Journal of ELECTRICAL ENGINEERING, VOL. 52, NO. 9-10, 2001, 323–328

REVIEWS - LETTERS - REPORTS

MULTIMEDIA BROADBAND NETWORKS

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This article gives a short view of possible implementation of ATM technology to higher level of existing PSTN network. This evolution goes to the model of one level universal access network with one type of switches and different node services with ATM transport layer. Universal telecommunication network includes PSTN/ISDN and other special networks for data services and multimedia applications.

K e y w o r d s: ATM technology, PSTN network

1 NETWORK ASPECTS

The most common strategy to introduce a new technology is the bottom-top approach. This means that the technology is first implemented at some local areas, and afterwards these local islands are interconnected. Normally this can be a very useful strategy, because of advantage that there is no big, "over-full" equipment necessary at the beginning. In the case of introducing ATM, things might be a little different. This is due to the facts that

- ATM is not a technically dedicated to a special service but a universal medium to transport very different data, ranging from voice over video to high-speed LAN-interconnection,
- Even the smallest ATM-hubs have a throughput of more than 1 Gbit/s, which is quite a lot for only local use.

2 TOP–DOWN APPROACH FOR INTRODUCING ATM

In the top-down approach, big cities or highly-industrialised areas are interconnected in a first step with ATM network. From the beginning on, this ATM-network could not be used for dedicated broadband-services via transmission, leased lines or existing data-networks. There are two main advantages of this strategy.

- ATM is available all across the country from the beginning on. In local areas, where a big amount of customers exist, a local access-network can be connected easily,
- There is no big capital spending necessary or even cost saving possible because the ATM-network can take over, at low costs, the growth in existing traffic and can be used instead of replacing obsolete conventional switches. Furthermore, there is another potential for cost saving because there is no more need for expensive transmission equipment like multiplexors and SDH-cross connects. Last but not least, the merging of different existing networks into one will result absolutely in lower running costs.

To implement an ATM-network as universal, the network has to have at its disposal some inter-working units and connectionless servers. At this point it is important to notice that there is no inter-working between different services. The IWUs and servers are only necessary to fit the different kinds of traffic to the requests resulting from using ATM. Another function of that IWU is the mapping of the different signalling systems used in N-ISDN and ATM. In this way the top-down approach could easily gather a lot of traffic, so that the starting capital investment should be redeemed very fast.

3 ATTRIBUTES OF THE EXISTING NETWORK STRUCTURE

The present networks were constructed on the base of the previous electromechanical switching technology and analogue transmission system. The environment was not enough adaptable to meet the customer requirements. Depending on the previous technological possibilities we have telephone network for mass communication with small areas and three or four network levels, small and high specialized data networks, leased lines and autonomous distributing networks for audio- and TV-programs. The required special technical solutions make it impossible to combine different services in common networks. First steps were done with common data networks before there were digital sources and switching and transmission methods. The next step is the present process of service integration, *eg* in the ISDN. The experience shows, that service integration with a consequent transposition can increase the network efficiency.

