Industry Overview

The telecom industry is undergoing a difficult period where **huge capital investments in 3G licences and infrastructure has given rise to large debts and over capacity, causing falling prices.** We have often heard that the slowdown of the economy has affected growth in the technology and telecom areas. On the other hand, it could be said that the telecom sector is a major contributor of this slowdown. They are not just the victims of unrealised expansion; they are a part of the problem.

The benefit of IP convergence and broadband technology has so far failed to meet customer expectation and needs on the global basis. Corporate customers as a whole are still not ready to embrace solutions such as Virtual Private Networks, Integrated Voice, Video and Data infrastructure on a large scale whereas consumers are longing for the day when ordering broadband services is a simple phone call away.

Clearly, customer readiness and technology innovation are out of sync. So what does the future hold?

Several sectors are candidates for benefiting from IP convergence. Foremost amongst these are networks based on legacy protocols such as IBM's SNA or ESCON, or X.25, or even IPX. Although these protocols served admirably in their day, developments in IP technology such as QoS and Gigabit Ethernet have helped in propelling IP to the position of protocol-of-choice for most applications. Much effort has been put into moving legacy applications to IP. This means that both customers and vendors are well set to reap the benefits of an end-to-end IP network.

Another growth area that has become feasible is Voice Over IP (VOIP). This does not mean putting an IP phone on everyone's desk and running bleeding edge QoS in the core of a network. It does mean that by running QoS on a tightly defined area of the network and targeting a small area of the voice network it is possible to save money with little operational exposure.

Creating secure VPNs is a good way of both allowing home users to connect via broadband or from hotels while travelling, and of reducing circuit costs by creating a packet switched "cloud" that allows access to many remote offices via a high bandwidth core. This technology will need to acquire the confidence of end users before it is preferred to leased lines, but with most of the large intercontinental carriers providing a VPN service in some form, this day cannot be too far into the future.

Video provided over data networks has a lot of potential but the technology is not quite there yet. End users would like to have the ability to stream broadcast quality video from servers to end users' desktops but the ability to do so requires two key technologies to stabilise before widespread deployments can be attempted.

Storage is an area that is getting a lot of attention- even when the economy is in a downturn data is still accumulated at a frightening rate. Backing up this vital information generally requires a data network if it is to be accomplished in a timely manner. Unfortunately, today's data networks are too likely to be adversely affected by large quantities of disk I/O flying across them for storage over IP to really take off yet. More suitable protocols than IP are available.

Finally, there is the potential for carriers to migrate their Frame Relay circuits to IP. This would be aimed at customers who are reluctant to deploy an IP VPN immediately, and would rather stick with tried and tested technology. This would have rather limited appeal, but may help to keep frame relay alive as a technology for a few more years.

Technology in Perspective

Legacy Protocols over IP

There are three or four key protocols forming legacy networks in enterprises today. These are generally used in mainframe networks running mission critical systems that cannot be modified to run IP natively. There are definite differences in the requirements of legacy protocols and the number of products that allow legacy protocols to be tunnelled through IP networks. Customers are keen to eliminate these protocols to reduce support headaches and to allow circuit consolidation. Vendors are as keen as ever to supply new networking equipment to replace the 10 to 20 year old equipment currently running these networks. Carriers, however, are generally uninterested in legacy protocols- at a technical level they may be interested in replacing aging systems with DWDM and SDH, but at a business level the revenue from old contracts that may not be renegotiated regularly is always welcome.

The protocol with the widest exposure to IP is probably IBM's SNA (System Network Architecture). This mainframe protocol is used in many old networks. Although not necessarily bandwidth intensive (SNA traffic was carried on TDM channels at data rates as low as 9.6 kbps) SNA generally has many channels between data centres. If SNA systems cannot be converted to run natively over IP then many vendors have solutions that encapsulate SNA in IP.

Several key players provide methods for transmitting SNA data over an IP backbone. Companies are providing hardware solutions rather than a managed service for this. The only carrier advertising an SNA over IP service is Equant. However, hardware vendors such as Cisco and Nortel have been in the market for 10 years. IBM (who wrote and developed the SNA protocol) also have techniques by which SNA can be transmitted over IP or frame relay.

