CHAPTER 9

Multimedia Networking Technologies

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ABSTRACT

Desktop conferencing systems and other distributed applications require digital networks for the transfer of audio and video data. Many current networks are not appropriate for these applications, the protocols that govern current networks and their limited bandwidths are ill-suited for digital audio/video traffic.

Multimedia networks, on the other hand, provide a better match to the communication characterisitcs of distributed multimedia applications. These networks are specifically designed for multimedia traffic. Multimedia networks differ from current local and wide area networks in several ways. They are distinguished by different features, these features are presented and discussed in this paper.

Keywords: multimedia, gigabit networks, Asynchronous Transfer Mode (ATM) reference model, performance guarantees, Broadband Integrated Service Digital Networks (B-ISDN), ISO (OSI).

1. INTRODUCTION

Multimedia computing and communications are areas of intense current interest, software and hardware development, and future promise. Multimedia standards organizations are actively producing new standards for the field. Yet, the term "multimedia" and the subject areas it covers remain. In the future, all computers and networks will support multimedia computing and communication to provide appropriate services for multimedia applications. The high-speed networks with their higher bandwidth and transmission possibilities of all media kinds, have led to networked multimedia systems. [1]

A multimedia networking system allows for the data exchange of discrete and continuous media among computers. This communication requires proper services and protocols for data transmission. [1]

Multimedia is the intergration of text, audio sound, graphic images, animations and full motion video. This technology is actually supported by three facts. [2.3.5.12]

1. The advent of VLSI that has led to producing powerful computers and workstations with high performance and huge storage capacities.
2. The evolutions of communications technology towards broadband ISDN and ATM switching.
3. The advances in fiber-optics have produced high quality monomode fiber transmission systems capable of delivering gigabits of data per second over distances of hunbreds or thousands of kilometers with extremely small loss rates. Some of these fiber-optic systems are capable of transmitting terabits of bandwidth by using multiple gigabit channels.

This paper discusses multimedia networking needs, the new and applicable solutions as well as the features of multimedia network. This paper also presents a trip report about GITEX' 97 (Dubi) including interviews with its partners, such as DIGITAL, COMPAQ, FORE system, Microcom and 3 COM .

2. SOME KINDS OF APPLICATIONS NEED GIGABIT NETWORKS

This section presents a few number of possible uses of gigabit networks: [3]

2.1 Multimedia conferencing

One use is multimedia conferencing. Essentially, the idea that users should be able to participate in conferences in which users sit in their offices and communicate using voice, video and data connection to remote sites.

Multimedia Conferencing is expected to require gigabit bandwidths because the video communication consumes a lot of bandwidth. In a conference with several participating sites, the bandwidth requirements repidly approach a gigabit for video alone.

2.2 Virtual Reality (VR) :

Another interesting application is virtual reality. The idea is to simulate an environment so realistically that the user believes that he is in the new environment. To construct such an environment requires a computer to accurately mix sound, visual images and sensations such as touch and temperature. If there are multiple participants in a single simulation, several computers may have to exchange a lot of data to keep track of each participant's behavior in the common area.

3. WHAT DO APPLICATIONS REQUIRE OF GIGABIT NETWORKS

Some guarantees are made about the bandwidth available between the two computers. To see why this is so, consider an extreme case: 1 gigabyte of data is transferred over a network in which one link runs at only 19.6 kilobits; the transfer will take at least 115 hours.

Potential parameters for guarantees include:

- Network delay
- Bandwidth
- Reliability
- Failure recovery
- Service setup times
- Interarrival times

4. MULTIMEDIA NETWORKS FEATURES

Multimedia networks differ from current local and wide area networks in several ways. They are distinguished by the following features: [4]

- **Bandwidth:** Multimedia networks are likely to have bandwidth of Gbps or more; this is essential in the long-haul sections of the network where many simultaneous video streams can be expected. B-ISDN and ATM are examples of relevant technologies and the basis of international standards for future multimedia networks.
- **Multicasting:** Distributed multimedia applications often require multicasting, the transmission of data from one source to many destinations. The protocols for multimedia networks allow the set of destinations to change over time. This would be needed, for instance, in an electronic classroom where students can enter and leave as they choose.
- **Real-time constrants**: The transmission of multimedia data is subject to timing constraints include limits on transmission delay and limits on the 'jerkiness' of delivery. This is essential for applications that have 'live' sources or must present synchronized audio and video stream.
- **Reliability:** In multimedia networks, reliability is a question of a quality. Audio and video data, in comparison to text or numeric data, are less sensitive to errors.

