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IP Convergence in Global Telecommunications - New Telecommunication Network Architectures for Integrated Services

Darren Wilksch and
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ABSTRACT

Global telecommunication networks are changing from their traditional role of providing voice services to one of data service provisioning. As a result, the strategic direction and future network architectures of telecommunication service providers are also changing. This report examines the drivers influencing this new direction, technologies supporting the change and likely next generation network architectures.

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IP Convergence in Global Telecommunications

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New Telecommunication Network Architectures for Integrated Services

Executive Summary

Global telecommunication networks are changing from their traditional role of providing voice services to one of data service provisioning. As a result, the strategic direction and future network architectures of telecommunication service providers are also changing. This report examines the drivers influencing this new direction, technologies supporting the change and likely next generation network architectures.

Service providers have been anticipating the rise of new services other than voice for some time. Architectures based on narrowband Integrated Services Digital Network (ISDN) and Broadband ISDN using Asynchronous Transfer Mode (ATM) technology have emerged for this purpose. However, user demand for data services based on Internet Protocol (IP) has exceeded expectations. This has primarily been caused by Internet commercialisation, e-commerce and the productivity gains achieved through corporate intranets.

To satisfy this increasing demand, network service providers are now considering the development of carrier grade IP networks to support their data and voice services in a single network. With emerging IP switching technology capable of carrier grade switching loads and the promise of guaranteed high quality voice communications, service providers see IP as the best business solution for converging their voice and data services. This is not to say that the Broadband ISDN approach was invalid, IP convergence is simply a more cost effective solution.

A significant capability that has enabled this new approach to carrier grade IP networks is optical fibre technology. Transmission rates over optical fibre continue to increase dramatically with advances in Wave Division Multiplexing, while the technology remains affordable. The problems of service management are greatly reduced if network loading can be sustained at lower levels, utilising these high capacity bearer services.

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Contents

1. Introduction

Global telecommunication networks have historically been used to provide primarily voice communications using analogue, and more recently digital, circuit switching technology [1]. Computer data services have generally been transported on separate packet switched networking technology using a variety of different protocols [2]. While data networks use packet switching for information transport, they often require circuit switched connections for wide area communications. This is due to the high costs associated with developing a separate physical network specifically for data communications.

As demand for data services grew during the 1980s, new telecommunication switching technologies and architectures emerged to integrate voice and data more efficiently on a single network. The result was the introduction of Integrated Services Digital Network (ISDN) architectures. With the then predicted demand for video services, and the need for future scalability in network capacity and size, Broadband ISDN (BISDN) using a fast packet switching technology called Asynchronous Transfer Mode (ATM) emerged [3].

Data is tending to exceed voice as the dominant service carried by wide area telecommunication networks. With this demand for data services, predominantly using the Internet Protocol (IP), and the relatively low cost of IP packet switching (router) technology, a shift from BISDN to an IP based wide area networking approach is emerging as the new architecture of choice for global telecommunication carriers (herein referred to as telcos) [4,5].

This report discusses these new directions in global networking. Section 2 identifies the drivers causing this trend towards IP based networking and considers the market and business forces influencing this fundamental change in direction. Section 3 examines the development of data service provisioning in wide area networks and Section 4 describes the technologies currently being deployed to support these services. Likely next generation network architectures are discussed in Section 5 with conclusions considered in Section 6.

2. Drivers for IP Convergence

One of the fundamental drivers for IP convergence is the rapid growth in data traffic carried over wide area networks (WANs). This growth has primarily been driven by the expansion of the Internet since its adoption for commercial use. Network service convergence at the IP layer is now seen as an economical solution to meeting these increasing demands for data, while still supporting other services such as voice.

2.1 Growth in Data Traffic

Telcos globally are observing sustained and significant growth in data traffic within their networks [6]. Service providers are beginning to see traffic profiles approaching 50% for data services and on some routes (e.g. international) data traffic is approaching 80% of all traffic carried. Voice continues to grow at around 8% per annum while data traffic, driven by the Internet and corporate intranets, is growing at an approximate rate of 35% [5]. By the year 2005 it is expected that data traffic will account for half the total global network traffic.

Growth in data services is strongest in the United States with aggregate network capacity for AT&T, Sprint, MCI WorldCom, Level 3, Frontier, Qwest, GTE, IXC and Williams being 1.2 terabits/second in 1996 and 21.7 terabits/second in 1999. Network capacity for 2001 is predicted to be 99.8 terabits/second for these carriers. In Europe growth in data services is also strong, primarily being driven by the Internet and electronic commerce (e-commerce) [7].

