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High Speed Networks Applications and Requirements

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Abstract: Business and Government Organization depend on Information Technology (IT) to meet business objectives of improving service and maximizing limited resources. This study presents some application scenarios which might make use of high-speed networking technologies for International environment. New and capable networks technologies will be required to respond to increased demand. New developments in high speed networking are helping to make these opportunities realizable.

INTRODUCTION

Business and Government organizations depend on Information Systems (IS) and their supporting Information Technology (IT) to meet business objectives of improving services and maximizing limited resources. In the next few years, there will be an increasing exploitation of IS/IT, especially, the use of telecommunications. New and more capable network technologies will be needed to respond to increase demand. There are nine factors that influence the ways in which these new networking technologies might be deployed, namely:

- Increased and changed use of IS/It
- Improved cost/performance/ubiquiting of computing and telecommunications
- Different architectures (e.g., client-server, peer-peer)
- Different and multiple medial (graphics, image, video, etc.)
- Convergence of services (voice, data, video, etc.)
- Growth in distributed applications
- Reduction or avoidance of travel between locations.
- Co-operative working within and between organizations
- The virtual office (e.g., home working, mobile users)

Figure 1 a model that relates generic applications requiring high speed networking to business functions and market sectors.

Example of future applications
Scenarios: Such as multimedia conferencing, distance learning, remote consultation and Information services.

Multimedia conferencing: Prof. Sayed is sitting in his office at his WS (Workstation) assessing student assignments. The terminal alarm signals that he is about to have an essential standards meeting in 30 min. Prof.

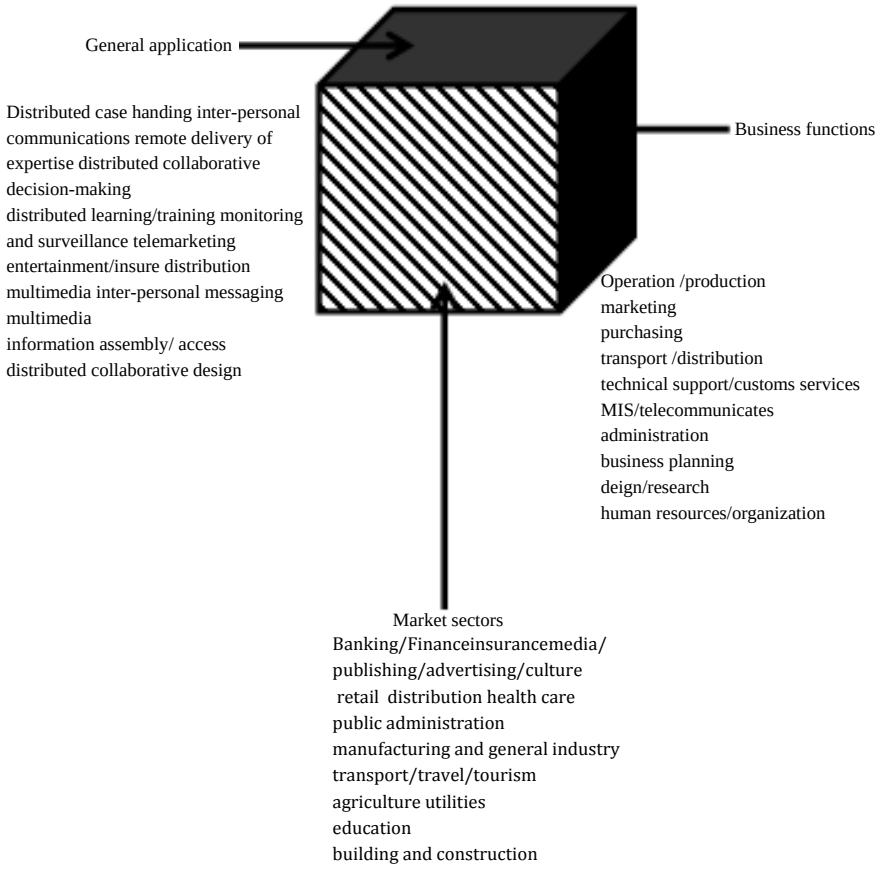

Fig. 1: A model that relates generic applications requiring high speed networking

Sayed saves his research and starts preparing for the meeting. He reviews the agenda for the meeting, his notes on those points he wants to make and last minute meeting-related messages received from his peers. He quickly checks his personal plants and objectives.