Multimedia networks cannot totally ignore reliability since as errors increase, noise is added which ultimately leads to unacceptable presentation quality.

- **Quality-of Service (QOS):** Different applications have different communications requirements. A conferencing system, where data is presented once and tolerate a higher error rate than an application that records a multimedia data stream for future playback. Although less sensitive to errors, the conferencing system requires fast delivery, while for the recording application long transmission delays are of no concern. One way that networks can support variations in requirements is by allowing each application to specify 'Quality-of-Service' or QOS, parameters. For example, consider an audio stream where data is produced by a source at a constant rate of 64 kbps. An application might request the following QOS parameters: a bandwidth of 64 kbps, a maximum delay of 100 ms, and a maximum loss rate of 1%. The multimedia network would then allocate sufficient resources to satisfy the applications's demands, or tell the application that the network is 'busy'. [4]

5. APPLICABLE SOLUTION FOR MULTIMEDIA NETWORK

This section presents the applicable solutions for multimedia network.

5.1 Advanced Communications Technologies and Services (ACTS) Applications :

The high performance network area addresses the definition of the target networks, accounting for the emerging technologies, the identification of the missing element, the development of the means to control these networks, and the integration of all the pieces while verifying their operation through experimental usage. The technology of choice for integrated broadband communications is ATM, a successful outcome of the RACE programme. A major benefit of ATM is the unification of traffic types. The ATM technology acts as a multi-service integrator allowing to combine isochronous traffic (with real time constraints), connection oriented traffic, based on variable data rate, and connectionless service, over a single set of physical links. These characteristics are well suited for supporting multi-media services, which are already attracting all kinds of users and service providers.

ATM is also distsnce, protocol and speed independent. It can be implemented through the entire network, offering LAN-WAN integration and simplifying network management and operation. ATM cells can be sent over SDH transmission at speeds of 155 Mbit/s and higher, as well as over PDH at speeds of 34 Mbit/s or over LAN speeds of 100 Mbit/s .

So far only the peak bit rate traffic is being offered or experimented with ATM backbone network. Realizing ATM networks with statistical gain for optimum use of the network would have to be conducted to generate stable standards and specifications on mutually agreed definitions of traffic parameters.

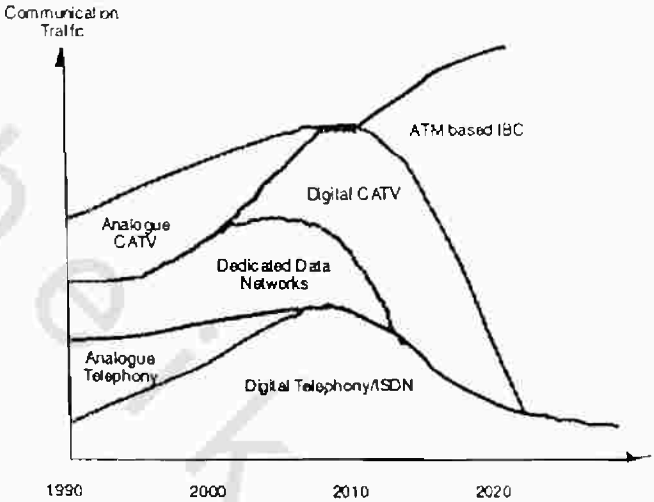

Fig. 1 : Evolution Timeframe [6]

The fibre optics infrastructure in Europe now amounts to more than 6.6 million fibre-km. This infrastructure offers almost unlimited bandwidth to permit a wide range of services to the user, such as HDTV, video on demand, multimedia, mobility, security, network management and others. The trend towards deploying ATM and laying more fibre is paralleled by the evolution on the application side. Organizations are now having a critical eye on their information processing capabilities and reassessing the way they transfer information with their customers and suppliers.

This technical evolution is mirrored by changes in competitive and regulatory environments. Network operators are starting to compete outside their territory. New entrants such as Cable TV operators, corportions with substantial assets in communication infrastructures (power utilities, railways, or others), teleport operators and mobile and satellite operators are also emerging. The blurring of the commpetitive lines means that a multiplicity of high-speed and lower-speed networks will coexist.

