IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re U.S. Patent No. 6,101,534 **Currently in Litigation Styled: Rothschild Digital Media Innovations, LLC v. Sony Computer Entertainment America LLC, Case No. 5:14-cv-03928-PSG** **Issued: August 8, 2000** **Application Filed: September 3, 1997** **Applicant: Leigh M. Rothschild** **Title: Interactive, Remote, Computer Interface System**	**PETITION FOR *INTER PARTES* REVIEW PURSUANT TO 37 C.F.R. § 42.100 ET SEQ.**

Mail Stop *Inter Partes* Review
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

DECLARATION OF DR. VIJAY K. MADISETTI

I, Vijay K. Madisetti, hereby declare the following:

I. BACKGROUND AND EDUCATION

1. A detailed description of my professional qualifications, including a list of publications, awards, and professional activities, is contained in my curriculum vitae, a copy of which is attached as **Appendix A**.

2. I have been a Professor of Electrical/Computer Engineering at the Georgia Institute of Technology ("Georgia Tech") since 1989. I lead several research and educational programs at Georgia Tech in the area of digital signal

processing, embedded computing systems, chip design, wireless and telecom systems, and systems engineering.

3. I earned a Bachelor of Technology (Honors) in Electronics & Electrical Communications Engineering from the Indian Institute of Technology in 1984, and a Ph.D. in Electrical Engineering and Computer Science from the University of California at Berkeley in 1989. I have published extensively, with about 100 technical publications and eight books in the areas of computing, signal processing and communications systems.

4. I am an Institute of Electrical and Electronics Engineers ("IEEE") Fellow and, in 2006, I was awarded the 2006 Frederick Emmons Terman Medal by the American Society of Engineering Education ("ASEE") and HP Corporation for my contributions to electrical engineering.

5. I have authored or co-authored several books and have been an active consultant to industry and various research laboratories (including MIT Lincoln Labs and JHU Applied Physics Laboratory). I have founded three companies in the areas of embedded software, military chipsets, and wireless communications.

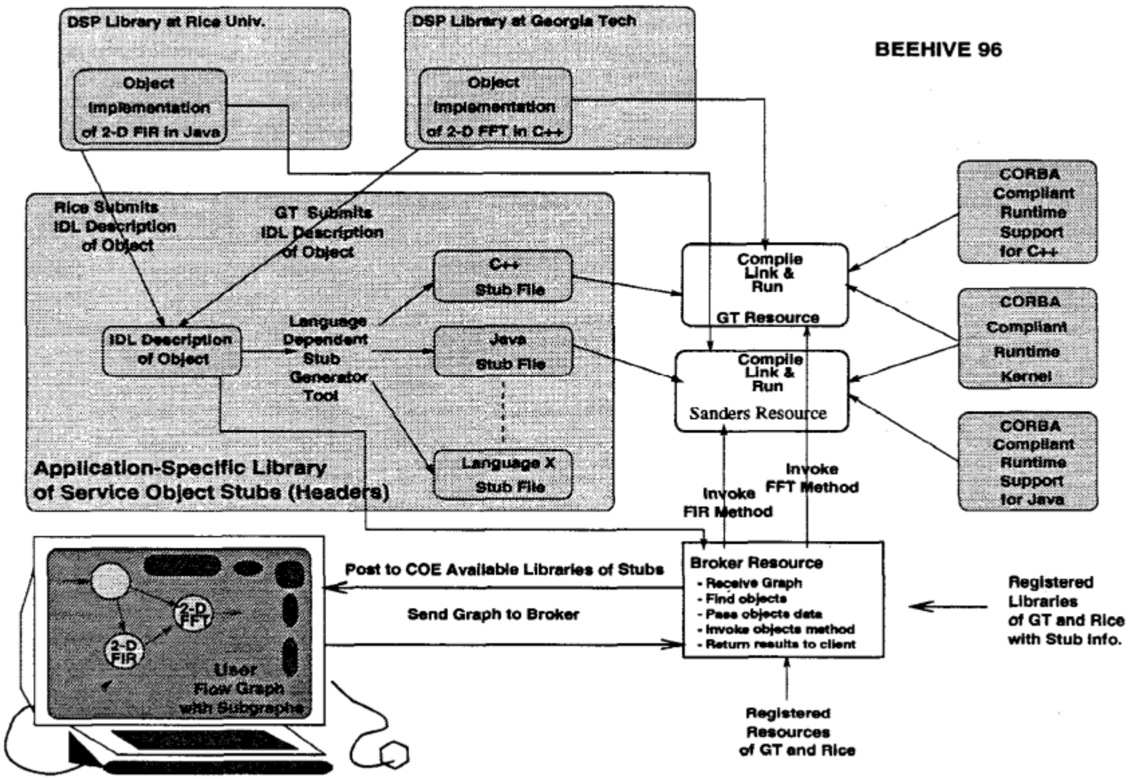
6. I have taught classes at Georgia Tech in the Electrical/Computer Engineering Department since 1989. Class topics have included embedded & networked software systems; wireless & networking; digital signal processing;

speech, audio, video, and image processing; digital signal processing hardware and software; and advanced computing environments.

7. I have been active in the area of development of protocols in the computer networked environment since the late 1980s, starting with my work on "GAFFES: A Design of A Globally Distributed File System" (EECS Technical Report, UCB/CSD-87-361, June 1987), which described early work on security, authentication and replication in the computer network context. I have also developed algorithms for detection of erroneous (or false) information that can be introduced and propagated into computer networks, and developed a preemptive algorithm called WOLF that has been efficient in limiting the propagation by rolling back the effects of incorrect messages within a network. (See *WOLF: A Rollback Algorithm for Optimistic Distributed Simulation Systems*, 1988). I have also published papers in the area of coding theory for secure information storage and retrieval on storage disks and in the area of communications and noise immunity in the context of computer storage networks (See, e.g., "Constrained Multritrack RLL Codes for the Storage Channel," IEEE Transactions on Magnetics, Vol. 31, Issue 3, 1995).

8. From 1996-1997, I collaborated with researchers at Lockheed Martin and the U.S. Army Research Laboratory in a collaborative Research Program (called the "Federated Research Labs Initiative" or "FedLabs") to develop a

networked Java/JNI/C/C++ based system called "*Beehive: An Adaptive Distributed Embedded Signal Processing Environment*" (Proc. IEEE ICASSP 97), where a real-time Java environment sits on top of a Real-Time OS PERC that was based on the Windows and UNIX platforms. Researchers would collaborate across geographically distributed locations by connecting to sensors, devices, servers and clients in a distributed manner to execute distributed signal processing applications. For instance, a researcher at Army Labs would capture data remotely from a sensor and route the video and image data to a server at Georgia Tech over a network, where it would be operated upon by algorithms developed by Georgia Tech faculty and students, and the results would be communicated over a network, and would be displayed at the University of Maryland. The project involved a variety of technologies that allowed distributed processing and control of networked resources, as further described in the BEEHIVE 96 diagram and next paragraph below.



9. The architecture of BEEHIVE version 0.1 system is described as follows, wherein Beehive provided a distributed access from remote objects to local processing and storage ("data stores") devices, and also to input devices (keyboards, sensors, PDAs, and cameras).

3. BEEHIVE V0.1

We will now discuss the current version of BEEHIVE as implemented at Georgia Tech. Java is a programming language of choice because it is architecture-neutral and portable; simpler and more efficient that C++ (with addition of multithread support, and support for real-time); provides support for run-time linking of objects (avoiding extensive recompilation) facilitating plug-and-play; and enjoys extensive support by the networking industry. Real-time extensions to Java are also currently being developed.

BEEHIVE (implemented primarily in Java) comprises of users, resources, services, and brokers as listed below.

Resource Objects: including (a) computational resources (workstations, HPC machines, PCs, special purpose hardware (FPGAs), PDAs, etc.,), (b) data source resources (keyboards, PDAs, cameras, sensors, reuse libraries), (c) data sink resources (displays, data stores, reuse libraries).

Service objects: (a) Java application subroutine libraries, (b) data handling/fusion routines, (c) FPGA/Embedded equivalents of library, (d) control monitors, (3) real-time OS, etc.

Broker objects: Objects which (a) handle requests, (b) maintain list of services, (c) schedule services on resources, (d) ensure stability, latency constraints, efficiency of distributed platform, and correctness, etc.

User COE Interfaces: (a) That request services from brokers through Java stubs or dynamic invocations via a common operating environment (COE) interface, (b) that download applications that run locally on the Java compliant-embedded system, or on remote resources through control procedures contained within the broker to enable rapid, portable, distributed computing.

10. In the 1998-2001 timeframe, I developed an infrastructure for web-based image and signal processing, called WebMPEG, that used efficient transcoding applications written in C/C++ over the Internet through a Java-based Web-based server environment running the Java Native Interface (JNI). *See "Web-Enabled Transcoding for Broadband Residential Networks (BRAN)*" available at http://cse.spsu.edu/yes/pub.htm. As shown in the following architectural diagram

for WebMPEG at that website, one could use WebMPEG to offload complex MPEG video transcoding tasks to a server that would interface with real-time custom hardware processing boards to speed up computation requested by remote clients.

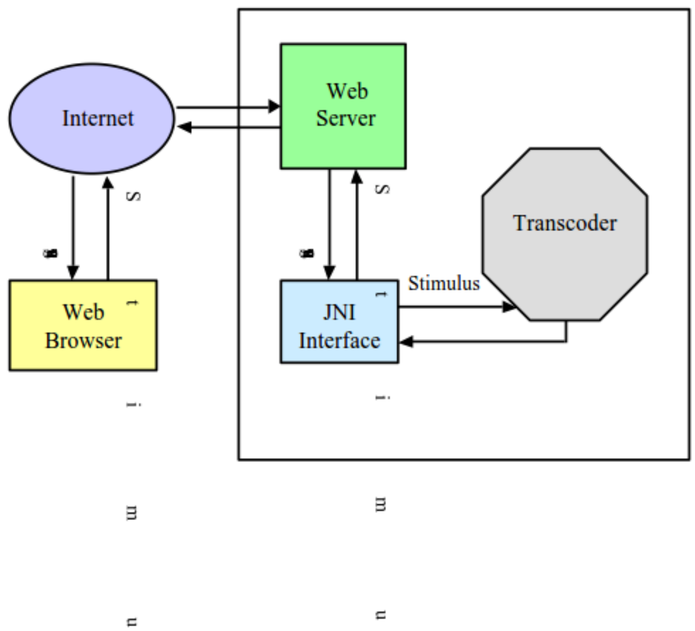


Figure 4.1: Proposed Architecture for WebMPEG.

11. I am knowledgeable and familiar with standards related to the mobile, avionics, wireless and telecommunications systems industries. As shown in **Appendix A**, some of my papers describe the application of these standards in optimizing the design and testing of these systems. I am also knowledgeable and familiar with microprocessor architecture and associated software and firmware design for embedded, wireless and telecommunications terminals and base stations.

12. I have authored, co-authored, or edited several books in the area of computer systems and distributed systems in the past twenty years, including:

- V. Madisetti, VLSI Digital Signal Processors, IEEE Press (1995).
- M. Romdhane, V. Madisetti, J. Hines, Quick-Turnaround ASIC Design in VHDL, Springer Verlag (1996).
- V. Madisett, D. Williams (Editors), The Digital Signal Processing Handbook (First Edition) (1998).
- V. Madisetti (Co-Editor), VHDL: A CD-ROM Interactive Tutorial: Electronics Systems Design Methodologies, IEEE Standards Press, (1997).
- V. Madisetti, A. Arpnikanondt, Platform-Centric Approach to System-on-Chip (SoC) Design (2001).
- V. Madisetti, The Digital Signal Processing Handbook – Second Edition (2009/2010).
- *A.Bahga, V.* Madisetti, Cloud Computing: A Hands-On Approach (2013).
- A. Bahga, V. Madisetti, Internet of Things: A Hands-On Approach (2014).

13. In the past two decades, I have authored several peer-reviewed papers in the area of computers, computer software applications, and software design, and these include:

- V. Madisetti, et al., "*The Georgia Tech Digital Signal Multiprocessor*," IEEE Transactions on Signal Processing, Vol. 41, No. 7, July 1993.
- V. Madisetti, et al., "*Rapid Prototyping on the Georgia Tech Digital Signal Multiprocessor*," IEEE Transactions on Signal Processing, Vol. 42, March 1994.
- V. Madisetti, "*Reengineering legacy embedded systems*," IEEE Design & Test of Computers, Vol. 16, No. 2, 1999.
- V. Madisetti, et al., "*Virtual Prototyping of Embedded Microcontroller-based DSP Systems*," IEEE Micro, Vol. 15, Issue 5, 1995.

- V. Madisetti, et al., "*Conceptual Prototyping of Scalable Embedded DSP Systems*," IEEE Design & Test of Computers, Vol. 13, Issue 3, 1996.
- V. Madisetti, et al., "*Incorporating Cost Modeling in Embedded-System Design*," IEEE Design & Test of Computers, Vol. 14, Issue 3, 1997.
- V. Madisetti, "*Electronic System, Platform & Package Codesign*," IEEE Design & Test of Computers, Vol. 23, Issue 3, June 2006.
- V. Madisetti, et al., "*A Dynamic Resource Management and Scheduling Environment for Embedded Multimedia and Communications Platforms*," IEEE Embedded Systems Letters, Vol. 3, Issue 1, 2011.

14. I have designed and implemented multiple processor networked computing systems that perform multimedia tasks (e.g., speech/audio recognition and video streaming) and avionics/embedded guidance systems since the early1990s, and I have also implemented real-time operating systems in the same time frame. Representative publications include: "*The Georgia Tech Digital Signal Multiprocessor* (DSMP)," IEEE Transactions on Signal Processing, Vol. 41, Issue 7, 1993, and "*Task Scheduling on the Georgia Tech Digital Signal Multiprocessor*," Proceedings of IEEE ICASSP 1992. More recent work that is related to multimedia processing on multiprocessor systems can be found in "*A Dynamic Resource Management and Scheduling Environment for Embedded Multimedia and Communications Platforms*," IEEE Embedded Systems Letters, Vol. 3, Issue 1, 2011. The table and figure below reflect the three generations of Digital Signal Multiprocessors (DSMP's) that were designed at Georgia Tech as part of my research and education efforts.

