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ATM: THE NEXT STEPS

ATM-based WAN services for data applications are commercially available today. The evolution keeps on going towards a universal broadband network for all type of services (B-ISDN). With the implementation of switched connections using signaling, ATM is suitable and very flexible for voice, data and video communication in all network areas (LAN, MAN, WAN). As an illustration, the article gives an example of a possible migration to ATM in the LAN environment and reflects the usage of ATM for voice communication.

The ATM technology has proven its functionality in several trials like the Euro ATM Pilot. As a consequence, ATM-based services are now commercially available in many countries.

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These services offer a wide range of possibilities in the WAN environment. Yet, the evolution keeps on going towards a universal broadband network which covers the whole range of services and networks (B-ISDN). What this vision transforms to reality are the implementation of switched connections using signaling capabilities and the support of voice and multimedia services.

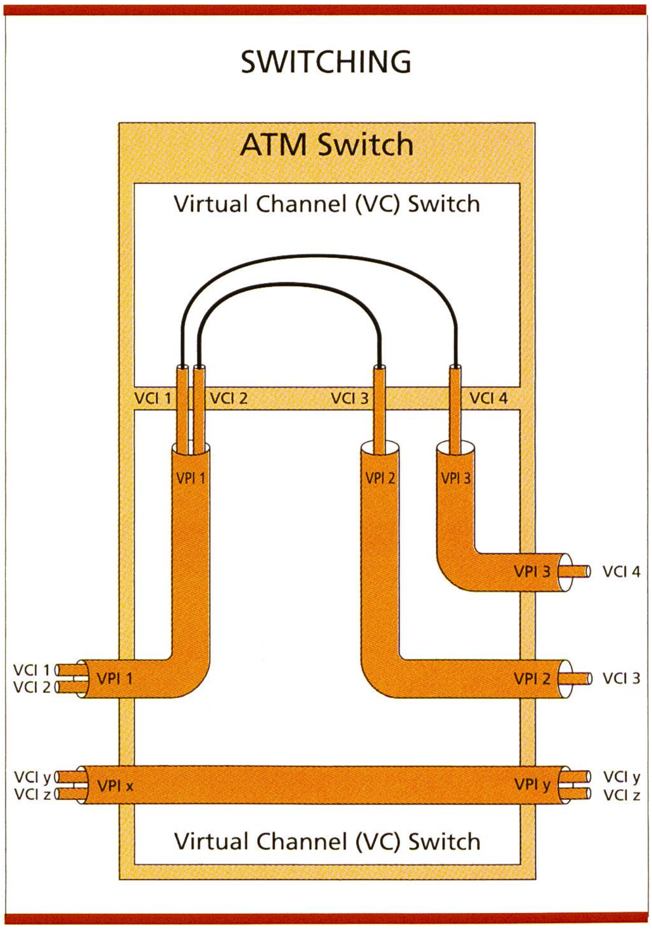

Fig. 1. ATM VP/VC switching.

VC switching

In the ATM technology, a source of information uses a virtual channel (VC), in which all cells related to this session use the same VCI and VPI values in the cell header *(Fig. 1)*.

In today's ATM services no single virtual channels are offered; therefore, complete virtual paths (VPs) have to be switched in the ATM switching element. Despite the fact that most cross-connect systems could handle single VCs, since connections are set up by management, it would be too complicated to do it. With the introduction of signaling, ATM providers are now able to offer optimized switched ATM services to the customers, based on VC switching in pre-established VPs.

Signaling

In any telecommunications system or network, three technologies are necessary:

- transmission: physical or virtual path through the network that supports conversations (sessions) between users (end systems)

capability set	NNI (B-ISUP)	UNI (DSS2)
CS-1	among others: point to point single connection bearer services supplementary services interworking with N-ISDN for circuit mode transport of N-ISDN functions	among others: bearer services supplementary services
CS-2, step 1	point to multipoint, single connection point to point, multiconnection edge-to-edge capabilities (look ahead)	metasignaling protocol negotiation/modification point to multipoint, single connection point to point, multiconnection
CS-2, Step 2, and CS-3	support of frame relay, VBR, semipermanent connections multimedia distributive services (broadcast) control functions	frame relay point to multipoint, multiple connections generic functional protocol distributive services

Table 1. B-ISDN capability sets. CS-1 has already been approved by ITU-T. CS-2, step 1, is planned for approval on February 1996.

- switching: process of establishing connections between end points of a system or network on either permanent or temporary basis for the purpose of transferring information
- signaling: mechanism that allows network entities (customer premises or network switches) to establish, maintain, and terminate sessions in network. In broadband networks, SDH is used for transmission, ATM for switching, and B-ISUP/DSS2 for signaling.