About 5 min before the meeting is due to start, his WS requests confirmation that he will participate in the meeting. He indicates yes and his WS establishes the connection in standby mode. Prof. Sayed notices that Dr-Mounir is already connected and a two-party connection is established with him and has just finished exchanging greetings with him when WS indicated that the participants are assembled and that the meeting has commenced. On the screen of Prof. Sayed's WS there is:

- A "talking head" image of Dr. Mounir
- A window with the agenda
- A window containing the number of current participants (30 days)
- "Talking head" images of the meeting chairman and the technical editor of the document being worked on today
- A window containing the current status of the meeting
- A stack of windows each corresponding to a document that Prof. Sayed wants read access to during the meeting
- A clock with the current time of date
- A clock with the time remaining in the meeting

The agenda is adopted and the meeting gets underway. As the meeting progresses all of the easy items are dealt with within the first h. The group breaks into 5 break out groups of 5 people each for 2 h to deal with two controversial issues. In the last hour the 5 groups report on their progress and 3 alternative solutions are identified. Volunteers are found to work on the ideas and the meeting is finished after the consideration of the recommendations.

DISTANCE LEARNING

This will enable the recipient to access remote multimedia databases and interactive instructions based on audio, image and video media. It will apply to a broad

range of subjects. As an example is the teaching of surgery. This type of teaching is heavily dependent on the transfer of visual images (still or moving).

The pool of patients that can be used is limited and changing patterns of treatment are reducing the length of time patients stay in hospital and therefore their availability for teaching. If medical students are to receive the necessary variety of information during training, it resources material, preferably in an interactive way. The students experience will be necessary to use video resources material, preferably in an interactive way.

The students experience will be more varied if facilities, patients and medical expertise can be shared between university departments. Systems are already in place to supply two way video and audio connections between the surgeon, tutors and students.

REMOTE CONSULTATION

High cost and low availability of different types of consultants provides a strong case against travel. Use of rare and expensive specialists would be more effective if the gap between them the clients and supporting facilities could be closed by suitable communications, namely, multimedia networking.

Example: In the medical professions, some health authorities are unable to employ enough pathologists to cover specialized areas. Only few consultants are covering the pathology of the bone and the rarer species of pathologists are found in universities, rather than hospitals.

A pilot scheme can be run to create a pathologists network, linking consultants with operating theaters via. Multimedia WS coupled with HD (High Definition) microscopes. This scheme could become larger and more powerful by extending it to smaller hospitals and practices and linking it to create an effective link for the entire medical profession and supporting facilities.

Information services: The high cost and short life expectancy of many types of books are posing some difficult questions in libraries questions and information centers. This appeared to access information more rapidly and have it in a suitable format (e.g., English, German, textual, audio, colour) and cost effective form electronic libraries are inevitable and multimedia network must therefore follow.

Bandwidth explosion: The following trends will collectively cause a dramatic increase in networking Bandwidth (BW) requirements over the next years.

