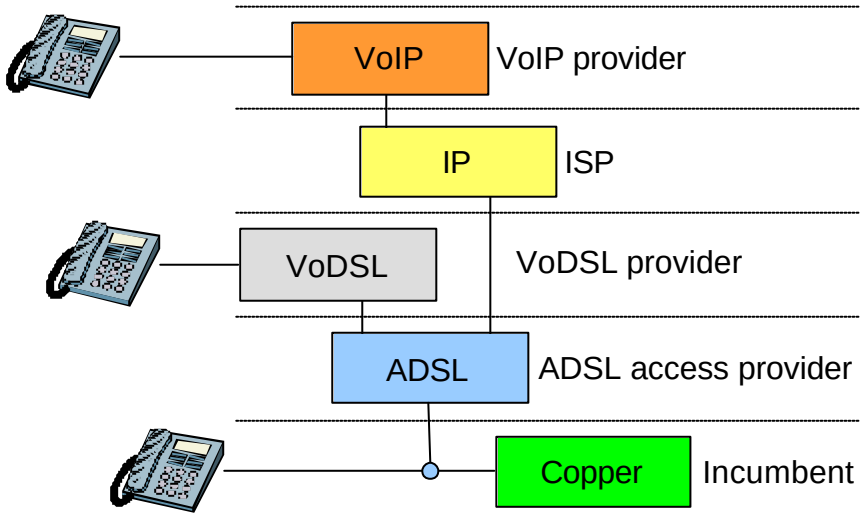

Figure 1: A layered market for telephony service

As a result, a customer may be offered three distinct telephony services from any number of parties over the copper loop alone; on top of this, the cable infrastructure can also support telephony using VoIP. All of these services can be offered with a wide array of options and with different levels of quality, performance, and price.

Of the services shown in figure 1, only the traditional telephony service over copper requires a geographically distributed voice telephony platform. VoDSL allows a more centralised approach, which makes it more attractive for new providers to develop their own infrastructure, whereas VoIP services can be offered from anywhere on the Internet.

These differences have a major impact on the economics of telephony services, on the regulatory aspects, and specifically on numbering.

1.3. Issues for the regulator

Although the new European framework is intended to be technology neutral, it does not provide a simple resolution for all the issues arising from the introduction of new delivery methods for voice services.
Issues that may concern a regulator or a policy maker include:

Numbering:

- Should a provider of new voice services be able to use the same numbering space as used by the traditional services, even when this number space has a geographic mapping which may no longer apply?
- Should different services with substantially different quality levels and options be "branded" through their number?
- How should a regulator deal with some of the other aspects usually linked to numbering space and which may no longer apply, such as tariff zones, fixed/mobile distinction, and location based routing?

Competition:

- Will the new technology lead to new monopolies, or combinations of parties with joint dominance, on the end-user market or on intermediate wholesale markets?
- How should relevant markets for voice services be defined? Should mobile, fixed, and "nomadic" services be considered to belong to one market or to several?
- What steps will the regulator have to take to ensure open competition?

"VoIP is the biggest regulatory issue at the moment"

"You can either shoehorn it into the current system, which would strangle it. That's what the incumbents want. Or it remains unregulated, and then it could destroy the incumbents. That's a big deal. It's a very political issue. But in my mind the migration to VoIP is inevitable." *

*Bill Kennard, managing director of the media and telecom group at Carlyle**, former FCC-chairman.*

* Kennard in Lightreading, October 17th 2003.
** The Carlyle Group owns 46% of Dutch cable operator Casema.

End-users:

- Will the new services lead to confusion in the consumer market due to large numbers of players, different services, and unclear pricing?
- Will a user still be able to reach all destinations, independent of the technology used by various networks?

- Will users still be able to use emergency services and other essential services under all circumstances?

None of these questions have easy answers, and the answers may change over time. At the same time, a regulator will soon have to make choices which may result in undesirable effects at a later date.

1.4. Method and scope

An effective method to evaluate options in the view of future uncertainties is *scenario planning*. In scenario planning, a limited set of scenarios is developed which covers different possible outcomes for a number of main uncertainties. Options are evaluated against each of these scenarios to identify which options are *robust*, meaning that they lead to desirable results in each of the scenarios, and are therefore likely to do so in any other combination of outcomes. Failing this, options may be found which at least have no undesirable results in any scenario.

In a combined workshop, OPTA and Stratix defined the scenarios described in this report. The evaluation of options was also carried out by OPTA and Stratix working together; all the other information in this report was gathered and analysed by Stratix. Most of this information comes from public sources, but Stratix also interviewed leading individuals at several players in the telecommunications market to establish trends in the market.

The scope of the study is limited to publicly available telephone services, using any form of voice-over-packet technology. This excludes private networks, such as corporate telephone networks, even if the technology used may well be the same.

1.5. Structure of the report

This report starts with a voice-over-packet primer in Chapter 2, discussing the various technologies and common standards, together with the architectures for public voice-over-packet services. Chapter 2 ends with an overview of the relevant technology trends. In Chapter 3 the market is discussed both from a perspective of end-user services and wholesale services. This chapter focuses on market players, their service offering and the main trends in the voice-over-packet market. Regulatory issues are discussed in Chapter 4 covering both the Dutch as well as the International context and trends. In Chapter 5 the scenario process is described, leading to various scenarios for the year 2009 and an analysis of the related issues and options for OPTA. The report ends with a overview of the main conclusions and recommendations in Chapter 6.

2. Technology, standards, architecture

2.1. General

Traditional voice services (telephony) are based on circuit switched networks. This implies that during a call, a defined amount of bandwidth is reserved to build a circuit within the network to transport the voice signal. This technology guarantees a certain Quality of Service (QoS) in terms of bandwidth, delay, and delay variation, resulting in a high quality call experience by users. On the other hand, these dedicated circuits occupy bandwidth in the network even when a signal is absent or not fully using the available bandwidth. This results in an inefficient use of bandwidth, especially in core networks where a large amount of traffic is aggregated.

Packet based technology offers the possibility of sharing bandwidth with more users / calls. Initially, packet-based (data) networks were characterised by low and badly predictable performance. However, over the recent years packet technologies like IP have evolved further, and are now able to provide the necessary quality to enable applications like Voice and Video. The integration of data, voice and video, as well as the open standards and multi-vendor interoperability, makes packet-based technology an attractive and cost-efficient alternative for the transport of multimedia including voice.

2.2. Types of voice-over-packet technology

While all voice-over-packet technologies transport the voice signal within data packets, there are significant differences between these technologies, resulting in different application areas. To provide an overview, the various technologies can be placed in several layers as shown in Figure 2. The main voice-over-packet technologies relevant for this study are VoIP (Voice over IP) and VoDSL (Voice over DSL). Therefore, the report will focus on these specific technologies. However, other commonly used voice-over-packet technologies are also briefly discussed in the sections below.

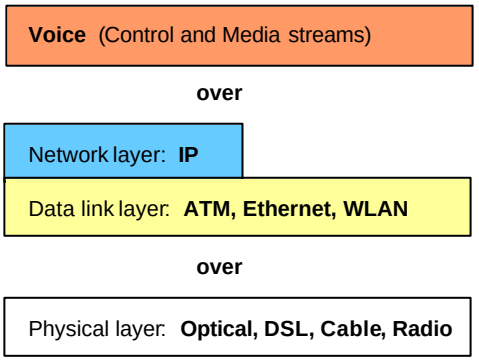

Figure 2: Layers of technologies for Voice-over-Packet

2.2.1 Voice over IP (VoIP)

Voice over IP (VoIP) technology is based on the conversion of voice signals into voice packets, which are transported using various IP based protocols for transport and for call set up and control, in compliance with the various specifications for multimedia transport (voice, video, fax, data) across IP networks. At the receiving end the voice packets are

converted back into voice signals enabling a telephony application. Therefore, VoIP is often referred to as IP telephony[1].

VoIP technology is used in private networks as a substitute for PABX infrastructures in LAN and WAN environments. In public networks, VoIP is used to offer public telephony services and peer-to-peer IP telephony.

2.2.2 Voice over ATM (VoATM)

Voice over ATM (VoATM) has evolved from a mechanism to converge voice and data transport in incumbent operators' networks, to a technology that can be applied to many other situations. In terms of public telephony services, VoATM is mainly relevant as used in VoDSL (below).

The original VoATM standards used a fixed bandwidth on the ATM network for every call in progress (64 kbit/sec Constant Bit Rate, or CBR), and therefore did not provide the main advantage of voice-over-packet technologies such as the efficient use of bandwidth. Implementations of VoATM over DSL now use a variable bandwidth (Variable Bit Rate real-time, or VBR-rt) service, allowing other applications to use the available bandwidth when the voice application is not using it – for instance during periods of silence.

2.2.3 Voice over Frame Relay (VoFR)

Voice over Frame Relay is mainly used for PABX interconnection over Frame Relay connections within enterprises. As it is not used for public voice services in the Netherlands, nor likely to be introduced in the future, it will not be discussed in this report.

2.2.4 Voice over Ethernet (VoE)

Voice over Ethernet (VoE) provides a voice connection within a single Ethernet environment, which means that some form of voice service routing has to be connected to every Ethernet segment in order to provide a telephony service extending beyond the segment. One vendor (3Com) currently has a VoE implementation for corporate networks; it is not practical for use in public telephony services except possibly in Fiber to the Home or other Ethernet to the home applications.

2.2.5 Voice over xDSL (VoDSL)

Voice over xDSL (VoDSL) provides voice transport over xDSL subscriber connections. In the case of consumer services, this will normally be an ADSL connection, but the same principle applies to SDSL and other DSL variants.

[1] The expressions Voice over IP, IP Telephony, and Internet Telephony are often used interchangeably; some authors use different expressions to differentiate between public and private networks. In this report, Voice over IP refers to both a technology and any type of service based on this technology.

In the Netherlands, DSL is generally based on ATM; this makes it possible to build a voice application on top of the ATM layer using a Voice over ATM (VoATM) standard. In situations where Ethernet based DSL is deployed, the Voice over Ethernet (VoE) standard can be used to provide a voice service.

Subscribers to an Internet access service based on DSL can also use VoIP over their DSL Internet connection; sometimes this combination is also referred to as VoDSL. In this report, we will use VoDSL to indicate a voice service directly on the data link layer (usually ATM) of the DSL connection, and not a VoIP service over an IP link based on DSL.

A characteristic of VoDSL is that it needs direct access to the data link layer of the DSL connection, which in the case of ATM implies a Permanent Virtual Circuit (PVC) within the ATM layer. As a consequence, a public voice service using VoDSL can only be offered by DSL providers or by resellers with access to the provider's ATM network.

VoDSL technology can not only be used to provide public voice services but also to connect telephone equipment in branch offices to a corporate telephone network, creating a single telephone network at lower costs than when using leased lines.

2.2.6 Voice over Cable

The term Voice over Cable usually refers to a circuit based technology used to transport voice over cable access networks. Due to its inherently inefficient use of bandwidth, this has proven not to be a popular technology among Dutch cable operators but is more commonly used in the US.

However, the broadband IP connection delivered over the cable network can also support voice services based on VoIP. The EuroDOCSIS standard for cable modems defines Quality of Service (QoS) functionality which can be used to offer VoIP services with guaranteed quality. Aside from this QoS aspect, the technology is identical to VoIP as discussed in the following sections.

2.2.7 Voice over WiFi / Wireless LAN (VoWiFi / VoWLAN)

Voice over WiFi (802.11…) in practice is always regular VoIP over Wireless LAN (WLAN) access, and not a separate protocol. Technically speaking, a voice service directly on top of WLAN is possible, but this adds little value and implies a need for local routing platforms duplicating much of the work already done by IP routing platforms.

2.2.8 Circuit emulation over packet based protocols

There are various techniques enabling circuit emulation over packet networks (besides ATM). These technologies offer traditional Time Division Multiplexing (TDM) circuits over Ethernet or IP networks maintaining legacy QoS and functionality but with some of the cost efficiency of packet networks. Just like traditional circuits these can be used to transport

(compressed) voice channels. This technology might be a cost-efficient way to interconnect legacy corporate PBXs but is unlikely to play a significant role in the public offer of voice services other than within provider networks. It is not effective for the transport of a single voice channel over a data link, due to overhead, but it can be quite efficient for the transport of a large number of voice channels (30 or more) over the same link.

2.3. General voice-over-packet architectures

As with traditional telephony services, a voice-over-packet architecture can be divided into two functional layers: a control plane and a media plane, both on top of a standards based infrastructure. The Control plane enables call registration, admission and status (RAS), call signalling and call control. The Media plane handles the actual media streams including packetised voice. The underlying network infrastructure can be based on one of the standards for packet networks.

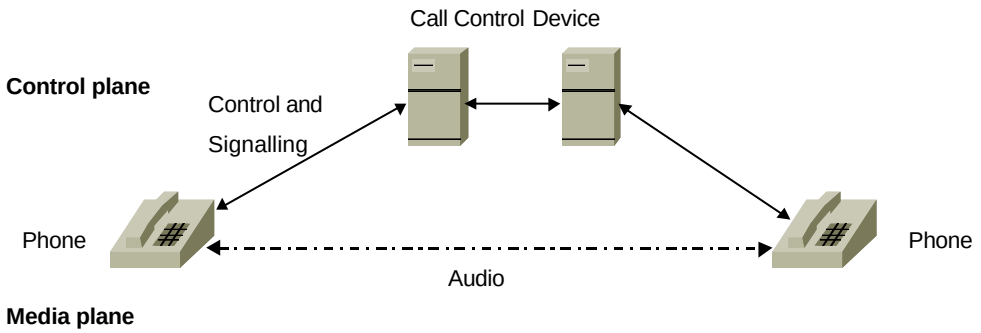

Figure 3: Control and Media plane in voice-over-packet architectures

The method used to transform a voice signal into packets is independent of the type of transport used, as long as there is sufficient bandwidth for the method chosen. Depending on the protocols used, the Control plane and Media plane may use completely different paths through the underlying network.

Most implementations support several of the standard audio codecs (Coder/Decoders) defined by the ITU (International Telecommunication Union[2]) for the coding and compression of voice signals. A range of codec standards is available, each providing a different balance between sound quality, bandwidth, and ease of implementation (refer to Appendix II for the most commonly supported ITU G.7xx audio codecs).

[2] The International Telecommunication Union (ITU) is an international organisation within the United Nations System where governments and the private sector co-ordinate global telecom networks and services. It is the leading publisher of telecommunication technology, regulatory and standards information. Standards are published as "ITU Recommendations".

2.4. VoIP protocols and architecture

Voice over IP (VoIP) technology is based on packet voice over IP networks. This means VoIP uses well known IP routing, connectivity and addressing functionality.
In VoIP networks the Control plane and Media plane in an application (call) between two VoIP devices (IP phones) can be physically separated, as shown in Figure 4.

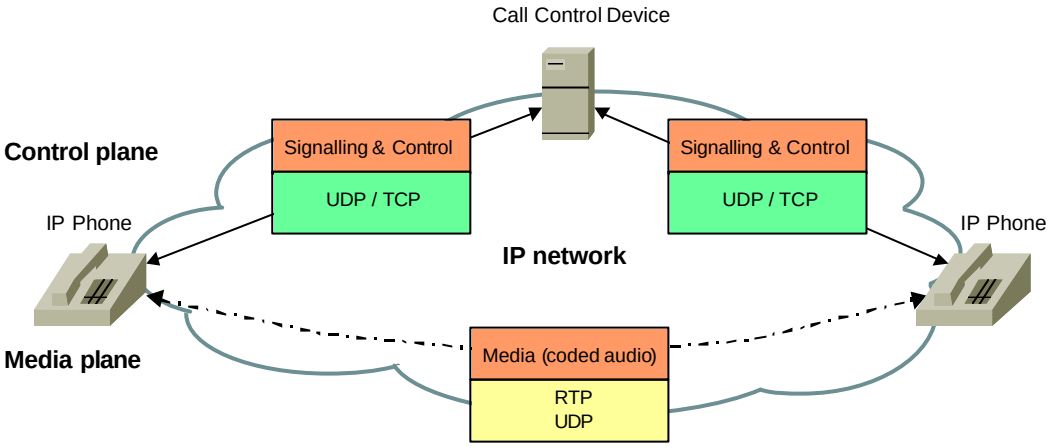

Figure 4: VoIP control plane and media plane over standardised IP network.

Both Control plane and Media plane are based on the underlying standardised layers, consisting of an IP network which is used for transport by TCP (Transmission Control Protocol) and UDP (User Datagram Protocol).

In the Control plane various protocols take care of control functionality like: registration, address resolving, signalling and call control. Connections are set up using signalling and call control protocols. This intelligent functionality is usually placed in specific call control devices but can also be part of the IP endpoints (IP phone) enabling “direct signalling”.

The Media plane consist of media streams (coded voice) transported by a real time transport protocol (RTP) over UDP. This combination ensures real time data transport using time stamps, sequence numbers, etc. without the need for sending “acknowledgements” and “retransmissions” as are common for TCP.

2.4.1 VoIP protocols

Most well known and most discussed VoIP protocols enabling call set-up are H.323 and SIP. These protocols provide register, admission and status (RAS) functionality as well as signalling and call control (capabilities exchange). These protocols are discussed in more detail in the following paragraphs.

H.323

H.323 is a ITU recommendation that defines ”packet-based multimedia communication systems” which is a distributed architecture for creating multimedia applications including VoIP. The protocol was originally developed as a multimedia conferencing protocol for the LAN environment and is used for the set-up of any type of session, which can include voice, video, etc. Currently, H.323 is the VoIP protocol with the largest installed base, especially in corporate environments.

H.323 is often described as an “umbrella protocol” as it defines different protocols for all aspects of call transmission. Appendix III gives a more detailed overview of the several H.323 protocols and their functionality in the process of call set-up. The call control device that handles RAS functionality is called “Gatekeeper” in H.323 terms. Call signalling and control can either be directed over this Gatekeeper or directly between endpoints.

SIP (Session Initiation Protocol)

SIP is a IETF (Internet Engineering Task Force[3]) standard for the set up of multimedia sessions (including VoIP) between Internet endpoints (called User Agents). SIP, originally defined in RFC 2543 and later improved in RFC 3261, is a lightweight, text-based signalling protocol, used for VoIP call set-up. It is a HTTP-like server / client protocol that builds on popular Internet technology. In order to build a complete Multimedia (VoIP) architecture, SIP works in conjunction with other IETF protocols.

Appendix III gives an overview of the functionality of SIP and other relevant IETF protocols. The call control device between two User Agents is known as the SIP proxy server. The User Agents terminate both the signalling and media path. The SIP proxy is usually integrated or linked with a registrar and redirect server for address resolving. The registrar dynamically registers the current location of user agents while a redirect server responds to request by redirecting them to the appropriate device. Most common SIP configuration includes direct signalling between user agents, although centralised control and signalling can be done using SIP back-to-back user agents (B2BUAs). In this configuration the signalling is terminated on both sides of the SIP proxy. As this prevents end-to-end encryption, the call control device needs to be a trusted party.

Deployment of SIP is growing rapidly as the “Internet world” is pushing the technology for multimedia applications, including VoIP. SIP is incorporated in the new Windows XP software, and the “Third Generation Partnership Project[4] (3GPP)” anticipates the use of SIP as the telephony signalling protocol for VoIP services.

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[3] The Internet Engineering Task Force (IETF) is an open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and operation. Standards are published as Requests For Comment (RFC).

[4] 3GGP is a co-operation of Third generation standards organisations and other related bodies for the development of a complete set of globally applicable Technical Specifications for a 3rd Generation Mobile System based on the evolved GSM core networks and the radio access technologies supported by 3GPP partners

Proprietary VoIP protocols
Due to the open character of the Internet everybody is free to use their own (proprietary) VoIP protocol. Both H.323 and SIP will need (proprietary) extensions for specific implementations. Obviously this complicates interworking with other VoIP protocols and networks, although the standards provide a framework on which extensions can be build without endangering interworking.

However, there are various proprietary protocols not directly based on the ITU or IETF standards. An interesting example is "Skype" which is a recent initiative of the makers of KaZaA. The Skype protocol is based on distributed peer-to-peer software (as with the KaZaA file transfer system) which enables peer-to-peer VoIP connections over the Internet. Skype claims a better sound quality than phones, a higher call completion rate than the traditional telephone network, and no problems with firewall or NAT[5] (Network Address Translation) traversal, a common difficulty with peer-to-peer IP streams. Although these claims may be somewhat exaggerated, the popularity of KaZaA has stimulated the use of Skype. At the time of writing, Skype has already measured nearly two million downloads since it was launched in September 2003. Future plans include (charged) interconnection with the PSTN and with other VoIP-providers, and add-on services like voicemail.

"SIP was simply not good enough for us"

claims Skype in its FAQ section on www.skype.com, answering whether the software can connect to SIP. Interworking with SIP is planned for the future.

2.4.2 Architecture and network interconnection

VoIP interconnection with circuit switched networks
A general VoIP infrastructure consist of endpoints (IP phones) and call control devices (registration, address translation, etc.) like a SIP proxy server or H.323 Gatekeeper. When a VoIP infrastructure interfaces with another (voice) network like the PSTN a so-called gateway is used. This gateway is an endpoint device which performs the conversion of different network protocols. In Europe the ETSI[6] initiated the project "Telecommunications and Internet Protocol Harmonisation over Networks" (TIPHON) to ensure that users connected to IP based networks can communicate with users in switched circuit networks (such as PSTN, ISDN, GSM).

[5] A NAT (usually combined with a firewall) converts a local IP address into a global address and vice versa. This functionality conflicts with existing VoIP standards; depending on the implementation it may not even allow any type of connection initiated from outside the local network.
[6] European Telecommunications Standards Institute

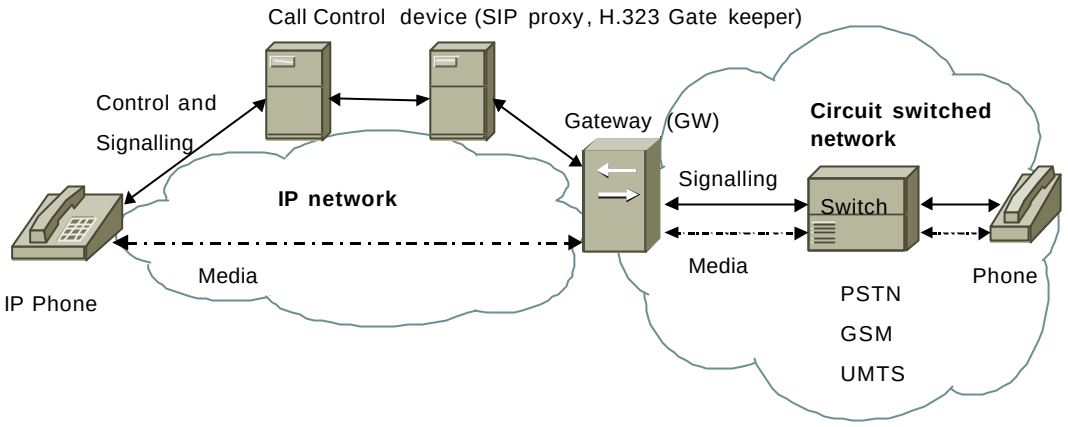

Figure 5: Gateway used for network interconnection

The gateway converts media streams (media gateway) and signalling (signalling gateway) between different kinds of voice networks. Appendix III gives an overview of the functional building blocks of a gateway. This functionality can be divided in a signalling gateway, media gateway and gateway controller unit.

Depending on the architecture, the intelligence (signalling, control) is distributed and integrated in the endpoints, or placed at central call control devices replicating traditional voice network architectures. Both SIP and H.323 are designed to support distributed VoIP architectures with intelligence (control) integrated in the endpoints which can handle both media streams as well as signalling and call control themselves. In these configurations call control devices are minimised to a database functionality taking care of registration and address translation. Centralised architectures place gateway control functionality on central intelligent call control devices (media gateway controllers) which control relatively simple endpoints. These architectures typically use the MGCP (Media Gateway Control Protocol, IETF) or Megaco / H.248 (IETF / ITU) protocols to control the gateway.