In Asia the growth in data traffic is not as great. This is due to the slower adoption of e-commerce brought about by the more regulated telecommunication industries in many of the Asian countries. Exceptions to this are countries such as Japan, Hong Kong, Singapore and Korea, which are more likely to adopt e-commerce. Even so, these markets are expected to be slower than North America and Europe [8].

2.2 Commercialisation of the Internet

Commercial use of the Internet was introduced in 1991. Since then it has been increasingly regarded as an efficient tool to improve business productivity through e-commerce and provide greater customer service [6, 9]. The ability to tailor customer interfaces to individual requirements is expected to be a significant mechanism in reducing customer churn.

In 1992 there were approximately 1 million Internet hosts, by 1999 there were around 100 million. This figure will grow dramatically with the expected widespread use of low cost Internet enabled devices and broadcast services. It is interesting to compare this growth with the 600 million telephones currently in service [5]. As a result, one of the major evolutions occurring within the telecommunications industry today is the provisioning for IP data services, the other is satisfying the demand for user mobility [6]. Moreover, mobile network vendors are themselves pursuing solutions for IP service delivery in next generation personal communication systems [10].

Globalisation and deregulation have become important drivers for Internet commercialisation [11]. To satisfy demand and meet commercial expectations, service providers will be required to build business class IP networks that meet contracted

Service level Agreements (SLAs) [7]. Such networks must provide quality of service beyond today's best effort Internet services.

2.3 Network Operating Costs

As Internet commercialisation and e-commerce stimulate user demand for data, telcos respond accordingly to provide wide area networking and data transport services to benefit from the new revenue opportunities. However, existing circuit switch networks are primarily designed for voice services and as a result are unable to efficiently carry data traffic. Operating and managing an additional and separate network infrastructure to support Internet IP traffic is very costly [12]. As the technology matures to provide voice services over IP networks, so called Voice over IP (VoIP), it becomes attractive to converge data and voice services at the IP protocol layer, and benefit from reduced costs by only operating a single network [13]. Furthermore, a single voice and data IP network offers new revenue opportunities to telcos with the possibility of new services such as virtual call centres and combining call centres with web based interfaces to enhance customer service [5, 14].

Business enterprise networks are also likely to move towards a single IP based network infrastructure for intranet data, wide area communications and voice services. In addition to reducing network operational costs by only managing one network, decentralised enterprises will also gain through savings in voice communications by avoiding intra-enterprise calls through the public switched networks. AT&T anticipates a global revenue shift, as a result of toll bypass using intranet IP telephony, to reach $22 billion by 2006 [5]. There are currently several manufacturers of Private Branch Exchange (PBX) equipment rapidly developing IP based PBX systems for these next generation corporate networks [15].

3. Evolution of Data Service Provision in WANs

The rapid increase in bandwidth requirements for data services has taken place in a world where telecommunication networks are designed to predominantly provide telephony services. In its simplest sense, a telephony service allows a user to make a bi-directional connection between his handset and that of another user that he has selected, for the duration of a call. The network providing the service must minimise the end-to-end delay throughout the call so that a natural conversation can take place.

Through endeavouring to provide such a service, the world-wide telephony network has grown into a complex system of switching nodes and communication trunks interconnecting these nodes. A user requests use of these resources by lifting the handset and dialling the number of a destination handset. The network then decides whether it has resources available (switching capacity and trunk bandwidth) to connect the two users. If so, a connection path through the network is created and user communication can then proceed. If not, the connection request is rejected and the user must try again at a later time.

Telecommunications companies evolved as government regulated (and generally owned) entities. As national economies increased their dependence on effective telephony networks, the desire for high reliability and universal access increased. Over time the telcos have deployed large networks, designed to be efficient in the provision of voice services. More recently however, there has been an increasing requirement to deliver other forms of information between users, the most notable being the transfer of data between computer systems. The call model for data transfer is quite different to that described above for telephony. Therefore, to be efficient, this form of communication requires capabilities that are not inherent in traditional telco networks.