INCREASED TAKE-UP OF NETWORKING, GENERALLY

- More people using IS/IT, more use per head
- Increased use of file servers for security, integrity, etc., especially for graphics, image and video
- Growth in demand for remote access over increasing distances
- More mobile users requiring access form multiple locations
- Increased use of distributed processing (especially distributed databases) and client-server architectures
- Use of the network for end systems managements including software distribution
- On-line back-up and recovery

Need for improved performance:

- Growth in computing power at all levels (especially, in PCs)
- More powerful WS and application servers optimized for faster inter interconnection
- Disk-less PCs-requiring program and file delivery in real time
- Client-server and client-client applications-real time requests across the network

New technological developments:

- Aggregation of voice and non-voice services over the network
- CAD/CAM
- Image, including document capture and distribution (e.g., medical imaging)
- Video including broadcast TV, training services, video conferencing
- Multimedia and hypermedia

It is not easy to forecast the growth in network BW requirements and therefore, flexible and scalable technologies will be very important in the future. Structured cabling within the customer premises will support a wide range of network technologies with:

- Continued reliance on high-grade twisted-pair copper cabling to the desk
- Optical fibre across the building and over the campus

Based on the SDHS (Synchronous Digital Hierarchy Standards), a similar case exists for investment in an optical fiber infrastructure for the WAN (Wide Area Network).

Use of high speed network technologies will then involve, partly be the growth in existing applications and partly driven by new applications and

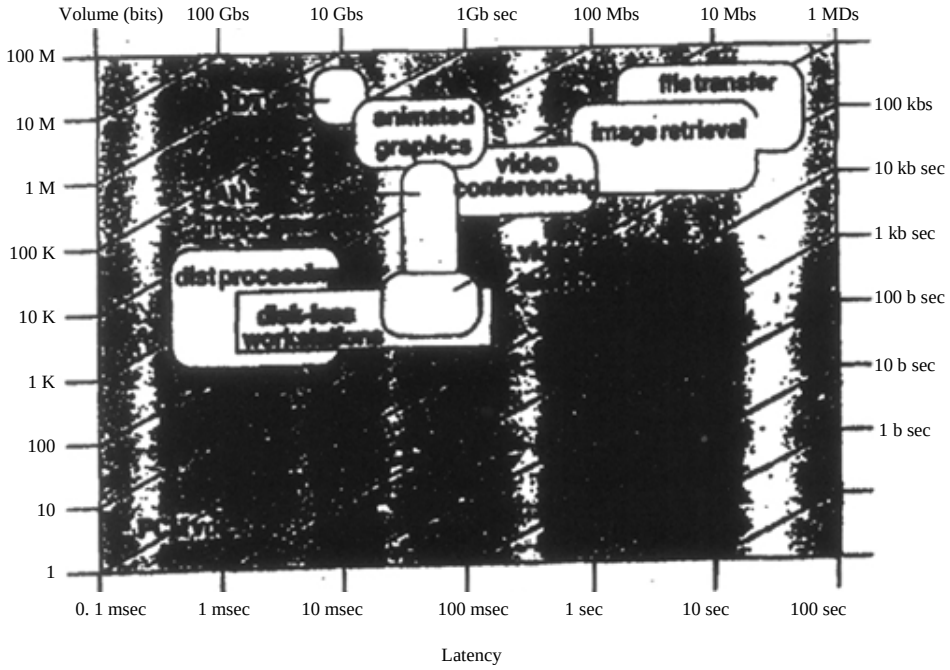

Fig. 2: Volume, latency and bandwidth requirements

opportunities. To put the requirements into perspective, Fig. 2 each application area in terms of BW (Bandwidth), L (Latency) and typical segment lengths transmitted over the communications network.

Example: Image retrieval typically requires the transfer of picture frames of between 500 kbit sec^{-1} and 20 Mbit sec^{-1}, depending upon the resolution or complexity. Applications would typically require access times for retrieved images to be as faxt as 0.5 sec or as long as 20 sec's. Thus, the network (BW) required to accomplish this transaction is then identified by the diagonal lines which will be in the range 25 kbit sec^{-1} to 40 Mbit sec^{-1}.

Increased usage of existing applications: People are making more use of IS/IT in the work place and placing greater demands on the network between systems. This will have major short-term implication for managing traffic.