IEEE TRANSACTIONS ON SIGNAL PROCESSING, VOL. 41, NO. 7, JULY 1993

TABLE II
FEATURES OF THREE GENERATIONS OF DSMP'S

Generation	Name	Processor/Word-length/MFLOPS	Number of Processors	Topology
DSMP-I	OSCAR I	Am29325/32/4	16	2-D grid/torus
DSMP-II	OSCAR-32	WE-DSP32/32/8	2–16	chorded ring
DSMP-III	DSMP-III	TMS320C40/32/40	16–128	3-D grid/torus

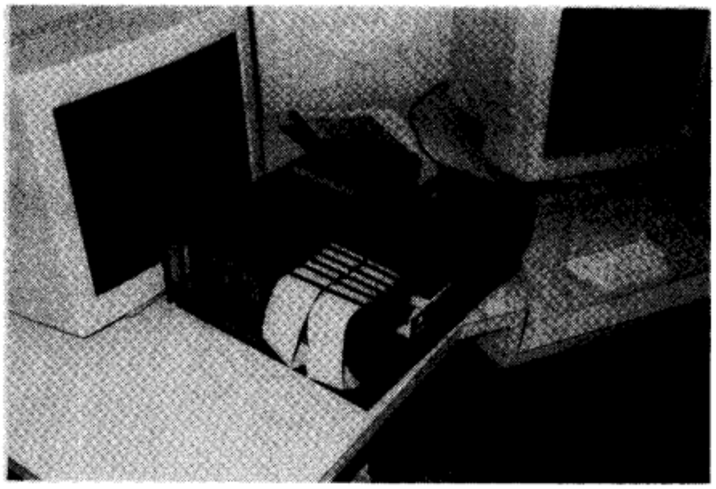


Fig. 10. Six-processor DSMP-II.

15. In collaboration with the U.S. Air Force, Lockheed Martin and Hughes Corporation, I designed and implemented DSMP models for a 192-processor multiprocessor system for processing real-time avionics data (infrared search and track imaging and video applications – IRST), and this represented one of the largest multiprocessor systems used in the mid-1990s timeframe on aircraft. See my publications, "*Virtual Prototyping of Embedded Microcontroller-Based DSP Systems*," IEEE Micro, 1995 (Source of Figure 8 excerpted below), and also "*VHDL Token-Based Performance Modeling for 2D and 3D Infrared Search and Track*," *Proc. SPIE VIUF, 1998*.

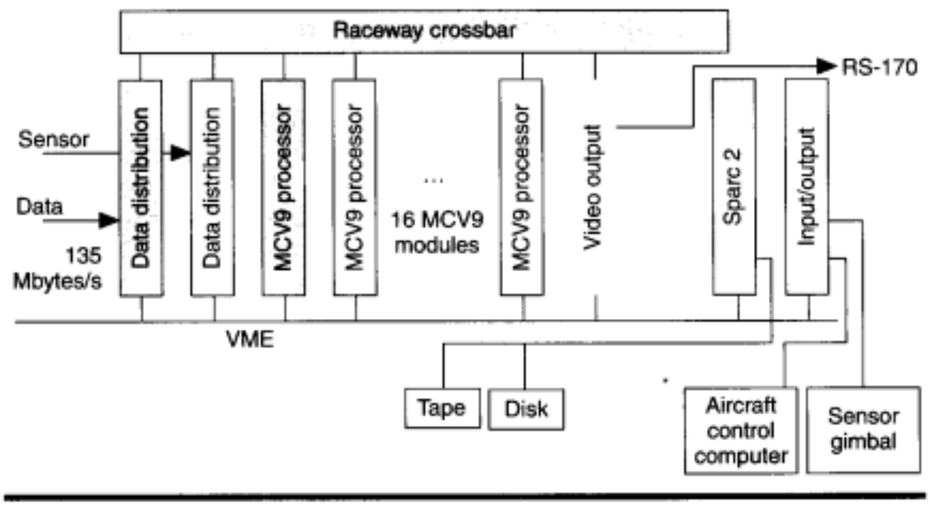


Figure 8. Block diagram of IRST signal processor representing MCV9 boards, data/video distribution, and Sparc cards.[9,11] Shaded components indicate the virtual prototype.

16. I have been active in the area of wireless OFDM-MIMO communications systems for several years. Some of my publications in this area include "*Frequency Dependent Space-Interleaving of MIMO* OFDM *Systems*" Proc. IEEE Radio and Wireless Conference (RAWCON '03), 2003; "*Embedded Alamouti Space Time Codes for High Rate and Low Decoding Complexity*," Proceedings of IEEE Asilomar Conf. on Signals, Systems and Computers, 2008; and "*Asymmetric Golden Codes for Fast Decoding in Time Varying Channels*," Wireless Personal Communications (2011).

17. Additional representative peer-reviewed publications in this area of wireless embedded systems are the following: (i) Turkboylari, M. and Madisetti, V.K., "*Effect of Handoff Delay on System Performance of TDMA Cellular Systems*," 4th International Workshop, Mobile & Wireless Communication Network, pp. 411-415, 2002; (ii) Jatunov, L. and Madisetti, V. K.,

"*Computationally-Efficient SNR Estimation for Bandlimited Wideband CDMA Systems*," IEEE Transactions on Wireless Communications, Issue 12, pp. 3480-3491, December 2006; and (iii) N. Radia, Y. Zhang, M. Tatipamula, V. Madisetti, "*Next Generation Applications on Cellular Networks: Trends, Challenges, and Solutions*," Proceedings on IEEE, Vol. 100, Issue 4, pp. 841-854, April 2012. I have significant experience analyzing, designing, and testing systems based on 3GPP Technical Specifications, including specifications describing WCDMA and HSDPA technologies, primarily used for 3G and 4G communications.

18. More recently, I have co-authored two books: "Cloud Computing: A Hands-On Approach" (2013) and "Internet of Things: A Hands-On Approach" (2014). These books discuss recent developments in security for cloud-based computer networks and networked systems, and these books are already being used as prescribed textbooks by several universities around the world.

19. I have worked as an expert in several legal matters in the prior four years, as identified on my CV.

20. In summary, by the time frame of mid to late 1990s, I have taught, worked, and performed research in the area of distributed computing systems, client-server technologies, distributed multimedia (audio, video, systems), distributed control environments over the internet, and web-based computing systems. I have published extensively in these areas in peer reviewed publications

during the time frame of the '534 patent, and also developed software and product prototypes in related areas.

II. OPINION

A. Level of a Person Having Ordinary Skill in the Art

21. In determining the characteristics of a hypothetical person of ordinary skill in the art of U.S. Patent No. 6,101,534 ("the '534 Patent") at the time of the claimed invention in 1997, I considered several factors, including the type of problems encountered in the art, the solutions to those problems, the rapidity with which innovations are made in the field, the sophistication of the technology, and the education level of active workers in the field. I also placed myself back in the timeframe of the claimed invention, and considered students who I had taught and with whom I had worked at the time. In my opinion, a person of ordinary skill in the art would be a person with: (1) an undergraduate degree in applied mathematics, computer science, computer engineering, electrical engineering, physics, or similar technical fields; (2) a working knowledge of computers and their processing, networking, storage, hardware, and software; and (3) two to four years of experience (or, with a graduate degree in the above-stated fields, one to two years of experience) in software and hardware analysis, design, and/or development related to computer networking, including a working familiarity with server and client communications.

B. Background of Remote Multimedia Systems

22. The solution to the problem in the prior art, according to the description of the '534 Patent, is to provide for enhancement of the online content of real estate viewing software, by accessing auxiliary information for which downloading would not be required (i.e., because the auxiliary data is locally-stored). *See* **Ex. 1001**, '534 Patent at Col. 1:6-13. Thus, a user at a local computer, having access to a CD-ROM or the like which has been previously distributed, is able to go online to access primary site information (e.g., through a website). *See*, *e.g.*, *id.* at Col. 13:43-14:32. When the interaction calls for interactive video, downloading is not necessary because the system accesses the CD-ROM and initiates utilization of auxiliary data stored thereon. *See id.* The auxiliary data is stored at specific auxiliary site addresses so that the data is readily accessible when needed. *See id.*

23. However, this stored auxiliary data solution has been known to one of ordinary skill in the art well before the time of the purported invention of the '534 Patent, and the so called "CD ROM/Online Hybrids" model uses a stored auxiliary data solution and has been described in open and published literature in a variety of contexts (online course delivery and education, online video delivery, etc.). For instance in "*CD-ROM/Online Hybrids: The Missing Link*" by Richard R. Reisman, in CD-ROM Professional, *Vol 7, No. 4, April 1995* (attached as **Appendix B**), it is disclosed that:

i. "In the online oriented model, supplemental CDs can be sent monthly to subscribers for us in conjunction with their online sessions. The first such CD was delivered by CompuServe in June 1994, and similar offerings are expected from America Online." *Id.* at 3.

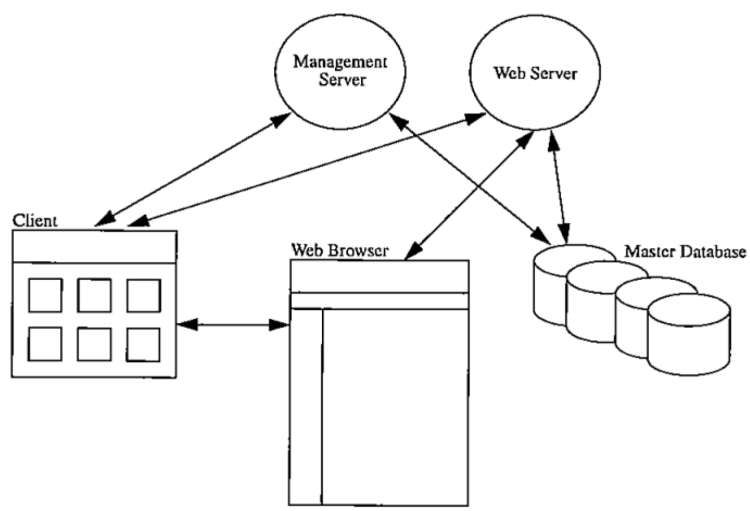
ii. "In an online oriented hybrid, the supplementary information distributed on a CD can be artfully integrated during an online session to enhance the online experience." *Id.*

iii. "Teleshuttle Corporation offers a specialized service that fills a critical gap in producing CDROM and online hybrid products." *Id.* at 4.

iv. "Another variant is to expand on the simple fetch-on-demand operation. For example, fetches may be automatically scheduled based on update availability, or be delayed to an off-hour, low cost period. A more advanced option would be to shift from a user-triggered "pull" to a *publisher-triggered "push" operation*. One of ordinary skill in the art would understand that the publisher triggered push is a combination of information and command from a remote server (i.e., the publisher) that directly accesses and controls the local storage contents and addresses associated with the local CD ROM". *Id.* at 7.

24. Other widely-known approaches to hybrid CDROM-Online delivery existed at the time as well. In "*Purdue-On-Line: A Facility and Distributed Learning Framework to Develop and Deliver Internet based Education,*" by Elias Houstis, et al, Computer Science Technical Reports, Purdue University, Oct. 2, 1997 (attached as **Appendix C**), the authors use the next two figures reproduced below to help describe a system that has been in use, prior to Oct. 2, 1997, by Purdue University in delivering online educational courses to students.

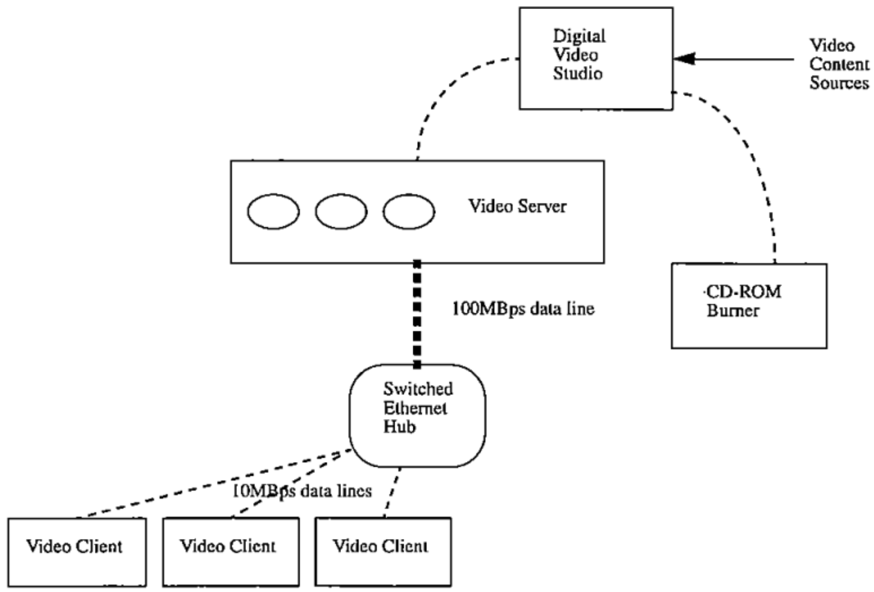
FIGURE 2. Architecture of the POL Virtual Classroom Environment: Functional View



25. As shown in the figure below, the Purdue-On-Line (POL) environment distributed video as supplemental information on a CD-ROM that is sent separately to users and to be used in conjunction with the online content (that refers to the local CD-ROM content/addresses) that is delivered over the internet from the remote

server. The delivered information and commands from the remote server would control and access the local addresses associated with the local CD ROM.

FIGURE 3. Architecture of the POL Video Environment



7.2 Virtual Course Content on CD-ROM Media

As mentioned above, video content delivery via the Internet is not yet feasible. An alternative is to burn CD-ROMs with the video content and deliver that via regular mail to course participants and have Web-based content refer to the local CD-ROM for video material. We are purchasing a CD-ROM burner to support this activity.

