Ethernet in the WAN – cause and effect

An independent report commissioned from Ovum by Fibernet

Ovum Ltd

2nd edition

August 2004
Ovum reference CLK74

London
+44 (0) 20 7551 9000
info@ovum.com

Boston
+1 (617) 523 1294
infousa@ovum.com

Seoul
+82 2 551 2749
infoasia@ovum.com

Melbourne
+61 (3) 9606 0499
infoasia@ovum.com

Sydney
+61 (2) 9247 6711
infoasia@ovum.com

www.ovum.com

Table of contents

1. Executive summary

Worldwide demand for LAN interconnect services continues to grow apace fuelled by:

- "routine" applications such as email and print serving
- capacity hogs such as networked storage
- increasing use of internet based applications
- emerging technologies such as VoIP.

Today's economic climate has required network managers to look closely at the cost of the infrastructure they use in support of this broad mix of applications. Conventional high bandwidth services, such as ATM, look increasingly expensive when compared to the lower purchase and operational costs of an Ethernet alternative.

The bandwidth range of Ethernet and an easy interface to LANs make it the most versatile of the wide area network services. The capability of Ethernet continues to grow as the technology matures in terms of security and support for Quality of Service (QoS). Within the next 12 months it will become a complete Layer 2 service alternative or complement to IP VPN.

This report, commissioned by Fibernet from Ovum investigates the growing use of Ethernet by corporates not just in metro areas but also for national network interconnect.

Key messages

The telecom industry has been through turbulent times but service revenues from data networking have continued to grow. All of the major carrier networking services – Frame Relay, ATM and IP VPN – are growing in terms of use and revenues. However, the signs are that the legacy Layer 2 services are peaking and part of the reason for this is the emergence of a strong Ethernet alternative.

With most corporate networks making extensive use of Ethernet within sites it is natural to consider using the same technology in the WAN. A single technology network is easier, hence less expensive to run. However, until very recently the technology to deliver carrier grade Ethernet WAN services was not available. Now improvements in LAN switching and the development of Resilient Packet Ring (RPR) technology enable carriers to offer national connectivity based on high capacity fibre networks.

As the price of ATM services has remained high more and more users are starting to investigate the Ethernet alternative. It offers a clear and flexible upgrade path towards connectivity at Gigabit speeds. In contrast, ATM has struggled to scale beyond 622 Mbit/s and changes to service configuration can be slow and costly.

Increasingly, only those users that have made a large investment in ATM will discount the Ethernet alternative.

Application drivers

Demand for LAN interconnect capacity is being driven equally by general growth in application traffic and by applications that demand a high bandwidth service, such as storage.

Growth in traffic for email and print services

Basic office automation applications – email and print serving – grow in use year on year in most corporate networks. At the same time the nature of documents has changed with the inclusion of text, graphics and multimedia now routine. Increasing file sizes for this traffic has caused a demand for more network capacity in the LAN and WAN. Switched Gigabit Ethernet backbones have addressed the intra-building requirements but conventional WAN services have not matched this capacity upgrade. The situation is worst where a user has just reached the limit of n*E1 WAN capacity and may be looking at an expensive upgrade to E3. Ethernet services have the bandwidth flexibility needed to address applications growth without incurring massive upgrade charges.

Storage networks

The cost and security of storage are an increasing concern for network managers – particularly those in the finance sector. Rationalising storage around a number of secure data centres helps to reduce costs of managing storage as well as simplifying the task of backup and disaster recovery.

Finance companies are under increasing pressure from the regulatory authorities to provide assurances that they can cope with the loss of data centres. This is requiring the adoption of a two stage backup strategy. First, SAN technology is used to link a secondary data centre mirroring the primary at a distance of several kilometres away. Secondly, a WAN service is used to support a non-real-time backup of the primary data centre to a location in another part of the UK.

Whilst support for nationwide synchronous SAN applications via Ethernet is at an embryonic stage (SCSI and Fibrechannel over IP) they are a cost-effective solution for long distance backup strategies.

VoIP

VoIP has become established in the enterprise market with organisations of all types and sizes now deploying IP phone and PBX infrastructure. For those companies that do not want to own voice switching infrastructure IP Centrex services are developing and we expect them to be a major market within two years. In either case, enterprises need LANs and WANs that can carry voice traffic. In essence, the network must deliver a latency of less than 100ms with a correspondingly low delay variation (jitter). Voice grade Ethernet services can deliver traffic across the UK with

a delay measured in low tens of milliseconds making them suitable for use in a VoIP network.

Ease of use

The simplest Layer 2 interconnect

Network managers that prefer a Layer 2 bridged network have had to choose a frame relay or ATM service. Both of these are based on ISDN technology and do not use Ethernet interfaces. As a result, the Ethernet frames generated in a LAN must be encapsulated for transmission in the wide area by a bridging device. This is inefficient and adds to the cost of the network implementation. ATM for example carries a 13% traffic overhead. In contrast, an Ethernet service provides a transparent extension of the LAN since it uses the same protocols.

Don't forget the management overhead

Network managers that have Frame Relay and ATM networks usually require management tools to match. They also have to acquire expertise in managing these protocols and even in debugging the services. With an Ethernet service the tools already used for LAN management can also be used to manage the WAN connections. This makes the services very easy to introduce to an existing network and reduces ongoing network management costs.

Service cost

The costs of using a network service include not just the direct cost of the service itself but also the costs of additional CPE that may be needed to access the service.

Service cost vs ATM

The cost savings from replacing an existing ATM backbone network with Ethernet vary according to the network topology. Incumbents are usually required to publish prices for ATM services by the regulator whilst most Ethernet services are offered as value added services on a custom contract basis. Our example later in this paper shows that savings of 80% are possible based on Fibernet's costing of our example network.

LAN extension services

LAN Extension Services (LES) have been a major enabler for Ethernet services in the UK. They provide short distance (up to 25km) extension of a LAN access to a service provider's PoP. With speeds of up to 1 Gbit/s available the services are a cost-effective alternative to leased circuits with the benefit of a LAN interface included in the price. Since BT started providing these services most other regional operators have followed suit keeping a competitive edge to the service.

Cheaper hardware interfaces

Ethernet technology costs less than alternative switching technologies for both enterprises and carriers. At a switching hardware level, the cost of a Fast Ethernet port for a router is 20% or less of that of an ATM port removing cost as an issue when considering adding an Ethernet service to an existing router. Many enterprises find they have spare Ethernet ports available on their routing equipment already.

Incumbent response

From a carrier perspective the cost per Mbit/s of deploying a network is significantly lower with Ethernet and independent carriers have passed much of this cost saving on to their customers. In contrast, the incumbents have regarded their broadband services as "premium" offerings with correspondingly high prices. They are now starting to enter the Ethernet services market in response to the threat generated by the new entrants.

Why have incumbents been so slow?

Incumbents have been slow to enter the Ethernet services market both at the metro and national level. The first independent service provider in the US launched in July 1999 yet it took until the Autumn of 2003 for the major European incumbents – BT, France Telecom and Deutsche Telekom - to launch services. The key issues for incumbents are the positioning of Ethernet relative to other LAN interconnect services and the platform to be used for the service. Incumbents want to manage the migration from "legacy" LAN interconnect services as well as to leverage their SDH and ATM infrastructure.

This has led incumbents to different network solutions. For example, BT is using its ATM platform for MegaStream Ethernet. France Telecom and Deutsche Telekom have favoured Ethernet over SDH and LAN switch based solutions. Their choice of technology and portfolio management issues have both influenced the service options they can provide. They are still lagging behind competitive carriers in terms of service options and flexibility in developing custom solutions.

2. Business benefits - applications

2.1 Ethernet markets

Business needs for data connectivity continue to grow unabated driven by greater penetration of data intensive applications and the need to connect more sites. Historically, leased circuits, Frame Relay and ATM services have been used to meet this demand but they now face a challenge from a new breed of MAN and WAN network services that capitalise on relatively inexpensive Ethernet transmission and MPLS.

Inverting the value proposition

Users, in Europe at least, have become accustomed to high prices for network services. They have been forced to shape their IT infrastructure and networks according to the balance between their budget and the cost of services. This has particularly impacted businesses' server and storage architecture and the support they provide for regional offices. It has been much cheaper to locate computers and storage in each remote location rather than to consolidate them at a central datacentre and deliver their services using a wide area network.

The changing social, trading and political climates are now influencing users to adopt storage strategies that place a greater emphasis on network resources.

From a sociological and economic viewpoint it is becoming less desirable to locate staff in expensive city centre locations requiring them to commute. Equally, the recent terrorist events have shown how vulnerable a company that locates all its resources in one place can be. Distribution to provide security is balanced against the opportunities for cost savings from consolidation. Commonly adopted models include:

- server consolidation to a central data centre followed by storage replication to a disaster recovery centre
- provision of dual-homed networks where each regional location has both a primary and secondary host data centre.

Application services are made available from both locations to remote offices via wide area Ethernet service.

New network technologies and service providers are challenging the conventional ways of building networks too. Ethernet has set a low price point for network transmission that some service providers have been quick to pass on to their customers in lower prices.

An Ethernet service is simply a better fit to corporate networks than the last generation of services – Frame Relay and ATM.

New network opportunities

Without the restrictions of incumbent telco pricing users can design IT and network infrastructure together to meet business needs at the lowest cost rather than limiting their opportunities to suit the telecom budget. For example, they can:

- design a storage architecture that provides the best balance between ease of data management and the location diversity needed for business continuity
- consolidate their web hosting and e-commerce strategy, leveraging the availability of GigE networks and peering in metro areas
- deploy VoIP and video applications to reduce operational and training costs.

2.2 The application case for Ethernet

Enterprises consume more bandwidth year-on-year because they adopt new applications and because the data formats used by applications are continually increasing in complexity as rich text and multimedia replace plain words. Storage, corporate email, VoIP and video applications have been the leading drivers for bandwidth over the past two years and are likely to remain so to 2005 and beyond.

Email and print serving

Although there are many new applications that will be drivers for Ethernet services routine applications remain one of the most significant. Enterprises continue to grow their LAN infrastructure and the resultant traffic volume from routine email and print applications follows suit. At the same time, the average size of email messages and print jobs has grown significantly. In the case of email, the use of HTML within messages and an increasing size of attachments is driving capacity growth. Increased demand for print serving is driven by organic growth plus increasing use of graphics and multimedia within printed documents.

Ethernet services are ideally suited to meeting the needs of these applications since they are not demanding in terms of transit delay within the network but are pushing requirements for bandwidth. Ethernet can be much more cost-effective than other broadband services in meeting this demand.

