



Voice over IP Equipment and Service Markets

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Internet telephony, Voice over IP, has attracted much attention recently due to its potential to significantly reduce long-distance and international voice communications costs, and because it presents entirely new and enhanced ways of communicating. This report introduces the main topics concerning the VoIP market - regulation, technologies, services and players. The growth and segmentation of the market is also discussed, and statistics regarding the future are given.

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1. Introduction to VoIP

Voice over Internet Protocol (VoIP) has attracted much attention recently for a number of reasons, the most notable being that it has the potential to significantly reduce the cost of long-distance and international voice communications, and that it introduces entirely new and enhanced ways of communicating.

The fundamental applications of VoIP are voice, fax, data and multimedia. Traditionally 'voice' has suggested voice telecommunications alone, however 'Voice over IP' is a general term used for all areas of traditional telephony – and further applications – that are to be offered over the public Internet and over private IP networks. As a result, fax, multimedia, and real-time data services can be considered sub-segments of VoIP.

VoIP had a difficult start, partly due to technological limitations, and partly due to the slow acceptance of new technologies characterised as being of poor quality and reliability. Technological improvements and strong public demand for lower phone tariffs are resulting in the widespread market acceptance of VoIP.

VoIP services are fast becoming practicable alternatives to traditional telephony services. Government regulated PSTN (Public Switched Telephone Network) services, with artificially high prices, are left vulnerable as this new technology steps in. Quality and other challenges to VoIP are being addressed, and the worldwide boom in Internet usage makes it a conceivable substitute, possibly resulting in the long-predicted integration of voice and data networks.

Current applications for VoIP technology are primarily focused around alternate long-distance voice services. Incumbent service providers are recognising the VoIP opportunity, as are non-traditional service providers and next generation telcos.

Voice over packet had been researched during the 1970's and 80's, but real developments in VoIP did not begin until 1995. Israeli firm VocalTec initiated the IP telephony market in 1995 with software that allowed a voice connection between two PCs over an IP-based network. Several other packages began to emerge, and in 1997 Delta Three launched the first phone-to-phone service for commercial use.

Although there are current market niches and segments where VoIP prevails, it has major obstacles to overcome before it becomes a mass-market success. These include regulation, quality of service, standardisation, infrastructure and network management, and bandwidth.

Section 2 of this report discusses the regulatory environment and how this may affect the growth of VoIP. Section 3 briefly introduces the methods by which VoIP may be implemented. Section 4 looks at the necessary equipment and its market. VoIP services, both network and retail, including value-added services, are outlined in Section 5. The advantages of and challenges to VoIP are discussed in Section 6. Independent ITSPs and telephone companies, and their VoIP strategies are examined in Sections 7 & 8. Section 9 looks at the VoIP market segmentation and uptake, and Section 10 gives statistical forecasts for the future of the market. Section 11 wraps up significant market observations. A brief

glossary is also provided, with entries marked [glos].

2. Regulation of VoIP

Regulation of VoIP is largely questionable. Telephony services have traditionally been heavily regulated. Most governments operate telecommunications monopolies, and deregulation has come recently in others (1996 in the US, 1998 in most of the EU).

Most governments' policy (both in developed and developing countries) towards the Internet has been to encourage growth and competition by adopting a laissez-faire attitude. The rapid development of the Internet has, in large, been due to this lack of regulatory intervention. The introduction of most forms of regulation would almost certainly retard innovation in the Internet, and would create a barrier to entry for start-up companies. Those that would stand to gain from this would be, in general, operators that have enjoyed a monopoly position for many years. Both the FCC (Federal Communications Commission) and the European Commission welcome this aid to forcing down international phone tariffs. Regulatory constraints that are specifically related to the Internet may put new entrants at a severe disadvantage, and would assist the continued over-pricing of long-distance and international telephony. However, general telecoms regulation may have advantages for the small VoIP provider.

The main barrier to changing telephone companies, for a consumer, is having to change phone numbers, and the associated inconvenience. Number portability allows customers to keep their number when changing companies. When phone-to-phone VoIP becomes convenient and commonplace, the ability to offer a total VoIP service without having to change phone numbers will work to the advantage of smaller providers.

With the introduction of high-speed local loop [glos] technologies, the ability to access the local loop will become necessary in order to provide a competitive service. Regulation has resulted in the unbundling of the local loop in the US, Hong Kong and some European countries. Recently (July 1999) BT was ordered to open up their local loop. This will give the opportunity of high-speed access provision to small providers.

Although there is enormous growth potential in the short term, with increased choice and competition, the uncertainty over the future of the regulatory structure is still impeding investment and development. Telcos, not wishing to obliterate existing profitable business, may be banking on regulation, assuming the threat of VoIP will peter out as ITSPs (Internet Telephony Service Providers) become classified as voice telephony providers. Many others will not want to invest in VoIP solutions until its technical problems are overcome.

Enhanced data services are those that can be provided economically by independent service providers (non facilities-based service providers, [glos]) in competition with network providers, as long as they can gain access to the networks. Examples of enhanced services are the provision of content for premium rate services and the provision of retail Internet services. ITSPs, and ISPs (Internet Service Providers) in general, as ESPs (Enhanced Service Providers), are not subject to long-distance access charges. Telcos are urging this regulatory position to change. As ITSPs become increasingly competitive with telcos, it is argued that they should be classed identically. At the same time, it is very difficult to distinguish between different types of Internet traffic, and hence a method of levying access charges on ITSPs seems almost impossible.

The European Commission has defined voice telephony as 'the commercial provision for the public of the direct

transport and switching of speech in real time between public switched network termination points, enabling any user to use equipment connected to such a network termination point in order to communicate with another termination point' [1].

Thus the following conditions must be met:

- the service offered must be part of a commercial offer
- the service is provided to each member of the public
- the service involves direct transport and speech in real time
- the service is provided between public switched network termination points in the fixed telephony network

VoIP clearly lacks some of these criteria, most notably real-time transmission. It also falls short of traditional telephony in that it is not fully reliable, ubiquitous, nor transparent.

VoIP is not a generally available voice transmission service, but an application available to those who have already subscribed to a basic Internet package. Because of this 'closed-user group' offering, the European Commission may not force ITSPs to pay access charges. Also, due to the telephony restrictions in Europe, VoIP is seen as an effective way of introducing competition.

It has been suggested [2] that additional regulatory movements may affect the VoIP industry. These include market entry requirements and entry rules:

Because most Internet services have been classified as non-basic or non-voice services, providers have not been subject to restrictive licensing and market entry requirements applicable to other telecommunications providers. As VoIP becomes a serious competitor to traditional telephony, regulators may start to impose registration, licensing, or other requirements on ITSPs. These processes can be time-consuming, increasing the time-to-market of new entrants.

If ITSPs are classified as carriers of basic voice services, they may be required to comply with routing restrictions and rules. These may restrict services that bypass accounting systems. However, given the complex topology of the Internet, it would be virtually impossible to monitor individual packets and impose routing rules on them.

3. Methods of VoIP

Initially VoIP was easily dismissed. Client software gave poor quality, similar to CB radio, and allowed only one party to speak at a time. Both communicating parties had to be online together and had to have compatible software running on their PCs. However, potential for the service was seen by vendors such as Netscape, Intel and Microsoft, all launching VoIP products in 1996. By this stage, both computing power and Internet backbone capacity had improved such that much better voice quality was available with VoIP. At the same time, VoIP communications received ITU (International Telecommunications Union) standardisation and by 1997 standards-based products became available.

The basic necessity of all early VoIP products was that the users at each end had an Internet connection. The development of the VoIP gateway has changed this such that PC-to-phone, and even phone-to-phone calls can be made. This has removed one of the most important barriers to broad market acceptance. With gateways installed, users need not have PCs, special software or even an Internet connection to place calls that are routed mainly over the public Internet. Gateways allow users to circumvent the PSTN and its tariffs, using the Internet for voice communications of variable quality, and for significantly reduced prices.

Many new operators* and equipment manufacturers/vendors have emerged since the release of the Internet Phone product, the first robust and scalable VoIP product and the initial VoIP service offered by Delta Three in late 1995. Client software is now supported by most operating systems (Windows, Unix, Mac).

PC-to-PC telephony is the original form of VoIP. Both users are required to be online before any connection is set up, and must use compatible software and multimedia computers. It is not practical to separately tariff or regulate this form of VoIP, as it is difficult, and probably counter-productive, to try to distinguish audio bits from other bits. It is also difficult to distinguish between real-time, full-duplex communication and time-insensitive store-and-forward information. Unless the Internet is regulated as a whole, it is not feasible to regulate this form of VoIP.