26. Before the time of the claimed invention of the '534 Patent, it was also well-known to use multiple methods for distribution of multimedia content from a remote server to a local client over several different types of transport pipes: internet, broadcast television, satellite, to name a few. *See*, *e.g.*, Nortbert Gerfelder, "Video Applications in the Era of Computer Networks – Computer & Video = Multimedia," Proceedings of 137th SMPTE Technical Conference and World Media Expo," New Orleans, September 6-9, 1995, pp. 54-68 ("Gerfelder") (attached as **Appendix D**).

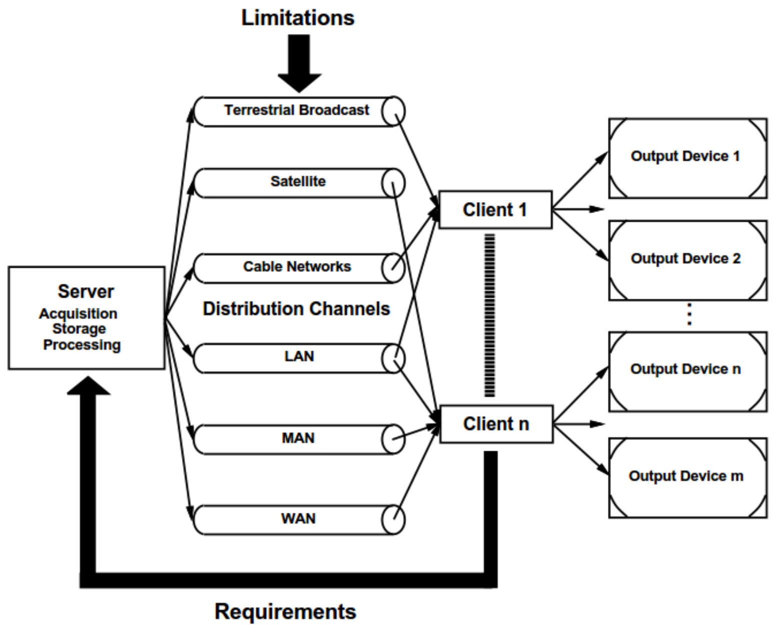


Fig. 2: Communication model for distributed multimedia systems

27. The '534 Patent also specifies that, in the preferred embodiment, access to auxiliary site addresses by the local processor is restricted, "unless the access is directed by the remote server assembly." *See* **Ex. 1001**, '534 Patent at Col. 14:33-15:2. Stated another way elsewhere in the '534 Patent specification, also describing the preferred embodiment, the remote server assembly initiates utilization of selected auxiliary site data by a local processor, and the auxiliary site data includes "operating instructions" which serve "to instruct the local processor assembly to generate various display images …." *See id.* at Col. 5:40-6:5. The stated purpose of this restriction is to prevent the user from utilizing auxiliary site data (e.g., data stored on the CD-

ROM) unless the use is in conjunction with a visit to a particular website or content provider that is providing the primary site data. *See id.* at Col. 14:33-15:2.

28. Before the time of the claimed invention of the '534 Patent, it was also well-known to use a network of computers, each with information stored on a CD-ROM, to make this information available to remote computers over the Internet as part of distributed libraries and archives. Thus, remote users would control access to data and addresses in local CD-ROMs stored at digital libraries. This is another example of how controlling addresses and data stored at local CD-ROMs was routinely performed in the early1990s as part of digital libraries in the U.S. and abroad. *See*, *e.g.*, J. Marshall, "*Networking Biomedical Information on CD-ROM at the Walter and Eliza Hall Institute of Medical Research*", Information Transfer: New Age – New Ways, 1993, pp. 285-288 (*Proceedings of Third European Conference on Medical Libraries*, France, September 23-26, 1992) (attached as **Appendix E**). Similarly, in "*Hello Users: This is Control or CD ROM Access for All,*" by S. Berta, in *ACM SIGUCCS XXI*, 1993 (attached as **Appendix F**), a service to allow network CD-ROM access to remote users at the University of Delaware was described, expanding access of CD-ROM-based reference materials, which were previously only accessible to users physically present in a library room, to users anywhere on the network. In all these instances, one of ordinary skill in the art would understand that

the remote server (supporting the remote user) would be accessing and controlling data and addresses associated with a local CD-ROM over a network.

29. The background examples I provide above, which comport with my memory of the relevant time period, make clear that CD-ROM and online hybrid systems were very common at the time of the claimed invention of the ‘534 Patent.

30. I describe below straightforward combinations of the following prior art references: U.S. Patent No. 5,892,825 to Mages et al. (“Mages”); U.S. Patent No. 5,724,103 to Batchelor (“Batchelor”); a 1996 printed publication titled “VEMMI: a new On-line Client/Server Multimedia Protocol for the Internet” (“VEMMI”); U.S. Patent No. 5,861,881 to Freeman et al. (“Freeman”); and U.S. Patent No. 5,736,977 to Hughes (“Hughes”). These combinations would render claims of the ‘534 Patent obvious under 35 U.S.C. § 103(a), with the results being very predictable, and with the combinations not requiring undue experimentation. The benefits of these combinations would have included increased server control of, and access to, data stored on a local CD-ROM. The benefits would also have included improved server-client communications, providing for improved display of locally stored multimedia content in connection with remotely stored content from a server. As such, a person of ordinary skill in the art would have been highly motivated to combine the prior art.

C. Legal Framework

31. I understand that a patent claim is not patentable under 35 U.S.C. § 103 if the differences between the patent claim and the prior art are such that the claimed subject matter as a whole would have been obvious at the time the claimed invention was made to a person having ordinary skill in the art to which the subject matter pertains. Obviousness, as I understand it, is based on the scope and content of the prior art, the differences between the prior art and the claim, the level of ordinary skill in the art, and, to the extent that they exist and have an appropriate nexus to the claimed invention (as opposed to prior art features), secondary indicia of non-obviousness.

32. I have been informed that whether there are any relevant differences between the prior art and the claimed invention is to be analyzed from the view of a person of ordinary skill in the art at the time of the invention. As such, my opinions below as to a person of ordinary skill in the art are as of the time of the invention, even if not expressly stated as such; for example, even if stated in the present tense.

33. In analyzing the relevance of the differences between the claimed invention and the prior art, I have been informed that I must consider the impact, if any, of such differences on the obviousness or non-obviousness of the invention as a whole, not merely some portion of it. The person of ordinary skill faced with a

problem is able to apply his or her experience and ability to solve the problem and also look to any available prior art to help solve the problem.

34. An invention is obvious if a person of ordinary skill in the art, facing the wide range of needs created by developments in the field, would have seen an obvious benefit to the solutions tried by the patent applicant. When there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, it would be obvious to a person of ordinary skill to try the known options. If a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique would have been obvious.

35. It is my understanding that a precise teaching in the prior art directed to the subject matter of the claimed invention is not needed and that one may take into account the inferences and creative steps that a person of ordinary skill in the art would have employed in reviewing the prior art at the time of the invention. For example, if the claimed invention combined elements known in the prior art and the combination yielded results that were predictable to a person of ordinary skill in the art at the time of the invention, then this evidence would make it more likely that the claim was obvious. On the other hand, if the combination of known elements yielded unexpected or unpredictable results, or if the prior art teaches

away from combining the known elements, then this evidence would make it more likely that the claim that successfully combined those elements was not obvious.

36. I understand that hindsight must not be used when comparing the prior art to the invention for obviousness.

37. It is my understanding that obviousness may also be shown by demonstrating that it would have been obvious to modify what is taught in a single piece of prior art to create the subject matter of the patent claim. Obviousness may be shown by showing that it would have been obvious to combine the teachings of more than one item of prior art. In determining whether a piece of prior art could have been combined with other prior art or combined with or modified in view of other information within the knowledge of one of ordinary skill in the art, the following are examples of approaches and rationales that may be considered:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of a known technique to improve similar devices (methods, or products) in the same way;
- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

- Applying a technique or approach that would have been "obvious to try" (choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success);
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art; or
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

38. I understand that the rationale for modifying a reference and/or combining references may come from sources such as explicit statements in the prior art, or the knowledge of one of ordinary skill in the art, including any need or problem known in the field at the time, even if different from the specific need or problem addressed by the inventor of the patent claim.

39. I understand that even if a *prima facie* case of obviousness is established, the final determination of obviousness must also consider "secondary considerations" if presented. In most instances, the patentee raises these secondary considerations of non-obviousness. In that context, the patentee argues an invention would not have been obvious in view of these considerations, which include: (a) commercial success of a product due to the merits of the claimed invention; (b) a long-felt, but unsatisfied need for the invention; (c) failure of

others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention within a comparatively short space of time; and (h) teaching away from the invention in the prior art.

40. I further understand that secondary considerations evidence is only relevant if the offering party establishes a connection, or nexus, between the evidence and the claimed invention. The nexus cannot be to prior art features. The establishment of a nexus is a question of fact.

D. Mages and Batchelor

41. I have been asked to consider the combination of Mages and Batchelor, and it is my opinion that it would have been obvious to a person having ordinary skill in the art to combine the command and address information sent from the server in Batchelor with the system and functionality described in Mages.

42. One of ordinary skill in the art would understand Batchelor to disclose a server that sends both video and associated text/binary data/commands that is broadcast over a packetized and digital network (i.e., satellite or cable). **Ex. 1004**, *Batchelor* at Col. 2:10-25, Col. 3: 1-25, Col. 3: 27-45. Batchelor also discloses that the video signals and associated data/text/binary commands may be stored in digital packetized format at the transmitter. *Id.* at Col. 3:1-50. Gerfelder discussed

above also provides a disclosure of a remote server broadcasting video/data to local clients over a satellite and/or cable network. One of ordinary skill in the art at the time of the claimed invention of the '534 Patent would also know that transmission over cable would utilize digital packetized standards supporting the internet protocol, such as ANSI/SCTE 136-2 2013 and referenced standards. See also U.S. Patent No. 5,534,913 to Majeti et al., filed on March 31, 1994, for examples of computers accessing the internet over a cable modem/connection/network. Thus, one of ordinary skill in the art at the time would have recognized that similar digital, packetized data could be transmitted over cable or satellite regardless of whether it is being transmitted in use of the internet or some other data or broadcast network.

43. Similar to Batchelor, and in the same field of endeavor, Mages describes a system wherein a remote server communicates video and data with a local computer to cause data on a CD-ROM to be made readable. Mages describes a method of "triggering video and/or audio data on a "HyperCD" (CD-ROM) via a trigger through a network for instant local access of encrypted data on local media." *See* **Ex. 1005**, *Mages* at Abstract; see also *id.* at 1:22-25. Mages recognized that, at the time, there were drawbacks to transmitting video images over the Internet, due to download speeds and time delays. *See id.* at 3:28-52. Mages described including audio and video information encoded on a local CD-ROM that could be uncrippled by

triggering data sent from a server over the Internet. *See id.* at 3:62-4:6. Mages also explained that the server might send additional real-time data to supplement, and to be used in conjunction with, the data stored on the CD-ROM. *See id.* at 4:65-5:10. Mages also describes that "specific tracks" of a CD-ROM may be "controlled by the remote sever", thereby providing better control to a company on the Internet over its content. *Id*. at 4:7-17. One of skill in the art at the time would understand that CD-ROMs at the time, including that described in Mages, had a specific structure, such as according to the ISO 9660 standard, that would keep data in separate tracks such that a direction to access a specific track would not access any other information on the CD-ROM.

44. To the extent that sending the triggering data does not constitute a remote server accessing addresses and data on a local data storage device, as claimed by the '534 Patent, then it is my opinion that a person of skill in the art could have found this capability in Batchelor. *See*, *e.g.*, **Ex. 1004**, *Batchelor* at Col. 2:49-54 ("The CPU 32 receives the data separated from the video signal by the VBI decoder 26. The data typically contains command and address information that instruct the CPU 32 to retrieve specific text and graphic information from the optical disk 38 and display the information on the computer monitor 30."). More specifically, it is my opinion that a person of ordinary skill in the art at the time of the '534 Patent who read about the remote command and address information disclosed in Batchelor

would have understood they could have added that concept to the system disclosed in Mages. Given the server-client communications disclosed in Mages, adding command and address information would have required only a modest amount of additional data sent from the server. Thus, this addition would have accomplished one of the stated goals in Mages of server control, and would have done so without disrupting the other advantages of the online and CD-ROM hybrid system described in Mages. *See* **Ex. 1005**, *Mages* at 4:7-17; 4:43-46. The clear benefit would be improved server control of access to information stored on the local CD-ROM.

45. One of ordinary skill in the art would recognize that both Batchelor and Mages addresses the same types of problems (video and multimedia communications over a network) and include controlling local resources, such as CD-ROMS. Therefore, a skilled artisan would have been motivated to combine their teachings.

46. This combination is nothing more than adding command and address information from Batchelor to the data already being transmitted between the server of and client in Mages. One of ordinary skill would have achieved this modification by merely programming the remote server of Mages to include command and address information in the transmitted data. This combination, therefore, simply expands upon the teachings of Mages directed to server control of locally stored media data.

47. Therefore, upon reading the disclosure of Batchelor, a skilled artisan would have recognized that modifying the system of Mages to include the command and address information, as described in Batchelor, would be desirable.

48. This would have been natural and nothing more than the application of ordinary skill and common sense to combine the command and address information as instructions disclosed in Batchelor to the already transmitted data as described in Mages.

49. Accordingly, it is my opinion that it would have been obvious to a person having ordinary skill in the art to combine the command and address information as an instruction, as disclosed in Batchelor, with the system and functionalities described in Mages. This combination could have been accomplished using known methods in the art, and would have yielded predictable results without undue experimentation.

C. Mages and VEMMI

50. I have been asked to consider the combination of Mages and VEMMI, and it is my opinion that it would have been obvious to a person having ordinary skill in the art to combine the communications protocol of VEMMI with the system and functionality described in Mages.