Browser based applications

Many banks and other institutions have extensive branch networks. They have a "dual tier" network. High capacity networks are used to link major office locations and additionally, dedicated capacity is often used to support storage networking for the principal data centres. The branch network has been a very different proposition. Many branches are in locations that are remote from high speed network infrastructure. They have typically been supported through low speed circuits with an ISDN backup.

Browser based applications challenge the conventional branch network model. Most traffic to branches is currently a mix of text and transactions from automated teller machines. This does not necessarily include web traffic – some banks specifically ban this from their branch networks. However, many commercial applications are now designed for access though a web browser and customers' expectations are increasingly for web-based presentation of information.

These trends challenge the traditional model of branch networking. A web based interface requires much more traffic to the branches since each page may include graphical elements many tens of kilobytes in size. This can severely strain a branch connection at 64kbit/s!

Banks are reviewing their branch network architectures to determine how they can support web applications now. Complex trade-offs between functionality, topology and cost are involved.

Thin clients

Banks have a regulatory duty to maintain the integrity of transactions and they must safeguard client confidentiality. As a result, they are very sensitive to data being stored outside major data centres. Thin client applications, for example, using Citrix MetaFrame or Microsoft Terminal Server – where data is stored remotely and local terminals manipulate that data without retaining a local copy – are preferred. They ensure that all documents and transactions are logged within the data centre and backed up within the routine backup regime applied at that data centre.

Widespread use of thin clients means that banks have a rather different traffic profile to other organisations that have a more distributed data model. They need significant regional capacity to backhaul traffic to their data centres. As the richness of content within applications is increasing so they will need more capacity.

Ethernet services are an attractive option for expanding the bandwidth available in metro areas and regionally. They can provide simplicity and security with lower costs and higher throughput.

Storage

Most storage applications in use today are Storage Area Networks (SAN). A SAN provides a network link between a processor and a remote storage device. In PC terms, this is equivalent to introducing a network between your PC and its hard disc. Although this sounds strange to most PC users, it is a common way of building large computing systems where a processor or processors may communicate with a bank of networked stores. Fibre Channel is one of the most commonly used protocols and it can be extended over a Gigabit Ethernet service, using new protocols like fibre channel over IP (FCIP).

Regulations on archiving and auditing in the financial industry have been strengthened since 2000. One result of this is that it has become a business imperative for many organisations to have a remote backup store. During 2001 and

2002 businesses started to look for solutions and many service providers – incumbent and new entrant alike – started to develop storage services based on dark fibre. Gigabit Ethernet (GigE) will become a more realistic and often cheaper alternative to using a conventional wavelength or dark fibre solution. Companies that adopt a SAN based on GigE will be able to use surplus capacity to carry other enterprise traffic.

Ovum believes that there will be a broader storage market based on Network Attached Storage (NAS). In contrast with a SAN, a NAS provides remote volumes or folders that users can access as if they were local to their PC. NAS systems typically use protocols such as Microsoft's Common Internet File System (CIFS) or the standardised Network File System (NFS). With a wide area Ethernet network, the storage and computer devices can be separated by many tens or even hundreds of kilometres. Since NAS operate over most forms of infrastructure without special hardware, Ovum believes it will support a new generation of storage services and service providers.

Voice over IP

Voice over IP is growing in popularity although it isn't yet meeting some of the more extravagant claims made by network equipment vendors. The most radical VoIP solution uses no traditional PBX equipment at all but integrates voice and data within a single LAN infrastructure. This type of deployment is being made mainly at greenfield sites where it saves on the cost of deploying telephone wiring and a PBX.

Most enterprises introducing VoIP into their networks are doing so gradually either as part of a planned migration to secure voice applications or as existing PBX equipment reaches the end of its life. It is possible to buy upgrade cards for most PBXs that allow them to support VoIP clients alongside conventional digital phones.

VoIP is demanding of network resources. Most companies that have introduced it need to make some adjustments to their LAN infrastructure to meet voice traffic requirements. The key issues for VoIP are:

- low latency and latency variation – although the ITU-T deems up to 200ms delay acceptable a practical VoIP implementation should aim for 50ms
- low packet loss – most voice codecs exhibit severe quality drops when network packet loss exceeds 5%.

IP VPN services are starting to meet these requirements through "voice grade" options at extra charge. They use MPLS and traffic queuing and prioritisation to deliver low latency and jitter for real time applications.

WAN and MAN Ethernet services are potentially more attractive to VoIP users because they avoid the overhead of protocol translation inherent in Frame Relay and ATM services and hence introduce less delay. They can also provide significant bandwidth headroom as a hedge against network congestion.

Video applications

Companies have become increasingly interested in using video applications over networks as a means to save on travel costs or to facilitate staff training. Restricted bandwidth availability outside metro areas has been a key limiting factor on this application sometimes requiring companies to revert to satellite distribution to reach some sites.

Ethernet networks will provide a viable alternative infrastructure for video applications to large sites situated within operating reach of an Ethernet network PoP. Ethernet provides greater bandwidth flexibility than traditional fixed networks enabling users to increase their bandwidth subscription only for those periods when video is in use.

The viability of Ethernet as a video distribution network is well proven in the residential market already. Fastweb, an Italian company, offers integrated Internet access, television and video on demand in 6 cities using Gigabit Ethernet as the principal bearer technology.

Web services

Web services, being promoted by the software industry as the future model for application development, comprise a set of technology specifications that are used for packaging software into easily accessible, re-usable components. Web services allow software re-use and hence the delivery of software as a 'service'. It can become a utility, bought, sold and delivered in a similar manner to electricity or telecoms. Web services allow for geographic separation between the service requestor and the components that supply the service. The model requires a low latency network to succeed and is largely unproven in commercial applications. Enterprises will be cautious about adopting web services on a large scale until they are sure the technology works and scales. Once any enterprise concerns about the web services model are resolved, Ethernet services will make a good platform for delivering them.

3. Business benefits - server and storage consolidation

3.1 The essentials of business

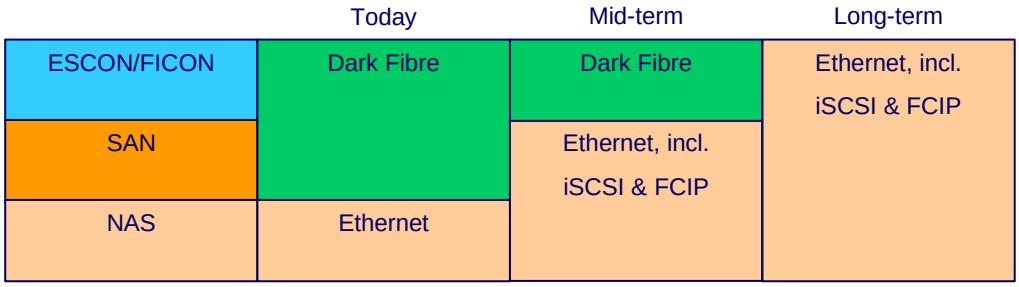
Businesses have some fundamental requirements on their IT systems. These include:

- business continuity
- satisfying regulatory and legal requirements in their industry
- maximising the business value of their systems and the information held in them

Minimising costs is always an imperative.

The storage technology used by enterprises and the way in which it is connected through networks will change with time, as shown in Figure 3.1.

Figure 3.1 Hierarchy of storage technology



Source: Ovum

Most of today's storage networks are built using dark fibre with only Network Attached Storage (NAS) on Ethernet. As Ethernet services are growing in capability and reliability so the role for dark fibre is diminishing.

Business continuity

Business continuity planning must address all the resources needed by the business: staff, IT environments, telecommunications and premises. It is a costly exercise to provision for business continuity and each business has to assess the optimum provision based on its operations and circumstances.

Business continuity is not only about surviving major disasters, power cuts and criminal acts. A business can be threatened by technical failures within the IT department. Around 70% of all data losses are due to either software or operator errors. So the strategy has to address a very wide range of scenarios.

Duplicating data at two or more sites is a component of most business continuity strategies.

If the time required to get back in business is critical, as it is for most companies, online connection to the disaster recovery resources is needed. Excellent data connections are needed for rapid data restoration. If the site is to be used as an operational centre in the event of a disaster, other factors, such as the physical transport links for staff and telephone network capacity also have to be considered.

Many companies are finding that Ethernet MAN & WAN services can help them achieve these ends for networked attached storage (NAS).

Satisfying regulatory requirements

Regulation is placing indirect pressure on financial institutions to deploy increasingly robust backup strategies. For example, they may be required to set aside funds to cover claims by customers. These funds will be forfeit in the case of a loss of data through inadequate backup strategies. To avoid this penalty, financial institutions must satisfy the regulators that they can safeguard their data to an adequate level.

Following the events of 11th September regulators have started to consider it inadequate to provide two sites within the same city. This is causing businesses to re-evaluate their backup strategy to include a tertiary backup site in another part of the country. Given the network latency over a nationwide distance it is not possible to use synchronous backup. The tertiary backup can be a snapshot or a company could use NAS technology to retain a near real-time copy of data. Since the traffic volumes are high a large capacity network connection with a latency that is as low as possible is desirable. The characteristics of Ethernet services are a good match to these requirements.

Turnbull Committee

All publicly quoted companies are subject to laws that require their directors to pay due attention to ensuring the continuity and stability of their businesses. For example in the UK the Turnbull Committee laid down rules for companies quoted on the London Stock Exchange. While the IT implications of these rules are not specific, the rules imply that due diligence must be applied to safeguarding IT systems and the data held and processed in them. External regulation is particularly prevalent in industries where a failure would have far reaching consequences, for example:

- financial services
- healthcare and safety critical industries

At the international level the Basel II accord, specifying how banking regulation should be performed, is indicative of the 21st century business environment.

Basel II and the Financial Services Authority

The Basel Committee on Banking Supervision has developed the New Basel Capital Accord (Basel II) which aims to raise the standard and international consistency of

banking supervision around the world. Its main provisions concern risk management and the balance between assets and liabilities of banks. Its provisions require some strengthening in existing operational practices in banks, although the implications for banking IT are not explicit. The practical difficulties associated with the changes have recently been acknowledged by the decision to postpone full implementation of the full accord from 2004 to 2006.

The FSA in the UK provides guidance in the FSA Handbook. The obligations to minimise operational risk are laid out in the FSA consultation paper CP142, which identifies operational risks in the areas of: people, processes and systems; external events and other changes (including business continuity management); outsourcing and insurance.