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Cisco's approach is to use STUN (Serial TUNneling) or DLSw (Data Link Switching). These approaches are not ideal for SNA- it would benefit greatly from QoS or CoS- but they do get the job done. Cisco also has dedicated SNA interfaces for 7200 and 7500 routers.

IBM has written a SNA protocol stack that uses TCP/IP for its network and transport layers. This is presumably used alongside a NIC designed for mainframe use. This is probably the technically superior solution, but it is less likely to be used, as politically it is easier to change the network than to change "the system that's been running smoothly for the last 20 years".

ESCON (Enterprise System CONnection) is a more modern mainframe protocol than SNA. This is another IBM mainframe protocol. It is also used as the basis for EMC's SRDF (remote data mirroring). Clocked at 136 Mbps, it needs significant bandwidth (more than, say, Fast Ethernet can provide). It is also very delay sensitive. As such, it is a poor candidate for transmission over IP networks. It is much better suited to direct transmission over a DWDM wavelength, probably using a sub-rate multiplexer. If this is not an option then there is one company producing an ESCON to IP solution.

ESCON is normally driven directly across fibre circuits. Due to the reliance on high bandwidth, low latency links, and the performance drop-off associated with data loss, it is rare to transmit ESCON over anything but a dedicated circuit. The only company that advertises an ESCON to IP gateway is Computer Network Technologies (CNT). CNT specialise in mainframe and SAN protocol conversion. A more common option than ESCON over IP is ESCON over ATM or another leased line. Both CNT and Inrange have solutions to deal with this scenario. Again, there is an associated performance penalty. The most common solution is to install DWDM boxes and multiplex dozens of ESCON links over a single fibre pair. All the key DWDM players have developed TDM cards that take in 4 or 8 ESCON circuits and transmit them down a single wavelength. This solution is becoming more widespread throughout the industry. Overall, ESCON is not particularly suited to running over IP but more suitable alternatives do exist.

X.25 is an older data transmission standard. It provides a robust layer-3 protocol for transmitting slow (~64 kbps) signals over poor quality infrastructure. It uses LAP-B for it's datalink layer and commonly uses RS-232 or X.21 serial links for the physical layer. This means that although it has been phased out of European and North American carrier networks, it still has a role to perform in emerging markets with poor telecom infrastructure. In general enterprise grade corporations have replaced their X.25 networks with higher bandwidth alternatives (leased lines or frame relay). However, X.25 still exists in some corporations.

X.25 over TCP/IP (XOT) was developed by Cisco and incorporated in IOS 9.21. As such, it has been available for some time now. It operates by encapsulating X.25 traffic inside a TCP/IP wrapper. As X.25 is clocked at low speeds and small packet sizes, and is designed to run over noisy voice lines, this does not affect performance unduly.

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Voice Solutions

Voice and data integration is taken as a sure-fire way to reduce costs. All major hardware vendors have Voice over IP (VoIP) or Voice over Frame Relay (VoFR) offerings. Voice over ATM (VoATM) is also possible. An alternative would be to replace the many voice leased lines by using SDH to multiplex T1 / E1 circuits into higher rate bearers alongside data traffic.

Voice integration is possible as a managed service from some carriers. These offerings are frequently Voice over Frame Relay - an additional PVC is mapped across the frame relay circuit. Worldcom offer a VoIP service. Carriers have the advantage of understanding how QoS works across their network. They also like offering managed services as these generate guaranteed revenue, and it is often awkward to change provider for this kind of service. This is probably a growth area for the carriers. The key concern would be in getting voice traffic from the desktop to the carrier's POP within the intranet.

Voice over IP started off with a reputation of being low quality and low reliability. Indeed, this was true two to three years ago. When Cisco introduced IP phones it was more reliable to call the account manager's mobile than their desk phone…

Since then improvements in QoS and CoS services have made VoIP a more realistic proposition. Initial deployment is likely to be in branch offices rather than corporate headquarters where leased line costs are a significant part of the office's budget. Cisco's VoIP product range spreads across most platforms, including 2600 / 3600 low-end routers. Of course, these routers will struggle to do software encryption so security could be an issue.