When the data transfer requirement was in its infancy, insignificant compared to the network traffic generated by voice, the problem of achieving data connectivity was primarily left to the users. They had to purchase, connect and configure equipment such as modems, multiplexers and routers in order to adapt the services provided by telcos into something capable of carrying data. During this same period telcos converted their backbone trunk networks from analogue to digital transmission schemes. This essentially resulted in the development of split architectures. The digital core having an analogue overlay to transparently support voice traffic, while the analogue access network has a digital overlay (e.g. modems) in order to carry data traffic [16].

As the telcos converted their networks from analogue to digital operation, the general architecture of those networks remained the same. Even with the advent of ISDN, where the benefits of digitisation were directly accessible by the user, the underlying network operation was still heavily based on the paradigm of conversational voice communications.

3.1 Original B-ISDN Vision of Telcos

With these issues in mind, the telcos began to consider how they would evolve their architectures to better cope with multiple forms of communication. An early view that they adopted (during mid-late 80s) was that their networks would need to evolve to handle "broad-band phone calls" [17]. This is based on the premise that services would experience similar usage patterns to telephony but with calls involving the use of greater bandwidths.

Their expectation was that the evolution towards next-generation networks would be carried out in response to market needs, but with the telcos controlling the roll-out rate of new services. There was also the belief that international bodies would prioritise their standardisation efforts in accordance with market demand. The key market areas predicted to drive this evolution were the requirement for business Local Area

Network (LAN) interconnect and the residential take-up of video distribution services, such as pay TV [18].

In the late 80s, these factors led to the CCITT (now known as ITU-T) developing a standardised framework for broadband-ISDN (B-ISDN). A new protocol known as Asynchronous Transfer Mode (ATM) was developed and sanctioned as the transport mechanism to support the realisation of the B-ISDN.

3.2 Problems/Impediments in Pursuing the Vision

In the early 90s, advances in telecommunications technology were proceeding at a rate that was exceeding the international standardisation process for B-ISDN. Developers sensed near-term market opportunities could be missed through having to wait for the production of standards by the traditional, telco-driven, standardisation bodies.

As a response to this issue, a vendor consortium called the ATM Forum formed to develop interoperability agreements, ensuring that their ATM-based products would work together. This created a de facto standardisation body, whose procedural time frames were much shorter than the entrenched bodies. Many other companies and organisations found this concept attractive and the Forum's membership quickly expanded. Thus the introduction of broadband products and services was becoming driven by technological capability rather than immediate user requirements.

Full realisation of the planned B-ISDN meant providing a fibre-based access network all the way to (or very close to) customer premises, replacing existing copper-based access network. Such an upgrade would have required a huge investment and was based on perceived future requirements, at a time when telcos were having to become increasingly competitive (and hence more short term focussed). It is also less attractive to build a universal broadband access network when those building it would likely be obliged to allow competitors to use it as well [19].

3.3 Growth of IP-based Networks

At the same time as telcos were experiencing impediments to pursuing the standardised B-ISDN model (early-mid 90s), IP-based networks were undergoing rapid expansion. This can be attributed to several factors which enabled the Internet of the time to break out of it's confinement to defence, research and educational circles.

The evolution of the Internet has had 2 major phases and is about to enter a 3rd [20]. The first was from the late 1960s to early 1990s - a physical, network and social engineering prototype of interest to military and research organisations. The second was from early 90s to today, encompassing mass adoption and commercialisation of narrowband access. The key applications of Phase 1 were e-mail and file transfer, and the dominant application of Phase 2 has been the World Wide Web (WWW). The third phase, which is just beginning, will see a large number of users experience "always-on" high-speed access to the Internet, and bring with it the capability for the development of many new services.

The emergence of the World Wide Web concept was a significant step forward in making Internet usage less about technical know-how and more about information access. The associated browser software, providing the user interface for this concept, experienced rapid uptake in its use, mainly because it could be downloaded for free over the Internet itself. The acceleration was also assisted through the Internet protocol stack becoming an integral component of the ubiquitous PC platform, whereas previously it was mainly associated with the Unix-based platforms used in educational and research institutions.

Also, Internet usage policy was opened up to allow commercial traffic to traverse the network backbone. This expanded the depth of information that could be accessed through the Internet and helped to generalise its usefulness to the wider community.

The deregulation of the telco sector has allowed competitors to buy trunk network capacity at wholesale prices. This has fuelled the emergence of Internet Service Providers (ISPs) and their ability to offer Internet access at prices attractive to the mass market, irrespective of the distance over which communication takes place. This is markedly different from the traditional telco pricing model.