51. VEMMI is an international standard (ETSI 300 382, ETS 300 709, and ITU-T/CCIT T.107), called VEMMI: Enhanced Man-Machine Interface for

Videotex and Multimedia/Hypermedia Information Retrieval Services. *See* **Ex. 1006**, *VEMMI*. As shown in the following excerpt, VEMMI is used for online multimedia, video and hypermedia services that can be accessed from any user at a PC using a VEMMI client to access the remote multimedia server over the Internet.

- *VEMMI is readily available on most personal computers (PC/Windows 3.1, 3.11, 95, Mac,...). It allows then the on-line multimedia services to be reached by anybody.*
- *from a technical standpoint, VEMMI offers all the features required by advanced today and tomorrow multimedia on-line services:*
  - *interactive multimedia session in the current user's terminal operating system and graphic user interface (Windows, MacOS, OS/2, Motif, and so on...).*
  - *object-oriented programming.*
  - *support of numerous data formats for text, sound, photo, moving video,...*
  - *bi-directional data transfer and local data and object storage on the personal computer.*
  - *activation of local programs on the personal computers during the multimedia session, allowing to extend the VEMMI functionalities as needed.*
  - *and so on...*

Ex. 1006, *VEMMI* at 2 (emphasis added).

52. VEMMI allows for bi-directional data transfer and local data and object storage on the local PC and activation of local programs under the control of the remote server during multimedia sessions. *Id.*

53. As shown in the following excerpt, VEMMI can be used for real-time applications, such as real-time interactive video, where the remote server over the Internet can control video and data stored on a local CD-ROM.

Real-Time capability

VEMMI may be used for real-time applications. To the difference of MHEG-5, VEMMI has not been designed for real-time interactive video (mainly because the synchronization mechanisms provided by MHEG-5 are not included in VEMMI right now), but it could nevertheless be used in numerous real-time multimedia applications:

- *any multimedia on-line services using text, images, sounds and video (with some restrictions regarding video, see below).*
- *video data stored on a local disk or CD-ROM and whose display is controlled by the remote server.on-line video, if the data throughput between the VEMMI client and server is sufficient. The release 3 of the standard will expand VEMMI capabilities regarding on-line video.on-line audio. The ADPCM facilities of VEMMI could be used in order to allow efficient on-line audio data transfert on slow lines.*

Id. at 7 (emphasis added).

54. VEMMI allows applications to use data that is already stored on the local PC or computer, and this avoids the transmission delay of communications and addresses the very same problem as that of the '534 Patent. For instance, in a VEMMI teleshopping example excerpted below (similar to the real-estate application in the '534 Patent), a combination of local video/data could be viewed under the control of the remote server by the user of the local PC or computer. *Id.* at 7. These local objects could be present in CD-ROMs or could be transmitted initially by the host and then later on used during the video and interactive teleshopping session. In both cases, the remote server would control and access addresses and content on the local CD-ROM, while the local PC would not have access to them.

Local storage and file transfer

In many multimedia applications, large data must be displayed or used: pictures, sound, moving video, data, executable programs, and so on...

The transmission of these data may require a long time, even when medium speed networks as ISDN are used. ***VEMMI allows to use and display data already stored in the user personal computer****, then avoiding both the transmission delay and the associated communication cost.*

Several methods may be used:

- *the information provider may store some objects on a floppy disk transmitted to the user, for example along with the VEMMI client software.*
- *if huge or numerous objects must be stored, the best way is to use a CD-ROM that is for example very well suited to teleshopping applications.*
- *an middle way is to transmit the objects during the first session and to store them on the personal computer disk. It could then be used again during future sessions.*

Id. at 7 (emphasis added).

55. Similar to VEMMI, and in the same field of endeavor, e.g., server/client communications over networks, Mages describes a system wherein a remote server communicates video and data with a local computer to cause data on a CD-ROM to be made readable. *See*, *e.g.,* **Ex. 1005**, *Mages* at 1:22-25. Mages recognized that, at the time, there were drawbacks to transmitting video images over the Internet, due to download speeds and time delays. *See id.* at 3:28-52. Mages described including audio and video information encoded on a local CD-ROM that could be uncrippled by triggering data sent from a server over the Internet. Mages also explained that one goal of the described system was server control of local media data. *See id.* at 4:7-17; 4:37-46.

56. One of ordinary skill in the art would recognize that both VEMMI and Mages addresses the same types of problems (video and multimedia communications over a network from a remote server to a local PC) and include controlling local

resources, such as CD-ROMS. Therefore, a skilled artisan would have been motivated to combine their teachings.

57. The combination of Mages with VEMMI is nothing more than adding features of VEMMI to Mages. A skilled artisan would have realized that adding these features would be beneficial, and that this modification could be carried out in a predictable manner with predictable results. The combination does not do more than expand on the teachings in a predictable manner, requiring nothing more than common sense, without requiring undue experimentation.

58. Therefore, upon reading the disclosure of VEMMI, a skilled artisan would have recognized that modifying the system of Mages to include server control of locally stored data, as described in VEMMI, would be desirable.

59. This combination is nothing more than adding server control functionality from VEMMI to the data already being transmitted between the server and client in Mages. One of ordinary skill would have achieved this modification by simply programming the server to include control instructions into the transmitted data in Mages. This combination, therefore, simply expands upon the teachings of Mages directed to server control of local media data.

60. This would have been natural and nothing more than the application of ordinary skill and common sense to combine the server control disclosed in VEMMI to the already transmitted data described in Mages.

61. Accordingly, it is my opinion that it would have been obvious to a person having ordinary skill in the art to combine the server control as disclosed in VEMMI with the system and functionalities described in Mages. This combination could have been accomplished using known methods in the art, and would have yielded predictable results without undue experimentation.

D. <u>Batchelor and Freeman</u>

62. I have been asked to consider the combination of Batchelor and Freeman, and it is my opinion that it would have been obvious to one of ordinary skill in the art to combine the functionality of Batchelor with the functionality of Freeman. In my opinion, it would have been obvious to combine the system and functionality of Batchelor with the remote server and two-way communications described in Freeman.

63. Both Batchelor and Freeman describe systems relating to communication of multimedia/streams video over a computer network consisting of servers and clients. The video streams of Freeman may be received from a broadcast transmission source or may be resident on local or external storage. *See* **Ex. 1007**, *Freeman* at Abstract. Use of cable and Internet networks is also disclosed in Freeman. *See id.* at 6:45-65.

64. Freeman describes the configuration of video servers and client stations as noted in Figure 4 of Freeman, which is reproduced below. The video

and data streams may be resident in local and external storage, including CD-ROM. *See id.* at 2:10-15; Fig. 4.

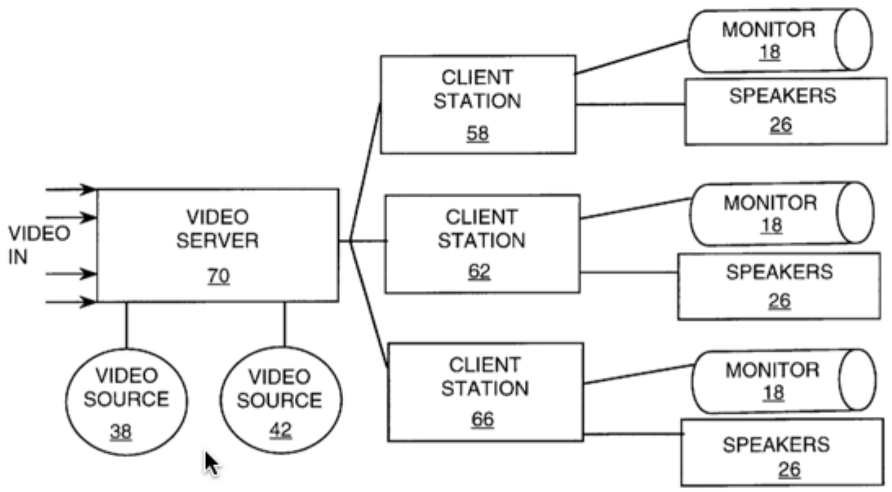


Figure 4

65. Freeman also discloses the use of "Trigger points" and associated codes or commands from the remote video server that can access and control addresses linked with multimedia audio and video segments stored on the local CD-ROM. *See id.* at 6:3-23; 19:40-47.

66. Since Batchelor and Freeman disclose functionality in the same field of endeavor and solve similar problems (distribution of multimedia video while accessing and controlling local storage media, such as CD ROMs), one of ordinary skill in the art would be motivated to combine the teachings of Batchelor and

Freeman, and these teachings would add to their functionality in a predictable manner with predictable results.

67. Therefore, upon reading the disclosure of Freeman, a skilled artisan would have recognized that modifying the system of Batchelor to include the remote server assembly and two-way communication described in Freeman would be desirable. This combination would have been desirable and one would have been motivated to make such a modification given the increased use of networked communications, such as over the Internet, at the time.

68. This combination does not require anything more than utilizing a remote server connected over a network, such as the Internet, as described in Freeman with the system and functionalities described in Batchelor. This combination, therefore, simply expands upon the teachings of Batchelor directed to server-client communications.

69. This would have been natural and nothing more than the application of ordinary skill and common sense to combine the server architecture disclosed in Freeman to the existing network described in Batchelor, but using the same or similar packetized commands and address information of Batchelor.

70. Accordingly, it is my opinion that it would have been obvious to a person having ordinary skill in the art to combine the two-way server communication of Freeman with the system and functionalities of Batchelor. This

combination could have been accomplished using known methods in the art, and would have yielded predictable results without undue experimentation.

E. <u>Mages and Batchelor and Hughes</u>

71. I have been asked to consider the combination of Mages and Batchelor and Hughes, and it is my opinion that it would have been obvious to a person having ordinary skill in the art to combine the floor plan and three-dimensional walk through display functionality described in Hughes with the Mages and Batchelor combination discussed above.

72. Like Batchelor and Mages, Hughes discloses audio/video presentations made over a network from a remote server to a local client, that also has a CD-ROM for local storage at a regional office. *See* **Ex. 1008**, *Hughes* at 3:35-45. The video stream is displayed locally in conjunction with video and audio data stored on the local CD-ROM at the local regional offices.

73. One of ordinary skill in the art would understand Hughes to disclose the functionality in same field of endeavor and solve similar problems as those in Batchelor and Mages (distribution of multimedia video over a network while accessing and controlling storage media and addresses on a CD-ROM). Therefore, one of ordinary skill in the art would be motivated to combine the teachings of Hughes with Batchelor and Mages, and these teachings would add to their

functionality in a predictable manner with predictable results at the time of the claimed invention of the '534 Patent.

74. Therefore, upon reading the disclosure of Hughes, a skilled artisan would have recognized that modifying the combination of Mages and Batchelor to include the walk through video files and floor plans on a local CD-ROM, as described in Hughes, would be desirable. This would be consistent with Mages and Batchelor's desire to reduce the amount of data transmitted over a network and provide a more efficient way for a real estate company to provide purchasers with a "feel" of visiting a property, as contemplated by Hughes.

75. This combination is nothing more than adding the walk through videos and floor plan data from Hughes to the combination of Mages and Batchelor. One or ordinary skill would have achieved this modification by merely adding the data to a local CD-ROM in the combination of Mages and Batchelor. Further, as with the combination of Mages and Batchelor, the remote server would send instructions to display specific walk through and floor plan data contained on the local CD-ROM. This combination, therefore, simply expands upon the teachings of Mages and Batchelor to include the data disclosed in Hughes on the local CD-ROM and would have been natural and nothing more than the application of ordinary skill and common sense

76. Accordingly, it is my opinion that it would have been obvious to a person having ordinary skill in the art to combine Hughes, Mages and Batchelor such that a remote server instructs the local computer to display walk through video and floor plans contained in specific tracks of a locally stored CD-ROM in conjunction with information received from the remote server. This combination could have been accomplished using known methods in the art, and would have yielded predictable results without undue experimentation.

III. CONCLUSION

77. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: 6/9/15

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- 1984-1989: Post Graduate Researcher (UC Berkeley),
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Startup Companies:

Director, **VP Technologies, Inc**. (1995-): A startup commercialized through Georgia Tech's Advanced Technology Development Corporation (ATDC) focusing on digital IC development and interconnect/memory for military market. http://www.vptinc.com

Director, **Soft Networks, LLC** (2001-2007): A startup commercialized through Georgia Tech support focusing on software development tools and compilers for Cellular/WiFi/VOIP/telecommunication products. http://www.soft-networks.com

Director, **Elastic Video Inc.** (2007- 2009): A startup commercialized through Georgia Tech's VentureLab (http://venturelab.gatech.edu) development image and video processing software for wireless & IP networking.

Litigation Experience (2010-2015)

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Expert for Mformation
(Mobile Device Management: 2010-2012)

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Technical Work Performed on Legal Matters (Pre-litigation/IPR/Rexams): Ericsson (2011, 3G/WiFi), KPN (2014, 3G), Sharp (2014, WiFi), Ubisoft (2015), Kia Motors (2014, Security Systems)

Earned Degrees

1. **B. Tech (Hons), Electronics & Electrical Comm. Engineering**
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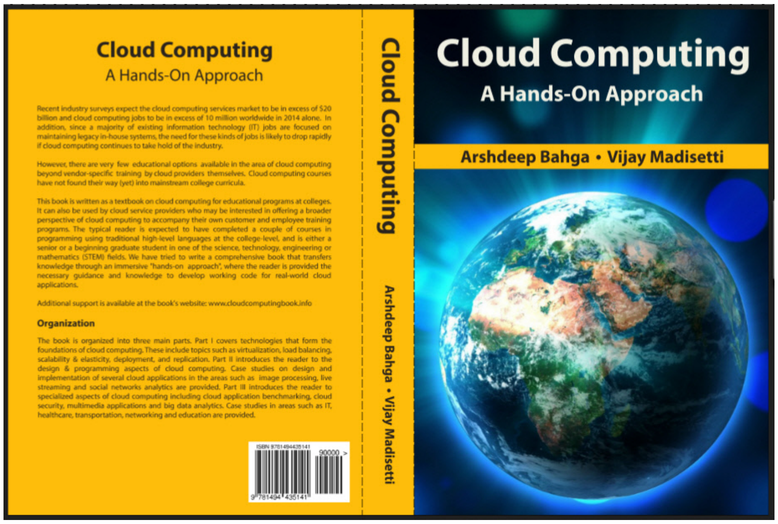

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Ph.D. Students Graduated

1. **Brian T. Kelley, 1992**
   VLSI Computing Architectures for High Speed Signal Processing
   Member of Technical Staff, Motorola.

