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Data Networks Integration

This paper discusses the role of data networks integration on an asynchronous transfer mode (ATM) core and compares the advantages achieved by the usage of ATM with those given by emerging technologies such Internet protocol (IP) over synchronous digital hierarchy (SDH) (giga-routers).

Data Networks Integration

A few years ago, most public network operators (PNOs) were confronted, for historical reasons, with many separated networks (voice, X.25, FR, IP, GSM, LL,etc.). Deregulation dramatically changed this situation: competition caused deep rationalisation processes aimed at cost efficiency, standard solutions and service excellence. At the same time, the push also came from the emergence of asynchronous transfer mode (ATM)—a standard technology designed to integrate the legacy networks.

ATM allows, by the integration of existing networks on an ATM core, economies of scale and economy of scope. A certain critical size, beyond which the cost/benefit ratio leads to profitable growth, must be achieved for any service to be successful. It is also important to integrate multiple services on to common networks and to provide a smooth evolution path for the customers.

This led to a vision in which multiple network technologies must co-exist, which implies that certain issues are very important:

- support for multiple service functionality on the network equipment;
- network-level interworking to interconnect customer sites having a mix of interfaces (frame relay, ATM, IP, etc.); and
- service interworking.

Today, the situation has changed again, mainly because of the evolution of the traffic pattern—ever more IP. Today's networking environment is becoming increasingly driven by Internet and intranet services: Internet doubles every six months and the old 80/20 rule, which stated (in former LAN and campus networks) that only 20 per cent of network traffic went over the backbone, has been scrapped. This results from the combination of intranet traffic and the increasing use of multicast applications.

As the telecommunications companies move up the Internet value chain by providing ATM-based IP backbones and speed up the access, perhaps using xDSL, the Internet service provider (ISP) role may in future be taken over by the telco—thus generating more IP traffic.

Mainstream data network services are fundamentally driven by the market and applications, not technology. It is now more than likely that IP will be the best service for use by end-system applications, while ATM will (currently) be provided as the underlying transport for it.

The same economical considerations that led us to integration a few years ago when ATM was considered as the ideal federating technology will now lead, due to this new imbalance, to a disintegration: separate networks again. One network would be optimised for IP transport and the other one would still be an ATM network, integrating all non-IP networks. Both could run on the same physical network.

Integration Benefits

The integration benefits include:

- reduction of transmission costs (suppression of redundant leased lines, better utilisation of backbone capacity),
- reduction of switching costs (reutilisation of existing switches, less ports wasted on the switches),
- savings on exploitation costs (scale savings, less equipment to manage, easier to upgrade, reduced stocks, etc.),
- shorter cycle time for provisioning and roll-out of new services,
- network management enhancements (networks are managed on the same platforms, allowing easier configuration and fault detection),
- performance/quality enhancements (switching hops saved—ATM is faster and more reliable),
- ATM quality of service (QoS) differentiation, and
- optimise assets utilisation.

Integrating the data networks and providing service interworking also allows a smooth evolution path to the customers between the different data protocols. A customer can mix the different technologies (ATM, FR, X.25) and interconnect them on the same network, and thus have coexisting ATM, FR, IP and X.25 sites. This allows the operator to offer a full range of differentiated services.

If we consider that 95 per cent of the traffic carried over the data network is IPv4 traffic, efficient transport of IP is one of the most important decision factors. The next section compares the several IP over ATM models with the IP over SDH technology.

IP over ATM

Strenuous efforts were made to map the fundamentally incompatible IPv4 on to ATM. The main problems that are encountered when transporting (TCP/)IP over ATM are:

- The inadequacy of TCP for ATM transport (window management, efficiency, sequence number wrap, MTU, etc.).
- The huge gap between ATM throughput and IP goodput.

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- How does the IP service model, with certain service classes and associated styles of traffic and QoS characterisation, map on to the ATM service model?
- How does the IP reservation model (whatever it turns out to be) map onto ATM signalling (especially when dealing with hybrid networks) and how is the address problem resolved?
- How does IP over ATM routing (QoS routing, broadcast and multicast routing, mobile routing) work when service quality is added to the picture? (ATM computes a route or path at connection setup time and leaves the path in place until the connection is terminated or there is a failure in the path.)

Edge routing over the ATM backbone

This approach to internetworking partly alleviates the performance bottleneck of router-based networks by equipping conventional routers with a fully configured set of ATM network links. But it is clear that as the number of locations and routers increase, the cost of maintaining the fully-provisioned mesh of virtual channels becomes costly as well as complicated to manage. Furthermore, ATM QoS capabilities are not utilised if the edge routers continue to treat ATM as just another highpeed link.

Classical IP over ATM

Classical IP over ATM is an approach that uses the power of ATM to forward IP traffic. It is used to connect subnets or workgroups that use only IP as the transport protocol. As in edge routing over ATM, QoS capabilities of ATM are ignored. It is possible to have multiple subnets on the same network, but at present each subnet must operate independently of the others and routers are required to provide communications between subnets. In complex environments, with multiple subnets, the router latency continues to be an issue.