3.4 Breeding Ground for Experimentation and Innovation

In its simplest sense, the Internet represents infrastructure that enables information bits to be passed between any computing devices attached to it. The infrastructure itself has no concern for what form of communication those bits may represent, so long as it has been packaged correctly for delivery. It is the applications running on the computers that send and receive the information bits to each other that ultimately add value for end users, such as file transfer, text, image, audio and video processing.

Having its roots in the research community, the Internet has always been a medium where dispersed user groups with common interests have shared and discussed new ideas. Being a network of computers it is also ideal for quickly distributing software amongst interested parties.

In traditional networks, the dominant carrier has offered a limited menu of service options to subscribers, with experimentation being virtually non-existent, except in well-defined small-scale trials [20].

In the Internet, the network itself does not define the services that are offered. This is totally the responsibility of the users. Thus experimentation with new and interesting applications can take place, without limitation by the network (other than performance related limitations), and without having to conform to strict regulations. It is simple to distribute experimental software, have others try it out, see if it works, and provide feedback. This makes the development time for new services potentially very short and often pushes the network to the limits of what it is capable of supporting.

3.5 Telco Response to IP Network Evolution

Initially (early-mid 1990s) telcos were not overly concerned with the emergence of IP networking. It just provided one, of various, means of connecting computers, which was overlaid on their infrastructure. They still perceived their voice networks as retaining the dominant source of revenue, even though data traffic travelling over IP networks was increasing rapidly.

It gradually became obvious that major corporate customers were creating large internal IP networks and connecting these over the WAN. Customers were then looking to these networks as possibly transporting their WAN voice traffic too, potentially undermining telco core service offerings. This trend was due to the disparity between the charges for long distance voice transport and long distance data transport (creating the so-called issue of 'toll bypass').

Telcos realised that this posed a significant threat to their telephony revenue. Their lack of IP data handling capabilities also meant that they were unable to benefit from the new markets that were being created through the growth of IP networks. With the additional pressures of competition and subscriber demands, telcos have since determined it to be faster and cheaper to roll out IP-based WAN technology to support data and voice services now, rather than continue to pursue a full B-ISDN architecture.

This has occurred despite the realisation that IP would not inherently support the same QoS that telcos have previously provided with their voice services. However, their approach to this issue has been to rely upon advances in optical fibre technology (such as Wave Division Multiplexing which can greatly expand the transmission capacity of existing cables) to make network over-dimensioning affordable. This helps to avoid the complexity associated with providing quality of service guarantees in limited capacity IP networks [21]. In parallel, there has also been expanding use of ATM technology in the core of telco networks. Here, it is primarily used as a mechanism to allocate bandwidth to different service classes, and hence enable a certain degree of QoS to be associated with these classes.

4. Technology

There has been much debate in the last few years as to which transport protocol will underpin the emerging public communications infrastructure. One view is that IP is the most natural choice, given its burgeoning use and constantly evolving nature. Another is that the protocol developed to handle integrated broadband communications, ATM, will still be the best positioned to support the services such networks will provide in future.

4.1 ATM

The ATM protocol was defined by the ITU-T (formerly CCITT) and specified as the transport protocol for B-ISDN. There are many references that describe in great detail the concept and operation of ATM and its related protocols, for example [22] and [23].

ATM is a packet-based protocol - in this case the packets are of a fixed length and known as cells. Each cell is 53 bytes long, with a 5 byte header and 48 byte payload. This cell size was selected as a trade-off between conflicting requirements. Real-time voice services require minimal delays to be imposed on packets and therefore benefit from the use of short packets. These require a small amount of time to fill with voice information. Data transport prefers the use of longer packets to minimise the overheads associated with packet headers and the packet assembly/disassembly process.

Even though ATM is packet-based, it is still connection oriented. All the cells in a particular stream follow the same path through an ATM network, with a path being defined at the start of a call. This makes it possible to specify constraints for a cell stream relating to parameters such as end-to-end delay and delay jitter. This is crucial for delivery of real-time services. Also, the bandwidth available to each connection is negotiated when a call is set up, meaning that a connection will not be granted unless the network can support its requirements. These elements contribute to the ability of ATM networks to enable QoS guarantees.

4.2 IP

IP is also a packet-based protocol, formed in the early days of the Internet, as a means of delivering information between computers on different networks. Again, many useful books have been written on the subject, including [24] and [25].