Traffic sizing and forecasting will become more important. Use of traffic analysis tools will become prerequisite in monitoring quality of service statistics and the growth in traffic BW. "Future proof" network technologies are expected to gain rapid deployment. For example, the use of FDDI (Fiber Distributed Data Interface) technology as a LAN backbone. There will be an increased requirement for effective network management and a higher level of interworking between dissimilar systems. Intra-and inter-LAN traffic is expected to enhance as existing applications each a growing user base and become more heavily utilized. Frame relay will steadily take over from X.25 as evidenced in the USA with over (200) corporate users.

File transfer: This cover the transfer of large blocks of information, typically:

- Download files from host computers to LAN servers
- Word processing documents and spread sheets
- Engineering drawings from a mainframe computer to WS

File transfer is growing steadily but only complex engineering drawings are presently taxing existing network technologies. Documents and spread sheets are expected to remain small (40-60 KB) but will be transferred more frequently by e-Mail in the future. Main frame to server data transfers tend to be once-a-day events, times for off-peak hours.

Thus, file transfer traffic will comprise large blocks of asynchronous data with no serious demands on delivery time. Local file transfer can be accomplished with most generally available LAN technologies, however careful design may be needed to guarantee access and delivery times if a high level of client-client and inter-server traffic exists. Remote file transfer will not.

Client-server architectures: Client-Server architectures exploit cheap processing power in PCs and WS by placing

the application as close to the end user as possible, typically within a powerful LAN server. This overcomes problems of delay/contention for bandwidth associated with earlier system architectures and provides a solid foundation for distributed applications. Client-server computing will enable all resources (e.g., printers, software, fax gateway) to be shared within a work group via. the LAN and will also remove the need for disk based PCs WS The use of peer-peer architectures is increasing rapidly as part of the trend toward establishing the most suitable architectural configuration for an organization. Thus, the high volume of real time requests across a network will require efficient access methods and high BW to achieve fast response, initially within a building them across the wide area as client and servers become geographically distributed. Whilst the burstiness within a network will remain high, the mean traffic level should generally reduce. Client-server architectures will drive the use of high speed LAN-attached WSs (rather than low-speed attachment such as RS 232).

Image-based applications: These applications are appearing in a number of market sectors including:

- Health (medical imaging)
- Finance and the utilities (capturing and storing paper records such as legal documents and customer files),
- Research and engineering (CAD)

These applications will find general use as costs fall-providing, for example on the job assistance in technical environment (text with graphics, scanned documents HD text, picture and desktop publishing). Animated images will also gain popularity as their use becomes established in the services industry (as design and sales tools) and also in training and education. Virtual reality is the ultimate application of animated images/graphics, although, many of the business uses of this technology have yet to be defined.

Most image traffic will initially be within a building (and also within a local user community) but the need for inter-building application is expected to follow.

Thus, the information content of RD images will place significant demands on network BW. For example, 625-line broadcast TV contains 3 Mbit sec^{-1} per frame and many CAD and medical images contain at least 10 Mbit of information[1].

Image transmission would be performed synchronously effectively as a large file transfer. The transport of images within local groups would require a high speed LAN technology such as FDDI, switched CSMAJCD (Carrier Sense Multiple access, Collision Detect) or the emerging 100 Mbit sec^{-1} CSMAJ CD. FDDI could be used to transport image traffic across a building or campus, however, the image traffic would need careful management-particularly if the FDDI was also supporting other applications. Using of ATM switching within the LAN hub and possibly across the building or campus, may have distinct advantages in providing high BWS and efficient LAN interconnection mechanisms[2-4]. Frame relay (a protocol for routing in the Data link Layer) could provide the site-to-site interconnection but once again, the level of image based traffic would need to be carefully managed. SMDS (Switched Multimegabit Data Service) could provide an ideal service within the metropolitan area as this operate at bit rates in the range 2-140 Mbit sec^{-1}. ATM/BISDN would become necessary if the aggregate traffic became excessive (i.e., greater than 100 Mbit sec^{-1}[1, 3, 5]. The resolution of group fax is up to (400) lines per inch which represents an upper limits of (5) Mbit sec^{-1} for an A4. N-ISDN is an ideal transport mechanism for this[6].