SIP and H.323 interconnection

Recent drafts of the IETF define the interworking between H.323 and SIP VoIP networks. The main issue here is to convert the signalling and control functionality between the two protocols. The media stream is the same in both cases: coded audio over RTP/UDP over IP, using G.7xx codecs. Therefore, the audio transport can still be end-to-end, similar to a homogeneous VoIP network. For the signalling and control a so-called Interworking function (IWF) is defined to map the specific functionality of the two protocols. Current drafts specify interworking for the basic call functionality and mandatory features of SIP v2.0 and H.323 v2.0. The IWF device can either be stand alone or be integrated with the respective call control devices (SIP proxy server and H.323 Gatekeeper). Figure 6 shows a typical architecture for this type of VoIP interworking.

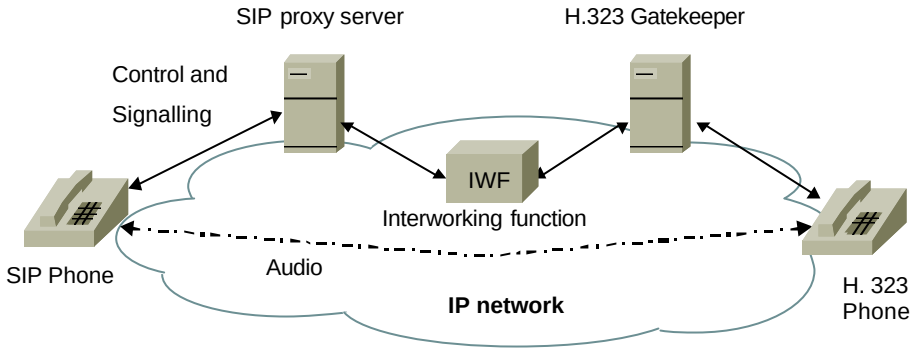

Figure 6: SIP – H.323 interworking

The SIP and H.323 phones can either communicate the signalling via their respective call control devices (as shown in Figure 6) or directly via the IWF. However, the interworking architecture does not support direct signalling between (heterogeneous) endpoints.

2.4.3 VoIP Service architecture

To provide a public telephony service based on VoIP, a provider would need a call control device (which could be positioned anywhere on the Internet), and a gateway to interface to the PSTN. The control device could connect with other call control devices anywhere on the Internet, which would allow calls to terminate to its associated VoIP subscribers or gateways into the PSTN. Figure 7 shows the main elements of such architecture.

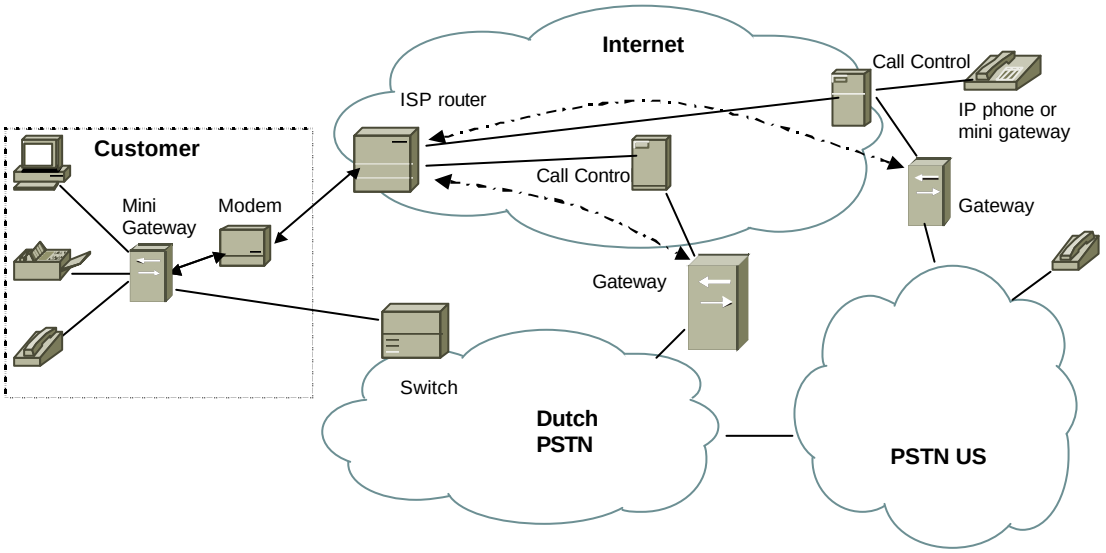

Figure 7: Public VoIP service architecture

A crucial part of the call control functionality is the registration and address resolving. In order to set up a call between two VoIP endpoints a user needs to know the identifier of its peer. This could be an ordinary telephone number, URI, alternative number, name etc. Ultimately the call control device needs to resolve the corresponding IP address in order to enable a VoIP session between the two endpoints. This functionality requires a directory

service like ENUM (RFC2916) which maps various identifiers like e-mail address, fax number, SIP number, IP number, website address, etc. to one E.164 (traditional) phone number. This functionality is derived from the Domain Name System (DNS) as the E.164 number is translated by ENUM into a globally unique domain name.
Another directory service is provided by the ITU H.350 protocol supporting H.323, SIP, H.320 (video conferencing over ISDN) and various proprietary VoIP protocols.

When VoIP networks use PSTN numbers, a look-up in a database for ported numbers (in the Netherlands the COIN database) is required as well.

The elements in the architecture described before can be in the domain of different service providers. This would require commercial arrangements between the different providers for the interconnection and the corresponding financial settlement. This is especially relevant if one provider allows another provider to use its gateway to connect to the PSTN. Figure 8 shows the same architecture, this time with a possible distribution of market players.

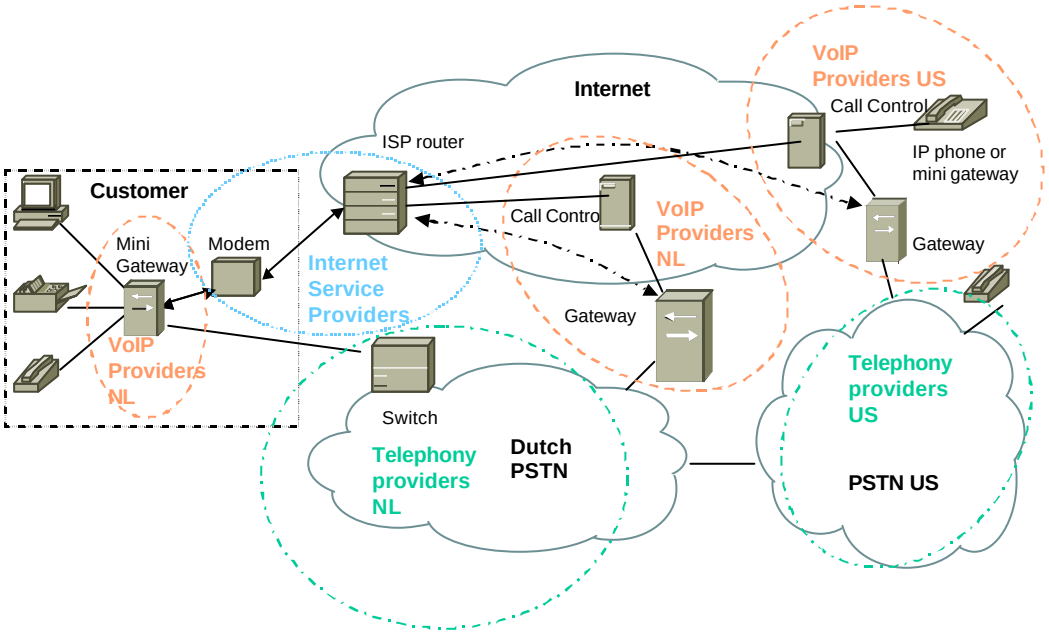

Figure 8: Positioning of market players related to public VoIP services

Address resolving and signalling is the core business of public VoIP service providers. The actual media stream and even the gateway platforms might very well be handled by other providers. Depending on the business case, the VoIP provider may provide customer equipment (mini-gateway or IP phone) or PC software.

In the architecture as shown in Figure 8, a call originating with a VoIP customer and terminating with a phone in the Dutch PSTN will be routed according to the following path.
The mini-gateway at the customer site converts the voice signal into VoIP. Call set up (signalling and control) is performed by the call control device of the VoIP provider which,

after authentication and address resolution, directs the media stream of the call to the gateway connected to the Dutch PSTN. Both signalling and the actual audio stream are sent (over different routes) across the public IP network to the gateway via the Internet Service Provider of the originating customer. The gateway decodes the VoIP call and forwards the call to a telephony provider for termination in the PSTN.

If a VoIP provider in the Netherlands had a direct interconnection with a VoIP provider in the US, this architecture might look like Figure 9. as discussed in 2.4.2, if the providers use different standards then this interconnection requires a “Interworking function” device, which might be managed by either one of the VoIP providers involved. If both providers use the same standard, then the call control devices can interconnect directly.

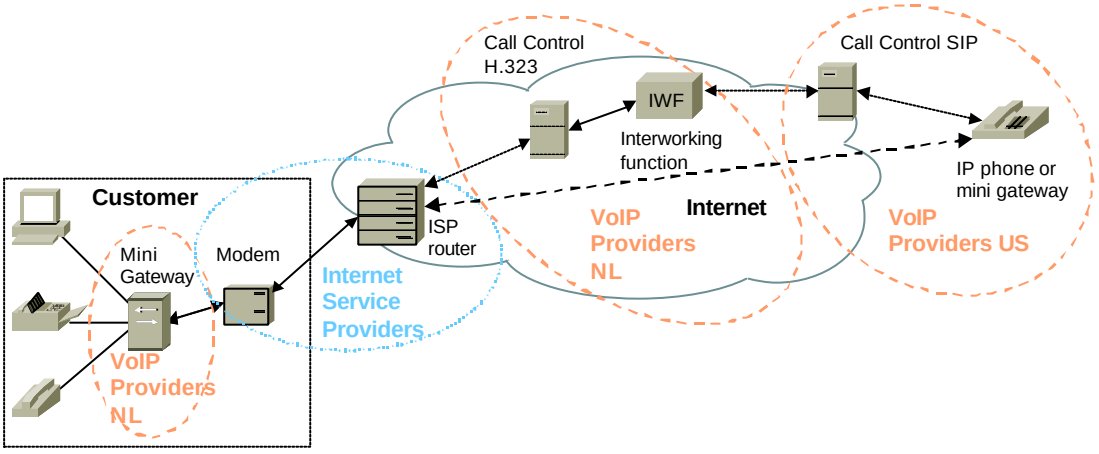

Figure 9: Interconnecting VoIP providers with different VoIP platforms

The call signalling and control will be routed via the VoIP provider managing the IWF, as they have to be converted at the IWF device. The media stream can be routed directly between the IP endpoints over the Internet, as is indicated by the dotted arrow in the figure above.

2.5. VoDSL protocols and architecture

VoDSL protocols are used to enable voice traffic between an Integrated Access Device (IAD) and a central voice switch in the PSTN. The IAD is the interface between the DSL network and the customer equipment, which is generally a DSL modem.

VoDSL architectures usually use the ATM sublayer AAL2 (ATM Adaption Layer 2), which enables voice and associated signalling to be carried on a single permanent virtual circuit (PVC) of variable bitrate. The PVC shares the connection bandwidth with an additional PVC for the data connection. On top of the AAL2 layer, a standardised voice signalling and trans-

port service is available called Broadband Loop Emulation Service (BLES). BLES enables PSTN signalling functionality between the IAD and the (VoDSL/VoA) switch. Appendix IV gives a more detailed overview of the functionality of VoDSL protocols.

Using BLES and a PVC from end-user equipment to a switch, a service provider can provide a telephony service. In this case, the media and control planes are not separated, and the user can only use the telephony service provided on the switch to which the PVC is connected. This switch would normally connect into the PSTN, but it might also terminate the call on another VoDSL connection or convert the call to VoIP. Figure 10 shows such an architecture.

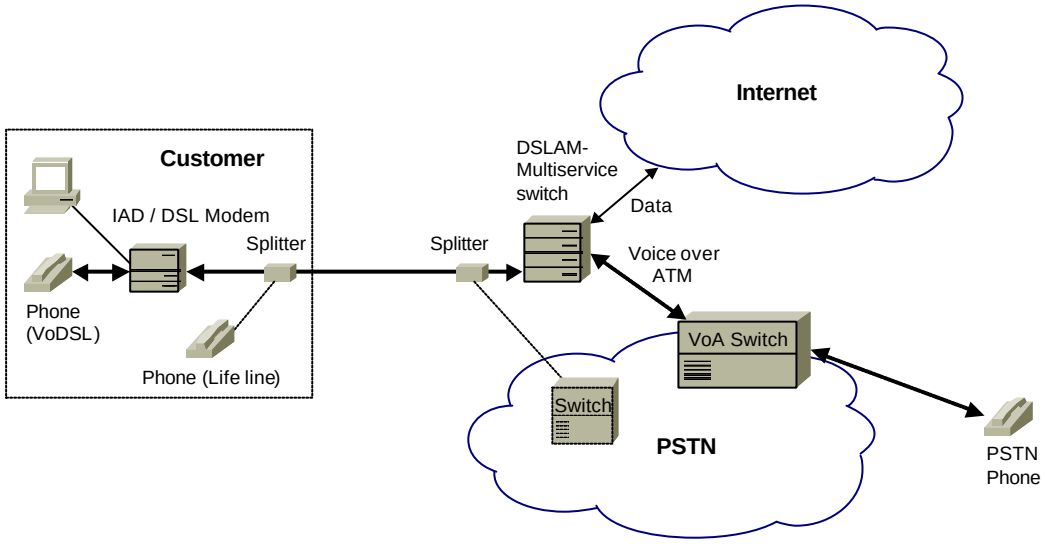

Figure 10: VoDSL public service architecture.

In addition to BLES, other service architectures are possible which allow for a more flexible termination of the media stream on different switches; however these architectures are currently not being used for publicly available services.

The market players in the VoDSL service architecture are clearly different from the VoIP case. As shown in Figure 11 the main parties in the VoDSL "chain" are VoDSL providers which offer voice enabled DSL modems and posses an own Voice (over ATM) Switch in the PSTN. Connectivity between the customer and the switch of VoDSL provider is offered by DSL providers by means of ATM PVC's. At first sight, there seems to be no role for ISP's in this architecture. However, DSL providers usually only offer (whole sale) PVC connectivity for VoDSL and for Internet access to a single third party. This implies that in practice the VoDSL provider is also the only party in a position to offer Internet access to the customer across the DSL link. The IAD (DSL modem) offers both Internet access as well as VoDSL functionality.

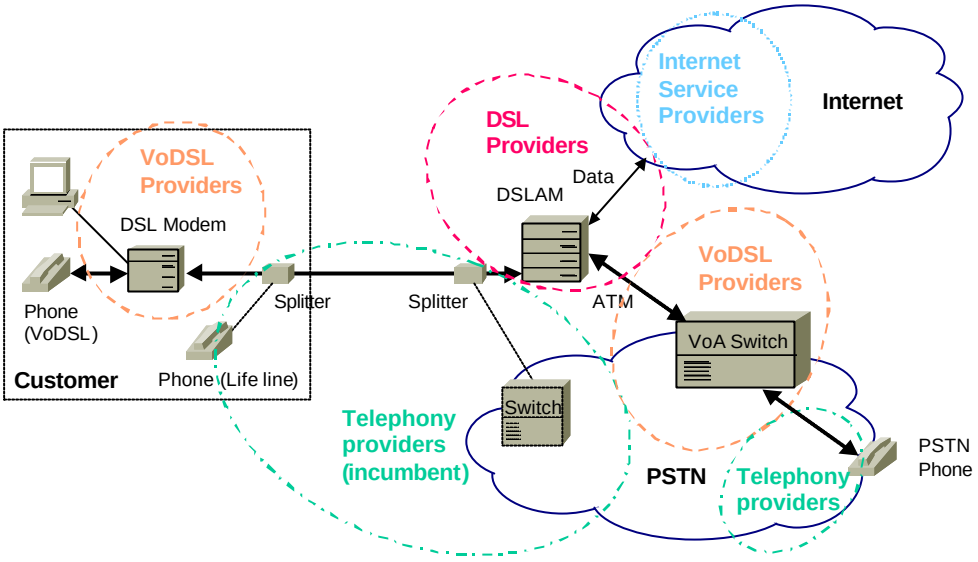

Figure 11: Positioning of market players related to public VoDSL services

A call between a VoDSL phone and a normal PSTN phone would follow the accentuated arrows as presented in Figure 11. This means that a phone connected to an AID (DSL modem) connects to a VoA enabled switch of a VoDSL provider via the DSL platform of a DSL provider. The VoDSL provider will forward the call for termination to the telephony provider of the customer with the PSTN phone.

2.6. Technology trends and uncertainties

Voice-over-packet technology has reached the stage where it is possible to provide services which are practically equivalent to the PSTN, offering the same range of options and supplementary services end-users are already used to. Further development in the coming years is expected to be incremental, providing additional features and improving the interworking between various standards. Further development will also take place in the underlying infrastructure, leading to a better quality of service for the voice-over-packet service.

VoDSL (if based on a VBR-rt PVC) can already provide the same level of quality as PSTN. VoIP can do the same, if the underlying IP service provides the quality of service and the bandwidth needed. Operators controlling both the IP layer and the VoIP service are therefore able to offer VoIP with PSTN quality. A good example of such a combination is a VoIP over cable offering from a cable operator using EuroDOCSIS, which supports differentiated quality of service for different types of IP traffic.

Service features

Current technology, both for VoIP and for VoDSL, has the ability to support all the features common to PSTN service, including:

- Conditional and unconditional call forwarding
- Call waiting
- Call completion on busy subscriber (CCBS), ("Dial 5 when busy")
- Calling Line Identification (CLI)
- Blocking of numbers (e.g. premium rate)
- Carrier Pre Select (CPS) / Carrier Select (CP)
- 0800 / 0900 numbers
- 112 emergency number calling, including location information
- Fax transmission
- DTMF dialling[7]

From a technical point of view all of these (and many additional) functions can be implemented in public VoIP services. However, this does not necessarily mean that providers will support all of these functions. VoIP providers are more likely to vary their service offering depending on the positioning of the product in the market, and on relevant regulation. For instance, Carrier Select access is usually the result of regulation; a provider is not likely to offer it unless forced by the regulator.

Of the technology types described earlier, there is clearly a place in the market for both VoIP and VoDSL. Within each of these, there is some uncertainty about future development; the most relevant issues are discussed here:

H.323 vs. SIP

There is a continuing discussion about which of the main VoIP protocols (H.323 or SIP) will prevail in the longer term. H.323 offers a range of functionality with a large installed base, especially in corporate environments. SIP, however, is typically associated with flexible Internet multimedia applications and is used in recent peer-to-peer software (MSN messenger, etc). There are continues developments in both of these and related protocols with regard to improving and adding functionality. For the moment, both protocols have their own merits depending on the desired implementation. As both standards are continuing to evolve and accommodate to the needs of IP telephony, we will most likely encounter a mixture of both in future applications, especially as the interworking issue has been more or less overcome and modern VoIP equipment supports both standards.

[7] DTMF: Dual Tone MultiFrequency, also known as tone dialling; this service may not be relevant to the dialling procedure in a VoIP call but the signals must be transported end-to-end in order to communicate with interactive voice response systems.

VoIP in PBX environments vs. public services

At the moment VoIP as a technology for IP telephony is mainly deployed in Corporate PBX networks. Currently 1% of Corporate PBX systems in the Netherlands uses VoIP. The percentage of larger corporations (over 200 employees) using VoIP doubled over the last 3 years (now 8%) and is rising[8]. Outside of the corporate domain, VoIP is used in a number of private initiatives and recently for public services (towards the end user). VoIP as a technology for voice transport within service provider networks has been around for many years.

There is an inherent difference between corporate and public voice services. PBX environments demand feature rich telephony whereas public voice services are normally restricted to ordinary point-to-point conversations. Public services however, usually require higher demands in terms of authentication, encryption, billing, management and directory service functionality. Therefore, these services need a different implementation, even though the underlying technologies are identical.

VoDSL vs. VoIP

While VoDSL and VoIP are emerging as public services based on voice-over-packet technology, they are quite different implementations on different network layers with different consequences. VoDSL is a voice service directly on top of the DSL layer; it can only be offered by a provider with access to this layer.

VoIP services however, are implemented on top of the IP layer. As a result, these services can be offered by any party with access to the Internet, even though the quality depends heavily on the IP layer.

Public vs. private numbers and directories

Currently, there is a growing number of public services based on voice-over-packet technologies. Many of these are designed to be compatible with the existing public network, and therefore use telephony numbering plans. However, there are various initiatives using different numbering plans, either with a built-in directory system (such as Skype) or using the Internet uniform resource naming scheme (e.g. sip:username@host.nl) and the Internet standard directories (DNS). It is also possible to link these schemes together using ENUM.

Recently, a number of international universities have interconnected their private VoIP networks (H.323 Gatekeepers) based on the recent H.350 recommendation, which describes a global directory infrastructure for multimedia services. Parts of the resulting network structure use public telephony numbering plans, whereas other parts use various private numbering plans. This combination shows how future services might use a mix of different types of numbers and directories, both public and private.

[8] According to Heliview, MITEL article, in Gelders dagblad October 2003

3. The market: players, services, users

The protocols and architectures described before allow existing and new players to offer a wide range of services, varying from plain telephony substitutes to sophisticated value added services. However, not all of these services are currently being offered, and it is not certain that they will be. This chapter describes the main players currently in the market, their service offering, and the users they serve or intend to serve. It also offers a preview of services that are likely to be offered in the future, and the players that may be involved.

The scope of this report is limited to public service offerings. However, many of the services described here can also be offered internally through corporate networks, either in the form of a complete VoIP environment within a corporation or as an add-on to existing PABX-based networks.

3.1. Supply side

Players in the voice-over-packet market can offer end-user services, targeted at individuals or corporate users, and wholesale services, which are targeted at other service providers (or larger corporate clients). As the services offered tend to be different, they are discussed separately here.

3.1.1 End-user services

While voice-over-packet services have been technically possible for quite some time, it is only recently that service providers have begun to offer mass market services on this basis. The first providers in this arena have been US based companies, such as Net2Phone which started with a first version of its PC to telephone service in 1996. At this time, the majority of players are still US based, but there are local players in many other countries. The following section gives an general overview of the end-users services on offer and describes the various market players and their (possible) service offering.

End-user services on offer

Several voice-over-packet based public services are now generally available to Dutch users, either from Dutch companies or from abroad.

Services offered include:

IP to phone: a VoIP based service which allows a user to call from a PC or IP enabled phone (which may be a mini-gateway and a regular phone) to a PSTN subscriber, for a per minute rate somewhat cheaper than the incumbent's rate. There is a wide range of IP-to-phone services with different performances and perceptions by the end-user.
Services vary from low quality PC phones with low performance connections to traditional phones that, with a VoIP gateway, resemble PSTN performance.

Phone to IP: a service which allows VoIP subscriber to be reached on a PC or VoIP enabled phone by PSTN subscribers, using a number allocated to the VoIP subscriber. Numbers used are geographic numbers, either from a block, allocated to the provider or ported from another provider. This service is usually offered in addition to a IP to phone service.

End-to-end IP: a service which allows VoIP subscribers to call each other. In most cases, the media stream bypasses the service provider, so this service is actually only a call set-up service. However, in case some sort of tunnelling technique is applied between endpoint and provider, (for instance to overcome NAT traversal problems) the media stream is routed via the service provider. At this time, most providers only offer end-to-end IP service among their own customers, although some interconnection agreements have been set up.

Phone-to-Phone: a voice service using packet over voice technology between a piece of equipment (mini-gateway or IAD) at the customer premises (with attached traditional phones) and the PSTN gateway of the provider. The mini-gateway or IAD is located at the customer premises but managed by the service provider. The service is typically perceived (by the customer) as an ordinary PSTN (or ISDN) service, and charged accordingly. For the moment this type of public service only applies to VoDSL offerings, although cable companies could offer VoIP over cable service this way.