Besides the communicating computers, the other elements in an IP network that are aware of the IP protocol are packet processors, or routers. These devices use look-up tables to make decisions about which, of many, output links an incoming packet should be forwarded to. If it has insufficient resources to do this, such as internal buffer space or bandwidth on an appropriate link, it will discard the packet without attempting to inform the packet's source or destination that it has done so. As such, IP is said to provide only a best effort service. Also, no connections are treated with greater importance than others when it comes to deciding which packet should be discarded. The network can discard packets during adverse conditions, leaving it up to the communicating computers to detect such losses and decide how to recover from them.

This means that, historically, IP networks have had no inherent way of offering guaranteed performance levels to users of the network. Network design and planning has been used to try to ensure that the 'best effort' functionality of the network translates into an adequate level of service for most of the users, most of the time.

IP standards to support quality of service, traffic control and management are currently being developed. It is likely that the implementation of these standards and associated control/management strategies will be cheaper than those for ATM networks because of the widespread deployment that IP has achieved.

4.3 Which is More Appropriate?

ATM is still more scalable and flexible to support services like real time broadcast quality video. Perhaps if real time services such as these were more in demand, ATM may have been the technology of choice. Data services such as those for the WWW and e-commerce operate satisfactorily over a best effort service like that provided by IP networks.

5. Next Generation Architectures

Telcos today have extensive investments already committed to digital circuit switched network infrastructure. It is not economically viable for these companies to migrate all of their existing services over to a new technology platform. Instead, IP wide area networks will be developed as overlay network structures to support and grow with demands for switched data services. As vendors of wide area network communications equipment roll out solutions for the provision of integrated voice and data services over IP, telcos will begin to consider the business case for migrating to this new technology [26]. The main issue to be assessed is the trade-off between operations and maintenance costs associated with existing equipment versus the procurement costs for new infrastructure. The long term objective here is to operate fewer networks and reduce network operations, administration and maintenance costs. Public carriers considering such strategies are now beginning to initiate large projects in this direction [27].

During the migration stages to IP based wide area network architectures, interoperability issues associated with existing circuit switched infrastructure and Public Switched Telephone Network (PSTN) services will be of great concern [28]. Of course the new network operators emerging in the deregulated markets do not need to consider legacy systems and are able to move directly to IP based network solutions. Some of these companies are already considering the move towards transmitting IP directly over optical fibre bearer services [29, 30].

- Quality of service guarantees are of a major concern to service providers, particularly if voice services are degraded by bursts of data traffic in the IP wide area network. Such problems are inherently avoided with circuit switching and easily controlled within ATM networks. As a result, ATM is expected to play a key role in early migration strategies by underlying the IP layer to enable effective control and management of service quality [9, 13, 29]. Furthermore, some mechanism will be required to transport the substantial amount of existing non-switched data through the network, e.g. leased line services. The operation of ATM over the bearer services will provide a flexible transport mechanism for this purpose. As quality of service mechanisms develop for IP networks, less reliance upon ATM may be required. Alternatively, the exploitation of high capacity optical fibre transmission and over dimensioned networks is also being considered a possible cost effective solution to alleviating quality of service problems [13]. If networks are lightly loaded, user quality of service is less likely to be compromised.

Various architectures, network devices and signalling protocols are currently being developed to provide voice services over IP network infrastructure [31, 32]. While these techniques are being described in the Internet context, for so called Internet Telephony, many telecommunications service providers and vendors believe VoIP will appear sooner in enterprise networks and public carrier infrastructure [5, 26, 33]. Primarily this will be for the drivers described in Section 2.

5.1 Enterprise Networks

Enterprise networks today generally use the PSTN in a number of ways to interconnect voice and data users. For example, telephone calls from corporate PBXs are routed through the PSTN to external non-company subscribers, while calls to staff in other company sites communicate through leased PBX tie lines. Furthermore, to form a corporate intranet, routers interconnecting company Local Area Networks (LANs) are generally connected between sites using public leased lines, forming a private Wide Area Network (WAN). This approach is shown in Figure 1.