Voice over SDH networks is comparatively simple if the SDH network already exists. SDH was designed to pull together many low speed circuits into one large pipe and has resilience built in. This is a simple way to consolidate voice and data traffic without compromising network integrity.

Voice over Frame Relay uses QoS on the frame relay equipment to prioritise voice PVCs at a higher level than data. Voice over ATM is also relatively easy (if anything ATM related can be considered simple) as QoS has always been integral to the ATM network.

Banks are certainly looking at this technology- mainly for smaller offices, but they are considering it for new buildings also. The factors holding this back can be categorised in two broad areas: technical limitations and operational limitations. Technically, QoS is still viewed as a new (and hence dangerous) technology in enterprise networks. Operationally, if a data network is down for two hours it is a serious outage- indeed, it may cost the business serious money- but it is accepted as a part of the cost of running a cutting edge network. If a voice network is down for two hours, it is unprecedented. The scene of a hundred traders with no market data, no Hoot-and-Holler and no desk phone attempting to call the helpdesk on their mobiles must bring sleepless nights to all but the bravest support managers.

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Hoot-and-Holler services rely heavily on point-to-multipoint communications. In IP terms, this is multicast. It seems likely that no corporate network has end-to-end multicast enabled along side QoS. These are needed before Hoot-and-Holler services over IP can be provided with guaranteed voice quality and without crippling traditional network traffic.

VPNs and Remote Access

VPNs have been a hot topic for over 12 months now. Hardware vendors have produced either software features for existing platforms, or dedicated hardware solutions, to facilitate the deployment of VPNs by enterprise companies. Telcos have engineered solutions around these new products to provide a managed VPN service off the shelf.

With so much choice and flexibility, VPNs will be the option of choice when WAN circuits are renewed and global backbones overhauled. This should lead to a slow but steady deployment of VPNs, possibly with a boom when confidence is gained and the VPN provides an obvious economic or business advantage.

VPN technology can also be applied to remote access or teleworking. For example, Nortel have a product that allows the user's desk phone extension to be presented along with a data connection at the user's home (via ISDN). Applying VPN technology to ADSL lines could replace costly low bandwidth ISDN connections for addicted home workers. The VPN solution allows seamless connection to the corporate network from any Internet connection- whether at a conference, at home, in a hotel or on a customer site. The most difficult part of the proposition would be finding a suitable pair of partners to allow resiliency and global coverage.

Nortel (Shasta 5000), Cisco (VPN 3000) and Lucent (VPN Firewall Brick) all have products suitable for building both global and remote access VPNs. These all tunnel IP traffic from the client's device to a point within the corporate network. Authentication and access control are provided. Possible tunnelling technologies are IPSec, L2TP or PPTP. Authentication could be done via the current method for a particular enterprise- for example, TACACS+ or Radius and SecurID.

Carriers are taking these products and concepts and turning them into mass-market solutions. For example, Worldcom use Lucent routers with IPSec tunnels and your choice of encryption (probably 3DES or MD5). Viatel use Cisco equipment. Equant use IPSec tunnels, but offer the option of MPLS. The market has many options.

Generally, customers will not rush into replacing the core of their global network- whether it is ATM, frame relay or leased line. This is a very major step to take and poor engineering of the eventual solution could easily cripple a company. This will make the adoption of VPNs a painful process in the beginning. An acceptable strategy may be to create a VPN using several low importance offices (i.e., connect Madrid, Paris, Frankfurt to London using a VPN but leave London-New York-Tokyo on proven technology). Once confidence is gained then more ambitious rollouts may be attempted.

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It is likely that enterprises will opt for managed services from carriers rather than building their own VPNs from vendor equipment. This will reduce support overheads and allow a single point of contact to resolve outages. Global purchasing agreements should drive down prices for larger corporations.

Video and Content Services

It is possible for carriers and hardware vendors to provide solutions that enable video to be used efficiently over IP. However, these sources do not tend to provide content. Dedicated vendors, such as Reuters (Reuters Video Online) and Bloomberg (Bloomberg TV) provide video over IP services aimed at the financial markets. Several other video-over-the-internet projects (such as NetAid) have also been one-off successes.