5.2 Germany Applications :

The experience gained with the Berlin metropolitan network led to building a German ATM pilot network in 1994, [7] which was later linked to the European ATM pilot network. A broad range of multimedia experiments was carried out on that pilot ATM platform in preparation for public ATM services.

In addition, multimedia trials were set up focusing on services for residential customers in order to gain experience with multimedia applications specific to private households. Alternative technologies for residential broadband access needed to be evaluated in conjunction with multimedia application scenarios for residential customers.

Several infrastructures were employed to conduct the field trials. Business multimedia projects mainly utilize the ATM. The network platform was extended beyond the German border by linking with the European countries. For residential projects based on current telephone or cable TV infrastructures, different broadband access technologies were employed.

Switches of the ATM network are located in major German cities (Fig. 2) User-network interfaces (UNI) of 2, 34, or 155 Mb/s bandwidth are offered to interconnect multimedia applications on the ATM level, or terminal adapters to acccss legacy scrvices. Permanent virtual and connections (PVPs and PVCs) are set up via a management system. Switched virtual connections (SVCs) are also available. The ATM network also forms the backbone for the 34-155 Mb/s research network connecting universities and research facilities.

Management of ATM connections is conducted from a central ATM network management center (ATM-NMC). A network management software was developed to support configuration and fault management of PVP connections on the network management layer. The ATM-NMC communicates with ATM switches via a Q3 interface based on the European Telecommunications Standardization Institute (ETSI) NA5 model.

Since the German ATM nctwork forms part of a European ATM pilot nctwork, means to manage ATM nctwork in a multi-operator environmemt were also developed and tested. Linking of network management systems via a telecommunications management nctwork (TMN) X interface on a cooperative basis (Xcoop) is needed as an importantant prerequisite to automatically establishing ATM paths across interconnected networks. Within the European Institute for Research and Strategic Studies in Telecommunications (Eurescom) program, an Xcoop field trial for ATM technology was conducted among several European project partners. The procedure was to agree on a common specification of the information model at the X interface for ATM configuration and fault management processes as well as supporting communications protocol stack. Each partner would then implement the specification in its own laboratory using different platforms. In consequential tests the implementations were validated against each other.

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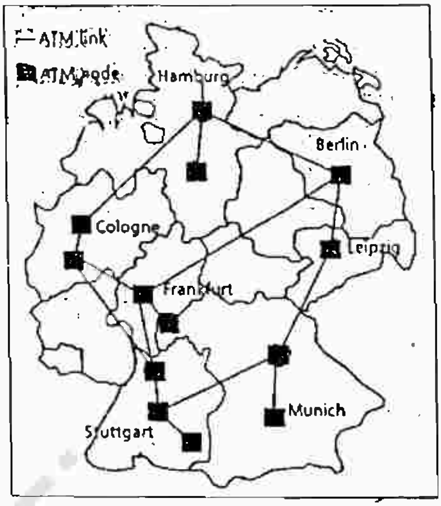

Fig. 2 : ATM Pilot Network [7]

5.3 DEC Applications :

ATLANTA, GA., October 8, 1997 [8]- Digital Equipment Corporation today announced its next generation Ethernet switch, the GIGA switch/Ethernet, providing up to three times the backbone capacity of competitive offerings. Featuring smooth migration from high-density Fast Ethernet to powerful Gigabit Ethernet switching, DIGITAL's GIGA switch/Ethernet enables customers to upgrade their networks to speeds of 1000 Mb/s as LAN bandwidth requirements of Intranets grow.

Digital has added a new high-density Gigabit/Fast Ethernet solution called GIGA switch/Ethernet to the GIGA switch family. When fully saturated, this intelligent 100/1000 Mb/s Ethernet switch delivers switching throughput of more than 33 million packets per second on a 45 + gigabit per second (Gb/s) backbone. Based on the same robust and reliable features as the GIGA switch/FDDI, ATM, and IP products, the GIGA switch/Ethernet switch offers up to 24 full-duplex Gigabit Ethernet ports, up to 120 auto-negotiating 10/100 Fast Ethernet ports, up to 60 fiber optic Fast Ethernet ports, or a flexible combination of these configurations. It is designed with a fault tolerant, non-blocking crossbar switch architectur with no single point of failure. And it is easily managed with integrated clear VISN Web-based management.