LAN emulation (LANE)

LANE is used as a service that emulates the services of existing LANs across an ATM-network running the LANE protocol; that is, the shared medium of a traditional LAN has been replaced by an ATM network. In fact, it is a way of mapping the connectionless LAN service to the connection-oriented ATM service. Due to this mapping based on OSI-layer 2 with MAC-to ATM-address resolution (this address resolution is done by the LAN emulation server (LES)), all ATM attributes will be hidden by the LANE protocol for the LANE users, with its most important impact that the quality of service offered by ATM cannot be accessed by the LANE user (Figure 1).

Depending on the implementation in equipment, LANE will support the Ethernet, IEEE 802.3 and IEEE 802.5 standards and higher layer protocols as IP, IPX, etc.

The broadcast and unknown server (BUS) handles all broadcast and multicast traffic. Moreover, data traffic, whose destination (ATM-address) is unknown until address resolution is performed and a data direct connection is set-up to another LAN emulation client (LEC) is also handled by the BUS.

Enhancement of LANE service will provide new features as ATM QoS support, enhanced multicast, MPOA support, LANE NNI (LNNI), multiple and redundant server elements per ELAN, LLC multiplexing for VCC sharing.

Because LANE service requires the ATM-Forum ATM-transfer capability unspecified bit rate (UBR) the equipment used produces bursty output at link rate. Due to this fact shaping of the bursty ATM-traffic **must** be applied before the traffic can be transferred over an ATM-network using the VP-bearer service.

Figure 1—LAN emulation

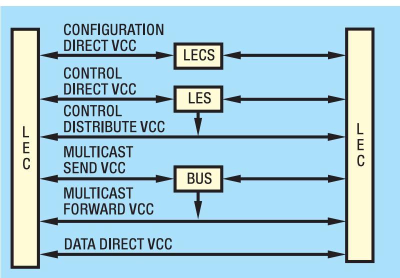
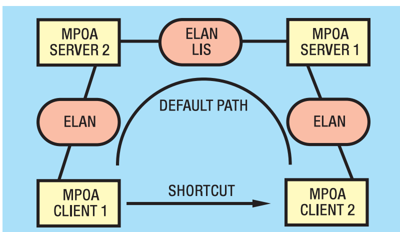


Figure 2—The MPOA model



MPOA

The MPOA model distributes routing among edge devices and ATM attached hosts with MPOA clients, that forward packets, and MPOA servers, which supply routing information. MPC's examine the destination address of packets received on legacy LAN segments in order to make the correct forwarding decision. If the packet is to be routed, it will contain the destination MAC address of the MPOA router interface. If so, the MPC will look at the destination network layer address of the packet, and resolve this to the correct ATM address based on information received from the MPOA server or use information in its cache. The MPC will then establish a direct virtual channel connection to the appropriate destination.

If the packet is destined to a host in the same subnet so that it can be bridged, the MPC will use LANE to resolve the ATM address and establish a virtual-channel connection to the destination.

If the local MPOA server does not know the appropriate ATM address, it can propagate the query to other MPOA servers or routers using next-hop routing protocol (NHRP) functionality. The destination ATM address from the MPOA server can be the address of the host (if the host is ATM-attached), or the address of the appropriate edge device to which the packets should be forwarded.

IP over SDH

Routed networks topologies evolved during the last 20 years using emerging technologies in order to enhance the cost, the management and the scalability of the networks.

The growth of the Internet and intranet (IP) traffic is seen today as the driving force for the deployment of data networks. The technologies built around IP will evolve in order to accommodate several requirements like low latency, quality of service, dynamic bandwidth, etc. However today there already is a strong pressure towards more bandwidth. In this regard, SDH is an excellent medium; it is reliable and widely implemented in large telecommunications infrastructures.

Until recently, ATM appeared to be the only viable method of aggregating voice, video and data traffic on high-speed networks. In this concep-

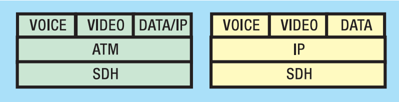


Figure 3—Paradigm shift between an ATM platform to an IP platform

tion ATM is a platform for all services. In Figure 3, we compare the ATM concept to the situation where IP plays the central role. These new approaches, called *packets over SDH*, lead to new backbone architectures that preserve investments made in SDH and rely entirely on IP. The shift to IP instead of ATM is also observed in the LAN environment (gigabit Ethernet has been optimised for IP traffic).

Running IP on top of SDH eliminates the overhead needed to run IP over ATM. The issue is important because half of the packets on the Internet are around 60 bytes long. Moreover, several techniques are under development to provide QoS at the IP level; ATM QoS would not be further needed, which would solve the problem of mapping layered QoS into each other.