Market players

Players currently active or planning to become active in this market include:

Newcomers: these companies attempt to enter the telephony market through VoIP based services. As VoIP is based on standard IP, they are able to offer services independently of the Internet access technology. However, the quality they can offer is restricted by the properties of the access method and intermediate networks. Most likely these parties will initially be small start-ups. However, significant players like Microsoft might step into this market as well. Unlikely but technically possible, large enterprises outside the telecom market might use wholesale VoIP services to offer “semi-public” VoIP services themselves. For instance, Shell offering telephony services to its petrol stations.

There are several foreign providers offering IP to Phone services in the Netherlands. Some of the most notable are Net2Phone, a US based provider, and the British CallServe. Both offer software downloads (for PC use only) for free, but charge per call on a prepaid basis. According to recently published tests[9] the call quality of CallServe is good, whereas Net2Phone shows some call delay due to the fact that the gateway is located in the US. Neither provider supports calls to 0800 and 0900 numbers. Furthermore, since the user is not provided with a phone number, only outgoing calls (to the PSTN) are supported.

[9] Computertotaal.nl July/August 2003

Rits tele.com, a Dutch player, offers a similar service to Net2Phone and CallServe, called Pilmo Blue. A recent voice service of Rits tele.com, marketed as Pilmo Gold, shows another approach. The user is provided with a mini-gateway which is located between the broadband modem (Cable or DSL) and the traditional phone. This situation resembles the configuration that was shown before in Figure 7. The initial costs for the gateway (named VoiceFinder) are about 150 Euro. However, the customer can now use a geographical PSTN phone number and even port an existing number, call 0800, 0900 and emergency numbers, and experience a full alternative for the original PSTN connection. According to various user reports the call quality is very good. In addition to a monthly fee, calls are charged per minute with pricing somewhere between the rates of CPS providers and the incumbent, depending on destination. Calls between Pilmo users are free. Additional services include: a directory with Rits tele.com users ("Ritsgids"), free voice-to-email service and online account information. Optional is a tunnel between the mini-gateway and the central call control device to avoid problems with Network Address Translation. Most notable limitations of the service are its vulnerability to a power outage and the fact that no carrier select functionality is supported.

International case: Vonage (US)

Vonage, a US based VoIP provider purchased various local E.164 number blocks over the US and offers customers a set of up to 8 different local numbers at choice independent of their home location. Traditional PSTN carriers now have to charge calls to Vonage customers against local rates. These type of services will have its impact on the numbering plan since now numbers planned for a certain local area can be allocated to anyone which may result in a number shortage for popular regions like New York or other main cities.

BelCompany stores are currently reselling the Pilmo gold service. Some smaller ISPs like UNET and Zeelandnet have integrated Pilmo in their service offering.

Over the last year there were several VoIP pilots and test by various Dutch parties. In Wageningen for instance, there is currently a VoIP pilot running with Vocalis, a UK based voice solutions vendor, serving student housing. At this time only Rits tele.com is offering a substitute telephony service in the Netherlands based on VoIP. However, as VoIP services can be offered from anywhere on the Internet, it is also possible for Dutch residents to use the services of providers situated in a different country. This flexibility complicates regulatory issues and transparency.

"The market for broadband services is still a niche market"

From this perspective, VoIP services are definitely not in the picture for CPS providers.

Per Borgklint, CEO of Tele2 in the Netherlands, September 2003, interviewed for this study.

Internet Service Providers (ISPs): while able to offer the same services as newcomers, these companies have more control over the access method which allows them to provide a more stable quality of service. An ISP might decide to provide voice services simply for the additional revenue from these services, but a more likely reason is to prevent churn on its Internet access offering by tying the customer in with additional services. Services offered can be based on VoIP, but an ISP is more likely to use VoDSL for its ADSL based customers. As the ISP is (usually) connected directly to the ATM network supporting the ADSL service, it can control the quality of service more directly than a newcomer can. As VoDSL services based on BLES are set up to connect to a single switch, this mechanism creates more of a customer lock-in than a VoIP service can. Recent announcements of BBned suggest some of its ISP partners, including Scarlet and ZeelandNet, plan to offer VoDSL to consumers before the end of 2003.

International Case: Yahoo!BB (Japan)

Yahoo Broadband, a DSL provider on the Japanese market, offers VoIP over DSL services to its customers. With 2,6 million users of the "BB phone" representing 90% of its fast growing customer base* Yahoo!BB poses serious competition to NTT, the Japanese incumbent, on the consumer (residential) market for fixed lines. NTT lowered telephony rates (especially to the US) and has recently started offering VoIP services itself, though aiming more at the business segment. It has to be noted however, that while growing fast, the absolute impact of Yahoo!BB on NTT revenues is still moderate. According to Goldman Sachs, Yahoo!BB revenues will sum up to less than 4% of NNTs total fixed line revenues by 2008.*

* Yankee Group, article "VoIP attacks", Total Telecom magazine September 2003

Cable companies: these companies are attempting to broaden their service base, as they have limited scope for additional revenue from their core radio and TV broadcasting service. "Triple play" strategies (meaning Radio and TV, Internet, and Voice) have not been very successful in the past but may have a comeback on the basis of VoIP. As cable companies already tend to offer ISP services (either through a subsidiary or with a partner company), voice services can be deployed fairly effectively. The current cable modem standards offer functionality to control the quality of service in their networks directly. This enables cable companies to provide a controlled quality of service for VoIP telephony. Since 2Q 2003 Multikabel, part of the German PrimaCom, offers telephony services based on VoIP technology to small businesses and consumers. This services is marketed as a PSTN equivalent.

Telecom operators: an incumbent might be interested in providing packet voice services such as VoIP or VoDSL as a way to add a lower priced[10], less regulated alternative to its regular voice offering, or as a way to protect its customer base from other providers offering such a service. Other telecom operators could use VoIP or VoDSL as an access method in

[10] Although not necessarily at a lower cost

order to offer telephony services without the need to deploy a local loop or to traverse the incumbent's switches.
In the Netherlands, a few telecom operators including Colt and Versatel offer ISDN services based on VoDSL to small and medium enterprises. These services are positioned as regular telephony, without reference to the underlying technology, and can be bundled with Internet access. As the operator in question has its own DSL infrastructure, it has sufficient control over the quality of the service. Voice-over-packet services do not seem to fit into the business case of Carrier Pre Select (CPS) operators for the moment. Tele2 still labels the broadband market as a niche, let alone the market for VoIP services. These parties clearly focus on a good quality mass product that can be offered in a cost efficient way (with a minimum of required investment in infrastructure).

Not-for-profit "clubs": as providing a VoIP service within a VoIP user group costs very little (there is no gateway involved, and the IP access is often flat rate), some organisations have started to offer free calls between their members. A notable example is Free World Dialup, which allows anyone to join and to call other members for free. Most of these initiatives include some form of advertisements and/or are aiming for a strong market position for future exploitation. Partner companies use the same mechanism to offer other services, including calls into the PSTN. Another international example is Skype, a peer-to-peer telephony service which is an initiative of the makers of KaZaA. These companies mostly offer a free VoIP software download enabling PC-to-PC telephony.

Current numbers of public voice services

To indicate the current position of VoIP services in relation to traditional voice services the data of the main providers is listed in the table below. The number of subscriber lines and voice grade equivalents are shown for both fixed telephony and VoIP (experimental) services.

Table 1: Numbers of subscribers to traditional voice services and (experimental) public VoIP services in the Netherlands[11]

Fixed telephony direct access market	June-2003	June-2003
Provider	Subscriber Lines	Voice Grade Equivalents
Operational services		
KPN PSTN	6.217.809	6.217.809
KPN ISDN-2	1.532.528	3.065.056
KPN ISDN-15, -20, -30	23.210	696.300
UPC PSTN	160.600	188.100
Essent Twinner PSTN [a]	30.000	± 34.000
Multikabel (VoIP)	605	n.a.
Rits Telecom Pilmo (VoIP) [b]	1.500	± 1.500
Business access alternative telco's (CLECs) [c]	10.000	± 200.000

[11] Stratix analysis of company reports

Fixed telephony direct access market Provider	June-2003 Subscriber Lines	June-2003 Voice Grade Equivalents
Experimental VoIP-services		
Cistron Pilmo trial [b]	30	n.a.
Zeelandnet Pilmo trial [b]	± 200	n.a.
Tellme/Vocalis Wageningen trial	Few	Few
KPN Kenniswijk Teenage VoIP	Few	Few

[a] No new subscribers taken in anticipation of VoIP

[b] October 2003 figures

[c] Stratix estimate

In general, voice grade equivalents are not applicable for VoIP services, as multiple connections can be set-up by one subscriber. Since the Pilmo VoIP service of Rits tele.com is limited to one connected telephone the number of subscriber lines are equal to the voice grade equivalents.

3.1.2 Wholesale services

As a provider is usually not able to provide a complete end-to-end service on its own, there is a market for wholesale services which enable providers to deliver end-user services. Newcomers will need to acquire most of these services from other providers, whereas existing players may be able to provide a larger part of the service by themselves.
Relevant wholesale services include:

- *Broadband access:* depending on the service offering, there may be a broadband access component bundled with the voice-over-packet service. This is usually not the case for VoIP, where the offering assumes that the user will have or acquire broadband Internet access separately. However, a cable company could offer a wholesale broadband access product to a provider of VoIP services, which could then offer a bundled service for voice telephony including the access component. Similarly, a DSL access provider could offer a "PVC over DSL" wholesale product, enabling other providers to offer VoDSL services. In the Netherlands, several DSL access providers currently offer such a PVC service (known as bitstream access or VBR-rt[12] PVC). Recently BBned, a Dutch DSL provider, announced that it will offer VoDSL services to consumers by the end of November 2003 via its partners (Scarlett, ZeelandNet and others).
- *Line sharing/Unbundled Local Loop:* underlying a DSL-access service is a service which provides access to the copper loop, either through line sharing (providing the DSL spectrum portion of the copper loop) or through Unbundled Local Loop (ULL), which makes the entire copper loop available to the DSL access provider. A voice service provider could buy such a service directly or through the DSL access provider. In either case the total cost of broadband access will increase if the end user cancels his PSTN subscription, as line sharing is no longer available in this case and the ULL service is

[12] VBR-rt: Variable Bit Rate real-time, the ATM PVC type used for AAL2 voice services

more expensive. The difference is sufficient to have a significant effect on the economics of providing voice-over-packet service as a telephony substitute[13].

- *Voice interconnect (originating, terminating):* in order to provide a complete voice service, a provider will need to interconnect to other voice providers. Interconnection between VoIP providers may be based on VoIP (although there are currently few instances of such a co-operation), but interworking with the PSTN is essential if the VoIP customers are to be able to call and be called by PSTN subscribers. PSTN interconnection with the incumbent is a regulated service, for which tariffs are controlled by the regulator. Newcomers such as Rits tele.com would use these services from the incumbent or other existing telecom operators.
- *VoIP gateway services:* a VoIP provider might prefer not to operate a gateway for interworking with the PSTN, but to purchase PSTN interworking services at VoIP level instead. Such a service is currently on offer by several companies around the world such as ITXC. Companies within the Netherlands, who currently operate large dial-up facilities for Internet access may well offer such a service in the future, as this would allow them to reuse their platforms now that dial-up traffic decreases.
- *Directory services:* registration and address resolving are key functions of the VoIP service but might be rather complex or require much effort when the number of VoIP users grows. Directory services as ENUM, H.350 or other might be offered by providers as an intermediate service.
- *Billing and customer administration:* since the billing of VoIP services can be complicated especially if the VoIP provider does not control the relevant gateways third party billing might be an attractive alternative for newcomers. Depending on the regulation of the new services customer administration may be of importance.
- *Number portability:* in order to interconnect with the PSTN, VoIP providers need to be able to handle ported numbers. A connection with the COIN database might be too much effort for low scale newcomers which can obtain this service from other providers. For example Rits tele.com currently obtains this service from established telecom operators.
- *Front office:* front office and helpdesk services could be more efficiently positioned at existing players with a large customer base.

3.1.3 Equipment and software

The market for voice-over-packet equipment is quite diverse with many players and strong competition. VoIP client software (for PCs) is offered by many different players. Clear market leader on IP hardware in the VoIP market is Cisco. Traditional vendors of telecom equipment like Avaya, Nortel and Siemens are well positioned at the market for Hybrid (IP and TDM) solutions. For VoDSL equipment (gateways and IADs) the market is more fragmented. Large players in Europe are TDSoft, Siemens, Zhone (Ericson) and Alcatel.

[13] At the time of writing, € 9.89 per month for ULL compared to € 2.25 per month for line sharing (source: http://www.kpn-wholesale.com/cms/asp/acrobat.html?Tariff_schedule_RA_ULL_september_2003_4_01.pdf)

In general, cost of VoIP and VoDSL equipment are declining. Additionally, the functionality is converging, improving both vendor and platform interoperability. The following section discusses the various market segments of voice-over-packet equipment.

Soft Phones

Soft phone refers to software used for PC-PC and PC-Phone calling which can be installed on user PCs (in combination with a headset). Most peer-to-peer applications can be downloaded for free or are an integrated part of common software. Examples are: Net2Phone, Free world dial up, Skype, MSN messenger, MS Netmeeting, CoolTalk (Netscape), React (CallServe) amongst many others.

More robust software with additional features as required in the corporate environment is offered by large equipment vendors like Nortel, Lucent and some smaller niche players. Price levels depend on functionality but several tens of Euros per client (user) are common. Most of this software supports either H.323 or SIP.

Hardware IP phones

IP phone equipment is offered by a variety of vendors including Cisco, Siemens, Alcatel, Nortel Networks, Mitel and others. These phones are mainly focussed on the corporate market segment and used in hybrid PABX or IP telephony environments. Most IP phones use either a proprietary signalling protocol, H.323 or SIP. Vendor interoperability is still an issue, but there are signs of improvement in this regard.

VoIP Gateways

The variety of vendors of gateway platforms is even more diverse than IP phones. Besides the main equipment vendors already mentioned, other well know vendors as Texas Instruments, HP, Motorola, ECI Telecom and NEC are in this market as well as many other smaller players like AddPac (Korea), VocalTec, RadVision etc. The gateways vary from massive platforms interconnecting VoIP and PSTN core networks to smaller SOHO equipment referred to as a mini-gateway or terminal adapter. Most of the recent gateway platforms support both H.323 and SIP and MGCP; some support Megaco.

AddPac's mini-gateway "Voice Finder" as used by Rits tele.com

VoIP call control devices

There is a wide variety of vendors selling different call control devices or call servers. This market shows similar players as are operating in the gateway segment. Many support proprietary VoIP protocols together with H.323 (Gatekeeper) and SIP (proxy, redirect server) standards.

VoDSL gateways and IADs
Prominent vendors of VoDSL gateways and IADs (Integrated Access Devices) are: TDSoft, Siemens (Efficient), Verilink, Coppercom, Ericsson (Zhone) and Alcatel.

3.2. Demand side

3.2.1 User segments

Consumers
Public VoIP services are currently targeted primarily at residential customers who already have broadband Internet access. As the service is relatively new, it tends to be taken up by customers who are interested in new technologies (early adopters). As services will develop further, VoIP providers could address the much larger market of price sensitive residential customers. This market is currently being served by the incumbent as well as a large number of Carrier Select / Carrier Pre-Select providers.

Small and medium enterprises
Small and medium enterprises form a large potential customer base for providers of public VoIP and VoDSL services. As these customers will tend to place higher demands on reliability, providers would have to be able to offer some level of end-to-end service guarantee. This may lead to close links between the broadband access provider and the voice service provider, where access and voice service are offered as a single bundle. At this time several providers offer VoDSL voice services targeted at this segment.

Large enterprises
Currently large enterprises are mostly interested in VoIP as a technology for their corporate networks, especially for VPN connections to remote sites or home workers. VoIP is for instance used by a few call centres enabling cost efficient connections with employees answering the phone from their home office. Services offered to these enterprises are more customised, and may include fully managed corporate VoIP networks, PSTN interworking, and VPN based VoIP services as part of IP VPN services like KPN's Epacity.

3.2.2 Reasons to buy

PSTN Substitution
The service offered may well be equivalent to the regular voice service, enabling users to cancel their regular PSTN service in favour of a VoIP service. However, there are at this time some remaining issues:

- The cost to the ADSL provider for the unbundled local loop is much higher than the cost for line sharing. Therefore, if an ADSL customer cancels the PSTN subscription, the ADSL connection may become much more expensive or unavailable. This is not currently an issue for cable Internet subscribers.

- Emergency number access: as most ADSL equipment uses mainline power, customers may not be able to reach emergency services in case of a power failure[14]. However, most consumers now have mobile phones, which will continue to work unless a major power outage affects the mobile networks.
- Quality, or perceived quality: VoIP service has a reputation for low and unpredictable quality. However, depending on the access network and the level of control the voice provider has, voice quality can now be better than mobile, and in some cases as good as PSTN.
- Reliability and availability: ISP's and other providers of Internet based services tend not to achieve the reliability of an incumbent operator. This is especially true, when the VoIP service requires an operating PC including a highly unstable operating system and other software. However, this is not the case for recent VoIP services like Pilmo, which only requires a PC for configuration of the mini-gateway. Therefore, the reliability may well be good enough as a primary service for a customer who has a mobile phone as backup.

Whether a VoIP service is a telephony service in a legal sense is a different matter, to be discussed in Chapter 5.

Cheap telephony

In the past years VoIP services have been marketed as cheap telephony with limited features, mostly restricted to PC-PC connections. Perceived call quality of these services was low. Nowadays the quality perceptions seem to be reasonable to good. Especially due to the increasing penetration of broadband as discussed in the next section these developments might lead to a serious and cheap VoIP alternative for international and interregional calls (Vonage case). Additionally, there is the draw of free calling within the user group.

VoDSL services for the Small and Medium Enterprise segment can be substantially cheaper than traditional telephony, especially if a service bundle provides multiple telephony lines over a single DSL connection (and therefore a single line rental), possibly combined with Internet access.

Add-on services

Additionally to the plain voice service, add-on services might be integrated with the VoIP service such as: Videophone, Instant Messaging, Directory services (Yellow pages), and Universal Personal Telecommunications. On the other hand, VoIP itself could very well be marketed as an add-on service to broadband Internet access as in the case of Yahoo!BB.

[14] Note that although ISDN is able to power one ISDN phone, most residential ISDN users do not have an ISDN phone but use a much cheaper analogue phone in combination with a converter or home exchange, and are therefore already dependent on mainline power.

3.3. Market trends and uncertainties

Voice-over-packet based public telephony services, and more specifically services based on VoIP and VoDSL, are just starting to have an impact on the telephony market. There are few fully operational services, mostly from small players, and a small customer base. However, many of the larger players (ISPs, cable operators, and telecom operators) are conducting commercial trials, testing new equipment, or partnering with small players such as Rits tele.com to provide these services on their infrastructure. These are indications that voice-over-packet services may well start to have a real impact on the market within the next few years.

Availability and penetration of broadband access increases

Besides the technology development of VoIP applications and equipment itself, the main enabler for public VoIP services is the availability and penetration of broadband access. Currently there are about 4.5 million Internet access connections in the Netherlands, of which about 1.5 million are broadband connections (600.000 DSL and 900.000 Cable). The total number of fixed telephony lines is close to 8 million. A detailed overview of the addressable market for voice over Cable and DSL, as well as the current position of ISPs in this market, is given in Appendix V.

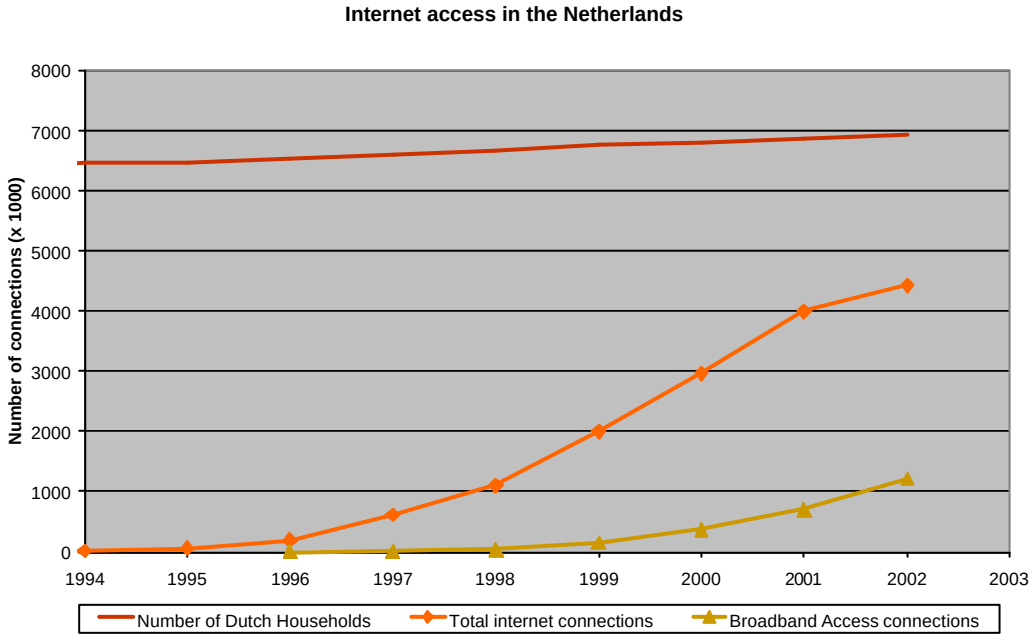

Figure 12: Both Internet access and broadband penetration are increasing[15]

The Netherlands holds quite a special position with respect to the penetration of cable television. The high penetration, with over 6.2 million active connections[16] on a total of 7 mil-

[15] Based on Stratix report for OPTA: ISP Market, December 2002.
[16] Vecai, September 2002

lion households, implies a valuable asset for delivering broadband over cable. However, due to a lack of standardisation and a lack of regulatory pressure, competition on the cable broadband infrastructure is currently limited.

Although cable access is still the most popular technology for broadband Internet, DSL access is growing faster. Currently, aggressive marketing in the Dutch market for DSL Internet access is resulting in a large growth of DSL customers.

In addition to current cable and DSL broadband developments, there is an increase in the deployment of fibre in the last mile, either to the home (FttH[17]) or to a point close to the home (FttC[18]). However, total numbers are still limited.

Convergence to IP in corporate environments

In the corporate environment there is a current trend of convergence of data and telephony towards IP. Currently, 1% of Corporate PBX systems uses VoIP. The percentage of larger corporations using VoIP doubled over the last 3 years (now 8%) and is rising.[19] However, as the Merrill Lynch case shows, there are some drawbacks concerning security and vulnerability of all IP solutions. These concerns will need to be addressed for. Meanwhile shipment figures of corporate telephony equipment are shifting towards IP. According to Gartner, about half of the user endpoints shipped in Europe will be IP by 2006.[20]

Merrill Lynch: from all IP to hybrid solution.

Merrill Lynch implemented a Cisco VoIP solution in 2000. However due to "increasing concerns about the risk of losing both voice and data communications as a result of an IP outage"*, the company switched to a hybrid Avaya TDM/IP approach. Since the platforms of the different vendors could not be integrated this implied a replacement of all Cisco IP phones.

* A spokes woman of Merrill Lynch in Total Telecom Magazine, Sept. 2003

Shift in VoIP service offering from PC-Phone to Phone-to-Phone

After years of Internet peer-to-peer VoIP applications with doubtful quality, VoIP services are now being positioned offering a full substitute to PSTN services. This includes dialling from and to ordinary (analogue) phones with no need to have a PC switched on.

Integration at the user side

With the shift from PC based VoIP to Phone-to-phone services, VoIP enabled customer premises equipment is being introduced into households. These VoIP gateway and terminal adapters are now being integrated into other customer equipment such as PABX, DSL/cable modems, and routers, resulting in lower cost and less complex operation for the user.

17 FttH: Fibre to the Home
18 FttC: Fibre to the Curb
19 Heliview, MITEL article, Geldersdagblad October 2003
20 Gartner, Total Telecom Magazine September 2003

Lowering cost of VoIP equipment
With the increasing volumes of VoIP equipment deployed globally, the cost of this equipment is coming down. Already the retail price of a simple mini-gateway (Voicefinder) has come down to around € 150.-, a level comparable to the price of DECT wireless phones a few years ago, and can be expected to go down further within the next few years. Integration with other equipment can accelerate this trend.