Cisco's AVVID and IP/TV offerings allow broadcast quality video to be delivered to the desktop- as long as there is a multicast enabled network available. As multicast strategies are still in the embryonic stage, and router multicast code is at best average, and at worst a liability, widespread deployment of these systems is being hindered.

Currently, video tends to be delivered to large screens on the trading floor. There may also be some applications that stream video to a window on the desktop (such as Real Player). This reduces the range of viewing options and could possibly cause a distraction to workers. The potential to deliver personalised video to the desktop is intriguing.

Video delivery over IP relies heavily on multicast. This is the most suitable way to avoid flooding the network with high bandwidth video data. If, for example, each trader receives 1x1mbps video stream to their desktop, and if this data is sent as a unicast, the solution will not scale and bandwidth in the core and distribution layers will be consumed at a rapid rate. The source server will also probably need multiple gigabit interfaces to keep up with demand.

Multicast solves this problem but creates several more. As mentioned above, although multicast as a technology has been available for a number of years, the Cisco Catalyst 6500 range (potentially the only platform in the access and distribution layers) has generally buggy multicast performance. Although Cisco is working hard to resolve this, and "normal" routing is not adversely affected, it is possible that applications could cause network problems. If multicast may possibly destabilise the core component of the network then a parallel network can be deployed to provide multicast services to the desk. This requires twice the infrastructure (patching and hardware), increasing the deployment cost of multicast.

Video to the home over broadband VPNs (ADSL or cable modems) or ISDN is another fascinating application. This would add to the opportunities for working from home, but is more of a spin off of VPN technology than video over IP.

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All this combines to slow down the take-up of video delivered over IP. Once the multicast code stabilises and is trusted then we can expect to see video delivery to the desktop become much more commonplace.

Customers have definitely identified a need for video to the desktop. Today's high bandwidth, low latency networks have the potential to deliver this content. The challenge is in delivering the content at an acceptable quality without compromising network performance.

Vendors are keen to promote this technology as in the current slowdown they are desperate to shift any new units they can. The combination of customer desire and vendors keen to promote new technology should see video over IP taking off in the near future.

Storage over IP

SANs over IP really do not work yet. Although iSCSI and similar offerings purport to allow disk IO to be sent over the network, latency is too high and it is difficult to guarantee delivery. Basically, hard drives were designed to be integral to the computer they serve. Companies such as EMC and Hitachi have stretched this by using long (20m) SCSI cables, or fibre channel interfaces, but latency issues cripple performance if distances are extended sufficiently far that IP is the only plausible solution.

Possibly the only application not slowed by latency is file serving. In this case, there is a very good solution to take the load off expensive enterprise servers and to allow remote storage to become plausible. This is not SAN (Storage Area Networks) but NAS (Network Attached Storage). Companies such as EMC and Network Appliances provide what is essentially a disk array with multiple Gigabit Ethernet connections that presents an NFS front end to the network. These devices are deployed within several companies to reduce the need for expensive servers that provide only file and print services.

The volume of data generated by a SAN justifies a dedicated network in most cities. If a dedicated network is to be built then there is no need to build an IP network- a fibre channel network is better suited to SANs. This can be integrated into any DWDM MAN present as fibre channel and Gigabit Ethernet share a common physical and datalink layer (Gigabit Ethernet was based on the physical layer and the lower half of the datalink layer of fibre channel).

Migrating file servers to NAS devices does make sense. These allow consolidation of expensive data centre space by removing the need for external file servers to drive disk arrays.

Customers are ready for NAS if they have over 500 GB of data stored and a Gigabit speed network. Any enterprise with managed storage (most…) should find little difficulty in migrating file and print services to NAS devices.

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SAN over IP should be restricted to specific applications, and definitely not real time ones. For example, backing up data from a server to a tape drive overnight could use iSCSI. However, a dedicated IP to SCSI router (such as one of Cisco's latest offerings) is completely unnecessary.