   Winner of Dr. Thurgood Marshall Dissertation Fellowship Award

2. **Bryce A. Curtis, 1992**
   Special Instruction Set Multiple Chip Computer for DSP
   Member of Technical Staff, IBM

3. **Jaejin Lee, 1994**
   Robust Multitrack Codes for the Magnetic Channel
   Professor, Yonsei University, Korea

4. **Mohamed S. Ben Romdhane, 1995**
   Design Synthesis of Application-Specific IC for DSP
   Director of IP, Rockwell.

5. **Shoab A. Khan, 1995**
   Logic and Algorithm Partitioning on MCMs
   Professor, National University of Science & Technology, Pakistan

6. **Lan-Rong Dung, 1997**
   VHDL-based Conceptual Prototyping of Embedded DSP Architectures
   Professor, National Chaio Tung University, Taiwan.

   Winner of VHDL International Best PhD Thesis Award, 1997

7. **Thomas W. Egolf, 1997**
   Virtual Prototyping of Embedded DSP Systems
   Distinguished Member of Technical Staff, Agere

8. **Alvaro Marenco, 1997**
   On Homomorphic Deconvolution of Bandpass Signals
   Professor, Texas A&M University.

   Winner of GIT ECE Outstanding Teaching Assistant Award

9. **Shahram Famorzadeh, 1997**
   BEEHIVE: A Distributed Environment for Adaptive Signal Processing
   Member of Technical Staff, Rockwell.

10. **Timothy J. Klausutis, 1997**
    Adaptive Lapped Transforms with Applications to Image Coding.
    US Air Force/Univ. of Florida.

11. **Lan Shen, 1998**
    Temporal Design of Core-Based Systems
    Member of Technical Staff, IBM

12. **James DeBardelaben, 1998**
    Optimization Based Approach to Cost Effective DSP Design
    Research Scientist, Johns Hopkins University

    Georgia Tech ECE Faculty Award

13. **Sangyoun Lee, 1999**
    Design of Robust Video Signal Processors
    Professor, Yonsei University

    US Army Sensors Lab Research Excellence Award, 1999

14. **Rahmi Hezar, 2000**
    Oversampled Digital Filters
    Member of Technical Staff, Texas Instruments

15. Yong-kyu Jung, 2001
Model-Based Processor Synthesis
Professor, Texas A&M University

16. Mustafa Turkboylari, 2002
Handoff Algorithms for Wireless Applications
Member of Technical Staff, Texas Instruments

17. Yun-Hui Fan, 2002
A Stereo Audio Coder with Nearly Constant Signal to Noise Ratio
Post-Doctoral Research Associate, Northeastern University

18. Subrato K. De, 2002
Design of a Retargetable Compiler for DSP
Member of Technical Staff, Qualcomm

US Army Sensors Lab Research Excellence Award, 1999

19. Chonlameth Aripnikanondt, 2004
System-on-Chip Design with UML
Professor, King Mongkut's University, Thailand.

US Army Sensors Lab Research Excellence Award, 1999

20. Loran Jatunov, 2004
Performance Analysis of 3G CDMA Systems
Senior Research Scientist, Soft Networks, LLC.

21. Antonios Argyriou, 2005, Serving in Hellenic Army.

22. Pilho Kim, 2009, Scientist, VP Technologies, Inc.

23. M. Sinnokrot, 2009, Staff Engineer, Qualcomm.

Awards & Honors

1. **Jagasdis Bose National Science Talent Fellowship**, Indian Institute of Technology, Kharagpur, 1980-1984.

2. **General Proficiency Prize**, Indian Institute of Technology, Kharagpur, 1984.

3. **Demetri Angelakos Outstanding Graduate Student Award**, Univ. of California, Berkeley, 1989

4. **Ira Kay IEEE/ACM Best Paper Award** for Best Paper presented at IEEE Annual Simulation Symposium, 1989

5. **IBM Faculty Development Award** 1990

6. **Technical Program Chair**, IEEE Workshop on Parallel and Distributed Simulation. 1990.

7. **Technical Program Chair**, IEEE MASCOTS'94

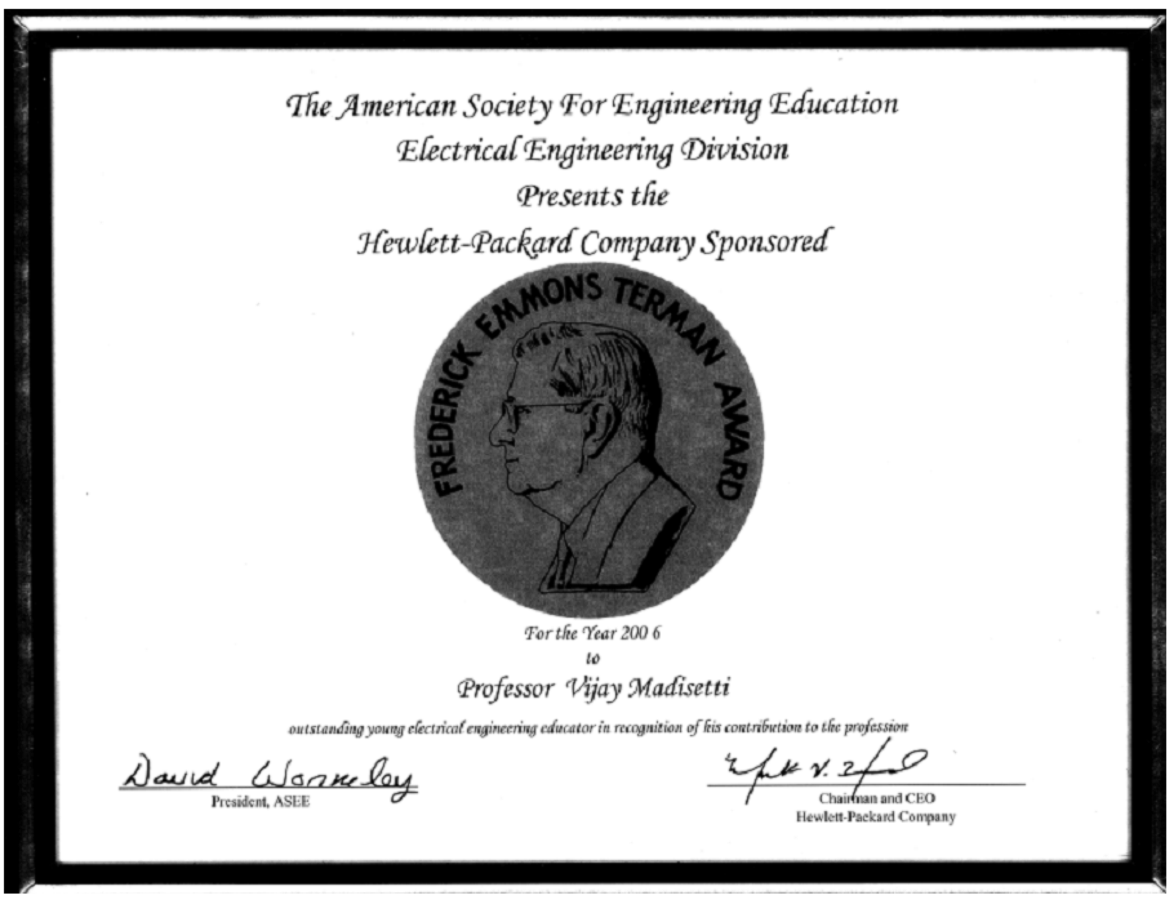
8. **NSF RI Award**, 1990

9. **VHDL International Best PhD Dissertation Advisor Award**, 1997

10. **Georgia Tech Outstanding Doctoral Dissertation Advisor Award**, 2001.

11. **ASEE 2006 Frederick Emmons Terman Medal, 2006.**

12. **Fellow of IEEE**



Intellectual Property Disclosures (Georgia Tech)

Patent	Date	Description
2843	2004	Method and Apparatus for Improving the Performance of Wireless LANs
2825	2003	Method and Apparatus for Optimal Partitioning and Ordering of Antennas for Layered Space-Time Block Codes in MIMO Communications Systems
2815	2003	How to Rapidly Develop a SyD Application
GSU-023	2003	Rapid Development of SyD Applications
2810	2003	System on Mobile Devices Middleware Design
2718	2003	A Transport Layer Algorithm for Improved Anycast Communication
2717	2003	A Novel Transport Layer Load-Balancing Algorithm
2716	2003	A Transport Layer QoS Algorithm
2715	2003	A Novel Transport Layer Algorithm for MPLS Performance
2659	2002	A New Algorithm and Technology for Implementing Mobile IP with Applications to Voice and Video over Mobile IP
2656	2002	Debugging with Instruction-Level Reverse Execution
2655	2002	Embedded Software Streaming
2539		System of Databases: An Enabling Technology for Programming
2517	2002	A Dynamic Instantiated Real-Time Operating System Debugger
2516	2002	A Dynamic Real-Time Operating System
GSU-009	2001	System of Databases: Architecture,, Global Queries, Triggers and Constraints
2480	2001	Mobile Fleet Application based on SyD Technology
2479	2001	System of Databases: A model with coordination links and a calendar application
1893	1999	Beehive
1726	1995	Very High Scale Integrated Circuit Hardware Description Language Models (VHDL Models)
1401	1995	Self-Compensation Receiver (SCR)

The ghost of Teleshuttle past: *Pages retained for historical interest -- Not current, may have broken links*

CD-ROM/Online Hybrids
The Missing Link?

Richard R. Reisman

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Preliminary electronic reprint - Figures not yet included.

The two most effective and popular technologies in electronic publishing and the much heralded information highway CD-ROM and online have complementary advantages and disadvantages. CD-ROM has evolved into a cheap, easy to use and powerful repository for all kinds of multimedia information. But because the discs are inherently static and unchanging, their content rapidly becomes outdated. Online services, on the other hand, have gained popularity by offering up-to-the-minute access to massive libraries and news feeds. However, online services can be expensive and difficult to use, while finding relevant information online is often frustrating and time-consuming.

The developing convergence of computer and communications technologies promises solutions to this dilemma we can enhance today's still-primitive online services to offer higher speeds, as well as easier access, navigation and control but the hard realities of infrastructure building will make that a long and turbulent evolution.

In the meantime, a significant, if partial solution to this dilemma is to combine these two current technologies. Such a hybrid, formed by embedding a specialized software communications module into a conventional CD-ROM product, maintains all the features of the original CD-ROM while adding an easy to use, inexpensive communications facility to retrieve updated information from a remote service. For a wide spectrum of applications this approach brings to CD-ROM products the immediacy of online access while retaining none of its disadvantages. And it does this with plain old telephone service.

The idea of combining CD and online has been germinating for some time. It first gained a degree of industry attention at the Intermedia Conference in March 1994, when Microsoft Corporation announced its consumer CD-ROM title Complete Baseball, which incorporated a modem-supported daily baseball statistics update feature. Wider recognition of its potential is still slowly growing.

Also growing are the tools and technologies to make CD-ROM/online hybrids not only possible, but likely, as seen by Microsoft's recent efforts and the successes of CompuServe and old CD-ROM/online pioneer Nautilus. The first serious signs of the new wave of hybrids may have been in August 1994, when a new service called Teleshuttle announced software and operations/support services to enable hybrids by any publisher.

SEPARATE SUCCESSES BREED NEED FOR HYBRIDS

Ease of use for CD-ROM is unparalleled, and because CD-ROM provides speed and high capacity, custom-designed user interfaces can readily be applied to simplify data access to the point that a pre-schooler can easily use it. This has resulted in one of the hottest markets, illustrated by discs such as *Grandma and Me*. The limitation of CD-ROM is that it is a static medium, which has a number of publishers moving to subscription update programs, and other publishers sticking with content that is, itself, static in nature.

The other big success story in new media is the emergence of online services. Internet user counts are now in excess of 5 million, by conservative reckoning, and commercial services like America Online are bursting at the seams. The appeal of these services is unlimited "information at your fingertips," as Bill Gates has tagged it. Anything from the "Great Books" and federal regulations, to the latest news and stock quotes, to the chatter of fans about the soap opera episode now airing on TV or the oddities of "alt.sex.bondage" can now be obtained on "the Net." Unfortunately, these services are still rather hard to use. First, just getting a modem to dial and connect successfully to a remote service presents a significant hurdle to most novices. Communications software ranges from arcane and complex to just moderately easy to use at best. Finally, the task of finding a desired information item may be a nuisance on the better designed services, and a labyrinthine quest through obscure terrain in the farther reaches of the Internet.

Compounding online's degree of difficulty is the fact that these services work on a subscription basis, rather than a discrete purchase, product basis. You can buy a CDROM as easily as a magazine or book, but to get information online you must subscribe to a service in advance. Consumer online services generally run about $10 per month, while also billing to an open credit card additional charges based on time used. They typically average about $20 per month. Business online services can run at $1 to $10 per minute, a rate that generally leads to very rationed use.

Because online services are operated as broad utility services, their user interfaces tend toward rigidity and are by and large less enticing than those provided with the better CDROM products. Current developments are gradually permitting more attractive and tailored interfaces, but the complexity of online communications and navigation will limit this for some time yet. An ongoing constraint of online services is the low speed of dial-up telephone communications, which are about 100 times slower than the transfer rate of a CDROM. Although this will change gradually over the next decade, as high speed network services are deployed locale by locale and compression techniques are improved, infrastructure issues will continue to limit the use of online multimedia to small numbers of pictures and sound bites for quite some time.