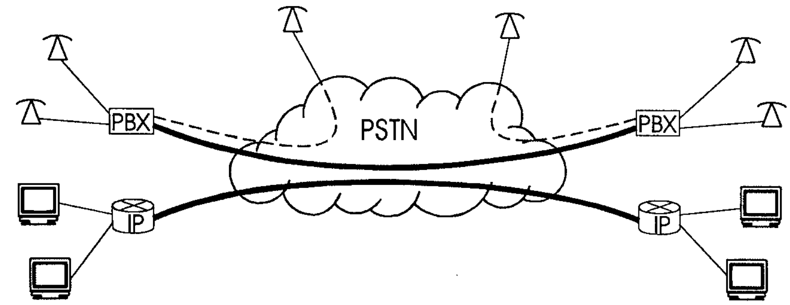

Figure 1 – Enterprise Networks Today

With the advent of VoIP technology, it will become possible to reduce operating costs by redirecting PBX tie line traffic over the corporate intranet, see Figure 2. Costs are reduced through the removal of tie lines, while only requiring a relatively small cost to increase capacity on the data leased lines for the extra voice loading. With IP equipment vendors and PBX suppliers offering products to achieve this, companies are now considering the advantages of this toll bypass opportunity. Of course connectivity to the PSTN is still required for external calls.

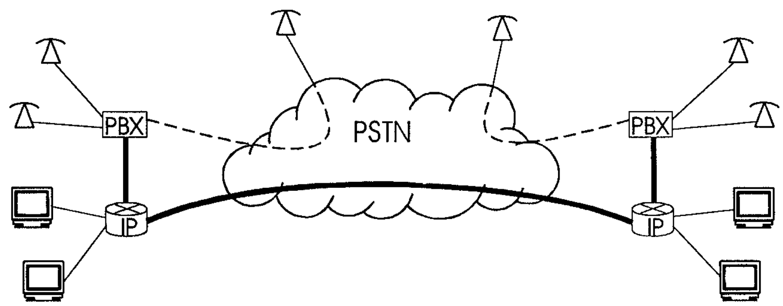

Figure 2 – PBX Tie Line Traffic Carried Over Data Network

A prime motivator for the provision of voice services within intranets is the cost savings associated with operating a single corporate network. As companies move towards voice service provisioning over IP, it becomes possible to update telephony equipment with new IP telephones or computer telephony integration, using desktop computer telephony software. Now with more intelligent voice terminals, PBX functionality can be distributed, greatly reducing the costs associated with telephone adds, moves and changes [15, 31]. Once PBX functionality migrates fully to IP technology, all corporate voice and data services can be provided by the one enterprise network. This is shown in Figure 3. Then as IP service provider networks develop, PSTN leased lines (and ATM permanent virtual circuits) can eventually be replaced by

IP Virtual Private Network (VPN) services. This will become available as IP security and business class QoS mechanisms mature. Gateway functions to the PSTN will also move from an enterprise to service provider responsibility.

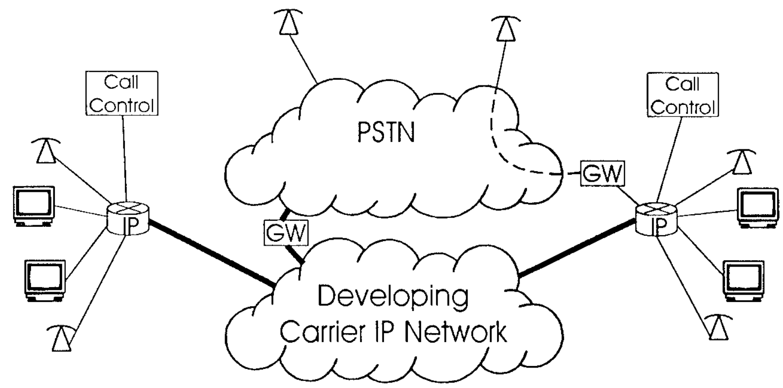

Figure 3 - Voice and Data Service Convergence

5.2 Service Provider Networks

Service provider networks are being driven by enterprise networks and the new revenue opportunities possible by bringing content closer to subscribers [34]. Naturally providers want to achieve this at the lowest possible cost. So with the rapid growth in data traffic, service providers plan to migrate to an IP based network infrastructure for all switched services as demand and business case dictates [5, 35].

Initial migration steps will be the development of carrier grade IP WAN infrastructure. With global connectivity via other network operators, this will provide efficient transport mechanisms for Internet traffic as well as supporting business class users paying for higher QoS. Today's leased line data services (Figure 4) will most likely migrate to ATM permanent virtual circuits (Figure 5) where QoS is managed [13, 29]. Other Internet best effort data services can be carried by the switched IP infrastructure directly, see Figure 5. Gateways will be required to interface existing PSTN services and subscribers. Network services will be provided using today's Intelligent Network architecture and signalling system [32, 33].