The GIGA switch/Ethernet is a cost-effective backbone solution that is complementary to existing 10 Mb/s and 100 Mb/s Ethernet technology. It shares the same advanced features as its GIGA switch siblings, including non-blocking crossbar technology, high throughput, scaleability, high availabilty and reliability, and quality of service. The GIGA switch/Ethernet can be integrated with other GIGA switches as well as with other members of the MultiSwitch 900 and 600 families.

By combining the new GIGA switch/Ethernet system with Digital's 64 -bit Alphaservers, GIGA switches. MultiSwitches, VNswitches, Ether WORKS adapters, Internet/Intranet software, and web-based management, Digital offers the highest perfoming and most scaleable Gigabit/Fast Ethernet solution in the industry.

LAS VEGAS, May 6, 1997 [8]- At the Net World + Interop exhibition here today. Digital Equipment Corporation announced plans to extend its industryleading GIGA switch and MultiSwitch 900 enterprise switching platforms to support high performance Gigabit Ethernet solutions. Digital will offer the industry's broadest range of high-performance switching options including 10 Mbps, 100 Mbps, and 1000 Mbps Ethernet, FDDI, ATM, and IP switching for both cells and packets. Digital's proven, integrated GIGA switch and MultiSwitch architectures provide customers reliable, cost-effective migration options to support even the most demanding Intranet bandwidth requirements.

For proven ATM performance with industry-leading scaleability and flexibility, nothing beats the DIGITAL GIGA switch/ATM family. These ATM Forum-compliant systems deliver awesome throughput with guaranteed zero cell loss. And with ATM, IP Switching, and LAN emulation all on the same switching system, you get outstanding flexibility for adapting to changing network requirements without changing your hardware.

From small high-performance workgroups to large campus backbones, the GIGA switch/ATM systems scale seamlessly to handle your most demanding LAN, VLAN, and WAN applications while protecting investments. You get a choice of GIGA switch/ATM systems, each offering industry-leading performance to support a wide range of high-performance applications. The 5-slot modular chassis features the lowest cost for an entry-level system, supporting from one to 16 ports, while the 14-slot chassis offers high capacity-supporting up to 52 ports. Both systems provide component redundancy for large, high-volume backbone applications and use a nonblocking crossbar switch architecture for high throughput and low latency.

The DIGITAL family of switched networking solutions lets you evolve easily into switching technology without disrupting your existing networking infrastructure. Because our high-performance switching products coexist with existing LAN technology, your ATM and other switched networks can integrate with today's FDDI, Ethernet, and Fast Ethernet LANs. This means you add switched networking as needed to protect your investment in existing technologies, and later evolve those networks to full switch-based capabilities.

Plus, all our products are scaleable, no matter what size network you currently operate. DIGITAL has the technology in place so that you can start small and grow comfortably and seamlessly as your business evolves. Whether you need to upgrade next year, our switching solutions work with you in mind. DIGITAL offers a variety of high-performance solutions that protect your current investment while meeting you ever-expanding performance needs. Both the GIGA switch/FDDI and ATM systems have been recognized by the industry as top choices.

The GIGA switch/FDDI System - Named Data Communications "Hot Product of the Year" and the winner of R&D magazine's "R&D 100" award for technology leadership, the GIGA switch/FDDI system provides an easy way to implement switched networks today, with the flexibility to grow to ATM technology as you require.

The GIGA switch/ATM System - This high-performance networking switch has been designated as Network World's ATM Buyer's Guide's "Editor's Choice". The GIGA switch/ATM System, a 10.4-Gb/s ATM switch, is the only ATM switch that ensures network stability with FLOW master flow control, a zero cell loss traffic management technique.

