AN EVOLUTIONARY APPROACH TO A COMMUNICATIONS INFRASTRUCTURE FOR INTEGRATED VOICE, VIDEO AND HIGH SPEED DATA FROM RANGE TO DESKTOP USING ATM

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ABSTRACT

As technology progresses we are faced with ever increasing volumes and rates of raw and processed telemetry data along with digitized high resolution video and the less demanding areas of video conferencing, voice communications and general LAN-based data communications. The distribution of all this data has traditionally been accomplished by solutions designed to each particular data type. With the advent of Asynchronous Transfer Modes or ATM, a single technology now exists for providing an integrated solution to distributing these diverse data types. This allows an integrated set of switches, transmission equipment and fiber optics to provide multi-session connection speeds of 622 Megabits per second.

ATM allows for the integration of many of the most widely used and emerging low, medium and high speed communications standards. These include SONET, FDDI, Broadband ISDN, Cell Relay, DS-3, Token Ring and Ethernet LANs. However, ATM is also very well suited to handle unique data formats and speeds, as is often the case with telemetry data. Additionally, ATM is the only data communications technology in recent times to be embraced by both the computer and telecommunications industries. Thus, ATM is a single solution for connectivity within a test center, across a test range, or between ranges.

ATM can be implemented in an evolutionary manner as the needs develop. This means the rate of capital investment can be gradual and older technologies can be replaced slowly as they become the communications bottlenecks. However, success of this evolution requires some planning now.

This paper provides an overview of ATM, its application to test ranges and telemetry distribution. A road map is laid out which can guide the evolutionary changeover from today's technologies to a full ATM communications infrastructure. Special

applications such as the support of high performance multimedia workstations are presented.

KEY WORDS

Integrated Services Digital Network (ISDN), Broadband ISDN (B-ISDN), Asynchronous Transfer Mode (ATM), Data Communications, Telecommunications, Local Area Networks (LAN), Wide Area Networks (WAN), Distributed Processing

INTRODUCTION

Today Asynchronous Transfer Mode (ATM) is the hottest buzzword in communications, two years ago it was virtually unknown. There are many reasons for this. Perhaps most important is that ATM is the first communications technology in a long time to be embraced by both the computer industry and the telecommunications industry. With this backing, its acceptance was assured, but still, the swiftness of this acceptance is somewhat surprising.

This swift acceptance has been partially due to being in the right place at the right time. ATM promises to combine voice, data and video at a time when many enterprises are looking to do just that in their own networks. In addition, ATM offers support for very high speed data applications. Another reason is that ATM is actually being implemented with no successor technology on the drawing board. This is unique in today's rapidly evolving technology environment. Repeatedly, independent evaluations are selecting ATM as the optimum long term communications solution. ATM's own acceptance has led to even greater acceptance, in a self-feeding phenomenon not uncommon in today's marketplace. This is because as more vendors support a standard, users are more accepting of the new technology.

For these reasons, along with the ATM standards development in an international standards organization (i.e., non-proprietary technology) and its underpinning in previously standardized technology, ATM will be the target for high speed communications for the foreseeable future.

BRIEF OVERVIEW OF ATM

As the successor to Integrated Services Digital Network (ISDN) the CCITT has been defining standards for Broadband ISDN (B-ISDN). A key part of B-ISDN architecture is ATM. It is intended to provide optimum service to traditional packet switched applications (data communications) and circuit switched communications (voice communications). Additionally, high speed data and video transmission are strongly supported.

ATM is a variant of cell relay technology. It uses a small fixed packet, or cell, length to allow for low latency and fast cell processing. To achieve this a cell size of 53 bytes was selected. Figure 1 shows that the 53 bytes consist of 5 bytes of header data and 48 bytes of information. The header holds routing information. This routing information is used by the ATM switches in the network to pass the cell along to its final destination. The use of the small cells allow the efficient use of bandwidth and allows many devices using different data rates to share the network.

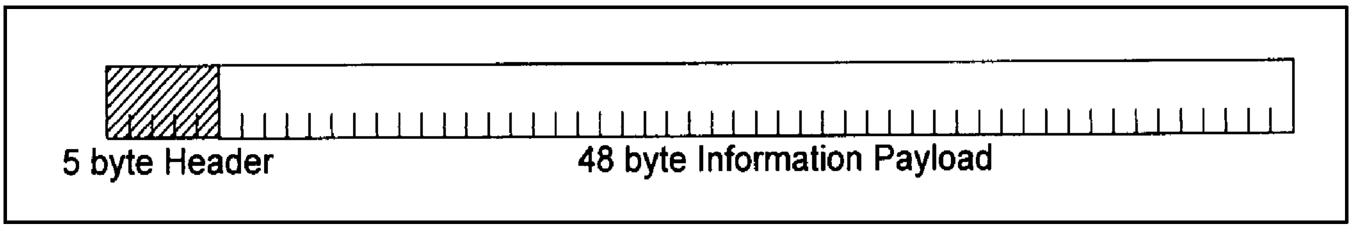

Figure 1. ATM's 53 byte cell.