Frame Relay

Frame Relay over IP is not yet readily available. The draft IETF specification was produced in March 2001. This has not left much time for industry take-up. Frame Relay over IP would probably appeal only to the carrier market in any case.

The IETF proposal suggests creating a new service type for L2TP (Layer 2 Tunnelling Protocol). L2TP takes the best features from Microsoft's PPTP (Point to Point Tunnelling Protocol) and traditional router tunnelling methods to create PPP tunnels through secured IP tunnels.

It is likely that other existing tunnelling technologies could be used on an ad-hoc basis to create a tunnelled frame relay network, but why anyone would do this instead of migrating to a VPN is not clear.

Carriers may embrace this to reduce their frame relay network costs. It is unlikely to find widespread deployment at all, although it may see limited use towards the end of this year. It should hold little attraction for enterprise companies- where is the benefit of adding another layer of complexity when they can engineer and migrate to an IP VPN instead?

Conclusion

The Internet revolution has driven IP Infrastructure development to the point where there is no other realistic candidate for building a data network. Switching IP traffic at application level is possible, reducing the latency through today's high capacity networks. Link aggregation technology allows 8Gbps channelled links to be deployed now and 10Gbps interfaces are available in carrier class equipment, and are just around the corner for enterprise class kit. This means that there is potentially an excess of bandwidth to be tapped in many companies' networks.

IP convergence is often promoted on the back of promises of reduced infrastructure costs and a reduction in recurring costs for circuits between cities and buildings. However, the rapid pace of development of these new technologies has outstripped demand in several places. IP telephony, for example, is now becoming a mature, reliable technology…five years or so after it was launched.

Moving legacy data protocols to IP is a very good thing, consolidating voice circuits into IP is now possible, but that some of the other options (video over IP, storage over IP) should be treated with extreme caution.

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IP Convergence Summary

Service	Technology ready?	Customer ready?	Likely take-up period
Legacy Protocols	Yes	Yes	Has been happening for some years
Voice Solutions	Yes	Yes	6 months
VPNs and RAS	Yes	Yes	12 months
Video and Content Services	No	Yes	12 months
Storage	No	No	2 years
Frame Relay	No	Yes	6 months if it happens, short lifespan

Glossary

3DES	Triple DES encryption algorithm
3G	Standard for high speed data GSM networks
ADSL	Asymmetric Digital Subscriber Line
ATM	Asynchronous Transfer Mode
AVVID	Cisco's voice, video, and data integration project
CNT	Computer Network Technologies
CoS	Class of Standard
DLSw	Data Link Switching
DWDM	Dense Wave Division Multiplexer
ESCON	Enterprise Systems Connection
Gbps	Gigabits per second
IETF	Internet Engineering Task Force
IOS 9.21	Internet Operating System - Cisco software
IP	Internet Protocol
IPSec	Encrypted data standard for high security
IPX	Internet Packet Exchange
ISCSI	Internet Small Computer Systems Interface
ISDN	Integrated Services Digital Network
L2TP	Layer 2 Transport Protocol
LAP-B	Link Access Procedure Balanced
MAN	Metropolitan Area Network
Mbps	Megabits per second
MD5	Encryption algorithm
MPLS	MultiProtocol Layer Switching
NAS	Network attached storage
NFS	Network File System
NIC	Network Interface Card
POP	Point-Of-Presence

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PPP	Point-to-Point Protocol
PPTP	Point-to-Point Tunnelling Protocol (Microsoft)
PVC	Permanent Virtual Circuit
QoS	Quality of Service
RS-232	Electrical standard
SAN	Storage Area Networks
SCSI	Small Computer Systems Interface
SDH	Synchronous Digital Hierarchy
SNA	Systems Network Architecture - IBM's connection standard
SRDF	Symmetrix Remote Data Facility
STUN	Serial Tunnelling Protocol
TCP/IP	Transmission Control Protocol / Internet Protocol
TDM	Time Division Multiplexing
VoFR	Voice over Frame Relay
VoIP	Voice over IP
VPN	Virtual Private Network
WAN	Wide Area Network
X.21	Electrical serial cable standard
X.25	X.25 A legacy transport protocol
XOT	X.25 over TCP/IP

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