Substitution fixed to mobile
In the last few years there has been a trend of fixed line PSTN subscribers migrating to mobile of about 7%. Direct implication of this churn is the fact that ISPs offering DSL are confronted with unbundled local loop costs which are substantially higher than the cost of lines shared with PSTN service, leading to increased cost for DSL access providers. This may stimulate ISPs to offset the extra cost with new revenue, by offering VoIP services over to these customers. If this happens, VoIP in effect becomes a partial substitute for mobile services which have substituted fixed lines.

Voice-over-packet as extension of a broadband offer
Yahoo!BB in Japan shows an example of an ISP successfully marketing VoIP over DSL as an extension to broadband access. In the Netherlands, some providers already offer VoDSL and broadband access as a bundle for (small) businesses, while others have announced similar bundles for the retail market. This trend is expected to accelerate in the next few years.

As mentioned before, cable operators can offer quality VoIP services over their access networks using EuroDOCSIS. Until now, these VoIP services over cable are not operational in the Netherlands. UPC is the largest cable operator offering voice over cable to consumers based on TDM technology, with a customer base of about 160.000; others have been waiting for VoIP to become a viable option. Cable operators can be expected to start offering VoIP services in earnest within the next two years.

Foreign VoIP initiatives show major growth but absolute impact is still modest
The recent success stories of foreign initiatives like Vonage and Yahoo!BB show spectacular growth of VoIP users, but only in relative terms. The absolute numbers behind these providers are still moderate compared to PSTN customer base and revenues. For instance, Vonage has gone from 10,000 to 60,000 users in about nine months, as shown in impressive for a newcomer, but (so far) insignificant compared to an incumbent telephony provider.

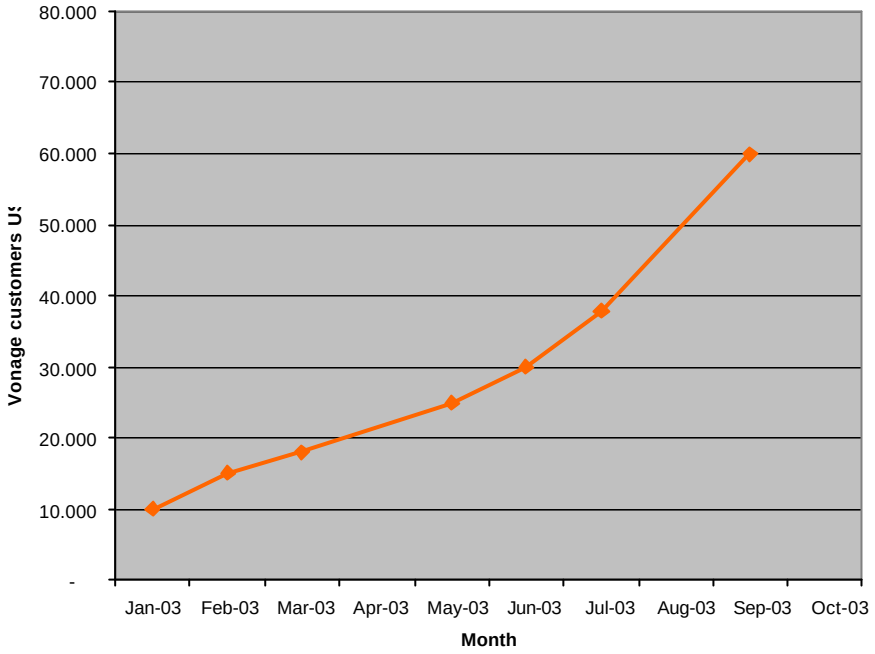

Figure 13 Vonage: spectacular growth but absolute numbers are still modest.

Use of "Network Address Translation" by ISPs complicates VoIP roll-out

Network Address Translation (NAT) is used to convert local IP addresses into globally unique IP addresses, and vice versa. Sometimes the equipment also acts as a firewall by allowing connections to be set up only from 'behind" the NAT and not from the outside world. This complicates the introduction of VoIP, as VoIP protocols require the equipment to know its own global address, and to receive connections from the outside world.

NAT technology was originally deployed to reduce the need for IPv4 numbers. However, scarcity of IP numbers is not the only issue here. ISPs tend to use the constraints imposed by NAT technology to differentiate their service offering. Therefore, it is unlikely that ISPs will respond to the introduction of IPv6 (which provides sufficient numbers) by providing enough globally unique IP numbers to end-users for all their equipment.

A way around the limitations created by NAT technology is by setting up VoIP sessions through a central proxy server on the Internet (which is not behind a NAT). But in that case the media stream is directed over a central server, which eliminates some of the advantages of the peer-to-peer nature inherent to VoIP.

4. Regulation and consequences

The regulatory regime governing a public voice-over-packet service, and therefore the options a regulator has to influence the behaviour of market parties, strongly depends on the classification of such a service. Regulators in most countries have far more control over a service which is classified as a "publicly available telephone service" than over other tele-communication services, and more control over telecommunication services than over value added services which happen to use an underlying telecommunication service. It is not always entirely clear how a voice-over-packet service should be classified, as the existing rules were not designed with this type of service in mind.

The following identifies the position of public voice-over-packet services in the current regulatory environment, including the new European regulatory framework, and outlines the consequences for service providers and for regulators[21].

4.1. European legislation

The intent of the new European Framework[22] is to regulate telecommunications services independently of the underlying technology, and to impose only minimal *ex ante* regulation on service providers in order to stimulate competition. As soon as sufficient competition is established within a "relevant market", all *ex ante* regulation should be removed.

By setting a framework for the identification of relevant markets, rather than identifying specific markets, the legislation allows national regulators to stimulate competition for new services and in new markets, without having to change the legislation. A separate recommendation[23] identifies a number of markets as a starting point.

The new Framework replaces a number of directives based on outdated assumptions regarding the relation between infrastructure and services, the structure of the market, and the role of the government.

4.1.1 Classification of voice-over-packet services

Under the framework, it should not make a difference through what technology a voice service is delivered. The relevant questions for a new service are only:

- To which relevant market a service belongs: currently, "access to the public telephone network at fixed location" is treated as a separate market from "local/national telephony

[21] Note that the information presented here is the result of an analysis by Stratix and does not represent legal advice

[22] For more information see: http://europa.eu.int/information_society/topics/ecomm/all_about/todays_framework/overview/index_en.htm

[23] See Recommendation 2003/311/EC on relevant markets for products and services in the telecommunications sector.

service" and "international telephony service", and each of these is divided into markets for residential and non-residential customers;
- Whether it is a "publicly available telephony service" for the purpose of the universal service directive.

In the case of a public VoDSL service, it can be argued that the service offers "access to the public telephone network at fixed location", and should be included in these relevant markets. After all, a VoDSL service provides access to the public telephone network (through a VoATM switch), and it is provided to a fixed location as the service is linked to a specific local loop through the DSL equipment, while the physical local loop is attached to a fixed location. Assuming that the provider also offers local, national, and international termination, the service should also be included in the corresponding relevant markets for telephony service.

In the case of a public VoIP service, the classification is less clear-cut. The service does offer access to the public telephone network, but not necessarily at a fixed location, and the provider may have no awareness of the customer's location or whether that location is currently fixed or mobile. It is therefore unclear whether the service should be included in the market for "access to the public telephone network at fixed location". If the provider offers local, national, and international termination, the service should certainly be included in the corresponding relevant markets for telephony service; however if a provider offers a service between VoIP subscribers based on a peer-to-peer connection the service may, in fact, be no more than a public look-up service with the actual call taking place directly between endpoints. Such a public look-up service could well be considered to belong to a separate market.

For the purpose of the Universal Service Directive, a public VoDSL or VoIP service can be considered a "publicly available telephony service", as long as it offers both outgoing and incoming calls. Again, a VoIP service which only provides service between VoIP subscribers on a peer-to-peer basis may be considered to offer only a look-up service and not a telephony service (this is not possible with VoDSL). According to the definition, IP-to-phone and phone-to-IP individually are clearly not "telephony services", as they each offer one direction only, but the two services combined into a bi-directional service should be considered a "telephony service". If this service is offered to the public then it is a "publicly available telephony service", regardless of the quality, the numbers used, or the underlying technology.

The framework leaves it to the national regulators to define the Network Termination Point, which determines the logical or physical point up to where any regulations on the service apply. In the case of a traditional telephone service, the Network Termination Point can be easily identified as a physical location within the customer premises, but with voice-over-packet services the situation is less clear. A VoDSL service could be said to terminate within

the DSL equipment at the customer premises (at the end-point of the ATM PVC), but a VoIP service does not necessarily include the underlying IP service and therefore has no clearly identifiable network termination point. It is therefore unclear up to what point the service can be regulated.

Note that the Network Termination Point is not necessarily related to numbering; numbers are related to an application (for instance, a voicemail service) which may or may not have any relation with a Network Termination Point. Therefore, a regulator might decide to assign numbers for a VoIP service based on the actual location of the user even if the Network Termination Point is deemed to be the edge of the call control server.

4.1.2 Consequences for service providers

Assuming that a regulator will conclude that a VoIP or VoDSL service does indeed belong to the same relevant markets as the corresponding PSTN service, the consequence is that, if market failure can be demonstrated, the regulator can impose constraints on a party with significant market power in these markets. In this case these constraints would apply for such a party's VoIP and VoDSL services as well as for its traditional public telephony services. In other words, the regulator will have the ability to apply for these parties the same retail and wholesale tariff regulation, price squeeze constraint, and obligations for interconnection and access for VoIP and VoDSL services as for the existing telephony services.

If a service is deemed to be a "publicly available telephony service", the provisions of the universal service directive also apply. These provisions are predominantly relevant for a designated operator (usually the incumbent), but there are several obligations applicable to all providers of such services:

- Provide access to 112 (emergency service), free of charge and "to the extent technically feasible" including location details;
- Provide access to operator services and directory inquiry;
- Provide number portability between providers, within the same location (for geographic numbers) or at any location (for non-geographic numbers);
- Provide information for inclusion in directories and directory service;
- Publish services offered, standard tariffs, standard contract details, and other information.

4.2. Dutch law

4.2.1 The current Telecommunications Act

From the definitions in the existing Telecommunications Act[24], it seems clear that a VoDSL service is a fixed telephony service. Whether a VoIP service can be construed to be a telephony service is unclear: there is no concept of a telephony service in the Act, only a fixed telephony service and a mobile telephony service. A fixed telephony service is provided to a fixed location, which is not necessarily the case for a VoIP service, while a mobile telephony service uses radio communications in the access part – which may also not be the case for a VoIP service. Under these definitions, a public VoIP over WLAN service using public access WLAN hot-spots is a mobile telephony service, but most other VoIP implementations should be considered to be either a fixed telephony service or not a telephony service at all. This structure mirrors the structure of the old European directives which have now been replaced by the new Framework.

If VoIP is not considered a fixed telephony service, it is still a telecommunication service according to the Telecommunications Act. In this case the regulator has limited power to regulate retail and wholesale tariffs or special access, as the Act reserves those powers for leased lines, use of the local loop, and fixed and mobile telephony services.

According to the Act, a provider of any telecommunication service has to:

- Register as a telecommunications service provider;
- Provide a capability for lawful interception;
- Deliver traffic data and user data to authorities if available;
- Interconnect with other providers (only if the provider has control over the network termination point), under conditions bilaterally agreed or imposed by the regulator if no agreement can be reached;
- Protect the customer's rights, in particular relating to privacy.

However, if VoIP is considered to be a fixed telephony service, then several additional rules apply as defined by the Telecommunications Act and underlying decrees[25]. These rules will also apply to VoDSL services. In addition to the above, any provider of a fixed telephony service has to:

- Provide free access to emergency services;
- Provide access to directory inquiry and operator services;
- Publish tariffs and conditions;
- Publish details of the quality provided after 18 months of service, and improve the service if requested by the regulator;
- Ask for permission from the regulator before discontinuing or significantly amending the service offering;

[24] The "Telecommunicatiewet" of 1998

[25] Specifically, the Decree on ONP for Leased Lines and Telephony ("Besluit ONP Huurlijnen en Telefonie", BOHT)

- Abide by conditions agreed by the regulator when disconnecting customers who have not paid their bills;
- Provide DTMF[26] dialling;
- Provide selective barring, for expensive or special destinations (e.g. adult entertainment services);
- Provide itemised bills;
- Provide number portability within a geographical area, if geographic numbers are used

Also, if a fixed telephony service is offered by a provider with significant market power in the fixed telephony market (currently only the incumbent), the provider has to:

- Establish fair and equitable interconnection conditions, using cost-based prices approved by the regulator;
- Satisfy all reasonable requests for access to elements of the network;
- Provide access to other providers using Carrier Select and Carrier Pre-Select mechanisms;
- Apply non-discriminatory retail tariffs approved by the regulator.

This set of obligations allows the regulator to ensure that other providers have an equal opportunity to compete with the incumbent. It would seem that these obligations apply to all fixed telephony services, including VoDSL and possibly including VoIP. This implies that if the incumbent (or any party with significant market power) offers a VoDSL service, tariffs for this service have to be approved by the regulator who may well apply a "price squeeze" test.

Use of numbers within the ISDN/PSTN numbering plan in the Netherlands is not necessarily limited to voice telephony services, as long as the numbers conform to the numbering plan and the service can be accessed from the telephony network. The numbering plan distinguishes between "geographic" and "non-geographic" numbers, without reference to a voice service. Geographic numbers do not explicitly relate to fixed locations or fixed telephony service, so that a non-fixed service offered within a geographic area (defined by an area code) could conceivably use a geographic number.

4.2.2 The draft new Telecommunications Act

The Telecommunications Act is due to be updated in order to implement the new European framework. At the time of writing, the new Act is still being debated by the Dutch House of Representatives, while the new European Framework is already in force.

The new Act differs from the existing one in a number of respects. The Act will include a more general concept of a telephony service, as well as the existing concepts of fixed and

[26] DTMF: Dual Tone MultiFrequency, also known as tone dialling; this service may not be relevant to the dialling procedure in a VoIP call but the signals must be transported end-to-end in order to communicate with interactive voice response systems.

mobile telephony services. As a consequence, the obligations mentioned above for fixed telephony will now be applicable for any telephony service, even if it is neither a fixed nor a mobile service as defined under the current act. The Act also implements the new rules under the European Framework regarding the identification of relevant markets that may require *ex-ante* regulation.

Once a regulator has identified a relevant market on which market forces fail to create a competitive market, there are several obligations that can be imposed on providers with significant market power, including an obligation to provide access to a much wider range network elements and other facilities than under the current Act.

4.3. Situation in other countries

As voice-over-packet services, and specifically public VoIP services, become popular around the world, regulatory issues as described above are becoming increasingly relevant. The classification of VoIP either as a value added data service over the Internet or as a voice service has serious implications in practically every country, and very few countries have made a decision at this point.

In the US, a number of regulations apply only to the licensed providers of voice services. In August of 2003 the State of Minnesota ordered VoIP provider Vonage Holdings to file for such a license, as it considered the service Vonage offers to be a voice telephony service. Other States quickly followed. However, on October 7 of 2003 a federal judge barred the State from applying telephony regulations to Vonage, in effect defining its VoIP service to be a data service. This is more in line with the FCC's policy to minimise the regulatory obstacles to new services.

As a result, VoIP providers in the US (at least for the time being) do not have to contribute to a Universal Service Fund, nor do they need to provide access to emergency services, to file tariffs, or pay all the other special telephony taxes that US operators pay. At this time, VoIP providers also do not need to provide lawful interception facilities as the traditional telephony providers do, although the rules[27] allow the FCC to designate a service as equivalent to telephony for lawful interception purposes without implications in other areas.

In Japan the government has decided that VoIP services are voice telephony services; a separate number block (050-abcd-xxxx) has been allocated to VoIP providers. Only providers guaranteeing a minimum quality of service can apply for telephone numbers. A few other countries have taken a similar approach, reserving specific number blocks for VoIP services; others have allowed VoIP providers to use geographical numbers without specific constraints. In the US this has led to a situation where a VoIP provider can allocate numbers from multiple local areas to a single customer, allowing the customer to call into

[27] Communications Assistance for Law Enforcement Act (CALEA)

these areas and be called from these areas for free. Incumbents have obviously objected to this practice, but so far the FCC has not intervened.

A number of countries have either banned VoIP altogether or attempted to block VoIP services in some way. These countries seem to see VoIP services as a threat to their existing incumbent operator's revenues or as a risk to national security.

4.4. Regulatory trends and uncertainties

Treatment of VoIP will remain unclear for some time

The legal situation for voice-over-packet services, and especially for VoIP, is somewhat unclear at this time. Even under similar laws, countries may come to different conclusions concerning the treatment of these services and the companies that offer them. This is likely to remain the case in the coming years, until the services and market structures have become more stable. By then the effects on competition and on end-users will become clearer, enabling regulators and policy makers to decide on the best course of action, possibly including new laws. In the meantime, regulators will need to take a position on the various issues surrounding these new services, in terms of numbering, interconnection, wholesale pricing, and end-user expectations.

The European Commission has realised that VoIP creates a number of new issues even under the new Framework. Although the Framework was designed to be independent of the technology used, it does not necessarily cover situations where not only the technology but the structure of the offering is different from the existing situation. The Commission is now studying some of these areas.

International treatment of numbers creates new issues

One example where unexpected results may happen is in the area of numbering: VoIP allows a provider in one country to allocate numbers from another country to a user in an entirely different country, bypassing the traditional hierarchy of country codes linked to geographical areas. If it is easier or cheaper to acquire numbers in one country than in another, providers might choose to acquire all their numbers there, regardless of the actual location of provider and user. Preventing this might even be construed as an improper barrier to the internal market, if the provider is within the European Union. In this respect it is interesting to note that in the Netherlands, some types of numbers (0800 and 090x) are allocated directly to end-users rather than to providers, so that a user anywhere in Europe might decide to get a Dutch number in order to bypass the providers entirely.

Existing cost models will need to be revisited

Another area which the Commission is studying concerns the cost models generally used to determine wholesale prices. These models tend to model the existing structure of networks, and may start to unravel as these structures change. For instance, most models assume that telephony service has a fixed component, covering the cost of the local loop and the access

switch, and a variable component covering the traffic over the rest of the network. A VoIP service, on the other hand, may not have a local loop component (if the user acquires the broadband connection from another provider), nor a traffic part (if the VoIP provider has no relation with the media stream). Instead, VoIP may have components related to call set-up, number lookup, registration, and gateway access; while the underlying IP network has fixed and variable components based on IP traffic.

5. Scenario analysis: visions of the future

This chapter analyses a limited number of scenarios of future developments in voice-over-packet services, seen in relation to the regulator's position. The scenarios and the inputs needed to create the scenarios were established in a workshop with OPTA, the Dutch regulator, and experts from Stratix.

A starting point for a scenario analysis is the key question to which an actor (in this case, OPTA) seeks an answer. For this analysis, OPTA decided to focus on the following key question:

> ***Key question:*** *What are the options for OPTA (in the years to come) in order to avoid a monopoly situation in the market for voice (and underlying) services caused by new voice-over-packet (VoDSL, VoIP) technologies?*

The scenarios were projected with a time horizon of 6 years, until the year 2009.

Scenarios are built on the basis of **trends and uncertainties** related to the key question. Depending on the way uncertainties develop, we end up with one of a number of different **scenarios**; as the scenarios are designed to represent extreme (but plausible) combinations of outcomes, the future will most likely end up somewhere between the scenarios described.

Each scenario will lead to different **issues** with regard to the key question. To address these, **options** can be defined that have a positive impact in all scenarios or at least have a positive impact in some scenarios and no negative impact in others.

5.1. Trends and uncertainties

The trends and uncertainties that result from the research and the workshop with OPTA are used to define scenarios with regard to the specified key question and time horizon. Both trends and uncertainties are listed below:

Trends related to the voice-over-packet environment

1. The availability and penetration of broadband access penetration increases. (As described in 3.3)
2. Bandwidth and QoS for broadband access are improved. Currently, latency for DSL connections is 25 ms and will not decline much further. However, jitter will improve due to increasing performance (bandwidth and routing) of various platforms. Stability and availability of the various platforms will also improve.
3. VoIP will increase in quality and features. VoIP applications have shown increasing quality and functionality over the past years, and are expected to provide quality and

features at least equal to PSTN before the year 2009, subject to the quality of the underlying IP connection.

4. All systems become interoperable. There is a trend of interoperability between all telecommunication systems (packet based as well as circuit based), so that networks based on different standards will have few technical barriers to interconnection.
5. VoIP will continue to be used in PBX/corporate environments. As described in 3.3, currently 1% of Corporate PBX systems uses VoIP. The percentage of larger corporations using VoIP doubled over the last 3 years (now 8%) and is rising[28].
6. Surplus capacity in dial-up platforms. Due to the decline of dial-up Internet connections, providers experience an increasing surplus of dial-up equipment. As discussed in 3.1.2, this equipment can be easily transformed to VoIP gateways using software upgrades. By the year 2009, dial-up access to the Internet is expected to be a small part of the total access service (mainly for travellers or as a backup), leaving large amounts of dial-up facilities available for such re-use.
7. Increasing level of acceptance for new services. The consumer (especially the younger generation) shows growing eagerness for new services such as SMS and Instant Messaging, and may well respond similarly to new service offerings based on voice-over-packet technologies such as speech based Instant Messaging.
8. Increasing segmentation of pricing methods (to customer segments). Price offers are differentiated and more focussed on different user groups
9. Substitution of fixed to mobile. Over the past 4 years there has been a transfer from fixed to mobile of 7% (down from 97% of households connected to 90%). The estimate for 2009 is that anywhere between 20 and 40% telephony users will no longer have a PSTN subscription.
10. Growth of demand for video conferencing. The cost of multimedia equipment (webcams) is declining. However, while there is a growth of demand for this application, the total impact is expected to remain small.
11. Increasing desire to communicate. The dependence on communication growths due to people getting increasingly used to communication and communication technologies.
12. Less pricing transparency. Telephony rates are becoming less transparent due to the growing offer of various services.

Uncertainties

In addition to trends listed above there remain many uncertain factors. Some of these have been discussed at the end of the previous chapters. These uncertainties are the driving forces behind the scenarios. In the workshop with OPTA, the uncertainties were clustered into four main clusters related to the following questions:

1. How do we want to communicate?
2. How are services marketed?
3. Who will provide which service?
4. How do we find each other?

[28] Heliview, MITEL article

1. *How do we want to communicate?*

- Lifeline perception fixed vs. mobile. Can VoIP services become a substitute for fixed lines, in the view of mobile's role as backup lifeline?
- Do we want to talk or SMS? There are signs of shifts from real-time towards near real-time interaction (SMS, Instant Message, voicemail) between individuals.
- Will call centres be amongst the early adapters of VoIP? These large users moving to VoIP would add a tremendous momentum to VoIP developments.
- Increasing demand for video telephony. Multimedia equipment costs are declining, but there is no indication (yet) of a significant demand for video telephony. If this demand does develop, this would stimulate VoIP deployment since similar platforms are used.

2. *How are services marketed?*

- How does the Price / Quality ratio of VoIP services evolve? How will the quality, functionality and pricing (flat rate?) of VoIP services be positioned compared to traditional voice services. This is directly related to broadband penetration and technology development as well as marketing. Will it become a (geek) service or (mass) box market.
- Decreasing transparency. The transparency of services (quality, interconnection, pricing, etc) and providers (Access, ISP, VoIP, billing, gateway, helpdesk) might decrease for both consumer and regulator.