PC-to-phone telephony arose as IP-to-PSTN (and PSTN-to-IP) gateways became available. A gateway packetises and compresses voice traffic from the PSTN and places it on an IP network, and assembles and decompresses traffic in the other direction.

Regulating PC-to-phone VoIP is a difficulty. The originator of the call pays no access charge, as to the service provider this looks the same as a PC-to-PC call. This greatly reduces access charges as the originator usually pays about two-thirds of the overall access charge. At the terminating end, the service provider may provide termination services to both local and long-distance callers, but cannot know where any particular VoIP call originated, spurring problems with regulation and tariffing. Similarly, with phone-to-PC VoIP, there is no access charge at the termination point, as the originator cannot know where the call will be terminated.

Phone-to-phone VoIP eliminates the need for a PC altogether, using the Internet to

carry the voice between two gateways. Phone-to-phone VoIP calls can now offer greater quality than PC-to-PC or PC-to-phone VoIP calls, as the former may be offered over a dedicated IP network. There is breakout to the PSTN at both ends, but because the originator cannot know the termination of the call, and vice versa, problems regarding regulation and access fees will exist.

Fax over IP (FoIP) is arguably superior to traditional fax because it does not require real-time transmission. Transmitting a fax, which has traditionally been associated with the PSTN, is no different from sending any other file. Fax messages are able to absorb delay and retransmitted packets without any negative impact on the final received message.

Multimedia conferencing will involve the combination of real-time voice, video and data transmission over the Internet. Although standards are emerging, it will lag behind other VoIP applications somewhat due to the substantially greater bandwidth required for multimedia applications.

4. VoIP Equipment

In order to provide VoIP solutions, the Internet and other IP networks must interface seamlessly with the PSTN through gateways. These gateways will be one of the key areas of revenue for VoIP equipment vendors. IP networks will also have to acknowledge the resource reservation and prioritisation schemes needed to guarantee quality of service for delay-dependent data.

The hardware required to provide VoIP services ranges from standard networking equipment such as routers and switches, to gateways, to IP phones.

4.1.1 IP Phones

IP phones function as regular phones do, but instead of connecting to the PSTN,

* see <http://www.iptelephony.org/frame/providers.html>

they connect to an IP data network and transmit voice messages through IP packets.

Presently, IP phones are very expensive, and using VoIP can be cumbersome and inconvenient. Traditional telephones are cheap to buy and simple to use, and marginal costs are close to zero, allowing prices to be reduced hugely. Hence IP phones (and VoIP in general) have to develop further in the way of ease of use, and decrease in price, before they can invade traditional telephony space.

Until now, IP telephony has been difficult for the average user to adapt to because the interfaces were inconvenient. By bringing many of the familiar and necessary features of traditional telephony to the IP environment, the move towards seamless integration of the PSTN and IP networks has begun.

Selsius, purchased by Cisco in late 1998, has introduced a phone that provides all of the functionality found in a traditional phone, and connects directly to an IP network. This signals an important shift in the telephone equipment industry, possibly suggesting a new opportunity for PBX (Private Branch eXchange, [glos]) and telecoms service vendors. In theory, IP telephones are as functional as traditional phones, whilst being able to add new capabilities.

Nokia's IPCourier Ethernet Phone provides PBX functionality (such as multiple line appearances and call control features) without a PBX. It is an Ethernet telephone with a familiar interface that links directly to an IP network. It also supports telephony features such as call waiting, caller ID, call forwarding, and call transfer.

Nokia's IPShuttle product is a customer premises device that allows standard telephones to be plugged into an IP network. It is aimed at residential environments and is designed specifically to serve new voice and data services being

offered by cable companies and telephone companies [3].

Siemens has also released (April 1999) an IP telephone with enhanced capabilities [4] - a new interface, ability to retrieve the names and addresses of IP callers, and information regarding unanswered calls. Their HiNet LP 5100 IP telephone is to cost \$425, but this price will fall rapidly.

Ericsson has released the telephone Doubler, which allows use of a virtual telephone line, enabling the user to receive phone calls (over IP) without having to log off the Internet. The voice traffic is carried over IP between the user's PC and the gateway, with the rest of the call carried on the PSTN, thus Quality of Service (QoS, [glos]) is directly dependent on the user's connection speed and on the traffic they generate.

4.1.2 VoIP Gateways

Gateways act as interfaces between the PSTN and IP networks. When making a VoIP call, there is usually breakout to the PSTN at each end, for the first and last legs of the link, with the Internet or another IP network used for the trunk connection.

The gateway accepts connections from a traditional phone or fax machine, determines the termination point of the call, and decides what is the best and cheapest way to route the call (i.e. how much of the link will be over the PSTN).

Although gateways were originally aimed at business customers, they are increasingly being aimed at ISPs and carriers wanting to offer VoIP services as a competitive advantage. As scalability increases, the opportunity is there to supply products to service providers rather than smaller enterprises.

Gateways tend not to interoperate well, leaving users confined to the network of their provider, or one formed through partnerships. H.323 [glos] is likely to become the standard interoperability

protocol, and this standardisation will happen soon (by the end of next year, 2000 [5]) due to pressure from service providers.

Motorola has teamed with Vsys (June 1999) to develop a VoIP gateway based on its Vswitch VoIP solution for intelligent network applications [6]. Vswitch is a UNIX-based software product that provides interfaces for both H.323 and SS7 (Signalling System no. 7, [glos]) standards to support voice, data and fax. Its capabilities include billing and provisioning, and advanced intelligent network services such as freephone numbers and single-stage dialling. The product is to be commercially available later this year.

Gateways can be implemented through the following methods:

- router-based voice modules
- concentrator-based voice modules
- PC-based servers

PC-based gateways move data through an interface, across the LAN and to the router. These standalone devices cannot move delay-dependent traffic to the front of the router queue, however they have several advantages:

- they are independent of the router and can be installed in mixed equipment networks
- they are easily scalable
- they do not require router upgrade
- their market is more competitive than other gateway markets, resulting in lower prices
- they were specifically designed for this purpose

Router- and concentrator-based gateways [glos] can reduce delay time as they can eliminate the extra hop PC-based gateways require. This can improve the quality of the system. The traffic is moved directly into the router queue and to the WAN interface. Simple forms of prioritisation may also be employed.

Suppliers to the VoIP market must bridge the dynamic world of the Internet and the rather more static world of traditional telecommunications.

The VoIP equipment industry grew from small players such as VocalTec. As the industry has grown, much acquisition has occurred. Nortel acquired Micom, the gateway vendor, and Bay Networks, Cisco acquired Selsius and has incorporated voice modules into its routers, and Nokia has acquired Ipsilon, an IP switching firm. Smaller vendors are teaming with larger players*, such as software provider eFusion announcing deals with Ascend (who have merged with Lucent) and 3Com, providing IP gateway functionality through DSPs (Digital Signal Processors, [glos]) in the formers' equipment. These partnerships intend to build upon the experiences of each member. This will lead to new products as well as the adaptation of existing technology.

Although the market is growing, Internet equipment is not recognised as being as reliable as PSTN equipment. However, as the world of telecommunications moves towards IP, new equipment will be in the form of data equipment. Hence data equipment will be updated to handle voice rather than vice-versa. This will give an advantage to data networking equipment vendors, as this is where they have experience.

Telecoms operators with their own access networks have been the main customer of traditional suppliers such as Nortel, Alcatel and Siemens. There is often a supplier relationship that has been built up over years with the main provider in their country.

Data networking suppliers understand IP networking better than traditional suppliers, but may not satisfy the quality and management requirements of a company as strong as a telco. These companies have experienced huge growth

4.2 Equipment Market

* see <http://www.iptelephony.org/GIP/partners/>

in recent times, and need new applications to continue this growth. VoIP is a great market opportunity for them. As well as with the tremendous number of new entrants, these suppliers are developing relationships with traditional telco equipment suppliers, and either by acquisition, alliance or marketing are making relationships with the telcos themselves.

Large data and VoIP vendors have great experience with packet switching and have relationships with ISPs and ITSPs. They need to build on their expertise in real-time communications. The key challenge for them (and for other businesses operating in this area) will be to understand the integration of voice and data, and to be able to realise this integration both technologically and economically.