From an IT perspective the main demands are likely to be:

- more storage will be needed for retaining fuller historical data
- data mining tools will be deployed to help detect money laundering operations and accounts or investments which share common ownership
- greater emphasis will be placed on authenticating the identity of customers and users
- more stress testing will be performed to ensure adequate processing capacity.

To quote the FSA: "A firm should have in place appropriate arrangements, having regard to the nature, scale and complexity of its business, to ensure that it can continue to function and meet its regulatory obligations in the event of an unforeseen interruption. These arrangements should be regularly updated and tested to ensure their effectiveness". The need for physically dispersed IT systems and reliable communications between these systems is clear.

Maximising business value of data

Businesses are becoming increasingly aware of the value of the data that they hold. The information it represents often has value beyond the purpose for which it was collected and which data mining technology can now unlock. For example, the *Financial Times* has an interactive query system built on its archived news database. Most telcos, banks and big retailers are exploiting historical data for marketing purposes. However these techniques can only be used once data has been consolidated into a coherent entity to which there is reliable access.

3.2 Economic benefits of consolidation

Capital costs are only a small part of the Total Cost of Ownership (TCO) of IT systems. For example, Ovum's research shows that 70% of storage costs are incurred in managing storage over its lifespan, and only 30% is represented by the cost of acquiring the storage equipment. If action is not taken to change this, the imbalance will grow further.

IT infrastructure has spread across businesses in a fragmented way since cheap and powerful machines became available to workgroups and individuals. Distributed computing has brought high performance and responsive computing at low capital cost. However the overhead costs of administration, management and ensuring business availability, have multiplied much faster than the up-front capital costs of hardware have fallen. Software costs have also tended to rise, albeit while giving more functionality. The result is that powerful resources are being heavily under-utilised. Thus IT departments are now re-assessing de-centralisation decisions.

Consolidation offers several benefits. But simply going back to the old ways of having a single enclosed IT site is not an acceptable option because IT has become an integral part of most people's working lives. Maintaining universal access while consolidating IT resources, requires reliable, cost-effective and high capacity networks. The increasing availability of such networks is enabling enterprises to re-assess the optimum distribution of IT resources.

Server consolidation

Employing fewer, but larger, devices reduces the unit cost of IT operations. The basic structure of LAN networking makes Ethernet-based services an efficient form of systems and LAN interconnect. More importantly, centralised management simplifies system administration tasks such as system monitoring, software licensing and data back-up.

> Companies that have undertaken server consolidation projects have found that 70% of their cost savings have come from reduced staffing requirements, with additional savings from reduced accommodation costs.

Software is typically licensed on a "per server" basis and so server consolidation offers a way to rationalise the software licenses required.

As the number of servers is reduced it becomes easier, and cheaper, to provide consistent versions of software across the enterprise, saving staff training costs and enhancing interoperability. It also becomes easier to ensure that the correct number of software licenses is bought.

Service levels

Consolidation gives more consistent and predictable performance levels. It is easier to deploy standby and reserve resources within the consolidated network to ensure business continuity in the event of a loss of part of the infrastructure or data.

A consolidated IT infrastructure enables all employees and business partners to benefit from access to a consistent view of corporate information and applications from wherever they are located. Despite the greater interconnectivity, consolidated infrastructures are usually more securely managed than distributed ones.

Forms of server consolidation

There are basically three elements to server consolidation:

- the deployment of common procedures and software across the enterprise
- co-location of servers in a small number of places
- centralisation of processing on fewer but larger processors to reduce the unit processing cost. There can be problems where applications require incompatible databases to be installed on the same machine however.

Storage

The volume of stored data is growing by between 50% and 100% per annum in most organisations because:

- e-business and websites are growing rapidly
- storage-hungry technologies, such as multimedia and document imaging, are becoming commonplace
- regulatory requirements for long-term retention of data are increasing in many industries, including financial and healthcare
- data mining is being increasingly used to establish business advantage.

Storage represents up to 50% of total IT hardware spending. As corporate IT at the user level becomes more distributed, with mobile devices, laptops, home working and collaboration becoming commonplace, data storage and back-up has to evolve to support it.

Storage networks cut costs - dramatically

The cost of storage devices and storage media is falling fast, but overall storage costs are not. Storage capacity is poorly utilised, data is needlessly replicated and IT management is weighed down by the burden of routine storage management. Many organisations have enhanced the efficiency of their storage infrastructure by using networked storage. For example:

- a large financial services company was able to reduce the number of data centres it operated from five to three as a result of consolidating its storage provision
- one of the world's leading investment houses was able to replace 12 Compaq servers with each NAS Filer that it deployed in its UK data centres. At the same time it raised its disc space utilisation from around 40% to 70%, saving nearly half of its capital expenditure on storage hardware
- a European Telco saved about 25% of its storage running costs as a result of its first Storage Area Network project.

Data availability is one of the core requirements of business continuity. Storage consolidation, enabled by efficient WAN communications, enables enterprise data to be duplicated and restored consistently across the organisation in accordance with business-led policies.

Service levels

Networked storage provides a much more efficient back-up mechanism than is possible with storage that is fragmented across many servers, resulting in a better basis for disaster recovery. It facilitates automated notification of capacity constraints and operating difficulties, thereby improving the entire IT delivery to the enterprise.

3.3 Maintaining availability of IT assets

Avoiding single points of failure

Consolidated IT infrastructures are inherently more robust than fragmented ones because usually the various parts of a fragmented network provide different functions to the business. Thus if one site is down, its functions go unprocessed. However businesses should take the opportunity to add a prudent level of contingency provision when consolidating. Critical business processes may need to have "hot standby" centres available to take over if the main processing centre fails. Both external and internal services have to be considered, including public utilities.

Focus on restoration of systems and data

The whole point of backing up data is to be able to restore it when needed. Data restoration is much quicker when this can be done across a high speed network, rather than by the physical transport of storage media. The essential requirement is to be able to meet the business timetable for restoring critical data. Data can be lost in several circumstances:

- operator error
- software or system error
- loss or failure of storage hardware
- loss of a building containing a computer room
- area power failure
- loss of a processing site.

Statistically, most incidents fall into the first three categories. Business continuity provision is needed to cope with "everyday" problems, and not just for headline-grabbing disasters.

Location

To protect against terrorism, earthquakes and natural disasters, there must be a copy of the data far enough away from the usual premises to ensure that it isn't affected by the same incident that disables the frontline copy of the data. However the cost of bandwidth to link the premises is an important factor. Some organisations have decided that they must have three centres with copies of their most critical data:

- a frontline data centre

- a full, up-to-date, online copy in a fully provisioned hot standby centre at a modest distance from the main centre (within commuting distance for staff). In practice this distance has until now been limited to just a few kilometres by technological factors affecting the storage network
- a near real-time copy of the data at a substantial distance (hundreds of kilometres away) to ensure that it is independent of factors affecting the main site.

Since unreliable electricity supply is one of the major concerns, a back-up site should be on a different electricity supply network.

Consolidation requirements

Consolidation makes the enterprise more dependent on efficient and reliable networks connecting its various operating locations. The cost and poor availability of these links was historically a major reason for IT infrastructure being distributed.

Ethernet now offers a highly available and cost-effective means of accessing consolidated IT resources from multiple business locations.

It is important to select the right transport service to meet business needs. There is a growing trend to run storage services over IP transport and simply connecting to the Internet is not acceptable for many needs. It lacks assured service levels, throughput and security. The Internet is fine for reaching individual users or small branch offices so long as adequate security can be layered onto the basic communication channels, but managed communication services are needed for core corporate networks such as those which link data centres and major offices.

3.4 Evolution of storage networks

Why networked storage?

Organisations are seeking ways of handling the explosion of stored data efficiently. In particular the burden of managing storage has become critical for many organisations. The traditional model of storage, consisting of numerous disks and tape drives directly attached to individual servers, does not scale up without incurring unacceptable workloads. Networked storage offers:

- automation of storage management
- economy through consolidation of resources
- enhanced resilience through improved data back-up and recovery.

SAN and NAS

The two main storage network technologies in use today are Storage Area Networks and Network Attached Storage.

SAN is a high performance, block-based, technology that links storage devices into a network based on a protocol called “Fibre Channel” running over a dedicated fibre

link. It is dogged by substantial interoperability problems between different vendors' equipment, mainly concerning interfaces at the Host Bus Adapter level. Progress is being made on generally accepted standards, but deploying a SAN is still a major implementation task requiring specialised skills.

Fibre Channel operation is distance limited and FCIP provides a way to extend SANs over Ethernet MANs and WANs.

NAS is an IP-based technology that enables multiple storage devices to exchange data with networks of servers, working at the file and record level. It is relatively cheap and easy to deploy, but its performance depends on the configuration that is adopted. It can be deployed as a collaborative working tool in work groups using the existing LAN infrastructure, but in this case data transfer rates will be unpredictable and may conflict with other traffic on the LAN. Current research is dramatically increasing the throughput of the NAS gateways and filers and the future for the technology is bright. It has gained the backing of major software vendors such as Microsoft and IBM.

However the reliance of NAS storage on IP networks raises concerns about data security when it is deployed across public networks, and so business critical NAS deployments should be based on non-public accessed Ethernet connections.

The network is the most critical factor

The cost and the range of dark fibre links impose a limitation on the deployment of storage networks. Managed transmission services can extend the range of basic unmanaged fibre links - at a price. On the other hand IP networks have traditionally suffered from low throughput.

It is likely that Ethernet will provide the most cost-effective solution for the majority of wide area storage networks as the unifying technology for applications.

Emerging technology

In addition to NAS, other storage network technologies based on IP networks are being developed. These allow organisations to take advantage of cheaper and easier to manage Ethernet technologies. The two leading projects are iSCSI and FCIP.

iSCSI

The iSCSI specification is one of the IP-based storage protocols being developed by the IETF. It reached the final draft stage at the IETF in September 2002, clearing the way for vendors to start producing products based on it.

iSCSI provides a mechanism to get large-scale data transfer using SCSI protocols working over IP networks. iSCSI presents a homogeneous SAN. It encapsulates SCSI commands over a TCP/IP network. It is particularly attractive to organisations with several sites that would be expensive to link together with dedicated fibre

connections. iSCSI is likely to cost around $400 per connection – considerably less than a Fibre Channel connection, which requires dedicated fibre.

iSCSI requires Gigabit Ethernet in the LAN, MAN and WAN to compete with dedicated fibre channel storage protocols, and so has not been widely used in the past. For security and performance reasons, most enterprises need to run iSCSI on a dedicated IP network, rather than on the Internet. However, security can be provided on lower-volume links by simply using an IPsec VPN connection over a public network. This mix-and-match capability within a single protocol is one of the attractions of iSCSI.