3. *Who will provide which service?*

- Is VoIP perceived as an Internet or as a telephony service? This perception is related to the type of company offering the service, ISP-like vs. Telco-like and marketing, mass product vs. geek product. Of special importance is which type of company is offering the public VoIP services first.
- Public vs. private arrangements for VoIP communication. Will there be a growing "private" VoIP platform of interconnecting private VoIP networks more or less parallel to the PSTN.
- The position of telecom operators. Will the incumbent aim for a wholesale role in the VoIP market, based on its strength in transit services, gateways, etc. or for a retail position?
- National vs. International position of service providers. Due to the "Internet character" of the VoIP services there might be international players of significant importance on this market. (For instance what will Microsoft do?)
- VoIP over cable vs. alternative media. It is not clear which access platform (cable, DSL or other) will be leading in future VoIP offerings.
- Market evolution (substitute vs. additional service). Will VoIP services be perceived (and classified by regulators) as an substitute for traditional voice services or will we see a new market with additional services emerge.
- VoIP vs. VoDSL. Voice over DSL is already operational and proven technology with respect to public services offered by some DSL providers. Are DSL providers aiming for VoDSL or VoIP.

4. *How do we find each other?*

- Role of numbers and number directories. Depending on the positioning of VoIP, we might use ordinary (geographical) telephony numbers, special number blocks or a completely different set of identifiers (private number plans, special VoIP dialling plans, Uniform Resource Identifiers, etc).
- Who will own the number?
- How will addressing and routing information be provided? (Intelligent Networks in the PSTN, DNS and ENUM, public LDAP services based on H.350, etc.)

5.2. Scenarios

In order to build the scenarios for 2009 the uncertainties need to be assessed in terms of "degree of uncertainty" and "impact" with regard to the key question. The scenarios are built using 2 axes based upon the most relevant uncertainties as perceived by the workshop participants. The axis can, and in fact do, include several related driving forces.

Collectively the following axis are defined:

- Horizontal: ***Price / quality of VoIP services***, bad versus good (note that the axis defines the ratio of price to quality, not the actual price or quality levels). This axis includes most other uncertainties in the cluster "How are services marketed?" related to pricing, technology developments and broadband penetration.

- Vertical: ***Strategic position of the incumbents*** (Both telco's and cable) with respect to VoIP, primarily based on *retail* of VoIP services versus dedicated to *wholesale* services. This axis is strongly related to the perception of VoIP (Telephony vs. Internet).

The outcome is the diagram as shown in Figure 14, the 4 different scenarios as seen in 2009. The four scenarios are described in terms of trends and uncertainties and are labelled as follows:

I. "Frozen World"
II. "Incumbent rules"
III. "Dynamic multi-platform competition"
IV. "CPS provider's dream"

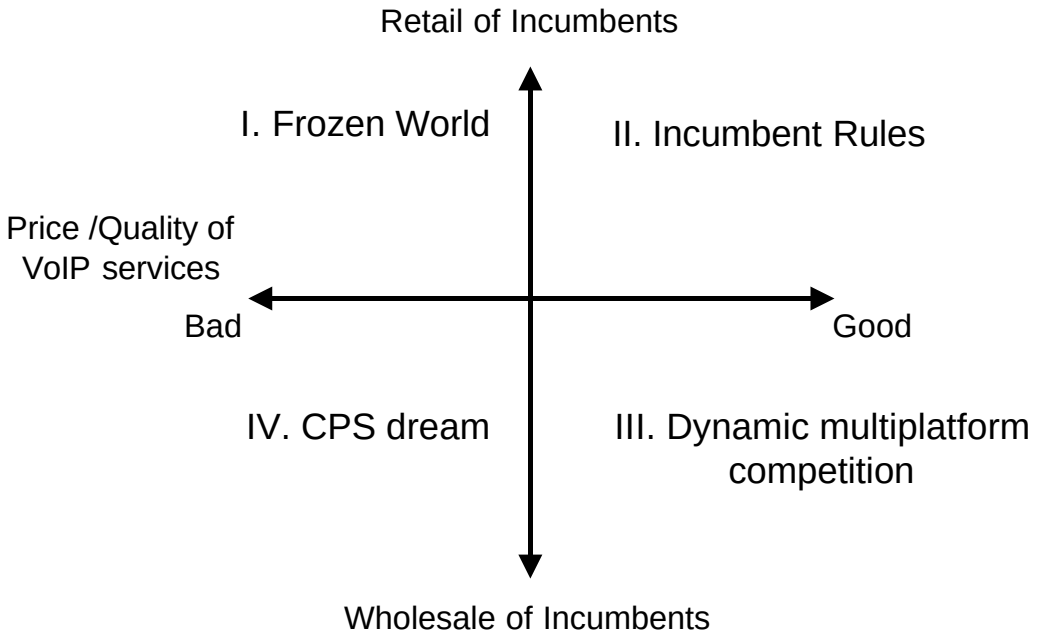

Figure 14: Four scenarios defined by major driving forces on both axis

Besides the main driving forces which are the uncertainties on the axis in the diagram other uncertainties are mapped on the scenarios as well.

Scenarios

I. Frozen World

- Incumbent offers VoIP (retail) services as a defensive strategy
- Low (price) quality VoIP offer on the bottom of the market (Competition for CPS offering, comparison with IMB business model)
- No serious marketing of VoIP services
- Upper market segment does not change
- Traditional services (Incumbent and CPS) might become more costly if VoIP is successful
- Limited new features (flat rate, etc.)

II. Incumbent rules

- Incumbent offers VoIP (retail) services as an upgrade of PSTN services
- Good price quality offer of VoIP services with many new features
- Strong marketing of Incumbent uses all market channels
- Commercial push by cross subsidy on hardware (single brand: Philips?) locked to provider network
- Incumbent holds strong position in Gateway platform

IV. CPS dream

- Incumbent offers wholesale VoIP services (including large corporate)
- Retail VoIP services of low quality with low margins by niche players (Rits tele.com) comparable to current situation
- Small product volumes, no serious threat for telephony services of CPS providers or incumbent
- Incumbent is still dominant on declining PSTN market.

III. Dynamic multi-platform competition

- Incumbent offers wholesale VoIP services (including large corporate)
- Good price quality offer of VoIP services with many new features
- Consolidation of wholesale offering (oligopoly), diversification on retail
- Retailers: Rits tele.com(s), ISPs, CPS, Cable companies, other (Shell, AH, etc.)
- VoIP will be mainly a signalling service
- Split in product portfolio of incumbent (outsourcing: Billing, admin, retail, etc,)
- IP telephones of various vendors
- Alphanumerical dialling and other number plans are most likely

I. Frozen World

In this scenario the incumbent will offer low (price) quality VoIP services (as a defensive strategy) in the lower market segment of voice services. Hereby, the incumbent positions a low price/quality offer on the bottom of the market as an alternative for CPS services. (compare the IBM Mainframe / minicomputer / PC strategy which squeezed the mini-computer companies). The upper market segment does not change significantly but traditional services, including CPS offerings, may become more costly (based on the current cost models) if the total PSTN market declines due to a transfer to mobile services. On the other hand, there might be a shift (back) from mobile use to cheap fixed VoIP services. The VoIP services will typically offer little additional functionality (simple, flat rate, cheap alternative targeted at pre-teens). In this scenario OPTA will still need to regulate the incumbents monopoly on fixed line voice services.

II. Incumbent Rules

This scenario is based on the incumbent offering VoIP (retail) services as an upgrade of PSTN services. Therefore, there will be a strong marketing effort of the incumbent using all marketing channels (installation, counter retail, hardware, etc). The incumbent will push VoIP services through both software (e.g. Microsoft Windows shipped with settings to use incumbent's VoIP gateway) and hardware cross subsidy (joint effort with large consumer electronics equipment vendors). Most likely the necessary customer hardware will be locked to the provider network (a similar SIM lock technology as applied to mobiles). The incumbent holds a strong position due to its gateway platforms. Other VoIP providers (including cable companies) will need to terminate in the PSTN. Therefore, the incumbent will act as the "spider in the web". OPTA will need to address both the "significant market power" of

the incumbent in the PSTN as well as in the VoIP market. Since the VoIP technology is pushed by the telco's, VoIP services will be mainly perceived as telephony services with numbers, quality and functionality comparable or exceeding traditional services.

III. Dynamic multi-platform competition

In this scenario the incumbent's VoIP offering is limited to wholesale VoIP services (including large corporate VoIP solutions) There will be a consolidation of wholesale offering with a crucial role for the gateway providers (oligopoly).) Due to a good price quality level of VoIP services, retail VoIP providers will diversify possibly including: new VoIP providers (Rits tele.com(s) etc.), ISPs, and cable companies. In a somewhat later stage CPS providers and others (large corporations: Shell, AH, etc.) may follow. There is a reasonable chance that large parties like Microsoft might enter the application market.
The incumbent will split it's product portfolio by for instance outsourcing: billing, admin, retail, etc. There will be a wide market for sub services like: third party billing, helpdesk, database services (connection to COIN), 112, etc. Since VoIP will be mainly a signalling service, there is no longer a "network owner", which will complicate regulation related to interconnection, portability, universal service, etc.
Various vendors will offer IP telephones with or without cross subsidy. Alphanumerical dialling and alternative number plans are most likely to occur in this scenario.
There is a lack of transparency in offerings, interconnection and mutual billing, and consequently, lots of work for a regulator. (chaos?!)

IV. CPS dream

This scenario holds very close to the current situation. The incumbent offer is limited to wholesale VoIP services (including large corporate VoIP offer). Retail VoIP services of low quality with low margins are offered by niche players (Rits tele.com, etc.) comparable to current situation. There emerges a small market for low volume products, which forms no serious threat to traditional telephony services of CPS providers or the incumbent. Obviously, the incumbent will still be dominant on a somewhat declining PSTN market.

5.3. Issues resulting from the scenarios

Issues

In the four scenarios different issues and consequences emerge with regard to the stated *key question.* The main issues are listed in the table below.

I. Frozen World	***II. Incumbent rules***
• Are low quality VoIP services classified as traditional voice services (same market, price squeeze, etc)? • The incumbent positions the Gateway	• Same issues apply as in Scenario I. though the impact is more serious • Possible monopoly on application layer (Joint offer of the incumbent and

functionality outside the regulatory domain • What is the impact on the current cost models?	Microsoft?) • Hardware locked to VoIP platform • Many disputes related to: Gateways, SIM locks, co-location, price bundling (as with mobile services) • Incumbent can follow current number plan. However geographical numbering might be unrealistic • Strict regulation (on numbers) obstructs low scale initiatives
IV. CPS dream	***III. Dynamic multi-platform competition***
• Regulator may be pressured to allocate separate numbers for low quality voice offerings (e.g. 089… or two stage dialling) • Heavy regulation will easily kill VoIP initiatives • Conflicts between VoIP providers and incumbent (s) • Incumbent still dominant on declining PSTN market • Pressure on regulator from incumbent and alternative PSTN providers to impose barriers for VoIP providers through strict interpretation of service provider obligations	• Many international providers claiming number blocks • Serious fragmentation losses in number blocks • Operational implementation of number portability (access to COIN) • Transparency in interconnection, billing etc. (is low) • Explosion of numbers (including alphanumerical or other) • There is no network owner (how to define portability, universal service etc.) • Many sub-services like third party billing, helpdesk, 112, database (COIN), transit, etc. • Regulation of Gateway (access to PSTN) • How to deal with international/private initiatives (parallel numbering schemes)

5.4. Options and impact analysis

The regulator has a number of options to resolve or mitigate the issues listed above. Some of these options will turn out to have positive effects in all scenarios. This suggests that these options are robust enough to be valid in any scenario; others will be positive in some scenarios and negative in others, in which case it may be prudent to either add mitigating actions to counter the negative effects, or to delay the activity until a clearer picture of the future emerges.

The following paragraphs discuss a number of options open to the regulator followed by a short analysis of the consequences in each of the scenarios.

5.4.1 Options

With regard to numbering:

Geographical numbers are meant to be allocated to telephony services at fixed destinations within the corresponding geographical area. The regulator will need to decide how to deal with the case of a VoIP service for which the provider has no means to enforce or verify the physical location of the end user equipment, and how to deal with services that do not completely substitute regular telephony services. These decision points result in a sliding scale of options:

1. **Very restrictive:** Decide that the telephony numbering plan is only available for regular telephony service or services which provide a complete substitute for this service. Any other services would have numbers in their own, separately managed numbering plans. These services could be accessed from the PSTN through gateways using two-stage dialling. The gateways themselves would have a number designated for data network interworking[29].
2. **Restrictive:** Allow the use of geographical numbers only for services which are considered a full substitute for traditional telephony service, and only where the provider can verify that the numbers are indeed used in accordance with their purpose. In all other cases a provider would have to allocate numbers which are not associated with a telephony service at fixed locations, such as mobile numbers or Universal Personal Telecommunications (UPT) numbers[30].
3. **More flexible:** Allow the use of geographical numbers only for services which are considered a full substitute for traditional telephony service, but accept that the provider can not verify the end user's location, and only demand that the provider makes a "best effort" to ensure that numbers are used in accordance with their purpose. For instance, a provider could implement this through contractual conditions or by verifying that a customer's billing address is within the area implied by the number. For services which are not considered a full substitute telephony service, or for customers who wish to use the service in a more nomadic fashion, a provider would again have to allocate numbers which are not associated with a telephony service at fixed locations such as mobile or UPT numbers.
4. **Service neutral:** Allow the use of geographical numbers for any service, as long as the provider makes a "best effort" to ensure that numbers are used in accordance with their purpose. For customers who wish to use the service in a more nomadic fashion, a provider would again have to allocate numbers which are not associated with a telephony service at fixed locations such as mobile or UPT numbers.
5. **Full flexibility for geographical numbers:** Accept that the current significance of geographical numbers will disappear over time, and allow all geographical numbers to be used anywhere within the country, for any (non-mobile) service.

[29] In the Netherlands, this would be a number from the 067 range.
[30] In the Netherlands, the 087 range is reserved for UPT

6. **Full flexibility for all numbers:** Accept that all differentiation within the numbering plan will disappear over time, and allow all numbers to be used anywhere within the country, for any (non-content-based) service.

Separate from the issue of which type of number to allocate, there may be a problem regarding numbering space if a large number of players enter the market who each requests large number blocks. Not only may customers end up having multiple numbers for multiple services, but the amount of unused numbering space will increase, which may lead to shortage. There are several options to resolve such a shortage:

1. **Expand the numbering space:** Independently of the reasons behind the shortage, a possible resolution is to increase the amount of available numbers, for instance by adding a digit to all numbers. This is not a decision the regulator can make (in the Netherlands), but the regulator could recommend it to the department responsible for numbers[31].
2. **Issue smaller number blocks:** By allocating smaller blocks, the regulator could prevent or at least delay a shortage of numbers. The most far-reaching form of this option would be to allocate single numbers to providers as they need them
3. **Issue numbers directly to users:** Allocating numbers to end-users directly rather than to service providers would prevent or delay shortage by making available all numbers not in use.

With regard to competition:
With voice-over-packet services, and particularly VoIP, blurring the boundaries between fixed and mobile telephony, defining "relevant markets" will become more complex. According to the Framework Directive, the regulator will have to start a market analysis (under the new European framework) to establish relevant markets for telephony services. Depending on the results, the regulator could decide on several combinations of relevant markets:

1. **One market for voice:** Treat all voice services as a single relevant market, regardless of whether they are delivered to a mobile, fixed, or "nomadic" end-point. The distinction between access to the telephone network, local/national service, and international service may have to be revisited; for instance, access to the network may have be split into physical access and the provision of telephony identity, and there may no longer be a useful distinction between national and international.
2. **Mobile and fixed markets:** Treat mobile and fixed voice services as separate markets, with VoIP and other nomadic services either belonging to the fixed or to the mobile market, depending on their characteristics; again the distinction between access to the network, local/national service, and international service may still apply.

[31] In the Netherlands, the number plan is established by the Department of Economic Affairs, Directorate-General for Telecommunications and Post

3. **Separate markets:** Treat mobile, fixed, and nomadic voice services as distinct relevant markets. In this case, the nomadic service may well have different boundaries than the mobile and fixed services.

Note that in all three options, the distinction between residential and non-residential (as per the current EC recommendation[32]) may still be appropriate.

Beside the retail markets defined in these options, a market analysis will also be necessary to define relevant wholesale markets. Besides the markets already recommended by the European commission (including voice termination and broadband access), the regulator could conclude that there are additional wholesale markets for essential services which enable VoIP services:

1. **A market for gateway services:** Define the gateway service between PSTN and VoIP as a relevant market. Although current VoIP providers tend to operate their own gateways, the incumbent and other major Internet dial-in platform operator have the advantage of being able to reuse existing platforms, which may result in joint dominance in this market.
2. **A market for number portability services:** Define the number portability lookup service as a separate market. Small players in the voice services market tend not to make their own arrangements for the routing of ported numbers; instead, they rely on the major telecommunications operators for routing and transit of all calls to users other than their own. If the number of providers and the number of customers on alternative platforms increase, these providers may not be able to interconnect with each other due to the complexity associated with number portability, giving the existing players joint dominance in this market.

With regard to end-users:
As the diversity of services increases, the cost of a call may become less transparent. A call from a cheap service may terminate on a more expensive one, without the originator being able to deduce or influence the price. To enable both operators and customer equipment to bar calls to expensive destinations, a more transparent mechanism than is currently available may be necessary to predict call charges.

There are several ways transparency in call charges could be improved:

1. **Advice of Charge:** Mandate that all voice services should carry Advice of Charge information before the call, so that end-user equipment can be programmed to bar expensive calls; or users can decide before incurring charges.
2. **Branding through numbers:** Enforce a strong linkage between number ranges and tariffs, so that calls charges can be deduced directly from the terminating number.

[32] See Recommendation 2003/311/EC on relevant markets for products and services in the telecommunications sector.

3. **Depository of rates:** Mandate that all providers either maintain a register of rates to all destinations on their own web-site, or provide this information through a central register. In either case it should be possible to download the information for further processing.

5.4.2 Impact analysis

This section discusses the impact of the various options available for the regulator in relation to the key question and relevant issues in the scenarios as described in the previous sections. In order to define robust options that hold in all scenarios the various options are scored in terms of -/-, -, +/-,+ and +/+ for each scenario with regard to primarily the key question for OPTA as stated in the introduction of this chapter, and secondary the general impact in a specific scenario. In addition the feasibility and overall impact in terms of effort and complexity for regulator, industry and users, is scored for each option. An overview with all options and their impact in the various scenarios is shown in Appendix VI. OPTA requested 6 specific options to be described in more detail. For these more detailed description please refer to Appendix VII as indicated at the options in the text below.

Numbering:

Regarding the numbers to be allocated to voice-over-packet services:

1. **Very restrictive:** If only services which provide a full substitute for voice telephony can use the telephony numbering plan, many of the VoIP services which are currently being introduced or tested will have to use a form of two-stage dialling. VoDSL services and possibly some VoIP services might be considered to be a full substitute for telephony, except for the fact that these services are dependent on a power supply for emergency operation.
   In scenarios I and IV, this option will reduce the attractiveness of VoIP services as reaching these services from the public network will be more complex. This will reduce the potential of VoIP as a stimulus for competition in voice services. At the same time it will lead to a proliferation of numbering plans specifically for these services, either numeric (as various VoIP services already do) or alphanumeric (based on Internet URI[33] conventions).
   In scenarios II and III, the same will happen initially, but VoIP services will eventually become equivalent to telephony. At that point they would be eligible for telephony numbers, in which case a major renumbering may be necessary from alternate numbering plans to the telephony numbering plan, or users might get a telephony number in addition to one or several other identifiers.

2. **Restrictive:** This option is slightly less strict in the sense that current VoIP services would get numbers which are different from regular telephony services, but which are part of the telephony numbering plan. This makes these services easier to access from the public network. It would still make VoIP services less attractive compared to using geographical numbers, as this would rule out number portability from existing fixed

[33] URI: Uniform Resource Identifier

telephony. There is also a risk that VoIP service numbers would get a negative image in terms of quality and transparency of calling rates.
Again, in scenarios I and IV this would reduce the potential of VoIP as a stimulus for competition. In scenarios II and III, providers would sooner or later implement services which can be considered equivalent to telephony, and for which the end-users location can somehow be verified (e.g. through a link between the broadband access connection and the VoIP service). This will increase the technical complexity of the solution, and make it more difficult for niche players to compete; it also increases the risk that at that point a renumbering will be necessary from the specific number ranges (mobile, UPT, etc) to geographical numbers.

3. **More flexible:** By reducing the technical complexity of a VoIP service in terms of verifying the end-user's location, and still allowing the use of geographical numbers, this option makes it more attractive for niche players to compete in the VoIP market. It also reduces the likelihood of a future renumbering from special number ranges to geographical ranges.
   In scenarios I, III and IV this is likely to evoke opposition from existing telephony providers, who might claim that providers of VoIP services have more flexibility in the use of numbers than they do; in scenario II this would not be an issue as the existing players would use the flexibility for their own offerings.

4. **Service neutral (see Appendix VII for a more detailed description):** If a VoIP service can use geographical numbers without being equivalent to a voice service, the potential of VoIP to stimulate competition is greatly increased. This may lead to a large number of different services, offered by providers located anywhere in the world, all using geographical numbers. Some of these providers will offer only a partial telephony service, or services for which voice is only a minor component.
   In scenario III, this option could lead to a shortage of geographical numbers. In the other scenarios this is less likely, because in scenario II the number of players is smaller and numbers can be reused across services, whereas in I and IV the total number of users of these new services will remain small.

5. **Full flexibility for geographical numbers (see Appendix VII for a more de tailed description):** Dropping the requirement that a geographical number terminates within a certain area would necessarily have to apply to existing services as well as to VoIP. Over time, the association of a number with a location as a user currently perceives would disappear entirely, and the current distance based tariff differences would have to be eliminated, as they would no longer make sense.
   This option will lead to even more competition than the previous one, as even the "best effort" required in that option is now removed. It may also lead to a situation as is already occurring in the USA, where customers can choose numbers from multiple area codes independent of their own location. This increases the risk of shortage of

geographical numbers in the short term. The problem will be temporary, because in the long run demand for specific area codes will disappear as these codes no longer have any meaning.

6. **Full flexibility for all numbers:** Dropping all requirements for the way numbers are used would necessarily have to apply to existing services as well as to VoIP.
   Over time, the association of a number with a location or a type of service as a user currently perceives would disappear entirely, and the tariffs for different destinations would either become equal or have to be communicated in a different way than through the number (this is already partially the case, but the situation will become far more extreme). This options applies for all numbers excluding content based services (0800. 090x). This option will lead to similar competition as the previous one, and similarly increase the risk of shortage of geographical numbers in the short term. The problem will be temporary, because in the long run demand for specific area codes will disappear as these codes no longer have any meaning.

Table 2: Impact of the options regarding numbering in relation to the key question of OPTA: "Avoid a monopoly situation in the market for voice caused by innovative voice-over-packet technologies" as stated in the introduction of this chapter.

Options for the regulator		Impact on Scenarios			
	Feasibility and overall impact	**I Frozen world**	**II Incumbent Rules**	**III Multi-platform competition**	**IV CPS dream**
Regarding numbering: Number allocation					
1. Very restrictive	-	-	-/-	-/-	-
2. Restrictive	+	-	-/-	-/-	-
3. More flexible	+	+/-	-	+	+/-
4. Service neutral	+	+	+	+	+
5. Full flexibility	-	+	++	++	+
6. Full flexibility (all numbers)	-/-	+	++	++	+

Regarding the increased demand for numbering space due to fragmentation losses:

1. **Expand the numbering space:** At what time existing numbers will run out depends on the decisions regarding numbers for VoIP services, as well as on which scenario turns out to be closest to reality. Scenario III has the largest risk of numbering shortage, both due to users getting multiple numbers from multiple service providers and due to fragmentation losses within each provider. Renumbering has a major impact on society as whole, and especially on operators and other telecommunications companies. It is therefore expected to be a solution of last resort.

2. **Issue smaller number blocks (see Appendix VII for a more detailed description):** Allocating smaller blocks results in more operational complexity for the regulator, but does deliver more efficient use of numbers. In the extreme case, where numbers are allocated in blocks of one (or larger when an end-user requests a "direct dial-in" range), the regulator ends up managing numbers individually. In the Netherlands this is already the case for 0800 and 090x numbers. The operational complexity for service providers increases, but the impact can be reduced by defining standardised, automated interfaces between provider and regulator. There would have to be a transition period during which existing providers can use up the numbers already allocated to them. The current market power which major players have in the area of managing number portability information will increase in this option, unless specific measures are taken to avoid this. This option is valid for all scenarios, but the positive impact is greatest in scenario III as this scenario presents the greatest risk of running out of numbers.