The implementation of ATM switching (switched virtual channels, SVCs) and signaling capabilities (B-ISDN) allows that the customer as the user of the service can set up calls from the terminal equipment by himself. Using access signaling offers an improved flexibility in terms of changing parameters like bandwidth or quality of service.
In addition, signaling supports the possibility of multiconnections and point-to-multipoint connections. In B-ISDN, bearer and supplementary services will be offered similar to N-ISDN. In contrast, in B-ISDN it is possible to establish and terminate different connections within a single call with different profiles.
ITU-T has been standardizing the B-ISDN signaling in different steps, called capability sets *(Table 1)*.

Network evolution

In a universal network, three types of traffic occur:
- voice
- data
- video

These traffic types have different characteristics in terms of timing relationship between source and destination and their need of supporting either constant bit rate (CBR) or variable bit rate (VBR). Furthermore, sessions can be connection-oriented or connectionless.
Voice, data and video are found in different environments:
- local area networks (LAN)
- metropolitan area networks (MAN)
- wide area networks (WAN)

What makes ATM appealing is the fact that this switching technology can be used not only in all three network areas (LAN, MAN, WAN), but also for all mentioned types of traffic!

ATM in local area networking

Personal computers in today's LANs are connected in most cases to an Ethernet or Token Ring system. All devices share the available 4, 10 or 16 Mbit/s of bandwidth. While the number of single entities increases, a single network may not be sufficient. Segmentation via bridges and routers will be introduced as a first step to

avoid decrease of performance. Indeed, a lot of traffic between segments will remain with this solution. A next step could be the implementation of a LAN backbone. FDDI (100 Mbit/s) or Ethernet switching have become very popular in this area, as they offer a real perceived performance.
The use of ATM in the backbone can be an alternative to this approach, considering these aspects *(Fig. 2)*:

- ATM speeds will operate at up to 1.2 Gbit/s and higher.
- The configuration will allow that each LAN segment has its own high-speed connection to every other LAN segment (no transit).

Using ATM in the backbone and considering the vast potential of B-ISDN signaling, ATM access directly to the desktop station can be taken into account. A lot of major advantages could be achieved:

- Each device has its own dedicated bandwidth to its destination.
- The information is packaged into cells at the desktop and can remain as cells to the ultimate destination, eliminating unproductive translations, since ATM is used end to end.
- Voice and video services can be added to the workstations, as ATM supports all these applications.
- As the public network (WAN) is also migrating to ATM, it does not matter whether the connection is local or wide area. The performance can be the same.

ATM for voice communication

For an optimized usage of network resources, having ATM in the WAN environment for data services like LAN interconnection and considering ATM as a universal bearer service for all kinds of communications, also voice connections can be mapped onto ATM.

Voice is very sensitive on timing relationship between source and destination; therefore, additional delays generated by the mapping of voice onto ATM cells and back are the critical issue. ITU-T has defined maximum values of acceptable delays. 25 ms are defined as one-way delay without any measures on echoes. For a telephone conversation up to 150 ms one-way delay is acceptable, if the echo is controlled, for example using echo cancellers. *Table 2* gives some characteristic values on processing delay. Considering voice over ATM, either single 64-kbit/s channels or complete 2-Mbit/s systems (PCM-30) can be mapped on ATM cells.

64-kbit/s emulation

In a pure ATM network, where no STM nodes are available to handle the 64-kbit/s traffic, single-voice channels have to be routed within the ATM network and therefore mapped individually. Voice can be handled in such a network, but care has to be taken on the overall delay, as one STM/ATM/STM conversion adds about 6.5 to 7 ms delay to the overall delay budget *(Fig. 3)*. This includes the packeting delay and some buffering for cell delay variation (jitter).
That value is still about ten times better than GSM air access, but regarding the maximum delay for voice in the PSTN (25 ms one way, end to end), only one single ATM subnetwork (island) within a connection is allowed. Otherwise, echo control equipment has to be used.

2-Mbit/s emulation

Mapping a full primary rate system (2-Mbit/s PCM 30), the basic trunk interface in today's digital exchanges, onto an ATM VC connection adds only very limited delay in the range of 0.5 ms. The contribution to the overall delay is of very little impact. Furthermore, the delay across an ATM switch