Table 1: Communivation services

Variables	Parameters
Voice	64 Kbit sec^{-1}
Music	700 Kbit sec^{-1}
Bit-mapped image	384 Kbit sec^{-1}
Video	70 Mbit sec^{-1}

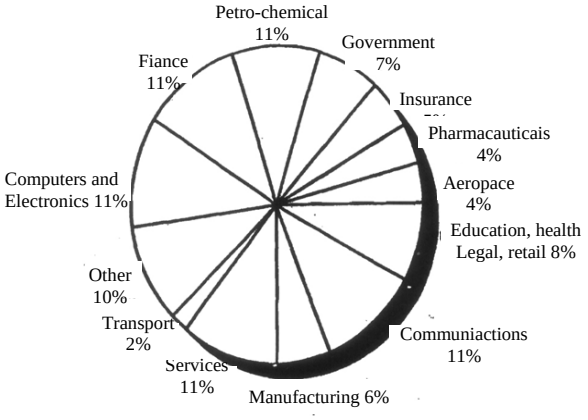

Fig. 3: Use of video conferencing by market sector

Video applications: It include: video telephony, video conferencing, training, bulletins, security surveillance, support of broadcast TV and in -store catalogue shopping (precursor to multimedia). Video telephone will eventually provide a service to the office and the home[7, 8] (Table 1).

Video conferencing is already common place within medium/largabuzatuibs. Figure 3 depicts an analysis of the use of video conferencing which is based on actual purchases made during 2 H9. High quality video supporting broadcast TV and training are supplied today via. off-air receivers and VCRs. Cable service is expected to become more suitable for future high quality video due to congested radio spectrum and the wide BW needed to

accommodate HDTVBISDN will carry distributive video services for commercial, education and entertainment applications in the future[9, 10]. Thus, video conferencing is generally accomplish today (inter-site, inter-organization) at bit rates in the range 64 up to 384 k bits. This could be supported easily and economically by Herr and Plevyak[6] and Wang *et al*.[5].

There are clear financial benefits associated with the integration of video telephony into a WS having a LAN connection plus ISDN, gateway, this being one of the prime objectives of the IEBE 802.9 ISLAN project. Also, video traffic could be carried over FDDI in its packet switched or hybrid switched (FDDI-11) form, although some traffic balancing would be needed in the case of straight packet switched FDDI.

Digital transmission of high quality (uncompressed) video is extremely demanding on BW, channel integrity and delay variance 625-lines PAL, for example would require between 70 Mbit sec^{-1} and 140 Mbit sce^{-1}, depending on whether it was domestic or studio quality[1,8]. Digital, uncompressed HDTV will require (10) times this BW. Future developments in data compression will ease these requirements Today, it is possible (and economically viable) to transfer quality compressed video for presentation in small window at a rate of 1.5 bit sec^{-1}. AMT has recently proposed a 1.5 Mbit sec^{-1} domestic US NTSC TV service to be delivered via. existing twisted pair telephone lines (10).

Voice/audio applications: Interactive voice communications will soon be based on 64 kbit sec^{-1} PCM (pulse code modulation) with Adaptive PCM (ADPCM) techniques following to compress its BW to 32, 16 or even 8 Kbit sec^{-1} (silence not encoded). About 64 kbit sec^{-1} transmission will be used for the majority of interactive voice communications in the local environment (which is mostly cabled and where channel BW not an issue) and ADPCM voice transmission will be used for long distance transmission and for wireless WANs (where channel BW is limited). Real time voice communications will impose end-to-end delay limits on the transmission channel generally maintaining this to within 100 m sec (and often requiring the application of expensive echo cancellers)[1, 11]. Also, real time voice communications will have strict requirements on delay variability, especially when compressed[12]. Voice, messaging applications will not have the same BW or delay variability constraints. Generally, voice communications will not require high channel integrity (i.e, low bit error rate)[1, 12].