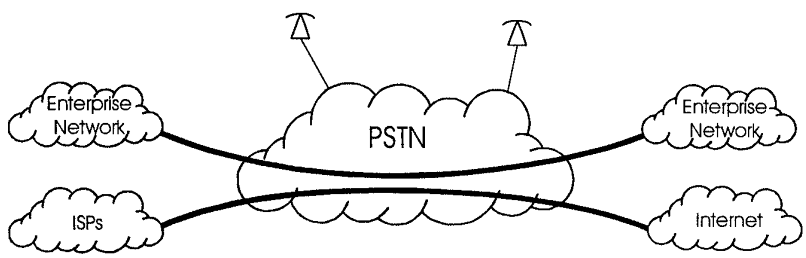

Figure 4 – Service Provider Networks Today

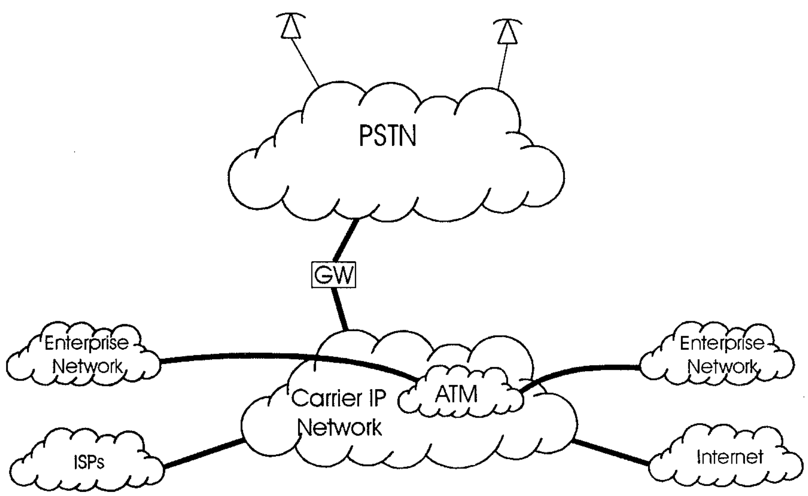

Figure 5 – ATM Interconnecting Enterprise Networks

As demands for data services grow, so will this new IP network infrastructure. As more service providers roll out their new IP wide area networks, increasingly telephone calls between existing PSTN subscribers will be routed through the PSTN and IP network infrastructure. Eventually as the IP networks become dominant, individual subscribers and network services will be migrated from the PSTN to the IP network. The Lucent proposed architecture [33] for this approach is shown in Figure 6, with gateways to legacy subscribers on the PSTN. In the long term, QoS protocols and VPN security will be such that enterprise networks will also be interconnected via the switched IP infrastructure.

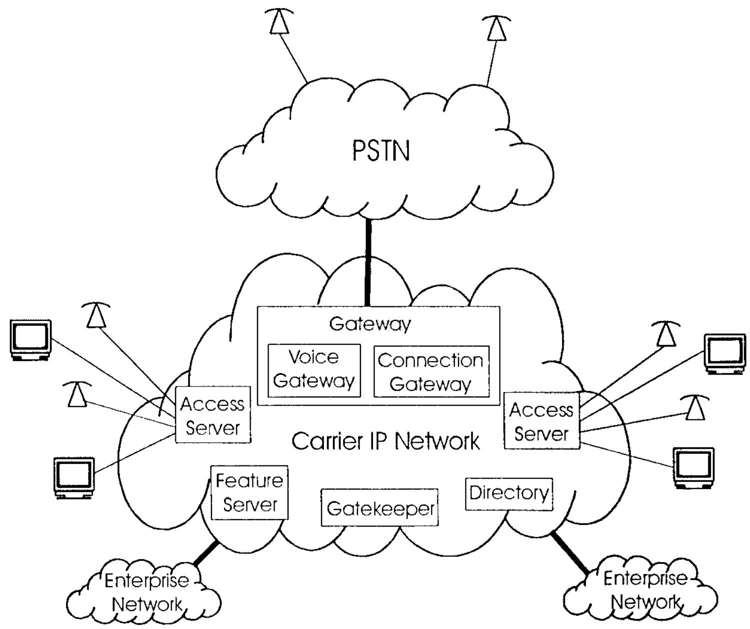

Figure 6 – Voice and Data Service Convergence

6. Conclusions

Over the last 100 years, telcos have evolved into massive companies, highly adept at providing voice communications. They have grown to have a very good understanding of this market and have been used to a high degree of control through their (generally) monopolistic existence.