Most data networking vendors have added VoIP capabilities to their equipment, such as routers and remote access equipment. They are also extending their networks to enable more sophisticated functions. This is the strategy for the integration of voice and data networking in order to create a multi-service network.

From a provider perspective, deploying VoIP gateways is much more expensive than deploying PSTN switching equipment on a per-port basis. VoIP gateways cost an average of over \$1,800 per port in 1997 and now (1999) have fallen as low as \$600 per port. The same capacity (i.e. per line) for traditional telephony costs about \$100-\$200. Carriers are placing enormous pressure on vendors to lower costs to the \$100-per-port range within the next year. Increasing scale (more ports per product) and economies of scale will lower prices. Standardisation will add to economies of scale, and in all high-tech industries engineering tends to improve, thus lowering prices.

Although the Internet enjoys significantly more users in the US than in Europe, the market for VoIP equipment is likely to be

split approximately equally between the two geographic areas. Because telephony prices in the US are much lower than in Europe, the opportunities for new entrants are lower in the US, and hence the enthusiasm is generally reduced. However, due to new IP networks being built by ITSPs, and the fact that the US is a more IP-developed region, there is still expected to be a high uptake of VoIP.

The worldwide market for VoIP gateways will reach \$1 billion by the end of next year, growing by 75% the following year, and a further 40% in 2002 [5]. The suggested decline in rate of increase could be due to the falling prices for such equipment. The number of ports shipped will also increase greatly over the next couple of years, to over 8 million by 2002, but rate of increase will decrease significantly after 2000.

The uptake of VoIP may also affect the WAN switch carrier market, with switches purchased specifically for VoIP purposes to increase from less than 1% now to around 6% by 2002, producing revenue of nearly \$.25 billion [5].

5. VoIP Services

The VoIP industry is changing from one essentially catering for hobbyists into one in which services are offered to the general public. These services are low in quality but tariffs are substantially lower than for PSTN telephony. The next phase of this transition will be to a market where quality is comparable to the PSTN and functionality is significantly more advanced.

Service providers offering reduced price VoIP services can do so due to the efficiency of packet switching over circuit switching, and due to the lack of regulation, and hence access charges. Traditional telcos will reduce their PSTN prices, develop their own VoIP strategy, or face the loss of substantial market share.

Although many facilities-based operators [glos] have their primary focus on the wholesale capacity market, almost all of them are offering end-user consumer services. In addition to this, there are numerous ISPs and ITSPs offering VoIP services, with many new entrants making their presence known in the market.

The key focuses of retail VoIP providers are the long-distance and international markets. Due to the avoidance of access charges (long-distance and international), tariffs can be significantly cheaper for these markets. International markets have generally been difficult to enter, but smaller providers can now use the Internet to offer international services. Aside from difficulties obtaining access to local networks, it is also the case that in the local loop, the trunk link length is reduced significantly (and sometimes even eliminated completely), and because VoIP tends to use the PSTN for first and last leg connections, using the Internet for the short trunk length would reduce the cost benefits. In the longer term, local access will become more important as last mile technologies become increasingly sophisticated.

Fax will also be of importance, and will move to IP before voice telephony due to its latency tolerance. Sending a fax over an IP network is no different from sending any other file, so much fax traffic will use the Internet as its trunk connection. An estimated 30-40% of long-distance and international traffic is fax [estimate based on numerous sources], and this can be very easily switched onto the Internet. Fax over IP is discussed below (Section 5.4).

As an increasing number of providers are interested in providing long-distance services, those that own the networks are in a prime position to take advantage of this.

5.1 Network Services

The communications network can be broken down into two sections - the backbone network and the access network.

Backbone network providers supply wholesale bandwidth to service providers closer to the end user. They may own the network or lease it from other backbone providers. Backbone providers tend to be incumbent telcos or large traditional operators, but a new generation has begun to emerge, including companies such as Level 3 and Qwest, building brand new IP-based networks. Large ISPs and cable operators are also involved in offering backbone capacity.

Technologies such as ATM (Asynchronous Transfer Mode, [glos]) and frame relay will allow the backbone networks to carry different types of traffic, and to offer quality of service guarantees for real-time services. In situations where quality and latency are the issues, it is likely that IP over ATM will be the dominant technology, however where efficiency is important, IP may be run directly over SONET (Synchronous Optical Network) (or SDH, Synchronous Digital Hierarchy) [glos, and see Appendix 1]. Whatever the physical/link layer technology, the future backbone appears to be IP - it is a universally accepted network protocol and is independent of lower layer technologies.

QoS issues are the responsibility of the backbone operators, as are Virtual Private Network (VPN, see Section 5.3) obligations offered as value-added services.

Access networks essentially belong to incumbent telcos and, to some degree, cable operators. It can be difficult to get access to the local loop, and the construction of entirely new access networks is economically impractical. Although regulation in some countries is pushing for an unbundled local loop, its owners still have enormous market strength.

The local loop speed will increase greatly with the mass deployment of high-speed technologies such as xDSL (Digital Subscriber Line), cable, satellite and radio.

The improvement of VoIP quality compared to that of the PSTN may have an impact on the local loop and its owners. This will be discussed in Section 8, Telephone Companies and VoIP.

Unlike telcos, most small providers have not evolved sophisticated billing systems, and it can be difficult for them to develop these systems over short periods of time. This has pushed the idea of pre-paid calling cards by small providers. This offers many advantages to providers and customers. Customer identification and authentication is simple – the customer dials in his account number and his information is captured. If the calling cards are pre-paid, no bad debts can accumulate. Essentially no billing is involved. The cards can be obtained and recharged directly through the company's web-site with automatic billing by credit card. A manager having employees with frequent changes to their calling requirements can do this. Although this method gives a good short-term way of promoting the service, in the longer term, users will require more convenience.

5.2 Retail Services

The enhancements to traditional telephony services will be the main market attraction once the tariff arbitrage has dissolved somewhat, as it appears it will.

Current PSTN caller ID allows the receiving party to see the number of the calling party and nothing more. An IP environment can support more information – who the caller is, where he is, the request for a multimedia connection, or any other information he wishes to send.

The call waiting function available with VoIP is greatly enhanced compared to the PSTN version. When a call arrives, a new window can be displayed on the user's screen showing the caller's name and number (and any other information he has sent). Then the user can choose how to handle the call. The call can be answered on the phone (either by disconnecting the Internet connection and taking it on the

PSTN, or by receiving it by VoIP over the Internet connection). The call can be forwarded to another number, such as a mobile. The call can be forwarded directly to voice mail or a busy tone can be provided to the caller (these apply if the user does not wish to be disturbed). A message can also be played for the caller to hear, instructing him what to do next.

Click to talk - an individual can initiate or establish a voice connection by clicking on a web page. This service has applications for catalogues and call centres, amongst others, enabling a customer to speak to a representative while looking at a company's web site. The customer can click on an item to initiate a call to the catalogue and speak to the sales representative through their PC without having to take down the Internet connection. This is discussed further in Section 9.1.1, Business Usage.

The integration of services such as voice mail, fax, email and other information will become important as customers become more mobile. A number of mobile telecommunications companies have already begun to offer some sort of integrated service, allowing customers to check their email over their mobile phones. These services may also allow the sending of messages from the Internet directly to a mobile phone. Deutsche Telekom offers an extension to this, by way of their NOVICE system, using voice-synthesis software to convert email messages into speech, and customers can have their messages read over the phone to them. Other companies provide services whereby information such as football results or stock market quotes can be obtained on mobile terminals via SMS (Short Message Service, [glos]) [7].

Real-time administration (billing and provisioning) is becoming a service in itself. The unification of bills for all services, and the ability to view bills online (real-time, up-to-date) will be seen as a huge convenience. Provisioning of services may also be available 'on the fly' over the

Internet, e.g. do I want call waiting services for this session? Yes, click, and they are available.

As Internet penetration grows, the technical literacy of the average user will decrease. Thus, a more robust and comprehensive customer service will be necessary to serve less savvy users.

5.3 Virtual Private Networks

VPNs are private data networks that make use of the Internet, maintaining privacy through the use of a tunnelling protocol and security procedures. They can be contrasted with a system of lines leased from a telco that can only be used by one company and which can be incredibly expensive. A VPN gives a company the same capabilities at a much lower cost by using the public infrastructure rather than a private one.

Because market demand has not yet been high, Internet VPN services have not been pushed as a key element of most providers' offerings. It is supposed that the market will be demand-lead, and so although many providers have the technical ability to offer these services, they have not seen the necessity to promote it. However, they do feel that VPNs will change the service provision market dramatically and offer great opportunities to providers.