Thus, voice messaging can easily be supported by all types of local and wide area network technologies. The transmission of interactive voice services may be supported by technologies which provide isochronous channels (e.g., ISDN, IEEE 802.9 ISLAN, FDDI-II) or ATM[3, 5].

Multimedia/hypermedia applications: Multimedia provide more user-oriented computer systems, targeted at increasing the effectiveness of IT as a vehicle for inter-personal communications and cooperative working[1].

Multimedia include education. training, in-store catalogue shopping and interactive job assistance in technical environment (e.g., repair manuals for distributed multimedia applications initially across a building and eventually across a WAN; Figure. 4 shows the current attitude on the benefits and the barrier for multimedia applications[2, 1, 13-15].

Hypermedia refers to a set of technologies that deals with a new way of organizing and providing associations between different elements of multimedia information. It has the potential to deliver new freedom to users in exploring large amounts of multimedia information. It has the potential to deliver new freedom to users in exploring large amounts of multimedia information at their own place and according to their own interests. Hypermedia will lead to very high levels of user interaction and consequently very low latency! high BW within the communications channel[1, 14]. Thus, the raw (uncompressed) information content associated with high quality communication services are typically as follows:

Compression techniques are available to reduce these high levels of information with video being transferred at bit rates in the range 64 kbit sec^{-1} to 4 Mbit sec^{-1} having acceptable quality for the applications listed above. Real time services (compressed and uncompressed) will need careful control over delay variability within a. PSN (packet switched network).

Table 1 lists the media profiles for the different multimedia applications and their requirements upon the communications network[4].

Unlike the majority of existing networked applications which support single media and homogenous traffic, multimedia networks must carry heterogeneous traffic (i.e., both continuous and bursty, narrow band, low and high quality of service). It is difficult to forecast traffic volumes, due to the bursty nature of some of the media and also the infancy of multimedia applications. The following guidelines have been offered:

The benefits of integration of multimedia service within the communications network are as follows: a single connection, common management, Co-ordinated dialogues and potentially lower costs. ISDN may fulfill some requirements but EIII 802.9 ISLAN may represent a more natural candidate for local access in the