3. **Issue numbers directly to users:** Allocating numbers to end-users directly would create a far greater operational complexity than the previous option, but it would also completely resolve the issue of inefficiencies created by large numbers of providers with large allocations of telephony numbers. In addition to maintaining individual numbers, the regulator would need to create a simple process for private individuals to apply for numbers, and an invoicing and collection process or a different mechanism to finance the operation. Depending on the operational implementation, this option could lead to new monopolies for management of routing and numbering databases; one way to avoid this is for the regulator to assume a major operational role. Again, this option is valid for all scenarios, but the positive impact is greatest in scenario III. However, the cost and complexity are far higher than for the previous option, while the benefits are not much greater.

Table 3: Impact of the options regarding numbering in relation to the key question of OPTA: "Avoid a monopoly situation in the market for voice caused by innovative voice-over-packet technologies" as stated in the introduction of this chapter.

Options for the regulator		Impact on Scenarios			
	Feasibility and overall impact	**I Frozen world**	**II Incumbent Rules**	**III Multi-platform competition**	**IV CPS dream**
Regarding numbering: Increased need for numbering space:					
1. Expand the numbering space:	-/-	-	+/-	+	-
2. Issue smaller number blocks:	-	+/-	+	+	+/-
3. Issue numbers directly to users:	-/-	-	+/-	+	-

Competition

Regarding retail markets

1. **One market for voice:** Treating all mobile, fixed, or "nomadic" voice services as a single relevant market for competition purposes will not lead to major changes in market conditions. The incumbent would (at this time) be the only company having significant market power on the combined market for access to voice networks, as well as for the delivery of national and international calls. As a consequence, the regulator would be able to set constraints on all types of voice service offered by the incumbent, including VoIP and other new services.
   In this case there would be no need to decide on a case by case basis to which relevant market a new voice service belongs. VoIP, VoDSL, and other voice services would all belong to the voice services market (or markets, if access and delivery of national and international calls are still separated). An incumbent would not be able to bypass regulatory constraints on fixed or mobile services by creating new services which don't fit either of these definitions.

2. **Mobile and fixed markets (see Appendix VII for a more detailed description):**
   If mobile and fixed voice services remain separate markets, with VoIP and other nomadic services either belonging to the fixed or to the mobile market, the regulator will have to decide on a case by case basis to which of these relevant markets a new voice service belongs. At this time, the incumbent in the Netherlands would have significant market power in the fixed voice market but might be found not to have significant market power in the mobile voice market.

3. **Separate markets (see Appendix VII for a more detailed description):**
   Treating mobile, fixed, and nomadic voice services as distinct relevant markets would allow the incumbent to use a VoIP as a separate offering without regulatory constraints at least until it is found to have significant market power in this market.

Table 4: Impact of the options regarding numbering in relation to the key question of OPTA: "Avoid a monopoly situation in the market for voice caused by innovative voice-over-packet technologies" as stated in the introduction of this chapter.

Options for the regulator		Impact on Scenarios			
	Feasibility and overall impact	**I Frozen world**	**II Incumbent Rules**	**III Multi-platform Competition**	**IV CPS dream**
Regarding competition Retail markets					
1. One market for voice:	-	+	++	+	+
2. Mobile and fixed markets:	+	++	+	+	+
3. Separate markets:	-	-	-/-	+	+

Regarding wholesale markets

1. **A market for gateway services:** The regulator will need to define a market for gateway services. The impact of this option depends on which relevant markets are defined and what will be the constrains for the Significant Market Power.

2. **A market for number portability services:** The regulator will need to define a market for number portability services. The impact of this option depends on which relevant markets are defined and what will be the constrains for the Significant Market Power.

Table 5: Impact of the options regarding numbering in relation to the key question of OPTA: "Avoid a monopoly situation in the market for voice caused by innovative voice-over-packet technologies" as stated in the introduction of this chapter.

Options for the regulator		Impact on Scenarios			
	Feasibility and overall impact	**I Frozen world**	**II Incumbent Rules**	**III Multi-platform competition**	**IV CPS dream**
Regarding competition Wholesale markets					
1. A market for gateway services:	+/-	+	++	+/-	+/-
2. A market for number portability services:	+/-	+	++	+/-	+/-

End-users:

Regarding tariff transparency

1. **Advice of Charge (see Appendix VII for a more detailed description):** This option would have a high impact on all operators due to its complex implementation. the regulator will need to perform a feasibility study in order to assess this huge impact. The implementation will be complex for both traditional operators as well as for VoIP providers. However the result will be increasing pricing transparency for end-users.

2. **Branding through numbers:** This option will be complex for both regulator and operators. First of all, this action is not within the regulators control, since it requires political change. Port numbers will not be possible between VoIP and PSTN services (as these are priced different). This results in a lower penetration of VoIP services. The incumbent and other parties operating an infrastructure, will therefore be best positioned for offering VoIP services.

3. **Depository of rates:** The impact of this option is low in terms of complexity. In fact this option is already part of current legislation. Implementation for operators and VoIP providers is relatively simple. The improvement in pricing transparency will primarily benefit the corporate end-users.

Table 6: Impact of the options regarding numbering in relation to the key question of OPTA: "Avoid a monopoly situation in the market for voice caused by innovative voice-over-packet technologies" as stated in the introduction of this chapter.

Options for the regulator		Impact on Scenarios			
	Feasibility and overall impact	**I Frozen world**	**II Incumbent Rules**	**III Multi-platform competition**	**IV CPS dream**
Regarding End-users: Tariff transparency					
1. Advice of charge:	-/-	+/-	+/-	+	+/-
2. Branding through numbers:	-/-	+/-	-/-	-	+/-
3. Depository of rates:	+	+/-	+/-	+	+/-

6. Conclusions and recommendations

6.1. Voice-over-packet technology has the potential to create radical change

Voice-over-packet technology, and specifically VoIP and VoDSL, provides new ways to deliver voice telephony services. Traditional voice service, or at least the access component of that service, can only be delivered through physical access to the local loop and switching equipment close to the customer. This leads to a large cost base for any provider wanting to provide significant coverage, resulting in a "natural monopoly" for the access service in residential areas.

New services based on VoDSL and VoIP, on the other hand, can be delivered with a minimum of equipment, located further away from the customer, and with a more indirect access to the local loop. Because of this, small providers can provide services without incurring major costs, and multiple providers can offer different services to the same customer. Such services can vary between a cheap and low quality substitute for some part of the existing telephony service, and a full PSTN replacement with all the features of the existing telephony service.

Although voice-over-packet telephony services can be based on a number of standards, there are mechanisms to ensure interoperability between services based on different standards. Therefore, a provider is able to ensure that a customer can reach anyone and be reached by anyone. Whether a provider actually implements such interoperability is a different matter; a provider may well decide to interconnect with a traditional PSTN provider for transit services rather than implement complex arrangements with other voice-over-packet providers.

A fundamental driver for the growth of VoIP and VoDSL services is the penetration of broadband access. As this penetration is already substantial[34], and increasing rapidly, the addressable market for these services is now large enough for providers to make an impact on the voice market as a whole.

A VoIP service can be offered by any party with access to the Internet, anywhere in the world, although a party with control over the IP access layer can provider a better quality service. A VoDSL service can only be offered through direct access to the xDSL connection, making it attractive for an ISP to offer a combination of Internet access and VoDSL service on the same xDSL connection.

[34] Penetration of broadband access (cable and xDSL) in the Netherlands now stands at approximately 20% of households.

At this time, there is a limited number of voice-over-packet services on offer in the Netherlands. However, various providers are currently performing technical and commercial trials; these trials are likely to lead to commercially available services within the next year.

Current regulation is not clear on how voice-over-packet services should be treated. Although the rules are designed to be technology neutral, they do not set clear criteria to determine whether a service is a "telephony service at fixed location", with all the obligations specific to such a service. It is also not clear what services belong to the same relevant markets as the existing PSTN services; this will have to be resolved through market studies. In general, a VoDSL service may be assumed to be a telephony service at fixed location, whereas VoIP services can fit different descriptions depending on the implementation.

6.2. Changes caused by voice-over-packet technology create new issues for the regulator

Numbering:
With all the different services which voice-over-packet allows, regulators will have to decide what type of numbers to allocate to these services, and under what constraints. If some of the new services are found to deliver a full PSTN substitute, whereas others only deliver a small part of that functionality, it will prove difficult to define clear boundaries as to what type of service may use PSTN numbers.

This is further complicated by the fact that existing numbering plans differentiate between fixed and mobile telephony, while the new services may be something in between. Even when the service is used at a fixed location, and therefore perceived as a fixed telephony service, the provider may not be able to verify that the end-user is actually within the geographic area implied by the number. The situation may also change at any time, as the user can simply take his service (and possibly the equipment) to a different location without the provider being aware of the fact. The number plan currently defines geographical areas, but does not specify whether the provider has to ensure that the customer adheres to this definition.

Competition:
While the new services have the potential to create new opportunities for competition, this may not happen without intervention by the regulator. Established providers with access to the local loop, the telephony infrastructure, and the broadband Internet access infrastructures all have major advantages in this market compared to newcomers. This may well lead to new monopolies or oligopolies.

As these new services develop, the regulator will have to define relevant markets for telephony and for the underlying services, and determine whether market forces are creating

a competitive arena in each of them. Given the ability of VoIP to blur the boundary between fixed and mobile services, the regulator may end up allocating services to different markets on a case by case basis – unless it finds that fixed, mobile, and in-between services turn out to form a single market.

As there is a risk of new monopolies in the wholesale area, the regulator will also need to define relevant wholesale markets. Besides the traditional markets of wholesale origination and termination, there may be a separate market for routing analysis, for gateways between PSTN and voice-over-packet services, and for interworking functions between voice-over-packet networks.

End-users:
Voice-over-packet services have the potential to reduce the transparency of telephony services. If the services are allowed to use the same number ranges as existing services, a calling (PSTN) user may not know the price of a call in advance, nor will he know what quality to expect. These issues already exist to some degree within the PSTN, but if a large number of providers offer voice-over-packet services, with different quality levels and different prices, the situation will become far more complex.

Services offered may not necessarily be full telephony services; a user may well subscribe to several services, each offering different functions. In that case, there is therefore no certainty that a user will be able to reach all destinations on all telephony networks; in particular there is a risk that a user will not be able to reach emergency services.

6.3. Current uncertainties further complicate these issues

At this moment there are several uncertainties in the way the market for voice-over-packet will develop in the years to come. These uncertainties are outside the span of control of the regulator. The following uncertainties where identified as most relevant with regard to the objective as stated by OPTA with the time horizon at 2009 : *"Avoid a monopoly situation in the market for voice (and underlying services) caused by innovative voice-over-packet (VoDSL, VoIP) technologies"*

Price/quality/features
It is unclear how the price quality ratio of especially VoIP services will develop. The position of VoIP services versus PSTN like voice services will be highly related to (VoIP) technology developments, marketed features, broadband penetration and pricing.

Strategy incumbent and new entrants
Market development will be strongly influenced by the strategic positioning of the incumbent. The incumbent might choose to focus on VoIP wholesale services only or position itself as a VoIP retailer either with or without partners. This positioning will also

affect the customer perception towards VoIP which can be either perceived as a telephony or more like an Internet type of service.

The strategy of new entrants on the VoIP market is also unknown. Large international parties might play a significant role. However, the VoIP market for public services may as well remain a niche market. VoIP services can be positioned as an extension of broadband offering with either a cheap low quality voice alternative or a feature rich voice service. Combined private initiatives may result in a VoIP infrastructure parallel to the PSTN.

6.4. The scenario analysis helps to identify robust options for the regulator

The most relevant trends and uncertainties in market developments with respect to OPTA's objective on the longer term are used to construct plausible scenarios. Analysis of the impact of the various options available for OPTA on these scenarios helps to define certain robust options. All option are scored in terms of impact on the various scenarios. Additionally, the impact of a number of options are analysed in more detail. The following options are labelled as robust in terms of feasibility and their positive impact on the possible scenarios with regard to OPTA's objective.

Number allocation:
Service Neutral: Allow the use of geographical numbers for any service, as long as the provider makes a "best effort" to ensure that geographical numbers are used in accordance with their purpose
Full flexibility: Allow the use of geographical numbers for any service (excluding mobile), regardless of location.

Since VoIP services are already on offer using geographical numbers action is required now. In order to prevent confusion a clear set of rules should be provided on the short term.

Numbering capacity:
Issue smaller number blocks: Allocate smaller numbers blocks to prevent or at least delay a shortage of numbers.

The necessity of expanding the numbers space is highly related to the success of VoIP services. Since this option requires limited preparation, a decision can be made at a later stage.

Competition / relevant retail markets:
One market for voice: Treat all voice services as a single relevant market, regardless of whether they are delivered to a mobile, fixed, or "nomadic" end-point.

Mobile and fixed markets: Treat mobile and fixed voice services as separate markets, with VoIP and other nomadic services either belonging to the fixed or to the mobile market.
A market study needs to be performed after the new Telecomwet is in place. This study will define the relevant markets for voice services.

Competition / relevant wholesale markets
A market for gateway services: Define gateway services (PSTN-VoIP) as a separate market.
A market for number portability services: Define the number portability look up service as a separate market.

The relevance of these options depends on the developments in the VoIP market. An emerging significant market power might on VoIP gateway services or number portability services might require the definition of separate markets and consequent regulation of these services.

End-users (tariff transparency)
Depository of rates: Mandate that all providers either maintain a register of rates to all destinations on their own web-site, or provide this information through a central register.

Action is required when pricing transparency becomes an issue. This will depend on market developments an the execution of other options.

Four of these options were pointed out by OPTA to be analysed in further detail. These can be found in Appendix VII together with two non-robust options that where also somewhat further explored.

6.5. Regulator should keep tracking developments

Further develop scenario analysis
The next step to be taken by OPTA would be to develop this scenario analysis in further detail. This means that the options, especially those labelled in this study as “robust”, should be analysed further in terms of impact and feasibility. Per option a feasibility study should be performed and the relevant industry parties will need to be consulted. For certain options, if not all, it will be relevant to discuss the implementation with DGTP. Depending on the outcome of all of the actions mentioned above the regulator may decide to either execute an option or not.

Watch for hints that world develops in one direction or the other
The scenarios as used in this analysis are driven by major uncertainties. However, over time these uncertainties will develop and become more certain. At that point the situation is actually moving to one or two of the scenarios. Therefore it will be very important for the

regulator to keep tracking the market developments. Especially important are the driving forces that were defined in the scenario analysis as described in this report. In a situation where the market is moving towards one of the scenarios, the regulator will need to evaluate its options in terms of the desired effects in the specific scenario's. Depending on this evaluation consequent action can be taken.

In addition to tracking these market developments, OPTA should keep an eye on the actions taken by foreign regulators. As all these developments have a highly international character as well as impact, the regulator will need to discuss this matter with foreign peers.

Appendix I: Glossary

3GPP	Third Generation Partnership Project - co-operation of standard organisations to set the technical specifications for 3rd Generation Mobile Systems
AAL2	ATM Adaption Layer 2 - ATM sub-layer defining a PVC with variable bit rate
ACELP	Algebraic Code-Exited Linear Prediction - an algorithm for digitalisation and compression of voice
ADPCM	Adaptive Differential Pulse-Code Modulation - an algorithm for digitalisation and compression of voice
ADSL	Asymmetric Digital Subscriber Line
ATM	Asynchronous Transfer Mode – Cell based switching technology
B2BUAs	Back to Back User Agents – Centralised SIP configuration
BLES	Broadband Loop Emulation Services – Signalling and transport service for voice over ATM (over DSL)
Codecs	Coders / Decoders - used for audio or video
CBR	Constant Bit Rate - type of ATM PVC
CPS	Carrier Pre-Select
DNS	Domain Name System – Relates a Internet domain name to an IP address and vice-versa
DOCSIS	Data over Cable Service Interface Specifications
DSL	Digital Subscriber Line
DTMF	Dual Tone Multi Frequency - also known as tone dialling
ENUM	Directory service which maps various identifiers to E.164 numbers
ETSI	European Telecommunication Standards Institute
EuroDOCSIS	European version of DOCSIS
FCC	Federal Communications Commission - US telecom “watch dog”
FttC	Fibre to the Curb
FttH	Fibre to the Home
G.7xx	ITU recommendations referring to audio codecs
GKRCS	Gatekeeper Routed Call Signalling – Centralised H.323 architecture
IAD	Integrated Access Device – multifunctional DSL modem
IETF	Internet Engineering Task Force
IPDC	Internet Protocol Device Control -
ISDN	Integrated Services Digital Network
ITU	International Telecommunications Union
KaZaA	Popular peer-to-peer Internet file sharing program
LDAP	Lightweight Directory Access Protocol
MGCP	Media Gateway Control Protocol - IETF protocol for (media) gateway control
Megaco	Media gateway control - IETF protocol equal to ITU H.248
OAM&P	Operations, Administration, Maintenance and Provisioning

OPTA	Onafhankelijke Post en Telecom Authoriteit – the Dutch telecommunications regulator
PABX	Private Automatic Branch Exchange
PCM	Pulse-Code Modulation - Modulation technique for digital voice
PVC	Permanent Virtual Circuit - type of ATM circuit
PSTN	Public Switched Telephone Network
Pilmo	VoIP service of Rits tele.com
QoS	Quality of Service - delay, delay variation (jitter) and packet loss
RTP	Real Time Transport Protocol - IETF protocol used for transport of real time media including coded voice over data networks.
SCCP	Skinny Client Control Protocol - Proprietary Cisco protocol used for control of 'thin' VoIP endpoints
SDP	Session Description Protocol - VoIP protocol used for capability exchange in combination with SIP
SGCP	Simple Gateway Control Protocol - Dated IETF protocol to control VoIP gateways
SIGTRAN	Signalling Transport - Protocol that defines PSTN signalling over IP networks
SIM	Subscriber Identify Module
SMS	Short Message Service
Skype	Recent Internet peer-to-peer VoIP service (the makers of KaZaA)
TCP	Transport Control Protocol - Transport protocol on top of IP layer
TDM	Time Division Multiplexing - Circuit switched technology based on multiplexing data signals in separate timeslots
TIPHON	Telecommunications and Internet Protocol Harmonisation over Networks - ETSI project ensuring IP-PSTN interoperability
UDP	User Datagram Protocol - Transport protocol on top of IP layer
ULL	Unbundled Local Loop
UPT	Universal Personal Telecommunication
URI	Universal Resource Identifier
VBR-rt	Variable Bit Rate- real time, ATM PVC used for bitstream access
VPN	Virtual Private network - Non-physical segmentation of data traffic
VoA	Voice over ATM
VoATM	Voice over ATM
VoDSL	Voice over DSL
VoE	Voice over Ethernet
VoFR	Voice over Frame relay
VoIP	Voice over IP
VoWLAN	Voice over WLAN
VoWifi	Voice over Wifi
WLAN	Wireless Local Area Network
WiFi	Wireless Fidelity
xDSL	Generic designation for various types of Digital Subscriber Line

Appendix II: ITU audio codecs

The ITU defines a wide number of audio codecs (coders and decoders) but the following are most commonly supported by the various voice-over-packet protocols:

G.711: 64 kbits, Pulse Code Modulation (PCM) as used in circuit based networks; voice quality: good.

G.726: 32 kbits, Adaptive Differential PCM (ADPCM), originally designed for circuit switching; voice quality: good

G.722.2: 16 kbits, Adaptive Multi-Rate Wideband (AMR-WB); voice quality: fair

G.729A: 8 kbits, Conjugate-Structure Algebraic-Code-Excited Linear-Prediction (CS-ACELP); voice quality: fair

G.723.1: 5.3 or 6.4 kbits, Dual rate codec using ACELP or Multi Pulse-Maximum Likelihood Quantization (MP-MLQ); voice quality: low

Appendix III: VoIP protocols

Distributed architecture protocols: H.323 and SIP

H.323

H.323 is a ITU recommendation that defines “packet-based multimedia communication systems” which is a distributed architecture for creating multimedia applications including. VoIP. The protocol was originally developed as a multimedia conferencing protocol for the LAN environment and is used for call set-up. Currently H.323 is the VoIP protocol with the largest installed base.

H.323 is often described as an “umbrella protocol” as it defines different protocols for all aspects of call transmission such as:

- RAS (Registration, Admission, and Status protocol) for call routing;
- H.225 protocol for packet transport;
- H.245 protocol for call control (such as capabilities exchange);
- H.235 protocol for security and encryption;
- H.332 protocol for large conferences;
- H.246 protocol for interoperability with TDM (circuit switched) networks;
- H.350 protocol for directory services
- Q.931 protocol for call signalling, based on ISDN

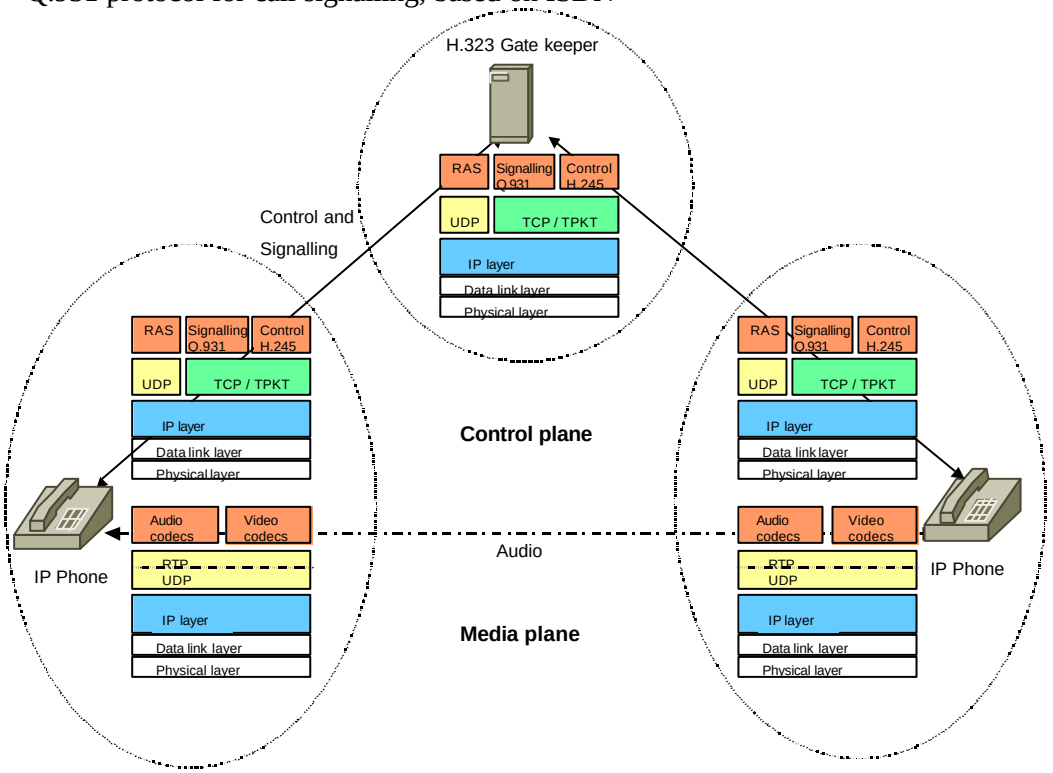

Figure 15: VoIP protocols under the H.323 umbrella

Figure 15 gives an overview of the H.323 protocol in the media and in the control plane. The call control device in H.323 terms is called the “Gatekeeper” which handles RAS functionality. Call signalling and control can either be directed over the Gatekeeper, known as gate keeper routed call signalling (GKRCS) or directly between endpoints.

Depending on functionality of the specific protocol TCP or UDP is used as transport layer. Media streams are transported using the Real Time Transport Protocol (RTP) over UDP. This combinations ensures real time data transport using time stamps, sequence numbers, etc. without the need for delaying “acknowledgements” en “retransmissions” as are common for TCP.

In H.323 the G.711, G.723, G.729 codecs are mandatory ensuring a guaranteed match during “capability exchange” between two VoIP devices. Others can be negotiated using H.245.