Consumer and small business VPN VoIP services over the Internet are likely to be offered by non-facilities based carriers, whereas facilities-based carriers are targeting large business customers.

Because of the individuality of each network, services will be priced according to the specific requirements of the customer. No particular markets have been targeted yet, with providers offering services to individual organisations. However, certain market segments present great opportunities for early adoption, including the IT sector, firms with a large number of small sites such as travel agencies, estate agents and insurance

brokers, and high-tech manufacturing firms [5]. Targeted companies will also be determined by size band, large companies being a prime target for long-term contracts, and medium-sized firms showing short-term potential.

5.4 Fax Over IP

In spite of predictions made in the face of email, the fax market is growing, not waning. Despite the popularity of email for general communications and file transfer, some functions, such as sending a hand-written, signed document cannot be accomplished effortlessly. Speed and reliability of email can also be unsatisfactory.

Traditional fax machines are connected directly to the telephone network, just as a traditional telephone is. Phone numbers let various local and long distance carriers initiate connections and deliver faxes. Internet fax servers collect traffic from standalone fax machines and route it to the Internet for delivery. The user dials the destination phone number, but it is the Internet fax server that interprets the dialled digits, not the PSTN, and the fax is transmitted via the Internet to the remote fax server.

The global fax market has been able to flourish due to the adoption of fairly consistent standards that are used worldwide. One of the problems of using fax over the Internet has been the lack of standardisation. It seems likely that the first standards-based FoIP will be a mail-type standard to transport fax image files, but session-based and real-time fax should follow closely as more immediate document delivery and confirmation of delivery become necessary.

Already an extensive number of fax services are available over the Internet, mainly by large backbone operators (AT&T, MCI, Sprint) or companies focused on providing FoIP (FaxSav, FAXiNET).

Mailbox services are provided, comprising a fax or unified messaging mailbox that can store and forward a user's faxes, can be configured to automatically forward messages to another location, and can often allow users to check voice, fax and email simultaneously.

Fax multicasting can be provided, allowing the sending of a single fax to multiple destinations, be they fax machines or PCs.

Overflow services take into account that the receiver's fax may be busy or not answering. The fax is stored by the service provider and then automatically forwarded to the destination machine at a later time.

Interactive fax/fax-on-demand services allow a customer to store documents on the service provider's server, such that clients without Internet access may retrieve these documents by calling into an interactive voice response system and requesting them.

Message translation can convert fax messages to email, email to voice, or other transformations for the delivery of messages. This is becoming a significant feature of the unified mailbox.

The primary target markets for FoIP (and unified messaging) will be the SOHO market and mobile professionals. The former will have increased functionality, whilst saving money, and the latter can receive all messages – voice mail, email and fax – at once.

The FoIP market will initially be mainly an international one, due to the price differentials between using the Internet and the PSTN. Until 1997, virtually all of the global international fax market was PSTN-based. According to Probe Research, by 2001, FoIP will account for 10% of originating international fax, and by 2006, almost 30%.

Multinational companies may be able to save a substantial part of their average of \$15m a year on fax-related transmission

charges (based on Fortune 500 fax usage) [8]. Revenues lost by PSTN operators may be in the region of \$1bn by 2002, and may reach \$2bn by 2006 [9].

6. Advantages of and Challenges to VoIP

6.1 Advantages of VoIP

The ISP market today is driven largely by a tariff arbitrage. Although QoS is unsatisfactory compared with traditional telephony, people wishing to make long-distance or international calls over the Internet may do so cheaply, saving 20-100% on a call by bypassing the PSTN [9].

There are three main reasons for the price advantage [10]:

1. Regulators have ruled that VoIP providers are not subject to the long-distance access charges levied on traditional providers
2. VoIP providers avoid the payment of settlement charges to foreign operators terminating their calls (of which US operators pay approximately \$5bn per year) [11]
3. The networks used are more efficient due to compression and packet switching.

The technical and economic advantages of packet switching are numerous. It appears that VoIP has a long-term cost advantage over traditional telephony based on efficiency and lower equipment costs.

Packet-switched technology uses the infrastructure with more efficiency than the circuit-switched technology used in traditional telephony. Although the cost of telephony switching equipment has fallen sharply in price, so has the cost of computer equipment. Port prices for VoIP are relatively high but are falling rapidly and will soon undercut prices per line for traditional telephony. Low cost routers are beginning to replace switches.

The unit economics, although debatable, seem to favour packet switching, with estimates suggesting that packet switching is almost four times as cheap as circuit switching at the per byte level [12].

The data overhead associated with packet switching is far less significant than the capacity wasted in circuit switching when no information is being conveyed.

Much swifter compression update can be made on the Internet than on the hardware of the PSTN. On a circuit-switched network, all hardware in the network must be updated in order to progress with advances in compression, whereas an Internet client on a standard PC can implement the latest technologies without concern for the rest of the network.

Multimedia services on IP networks will allow one network to be used for telephony and data, as well as more sophisticated multimedia services. Although there is not yet any practical evidence to support the argument that managing one network is more economical than managing two, the argument is straightforward.

Even in an unencrypted form, speech carried over the Internet is considerably harder to wiretap than analogue speech carried over a copper wire pair. Where encryption is used, decryption by an unauthorised party would be immensely time consuming, taking many weeks or months for a supercomputer to decrypt a two-minute phone conversation [12].

VoIP has not, until now, been a convenient telephony mechanism, being cumbersome and requiring awkward dialling, whereby the user is required to first dial an access number, wait until this call is routed to the access IP telephony switch, and only then can the destination number be dialled. Providers have begun (early 1999) to introduce VoIP services that will no longer require the user to dial any differently than he would when making a regular call [13]. Korea Telecom has been one of the first

providers to integrate the PSTN and IP networks in this way [14]. This is an important development to ensure the speedy evolution of VoIP. Lucent Technologies [15] and Nortel Networks [16] have developed packages that will support the delivery of enhanced VoIP services, including the above, single-stage dialling.

Once feature parity exists, future uptake of VoIP will depend largely on the introduction of enhanced applications. It is assumed that by this stage the price differential will be much less significant, due to lowering PSTN prices and/or regulation.

Applications already available include call waiting, caller ID, multicast, and multimedia conferencing. Simple traditional features can be much richer over a packet-switched network. The benefits of such enhancements are obvious. The need for separate lines for voice and data disappears, and flexibility and functionality are increased.

The possibilities for such applications on IP networks certainly extend beyond that available on the PSTN, and to applications not yet envisaged.

VoIP is driving the public network towards an open, client-server topology. Proprietary switching systems and legacy networks have retarded integration of voice and data for many years, but competition in the area of telephony has initiated the move towards an open network. This could be the trigger that brings about true convergence of voice and data networks, but this cannot happen until cost parity exists between packet-switched voice and circuit-switched voice technologies [17]. VoIP equipment, although falling rapidly in price, is still considerably more expensive than traditional equipment. This will change, but will take a number of years to do so [18].

The ubiquity of IP networks in enterprises is ensuring a large addressable market for VoIP equipment as well as facilitating the integration of VoIP equipment into existing networks. Enterprises are beginning to put VoIP on their WANs and LANs, cutting costs as the voice is treated as data. On such private networks, control of data is much easier than on the public Internet, with QoS exceeding that of VoIP on the Internet.

The value of any telecommunications network increases exponentially according to the number of users/computers attached to it (Metcalfe's law). As more and more IP equipment is attached to the Internet, the benefits derived from being part of a VoIP network will increase, fostering further demand.

To sum up, there is huge opportunity in the provision of VoIP. Presently, the main attraction is the low tariffing that can be offered by bypassing various access charges traditional providers must pay. VoIP is no longer a technology employed merely by hobbyists. A new generation of users has emerged, and as convenience of use and richness of applications become satisfactory and attractive, VoIP will become increasingly popular among general telephony users.

6.2 Challenges to VoIP

The low quality of service and unreliability of the Internet are the main market restraints for VoIP. There are many QoS issues experienced by packet-switched networks that do not affect circuit-switched networks.

The Internet is a best-effort network, where variable latencies and dropped packets occur. Because voice services require real-time transmission, VoIP often results in a heavily degraded QoS.

There are four types of delay in IP networks: propagation delay, network delay, accumulation delay and processing delay. The overall delay is the aggregate of these components:

Propagation delay is that which is caused by the signal having to travel a distance, and is therefore a function of distance. It is governed by the laws of physics and cannot be overcome.