HYBRID DESIGN AND TECHNOLOGY

The short-term solution that has been available for years is to build clever hybrids of CDROM title and online service. These hybrid technologies have begun to appear from both directions, with online services developing mechanisms to work with supplementary multimedia content on CDROM, and CDROM titles providing online access support for downloading update information. In the online oriented model, supplemental CDs can be sent monthly to subscribers for use in conjunction with their online sessions. The first such CD was delivered by CompuServe in June 1994, and similar offerings are expected from America Online, which builds on its acquisition of Redgate, and Ziff Interchange (or more accurately since the December 1994 purchase, AT&T Interchange), with all major online services thought likely to follow.

In an online oriented hybrid, the supplementary information distributed on CD can be artfully integrated during an online session to enhance the online experience; unfortunately, this approach will do little to open access to network neophytes. The hybrid from a CDROM-based orientation may stand a better chance of solving the access problem, through embedded communications modules that allow a user to retrieve updated information from a remote service, going online only when needed. Such a facility is easy to use--transparent, even--because its function is preset to work with that specific CDROM product, where the communications task is simply to call a designated number to obtain an information update and place it on the hard disk, making it available for use in conjunction with the existing information on the CDROM.

This CDROM-oriented approach follows the lead of professional products for obtaining stock quotes and other specialized databases, but has begun to enter the mainstream, as with Microsoft's Complete Baseball CDROM, which allows retrieval of a Baseball Daily newsletter. Other consumer CDROM titles are in development, such as a product for Kaplan's college preparation service being developed by Mammoth Micro Productions, and Microsoft Corporation indicates that similar functions will be added to many of its titles, including Encarta.

While the concept of communications enabled discs has tremendous potential, there is still a lack of tools and services needed for this approach to be fully exploited. The task of building and supporting CDROM with communications capability is beyond the expertise of most publishers. And the absence of an industry standard will tend to confuse users of various products that take individualistic approaches to the task.

In keeping with its strategy of complementing existing players, Teleshuttle is working with major authoring and database search software vendors to pre-integrate the Teleshuttle transporter with their products' user interface and data management functions. Teleshuttle currently is being developed to work as part of Folio Corporation's Folio Views, and Electronic Book Technologies' DynaText, as well as in collaborations with a number of vertical market companies.

THE TELESHUITLE APPROACH

Teleshuttle Corporation offers a specialized service that fills a critical gap in producing CDROM and online hybrid products. Teleshuttle's mission is to provide the transport software and services needed to enable hybrid CDROM and other similar media-based products.

Although some major players provide CDROM online hybrids on their own--Microsoft and CompuServe are two examples--few publishers have the resources and expertise necessary to build their own online connection, and most lack the scale to justify trying. Teleshuttle allows publishers to provide hybrid online services while avoiding the burdens of doing so. Teleshuttle is new and unique in providing the following:

1. a packaged communications software module (the Teleshuttle transporter)
2. a complete server operations and user support service (the Teleshuttle server)
3. a design that facilitates embedding these features into the products of any publisher, affordably, and with a minimum of effort.

CDROM developers can easily integrate Teleshuttle's modular component to work under the control of their products. Instead of complex communications programming, developers need be concerned only with the simple program interface (an "API") that controls Teleshuttle requests, and with the end-use of the information packages themselves.

Because Teleshuttle's modularity concentrates all dependencies on communications technologies, it can be designed to evolve to new network technologies and client platforms as they mature. The first version of Teleshuttle supports Windows 3.1 and Windows 95, and direct dial or X.25 communications. Versions are planned for

Macintosh, DOS, and other platforms, and for Internet, wireless, and cable television networks.

The Teleshuttle Service

Data communications remains a very arcane and troublesome technology. The technically adept can perform basic data communications chores reasonably well, but supporting national or global access from large, diverse populations is a daunting and resource intensive assignment. The Teleshuttle Service lets publishers and product developers out-source these tasks to Teleshuttle's staff experts in communications programming, wide-area network and server operations, and user support.

The economy of the Teleshuttle approach results partly from sparing use of network and remote resources, and partly from the flexibility and simplicity provided both publishers and users. This enables a very different business model Mom conventional online services, where prices can be based on flat onetime fees and included in the initial price of the product. A specialized, product-linked service can avoid the need for complex subscription or usage-based charging schemes, and the administrative burdens they impose; with Teleshuttle, the costs to a publisher or vendor may be as low as $3 to $5 per user, depending on the number of users and the total volume of data made available for transport.

Pricing for Teleshuttle is highly dependent on the specific choices from a wide range of options, with full service pricing currently administered on a special quote basis. Unit prices are keyed to the number of users actually utilizing the hybrid services, and not the total number of copies, to allow for wide distribution of products where usage of the online component may not be universal. Charges also depend on the average amount of data transmitted by users during a service contract period, and by the level of hours of user support provided (some publishers require only second-level support and only business-hours coverage).

While most users need no support, serving those that do involves significant expense. For low volume projects, minimum charges are negotiated to reflect the custom effort of setting up new and varying technical, operational, and business environments. The expectation is that such charges are to drop as Teleshuttle and its clients progress along the learning curve.

Pricing for in-house server options is significantly lower and more simple, since operations, end-user support, and related administrative costs are not involved. License fees start at $10,000 for a permanent license for a two-line server and an unlimited number of client module copies per product. This minimum system can support 500 to 1,000 users, assuming a moderate data volume. Pricing drops rapidly per additional lines for larger servers: a 32line server, for example, which might support 50,000 to 100,000 users, is

$30,000. The servers use commodity DOS or Windows NT-compatible technology, so the associated hardware costs are low.

Although the simplest form is a onetime charge included in the product purchase price, customer charging may take a variety of forms. The flat fee would include rights to a set number of updates for a set period of time. Use of ordinary direct-dial phone lines--where users pay any long distance charges--further enables minimal fees, where the very short connect times prevent long distance toll charges from becoming burdensome. The classic publishing model of customer-paid Shipping" works in this model as long as the "shipping" cost is small.

Another charging method is pay-per-call access using 900numbers or credit card charging. "Try-and-buy" offerings can make some information available at no extra charge, with additional materials provided for additional fees, based on an electronic credit card order placed via the hybrid service. For commercial applications, catalogs, or other sponsored services, toll-free lines or national public data networks may be used, just as with the major online services.

Even for hybrids which link to a major online service, it may be desirable to offer the independent Teleshuttle option as well. This allows users anywhere in the world to obtain the basic hybrid service without need for a monthly subscription to the online service. The advantages are not only for the potential customer not desiring to join the online service--use of the Teleshuttle service also offers higher profitability to the publisher.

Still, a significant feature of the Teleshuttle approach is the ability to reach individuals who are not regular online users. While the number of online users is growing strongly, the *1994 Jupiter Communications Online Services Report* projects that the total number of households with PCs and modems, but no online service subscriptions, amounts to about 15 million.

How The Hybrid Works

The way that conventional CDROM and online platforms compare is pretty straightforward: CD-ROMs hold content, with (usually) data and program files placed on the hard disk; online services provide content and programs, with the PC's hard disk holding data and program files. Hybrids combine the two capacities.

With hybrids, the CDROM is activated using an install routine that places control software on the hard disk, and that software is then used to view and search the data on the disc. In current practice, additional files, such as notes and annotations, may also be placed on the hard disk, since the CDROM cannot be used to store any new information. In such cases, the control software seamlessly combines the information from both the CD and the hard disk, with the user unaware of the two different origins. It is the same kind of seamless integration that is exploited by the hybrid.

With hybrids, such as those supplied with the Teleshuttle transporter, the CDROM title provides the user with a button or menu to use to select updates from a predefined list supplied with the title. Upon selecting an update, the title's control program invokes the transporter, passing control to the Teleshuttle transport module, which calls out to the remote server, identifies itself, and retrieves the desired update. The transporter then disconnects, unpacks and decompresses the update, and places it on the hard disk in a predefined location for use by the CD's control program, where the updated information is available for viewing and searching, just as if the new files had been there all along.

In fact, the CD-ROM title's control program need not be involved in any details of retrieving updates online, rather, it can simply treat the new information as just an additional database. It will often be desirable for the new information to be integrated with the old, however, to allow it to be viewed and searched seamlessly as a single database. This can be done without any modification to the original CDROM by making provision in the title's control program for a single user request to cause access to both databases in a coordinated fashion. All forms of access, including hypertext linkages, can be made to allow seamless integration of updated and original data, without any change to the original CDROM.

BUILDING ON THE HYBRID

A wide variety of functions can be based on variants of the CDROM/ online hybrid approach to network-enabled applications. Simple fetch functions can be combined to provide very powerful, open ended interactions. A CD can have a starter list of additional materials available to be fetched, and that list can itself be updated to open up access to unplanned additions. As with fax-on-demand, a whole set of information item catalogs can be available, each of which opens up a new range of current selections. The online connection can be automatically dropped after each fetch and reestablished for each new request, so there is no cost for extended periods of online "think time" while the user browses.

Another variant is to expand on the simple fetch-on-demand operation. For example, fetches can be automatically scheduled based on update availability, or be delayed to an off-hour, low-cost period. A more advanced option would be to shift from a user-triggered "pull" operation to a publisher-triggered "push" operation, where the server might automatically dial-out to the users whenever an update becomes available. (This has some obvious attractions, but it introduces significant problems, including failed deliveries if the user's system is not properly set to receive at the time the attempt is made, and the negative views of external access as a security exposure.)

Sending information into the central server is just as easy as fetching information out, which means that a wide variety of information collection applications, ranging from placement of catalog orders to user surveys and collection of registration and demographic information are enabled. For example, conventional CDROM catalogs require a customer to call a voice 800 number to place an order, but the hybrid technology supports the few mouse clicks needed to fill out an electronic order form and transmit it into the central server. In simplest form, these electronic orders would go to the merchant just like electronic mail orders, while a more advanced form could entail linking the server to the merchant's system to check credit and stock and then send back an order status report. Even in this full transaction scenario, the time online remains minimal, with no human interaction to extend it.

Catalog applications effectively illustrate the advantages of combined fetch and send usage. Fetches can be done to update the catalog with new and on-sale items, and sends done for ordering. Of course, the hybrid model is not restricted to CDROM; a diskette-based product such as a newsletter or an information-on-demand application can simply provide a browser program with an embedded transporter module that fetches information when desired. Indeed, several non-CD examples that use online connections to get stock quotes and financial reportsthe financial applications by Intuit (Quicken) and Reality (Wealth Builder)are, actually, among the earliest examples of consumer hybrid-style connections.

Hybrid Design And Business Issues

For the publisher or developer interested in exploiting hybrid technology, the emergence of services like Teleshuttle means that significant technical and operational barriers have been lowered. There remain many critical issues of product design to be considered, however.

The fundamental issue is how to combine maximum value in local and remote content. Static databases and rich multimedia content are best put on CDROM, and judicious use of relatively costly transmissions should be reserved for high time-value per megabyte content such as text or data and modest amounts of well-compressed image and sound files. Cost tradeoffs will vary with the nature of the target market, and the value of the content can increase or decrease in that context. Another major issue for publishers is the revenue model, and its relation to the selection of network service and charging mechanism.

There is also the basic question of how to balance occasional mailing of update discs with the alternative use of online updates, with the answer largely hinging on the size of such updates. For example, a $3 to $10 cost per user per year for the Teleshuttle service may be comparable to the costs for each monthly pressing and mailing of an update disc; in most applications, new disc editions will be needed periodically, perhaps yearly, depending on transmission speeds, hard disk accumulation demands, and requirements for huge update content.

Other issues include the design of the product control program or authoring tools. Some authoring packages offer powerful search and control capabilities appropriate for exploiting hybrids. Custom programming, while difficult and expensive, still offers maximum flexibility, particularly for complex data integration as with some financial applications that may require computations or other application-specific functions.

The need for timely support of content that hybrids demand may require editorial operations to gear up frequent cycles and short deadlines. Producing an encyclopedia, for example, shifts from a book-like process with update cycles in years, to more of a news-room or magazine-like process, with cycles in months or even weeks. The total amount of work may not increase much, but the way the editorial and production work is done becomes more time-sensitive. While this can be a significant change, it is likely one that will be required of most publishers in the not too distant future.

SO WHERE IS THE HYBRID? AND WHERE IS IT GOING?

The first product to use the Teleshuttle Update Service is Vista Intermedia's CDROM of the World Health Organization's International Digest of Health Legislation (IDHL). This disc provides users worldwide with quarterly updates to WHO's 10,000page infobase. The IDHL CDROM works with Folio Views, and is fully integrated to use this authoring and retrieval software's shadow file capability to combine updates with full-text searching. Additional Vista titles in the legal and healthcare market will be using Teleshuttle, and other Teleshuttle hybrids can be expected from major commercial and consumer publishers, as well as catalog and marketing companies.

The hybrid approach adds a useful perspective to the question of whether the CDROM will soon become obsolete, while showing that such considerations are largely beside the point. The specific CDROM format now in use may be rendered obsolete by higher density and writable discs, or another not yet familiar technology, but the need for high capacity local storage media, and the use of such media for cheap distribution of masses of information will not go away. Similarly, as high-speed networks are deployed, access to remote information will improve. But the case for a balanced mix of local and remote resources will remain, along with the desirability of simple, powerful software interfaces.

Nonetheless, the true essence of the hybrid concept is not the use of a CD, but the use of a local application with an embedded online component. From this viewpoint, the various hybrid examples can be viewed as points along a spectrum of distributed services, with purely local services at one extreme, and purely online services at the other. But even as the communications networks evolve, complex but seamless mixes of local and online services will become increasingly common. However, efficiency will continue to dictate that maximum use be made of local resources, which are generally owned and familiar, supplemented by sparing use of remote resources which are generally rented and less familiar.