Fibre Channel over IP (FCIP)

FCIP provides a more direct means by which existing SAN implementations can be ported to Ethernet infrastructures. It implements the Fibre Channel protocol on IP networks. It tunnels Fibre Channel traffic from switches in the storage network through an Ethernet link. It allows SANs to operate over long-distance links. It is relatively simple to deploy, and offers significant cost savings. IPsec security protocols can be used to ensure data integrity.

4. WAN services: technology issues and implementation options

4.1 Introduction

Public-carrier Layer 2 services, such as frame relay and ATM have been extensively used in the wide area for providing LAN interconnection. These services allow bridging between remote offices, both in the metro and farther afield. Although Ethernet is by far the commonest form of layer 2 framing encountered in the enterprise, other protocols are still in use today and their use is likely to persist for some time.

LAN bridging can be provided using:

- point-to-point private (leased) lines
- circuit-switched services such as ATM, Frame Relay and SMDS
- new Ethernet network services such as Fast Ethernet and Gigabit Ethernet delivered over four possible architecture/technology combinations.

Numerous platforms have emerged for service providers to implement Ethernet services. In most cases the standards for these platforms are, at best, recently agreed and in some cases still in development.

The early entrant service providers may still be using technology that is pre-standard but which continues to meet customer demand. Some issues, such as service restoration have been comprehensively addressed in new standards. Others, such as support for virtual LANs and QoS, are not yet fully standardised on all platforms but are likely to be by the end of 2004. As these issues are addressed Ethernet will progressively become a significant part of WAN solutions, mainly at the expense of services such as Frame and ATM that will be exposed as inflexible and more expensive to operate. Within ten years, Ethernet access will have become the dominant Layer 2 WAN technology and connectivity will be widely available from all service providers.

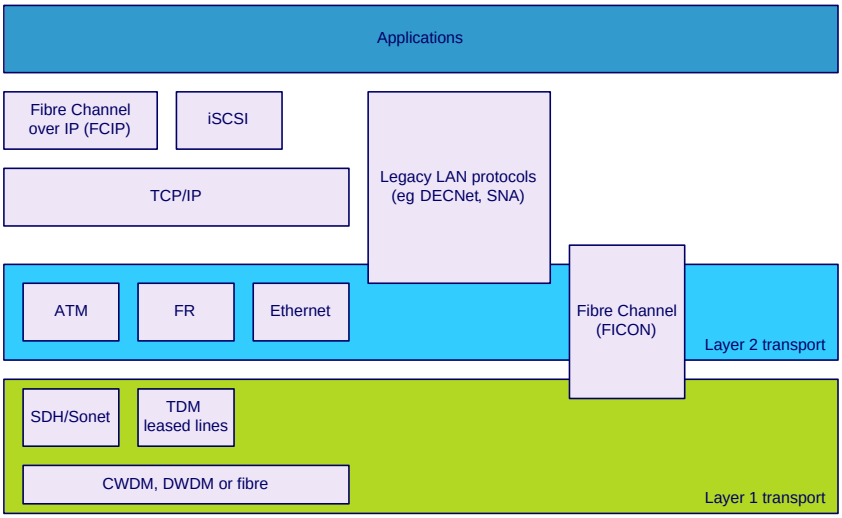
If users adopt a Layer 2 bridged Ethernet solution they can manage their LAN and WAN infrastructure with a common set of management tools. There is no need for specialist knowledge in Frame Relay or ATM. Even where an IP VPN solution is preferred, an underlying Ethernet infrastructure is more efficient than the alternatives.

4.2 ATM and Frame Relay over SDH

Most IP and LAN interconnect services are provided by encapsulating the higher-layer services within a layer 2 service such as ATM or Frame Relay. This has led to a complex mesh of protocols and associated switching in the LAN and WAN with many interaction paths possible between them – as shown in Figure 4.1. Ethernet is a newcomer to the network and most Layer 2 carrier services are currently carried by

Frame Relay and/or ATM switching equipment. User data, rather than going straight to Ethernet, as is possible now, is encapsulated in Frame Relay frames and/or ATM cells before reaching the transmission network. Considerable overhead is introduced.

Figure 4.1 Traditional highly layered approach to network service delivery



Source: Ovum

SDH platforms are also used for the delivery of private line services at speeds from 2Mbit/s to 622 Mbit/s and beyond. The layers of the communications hierarchy shown in Figure 4.1 are seldom integrated, which means that each individual layer has its own management and supervisory platform. The pros and cons of this approach are summarised in Figure 4.2.

Figure 4.2 End-user pros and cons of highly layered approach to network service delivery

Pros	Cons
• Well-understood and established technology with standardised network-node interfaces and service-interworking within multiple-operator environments • Network restoration and resiliency is well understood through the use of SDH transport	• Frame Relay WAN connectivity above E3/T3 rates is not possible • Overhead of packetisation • The long-term price trend for Frame and ATM services is poor compared to newer solutions due to higher operational costs • Service rates are tied to hardware port interface speeds. This leads to poor provisioning flexibility (long lead times). ATM services in particular have poor granularity meaning that customers pay for capacity they don't necessarily need

	• Integration of enterprise solutions is difficult owing to low level of integration between voice and data services, and between different generations of data-networking solutions • Many storage-based services are commonly employed over dedicated point-to-point fibre connections (e.g. Fibre Channel, ESCON, FICON) and share no integrated networking approach. Potential cost savings are not available.

SDH, designed to handle traffic segmented as multiples of 64kbit/s voice channels is ill suited to unstructured data which must be framed to suit.

The discrete leased-lines delivery of WAN connectivity also fits into this layered model. As shown in Figure 4.1, TDM/ leased lines can provide bandwidth to the enterprise, typically delivered using SDH transport. The user can buy a structured service or can buy bandwidth. This approach has been particularly favoured by corporations with national/global networks that have chosen to run their entire layer 2 services in-house. It is worth noting that many incumbent operators still also implement some leased line services using PDH (the predecessor to SDH); this is even more inflexible than SDH as it requires manual configuration (cross-connect) at every PoP in the network.

4.3 Gigabit Ethernet services over wavelengths or fibre

A number of new approaches to the delivery of Ethernet services have been devised in recent years. These are:

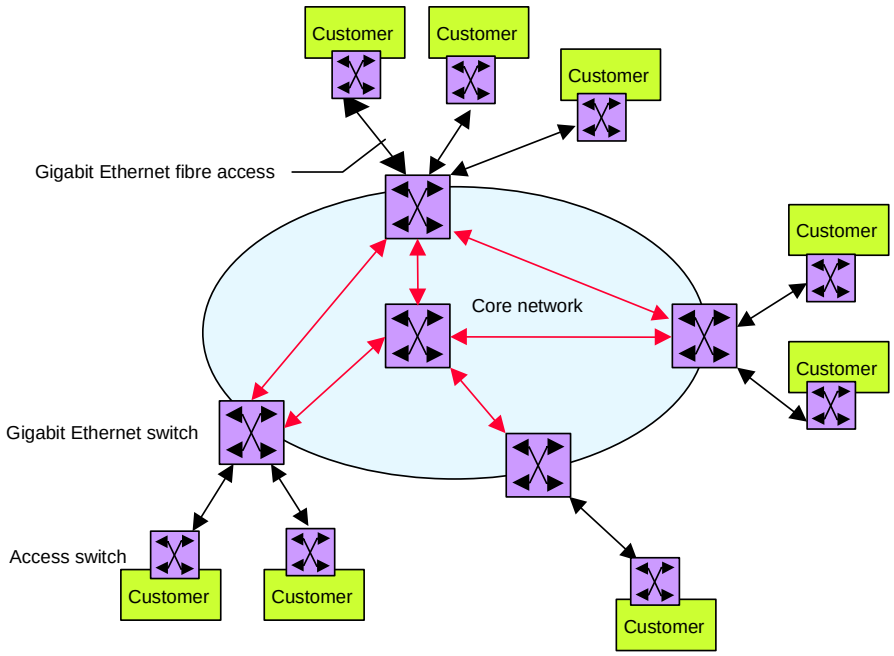
- native Ethernet (i.e. Ethernet not conveyed by another L1 or L2 service) over short-haul point-to-point links using a new generation of carrier-class Gigabit Ethernet switch with wide-area optical networking over fibre
- packet-based services using resilient packet ring (RPR)
- Ethernet services "encapsulated" into SDH transport (next-gen SDH)
- Ethernet over MPLS.

Native Ethernet

Native Ethernet services have arisen from the development of carrier-class Ethernet switches designed for the wide area, based on original LAN switch technology. Ethernet switches are typically employed on a point-to-point basis in a meshed architecture as shown in Figure 4.3. This solution has found favour with a number of new-entrant competitive access providers that have built metro Ethernet networks on

leased fibre. Their target markets are data-intensive users such as ISPs and certain classes of corporate customer.

Figure 4.3 A Gigabit Ethernet MAN/WAN network



Source: Ovum

Figure 4.4 outlines the relative capability of Ethernet services delivered in this manner. This is a rapidly maturing technology whose performance falls slightly short of more traditional data networking techniques but whose long-term future and cost basis are very favourable.