Network delay is a function of the capacity of the pipes in the network and the processing of the packets as they transit the network. The delay associated with jitter buffers (see below) is considered part of the network delay.

Accumulation delay depends on the type of voice coder used. It is caused because a finite amount of time (varying from a single sample time to several msecs) is needed to collect a frame before the processing begins.

Processing delay is caused by the actual encoding and collection of encoded samples into a packet for transmission. This also applies to decoding at the receiving end. It is a function of the coding algorithm used and the processing time.

Jitter is the variable inter-packet timing caused by the network a packet traverses. It can be considered the standard deviation in delay. Not only is it impossible to predict or control how many hops a packet from a VoIP call will traverse, packets from the same call are often assigned different routes, with varying numbers of hops and different traffic volumes along the way. Because of this, packets from the same source can experience different delays on the way to their destination.

Jitter is removed by buffering fast packets in order that the slowest packets arrive in time to be sequenced correctly. This causes additional delay, as the buffer must account for all packets, thus delaying them all by up to the delay of the slowest. The conflict of minimising delay and removing jitter has resulted in various methods of dynamically adapting the buffer size to match the time variations. This minimises the delay associated with jitter while preventing buffer underflow [19].

If the one-way delay exceeds about 200msecs, the two speakers will adopt a mode whereby one speaks, the other listens and pauses to make sure the speaker is finished, then speaks. Usually these pauses are ill-timed; thus speakers will end up stepping on each other's speech.

Present IP networks are best-effort networks and do not guarantee service. When a router becomes overloaded, it may intentionally drop packets to relieve the congestion. With traditional data traffic, there are error-checking methods built into the protocol (Transport Control Protocol, TCP) to address these situations and maintain data integrity. This protocol requires some overhead not conducive to real-time traffic, and has not been implemented for voice transport. Instead, UDP (User Datagram Protocol) is used as the transport level protocol. It requires less capacity, but does not guarantee delivery of the data to the destination, nor delivery of packets in the right order, nor does it avoid duplication of packets. It does, however, guarantee data integrity.

Fortunately, uncompressed voice communications tend to be highly tolerant of dropped packets. The human ear cannot detect the loss of a packet in an audio sequence if an adjacent packet is played in its place. It is only when several packets in a row are dropped that a noticeable degradation of quality occurs. However, many voice compression mechanisms result in the transmission of the changes (actual or predicted) between adjacent signals, rather than the whole signals themselves. Hence the loss or corruption of a packet can result in propagated errors, hugely degrading the quality of voice or video, often beyond recognition.

The use of UDP has a further challenge in that many networks protected by firewalls do not permit UDP traffic. For data to pass through many firewalls, some sort of registration must occur between sender and receiver. UDP, having no error correction or retransmission associated with it, need not set up any such registration between sender and receiver. This gives the need for an open port on the client, which results in its blocking by the firewall.

When a two-wire telephone cable connects to a four-wire exchange interface, a circuit called a hybrid is used to convert between the two wires and four wires. Echo is caused by signal reflections in a hybrid circuit. Although the circuits are very efficient in their conversion ability, a small percentage of the energy is not converted, and is reflected back to the caller. This is known as echo. If the speaker is close to the PBX or the telephone switch, the echo is sent back so quickly that it is hardly noticeable. As echo reflection time increases, the echo needs to be cancelled out. DSPs listen for the echoed signals and subtract a prediction of them from the speaker's audio signal. This is particularly important with VoIP, since echoed signals tend to have delays long enough to be noticeable, even annoying to the speaker. Although echo-cancellation is used, it is often insufficient as only a prediction of the actual echo is removed.

Quality problems are the most important barrier to the development of VoIP. Until a QoS management mechanism is available, this will remain a major restraint. Unreliability will also be cause for concerns in areas such as public safety. PSTNs are usually well engineered and very reliable. General services are rarely unavailable, and emergency services are extremely reliable. The Internet can be slow or unavailable for a number of reasons, and data can get lost or corrupted, making it extremely unsuitable as a dependable network.

Inability to connect, and slow traffic transfer are a result of network bottlenecks. There is no single bottleneck on the Internet; rather, each junction on the Internet can create a performance bottleneck.

The first bottleneck (for dial-up subscribers) is the connection to the telephone switch. The average phone call lasts about 3 minutes, while the average Internet user is online for 20 minutes [20]. The PSTN was not designed for calls of this length, and the abnormally long holding time is resulting in the absorption of much capacity of the switch, causing many call attempts to fail. The phone line also has significantly inferior capacity to the rest of the Internet. Because the overall connection is only as fast as its slowest pipe, the last mile (from the telephone switch or service provider to the premises) usually slows down traffic transfer dramatically.

The second bottleneck is the connection between the service provider and the Internet backbone. As these connections approach overload, some users may be denied access, while others will experience response time problems.

The third and fourth bottlenecks are in the backbone itself. The former is the backbone bandwidth. Although it has extremely high capacity, the dramatic

increase in demand has rendered this insufficient. The latter of the two backbone bottlenecks is the routers that receive and forward the data packets. The speed of routers has grown since the beginning of the Internet explosion, but this growth has not been able to keep up with the growth in Internet traffic, and thus delays result.

Finally, the original Internet backbone interconnection points are becoming severely overloaded. Over the last few years, the main exchange points of the Internet backbone, the Network Access Points (NAPs), have become congested and many providers have chosen not to use them anymore. It is also the case that they have not received funding from the National Science Foundation since 1998, and there has been a move to privately operated exchange points. This has meant that, as many providers enter private interconnection agreements, much traffic data is no longer available. The operators and providers involved have no obligation to disclose this information.

All of the above contribute to the unreliability and delay of the Internet.

The existence of legacy networks is a restraint on the growth of IP networks, particularly within enterprises. Compelling business cases are needed to replace voice networks that work perfectly and offer better quality than IP networks.

A variety of interoperability problems are presented to VoIP vendors, and the market will push hard until these are resolved. Current interoperability exists only at the client software level. This enables H.323 clients to communicate with other telephones through a H.323 gateway. However, no standard yet exists that allows gateways from different vendors to interoperate. This is slowing the adoption of IP by telcos [21].

Network vendors must supply gateways and gatekeepers (the software that provides

call control and address translation) that are interoperable. Service providers will not, in the long run, deploy large-scale proprietary solutions. Gateway interoperability is not fully addressed by the H.323 protocol, but is expected to be accomplished by protocol extensions such as MGCP (Multimedia Gateway Control Protocol). MGCP is used for controlling VoIP gateways from external call control elements called call agents or media gateway controllers. The call control intelligence is outside the VoIP gateways and handled by the call agents. In the MGCP model, the gateway focuses on the audio signal translation function, while the call agent handles the signalling and call processing functions. Consequently, the call agent implements the signalling layers of the H.323 standard, and presents itself as a H.323 gatekeeper. Several ventures are addressing interoperability at this level, with a Lucent alliance developing a gatekeeper that enables interoperability between gateways of different vendors [22].

The problem of integrating VoIP gateways with existing PBXs, switches and routers often results in a complex configuration. This is due to a lack of experienced technicians and the closed architectures of most PSTN network elements.

The VoIP community has not yet agreed upon a common Call Detail Record (CDR). This would make it possible for one network provider to access and settle with another network provider or owner. Without a common CDR, the areas in which ITSPs operate will be limited to regions where they have their own IP gateway.

Standard applications for billing and OAM&P (Operations, Administration, Maintenance and Provisioning) are not available, forcing users to rely on one vendor for a complete solution. This is a great restraint, especially if proprietary applications cannot be integrated with existing operations support systems.

Scalability is also a problem here because there are many needs in this area. The port density of each gateway can be easily increased, as can the overall number of users due to the distributed nature of the Internet, however sufficient business, service, network and element management tools and processes are not available, making scalability of general operations difficult [21].

When technical problems are overcome, an acceptable voice quality will be available, probably exceeding that of the PSTN. There will be widespread availability of VoIP without having to subscribe to a basic Internet package, and truly scalable, interconnected services will become available [23]. Much development and maturing will need to occur before this becomes reality.

7. Independent Providers in the VoIP Market

Due to the entry of the telcos, and the number of new entrants to the VoIP industry, it is expected that there will be a certain amount of market squeeze as the industry matures. The ability to survive in this market will be, in large part, determined by the competitive strategy of a provider, and its ability to change rapidly in the dynamic marketplace.

As in any market, those who grow large enough to generate economies of scale are in a position to survive, as are those finding a niche market to serve.