It is reasonable to anticipate a wide range of extensions beyond the basic shuttle transport function of sending and fetching, but which, while providing more advanced online functions, will still retain the idea of embedding the online activity as part of a predominantly local application. Examples include embedding electronic mail functions and bulletin board access in off-line editor and browser programs. Another important example is interactive multi-player games, where the economy of the "brief blink" online gives way to a continuing online session mode, where the individual product application still controls the function and presentation of the online interactions. With a simple embedded transporter module, such online connections can be simplified and standardized.

As all the converging technologies mature in power and flexibility, the hybrid will blur into a seamless combination of full-function online services embedded into "local" applications that have complete flexibility in their look and feel, and use network resources only as needed. Ultimately, the networks will be fully transparent media, where the user will not need to know or care which application elements and data are local and which are remote.

But already, today, hybrid technology is in place.

SIDEBAR 1: CD-ROM/Online Hybrid Product Application Examples

UPDATES AND SUPPLEMENTS

Magazines: new issues
Newsletters: new issues
Encyclopedias: updates, new entries
Almanacs: updates, new entries
Reference libraries: updates, new entries
Financial data: latest prices, statistics
Legal data: regulations, cases
Sports: latest scores, statistics
Games: additional games, puzzles, etc.
Recipes: new recipes
Medical information: updates, topical features
Tax programs: revised forms, instructions
Catalogs: prices, new items, deletions
Software products: updates

Software samplers: unlock keys
Advertisements: additional information
Product information: new items, specs, supplements
Government information: regulations, forms

RESPONSES AND INQUIRIES

Catalogs: ordering
Surveys: responses
Polls and contests: responses, entries
Advertisements: electronic bingo cards
Customer information: registrations, demographics

SIDEBAR 2: Comparison of Delivery Technologies

	CD-ROM-Online-Hybrid		
COMPARING BENEFITS TO THE END-USER			
Fixed, low price	yes		yes
Fast multimedia access	yes		yes*
Ease of use	yes		yes
Up to the minute content		yes	yes
Open-ended content		yes	yes
Basic 2-way communication		yes	yes
Extended interactive communication		yes	future?

(* for CD-resident portions)

COMPARING BENEFITS TO THE PUBLISHER/DEVELOPER			
No communications programming	yes	yes	yes **
No communications operations	yes	yes	yes **
No communications user support	yes	yes	yes **
Low entry cost	yes		yes **
Open to all publishers	yes		yes
Publisher creates any look and feel	yes		yes
Publisher controls pricing	yes		yes
Publisher controls distribution	yes		yes

(** benefits supported by Teleshuttle, but not usually applicable to custom hybrid efforts)

Richard R. Reisman is president and founder of Teleshuttle Corporation, which, when announced in August 1994, was called Dynashuttle. Reisman previously co-founded UNET, a pioneering online service developer, and managed computer, communications, *and information delivery operations for the Standard & Poor's unit of McGraw-Hill.*

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Past Resources Past Writings Teleshuttle Past

The ghost of Teleshuttle past: *Pages retained for historical interest -- Not current, may have broken links*

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Purdue-On-Line: A Facility and Distributed Learning Framework to Develop and Deliver Internet based Education

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Purdue-On-Line:
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2. Computer Science Department, School of Science
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5. Nuclear Engineering Department, School of Engineering
6. Department of Agricultural Engineering
School of Agriculture

1.0 Project Overview

We have started a distributed learning research and development effort to design technology solutions and methods which support collaborative learning *any time* and *any place*. This project is referred throughout as **Purdue-On-Line (POL)** The main research goal is to develop and integrate *telelearning* technologies with supporting services needed to enable existing courses, to design and deliver "on-line courses" and to meet the growing demand for distance education. Our first target areas include a) freshman education and specifically courses that involve large number of students currently taught in a lecture-recitation mode and b) professional programs in software engineering, computational finance, and veterinary medicine. Following we summarize the goals, activities, and challenges of the POL project.

What is the future scenario for a University? We are witnessing the start of a revolution in *"Telematics = Information + Communication"* technology that has the potential to impact the form and structure of the University beyond anything we can currently imagine. The evolving global information infrastructure has already impacted many facets of our lives. The way we disseminate information, conduct business, manage personal activities, and search for knowledge and information are undergoing profound changes. This technology and its future evolution has the potential of making *telelearning* the new educational paradigm at local (within a given institution) and global (nationwide and worldwide) levels. In the future, universities will advertise and offer courses via the Internet. Students will be able to choose the "best" course in the educational "marketplace" without being limited by spatial (class size limits, geographical proximity to classroom), or temporal (exact time at which the course is offered) constraints. Telelearning will enable the expansion of current course offerings through the addition of material from participating institutions; it will enable the expansion of enrollments. Most importantly, telelearning is the technology that will enable the creation of the Virtual University of the future.

What is Purdue-On-Line today? There are many new technical and educational issues related to on-line education that must be addressed. They concern the infrastructure needed to deliver such courses, the on-line courses content development, computer based educational environment, and on-line teaching paradigm. The list of current activities includes:

- *Design and prototype an environment for on-line instruction on stationary and mobile platforms*
- *Research teaching methodologies for on-line instruction*
- *Experiment with a set of traditional courses*
- *Evaluate courseware delivery models/software and on-line courses*
- *Evaluate video servers (hardware/software), videoconferencing, and communication technologies*
- *Assess the overall cost and impact of on-line education*

Who supports this effort? The main supporters are: Intel Corporation provides equipment and a student/faculty support of the order of $200, 000 a year for the development of the virtual classroom utilizing mobile and wireless technologies, Purdue University provides a grant of $37,000 a year for supporting the development and maintenance of POL facility and on-line courses, Department of Computer Science provides TA support and faculty teaching credit towards the development of CS on-line courses and classroom equipment, the School of Science has provided support for the virtual classrooms projection systems and application software, AT&T and IBM have provided support for computer and communication equipment.

What will be Purdue-On-Line tomorrow? Purdue University needs to create an organization and a physical facility to support activities such as:

- Research on distributed learning
- Training of faculty and students in the technologies needed to create content and deliver it in some on-line form
- Development and management of Internet based courses
- Delivery off-campus and on-campus instruction via the Internet

- Evaluation of internet based courses and educational activities

Why create Purdue-On-Line? The Internet has created a new medium for delivering distance education in "asynchronous" and "synchronous" modes in a cost effective way. It is inevitable that Purdue will be forced to develop and deliver Internet based courses in order to compete in the future educational market place. Peer CIC institutions like UIUC, Univ. of Wisconsin and Penn. State Univ. are already deploying courses on the Web. The educational establishment at Purdue must become familiar with this new educational paradigm, the associated technologies needed to sustain it, the organization and cost involved, and the physical infrastructure needed to implement it in a large scale. A recent internal report by the Distance Learning Committee titled "A Consideration of Purdue University's Involvement in Distance Learning" aptly discusses the need for serious effort in this regard [1].

There are many citizens that are both space and time bound that need/want higher education and the Internet is the efficient medium for delivering it. The majority of these citizens are associated with industry. Attracting these kind of students will increase the interactions between University and Industry, thus benefit indirectly the faculty, regular students, and the University as a whole.

How cost effective is on-line education? There several studies addressing this issue. It's worth referring to a study with title *"Costs for the development of a virtual university"* by Murray Turroff, http://www.aln.org/alnweb/journal/issue1/turroff.htm. Its importance lies on the fact that it was published 15 years ago and recently was republished to reflect current economic reality. According to this study a) a single classroom building on a physical education campus is estimated to cost $15,000,000 US dollars and b) the non faculty cost required to set up an academic program for 2000 students that is made up of students and faculty scattered around the world is estimated to be $1.8 Million or $900 per student per year. It is assumed that each student has its own computer and pays the internet subscription. This cost is only 10% of the tuition that an out of state Purdue student is paying today.

What are the non-technical challenges? We don't see any reasons to delay investing in this new educational paradigm; several other Universities already are doing it. It seems to us that some of the arguments presented against this new form of the University are only justified in terms of a) inertia, b) ignorance, c) technophovia, and the "bricks and mortar" syndrome vs. "silicon and fiber" syndrome; it is easier to get credit for physical artifacts than virtual ones. One has to recognize that education is getting very expensive and that virtual education is better than non education. Whole sale education is provided in most of the freshman courses today and it involves less human interaction than a virtual course of the same level. On-line education can become a significant tool to connect top high school students with Purdue, thus assisting Purdue's outreach efforts.

Are there historical analogs to telelearning revolution? What was the reaction of the establishment? We are witnessing the revolution not the evolution of *telematics*. Very soon we will become *symptiotic* with our network computers for home, education, goverment, health care, and work, just as the industrial revolution was symbiotic with the steam engine and later with electricity and fossil fuel[1]. Paper, *the civilization's first computer*, shows signs of obsoleteness. Techophovia is a natural reaction and defense. Technology was always seen by a society as the "necessary evil" (αναγκαιο κακο according to the Greeks). Let's place ourselves approximatelly 3,500 years ago somewhere in Egypt and follow the conversation between an inventor and a decision maker of the time (quotes from The Judgement of Thamus (Plato's Phaedrus)).

Thueth (The inventor of writing) declaring his invention to Thamus (the king of great city of Upper Egypt)

"Here is an accomplishment, my lord the King, which will improve both the wisdom and memory of the Egyptians. I have discovered a sure receipt of memory and wisdom"

1. *"Beyond calculation: The Next Fifty Years of Computing"*, P. J. Denning and R. M. Metcalfe, Springer-Verlag, NY, 1997.

To this Thamus replied

"... Those who acquire it will cease to exercise their memory and become forgetful; they will rely on writing to bring things to their remembrance by external signs instead of by their own internal resources. What you have discover is a receipt for recollection, not for memory. And as for wisdom, your pupils will have the reputation for it without the reality: they will receive a quantity of information without proper instruction, and in consequence be thought very knowledgeable when they are for the most part quite ignorant. And because they are filled with the conceit of wisdom instead of real wisdom they will be a burden to society."

The arguments against on-line education sound similar to Thamus' reaction. It's our observation that society was unable to stop technology and evolution. Our only alternative is to exploit its positive aspects and constraint its negative aspects through standards and policies.

What are other challenges to on-line education? There is a significant difference between publishing the notes/slides of a course on the Web and offering an entire course with pedagogical objectives in some on-line form. For this we need to address seriously some of the following issues:

- Development of pedagogically-sound content for delivery over the Internet
- Incentives for faculty, departments, and schools
- Copyright and ownership issues
- Quality control
- Library support
- Development of new software environments and tools

What is the initial scope of Purdue-On-Line (POL)? The technology to aid all Purdue courses with on-line material and conferencing is available today. For the success of on-line education we need to engage ourselves in serious experimentation with courses in which there is minimum teacher-student interaction or high level student maturity and motivation. Our initial activities in on-line education and technology have been restricted to the following objectives:

- Develop, test, and validate a set of high-quality cost-effective Internet based learning services and network technologies to support delivery of on-line courses
- Develop and deliver freshman on-line courses in computer science for engineering and science students; these courses would be open to high school students
- Develop and deliver professional degrees (i.e. Software Engineering, Computational Finance, and Veterinary Medicine)
- Develop and deliver technology oriented courses (i.e. Web, Window Systems, and Software Suites)
- Purdue University becomes not only the provider but leader in distributed education

Guide to the reader. This report describes primarily a) the design of the Purdue-On-Line facility and on-line course CS158a for teaching computer programming concepts and C/Java languages and b) the infrastructure available for the implementation of POL and delivery of CS158a. The first section defines distributed learning, compares it with the conventional TV/Video based distance learning paradigm, and assess its potential and impact. In the second section we present the functional specifications of the Purdue-On-Line (POL) facility designed to deliver and manage any course through the Intranet or Internet networking platform. The third section states the problem with the current paradigm of teaching freshman computer science courses and lists the design objectives of the new CS158a course. The distributed learning framework utilized in CS158a course is discussed in section 4. We describe the content of the CS158a and its delivery modes in section 5. Our proposal for an on-line MS professional degree in *Software Engineering* are presented in Section 6. We review the available tools for implementing POL in Section 7 and present our current choices of tools for supporting asynchronous delivery of virtual courses in Section 8. The experimental course material and presentations of CS158a can be found in the following POL Web site URL: *http://pol.cs.purdue.edu/*.

2.0 Distributed Learning Paradigm

We begin by briefly sketching what **distributed learning** means, in particular how it differs from the traditional notion of distance education which uses communications to extend the reach of the lecturer. The principal characteristic of any form of distance learning is that the student does not have to be present in a classroom in order to participate in the instruction. Broadly defined, **distance learning** is any approach to education delivery that replaces the same-time, same-place face-to-face environment of a traditional classroom. **Distributed learning** is a type of distance learning that we define as technology-enabled, team-learning focused education, facilitated by a content expert, and delivered anytime and anywhere.

The current practice of distance education is exemplified by the following familiar examples:

- Mind Extension University in the US, a venture by Jones InterCable in partnership with the University of Colorado at Fort Collins. This involves videotaped or live lectures being shown on some local cable channels. Questions are asked only by those physically attending the lecture at the Fort Collins campus, or by those who gather in designated remote sites with a phone link to the instructor.
- Many Universities offer courses remotely via satellite, with videos of the lecture available for the students who miss the lecture or want to see it again. Questions could be asked by calling the instructor via an 800 number, during the lecture. At the ITESM Institute in Monterrey, Mexico, the large number of students and the poor quality/availability of telephone lines have caused them to follow an email-based approach for handling the questions: email questions are screened and interpreted by assistants to the lecturing professor, and they either answer the questions themselves (on-line or off-line) or, based on their judgement, they relay the question to the lecturer (if, for example, the question is judged to be of interest to the whole class).