In the last 10 years they have had to not only cope with loss of market control through increased competition but also with rapid and far reaching changes in telecommunications capabilities and applications. This has meant that their long standing business practices and network architectures are becoming increasingly ineffectual. They have also had to review their approach to future network architectures and the evolution towards them. Competition dictates that they must become a lot more responsive than they have been in the past but their size and momentum makes this difficult.

Whereas their newly established competitors can design and build networks from scratch, existing telcos need to migrate to architectures that will provide continued support to existing services and also enable efficient, timely provision of new, advanced services. They believe that, given the ongoing increases in the volume of IP-based traffic to be moved, it will be critical that their networks handle this form of traffic effectively. At the same time, they see that continuing improvements to IP and optical networking will also enable the same networks to support legacy services until they are no longer required. Prior to these improvements reaching maturity, ATM technology is being employed in the network core to support QoS requirements that IP can currently not achieve.

7. References

1. Bellamy, J. (1990) *Digital Telephony,* John Wiley and Sons, Second ed.
2. Tanebaum, A.S. (1989) *Computer Networks,* Prentice-Hall International, Second ed.
3. Kessler, G.C. and Southwick, P.V. (1998) *ISDN: Concepts, Facilities and Services,* McGraw-Hill.
4. Nortel Networks `Voice/Fax over IP,' URL - http://www.nortelnetworks.com/prd/isppp/collateral/whtpaper.pdf.
5. AT&T `The Future of Online Communication,' URL - http://www.ipservices.att.com/ip_telephony/docs/ipt_evolution.doc
6. Baujard, O. (2000) `Future Proofing and Innovation: a Paradox,' *Alcatel Telecommunications Review,* 1st Quarter, 3-4.
7. De Prycker, M. and PIROT, J. (1999) `Alcatel IP Network Strategy: Creating the Service-Ready Internet,' *Alcatel Telecommunications Review,* 2nd Quarter, 84-91.
8. Carpena, M., EQUANT Network Services (2000) `The Emerging Application Service Provider,' *The Australian IP Summit,* March, Sydney.
9. Fowler, R., General Manager Alcatel Australia, (2000) `IP Service and Network Management,' *The Australian IP Summit,* March, Sydney.
10. Granberg, O. (1998) `GSM on the Net,' *Ericsson Review,* No. 4, 184-191.
11. Kohli, T., Cisco Senior Consulting Engineer, (2000) `Forecasting the Growth in IP Traffic,' *The Australian IP Summit,* March, Sydney.
12. Riezenman, M.J. (2000) `Technology 2000 - Communications,' *IEEE Spectrum,* January, 33-38.
13. Muller, N.J. (1999) *IP Convergence: The Next Revolution in Telecommunications,* Artech House.
14. Dalgic, I. *et al.* (1999) `True Number Portability and Advanced Call Screening in a SIP-based IP Telephony System,' *IEEE Communications Magazine* 37(7), July, 96-101.
15. Gartner Group (1999) `The IP/PBX in Europe,' Market Outlook, Alcatel.
16. Chirgwin, R. (1999) `Is TCP/IP the Future of the Carrier', *Australian Communications,* February, p57-63
17. Borrus, M. and Bar, F. (1993) `The Future of Networking', URL - http://brie.berkeley.edu/~briewww/pubs/rp/network.html
18. Day, A. M. and Dorman, D. M. (1990) `Towards an Australian Broadband Network Infrastructure', *Telecommunications Journal of Australia* 40(2), p3-14.
19. Fist, S. (1991) `Getting to Grips With the Broadband Future', *Australian Communications,* September, p61-79.

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Darren Wilksch and Peter Shoubridge

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19. ABSTRACT

Global telecommunication networks are changing from their traditional role of providing voice services to one of data service provisioning. As a result, the strategic direction and future network architectures of telecommunication service providers are also changing. This report examines the drivers influencing this new direction, technologies supporting the change and likely next generation network architectures.

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