To the advantage of independent providers, time to market has been very short for Internet products and services. Innovation in traditional telephony has never been a priority, as most providers were protected monopolies, so new services have generally not been promptly deployed. Data service providers realise how important it is to bring services to market quickly, as a competitive advantage. Their ability to do this will be seen as a great strength over

telcos in this market. Their dynamism in terms of technological upgrade and business processes will similarly be advantageous.

These companies, although they may be young, have been in the business of packet networking and have accumulated experience in this area. Telcos may find it difficult to transfer their knowledge to packet switching.

Independent ITSPs are willing to take risks because they have little to lose. Facilities-based providers, such as telcos and next generation telcos, have invested enormous sunk costs in their infrastructure, and will therefore be more conservative in their choice of activities. Those that have invested little more than some venture capital can take greater risks, and often these will pay off.

As there will be a huge number of new entrants in this market, there will be great potential for joint ventures among these companies, to increase geographic scope, customer base, business knowledge and technical know-how. There will also be the opportunity to partner with suppliers, bringing billing experience and high reliability. Traditional suppliers already have relationships with telcos, but data vendors incorporating voice capability into their products will want to partner with companies focused on providing VoIP services.

There is also the opportunity to cause disruption to the traditional telephony industry and negatively affect incumbent telcos. Those telcos who have not reacted yet to VoIP may be leaving themselves vulnerable in the long term.

In spite of the above, there are many disadvantages to being a small, independent provider. Although youth has led to strengths such as dynamism and willingness to take risks, it also results in an overall lack of experience. Business experience needs to be accumulated over

time, and billing systems and sustainable business models need to be developed. Most independent ITSPs will have much data experience, but little or no voice experience. Although some packet switching knowledge will transfer from data to voice, it cannot be assumed that this knowledge will be sufficient when dealing with a whole array of new services.

Dominant carriers tend to already have relationships with established companies, and prefer to do business with them. Companies like to do business with other companies of the same size, and this will disadvantage independent providers in the areas of interconnection and bundling of value-added services. Smaller providers simply cannot operate without the cooperation of large carriers, and to a certain degree will have to accept the market rather than shape it.

Regulation can be considered both a threat and an aid to any Internet service providers. Lack thereof has allowed the Internet to flourish, suggesting that any sort of regulatory intervention would stifle growth somewhat, putting smaller providers at a disadvantage. However, as discussed above in Section 2, general telecoms regulation has provided benefits for small providers as well as threats.

Incumbent providers also pose a threat to independent ITSPs. Most have realised the potential of IP and have acted accordingly. They are investing in VoIP equipment, and some have already begun to offer VoIP services.

To sum up, VoIP is growing rapidly, and will be huge. There are many possibilities for established companies and for start-ups. However, all such markets offer short-term potential and long-term market squeeze, sympathising only with those who have succeeded in their strategic positioning and relations, both customer and business.

8. Telephone Companies and VoIP

Telcos are starting to take the challenge of IP telephony seriously. Although it can be seen as a threat, it is also a huge opportunity. Incumbents have a natural tendency to work on improving existing technology and operations within existing business models, rather than embracing new technologies and industrial change, not wishing to cannibalise their lucrative business.

Telcos own the local loop infrastructure, and tend to own backbone networks; thus there are opportunities for them to leverage revenues from each part of the network, either as capacity providers or as retail service providers.

Within telecommunications, IP gave new companies a chance to enter the market by offering services that posed no major threat to existing traditional operators. However, as technologies have matured and progressed, a new range of applications becoming available are rapidly threatening traditional operators' core business, the most notable, of course, being VoIP.

VoIP, originally considered too unreliable for mass-market development, gives new entrants an easy and cost-efficient way to compete with incumbent operators through the current price arbitrage associated with Internet communications. Along with this price advantage, VoIP offers a platform for the integration of voice and data, richer applications and increased functionality. The opportunities presented by the Internet have resulted in many new entrants – without traditional business investments to protect – wishing to exploit the commercial possibilities of VoIP. The short-term economic advantages available will allow new entrants to build up their customer base and know-how (both technical and business), leaving them to gain potential for the longer term.

Incumbent telephone operators need to think very seriously about IP and its related

services. Several have already begun experimenting with VoIP, tackling the problem of undercutting their own prices before other ITSPs do. Future-thinking incumbents have been quick to respond to this challenge. Deutsche Telekom, Germany's incumbent telco, has become Europe's largest ISP, and due to the high number of new entrants planning to use VoIP, has purchased a stake in VocalTec, and has begun offering a VoIP service called T-NetCall. The company has expanded its service outside of Germany, installing gateways in Japan, the UK and the US, and is taking advantage of full liberalisation in the European market.

In the US, MCI is the most notable of the traditional operators who have entered the VoIP race, having already launched a technology enabling integrated voice and data transmissions for call centres. More services are being planned for the future as MCI continues to expand on its telephony revenues.

Other large operators in the US have seemed excited about the possibilities of IP, yet have been reluctant to offer these services in their own domain. AT&T offered commercial phone-to-phone services in Asia-Pacific (particularly in Japan) for nearly a year before commercial trials began in the US. AT&T's Japanese venture includes 27 Japanese companies, and offers business and residential VoIP service throughout the country, with calls offered at up to 80% cheaper than standard services.

Because long-distance and international tariffs in the Asia-Pacific region are generally high, and call volumes are rapidly expanding, many new entrants are trialling VoIP there. This has resulted in a response by the home incumbents offering such services. Japanese companies have begun to offer prepaid IP phone-to-phone calling card and FoIP services, while Telstra in Australia has been under pressure to offer VoIP services between Sydney and London.

8.1 Telcos in the VoIP Market

It is evident that the incumbent telcos are moving into the VoIP market, and have significant advantages and disadvantages in entering a market neighbouring their own. Their strengths, weaknesses, opportunities and threats are identified:

Strengths: telcos own the local loop, and often own large parts of the Internet backbone. This is a huge advantage because a high percentage of costs can be eliminated. Telecommunications, in general, are becoming very customer-centric, meaning that the most important part of the value chain is that nearest to the customer. In owning the local loop, telcos manage to be near the customer, whether they are providing services or leasing their infrastructure to others.

Incumbent telcos have been providers of telecommunications services for many decades, and as a result have accumulated knowledge of network management, dealing with large customer bases, and the outlook of a multinational company. General business practice is not abundant in start-up companies, many of whom have little more than some technical knowledge and venture capital.

Telcos already have a large customer base, and due to loyalty and convenience, many customers will be happy to accept VoIP services from this company rather than look further afield. They also have names that are known. They have huge capital resources, both existing and potential, and are big enough to undercut many other companies on price.

Weaknesses: the weaknesses telcos experiencing on entry into the VoIP market may be due to expectations that communications provision is the same across the board. They may fail to understand that the new networks and technologies with which they are dealing are not wholly analogous with those they have become familiar with. This could

lead to the use of business and other processes that are unsuitable or outdated.

The business model associated with telcos is not based on marginal costs, as will be for VoIP provision. Traditional telephony has also relied on cross-subsidisation and access charges so that universal service may be provided. The VoIP model will be based on marginal costs, which are minimal compared to fixed costs. The ability of large incumbent companies to adapt to this new scheme is arguable, as they have always had difficulty with rapid change. However, if telcos do manage to move away from their traditional cost model and lower prices towards marginal costs, the attraction based on price arbitrage will be minimised.

The idea that they are cannibalising existing business may retard some large operators. Those that have enjoyed monopoly status in the past are already suffering at the hands of new entrants, and may be averse to further reducing short-term margins, even if this may result in a long-term downfall.

Because the regulation (or lack thereof) of VoIP is questionable (see Section 2, Regulation of VoIP) many telcos have taken the attitude that the regulators will deal with their threat of ITSPs. This may result in telcos being unprepared for the coming market, and being left to play catch-up when they realise the extent of VoIP uptake.

Opportunities: telcos entering the VoIP market will experience many of the opportunities of ISPs and vendors, such as mergers and acquisitions of small and medium-sized companies. Deals and alliances may be formed to generate economies of both scale and scope. Many of these joint ventures and take-overs have been evident already, as telcos see this as an easy way of entering the VoIP market, and at the same time can acquire customer bases and technical expertise.

Large telcos owning much of their network will have the opportunity to leverage revenues at all points of the network: local loop, leased lines, backbone, as well as avoiding having to pay others to carry their traffic. It appears that this will be the greatest advantage of the telcos in this market. As the NAPs break down, interconnection agreements are becoming commonplace, and those that stand to gain the most from these are the owners and operators of the networks.