ATM networks will employ switches to route the cells to their destinations. These switches will be interconnected in a network topology which will look like today's telephone networks or packet switch networks. End user equipment, the ultimate data sinks and sources, will each have a dedicated link to the ATM switch. The cells will be routed across the network via virtual channels (VCs) over virtual paths (VPs). There are two types of virtual channels defined, permanent virtual circuits (PVCs) and switched virtual circuits (SVCs). A PVC would be setup manually and left established for a long time, an SVC will be established with signaling and will only exist for the duration of the data transfer (analogous to a phone call). Initial ATM implementations will only support PVCs.

B-ISDN's protocol model shown in Figure 2 roughly conforms to the International Standards Organization's (ISO's) Open System Interconnect (OSI) seven layer model. According to CCITT, SONET will be used as the physical layer. Thus, ATM switches will be connected over fiber at OC-3/STS-3c (155 Megabits per second (Mb/s)), OC-12/STS-12c (622 Mb/s) and OC-24/STS-24c (1244 Mb/s) rates. [The telephone companies will initially offer connections at DS-3 (45 Mb/s).]

The ATM Adaptation Layer (AAL), see Figure 2, processing is performed at network terminating equipment on the user side of the interface. It classifies the traffic into one of five types before segmenting it into 48 byte slices. The five types are: 1. Constant Bit Rate (CBR) Services, 2. Variable Bit Rate (VBR) Services, 3. Connection-Oriented VBR Data Transfer, 4. Connectionless VBR Data Transfer, and