Figure 4.4 Pros and cons of native Ethernet services delivery

Pros	Cons
• Simple and inexpensive access CPE makes a virtually seamless interface to LAN infrastructure • When required, an upgrade to 10Gbit systems (in the backbone) will be relatively straightforward • LAN/WAN traffic growth is in packet data applications to which Ethernet services are highly suited • Flexible bandwidth provisioning systems allow traffic growth to be	• Some solutions retain proprietary aspects particularly for QoS and VLAN management. Consequently network-node interfaces between different vendor solutions require additional interworking testing • The physical layer for 10 Gigabit Ethernet is limited in standards-based implementations to 40 km. Proprietary solutions may operate at 100+ km without the use of

progressively served. Customers pay for bandwidth consumed • Allows significant de-layering of IP networks leading to simpler future networks • The cost of comparable services implemented using Ethernet will be lower, (vendor estimates suggest approximately 40% lower) than the similar services delivered via more traditional service platforms e.g. FR and ATM. Hardware port costs in the service provider core are much less expensive with Ethernet when compared with FR/ATM/SDH	repeaters. Whilst sufficient for metro-area networking, longer distance operation requires additional networking equipment • Large meshed architectures can become complex and lead to network/service management scalability problems. [Rings overcome this]

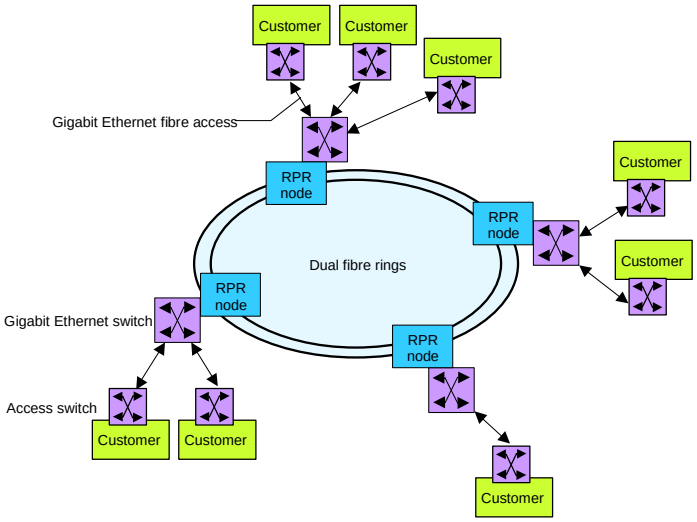
Resilient packet ring (RPR)

The development of Resilient Packet Ring technology has been driven by a need for reliable and efficient metro transport networks. Whilst a pure Ethernet switch platform has the benefit of simplicity many incumbent carriers have had doubts about its ability to meet the service restoration times of Sonet/SDH. Many of these have been allayed by standardisation work completed during 2003. On the other hand, Sonet/SDH is very inefficient for carrying bursty LAN traffic with time slots being provisioned on the basis of peak demand and remaining under-used for most of the time.

RPR is rapidly approaching the final stages of standardisation within the IEEE's 802.17 committee – it is out for "Sponsor ballot" with completion expected in mid 2004. However, certain important areas remain under discussion – such as QoS and some aspects of the resilience and topology discovery methods These are important for the long-term development of Ethernet services but they are mainly tweaks to existing work are not immediately needed.

RPR is an infrastructure that allows multimedia traffic from many customers to be transported efficiently in metro and now wide areas too. It is built from switching nodes linked by optical transmission in a dual ring topology as shown in Figure 4.5.

Figure 4.5 Ethernet services delivered using RPR on a ring-based architecture



Source: Ovum

Existing access networks or new Gigabit switches are used at the edge of the network to connect customer sites to the nearest RPR node. The RPR node functionality can be integrated into a Gigabit switch or router so that many types of traffic – including Ethernet, Frame Relay, ATM and even low speed Sonet/SDH accesses can be accommodated.

As with Sonet/SDH, the dual ring topology means that the services supported by an RPR network can survive a fibre cut. The latest draft of the IEEE 802.17 RPR standard describes a maximum 50 ms restoration time – the same as Sonet/SDH. Some vendor implementations of the standard are known to offer even faster recovery times.

RPR also makes more efficient use of the dual fibre rings. It is claimed that traffic throughput can be increased by up to a factor of five, depending on traffic patterns, since both rings can carry user data at high levels of utilisation. You may wonder what happens to traffic if both rings are carrying user data and a fibre is cut. RPR will continue to send traffic to a destination over whichever ring still has a path to it. Performance will degrade but network capacity is not halved by a fibre cut.

Two types of inter-node transmission are supported by RPR – Ethernet (1 or 10 Gbit/s) and Sonet/SDH. The former is a low cost option and will be preferred for new build. The inclusion of Sonet/SDH allows incumbent carriers to build an RPR network using existing Sonet/SDH capacity where it is favoured for economic or operational reasons. The pros and cons of RPR are summarised in Figure 4.6.

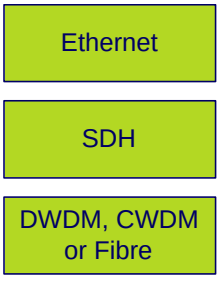
Figure 4.6 Pros and cons of RPR platforms for delivery of Ethernet services

Pros	Cons
• The use of Ethernet switch interfaces to the customer makes a virtually seamless interface to LAN infrastructure • LAN/WAN traffic growth is in packet data applications to which Ethernet services over RPR are highly suited • Flexible bandwidth provisioning systems mean traffic growth can be progressively served –customers pay for bandwidth consumed • Overall service tariffs will be lower than traditional highly-layered networks	• Many vendors' current solutions use proprietary or pre-standard solutions. These will take some time to be harmonised between vendors following the completion of standards in mid-2004. • Restoration and resilience levels will meet or exceed Sonet/SDH levels providing that carriers do not over-book the infrastructure

Encapsulated Ethernet services (Next-generation SDH)

Carriers that are primarily interested in providing point-to-point LAN interconnect are using next generation SDH solutions either at the IP layer or at the Ethernet layer. The rise of Ethernet services is focusing interest on "Ethernet over SDH/Sonet (EoS)" technologies which can encapsulate LAN traffic very efficiently within SDH virtual containers (VC). An EoS solution has the very simple network architecture shown in Figure 4.7 with efficiency benefits for the carrier and user.

Figure 4.7 Ethernet over SDH



Source: Ovum

Framing mechanisms for the encapsulation of 10M, Fast, Gigabit and 10 Gigabit Ethernet into STM-16 and STM-64 SDH transport services respectively have been defined through the ITU-T. By introducing Ethernet line cards (blades) into existing SDH equipment service providers can start to offer point-to-point Ethernet solutions cost-effectively over any distance that can be covered by SDH. They retain the network management and restoration benefits of SDH. A number of incumbent and

new carriers in the US and UK are providing LAN extension services with this technology.

The disadvantages of EoS stem from its point-to-point nature and its base in SDH equipment. As alternative native Ethernet solutions are now able to match the restoration capabilities of SDH new entrant carriers are more likely to use a native Ethernet solution because of its much lower cost.

Figure 4.8 Pros and cons of next generation SDH

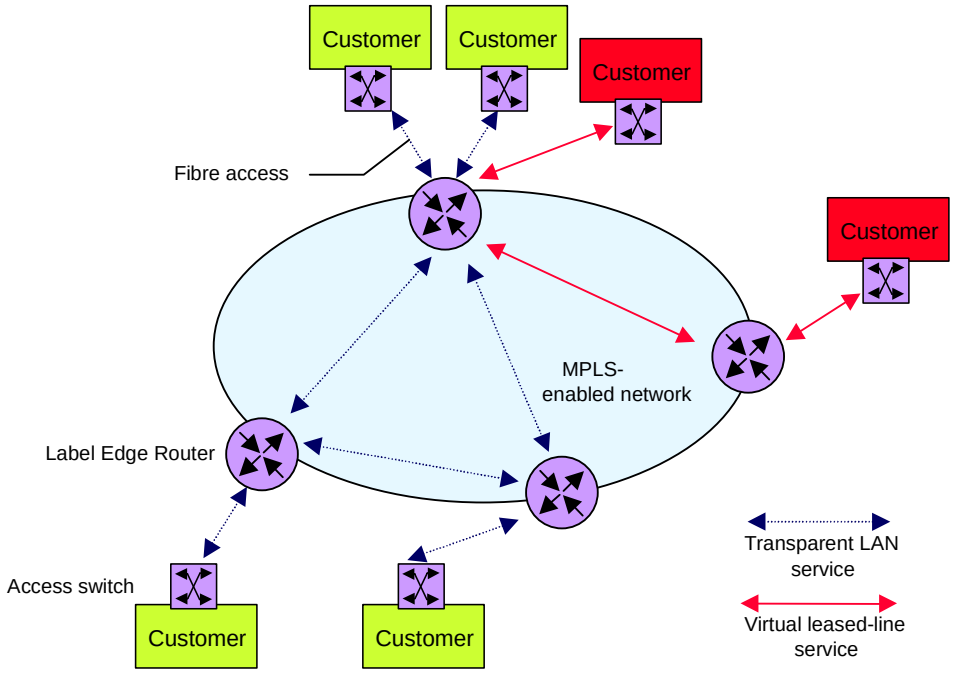
Pros	Cons
• More efficient carriage of LAN traffic for user and carrier • Exploits the resilience of SDH/Sonet; alternative physical mechanisms may offer no protection. Suitable for SANs • A secure, non shared medium. Suitable for high security applications	• Point-to-point solution, not as flexible as RPR or carrier switched solutions • Interface speed granularity and inflexibility of SDH/Sonet remains • The same SDH/Sonet slow provisioning of new interfaces remains • Higher cost than alternatives

Virtual leased line and transparent LAN services using MPLS

The fourth method of delivering an Ethernet (and other WAN services) uses an MPLS-enabled network together with IETF "draft Martini" encapsulation of the layer 2 service. MPLS employs label-switching techniques to routers and switches alike to produce more deterministic IP network performance, traffic engineering, VPNs and fast network restoration in the event of link or node failures.

Encapsulation of layer 2 services such as Ethernet and Frame Relay allows "pseudo-wire emulation services" (which are point-to-point "virtual leased line" (VLL) replacements) and transparent LAN services (i.e. operating on a multipoint to multipoint basis) to be established over an MPLS-enabled network. The key advantage of this approach is that it can support legacy access services such as Frame and ATM with Ethernet and other layer 2 data link protocols across a common MPLS network core. This means that service providers can deliver both new and legacy services on a future-proofed platform with consequent cost savings. The aim is to make the migration path for the end-user vastly simpler and more progressive. Both VLL and transparent LAN services are shown in Figure 4.9, with the Figure 4.10 highlighting the significant pros and cons of the approach.

Figure 4.9 MPLS-enabled Ethernet access services: Virtual leased line and Virtual Private LAN services ("Transparent LAN")



Source: Ovum

Figure 4.10 Pros and cons of MPLS-based Gigabit Ethernet services delivery

Pros	Cons
• MPLS will provide an elegant transitional solution for legacy WAN service over next-generation carrier networks, yielding more flexible service propositions and lower end-user tariffs • MPLS-based traffic engineering and re-routing capability can be used to provide QoS/CoS support and restoration respectively • Supports de-layering by using MPLS-enabled IP networks leading to simpler future networks	• Additional CPE required for some solutions • No IETF standards have yet been agreed, the Martini (and other) proposals remain IETF Internet drafts. Proprietary elements of vendors pre-standard solutions are likely to remain in the short-term, limiting vendor inter-working • Pre-standard implementations have been weak and complex to configure • Interworking to other WAN services is not fully specified

4.4 Access network traffic policing

Target end-user market

At present, there are relatively few end-users (e.g. in financial sector) that require the full capacity of Gigabit Ethernet for LAN or WAN service. The typical WAN bandwidth requirements of enterprises and ISPs range from tens of Mbit/s through to several hundred Mbit/s. The access speed onto a Gigabit Ethernet backbone is determined by the service contracts and policies set and managed at the access level. Where a higher class of service is required, higher prioritisation is given to traffic.