Because they have much experience in the telecommunications industry, and because they can offer bundled services (one-stop shopping – phone, Internet access, online banking etc.), they may be able to squeeze much of their competition on price and service offerings. Smaller providers, although in a prime position to service niche markets and to change rapidly, are simply not in a position to be able to offer bundled services without the co-operation of large operators.

Threats: because telcos will enter the VoIP market at a high level, there will be not only competition amongst themselves, but competition from the established players. These players know the market and know the customers, unlike telcos who may make the mistake of thinking that their knowledge will transfer to this market. The accumulated knowledge of large ISPs and ITSPs will need to be learned by telcos.

Whilst the opportunity for telcos to expand, both in terms of size and expertise, exists in the form of acquisition and mergers, similar activity is occurring amongst other ITSPs, making the surviving companies more dangerous.

The emergence of next generation telcos has shown the necessity for such a strategic focus. Telcos providing bundled services may lack such a dedicated focus, and as a result may not be able to service their customers adequately.

Regulation in this area is highly debatable and thus must be considered a threat.

<p><u>Strengths</u></p> <ul style="list-style-type: none"> Own infrastructure (backbone and local loop) Global presence and/or outlook Huge capital resources, both existing and potential Large existing customer base Name recognition Understanding of scaled network management Ability to bundle different services (1-stop shopping) Big enough to undercut on price 	<p><u>Weaknesses</u></p> <ul style="list-style-type: none"> New networks not wholly analogous Aversion to cannibalising existing lucrative business Business processes outdated Inability to adapt to volatile market conditions Lack of corporate understanding for the new competitive environment
<p><u>Opportunities</u></p> <ul style="list-style-type: none"> Leveraging revenues at all points of the network Unified service and billing proposition for customer Squeeze competitors on price and service offerings Sign deals and alliances to generate economies of both scale and scope Relationships with large ISPs Acquire small/medium companies 	<p><u>Threats</u></p> <ul style="list-style-type: none"> Effective marketing and customer service by competition Consolidation amongst competition Consumer choice Emergence of ITSPs Regulation

Fig 1 Telco SWOT Analysis [source 25]

There are three basic strategies that telcos can adopt in the face of VoIP.

The first involves staying still and hoping the VoIP phenomenon will never take off. This was the general strategy among telcos until recently, expecting that voice quality would never be sufficient on such a geographically distributed packet-switched network as the Internet. There was also an expectation that price differentials would eventually dissolve. Although this may prove true, the price arbitrage currently fuels VoIP adoption, but it is the availability of enhanced functionality that will take over as PSTN prices fall.

The quality of voice on the Internet will eventually exceed that of the PSTN, and other current PSTN advantages, such as the integration of intelligence into the network, are already entering the Internet. Nortel Networks has announced a next generation SS7/IP signalling gateway application, which is to deliver large scale, carrier-class PSTN/IP integration [24].

The above approach would maximise revenues in the short term, however as prices are forced down by competition from new entrants and VoIP providers, revenues would slip similarly. At the same time, innovative providers will gather a customer base and establish credibility.

Operators wanting, at a later stage, to enter the IP arena, will find themselves in a race to catch up, and with a tarnished brand image.

Operators seeking to become early movers have to make the difficult decision to offer low priced services in direct competition with their existing business. This strategy could take advantage of their known names and available capital to obscure competition. Telcos would be in a position to offer differentiated services over the Internet (or other IP networks) or the PSTN, depending on the requirements and sensitivities of the customer. They could also move into new markets as new entrants, as AT&T have done successfully in Japan, whilst learning about these new markets and services.

This approach seeks to maximise revenues in the long term by compromising some short-term margins. However, segmentation of the market and the offering of differentiated services does not necessarily mean revenues will drop significantly in the short term.

The final strategy involves operators looking to climb the value chain by exploring value-added VoIP services and offering them to their corporate customers. This could involve movement into any of the primary areas of value-added services generally associated with ISPs - content, systems integration, web hosting. Because these services are very far from the companies' traditional strategic focus and core competencies, many have failed to be successful in this area.

9. VoIP Market Segmentation

The VoIP market, in its immature stage, is highly segmented, with particular functionalities and enhanced services especially suited to certain customer segments. An industry that began by offering simple low-quality services to Internet-savvy hobbyists is now building customer bases in various areas of traditional telecommunications and data

communications, and will soon be able to offer mass-market and ubiquitous services to each member of the public.

The emphasis so far has been in two main areas – business use and long-distance/international use. Current VoIP markets are heavily biased towards business usage, but consumer markets are developing quickly as a result of next generation carriers.

9.1.1 Business Usage

Quality problems such as latency can be minimised over a local network such as a corporate LAN. For this reason, many businesses running IP LANs have taken advantage of the efficiency of packet switching. Technical problems are less daunting due to the closed nature of the network, which results in greater reliability than on the Internet. This means that delay in processing and reception can be minimised, and calls are closer to PSTN quality. VoIP may also be adopted for inter-office communications (on a WAN or LAN-to-LAN over the Internet), where quality is less of an issue than when dealing with customers or partners.

Businesses can also set up web-enabled call centres, so that customers wishing to contact them by phone can initiate a call without having a second line or disconnecting their Internet session. They can 'click to talk'. If the customer too has VoIP capability the call can be made over the Internet without the customer having to disconnect his connection. Otherwise, the customer can enter his information, send it over the Internet, disconnect and wait for a call centre agent to call him back.

Shared applications are also possible across an Internet connection, allowing both the caller and the agent to share information and to interact. This could signal a radical change in the way customers interact with a company, going from a purely auditory experience to one that can involve speech, information sharing through web interaction,

whiteboarding [glos] and file exchange. Push technology can be used to guide a customer to other pages on the Internet. Instead of the customer requesting these pages using HTTP, the agent can 'push' the information onto the customer's computer.

There are also advantages to VoIP call centres in terms of time. Forms can be filled in directly by the customer, and when he connects to the call centre the information is sent directly. Also, cookies [glos] can be left on the customer's PC that will identify them to the call centre the next time they call, saving both the caller and the agent time.

Businesses with high incoming toll-free call volumes can eliminate their toll-free number access charges by letting customers call a local number, from which they are transported to an internal, centralised network. This appears to be a local call to the customer, unaware that his call has been transported over a packet-switched network, and costs that for the business [26]. Businesses that have high telephony usage, such as travel agents and financial services, will be the target of many new entrant VoIP providers.

SOHO (Small Office/Home Office) premises tend to have higher penetration rates than consumers for multiple telephone lines, PCs, and online services. Their high connectivity and multiple needs are an opportunity for VoIP service providers. Being already connected to the Internet, a virtual second line can be provided by reception of VoIP and through the PC. Significantly enhanced services, which may be of great use to small businesses, can be offered. Small businesses are likely to be less concerned about the lack of QoS on the Internet, and will be willing to trade off convenience and quality for lower prices.

9.1.2 Residential Usage

Internet hobbyists, the original users of VoIP still use PC-to-PC calling. However, the primary focus in the residential market

has become phone-to-phone long-distance and international calling.

International and long-distance residential callers are willing to accept lower-quality international calls at a lower price. These users are less sensitive to quality, and do not necessarily require enhanced services. It is the price arbitrage alone that has attracted them to VoIP. Consumers generally tend to be cost-conscious and more flexible than business customers regarding quality and convenience.

Next generation telcos are moving towards catering for large cities having high densities of people with strong foreign links. Offering VoIP between, say, San Francisco and China, would allow service providers to build up large amounts of traffic between these locations. This backbone cost reduction seems to be one of the main objectives of the next generation telcos. Gateways can be appropriately positioned, and a dedicated line can be set up between these destinations. This may allow for VoIP without any use of the Internet, and hence overcome significant QoS problems, as capacity can be easily managed and long distances can be traversed in just one hop.

9.2 VoIP Uptake

From country to country, the development of VoIP will depend on a number of complex and dynamic issues. Certain environments are more inclined towards the take-up of VoIP for many reasons. For instance, in the US, tariffs are lower than elsewhere, and quality tends to be higher. Therefore, most customers will be reluctant to move to lower quality services when the price arbitrage is not so evident. On the other hand, in countries with poorly developed infrastructures the cost/quality trade-off of VoIP will be considerably more attractive. The regulatory environment may also have an effect here, as a competitive telecoms environment generally results in lower tariffs. However, such an environment can foster innovation,

leading to a quicker uptake of new services.