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ISSN 1335-3632

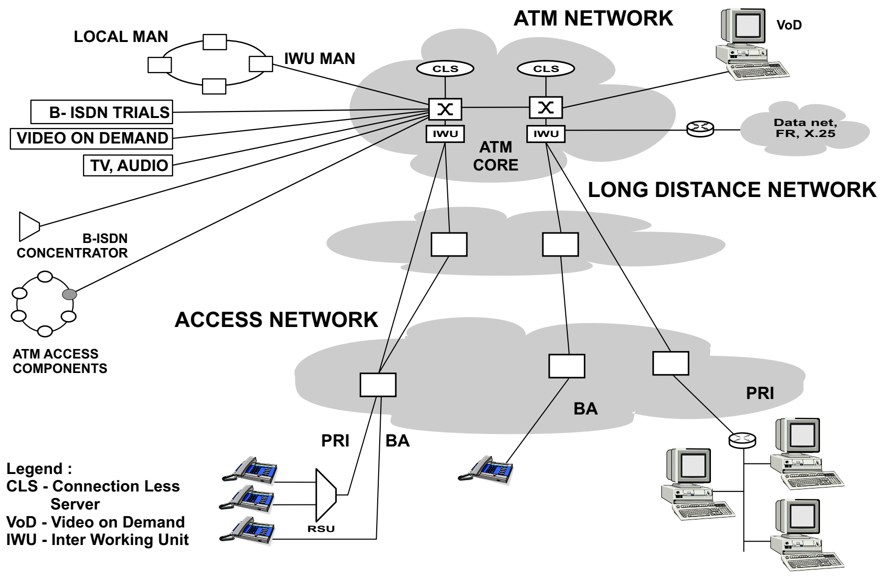

Fig. 1. First application

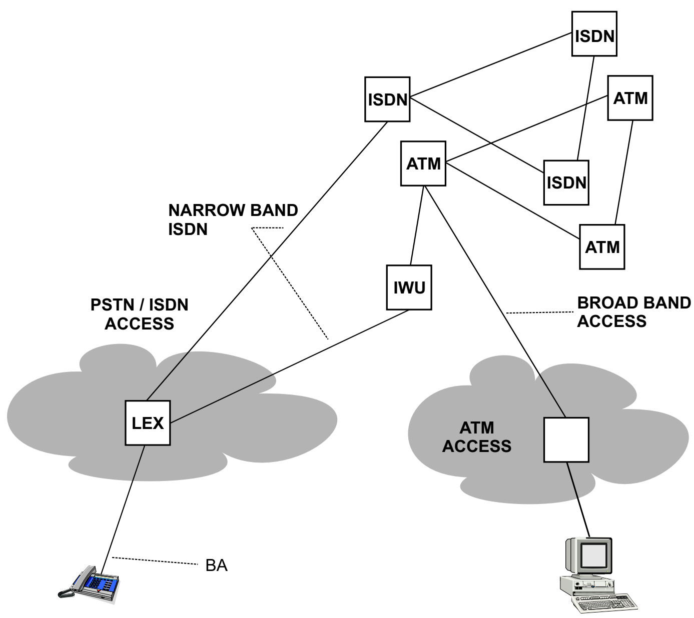

Fig. 2. Doubled Access Network

4 SELECTED NETWORK MODEL

Taking into account the existing influential magnitudes, there is developed a network model for the ATM transport platform, which is based very closely on the optimised network concept for the telephone network/ISDN. It is to be used in the first application of the ATM switching unit.

New routes will be operated as high-usage routes with overflow to the 2nd link to the long distance exchange. In the descending network section of the ATM switching unit, high-usage routes are only to be installed to the larger node exchanges of the long-distance exchange area. An internal bundle must be connected to a long-distance exchange switching unit of the same location for traffic to smaller node exchanges. The smaller node exchanges can then be reached via the outlet network of the long-distance trunk switching units.

The network model initially provides connection of only node exchanges with the currently running traffic to the ATM switching units via the high-usage routes, and to channel only some 10−20 % of the traffic through it. If positive results are achieved, the ATM network will be able to take on new sections of traffic, namely:

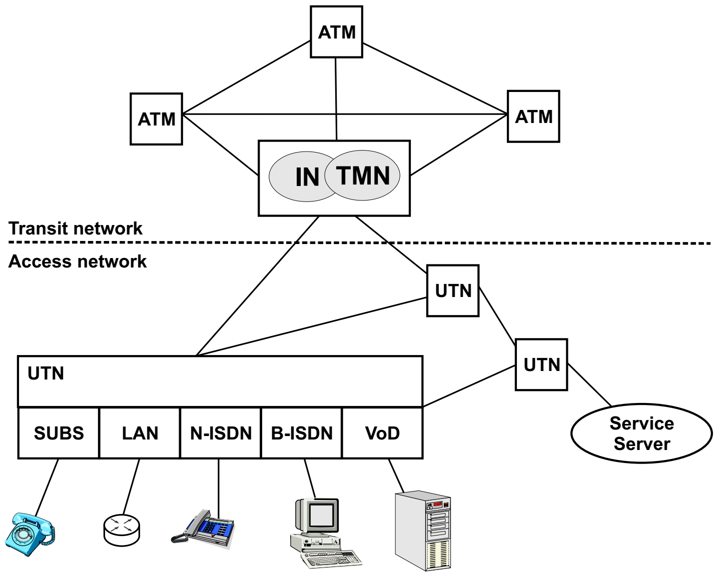

Fig. 3. Implementation of Universal Telecommunication Node

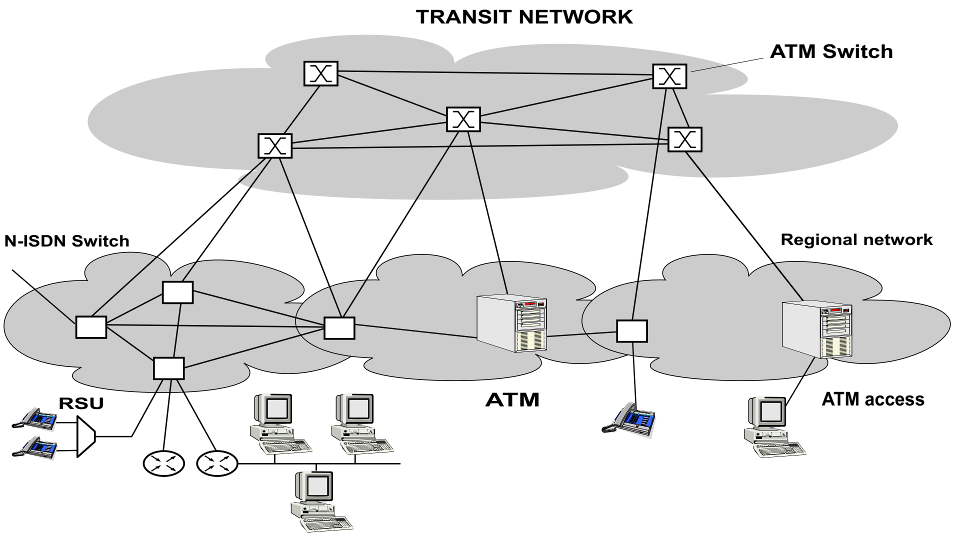

Fig. 4. Creation of regional overlapped networks

- Higher quality traffic (traffic to network gates, to IN facilities ...),
- Larger traffic parts (switching additional routes including from smaller node exchanges to the high-usage trunk exchanges to the ATM switching unit).

From this point in time onwards, the ATM transport platform will be introduced to cover demand in the telephone service/ISDN.

5 EVOLUTION STEPS

The described target network is not to realize it in one step. Carefully planned transition steps are necessary. The steps with their characteristic attempts are:

Step 1 :

At the locations of long distance exchanges new ATM-switches are added to generate universal telecommunication node. The ATM-switches have interfaces for broadband accesses from 2 Mbit/s to 155 Mbit/s and for SDH-links from 155 Mbit/s upwards. The connecting element to the existing telephone network is the special interworking unit (IWU). So the ATM-switch includes both functions:

- The function as a local switch for broadband services,
- The function as a transit switch for the PSTN/ISDN.

In this phase there is no change in the existing PSTN/ISDN. The ATM-switches are connected by SDH links not necessarily fully meshed, using the ATM routing capabilities. The access network is doubled in this phase.

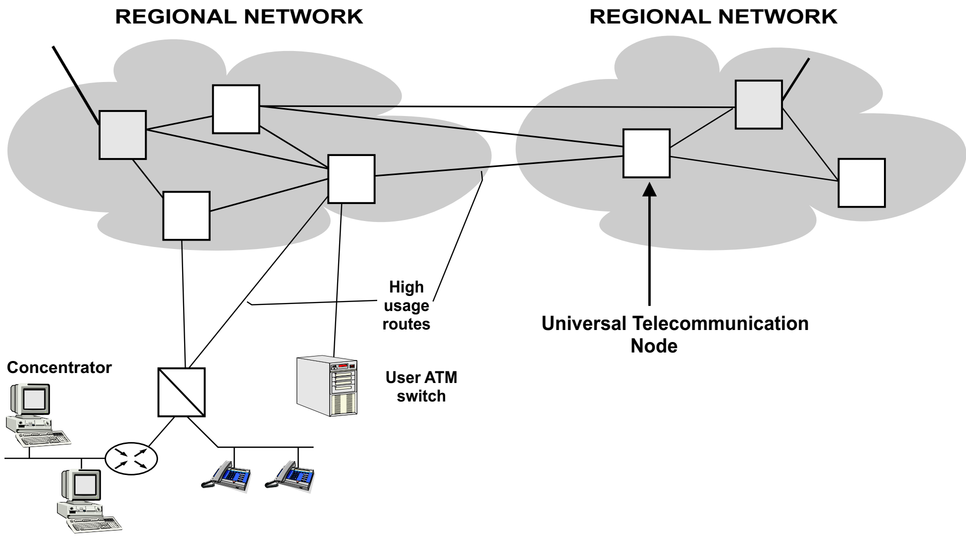

Fig. 5. One level universal network

The existing part for the PSTN connects telephone and ISDN accesses via copper cable to the concentrators or directly to telephone exchanges. Access with a bandwidth demand of 2 Mbit/s and more is connected by optical fibres to the ATM-switch. In the case of connecting some fibre accesses an optimal step in the access network by introduction optical fibre technology as an universal platform is possible.