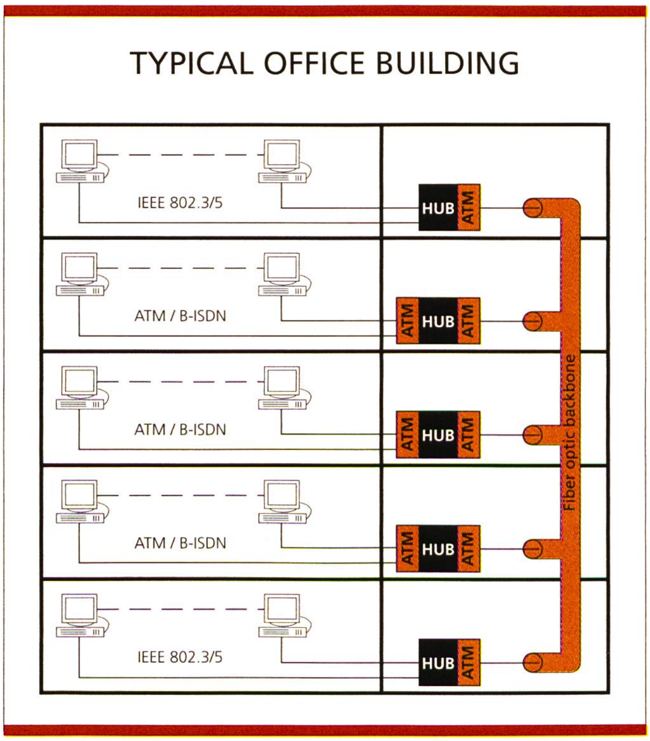

Fig. 2. ATM in local area networking.

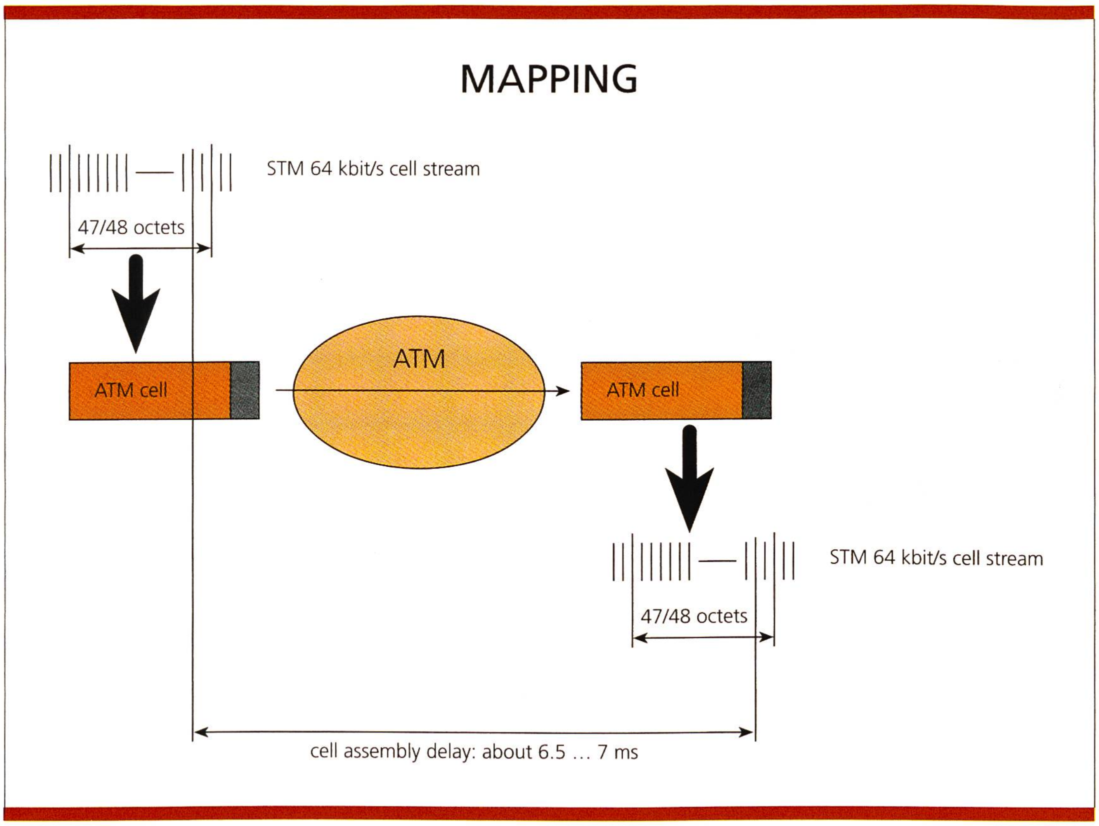

Fig. 3. Mapping of 64-kbit/s cell stream onto ATM.

or CC is usually lower than across an STM exchange (for example transit exchange).
The routing of a single 64-kbit/s channel is not possible in the ATM 2-Mbit/s emulation. Yet, in a normal ATM backbone network, only complete 2-Mbit/s systems are routed.

In summary, from a network point of view, ATM is suited for voice. The additional delay caused by the conversion to the ATM and back is of minor impact on 2-Mbit/s systems (0.5 ms) and can be accepted on 64-kbit/s channels (7 ms), if there is only one ATM island in a connection. Moreover, ATM offers significant potentials to voice services with various qualities of service, depending on applications or user requirements.

system	one-way delay
digital exchange, between 2-Mbit/s interfaces	0.450 ms
digital exchange, between analog-line interfaces	1.5 ms
DECT cordless telephone	10 ms
GSM access via air interface	90 ms
video Codec MPEG II	150 ms

Table 2. Characteristic values on processing delay.

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