As data traffic continues to increase, SDH will carry more and more data packets. This event has impacted the existing SDH infrastructure in some countries. SDH transport backbones are being stressed by the exponential growth of Internet more than by any other information source. It is expected that the platform of choice for IP will maintain low latency and resilience of SDH, and add dynamic throughput as well as performance based on differentiated quality of service in the network

Comparison

See Table 1 for a comparsion of gigabit Ethernet, ATM and IP over ATM.

QoS evolution?

- Efforts like QoS routing and RSVP really do pay off, and therefore ATM loses any of its advantages over packet-switched schemes, or
- RSVP does not work out as hoped, and ATM's circuit-based nature is an asset. In this latter case, if the drops to end users are on over-provisioned Ethernets, then you will probably have enough excess bandwidth to pretend you have QoS delivery.

ATM in LANs?

The cost and complexity of ATM to the desktop and the few rewards for the majority of users (due to lack of applications, drivers, spotty deployment, etc) made it a flop.

Conclusion IP/ATM

Finally, IP over SDH enables high-speed, packet-oriented, low-cost (lower level of services and functionality), IP-optimised WAN connections without the need to assemble/disassemble packets into cells for transmission over the WAN. The capabilities of Ethernet are increasing towards the current capabilities of ATM while preserving the compatibility with the installed LAN nodes (80 per cent of which are Ethernet) and installed protocols (which all operate over Ethernet).

Table 1 Comparison

	Gigabit Ethernet	**ATM**
Bandwidth	Low cost	Moderate cost
QoS	Class of service (CoS) with 802.1Q, RSVP	Guaranteed QoS
Service integration	High-speed data, potential for voice/video over IP	Data, video, voice
	Gigabit Ethernet	**IP over ATM**
LAN protocols	Yes: leverage installed base of Ethernet, fast Ethernet, and LAN protocols	Yes, with LANE and MPOA
Scalability	Yes	Yes, with LANE and MPOA
QoS	Emerging—MPLS	No direct mapping
WAN	Emerging	Yes

ATM provides voice, data, and video integration, while gigabit Ethernet delivers high-speed data. Voice and video capabilities over gigabit Ethernet will depend on the success of video and voice over IP. Note that there is an application overlap between Gigabit Ethernet and ATM. Both will be used for backbone, server, and building riser applications. However, today (as no QoS enforcement is possible on a gigarouter based network until the arrival of MPLS) only ATM can today provide WAN services in situations where bandwidth is still a scarce resource.

In the future, both networks are likely to coexist—an integrated ATM network and an IP-optimised gigarouter-based network.

X.25/FR Integration

X.25

X.25 is an internationally accepted ITU-T standard that defines a communication protocol between data-terminal devices and packet-switched data networks. The X.25 protocol facilitates the interworking of packet-switched data services across geographically dispersed public and private networks.

X.25 is a virtual call service that allows network users to set up calls using standard X.121 and E.164 addresses. The network establishes calls over virtual circuits, which are logical connections between the originating and the destination addresses. Through the use of statistical multiplexing methods, X.25 can support multiple virtual circuits over a single physical circuit, thus providing port sharing and dynamic bandwidth allocation.

The X.25 protocol implements various error correction and flow control mechanisms to ensure the reliable transfer of data across the network. Call-subscription options and facilities allow network users to individually customise their service based on application requirements.

Reasons for integration

Frame relay and ATM are technologies optimised for transferring data over high-quality transmission facilities.

While such facilities exist in certain parts of the world, many countries lack the network infrastructure required to support these newer technologies. In these regions, data communications systems using X.25 are required. International business networks that span the globe need a combination of all of the above communications technologies to meet their requirements. Currently, typical X.25 access is low speed, within the 9·6–64 kbit/s range.

As X.25 subscribers require greater access speeds and demand newer technologies such as frame relay, existing network infrastructures are unable to handle the added capacity requirements. The integration with frame relay allows the provision of a smooth migration path from X.25 to FR. Some customer sites can continue working on X.25 while some others, requiring more bandwidth, are migrating to FR.

Finally, the integration of the X.25 and FR/ATM networks allows the reduction of transmission costs by multiplexing the traffic between X.25 switches on the existing FR/ATM trunks.

Methods of integration

There are two main methods to carry X.25 traffic over a frame relay network.

The X.25 encapsulation can be done according to the following standards:

- ANSI T1.617a Annex G—Encapsulation of ITU-T X.25/X.75 over FR. Annex G encapsulation provides a means of encapsulating LAPB frames using a 2-byte header. Because of the low overhead, this is the preferred encapsulation method.
- RFC 1490 or ANSI T1.617a Annex F—Multiprotocol encapsulation over FR. RFC 1490 defines a multi-protocol encapsulation method for carrying network interconnect traffic over a FR backbone.

All frames contain information necessary to identify the protocol carried within the information field of the frame.

This method adds an 8-byte multiprotocol header in order to identify the LAPB frame.

Because of the higher overhead, this encapsulation method tends to be less used by the equipment manufacturers.

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