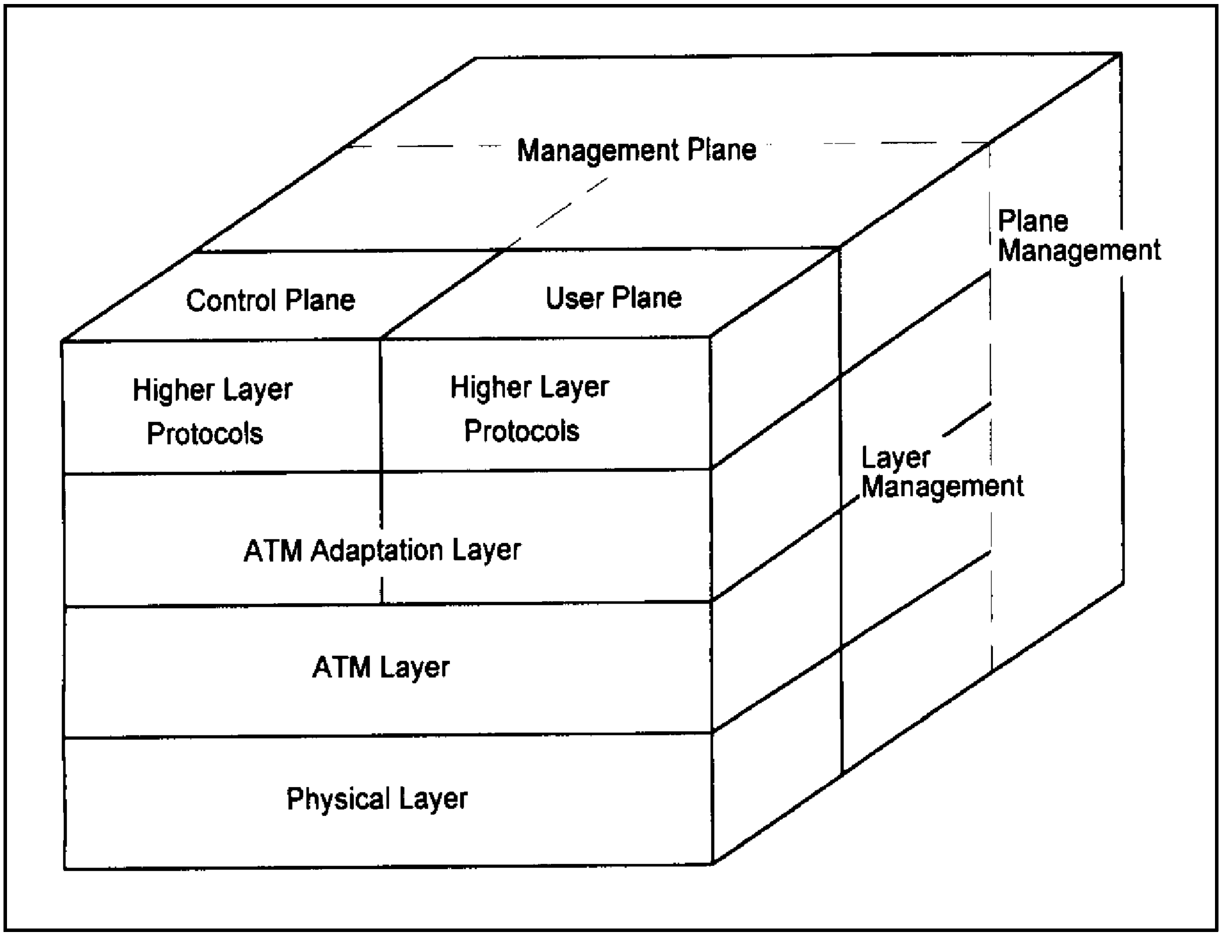

Figure 2. The B-ISDN protocol model.

5. Simple and Efficient Adaptation Layer (SEAL). (AAL 3 and 4 have been merged to a common 3/4 format.) It is the AAL which isolates the network from the traffic type and allows the network to be simply concerned with routing cells. This layer is a key element to ATM, it provided for the adaptation of a wide variety of communications requirements to the cell based transport mechanisms of ATM. This layer allows the constant and bursty data rate demands along with high speed, low speed and variable speed demands to all be well served by a single network.

Unfortunately, more detailed discussion the ATM standard is beyond the scope of this paper. The interested reader should refer to [1].

LANS & WANS WITH ATM

ATM will initially appear in the realm of Local Area Networks (LANs). As today's ubiquitous low speed Ethernet and Token Ring LANs begin to get congested they are generally divided into smaller networks interconnected by backbone networks. This results in fewer and fewer nodes per network segment. As the backbone networks carry more and more data they are generally upgraded to higher speed networks. This backbone application has been a common application for Fiber Distributed Data Interface (FDDI) which runs at 100 Mb/s.

In many applications today these FDDI backbones are becoming congested. As higher speed computers become cheaper and more wide spreads and applications are developed to use this computing power, more and more data will need to be moved over these networks.

ATM will solve this problem by allowing the FDDI networks to be divided and interconnected through ATM switches. These individual FDDI networks will each then be able to carry more traffic. Several vendors are already offering small ATM switches in the one to two dozen port size. These small switches are aimed at just these applications. In time, higher speed computers will require dedicated FDDI links to these ATM switches.

Individual ATM switches spread across a building, campus or range will ideally be interconnected with single-mode fiber. These switch to switch links will initially run at 155 Or 622 Mb/s. Inter-switch bandwidth can be increased as required by simply adding another fiber link between the switches on open switch ports.

As ATM grows in the LAN arena, the need to interconnect these ATM LANs at high speeds and across long distances will arise. Here ATM LANs will be seamlessly connected to the wide area ATM networks installed by the telephone companies. The large service provides will use much larger switches which will have port counts in the tens of thousands. Thus LANs and WANs will merge and provide high performance communications across great distances. Since ATM will remove the low speed bridge connections used by today's WANs there will be virtually no performance difference between local and wide area computer networks.

IMPACT ON RANGE OPERATIONS

This growth of ATM will have an impact on how test ranges operate for several reasons. This will first be seen as many smaller networks are combined across an ATM internetwork. This will allow much greater flow of information.

However, as the technology matures more and more data sources and sinks will be connected over ATM. This will occur for two reasons. First, the ATM network will allow anything to connect to anything - within reason. This is because one homogeneous network will have connections to low, medium and high speed raw and processed telemetry data, as well as voice, video teleconferencing and high resolution mission video. ATM connections will service personal computers, workstations, supercomputcrs, telemetry processors, and test personnel positions, in contrast to today's assortment of switches and networks dedicated to different types of data. Complete connectivity from range to desktop, and all points in between will be achieved. The underlying benefit of everything connected over one seamless network cannot be understated. This will greatly facilitate the processing and flow of information across the range community.

The second reason follows from the first, once nearly everything is on the ATM network, when a new piece of equipment is installed it will be only logical to connect it to the ATM network since it's sink or source of data will already be on the network. Additionally there will, more than likely, be access to an ATM switch relatively nearby.

As telemetry collection and processing assets get connected to the ATM network it will become transparent as to where those assets are located. Thus, inter-range testing will be greatly facilitated. Video and telemetry data could be collected at one test range, processed at a second and viewed and monitored at a third. Clearly the potential for distributed processing is greatly enhanced.