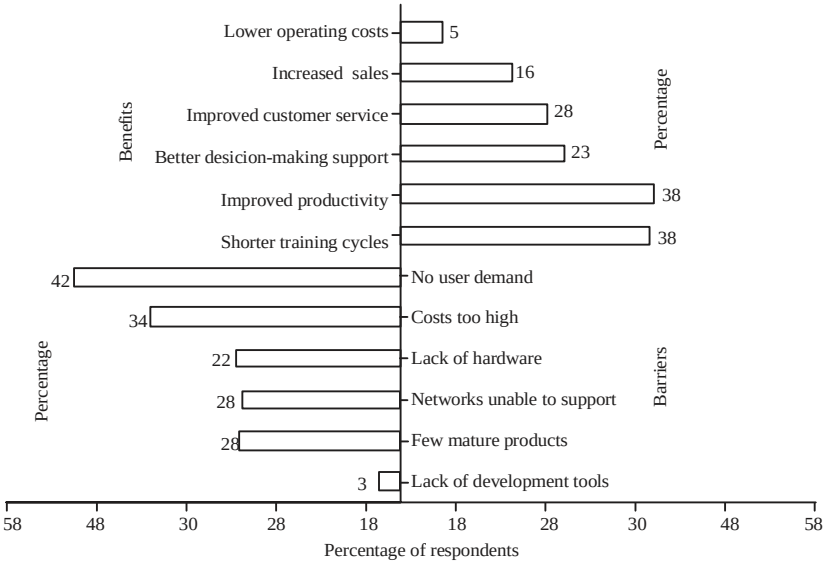

Fig. 4: Benefits and barriers of multimedia applications

Table 2: Multimedia applications

	Media profile						Network requirements		
Application	Voice	Data	Text	Image	Audio	Video	Distributive	Interactive	Bandwidth
Banking	*	*	*	*			H	M	M
Insurance	*	*	*	*			H	M	M
Medical imaging		*	*	*			L	M	H
Real estate		*	*	*	*	*	H	H	M
Education	*	*	*	*	*	*	M	M	M
Distance learning	*	*	*	*	*	*	H	H	H
Advertising			*	*	*	*	H	H	H
Publishing				*	*	*	H	H	H
Travel agency				*	*	*	H	H	M
Co-operative working	*	*	*	*	*	*	L	H	H
Library				*	*	*	H	H	M
Sales			*	*	*	*	H	M	M
Training			*	*	*	*	H	M	M
Medicine	*	*	*	*	*	*	M	M	M
Hypermedia	*	*	*	*	*	*	H	H	H

Table 3: Areas of network technology

Variables	Parameters (Mbit sec^{-1})
LAN-to-LAN	10-100
Image file transfer	10-100
Real time video	45-150

short to medium term. Other LAN technologies with provide necessary guaranteed BW service would include FDDIII (FDDI adapted for digitized voice and date), ATM and possibly choices for cross building/campus use, or perhaps local access (i.e., to the desktop) if cost and performance is appropriate. ATM would represent the ideal area network technology which is referred to as BISDN (Table 2 and 3).

Home working/telecommuting applications: Home working is an increasing trend in our life today and the majority of home workers will require voice, fax and data access to corporate organizations (and vice versa)[1, 8]. Some will also require HD graphics and/or video telephony. The requirement to network home workers into the fabric of corporate organizations will be prevalent in sales, marketing and software development.

Thus, using of dial-up PSTN will give inadequate data throughout for many applications today. Public ISDN will enable a more suitable level of service with the corporate network, providing simultaneous voice and data calls and group TV fax support. There is a requirement for an ISDN to X.25 gateway or better-an ISDN-LAN gateway.

Enterprise/corporate network: No common application, rather the extension of departmental or local area distributed applications such as resource sharing,

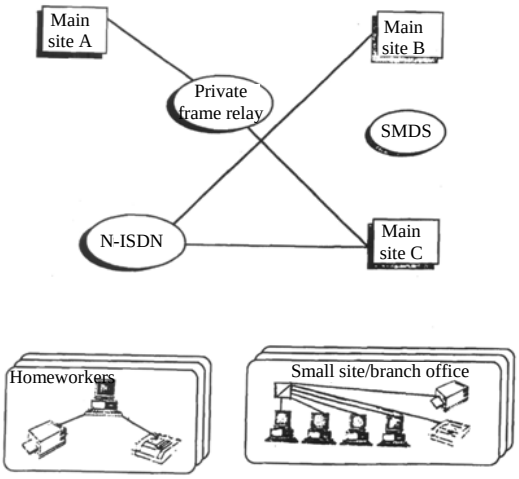

Fig. 5: Advanced high speed network for 2000

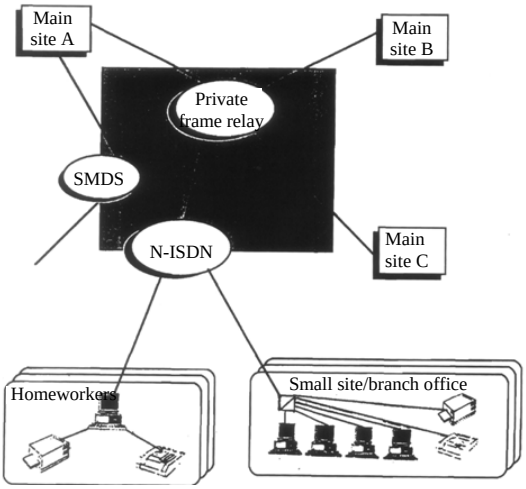

Fig. 6: Advanced high speed network for 1998

peer-peer applications. These applications will need to run such that their unconstrained distribution across the enterprise network is possible[1].