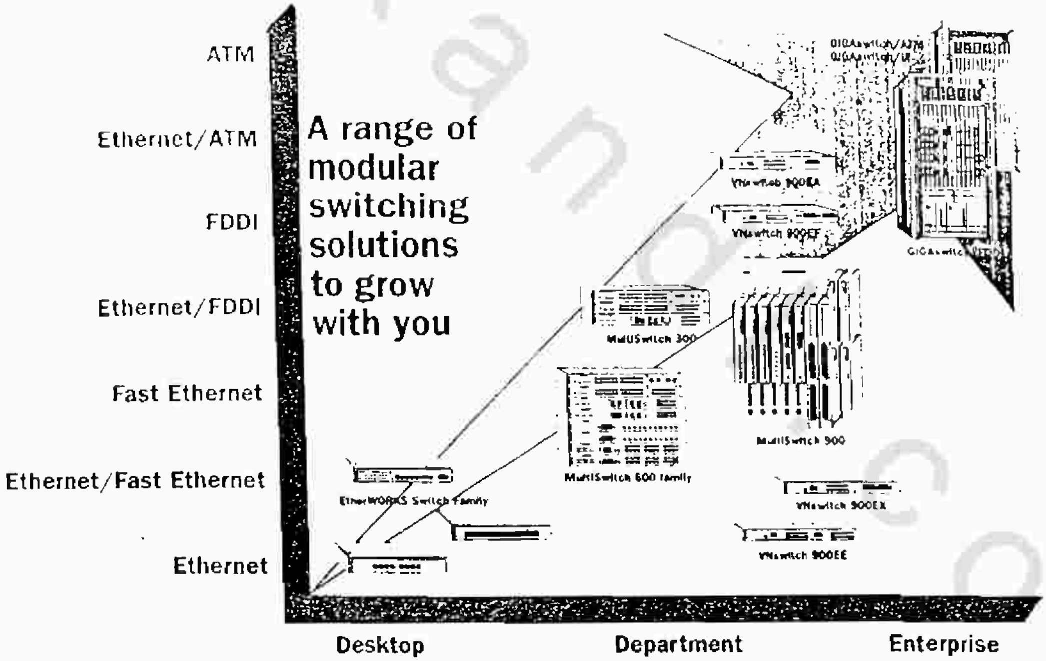

Fig. 3 : Digital Switches [8]

5.4 COMPAQ Applications :

The increasing complexity of desktop computing and bandwidth-hungry applications such as multimedia, medical imaging, CAD/CAM, and pre-press processing are demanding unprecedented LAN speeds. Out of all the availble high-speed LAN technologies, Fast Ethernet, based on the popular 10 Base-T Ethernet, has become the leading choice in meeting those demands by offering greater bandwidth and improved client/server response times. Now, however, the increased use of Fast Ethernet connections at the server and desktop is creating a need for even higher-speed network technology at the backbone.

An IEEE (802.3z) task force is developing a new Ethernet standard called "Gigabit Ethernet" that runs at 1000 Mb/s. Gigabit Ethernet employs the same CSMA/CD protocol, frame format, and frame size as its predecessors, plus interoperability and backward compatibility with the installed Ethernet. Gigabit Ethernet will also support existing applications, Network Operating Systems (NOS), and network management.

Gigabit Ethernet will initially be deployed as a backbone interconnection between 10/100Base-T switches and as a connection to high-performance servers.

In November 1995 [9], Compaq Computer Corporation recognized the need for Gigabit Ethernet technology and proposed the basis architecture to the IEEE 802 committee. In early 1996, the IEEE formed the Gigabit Ethernet Task Force (802.3z) whose commission was to draft a Gigabit Ethernet standard. Compaq has contributed significant technical input and resources to expedite the development of this standard.

In April, 1996, the Gigabit Ethernet Alliance was formed by Compaq Computer Corporation and a few other leading networking and computer companies to promote the Gigabit Ethernet technology and to ensure multi-vendor interoperability. Since then the Alliance membership has grown to more than 72 companies.

Gigabit Ethernet Characteristics :

Agoal of the Gigabit Ethernet Task Force is that the Gigabit Ethernet standard which meets the following criteria: [9]

- Run at 1000 Mb/s at the MAC/PLS service interface.
- Adopt the IEEE 802.3 Ethernet frame format.
- Meet the IEEE 802 functional requirement.
- Provide simple forwarding between 10 Mb/s, 100 Mb/s, and 1000 Mb/s Ethernet.

- Preserve the minimum and maximum frame size of the current IEEE 802.3 standard.
- Provide full-and half-duplex operation.
- Support star-wired topologies.
- Utilize the CSMA/CD access method with support for at least one repeater/ collision domain.
- Utilize ANSI Fiber Channel's FC-1 and FC-0 as a basis for work.
- Provide a family of physical layer specifications that support a link distance of:
  - At least 500 meters on multimode fiber.
  - At least 25 meters on copper (100 meters preferred).
  - At least 3,000 meters on single mode fiber.
- Support a maximum collision domain diameter of 200 meters.
- Support media selected from ISO/IEC 11801.
- Adopt flow control based on the IEEE 802.3x standard.
- Specify an optional GMII (Gigabit Ethernet Media Independent Interface).