Application requirements

Different application types will demand a different class of service from the network operator:

- real-time voice and video are highly demanding applications and require both low delay and jitter. These will be offered a high class of service.
- e-mail and web browsing are satisfied with a best-efforts service
- storage services may require a low or even zero rate of contention - effectively dedicated connectivity to a particular customer.

The need for a dedicated service may also be driven by the need for security, achieved through physical isolation. This in essence is no different from existing SAN services over fibre.

The key point is that a business migrates to a Gigabit Ethernet connectivity for simplicity and cost reasons.

VLAN and CoS implementations

The consolidation of LAN-based services, and voice and data in general means that traffic-types need careful management and segregation within an overall Layer 2 end-to-end service. At present, many VLAN and class of service implementations are proprietary and so do not inter-work within a multi-vendor environment.

4.5 Last-mile connectivity to managed Ethernet services

User-to-PoP connectivity

As previously described, Ethernet connectivity in the MAN and WAN has numerous possible solutions. The most taxing problem for many service providers is the final-mile access to reach customers. Suitable fibre or duct often does not exist, or the cost of providing it in a timely or cost-effective manner is prohibitive. In these circumstances the options for a competitive provider to provide connectivity from the customer's premises to their nearest PoP are:

- dig – the preferred method for users requiring very high capacity
- leased lines from another service provider, often the incumbent whose network has excellent premises reach
- short-haul LAN extension data service, also from an incumbent operator.

One critical aspect determining their suitability for use in a multiple network operator platform is the guaranteed (and actual) service level. Thus, on paper, many short-haul LAN extension services have low guarantees of service availability (perhaps in the order "three-nines" or 99.9% availability). This level of guarantee is probably as much to do with an incumbent not wishing to compete with its other portfolio services (such as Frame Relay) as it is to do with their actual *capability* to provide a highly available LAN extension service. Competitive operators using wholesale LAN extension services such as these have found that their reliability is often considerably better and have used these to great advantage not only for expediency but on a long-term basis.

The disadvantage of this approach is that the performance and reliability of the service is dependent on some components outside the Ethernet service provider's domain. It is worth noting that on short-haul links these final-mile tails are also competitive user-to-user services in their own right especially at lower data-rates in the range typically up to 1000 Mbit/s. There may also be availability problems, depending on location.

Where LAN extension services are either unavailable or unsuitable, operators resort to more traditional leased line access solutions. Depending upon application, their higher cost may be offset by their generally higher committed availability in their service level agreements,

5. Comparative costs - Ethernet v. ATM

The pricing of different services depends on many factors. For example:

- type and capacity of service required e.g. ATM, SDH leased line, LAN extension service, Ethernet (including Fast and Gigabit Ethernet) service
- proximity of the premises to be connected to the telco's PoP (which will be influenced by the reach of the telco's backbone network)
- the overall length of the connection
- security requirements, which may include route diversity to the premises or additionally, the use of separate PoPs
- whether guaranteed capacity levels are required
- initial connection charge and annual rental
- length of contract
- discount schemes.

There are potentially many ways in which a customer's premises may be configured and connected to take advantage of different pricing schemes from alternate operators.

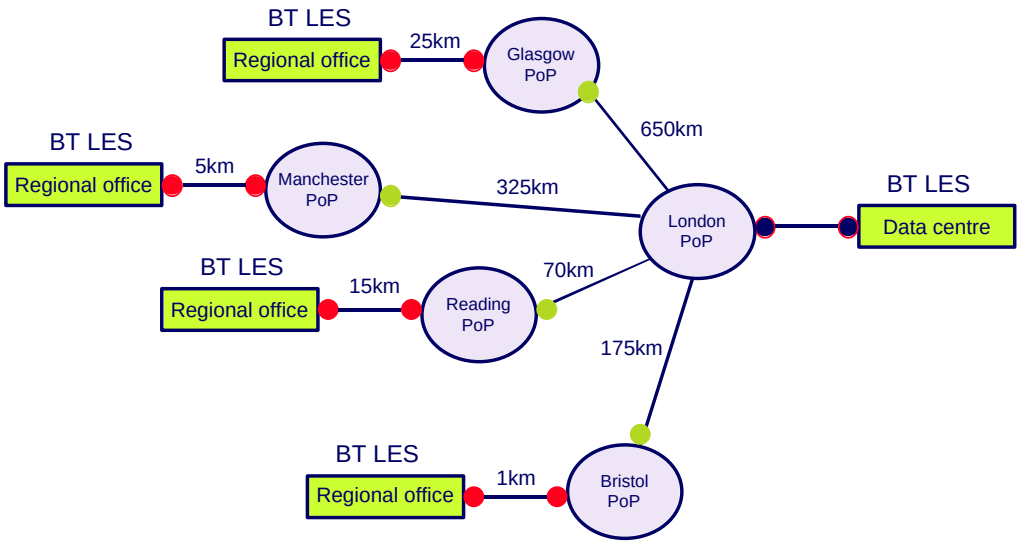
To provide a price comparison of Ethernet services with an ATM-based service we have considered a simple company network connecting four regional offices to a single data centre in London Docklands. The prices for the ATM service are from BT's retail price list, which is the only UK price list in the public domain.

The simple network cost analysis carried out, indicates a considerable price difference between ATM and Ethernet services. The total first year cost for the ATM solution is £1,817,812 compared with £356,000 for the Ethernet service for 1 year contracts in both cases.

5.1 Costing - Ethernet network

The Fibernet Ethernet network, shown in Figure 5.1 is costed with BT LAN Extension Services (LES) to provide the connection from the customer regional premises to the Fibernet regional PoP.

Figure 5.1 Simple Ethernet network with Fibernet Ethersphere solution



Source: Ovum

Figure 5.2 Fibernet Ethersphere service prices

	LES Install	LES Annual rental	Fibernet Install	Fibernet annual rental
Glasgow	£30,000	£48,000	£6,500	£44,000
Manchester	£10,000	£8,000	£6,500	£33,000
Reading	£20,000	£28,000	£6,500	£22,000
Bristol	£10,000	£8,000	£6,500	£33,000
Harbour Exchange			£25,000 £5,000	£1,100
Canary Wharf			£5,000	-
Total	£70,000	£92,000	£61,000	£133,100

Source: Ovum

Notes on Figure 5.1 and Figure 5.2:

- BT LES install prices all assume that suitable fibre already exists in both A end and B end locations
- Installation and annual rental of BT LES services are shown at BT retail list. Fibernet has a retail discount on these circuits to make margin
- Fibernet services are for 100Mbit/s ports at regional PoPs and 1Gbit/s port in London

- London PoP to customer data centre utilises Fibernet dark fibre from Harbour Exchange to Canary Wharf
- No CPE is included.

5.2 Costing – ATM Network

The alternative to the Fibernet network is to use BT CellStream ATM services to connect each of the local offices directly. Pricings are given in Figure 5.3.

Figure 5.3 ATM service prices

	STM-1 Install	STM-1 Annual rental	CBR PVC rental
Glasgow	£50,000	£30,000	£324,453
Manchester	£50,000	£30,000	£324,453
Reading	£50,000	£30,000	£324,453
Bristol	£50,000	£30,000	£324,453
Canary Wharf	£125,000	£75,000	
Total	£325,000	£195,000	£1,297,812

Source: Ovum

Notes on Figure 5.3:

- STM-1 services are installed at every branch and STM-4 services at the data centre. 100Mbit/s ATM PVCs (CBR) are included from each branch to the data centre
- Prices are based on one year contracts
- No CPE is included.

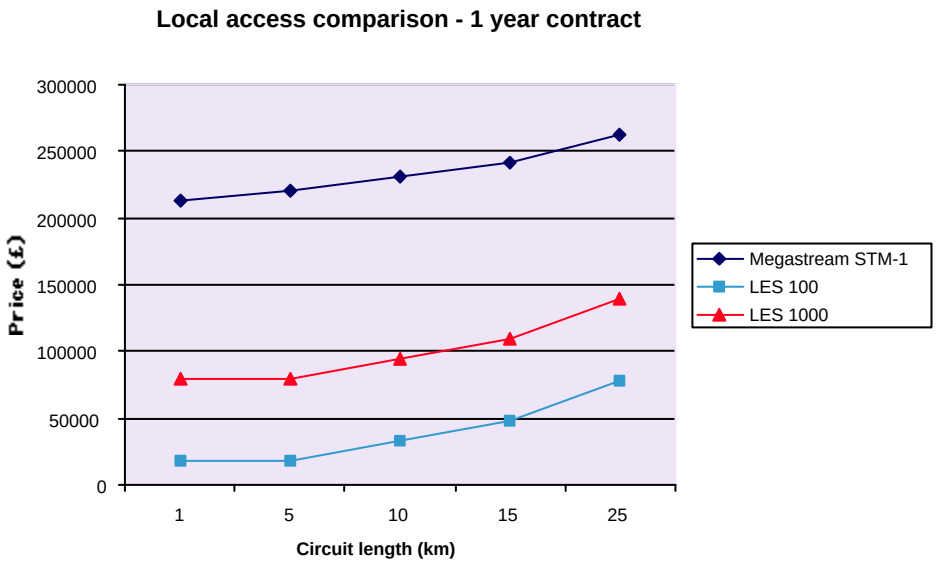
Overall, the cost of the ATM solution is significantly higher both in terms of installation and rental charges. The total annual rental cost for the Ethernet solution is - £225,100, 15% of the cost of a network built using ATM circuits.

5.3 Local access pricing

One of the most stark contrasts in price between the Ethernet and CellStream options occurs in the local access. BT's LAN Extension Services (LES) are priced significantly below that of a MegaStream leased circuit of equivalent bandwidth. Although the SLA associated with the LES services is not as stringent as that for a MegaStream, practical experience has shown that they are viable alternative tail circuits for connection to Ethernet backbone services. Buying a 25km STM-1 circuit on a one year contract costs £262k compared to £78k for a 100 Mbit/s LES service or

£140k for a 1000 Mbit/s LES service. Figure 5.4 shows the comparison for various line lengths.

Figure 5.4 Price comparison of BT LES and MegaStream local access



Source: Ovum

Notes on Figure 5.4:

- Prices are based on one year contracts
- It is assumed that suitable fibre already exists at both ends
- No CPE is included.