Step 2 :

The next phase is identified by the integrated interworking between low bitrate applications up to 64 kbit/s and high bitrate applications from 2 Mbit/s upwards in the TM-switch. With this step the vision of a universal telecommunications node, realised in a single switching unit, is perfect. Such a universal switching unit is able to replace the existing digital switches for the PSTN/ISDN. Additional access networks are developed to a universal platform by introduction of universal collective points with ATM - interfaces to the universal telecommunication node.

The introduction of ATM-switches is not limited to the locations of long distance exchanges. So like in the telephone network — regional networks are built, connected to long distance exchanges with ATM transit function (Cross-Connectors). The structure of this network — direct high usage links or only last choice routes is a result of a further optimalization process.

Step 3 :

The essential of this step is the transition to the really universal network by:

- Surrounding access networks to a universal access platform for all services,
- Placement of ATM-switches in all access areas,
- Optimizing the transit network relating to structuring and dimensioning the logical routes and the transmission links.

In all phases reliability aspects have to be watched. So it may be advantageous to have additional routes from a source exchange to more than one exchange in the next network level. Overlapped regional networks will be the result.

Step 4 :

In a consequent development of the described network approach and using the advanced ATM-routing principles a single level network can be the final result. The main components in such a visionary network are universal access networks, powerful universal telecommunications nodes, a high capacity ATM transmission network and the best network management equipment.

6 TOP DOWN APPROACH SAMPLE — CIRCUIT EMULATIONS

Migrating from a TDM-based network to an ATM backbone very often creates the issue of how to carry traffic from existing networks over the new infrastructure. In particular, how it is possible to successfully convey data (TDM) circuits, or voice traffic from PBXs end-to-end through the ATM network. Circuit Emulation addresses this issue. Circuit Emulation allows for a traditional point-to-point connection, such as a T1 or E1 circuit between TDM nodes, to be realized over an ATM backbone. This is accomplished by the adaptation of the digital bit stream into a Constant Bit Rate cell stream for transmission through the ATM network, followed by the reassembly of the cell stream into the original data for transmission out of the network to a terminating device. As far as the end nodes in the circuit are concerned,

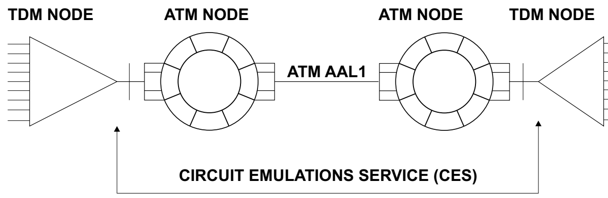

Fig. 6. Circuit Emulations Service

the fact that the intermediate physical circuit is passed through an ATM network is transparent.

The method by which the digital bit stream is divided up into cells and passed across an ATM network is defined in a number of specifications from standard bodies such as the ITU and ANSI, and other organizations such as the ATM Forum. In general, ITU-T I.363 and ANSI T1.630 provide the specification for ATM Adaptation Layer 1 (AAL1) which is the Adaptation Layer defined for carrying Constant Bit Rate traffic in the ATM network. The ATM Forum Circuit Emulation Services specification defines the method by which various types of Circuit Emulation Services are supported in the ATM network (for example, how physical layer alarms at an interface are propagated).

Issues in circuit emulation

Three critical issues may be identified for the support of a Circuit Emulation Service in a broadband network: These are:

- maintaining timing synchronization of the Circuit to be supported over the ATM network;
- controlling the deviation in the arrival of cells at the end-point (Cell Delay Variation);
- minimizing the latency or propagation delay of the circuit through each switching node.

Circuit emulation controller

The Circuit Emulation (CE) Controller is an AAL1 (ATM Adaptation Layer 1) interface to switch providing a Constant Bit Rate service to interconnect legacy equipment over the broadband network. The ability to pass serial bitstreams unmodified end-to-end across the network (or Unstructured Data Transfer) is suitable for applications where simplicity of configuration is required, or the bitstream in question is proprietary and cannot be interpreted at a standard physical interface. A comprehensive series of clock recovery techniques are available on the Circuit Emulation controller. These include Adaptive Clock Recovery, Synchronous Residual Time Stamp, Network Provided Timing and Loop Timing. Between them, these techniques cover virtually all the options available to synchronize devices attached to the asynchronous ATM network. Further options are presented when this controller is used in conjunction with the Node Timing Module.