Applications and Topologies :

Just as in 10 and 100 Mb/s Ethernet, Gigabit Ethernet will be switched, routed, and shared. All of today's Internet working technologies, as well as emerging technologies such as IP-specific switching and Layer 3 switching, are full compatible with Gigabit Ethernet. (The emergence of new protocols, such as RSVP, 802.1Q, and/or 802.1p, will provide multimedia support as well as VLAN and explicit priority support for Gigabit and 100 Base-T Ethernet). The initial application for Gigabit Ethernet will be in collapsed backbones between Fast Ethernet switches, repeaters, routers, and servers.

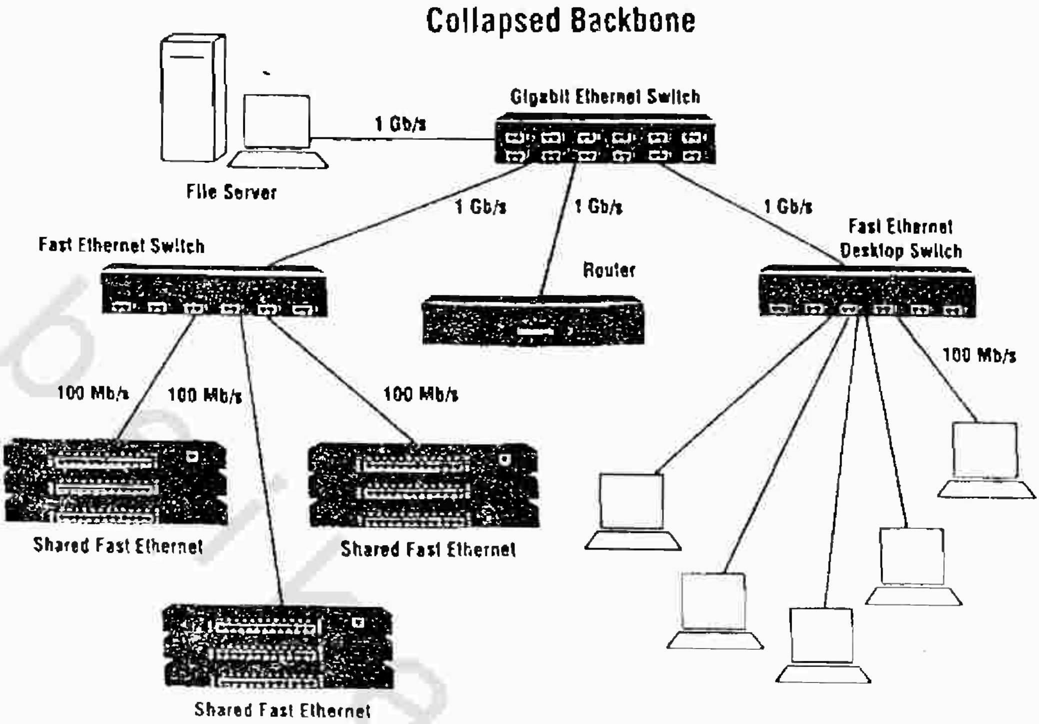

Fig.4: Gigabit Ethernet Application Example in a Collapsed Backbone [9]

6.THE LATEST AND THE MOST PROMISING TECHNOLOGIES IN THE NEAR FUTURE

The telecommunications field is now at a turning point where very high transmission speeds are complemented by an increased demand for this high speed. At the same time a cost-effective evolution from the current networks is required.

The planning of an ATM backbone network must be achieved with minimal disruption to existing network users while achieving economic benefits as soon as possible. A major issue for the future is to ensure the interconnection of advanced services on customer premises, corporate and public networks.

High development and investment costs will limit ATM based IBC coverage in the short to medium term. It is likely that existing networks will be extended progressively. Overlay networks will be provided with optical fibre access and later be incorporated within Integrated Broadband Communication - IBC.

To meet the objectives of this area, it is necessary to develop a broadband transport system embracing different networking technologies and providing a platform for advanced multimedia communication services. In this sense, high performance networking must concentrate on quality of service in integrated networks, on overall signaling and management issues and related operational recommendations, and on robust network and transport protocols. Operational experience will help deduce organizational and technical constraints and define necessary agreements.