Thus, a requirement for high end -to- end BWS, is to ensure fast response times with burst traffic[1, 2]. FDDI as the LAN backbone should ensure that the majority of building and campus-wide needs are met for the foreseeable future, however, it is indicated that higher BWS may be required soon to support a high level of image based applications. Multimedia applications will represent an excessive load for shared use of existing LANs (Token Ring, CSMA/CD, FDDI) and ATM-back plane switching, hubs will gain popularity in handling HD image! graphics applications. Hybrid LANs (IEEE 802.9. ISLAN and FDDI-II) will represent excellent candidate in the short to medium term if real time applications are supported (voice, video). In the longer-term ATM over LANs may feature as an ideal local transport technology and also as a compatible technology for linking to future generation, Broadband MANs and WANs. Frame Relay will have an essential role to play in the short to medium term, after which time SMDS (Switched Multimegabit Data Service) and -(later) BISDN will perform essential functionals in the wide area network[1].

Inter-enterprise networks: An increasing take up of inter-enterprise networking within the many communities of interest. Applications include ordering/ invoicing etc (traditional EDI), E-mail through to full electronic business applications for multi-enterprise projects (e.g., aerospace industry)[1].

Requirements include high availability high BW, open standards plus effective security and network management, X.4001X.500/EDTFACT standards will be key enablers. Inter-enterprise applications invlove the use of a WAN as a “clearing house” (i.e., value added network’) typically provided by a third party.

Future networking scenarios: Figure 5 depicts an advanced MAN/WAN high speed network. The primary technologies which are expected to be deployed in this scenario are private Frame Relay between remote major sites and the early use of SMDS across the metropolitan area. Both services should operate at data rates of up to 34 Mbit sec^{-1}. N-ISDN services are forecast to have a respectable penetration in the world by the next following years and therefore are expected to provide a powerful communications platform for smaller sites (or branch offices) and home workers, providing 2 Mbit sce^{-1} primary rate connections to branch offices and 144 kbit sce^{-1} basic rate to the home[2, 7, 8].

Figure 6 an advanced MAN/WAN high speed network which should be possible in the next few years. The primary technology which are expected to be deployed in this later scenario are BISDN (ATM) between remote major sites and the continued use of SMDS across the metropolitan area. These services should operate over the established SDH transmission network at data rates between 155 and 622 Mbit sec^{-1}. N-ISDN services are expected to become ubiquitous by this time and will continue to provide a powerful communications platform for smaller sites (or branch offices) and home-workers[1, 3, 7, 8].

CONCLUSION

Business and government organizations depend on IS and their supporting IT to meet business target of improvting services and maximizing limited resources. In the following few years, there will be an increasing

exploitation of IS/fl', especially the use of ISDN. New and more capable network technologies will be needed to respond to increase demand. Nine factors have been mentioned in this study and influencing the ways in which these new networking technologies be deployed. An example for future application was presented. Many trends will cause a dramatic increase in network Bandwidth (BW) requirements over the next years. An example (Image Retrieval) was presented for illustration. Traffic sizing and forecasting will become more important and the use of traffic analysis tools will become prerequisite in displaying quality of service statistics and the growth of traffic BW. File transfer is growing steadily but only complex engineering drawings are presently taxing existing network technologies.

The high volume of real time requests across a network will need efficient across methods and high BW to achieve rapid response, initially within a building, then across the wide area as clients and servers become geographically distributed. Virtual reality is the ultimate application of animated images/graphics, although many of the business uses of this technology have yet to be defined. An advanced MAN/WAN high-speed network was depicted which should be presented in the next few years. The primary technology which are expected to be deployed in this later scenario are BOOM (ATM) between remote major sites and the continued use of SMDS across the metropolitan area.

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