Users can commit to a 3 year contract and to volume contracts to reduce these costs still further. For example, with a 3 year contract, the price of a 25km LES 1000 service falls to an average £93k per year compared to £151k for a STM-1 MegaStream.

6. Forecasts

6.1 Drivers and barriers

The rollout of Ethernet services in the next five years will be shaped by a number of key factors, most significantly, that decreasing service prices will allow customers to increase their use of bandwidth to the benefit of the business.

Drivers	Barriers
• Ethernet solutions will allow delivery of new and lower-cost enterprise WAN services and consolidation of existing services • Lower cost base allows customers to buy more capacity for the same price • The high cost-base and inflexibility of Frame Relay and ATM networks compared with Ethernet means that the latter will become the preferred WAN-consolidation platform in the medium-long term • Ethernet-based services will be widely offered, helped by maturity of MPLS which is paramount, especially for the IP pure-play carriers • Wholesale fibre and wavelength services both in the metro and in national backbones are readily available • Enterprise WAN networking is using increasingly data-hungry applications: CRM support, HTML-based apps, extranets, IP telephony, remote offices and tele-workers • Many businesses, under pressure to maintain earnings despite flat or falling revenues are outsourcing non-core operations to cut costs. Furthermore, the internal consolidation of applications and the consequent growth in WAN connectivity is part of a general move towards centralisation of services that will assist outsourcing of operations at a later date • The high cost-base and inflexibility of Frame Relay and ATM networks compared with Ethernet means that the latter will become the preferred WAN-consolidation platform in the medium-long term.	• Service provider contracts of three years+ lock-in customers, at least in the short-term • Many enterprise users may be nervous about the vulnerability of alternate operators • Lack of understanding of new services (and mistrust of service providers) – some end-users will only switch to newer WAN services when they are better established • Higher levels of marketing and product support required to overcome this inertia and mistrust • Reduced levels of vendor support (marketing collateral, joint conferences/ seminars, staff secondments) due to reduced revenues in current telecoms climate • Incumbents have to prioritise investment and may be reluctant to invest and cannibalise existing FR and ATM revenues.

6.2 Developments in access technologies

2003 and 2004

- Institutional investment in competitive carriers for the expansion of new service capability will begin to return but with tempered expectations and realistic business plans.
- The incumbent carriers will operate Ethernet platforms side-by-side with current WAN platforms while starting to migrate key customers from Frame Relay and ATM services to Ethernet based networks.
- New service providers will cherry-pick traditional Frame and ATM customers.
- A more realistic marketing approach (particularly with a more viable service-pricing structure to that of the former data CLECs) will prevail. The emphasis is likely to be based on consolidation, flexibility and service.
- Incumbent and established operators will accelerate their own rollout of gigabit services in limited targeted areas while reducing prices where synergy and "cannibalisation avoidance" with other services - and regulatory factors allow
- Ethernet in the First Mile (EFM) standards will be finalised providing carriers with alternative short range copper and Ethernet PON local access solutions.

2005-2006

- Further but modest growth in the number of service providers offering Ethernet-based services will lead to increased competition. This will be seen in both service differentiation and pricing.
- Incumbent operators will be starting to push Ethernet services in favour of Frame and ATM. Further investment in these technologies will therefore be limited.
- Layer 3 (e.g. IP-VPN and Layer 2 Ethernet) services will dominate WAN new connections
- Range of locations reachable by Ethernet services is extended by EFM technologies making Ethernet services deliverable within most major business locations – not just top tier cities.

2007 and beyond

- Frame and ATM absolute numbers will continue to decline.
- MPLS, Ethernet and IP will drive all new networking solutions and integration with optical transport will become commonplace, driving further network simplification and thus costs
- Increasing general deployment of fibre in the loop reduces the incremental cost of providing Ethernet services and market growth accelerates
- Consumer data networking services in densely populated areas will be heavily influenced by real falls in core networking costs.

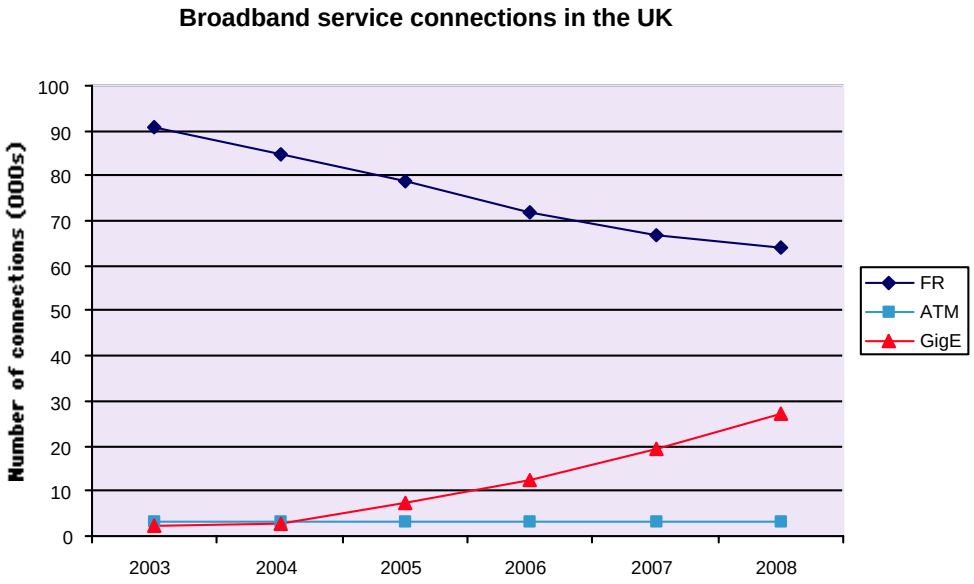
6.3 Summary WAN services line forecasts

Figure 6.1 shows the number of fibre connected Gigabit Ethernet lines for the UK for 2003 to 2008 (year-start in each case).

Note that these Gigabit Ethernet forecasts:

- are for access lines to premises or local distribution points (i.e. each consumer in a mutli-tenant unit or business served from a distribution point is not counted separately)
- exclude backhaul of other carrier services such as 3G and other wholesale services
- do not take account of inverse multiplexing ("fan-out") of Ethernet services at sub-gigabit rates beyond the building or PoP switch/termination point
- may be providing services at lower than Gigabit Ethernet rates

Figure 6.1 Broadband services in the UK

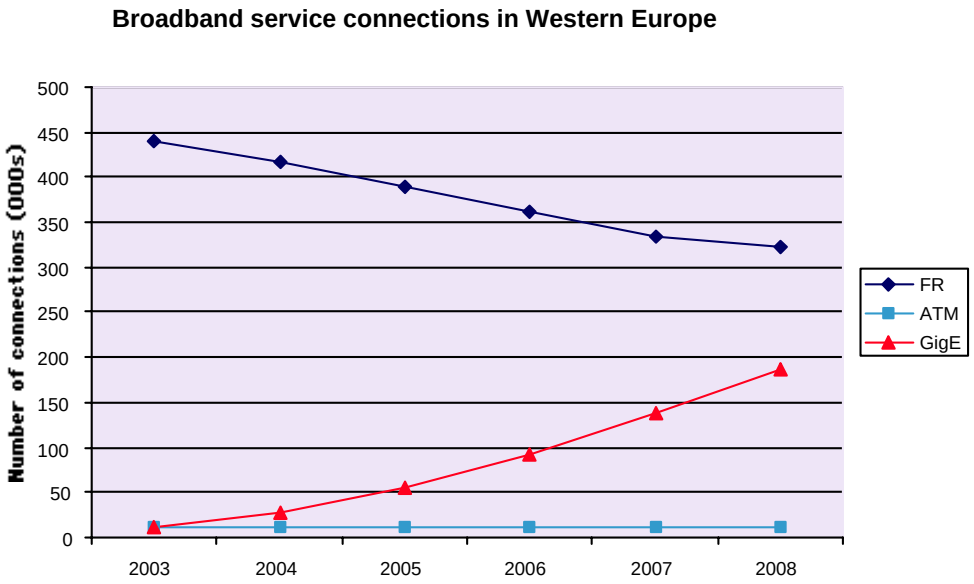


Source: Ovum

Although Frame Relay and ATM services will continue to be major revenue earners for the carriers they will decline in use as Ethernet services become established in the market. Given that Ethernet services cover the entire speed range of the existing services users will take advantage of them to rationalise their WANs onto a common platform. The UK has established an early lead in Ethernet services mainly due to the emergence of a buoyant competitive carrier market .

For comparison, the corresponding Ovum forecasts for Western Europe over the same period are noted in Figure 6.2 below.

Figure 6.2 Broadband services in Western Europe



Source: Ovum

A significant number of users will retain Frame and ATM services for long periods, as has been the case with X.25. A number of factors will shape this, mainly legacy requirements, the use of long-term contracts by service providers with consequent lock-in and a fall in prices as incumbent operators attempt to derive the most revenue from remaining inventory and network infrastructure.

7. Company profiles

7.1 Summary of findings

We interviewed several large companies, that are Ethernet users, about their networks and experiences with the service. Common themes among the interviewees are:

- a growing demand for network capacity driven by the increasing sophistication of desktop applications and use of web technology
- increasing storage volumes and the need to plan for continuous availability of business-critical data
- network rationalisation and consolidation either to improve data handling or to integrate business acquisitions
- deployment of new applications, including multimedia, where bandwidth flexibility and the almost "pay as you go" nature of Ethernet is a key enabler.

Conventional high bandwidth network services are proving increasingly costly and inflexible in meeting many of the application demands. The users we interviewed found that the cost of an Ethernet solution is significantly lower and gives them a bandwidth overhead they can use as a "safety margin" or to enable new applications.

Our profiles include a major financial institution and a professional services company – customers for whom a reliable network is essential and who, for that reason, are usually very conservative in the adoption of new technology. Most had some concerns about moving away from a classical leased circuit or ATM network to Ethernet. Their experiences have, however, been very positive.

The initial price/performance of Ethernet in these companies has been so good that Ethernet solutions are being considered for broader deployment. As access circuits become available there will be further migration away from low speed leased circuits and frame relay towards Ethernet.

7.2 Company A

Company A's business

Company A is a major financial institution with offices and customer-facing branches in the UK. It also has some overseas operations. It transacts business in and between its offices, and also via the Internet.

Network implementation

The company operates two major data centres. It buys bandwidth capacity services at various speeds from a number of suppliers, including Fibernet. Gigabit Ethernet is currently used for storage through Fibre Channel over IP (FCIP). This service connects Cisco MDS storage switches at the data centres in support of EMC disk, performing adaptive copying.