The fact that all equipment is on one network and ATM supports multicast (i.e., one source multiple destinations) will allow any computer access to all raw and processed data. Multicasting also facilitates transmission of real-time video to all mission participants.

Because ATM routes data with only the header information, setup of mission data distribution will be accomplished with just the issuing of addresses to the end equipment and/or the entries in address tables of the ATM switches.

A ROAD MAP TO FULL ATM

The most likely place for ATM switches to appear first is in the LAN backbones providing the internetworking as discussed earlier. This will occur for several reasons. The ATM portions of these networks will initially be small. This will allow a single vendor solution. Thus, postponing interoperability issues until the standards are more mature. Secondly, desktop ATM interfaces are roughly $10K each today. (ATM interface boards are available today for direct connection to most computer busses.) This will limit these to high performance computers involved in real-time applications, at least initially. Eventually, the cost per interface will drop and the data handling capabilities of the average computer will rise until a balance is found. At that point ATM to the desktop will spread quickly.

As was alluded to earlier, ATM switches will directly support FDDI interfaces. This is because the ATM Forum has defined FDDI, SONET STS-3C/OC-3, DS-3 and Fiber Channel (155 Mb/s) as the four physical layers which could be supported initially. (The ATM Forum is an industry consortium whose goal is to accelerate the adoption of the CCITT standards.)

For these reasons the selection and use of SONET, FDDI, Fiber Channel and single mode fiber optic cable for pre-ATM solutions will allow these assets to directly support ATM when it is implemented. Because interface boards to most popular computers are either available today or scheduled for delivery by the end of this year, the selection of processors can be independent of ATM.

The general conclusion of potential users is that ATM will be economically feasible in the 1996 time frame. Public offerings of ATM services by the commercial carriers will begin by early 1994 and probably be somewhat widespread by 1997.

APPLICATIONS

One application of particular interest to the test range community would be the support of test center personnel during a mission. The ground-based test participants could each be supported with a high performance multimedia workstation. This workstation would simultaneously provide displays of radar information, mission video, processed telemetry information, access to archived test results, and full mission voice communications. Each participant would have interactive voice and graphical communications with personnel involved in the test. Participants could also be provided interactive processing capability to dynamically adjust the analysis of data in realtime. This would make test positions generic and quickly adaptable to new and varying missions.

In this scenario, technical specialists could be called in to the mission on an impromptu basis if a special need arose. This specialist would have access to all information about the mission without leaving his or her desk simply by logging on to the ATM network via their desktop workstation. Further, this specialist could be down the hall or at another facility halfway across the country.

Today, significant effort is being channeled in to making video teleconferencing on the desktop feasible. Although most of this work is independent from ATM, this technology would easily accommodated by an ATM network. Thus visual interaction would blend with the other interactive elements

In addition to the inter-range personnel hookups, the distributed processing capabilities available across the entire network would offer a huge potential processing resource.

CONCLUSION

Truly ATM holds great potential for the future of data communications. But as is the case with all technology that has not reached maturity, many more claims of virtue are made than will ever be realized. This is to be expected. Someday a technology will be proposed which will better ATMs but until then ATM is the brightest star out there.

To guess at the near-term future of ATM, we need only look back at any developing communications standards. Initial product offerings will be hybrids which partially conform to the standards and partially provide proprietary solutions for the yet to be standardized portions of the technology.

Even after standards are finalized, there is often leeway in the implementation specifics. This is where the ATM Forum hopes to make its biggest impact. The ATM Forum aims to codify the details not in the standard to maximize interoperability. The Forum is not alone in this pursuit, no less than six multivendor testbeds have been established and about a dozen vendor alliances have been announced.

Even with this cooperation, there are some big challenges ahead, these mainly deal with the more complex portions of the technology which typically get bogged down in the standards committees. These issues, however, are essential to full featured multivender interoperable ATM. This includes, network management, establishment of SVCs, and support for multiple sessions from one ATM node. Additionally, development of the upper layer application protocols targeted at ATM and ATM internetworking are needed. The means to provide a level of security suitable for military operations without degrading the benefits of ATM is also needed. The development of low-latency, isochonious interfaces to ATM is another requirement for supporting the test range community.

Fortunately, market forces among the multitude to ATM vendors will force the implementation of these aspects. This will, however, take time. To believe the road to ATM will be short and bump-free would be naive. However, it is becoming ever clearer that all roads lead to ATM and this does appear to be the next significant destination. By targeting intermediate milestones along this trip, users can chart a route with minimal deviation from the optimal path to full ATM.

REFERENCES

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