In general a serial bit stream is received by the CE Controller and packaged into ATM cells using AAL1. Each of these cells has a one byte header followed by a 47 byte payload field. This means that each cell carries 376 bits of user data. In order to calculate the cell rate to support circuit emulation at a particular line speed, use the following equation: cells per second = (link speed in bits per second)/376. For example, a 2.048 Mbit/s circuit emulation generates 5446.8 cells per second. It is important to know this in order to configure traffic policing information for the PVCs involved in the circuit emulation. Due to the ATM overhead, the actual ATM bandwidth used by a 2.048 Mbit/s circuit emulation is 2.3 Mbit/s. The receiving end unpacks the cells and inserts the bits into the serial data transmit FIFO.

Unstructured data transfer

The UDT service describes where the entire T1 or E1 bit stream, regardless of format or content, is adapted into ATM cells and passed across the broadband network where it is reassembled into a T1 or E1 circuit. UDT may be used when there is a non-standard framing in use by the end-user equipment, where end-to-end communication of alarm states or Facility Data Link information is important, where timing is supplied by the end user equipment and carried through the network, or where simple configuration of a service with no regard to the bandwidth used is of overriding concern.

Applications

- Connecting Legacy Time Division Multiplexer Networks,
- Video Networking using external Video Codecs,
- Derive and transmit video streams from a Video Server device,
- Transport of Proprietary DataLinks,
- Establishment of meshed PBX Voice Network,
- Provisioning of Nx64 Kbps Services over ATM Network.

Typical applications include the connection of existing Voice and Data TDM networks over the ATM infrastructure, or to directly interconnect PBX systems for Voice Interworking over the ATM backbone.

Structured data transfer

The $N \times 64$ service is intended to emulate a point-to-point Fractional DS1 or T1 circuit. The service is typically accessed via either 1.544 Mbit/s DSX-1 interfaces, or 2.048 Mbit/s G.703 interfaces. For DS1, N of the 24 timeslots available at the DSX-1 interface, where N can be as small as 1 or as large as 24, are carried across the ATM network and reproduced at the output edge. For E1, N can be as small as 1, or as large as 31. Because the $N \times 64$ Service can be configured to use a fraction of the timeslots or channels available on the Service Interface, it is possible to allow several independent emulated circuits to share one Service Interface. The capability of allowing several AAL1 Entities to share one Service Interface, where each AAL1 Entity is associated with a different Virtual Channel Connection (VCC), allows for functional emulation of a DS1/DS0 of E1/DS0 Digital Cross connect Switch.

The SDT service describes the case where a fractional ($N \times 64$ kbit/s) T1 or E1 circuit is transmitted across the ATM network. An arbitrary number of channels from a T1/E1 interface may be transported across the ATM network, leading to considerable bandwidth savings compared to passing the whole T1/E1 stream. For the T1 case, up to 24 channels may be passed (24×64 kbit/s), whereas for the E1 case up to 31 channels may be passed (in E1, timeslot 0 contains local physical layer management information at each end of the circuit). SDT is particularly useful where it is necessary to minimize the bandwidth used in the ATM network by sending only some timeslots rather than the whole T1/E1 circuit, and where the alarm states and Facility Data Link are terminated at each end of the connection, leading to more accurate physical layer fault diagnosis. SDT does, however, require that timing is provided by the network, and is not passed through from one end station to another.

Applications

The essential function for ATM switches is to emulate existing Time Division Multiplexing (TDM) circuits. Since many voice and data services are currently provided by TDM circuits, seamless inter-networking between TDM and ATM has become a system requirement. The inter-networking function that satisfies this requirement is the Circuit Emulation Service (CES). Secondly, an access multiplexor allows voice circuits to be made across a single ATM service interface. The SCE card supports concurrent connection to a Private Branch Exchange (PBX). CAS signalling is needed to support a wide variety of legacy PBXs.

Many networks look for a framing structure and octet alignment to transport data streams. Installed fractional T1 and Digital Data Service (DDS) leased line services must still be supported when the backbone is changed to ATM. Generally, the backbone is either ATM or circuit switched, but not both. For those backbones which are ATM, all existing switched circuits must be migrated onto the ATM backbone through circuit emulation. Because of its extensive support of Digital Signal Level 0s (DS0), the SCE is an ideal vehicle for constructing ATM-based DACS and other circuit emulation devices. Structured data format is suited for these types of networks and underlying services.

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Received 31 May 2001

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