SIP

SIP is a IETF (Internet Engineering Task Force[35]) standard for the set up of multimedia sessions (including VoIP) between Internet endpoints (called User Agents). SIP, originally defined in RFC 2543 and later improved in RFC 3261, is a lightweight text-based signalling protocol, used for VoIP call set-up. It is a HTTP-like server /client protocol that builds on popular Internet technology. In order to build a complete Multimedia (VoIP) architecture SIP works in conjunction with other IETF protocols and standards such as:

- SDP (Session Description Protocol) used for capabilities exchange (call control);
- RTP (Real Time Transport Protocol) for the transport of real time data;
- URIs (Universal Resource Identifiers) for addressing;
- DNS (Domain Name System) for service location;
- MGCP or Megaco (for the control of gateways to the PSTN).

SDP is used to convey capabilities exchange in SIP connections and is transported in the text message body of SIP.

SIP provides a suite of security services, which include denial-of-service prevention, authentication (both user to user and proxy to user), integrity protection, and encryption services.

The used audio codecs are equal to the G.7xx ITU standards as mentioned before. However, there are no mandatory codes for SIP devices which means there is no guaranteed connection between two multimedia devices.

[35] The Internet Engineering Task Force (IETF) is a open international community of network designers, operators, vendors, and researchers concerned with the evolution of the Internet architecture and operation. Standards are published as Requests For Comment (RFC).

The SIP functionality in the control and media plane is shown in Figure 16. The call control device between two User Agents is known as the SIP proxy server. The user agents terminate both the signalling and media path. The SIP proxy is usually integrated or linked with a registrar and redirect server for address resolving. The registrar dynamically registers the current location of user agents while a redirect server responds to request by redirecting them to the appropriate device. Most common SIP configuration includes direct signalling between user agents although centralised control and signalling can be done using SIP back-to-back user agents (B2BUAs) (Similar with H.323 gate keeper routed signalling). In this configuration the signalling is terminated on both sides of the SIP proxy. This prevents end-to-end encryption, therefore the call control device need to be a trusted party.

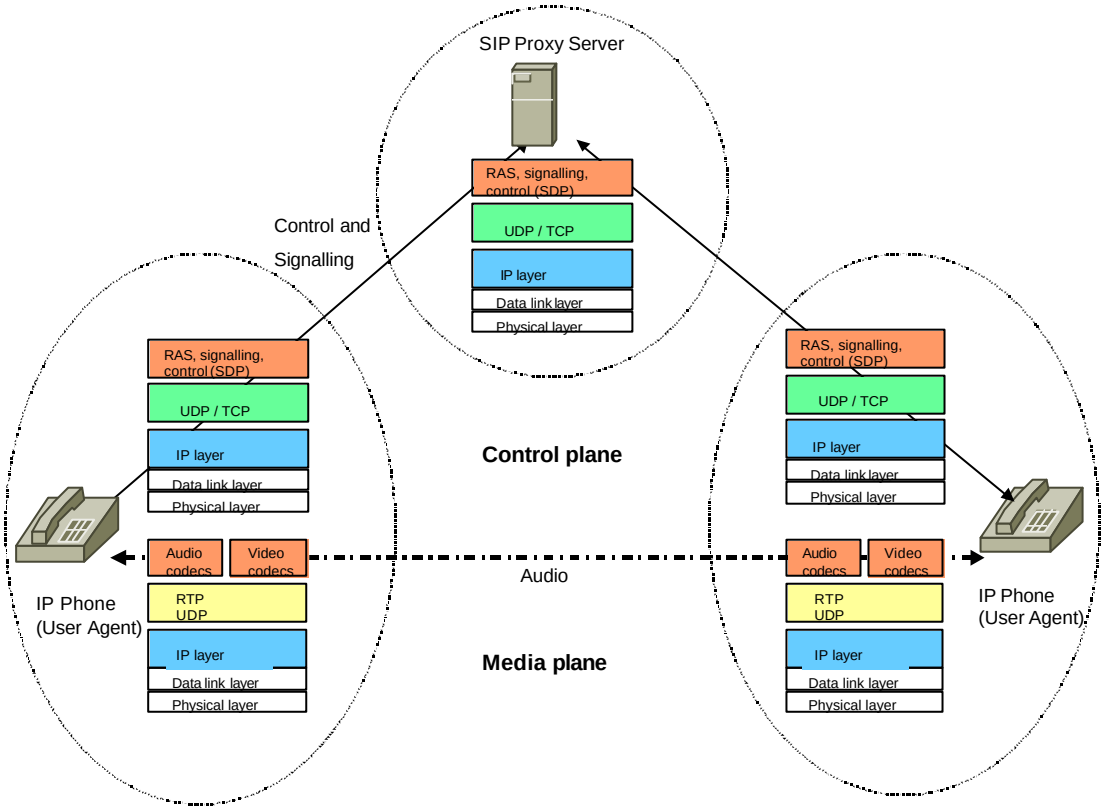

Figure 16: Functionality of the SIP protocol

Deployment of SIP is growing rapidly as the "Internet world" is pushing the technology for multimedia applications including VoIP. SIP is incorporated in the new Windows XP software, and the "Third Generation Partnership Project[36] (3GPP)" anticipates the use of SIP as the telephony signalling protocol in all-IP networks.

[36] 3GPP is a co-operation of Third generation standards organisations and other related bodies for the development of a complete set of globally applicable Technical Specifications for a 3rd Generation Mobile System based on the evolved GSM core networks and the radio access technologies supported by 3GPP partners.

Comparison: H.323 vs. SIP

	H.323	SIP
Standards body	ITU	IETF
Current version	H.323v5	RFC2543-bis07
Architecture / Intelligence	Distributed	Distributed
Call control	Gate keeper	Proxy / redirect server
End points	Gateway, terminal	user agent
Signaling transport	TCP, UDP	TCP, UDP
State awareness	stateless,statefull RAS	stateless
DTMF relay transport	H.245 (signaling) or RFC 2833 (media)	INFO (signaling) or RFC 2833 (media)
Fax relay transport	T.38	T.38
Addressing	Aliases (E.164, URI)	SIP URLs, E.164
Encoding	ASN.1,binary	HTTP-like, text-based
Protocol architecture	Stack	Element
Supplemental services provide by	endpoints or call control (H.450)	endpoints or call control

Gateway architectures and protocols

The gateway converts media streams (media gateway) and signalling (signalling gateway) between different types of networks. The functional building blocks of a gateway are shown in the figure below. This functionality can be integrated within a single device or divided into a Signalling Gateway, Media gateway and Gateway Controller unit. If separated, the Gateway Controller communicates with the Signalling Gateway using the SIGTRAN (Signalling Transport, RFC 2719) protocol for C7 signalling over IP networks. The Gateway controller uses the standard MGCP or Megaco / H.248 protocols or a proprietary protocol to control the Media Gateway.

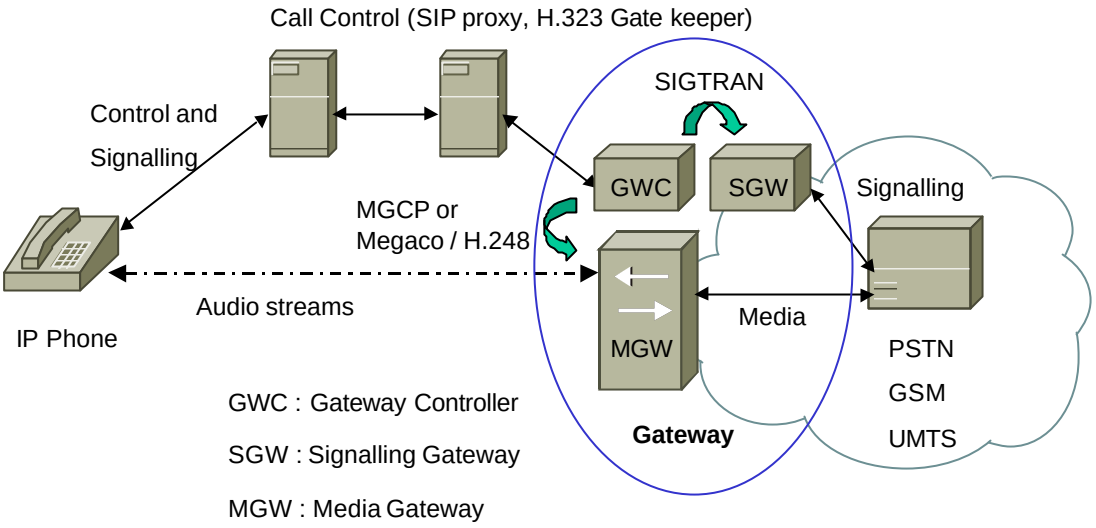

Figure 17: Gateway Architecture

Depending on the VoIP network architecture the intelligence (signalling, control) can be distributed and integrated in the endpoints or places at central call control devices replicating traditional voice network architectures.

Centralised architectures place gateway control functionality on central intelligent call control devices (media gateway controllers) which control relatively simple endpoints. These architectures typically use the MGCP or Megaco / H.248 protocols to control the Media Gateway. The Gateway Controller communicates with the Signalling Gateway using the SIGTRAN (Signalling Transport) protocol for PSTN signalling over IP networks.

MGCP

Media Gateway Control Protocol (MGCP) is an IETF standard based upon the former SGCP (Simple Gateway Control Protocol) and IPDC (Internet Protocol Device Control) with additional OAM&P (Operation, Administration, Management & Provisioning). MGCP is used for the control of VoIP devices such as VoIP (media) gateways and VoIP terminals. It is a master/slave protocol which defines a centralised architecture for creating multimedia applications. MGCP only allows for UDP in the transport layer.

Megaco / H.248

Megaco / H.248 is the result of a joint collaboration of the ITU (Recommendation H.248) and IETF (RFC2885). The protocol defines a centralised architecture for creating multimedia applications (incl. VoIP) and is an enhanced, but also more complex version of MGCP. The Megaco model allows more flexible control by the media gateway controller. Due to these greater capabilities Megaco is a more useful protocol for applications like multimedia conferencing.

SCCP (proprietary)

SCCP (Skinny Client Control Protocol) is a Cisco proprietary protocol. This is a lightweight MGCP/Megaco like protocol used in popular Cisco solutions for corporate environments with a central call control device (Cisco Call Manager) and thin clients in (dumb) IP endpoints (IP phones). SCCP can co-exist with the main other VoIP protocols.

Comparison: media gateway control protocols

	MCGP	Megaco/H.248	SCCP (Skinny)
Standards body	IETF	IETF/ITU	Cisco Prop.
Current version	MCGP 1.0	Megaco/H.248	
Architecture / Intelligence	Centralized	Centralized	Centralized
Call control	Call agent	Media gateway controller	Call manager
End points	media gateway, signaling gateway	media gateway, signaling gateway	IP phones
Signaling transport	UDP	TCP, UDP	
State awareness	statefull	statefull	statefull
DTMF relay transport	Signaling or RFC 2833	Signaling or RFC 2833	yes
Fax relay transport	T.38	T.38	yes
Supplemental services provide by	Call agent	Media gateway controller	Call manager

SIGTRAN

Signalling transport (SIGTRAN) is an IETF protocol (RFC 2719) that defines an architecture for the transport of PSTN signalling, such as ISDN (Q.931) and C7, over IP networks. In a VoIP network SIGTRAN is used between the Gateway controller and the Signalling gateway.

Appendix IV: VoDSL protocols

VoDSL architectures usually use the ATM sublayer AAL2 (ATM Adaption Layer 2), which enables voice and associated signalling to be carried on a single permanent virtual circuit (PVC) of variable bitrate. The PVC shares the connection bandwidth with an additional PVC for the data connection. On top of the AAL2 layer, a standardised voice signalling and transport service is available called Broadband Loop Emulation Service (BLES). BLES enables PSTN signalling functionality between the IAD and the (VoDSL/VoA) switch. The figure below gives an overview of the protocol functionality in the control and media plane.

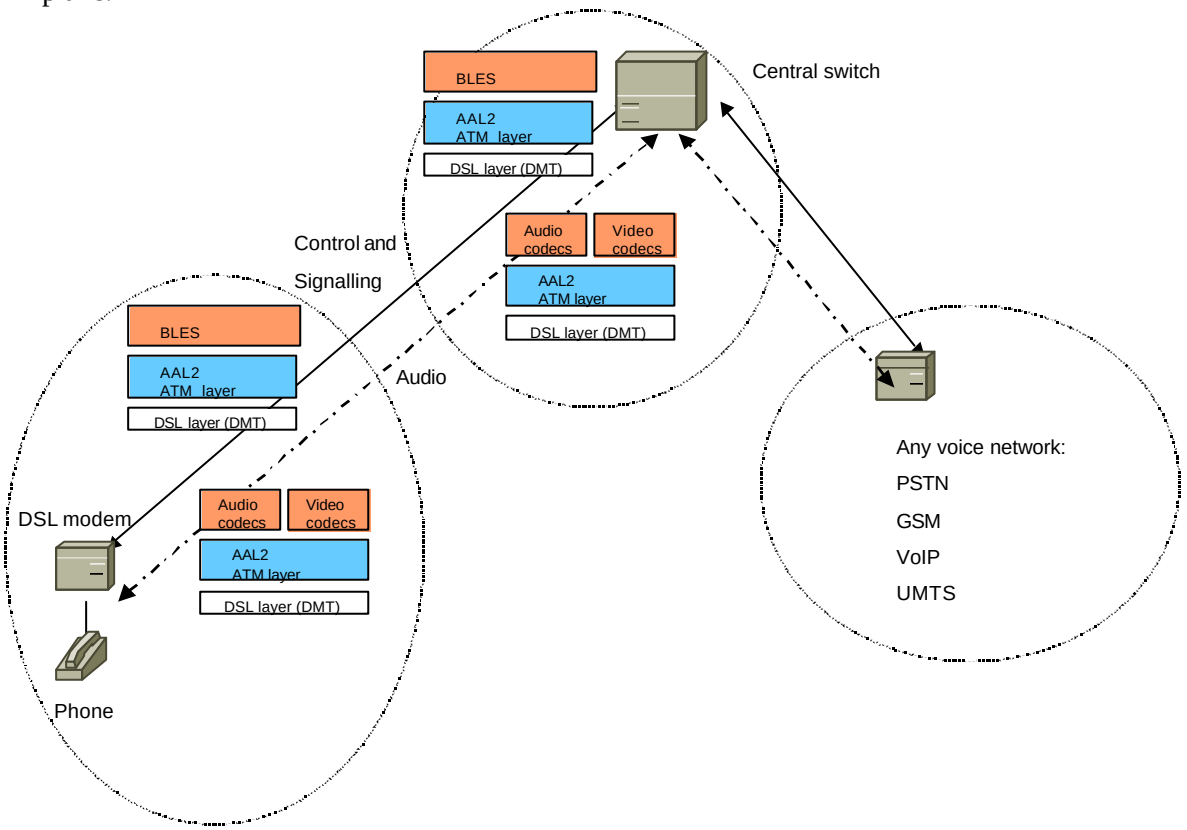

Figure 18: VoDSL protocol functionality

Stratix

Appendix V: Addressable market

Adressable market Voice over Cable(modem)	1 januari 2003	30 juni 2003
Cablemodem Platform	**CATV subscribers**	**Cablemodem subscribers**
Chello (UPC)	2.413.283	310.900
@Home (Essent Kabelcom)	1.835.383	225.000
CableWanadoo (Casema)	1.329.715	147.551
Quicknet (Multikabel)	305.000	62.141
Zeelandnet (Delta)	147.311	70.000
Kabelfoon (CAI Westland)	223.597	45.000
Other Cableplatforms	40.125	± 7.500
SME businesses & schools on CATV-networks		± 15.000
Non-served CATV-subscribers	± 55.000	-
Total Dutch households	± 7.000.000	
% of households subscribing to cable service	90%	
% on two-way capable networks	± 75%	

Adressable market Voice over DSL	30 juni 2003	30 juni 2003
Platform	**% of population DSL-enabled**	**Subscribers**
KPN ADSL	87%	513.000
BBned	75%	45.000
Versatel	50%	34.500
Tiscali	25%	21.000
Other DSL platform owners	15%	5.000
In comparison		
KPN PSTN/ISDN telephony lines	100%	7.773.547

Source: Stratix analysis of company reports

Market position Broadband ISP's		30 juni 2003
Broadband ISP	**Financial ties with network owner**	**Subscribers**
Chello	UPC	310.900
Planet Internet	KPN	229.000
@Home	Essent Kabelcom	225.000
Wanadoo Cable & DSL	Casema	203.000
XS4all	KPN	92.000
Zeelandnet	Delta	70.000
Zonnet	Versatel	69.000
Quicknet	Multikabel	62.141
Tiscali	Tiscali	50.000
Kabelfoon	Kabelfoon	45.000
Het Net	KPN	34.000
Other		151.950
Total broadband subscribers		**1.542.042**

Source: Stratix analysis of company reports

Appendix VI: Overview of the impact analysis

Options for the regulator	Feasibility / issues	Impact by Scenario *I Frozen world*	*II Incumbent Rules*	*III Multi-platform Competition*	*IV CPS dream*	Timing / action required
Regarding numbering: *Number allocation*						
1. **Very restrictive:** Separate numbering plan for VoIP (non-telephony) services	• The regulator has to define which services are a telephony substitute. • High complexity for industry. Two stage dialling for many VoIP service. • Alternative number plans (alphanumerical etc.) arise outside OPTA's span of control • Any regulatory action must be joint effort of international parties	• Reduction attractiveness of VoIP • Reduction of competition in voice services	• Reduction attractiveness of VoIP • Reduction of competition in voice • Eventually full substitute possible major renumbering operation	• Reduction attractiveness of VoIP • Reduction of competition in voice service • Eventually full substitute possible major renumbering operation	• Reduction attractiveness of VoIP • Reduction of competition in voice services	**Now,** since VoIP services are already on offer, more flexibility can be granted at a later stage
2. **Restrictive:** Restrict the allocation of geographical numbers to full voice service alternatives at fixed location only	• The regulator need to allocate special numbers for VoIP services. • Less attractive for industry than geographical numbers.	• Reduction of attractiveness and competition regarding VoIP	• Reduction of attractiveness and competition regarding VoIP • Higher complexity of solution but eventually full alternative, renumbering might be an issue	• Reduction of attractiveness and competition regarding VoIP • Higher complexity of solution but eventually full alternative, renumbering might be an issue	• Reduction of attractiveness and competition regarding VoIP	**Now,** since VoIP services are already on offer. More flexibility can be granted at a later stage

Options for the regulator	Feasibility / issues	Impact by Scenario *I Frozen world*	*II Incumbent Rules*	*III Multi-platform Competition*	*IV CPS dream*	Timing / action required
3. **More flexible**: Restrict allocation of geographical numbers to full alternatives for voice services. Demand "best effort" compliance of VoIP providers for linkage to geographical area.	• The regulator has to define "full alternative" voice services and enforce compliance to "best effort" adherence to location rules for VoIP services. • attractive for niche players • Renumbering in future less likely	• Stimulation of competition by VoIP niche players	• Stimulation of competition by VoIP niche players. • Advantage existing parties	• Stimulation of competition by VoIP niche players • Protests of existing players	• Stimulation of competition by VoIP niche players • Protests of existing players	**Now,** since VoIP services are already on offer
4. **Service neutral:** Allow allocation of geographical numbers to all fixed voice services. Demand best effort adherence to geographical areas	• The regulator has to define and enforce "nomadic" and "best effort" for non full alternative voice services. • Great flexibility and possibilities for (international) providers of various voice services • Many different type (and quality) of services on geographical numbers. • Pricing will become less transparent • Possibly a run on numbers by various (international) parties	• Many international niche players but total customer base remains small	• Many international players but "incumbent rules". • Numbers can be reused across incumbent services	• Many international players. • Possible number shortage	• Many international niche players but total customer base remains small	**Now,** since VoIP services are already on offer

Options for the regulator	Feasibility / issues	Impact by Scenario *I Frozen world*	*II Incumbent Rules*	*III Multi-platform Competition*	*IV CPS dream*	Timing / action required
5. **Full flexibility:** Allow geographical numbers for all fixed (voice) services	• Not within the regulator's control, requires policy change • More different type (and quality) of services on geographical numbers. • Pricing will become even less transparent	• Many international niche players but total customer base remains small • All sort of voice services • Tariff pricing will no longer be based on distance	• Many international players but "incumbent rules". • Numbers can be reused across incumbent's services • Differentiated (features rich) offer of voice services • Tariff pricing will no longer be based on distance	• Many international players. • Possible temporary number shortage • Explosion of various voice services • Tariff pricing will no longer be based on distance	• Many international niche players but total customer base remains small • All sorts of voice services • Tariff pricing will no longer be based on distance	**Now or** start with *service neutral* option and **wait** for market developments
6. **Full flexibility (all numbers):** Allow any number for any service.	• Many different type (and quality) of services on geographical numbers. • Pricing will become a lot less transparent • This option shows in al aspects a more extreme impact as options 4 and 5.	• Many international niche players but total customer base remains small • All sort of voice services • Tariff pricing will no longer be based on distance	• Many international players but "incumbent rules". • Numbers can be reused across incumbent's services • Differentiated (features rich) offer of voice services • Tariff pricing will no longer be based on distance	• Many international players. • Possible temporary number shortage • Explosion of various voice services • Tariff pricing will no longer be based on distance	• Many international niche players but total customer base remains small • All sorts of voice services • Tariff pricing will no longer be based on distance	**Now or** start with *service neutral* option and **wait** for market developments

Options for the regulator	Feasibility / issues	Impact by Scenario *I Frozen world*	*II Incumbent Rules*	*III Multi-platform Competition*	*IV CPS dream*	Timing / action required
Increased need for numbering space:						
4. **Expand the numbering space:** renumber existing number ranges	• Major impact on society (end users) • Huge effort for telecom operators • Decision not with the regulator but with the policy maker	• Renumbering turns out to be premature	• Probably renumbering turns out to be premature	• This option will reduce the bottleneck in available the numbers	• Renumbering turns out to be premature	Depends on other decisions and on scenario; needs long preparation
5. **Issue smaller number blocks:** allocate numbers as needed	• complex for regulator (operationally) • Flexible in choice of number block size • Extreme case: manage numbers individually (like 0800/090x) • More efficient use of numbers • Operators have to sort out every single number via (COIN) database	• Renumbering turns out to be premature • Impact limited if regulator starts with blocks of 100	• Probably renumbering turns out to be premature • Impact limited if regulator starts with blocks of 100	• This option will reduce the bottleneck in available numbers	• Renumbering turns out to be premature • Impact limited if regulator starts with blocks of 100	Depends on other decisions and on scenario; Requires less preparation, so decision can be made later
6. **Issue numbers directly to users:** allocate numbers to end-users, not to service providers	• Very complex for regulator • Need to collect payments from millions of individuals or find different financing method • Part of operational effort can be done by operators • Operators have to sort out every single number via (COIN) database	• Renumbering turns out to be premature	• Probably renumbering turns out to be premature	• This option will reduce the bottleneck in available numbers	• Renumbering turns out to be premature	Depends on other decisions and on scenario; needs long preparation