The company's core network runs over STM-4 links (622Mbit/s). There are additional regional concentration nodes at the company's major office locations. These connect to the core network at typically 45 Mbit/s or 155 Mbit/s. The branches are connected to the regional concentration nodes via 2 Mbit/s circuits typically running at fractional rates of 128 kbit/s to 512 kbit/s, with BT providing aggregation of service to present all circuits at 2 Mbit/s to the regional centres. The company runs its own ATM/Frame Relay network on top of these leased lines, it owns and operates the multi-service switch platform.

The company makes some use of dark fibre, most of which pre-dates WDM i.e. when optical multiplexing techniques were not available. Much of this dark fibre operates over short distances, for example in London.

SLAs and network resilience

The capacity services and leased lines have a service level agreement requiring problems to be fixed within four hours. There is built-in route diversification and duplication, and where possible a single source of supplier is avoided. With a few exceptions, no building at the national or regional level has a single network supplier. At the local level, only BT has the geographic coverage to provide access tails into branch offices.

Company A is considering a change in network deployment policy away from building its own highly managed Layer 2 infrastructure and towards the use of a service approach but excluding outsourcing. Service providers being considered for the network, including Gigabit Ethernet, will need to provide evidence of:

- Security of the solution
- Availability of the network
- Diverse routing

- Coverage from dual suppliers

Company A expects a considerable amount of detail to be provided by its suppliers including route maps to demonstrate diversity in the network.

Age of network, lease lifetimes and comparable services

The company is planning a gradual phase out of its ATM network and alternative approaches are under review. The current STM-4 network is expected to last about another two years in capacity terms. At the start of 2004, the price of a Gigabit service was roughly equivalent to a STM-4 circuit offering 622 Mbit/s capacity. Now that prices have converged the major issue is becoming the migration of applications and legacy network components onto Gigabit Ethernet connections.

Many network bandwidth contracts have historically been 3-5 years, although there are strong moves to reduce these terms. Many of the five-year deals were competitive at the time, but no longer are. The company would like to move to rolling one-year contracts, although two-year contracts are recognised as being more likely.

Network requirements

There are many factors driving the need for revised high bandwidth services.

Data replication and storage

The company uses significant data storage services, typically EMC Symmetrix Remote Data Facility that provides data mobility and replication. There is increasing demand for storage replication over large distances for which extended channels of interconnect are required over fibre links.

The goal, nationally, is to move to two main data centres. Dark fibre is an option for interconnection but the cost of this would depend on the distances involved. Options are being considered - the company already duplicates data between its main data centres in the UK. For example it operates multiple large databases at its main data centres and typically it can take up to four hours to recover service and data from one data centre to the other. The company is using Fibre Channel over IP (FCIP) over Gigabit Ethernet. In the longer term, there is the possibility of building a 3rd Data Centre closer to one of the existing Data Centres to reduce the recovery times and ease costs. There is also an option to back up to a data centre in another country. This would require significant data replication and long-distance high-speed Layer 2 services.

Layer 2 services

When Company A reviews the cost of bought-in Layer 2 services, it has nearly always found its in-house solution to be cheaper, and has kept to this strategy. The company has compared Gigabit Ethernet services with competing 622 Mbit/s ATM services and decision criteria will include not only price, but also resilience and availability. The use of alternative approaches may provide an opportunity to remove the provision of

dedicated switches to provide ATM/Frame Relay services but this is dependent on a move to an IP only network. This however will require a significant amount of effort to manage the legacy services in the short-term.

There is in general a strong move to reduce the technology platform count. However the company favours the multiple sourcing of both hardware platforms and networking services. So although they have significant Cisco hardware equipment, other suppliers are important too. This means maintaining a level of expertise within the company to manage a multi-vendor network, despite pressures to reduce head-count.

Managed services Layer 3 and gigabit Ethernet services

One reason for operating its own Layer 2 network is that managed Layer 3 services such as IP VPNs are viewed with some scepticism. There is a strong perceived risk of the lack of control within and over Layer 3 services and a mistrust of security capability in those services. Strong support remains to run end-end services in-house.

For this reason, the company is currently rather cautious about Gigabit Ethernet: it does not wish to be an early adopter in the industry, it is content to be a technology follower. However, the company does not believe that there are any missing features from current Gigabit Ethernet that could fall into the category of "showstoppers" for future extended deployment.

Legacy and Applications requirements

The company has significant legacy to remove from its network. There is a great deal to do internally with regard to application support and legacy services. Overall, the amount of 3270 terminal traffic is declining in the core and the amount of browser based traffic is growing although much of this traffic is encapsulate within IP over the Wide Area. Network bandwidth has doubled over the past 2-3 years driven by changes in traffic mix within the network and applications' growth.

IP telephony is currently under review. Issues under consideration include the migration to IP Telephony of voice services currently delivered via both Centrex and its own layer 2 network because of the high legacy cost.

The major barrier to more use of Ethernet in voice networking is now incompatibility with the voice switches. Essentially, none of the circuit switches has a direct Ethernet interface so IP routing over Ethernet is needed to support them – unfortunately this sacrifices the simplicity of the Layer 2 solution.

Ethernet will be deployed to all branches within the next few years. A telephony solution is needed to support branch networking – so purchasing decisions on Ethernet will be related to general IP telephony development within the bank. There are 2,000 branches to consider to it's no simple task to change.

Browser based applications

Growth in branch traffic is driven by changes in people's banking habits. People tend to use their banks more to buy services than to carry out financial transactions. This means that information on services must be available quickly and in an attractive format – a major driver for web based interfaces.

The move towards browser-based applications is another significant driver for bandwidth. Software development cycles are significantly faster using browser-based platforms than the more traditional dumb-terminal approach. The penalty of this is that network capacity is being consumed at a much faster rate because of the relative data-bloat of the application. Despite a recent move from multiple 2-Mbit/s links to 45 Mbit/s, some regional 45 Mbit/s lines are being filled within 10-12 months from introduction. This problem will only get worse because there is a strong move to unified branch-based applications with customer-based Internet banking applications in terms of graphical user interface design and overall application functionality.

Benefits

Alternative service approaches such as the use of Gigabit Ethernet have proved their value where deployed so far. Opportunities for new approaches to bandwidth provision are based around flexibility and network simplification possibilities as well as the desire to reduce costs.

Company A represents to some degree a common healthy scepticism of the claims of alternative operators, a challenge that Gigabit Ethernet oriented service providers need to step up to.

7.3 Professional service company

Business

The professional service company (PSC) is a global accountancy and management consultancy organisation. It is based in London, where there are approximately 5,000 staff. The company obtained revenues of £1.2 billion in 2003. Audit, tax and consultancy work each contributed approximately 27% of earnings with the remainder coming from corporate finance advice in areas such as mergers and acquisitions.

Network infrastructure

PSC has two data centres in central London that form the focus for networking to eight regional sites across the UK. The furthest site from London is in Aberdeen. The data centres utilise SAN technology for synchronous backup to maintain duplicate copies of information used within those sites and by hosted applications used at the regional offices.

The company built its original data network using a mix of technologies. The regional network was mainly constructed from BT's SMDS service. Fibernet's LAN Extension service was used in London for data centre networking. Each SMDS connection provided 4 Mbit/s capacity – a limit that was increasingly stretched as the company's applications grew. Further impetus for change arose through a business acquisition which introduced new LANs to be integrated with the existing WAN solution.

Before implementing a new network PSC carried out extensive analysis of application traffic. It has installed probes at the data centres and each regional office which enable it to track traffic on an application basis. These have pinpointed that there are approximately 100 applications running today of which the most significant in terms of network traffic is email - contributing 40% of total traffic. Each regional office has a Windows 2000 server implementation dual homed to Exchange servers in each of the data centres.

Demand for higher network capacity is coming from the continued growth of email, deployment of new applications and also from a general trend towards increasing use of web technology. Many of the company's applications are moving to browser based interfaces. This increases traffic loading because of the introduction of rich media within the user interface.

Network implementation

PSC's new network uses Ethernet services from Fibernet at every site. An ATM network has been retained in parallel as before – primarily for data centre networking. Fibernet was selected as the Ethernet service provider because of the service proposition and its sound track record in providing services.

Fibernet provides point to point Ethernet connectivity from each regional office to each data centre. LES 100 access services are used wherever fibre is not directly connected to the nearest Fibernet PoP. The new Ethernet network delivers approximately 75% more bandwidth for only a marginal price increase over the former SMDS installation.

Connections to the regional offices are currently operating at 10 Mbit/s with each regional office on its own VLAN. Since each site has a link to each data centre and its own VLAN a single fibre loss has no impact on the network performance seen by other users.

It is of growing importance for PSC to have a resilient network as a part of its business continuity planning. One option that was considered prior to selecting Ethernet was to expand the use of ATM by introducing a second, backup, network of ATM PVCs from a single supplier. However, when this was costed, introducing an entirely new Ethernet infrastructure was only marginally more expensive. Adopting Ethernet has not only brought benefits of flexibility but it has also enabled a more secure dual supplier, dual technology approach to be adopted.

Links to the regions are currently carrying 4-5 Mbit/s of traffic so the current bandwidth cap at 10 Mbit/s provides a good overhead for traffic. Traffic patterns are expected to change as PSC removes some applications running on legacy protocols (eg IPX) and introduces new applications such as SAP. Ethernet gives the flexibility to cope with the expected higher demands of the new applications.

The network goal is to operate an exclusively IP over Ethernet infrastructure offering tiered QoS to applications. The QoS support will be implemented at Layer 3 and once available the company will investigate the potential of TV distribution, multicasting and other multimedia services for applications such as training. There are no plans for a large move to VoIP at present due to the significant life left in the current PBX. However, some VoIP deployments may be made at smaller sites where there is a clear cost justification.

The company has found few limitations within Ethernet and where network issues were identified workarounds have been put in place. The issues that have been found mainly concern service management – an area of focus in the current development of Ethernet standards.

Benefits

PSC found that the Ethernet solution brought a range of benefits:

- Cost savings - the overall cost of network connections is less. Adopting Ethernet also enabled savings through use of cheaper router interfaces and by reducing the physical space requirement for equipment
- Flexibility – the service is easier to reconfigure being based on the industry standard Ethernet protocol

- Future proofing – Ethernet offers a capacity overhead that can be called up as the applications used in the network require more bandwidth. The allowed throughput on each 100 Mbit/s access can easily be increased up to the access capacity limit
- Service provider approach - Fibernet is a relatively small carrier and is much more flexible than a larger company. It is also a long established alternative carrier making it credible as an alternative supplier.