The Internet infrastructure and penetration of Internet usage will affect adoption. Customers already online will be more willing to try out VoIP, and a well-developed infrastructure will be able to give a higher quality of service. The penetration of high-speed local loop technologies will also facilitate VoIP. The last mile is usually the slowest part of an Internet connection, and with the introduction of xDSL and other high-speed technologies, enhanced VoIP service quality could increase dramatically.

The maturity and sophistication of the ISP market in a particular country will be an indicator of the time-to-market for new services.

Specific routes (e.g. east-coast USA to Ireland, UK to south Asia) with high volumes of consumer traffic will take advantage of the low costs of international calling.

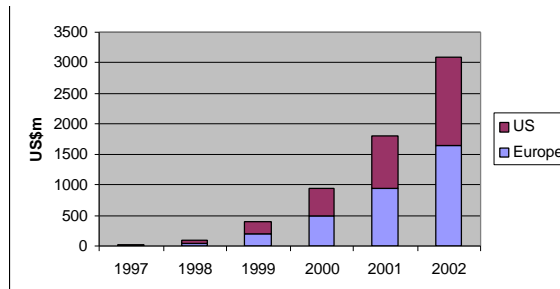
10. Market Forecasts

VoIP revenues are currently higher in the US than in Europe, but this is set to change due to both the current high tariffs in Europe, and the recently liberalised markets bringing competition. Usage will be greater in the US, primarily due to the superior Internet infrastructure, but margins will be higher in Europe, allowing providers to reap greater revenues.

Within Europe, the VoIP market is expected to develop fastest within mature communications markets such as the UK and Scandinavia, and in countries with high PSTN tariffs, such as Italy and Spain.

Fig. 2 VoIP Service Markets 1997-2002, source [5]

According to Frost & Sullivan, the total VoIP market will experience compound

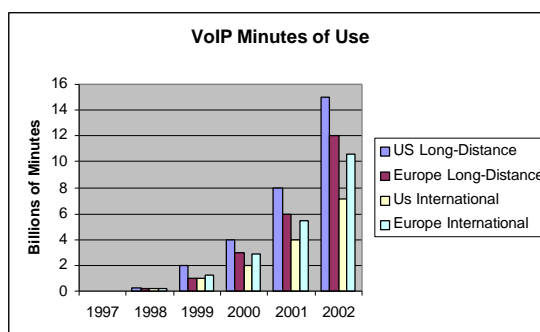


growth of 149% for the next few years, while minutes of use will increase by approximately 220% annually.

IDC (International Data Corp.) has suggested the market may be worth as much as \$24.4bn by 2002, with international calling generating more than 83% of this revenue, whereas Killen & Associates estimate revenues will reach \$63 billion by 2002.

Consultancy Phillips Tarifica estimates that AT&T will lose \$620m to \$950m in international calls by the end of 2001 due to VoIP. Digital estimates that VoIP could cost traditional phone companies \$8 billion in lost revenues over the next four years and may be able to eliminate the profits of U.S. long-distance carriers by stealing just 6 percent of U.S. telephone traffic [27]. According to Forrester Research, by 2004, ITSPs will offset the incumbent carrier revenues by \$3 billion in domestic long distance, \$2 billion in spending and \$1 billion in savings by end users. Forrester Research also predicts that prepaid calling card traffic will drive 50% of VoIP end user spending by 2002, reaching \$1.4 billion by 2004 [28].

Probe Research predicts that IP networks will carry 7% to 11% of the world's international voice traffic by 2002, 34% of the U.S. domestic long distance traffic, and 10% of the world's fax communication. They also suggest that as much as 50% of VoIP minutes will be additive, i.e. minutes the PSTN is not losing [29].



11. Conclusion

Although competition and demand will determine the market, a number of factors are clear in order that VoIP gain widespread acceptance.

QoS will be a pre-requisite for mass-market VoIP services, particularly business services. It is critical that networks have the ability to prioritise traffic to minimise network delay, and different service levels must be available for different classes of use.

The market is used to the PSTN, and is reasonably satisfied with it. Users require seamless integration of the PSTN and IP networks. They require services that are always available and reliable, with the high quality and enhanced calling features they have come to expect. The average user does not care about the network technologies involved as long as his expectations are met and modifications to his behaviour need not be dramatic.

End user equipment needs to become more user-friendly; reliability must approach that of the PSTN; interoperability amongst vendors needs to be accomplished through an open architecture and industry standards; and accessibility needs to be extended beyond the telephone to the fax machine, PC, and other compatible devices.

Once the price advantage dissolves, the market will be service-driven with enterprises pushing these services. Tariffs are lower than those for the PSTN due to a toll bypass, but it can be argued that the costs required to build an IP network with the reliability and features of the PSTN may yield only marginal cost benefits relative to the PSTN. Service providers, through business-oriented services and applications, can achieve higher margins. Those building dedicated IP networks are

in a prime position to grab a share of the business market, as they can offer QoS guarantees over their managed private network.

In Internet industries, the early mover usually wins vital market space. Netscape, for instance, a start-up in 1994, almost immediately became the largest provider of web browsing software, and did so because it saw the opportunity before Microsoft and other software houses. Equipment vendors need to enable service providers to offer business telephony features that transfer the features of the PSTN to the IP world, benefiting both themselves and the latter.

The long-term view (5-10 years into the future) sees quality issues as a thing of the past. By that time there will be no need to make the economic case for VoIP, as PSTN tariffs will have dropped in response to competition. Users will opt for VoIP because it is more efficient, has improved functionality, and is an altogether better solution to serve a technology-savvy market's needs.

Glossary

ATM – Asynchronous Transfer Mode, a multiplexing and switching technology used to transport small fixed-length packets, called cells, over a high-speed network.

Concentrator-Based Gateway – a concentrator (or aggregator) is a device that acts as an efficient forwarder of data transmission signals. A concentrator-based gateway is one that resides at such an aggregation point.

Cookies – special text files that a Web site puts on a PC so that it can remember something about the user at a later time.

DSP – Digital Signal Processor, a circuit used to improve the accuracy and reliability of digital communications. A DSP circuit is able to differentiate between human-made signals, which are orderly, and noise, which is inherently chaotic.

Facilities-Based Providers – those that build and operate their own networks.

H.323 – the standard for the transmission of real-time audio, video and data communications over packet-based networks.

Independent/Non Facilities-Based Providers – those that do not build their own telecommunications network infrastructure, leasing capacity from others, or paying per use.

Local Loop – the wired connection from a telephone company's central office to its customers' telephones at homes and businesses.

PBX – Private Branch eXchange, a telephone system within an enterprise that switches calls between enterprise users on local lines while allowing all users to share a certain number of external phone lines.

QoS – Quality of Service, the idea that transmission rates, error rates, and other characteristics can be measured, improved, and, to some extent, guaranteed in advance.

RBOC – Regional Bell Operating Company, one of the US regional incumbent telephone companies.

Router-Based Gateway – a node that translates between IP and PSTN information, and which resides at a router.

SDH – Synchronous Digital Hierarchy, the international equivalent of SONET.

SMS – Short Message Service, a service for sending messages of up to 160 characters to mobile phones that use Global System for Mobile (GSM) communication.

SONET – Synchronous Optical NETwork, the US standard for synchronous data transmission over optical media.

SS7 – Signalling System No. 7, the global standard for PSTN telecommunications.

Whiteboarding - the sharing of a document or image between by two or more users, allowing them to make notes or changes using the drawing capabilities of the particular program they are using.

Appendix 1: Comparison of Capacities of IP over ATM and IP over SONET

Based on a 155.520 Mbps capacity link running IP packets of size 576 bytes.

Protocol Layer	Available Bandwidth (Mbps)	% of Line Capacity	% Overhead Added by Each Layer
SONET	155.520	100	3.7
ATM	149.460	96.6	9.43
AAL	135.362	87.5	6.41
LLC/SNAP	126.937	80.7	1.37
IP	125.918	79.6	0

Protocol Layer	Available Bandwidth (Mbps)	% of Line Capacity	% Overhead Added by Each Layer
SONET	155.520	100	3.7
PPP	149.460	96.6	1.54
IP	146.15	95.4	0

source [30]

Based on the above figures, IP over ATM gives 79.6% of line capacity, compared to 95.4% for IP directly over SONET/SDH. The reason for this significant differentiation is that ATM and its related layers provide QoS guarantees.

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