Options for the regulator	Feasibility / issues	Impact by Scenario *I Frozen world*	*II Incumbent Rules*	*III Multi-platform Competition*	*IV CPS dream*	Timing / action required
Regarding competition *Retail markets*						
1. **One market for voice:** redefine access, local/ national/international.	• Market study is a prerequisite • Incumbent is the only significant market power (SMP) in Scenario I, II, IV. • Regulator can put the same constrains on all voice services (incl. VoIP) in Scenario I, II, and IV.	• Less interesting for incumbent to push VoIP services. • Incumbent is the only significant market power (SMP)	• Less interesting for incumbent to push VoIP services • Relative low penetration of VoIP services • Incumbent is the only significant market power (SMP)	• Possibly no SMP on voice. SMP on wholesale may lead to conflicts	• Incumbent is the only SMP on voice. • Other providers have access to wholesale voice services. Specific VoIP services (e.g gateway) might be treated separately	Market study now. Act if services are converging
2. **Mobile and fixed markets:** Separate mobile and fixed services, and position VoIP to one of these	• Default option, EU recommendation • Regulator has to decide on case by case basis whether VoIP services are fixed or mobile.	• VoIP services marked as "fixed" are less attractive for incumbent	• Mobile VoIP services are attractive for incumbent (e.g. Wifi phone). Incumbents fixed VoIP services are constraint	• Possibly no SMP in retail fixed voice, SMP on wholesale may lead to conflicts	• Possibly no SMP in retail fixed voice, SMP on wholesale may lead to conflicts	Market study now
3. **Separate markets:** Treat mobile fixed and nomadic as distinct markets	• Regulator can treat most VoIP services as a nomadic service (without initial constrains for the incumbent) • Define "Nomadic" • Market study needs to be done on Nomadic services	• Attractive for Incumbent to offer VoIP • Constrains will be put on SMP Nomadic market (incumbent)	• Incumbent SMP on Nomadic market • Different cost models for VoIP. (No comparison with PSTN)	• Incumbent not SMP on retail (nomadic) VoIP services, SMP on wholesale may lead to conflicts. • Possibilities to regulate new SMP on VoIP	• Incumbent not SMP on retail (nomadic) VoIP services, SMP on wholesale may lead to conflicts • Possibilities to regulate new SMP on VoIP	Market study now

Options for the regulator	Feasibility / issues	Impact by Scenario *I Frozen world*	*II Incumbent Rules*	*III Multi-platform Competition*	*IV CPS dream*	Timing / action required
Wholesale markets						
1. **A market for gateway services:** define gateway service (PSTN-VoIP) as separate market.	• Regulator needs to define gateway services market. • Impact depends on constrains for SMP	• This option might be relevant as the incumbent offers retail VoIP services and might not open up it's gateway platform to other VoIP providers	• This option is relevant as the incumbent is a SMP on this market and offers VoIP retail services	• This option might be relevant. The incumbent offers the wholesale gateway service.	• This option is not relevant	Later, depending on VoIP market developments
2. **A market for number portability services:** define the number portability look up service as a separate market	• Regulator needs to define number portability services market. • Impact depends on constrains for SMP	• This option might be relevant as the incumbent offers retail VoIP services and might not open up it's look up service platform to other VoIP providers	• This option is relevant as the incumbent is a SMP on this market and offers VoIP retail services	• This option might be relevant. The incumbent offers the wholesale portability service.	• This option is not relevant	Later, depending on VoIP market developments
Regarding End-users						
1. **Advice of charge:** Mandate advice of charge before all voice calls	• High impact on all operators, complex implementation. • Regulator needs to perform feasibility study • Increasing pricing transparency for end-users. • Increasing complexity for VoIP service providers	• Hardware and software adaptations for all operators, including VoIP • Little benefit (for VoIP) due to low penetration	• Hardware and software adaptations for all operators, including VoIP	• Hardware and software adaptations for all operators, including VoIP • Improved pricing transparency enables competition	• Hardware and software adaptations for all operators, including VoIP • Little benefit (for VoIP) due to low penetration	Depends on other options, when pricing transparency becomes an issue

Options for the regulator	Feasibility / issues	Impact by Scenario *I Frozen world*	*II Incumbent Rules*	*III Multi-platform Competition*	*IV CPS dream*	Timing / action required
2. **Branding through numbers:** Enforce clear relation between number ranges and tariffs	• Complex for both regulator and operators • Increasing pricing transparency for end-users. • Not within the regulator's control, requires policy change • Porting of numbers (between VoIP and PSTN) not possible	• Lower penetration of VoIP as VoIP services have recognisably different numbers • Low impact	• Incumbent and other parties with infrastructure are best positioned for VoIP services without threatening existing services	• Parties with infrastructure are best positioned for VoIP services • Improved pricing transparency enables competition	• Low penetration of VoIP • Low impact	Depends on other options, when pricing transparency becomes an issue
3. **Depository of rates:** Mandate general call rate register which can be downloaded.	• Part of current legislation • Relative simple implementation • Most helpful for corporate users, less interesting for consumers • Less conflict regarding transparency	• Increasing tariff transparency, especially for corporate user s	• Increasing tariff transparency, especially for corporate users	• Increasing tariff transparency, especially for corporate users. • Improved pricing transparency enables competition	• Increasing tariff transparency, especially for corporate users	Depends on other options, when pricing transparency becomes an issue

Appendix VII: Options in detail

<table>
<tr><td colspan="2">Area: Numbering</td></tr>
<tr><td colspan="2">Issues to resolve: Numbers are being requested for services which are not strictly complete telephony services, may have a different quality level, and do not necessarily correspond to the concept of a “fixed” telephone connection with a corresponding geographical area; even if the service is used at a fixed location in the corresponding area, the provider can not verify this.</td></tr>
<tr><td colspan="2">Option: Service neutral (4)</td></tr>
<tr><td colspan="2">Description: Allow the use of geographical numbers for any service, as long as the provider makes a “best effort” to ensure that geographical numbers are used in accordance with their purpose. For customers who wish to use the service in a more nomadic fashion, a provider should allocate numbers which are not associated with a telephony service at fixed locations, such as mobile or UPT numbers</td></tr>
<tr><td colspan="2">Feasibility: This option is open to OPTA, as it is not a change in policy but an interpretation of the existing numbering plan.</td></tr>
<tr><td colspan="2">Activities for OPTA:
Set out rules for a “best effort” a provider should undertake to ensure geographical numbers are used in accordance with their definition. These rules might specify (for instance) that if a service is not directly connected to a local loop or other connection with fixed location, the provider should at least specify in its contracts that the service must be used at a given location. The provider might also have to verify on a regular basis that the customer’s billing address is within the geographical area implied by the number.
Set out rules for the numbering of “nomadic” services, either using existing mobile numbers (possibly a distinct range of these numbers) or existing ranges for personal numbers.
Ensure that the public realises that geographic numbers do not necessarily correspond to PSTN destinations and may therefore vary in speech quality and price.</td></tr>
<tr><td colspan="2">Impact: In any scenario, such a flexible approach to the use of numbers will stimulate new services. Both the absence of negative “branding” of VoIP services through the number, and the availability of number portability from PSTN to VoIP will have a positive effect on the demand for VoIP, leading to a large number of different services.
The transparency for end-users will diminish, as the services offered, their quality, and their termination rates may vary substantially for numbers traditionally have been linked to PSTN services. As VoIP providers hold geographical numbers, they will need to become involved in routing and number portability discussions, or rely on existing players to perform these functions (transit services).</td></tr>
<tr><td>Scenario I:
Although take-up of VoIP services remains limited, numbering issues do not create any constraints on the service. The incumbent may well decide not to use geographic numbers for VoIP even though it is allowed, as it prefers not to have PSTN numbers associated with a low-end service. Some niche providers do use PSTN numbers, resulting in regular discussions with the regulator about the level of effort the provider should undertake to ensure that the service is actually used in the area specified. The incumbent keeps a close watch on these niche providers, as it sees them as spoiling the image of PSTN numbers. The incumbent complains to the regulator about these providers, stating that VoIP customers enjoy a higher flexibility compared to</td><td>Scenario II:
As PSTN is gradually substituted by VoIP (or VoDSL), numbers no longer differentiate between these services. However, with a quality of service and a termination rate comparable to PSTN, there is no longer any reason why the number should differentiate between services. The incumbent has implemented a technically complex solution based on its own interpretation of “best effort” geographical compliance, and insists that other providers must implement at least the same interpretation to ensure fair competition. Niche providers insist on a less stringent implementation. If a large number of users subscribe to both PSTN and VoIP service, geographical numbers may run out in certain areas.</td></tr>
</table>

PSTN customers and that there is therefore an element of unfair competition. Enforcing the "best effort" rules is complex, with the incumbent pressuring for stricter enforcement while the niche providers insist that too much regulation will kill them.	
Scenario IV: Although take-up of VoIP services remains limited, numbering issues do not create any constraints on the service. Niche providers use PSTN numbers, resulting in regular discussions with the regulator about the level of effort the provider should undertake to ensure that the service is actually used in the area specified. The incumbent keeps a close watch on these niche providers, as it sees them as spoiling the image of PSTN numbers. The incumbent complains to the regulator about these providers, stating that VoIP customers enjoy a higher flexibility compared to PSTN customers and that there is therefore an element of unfair competition. Enforcing the "best effort" rules is complex, with the incumbent pressuring for stricter enforcement while the niche providers insist that too much regulation will kill them. The incumbent provides number routing, transit, and termination services; given the size of the VoIP market in this scenario there is little incentive for providers to develop these functions for themselves; this does not stop them from complaining about the dominance the incumbent and a few other players have in this wholesale market.	**Scenario III:** Numbers no longer differentiate between PSTN and VoIP services. A large number of providers are offering various services, either as a telephony substitute or as a partial service. Most users subscribe to several different providers, causing geographical numbers to run out in many areas. Due to the large number of providers, number routing and portability become very complex, and some companies (including the incumbent) capitalise on this trend by selling number routing services separate from the existing transit and termination services. The incumbent is accused, possibly along with several other large PSTN player, of dominating this routing service market and attempting to prevent small players from implementing their own routing mechanism. The regulator is asked to intervene. The incumbent complains to the regulator about VoIP providers not truly undertaking a "best effort" regarding geographical numbers, stating that VoIP customers enjoy a higher flexibility compared to PSTN customers and that there is therefore an element of unfair competition.
Timing: VoIP providers are already using geographical numbers, and a clear set of rules is necessary in the short term to avoid confusion. As this option more or less confirms current practice, the immediate impact is minimal; however if the rules do not become clear in the short term there is a risk that a number of subscribers will have moved, or started to use their service in ways incompatible with the number plan, leading to disruption when the rules are put in place.	

Area: Numbering
Issues to resolve: Numbers are being requested for services which are not strictly complete telephony services, may have a different quality level, and do not necessarily correspond to the concept of a "fixed" telephone connection with a corresponding geographical area; even if the service is used at a fixed location in the corresponding area, the provider can not verify this.
Option: ***Full flexibility for geographical numbers (5)***
Description: Allow the use of geographical numbers for any service, regardless of location.
Feasibility: This option is a change in policy, requiring a change of the existing numbering plan. It would have to be decided by the policy body responsible for the numbering plan (in the Netherlands: DGTP). Implementation will be relatively simple, as it involves only a relaxation of existing rules.
Activities for OPTA: • Communicate to providers that the geographical nature of numbers becomes optional from a certain point in time. • Ensure that the public realises that geographic numbers do not necessarily correspond to PSTN nor to specific areas, and may vary in speech quality and price. • Evaluate existing distance based pricing models (local area/national rates) and decide whether the differentiation should be eliminated.
Impact: In any scenario, such a flexible approach to the use of numbers will stimulate new services. Both the absence of negative "branding" of VoIP services through the number, and the availability of number portability from PSTN to VoIP will have a positive effect on the demand for VoIP, leading to a large number of different services. Existing providers will start to offer full geographical number portability, compared to the current portability within the area covered by an area code. The transparency for end-users will diminish, as the services offered, their quality, and their termination rates may vary substantially for numbers traditionally have been linked to PSTN services. As VoIP providers hold geographical numbers, they will need to become involved in routing and number portability discussions, or rely on existing players to perform these functions (transit services). The existing tariff differentiation by distance may need to be eliminated from the current pricing models, as the relation between distance and number disappears.

Scenario I: Although take-up of VoIP services remains limited, numbering issues do not create any constraints on the service. The incumbent may well decide not to use geographic numbers for VoIP even though it is allowed, as it prefers not to have PSTN numbers associated with a low-end service. Some niche providers do use PSTN numbers. The incumbent keeps a close watch on these niche providers, as it sees them as spoiling the image of PSTN numbers.	**Scenario II:** As PSTN is gradually substituted by VoIP (or VoDSL), numbers no longer differentiate between these services. However, with a quality of service and a termination rate comparable to PSTN, there is no longer any reason why the number should differentiate between services.. Numbers may run out in certain area codes, as customers anywhere in the country apply for numbers from "favourite" codes (big cities?). This effect disappears after some time, because the codes cease to have meaning.
Scenario IV: Although take-up of VoIP services remains limited, numbering issues do not create any constraints on the service. Niche providers use PSTN numbers, offering numbers from any favourite "area" code; however due to the low take-up the impact on number availability is small. The incumbent keeps a close watch on these niche providers, as it sees them as spoiling	**Scenario III:** Numbers no longer differentiate between PSTN and VoIP services. A large number of providers are offering various services, either as a telephony substitute or as a partial service. Most users subscribe to several different providers, causing geographical numbers to run out in many areas. Due to the large number of providers, number routing and portability become very complex, and

the image of PSTN numbers. The incumbent provides number routing, transit, and termination services; given the size of the VoIP market in this scenario there is little incentive for providers to develop these functions for themselves; this does not stop them from complaining about the dominance the incumbent and a few other players have in this wholesale market.	some companies (including the incumbent) capitalise on this trend by selling number routing services separate from the existing transit and termination services. The incumbent is accused, possibly along with several other large PSTN player, of dominating this routing service market and attempting to prevent small players from implementing their own routing mechanism. The regulator is asked to intervene.
Timing: VoIP providers are already using geographical numbers, and a clear set of rules is necessary in the short term to avoid confusion. As this option only removes rules from the existing situation, the immediate impact is minimal.	

Area: Number space
Issues to resolve: In the scenarios (II and II) where VoIP services will show a strong growth, there is a serious possibility of shortage on geographical numbers. The regulator will need to expand the numbering space or allocate numbers more efficiently.
Option: ***Issue smaller number blocks (2)***
Description: Allocate smaller numbers blocks to prevent or at least delay a shortage of numbers.
Feasibility: This option can be operationally complex for the regulator depending on to which extend number blocks are being reduced. The impact for both industry and regulator can be limited as the regulator is flexible in defining the seize of number blocks. Within this option, the regulator can choose to postpone some of the operational complexity by temporarily reserving large blocks, and only allocating smaller parts of these blocks. Only when a need arises to allocate the remaining parts of the blocks reserved in this way to a different operator will the full solution have to be implemented.
Activities for OPTA: • Consult market parties in order to define feasibility and realistic time frame • Determine the initial breakdown of number blocks to blocks of 100 or in the most extreme case: allocate individual numbers, like the 0800/0900 numbers. • Define criteria that indicate when market developments require the allocation of smaller number blocks. The reduction of number blocks can be done in steps, initially starting with larger blocks
Impact:. The effort of implementation of this option will be high for all operators in all scenarios. Number routing will be more complex since every single number (block) will need to be resolved via the COIN database. The impact can be limited if the regulator starts with issuing 100 number blocks. However, in scenarios where a number shortage will arise the regulator can break down the number blocks even further, ultimately down to a single number. The operational complexity for service providers can be reduced by defining standardised, automated interfaces between provider and regulator. There would have to be a transition period during which existing providers can use up the numbers that are currently allocated to them.

Scenario I: The penetration of VoIP services will remain low. Therefore the no shortage of numbers will arise and renumbering will turn out to premature. However the impact of the renumbering will be limited as only relatively large number blocks are allocated. Due to fact that number routing will become more complex, new entrants will be depend more on access to whole sale services like access to the COIN database.	**Scenario II:** VoIP services will prove successful and the incumbent is offering VoIP retail services. New entrants demanding access to VoIP wholesale services including number portability services might lead to conflicts. Due to the increase of new VoIP services the regulator will need to break down the number blocks to smaller segments. The total increase of numbers largely depends on the re-use of numbers of VoIP services by the incumbent.
Scenario IV: The penetration of VoIP services will remain low. Therefore the no shortage of numbers will arise and renumbering will turn out to premature. However the impact of the renumbering will be limited as only relatively large number blocks are allocated. Due to fact that number routing will become more complex, new entrants will be depend more on access to whole sale services like access to the COIN database. Since the incumbent	**Scenario III:** VoIP services prove to be successful and are various services offered by many different parties all opting for numbers. Therefore number shortage is a serious issue. The regulator might need to breakdown number blocks into single numbers allocated to the service providers.

is offering (VoIP) wholesale services the impact of this complexity will be low for new entrants.	
Timing: Necessity of expanding the number space is highly related to the success of VoIP services. Other decisions might stimulate this market development. However, this option requires limited preparation, so decision can be made at a later stage when market developments are more clear.	

<table>
<tr><td colspan="2">Area: Competition (retail)</td></tr>
<tr><td colspan="2">Issues to resolve: When the new Telecommunications Act is in place a market study needs to be performed in order to define the relevant markets for voice. There are several possibilities for this market definition.</td></tr>
<tr><td colspan="2">Option: Mobile and fixed markets (2)</td></tr>
<tr><td colspan="2">Description: Treat mobile and fixed voice services as separate markets, with VoIP and other nomadic services either belonging to the fixed or to the mobile market</td></tr>
<tr><td colspan="2">Feasibility: This is the current definition of relevant markets for voice as well as the EU recommended definition. Therefore this would be the default option regarding market definition.</td></tr>
<tr><td colspan="2">Activities for OPTA:
Conduct a market study in order to define the relevant services, end-user perspective, and substitution possibilities. Subsequently, competition and market failure need to be assessed.
Boundaries of the respective mobile and fixed voice service markets need to be defined.
Emerging VoIP services need to be categorised as mobile or fixed voice service on a case by case bases.</td></tr>
<tr><td colspan="2">Impact:
If mobile and fixed voice services remain separate markets, with VoIP and other nomadic services either belonging to the fixed or to the mobile market, the regulator will have to decide on a case by case basis to which of these relevant markets a new voice service belongs. At this time, the incumbent in the Netherlands would have significant market power in the fixed voice market but might be found not to have significant market power in the mobile voice market.</td></tr>
<tr><td>Scenario I:
The incumbent is a SMP on fixed voice, therefore the same constrains apply to (fixed) VoIP services. Alternative VoIP parties can compete with PSTN services. This would lead to conflicts with the incumbent especially regarding access to wholesale VoIP services</td><td>Scenario II:
Scenario II might result in a situation where there is no SMP on the mobile voice market. This would make it interesting for the incumbent to position VoIP services as mobile services (e.g. wifi-phone). Alternative VoIP parties, both new entrants and operators will be able to compete with PSTN services. Conflicts regarding access to VoIP wholesale services might become a serious issue.</td></tr>
<tr><td>Scenario IV:
The incumbent stills holds an SMP on Fixed and mobile. Since the incumbent is offering wholesale VoIP services, conflicts here will be less likely. However, incumbent and PSTN operators might put pressure on regulator to impose barriers for VoIP providers through strict interpretation of service provider obligations</td><td>Scenario III:
In scenario III there is no longer a SMP on retail fixed voice services. This might lead to conflicts since the incumbent is still a SMP on wholesale VoIP and voice services. Since there is no network owner, the regulator will need to discuss how to define portability, universal service, etc.</td></tr>
<tr><td colspan="2">Timing: The market study needs to be performed after the new Telecommunications Act is in place.</td></tr>
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<tr><td colspan="2">Area: Competition (retail)</td></tr>
<tr><td colspan="2">Issues to resolve: When the new Telecommunications Act is in place a market study needs to be performed in order to define the relevant markets for voice. There are several possibilities for this market definition.</td></tr>
<tr><td colspan="2">Option: Separate markets (3)</td></tr>
<tr><td colspan="2">Description: Treating mobile, fixed, and nomadic voice services as distinct relevant markets</td></tr>
<tr><td colspan="2">Feasibility: The regulator will need to define the boundaries for a “nomadic” market. The results of the market study will need to prove that such a specific markets exist</td></tr>
<tr><td colspan="2">Activities for OPTA:
Conduct a market study in order to define the relevant services, end-user perspective, and substitution possibilities. Subsequently, competition and market failure need to be assessed.
Boundaries of the respective mobile, fixed and nomadic voice service markets need to be defined.
Emerging VoIP services need to be categorised as nomadic, mobile or fixed voice service on a case by case bases.
Over time, as the nomadic market is developing, a market study needs to be performed on the nomadic market in order to asses if a SMP arises and if market failure is an issue. Depending on the results, consequent action can be taken.
Regulation of a new SMP on the nomadic market will require some effort since cost models etc. will need to be redefined, as no direct comparison with PSTN services can be made</td></tr>
<tr><td colspan="2">Impact:
Defining a relevant market for nomadic services and positioning most VoIP services in this market would offer the incumbent the possibility to deploy VoIP services without the constrains that apply to current voice services. This would also allow VoIP services to comply to different quality and features than currently associated with fixed or mobile services.</td></tr>
<tr><td>Scenario I:
This option will make it attractive for the incumbent to offer VoIP services (categorised as nomadic). Therefore this scenario will probably result in a SMP of the incumbent on the nomadic market. The regulator will need to perform a market study in order to define a SMP and market failure. Depending on market developments this will lead to constrains put on VoIP services offered by SMP. A SMP on wholesale VoIP services can be regulated as well</td><td>Scenario II:
This option will definitely result in a SMP of the incumbent on the nomadic VoIP market. Eventually this will lead to constraints on retail VoIP services and regulation of wholesale VoIp services of the incumbent. The regulator will be confronted with conflicts regarding, VoIP wholesale services, co-location, SIM lock, price bundling, etc. A monopoly on the application layer (like a Joint venture between incumbent and Microsoft) might lead to conflicts as well</td></tr>
<tr><td>Scenario IV:
Initially, there will be no SMP on VoIP retail services. The incumbent hold a SMP on wholesale VoIP services. This might lead to conflicts However, due to the definition of a separate market there are now more possibilities for regulation on the new SMP. Regulation can be flexible and include specific VoIP wholesale services like gateway.</td><td>Scenario III:
Initially, there will be no SMP on VoIP retail services. The incumbent hold a SMP on wholesale VoIP services. This might lead to conflicts However, due to the definition of a separate market there are now more possibilities for regulation on the new SMP. Regulation can be flexible and include specific VoIP wholesale services like gateway.</td></tr>
<tr><td colspan="2">Timing: The market study needs to be performed after the new Tw is in place.</td></tr>
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<table>
<tr><td colspan="2">Area: End-users (tariff transparency)</td></tr>
<tr><td colspan="2">Issues to resolve:
An increase of various VoIP services with different quality and pricing will result in less tariff transparency. Depending on other options related to VoIP numbering and market development this might lead to conflicts between end-users and service providers</td></tr>
<tr><td colspan="2">Option: Advise of Charge (1)</td></tr>
<tr><td colspan="2">Description: Mandate that all voice services should carry Advice of Charge information before the call, so that end-user equipment can be programmed to bar expensive calls.</td></tr>
<tr><td colspan="2">Feasibility: The implementation is rather complex in terms of technology and organisation. Therefore the regulator will definitely need to perform a feasibility study prior to initiating this option</td></tr>
<tr><td colspan="2">Activities for OPTA:
• A feasibility study will be required before initiating this option. Impact on industry will be high and the technical implementation might prove highly complex and therefore not realistic.
• Consultation with market players considering time frame and impact.
• Formulate regulation regarding time frame for implementation.
• Define to which services this regulation applies.</td></tr>
<tr><td colspan="2">Impact:
This option will have a high impact on all operators since the implementation requires a huge effort . End users will perceive more pricing transparency, which will help the marketing of VoIP services. However, the increased complexity with regard to the implementation is also valid for VoIP providers.</td></tr>
<tr><td>Scenario I:
The implementation of this option will lead to significant investments of current operators. VoIP services will not come from the ground. Pricing transparency will improve for end users. However with regard to emerging VoIP services this option swill turn out to be premature.</td><td>Scenario II:
The implementation of this option will lead to significant investments of current operators. VoIP services will be successfully offered (by the incumbent). Pricing transparency will improve for end users</td></tr>
<tr><td>Scenario IV:
The implementation of this option will lead to significant investments of current operators. VoIP services will not come from the ground. Pricing transparency will improve for end users. However with regard to emerging VoIP services this option swill turn out to be premature.</td><td>Scenario III:
The implementation of this option will lead to significant investments of current operators. VoIP services will be successfully offered by various parties. Pricing transparency will improve for end users</td></tr>
<tr><td colspan="2">Timing: When pricing transparency becomes an issue. This depends on other options and market developments.</td></tr>
</table>