Realization of high performance networking will be in steps of evolution while keeping a backwards compatibility to "classical" data communication services and the connectivity and interoperability to the end systems (telephones, video-conference centers) of today's mass market networks. It goes beyond conventional data communication, as defined by the ISO-framework on "open Systems Interconnection", and beyond already established "audio/video-communications".

A realistic vision of evolution requires the observation of three different levels: [6]

- The development and introduction of high performance network (bearer) service with ATM as a starting point and end-to-end network/transport protocols, in order to ensure interconnection with established in-house and wide area networking technologies, which are capable of handling the different demands of multimedia communication.
- The development, introduction and management of high performance teleservices, by providing a service platform and thus ensuring interoperation between multimedia end systems.
- The introduction of "World Applications" linking users sharing the generic applications.

High Speed networking must include the two "lower" levels but with a clear view to and feedback from the application level.

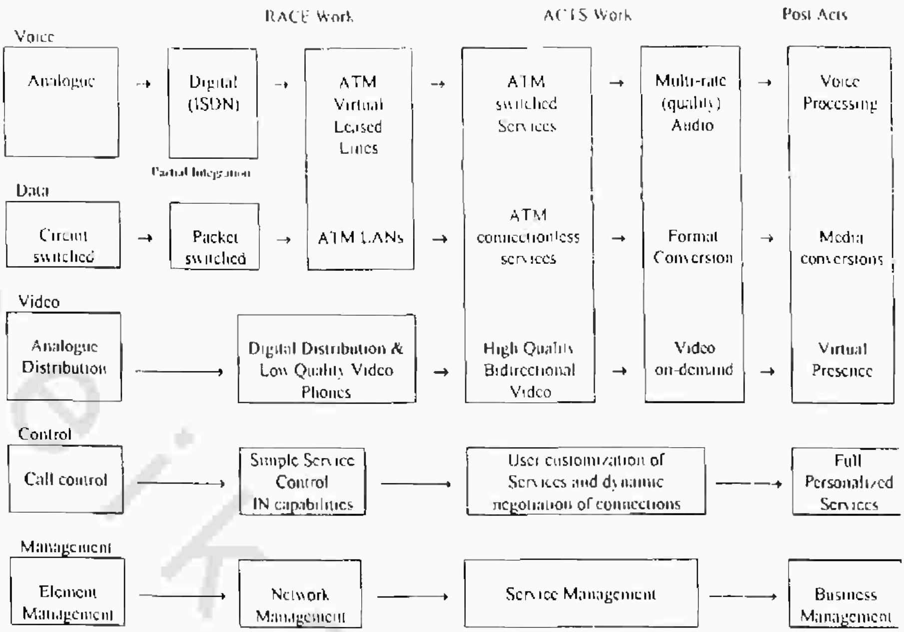

Fig. 5: High performance Networking - Technology Evolution [6]

Gigabit Ethernet is a logical extension of today's Ethernet and Fast Ethernet standards that will provide maximum performance for the client/server networks of tomorrow.

Gigabit Ethernet products are expected to be available starting in July, 1997, and the Gigabit Ethernet (IEEE 802.3z) standard is scheduled to be completed by January, 1998.

Local area network systems, in general, have been traditionally viewed as being incapable of carrying multimedia and/or high speed real time traffic due to data rate and protocol limitations. However, due to recent advances in video coding, on one hand, and the emerging high speed Ethernet versions, on the other data rate demands and resources seem to match quite well for many practical scenarios. Therefore, appropriate "integrated" media access protocols are needed that (i) support several classes of real time traffic; and (ii) compatible with the original data-only MAC protocol so that on an integrated/multimedia services Ethernet LAN, stations with integrated functionality can coexists with standard data-only stations. [10]

The exponential growth of Internet use may result in reduction of grade of service of telecommunication networks. Capacity increase is the challenge to telecom operators. Communication satellites "see" a large customer population and provide a large amount of - mainly entertainment - information. Interactive services are possible with enhanced communication satellite systems. [11]

7. CONCLUSION

Multimedia applications require Gigabit network. Multimedia networks have these features:

1. Bandwidth of Gbps or more.
2. Multicasting.
3. Real time constraints.
4. Reliability.
5. Quality of services.

It is obvious from the applicable study, which was performed at the GITEX '97 exhibition in Dubai that the greatest network companies have many solutions for multimedia networks. These solutions agree with multimedia network features mentioned above.

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