The traditional approach, as exemplified above, inherits unaltered the notion and structure of a class from the classroom in a building scenario. Its only major advance is to remove the barrier of distance and the limitations on the size of the target audience. In other words, the physical presence of the student in a particular room is no longer required. On most other pedagogical issues that face classroom instruction, it offers nothing new. The proposed approach, as will become clear in the following pages, differs radically from the above TV-based traditional ones. Let us point out some of the more significant differences:

- The *interactive multimedia* nature of the approach: The student controls, with some point-and-click device (e.g. mouse), the flow of the lecture. Contrast this with the traditional approaches where all the students take the class at a predetermined time (sometimes in a predetermined room that has the needed satellite reception facilities) and see the same lecture on the TV screen.
- The *self-paced* nature of the approach: Slow learners use their control over the flow of a lesson to make sure they have a slow pace, request many examples, etc. *Mutatis Mutandis*, the faster learners are not penalized either. Contrast this with how today's lectures are targeted to the average student, penalizing the slow learners (who are lost) as well as the fast learners (who are bored).
- The *adaptive* nature of the approach. The software can include some simple AI (Artificial Intelligence) mechanisms for learning about the level of the student. For example, a student repeatedly fumbling the mathematical portions of exercises could be given a choice, by the software, to undergo an on-the-spot remedial coverage of the problem topics. Contrast this with the current situation, where we either loose such students or are forced to inflict a review on all of the class.
- The potential for *automating* the testing process for some types of courses (and having the exams done "on demand", whenever the student feels she/he is ready). Not only is this more convenient to the students but it also frees up the

instructor for more productive endeavors than repetitive grading. Such a scenario helps people who know the material, but lack what are commonly described as exam taking skills.

- The potential for offering/testing knowledge in basic units with a *finer granularity* than the traditional one-semester course. This has the potential of increasing the "continuing education" type of enrollment, since an employed engineer who needs X, Y and Z can focus on just these topics instead of having to take a large course that includes these topics.

On the other hand, there are difficulties peculiar to our approach:

- The problem of *charging* for electronic access. This is the issue of how to avoid, e.g., a student sharing his access rights with non-students and costing large amounts of uncollected tuition. This problem is not as acute in the current situation, in which it is easy for the instructor to notice the physical presence, in his very popular lecture, of a large number of people not registered for the course. (In an encouraging development in that area, Folio Inc. has recently announced a method of using cryptographic protocols for solving the special case of copyrighted newsprint.)
- The *development and maintenance cost* of the educational software and courseware, which far exceeds those of a traditional course (cf. the previous comment about recording many versions of a lecturer's coverage of a topic X).

3.0 On-Line Freshman Education

The current freshman education of our students is primarily based on *wholesale lecturing* than *individual tutoring*. This teaching paradigm puts the burden of learning on students only and is unsuitable for teaching science and engineering. As a result many well motivated students get frustrated, discouraged, and leave these schools or get graduated with an incomplete education. True teaching and learning is much more than information and its transmission. We agree with the opinion that education is based on *mentoring*, *internationalization*, *identification*, *role modeling*, *guidance*, *socialization*, *interaction*, and *group activity*. We realize that the cost of delivering personalized education is very high in the current education environment. However, the utilization of telematics (i.e. computer based information and communication) technologies in the classroom can increase individual tutoring and student/instructor interaction and communication without significant additional resources. Moreover, the potential to deliver these courses in a distance mode and the expected additional revenues can off-set the infrastructure cost required. We strongly believe that the ability of delivering high quality customized and individual education in a cost-effective way will influence the prosperity of Purdue University in the upcoming competition from Cyber-U's and the already started transformation of private educational institutions!

We are currently designing and delivering a *computer programming course* (CS158a) for engineering and SoS students. The associated material under development is multimodal and customizable for the individual student. We are developing and testing a learning paradigm and environment associated with this course that i) puts the responsibility of student performance to the instructors, ii) improve student performance, iii) decreases the time to learn by at least 30%, iv) makes the course material, produced in consultation with the best instructors in given subject area, available in multimedia form on CD-ROM and Web "anytime" and "everywhere", and iv) delivers the course in direct, studio, telepresence, and distance-learning mode.

4.0 On-line MS. Degree In Software Engineering

A group of computer science faculty in collaboration with the industrial affiliates of Software Engineering Center (SERC) at Purdue are designing a new master's program in software engineering to serve Purdue students and outreach constituents who are time and space bound. For this, the model of synchronous distributed learning is considered and researched.

The MSE program is targeted to be offered starting in the fall of 1997. The program will use the Internet and POL facility including the advanced two-way audio-video conferencing technologies proposed to deliver educational material to on-and off-campus students. Off-campus students are expected to be sponsored by companies interested in furthering the education of their employees in advanced Software Engineering.

The infrastructure support for the MSE degree will consist of hardware and software in support of the MSE program. The hardware will consist of (i) equipment for audio-video conferencing (AVC) and (ii) multimedia PC's and workstations for use by students and instructors of the MSE program. The software will consist of (i) systems to support the delivery of educational material, (iii) software engineering tools necessary for use in the laboratory component of the MSE program. The AVC equipment will be used to deliver the MSE courses and support the interaction between instructor and students during the classroom and office hours. Multimedia PC's and workstations will be used as servers for the educational material on the Web, for development of software, and for laboratory experiments by the students.

Two PC's will be text, audio, and video servers for the educational material placed for access via the Internet by the students. Four PC's will be used by graduate and undergraduate students for software development. Sixteen PC's will comprise the laboratory associated with the MSE program. In addition we plan to acquire software engineering tools for use in the laboratory. The computer sciences laboratory 111 will be used to deliver the MSE and house the requested infrastructure. The facilities in CS111 and CS175 laboratories will be used to carry out this project. Some of the equipment in these two laboratories have been donated by Intel Corporation.

Status of the MSE program. A proposal for the MSE program is currently under preparation. Industrial affiliates of the Software Engineering Research Center (SERC) have been given a presentation based on a preliminary proposal. The feedback obtained from them will be incorporated in the design of the curriculum. Companies other than SERC affiliates (Motorola and Tellabs) have also been contacted to explore the possibility of their sponsoring candidates for the program. Tellabs has given positive indications that they will sponsor candidates starting in Spring 98 to attend the graduate course in Software Engineering. This course will be a part of the MSE program. The Spring 97 offering will serve to test the offering of SE courses in the distance education format.

We are also exploring the possibility of jointly offering one or more courses in the MSE program to students of both Purdue and the University of Oregon at Eugene. Such a joint offering, coupled with offering to employees of software companies, is likely to increase in enrollments at Purdue in critical areas and provide excellent opportunity for serving the needs of the US industry in education in SE.

Impact of the proposed work. We foresee the proposed work impacting two activities at Purdue. First, the infrastructure will be of direct benefit to students who enroll in the MSE program. Second, the software developed for the delivery of educational material will be usable by other educational program at Purdue, especially the ones that want to expand using the distributed education format. In addition to the above, the infrastructure will allow efficient operation of the MSE program which in turn will serve the Purdue well amongst companies who sponsor employees to the MSE program.

5.0 Purdue-On-Line Project

In this project we seek to create and maintain a facility for developing, implementing, and delivering Intranet and Internet based virtual courses. We are currently researching and experimenting with Internet based telelearning educational paradigm by offering a "virtual" course in "computer programming" to a limited number of students. It's worth noticing that the characteristics of this new educational paradigm make it different from existing video based learning paradigms. Internet based telelearning supports interactive, multimedia, self-paced speed, exam-on-demand, programmed educational modules covering different aspects of the same topic at varying levels of difficulty, adaptivity, and usefulness for learning disabled student.

The design of this experimental program satisfies the following criterion: a) maintaining the same quality as traditional classroom based courses, b) existence of a significant student population which will be interested in the telecourses (both credit and non credit), c) strong support and commitment from the academic units and deans, and a desire to see this effort continue long term, d) reuse of existing resources, research and faculty expertise, and e) produced material made available in multiple formats suitable for both real time and asynchronous delivery.

There are three distinct aspects to this project: technological, educational and organizational.

Technological Tasks. The goal of the technological activities is to develop (purchase and/or engineer) the infrastructure needed to develop and operate the Purdue-On-Line facility both at the individual virtual class level and also at the virtual university level. There are already several commercial software packages that are available for similar activities and one of our tasks will be to review and evaluate the viability of licensing such software instead of developing it. The specific goals for this task are:

- Adapt and advance technology to support a telelearning framework based on Internet infrastructure
- Design, implement, and evaluate a prototype facility for providing on-line virtual courses and a software environment for "virtual courses and classrooms"
- Design and implement an on-line server for delivering virtual course
- Design and implement an environment for the virtual university

The initial architecture of the Purdue-On-Line facility is concentrated on the development and delivery of virtual courses primarily, rather than the realization of the virtual university. The next section discusses the design and architecture of the virtual course environment.

Educational Tasks. The educational goals of POL are to study the pedagogical aspects of teaching and learning in the POL environment. We expect to interact with faculty from the school of education for these tasks. As prototypes, we will develop several virtual courses that will be delivered via POL. The specific goals for this task include:

- Develop and implement the new education paradigms of *learning anywhere* and *learning on-demand*
- Develop, implement, and evaluate "virtual multimedia courses" in several scientific, medical, agricultural and engineering areas

Organizational Tasks. An important task of POL is to develop the concept of a *virtual university*. There are several other efforts already in this regard and we expect to leverage from their work. The specific goals for this task include:

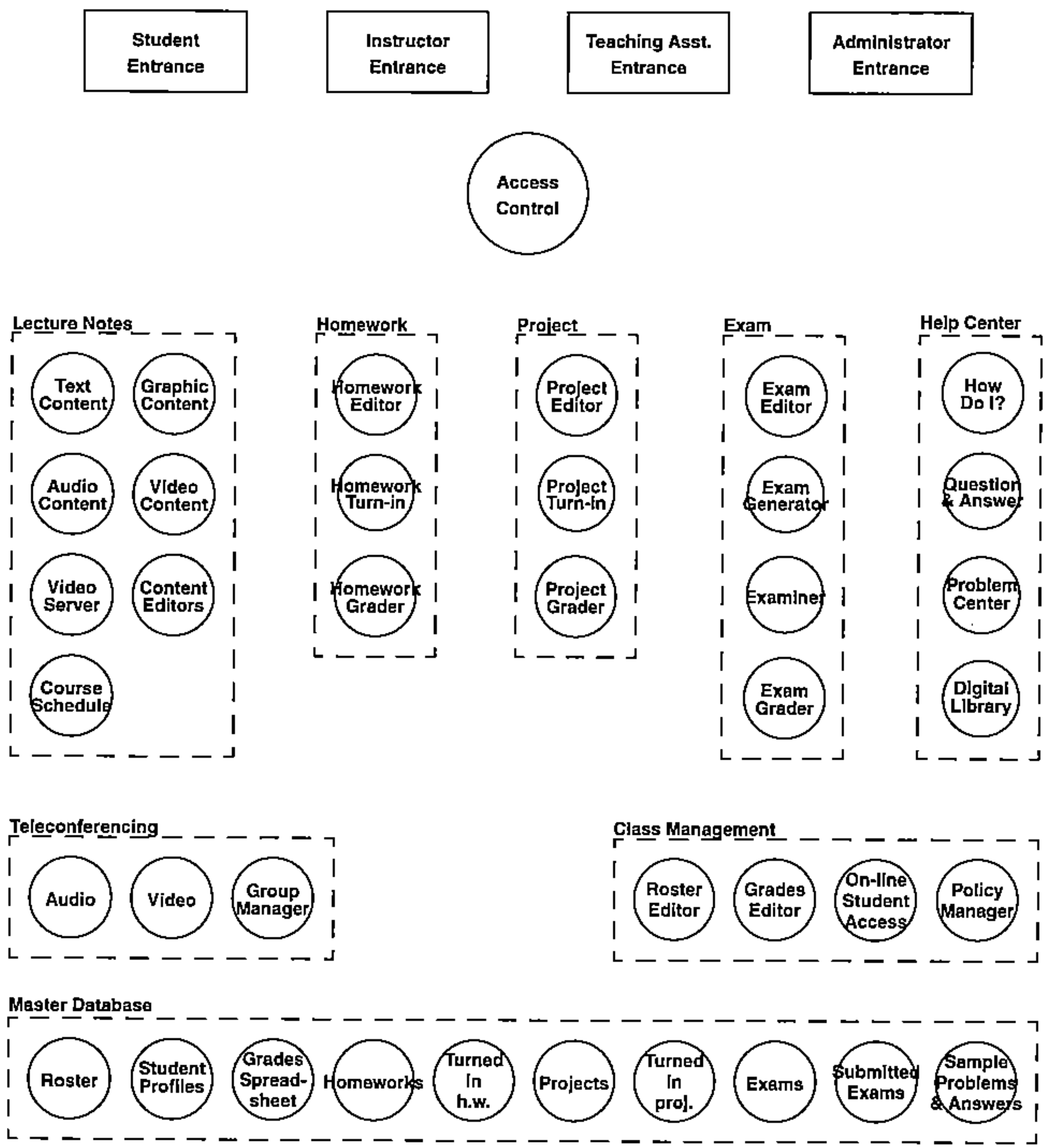
- Develop the institutional infrastructure to admit and administer "virtual" students
- Study issues of accounting and security

6.0 Architecture of the POL Course Development and Delivery Environment

The design of the course development and delivery (including administration) environment follows the design and structure of the traditional classroom in that it provides all of the facilities of the traditional classroom (and more). The architecture in terms of the main subsystems and their components is illustrated in Figure 1 on page 9. In the rest of this section we describe each of the subsystem. The next section discusses the implementation of this architecture using several servers and other components.

System Access. Access to all parts of the course, except for the first page ("homepage") is access controlled. Access is allowed at several access levels: student, teaching assistant, instructor or administrator. Access is managed using a personal access code (PAC) scheme using the class rosters and other information by the department / school / university administration. The access control subsystem represents the input interaction between the university and a class.

FIGURE 1. Architecture of the POL Virtual Classroom Environment: Component Subsystems View



Lecture Notes. This subsystem is the main activity area for a classroom. Content may be provided in any media, including text, graphic, audio and video. We expect to organize content in a hypertext style around a course schedule which allows the student to easily navigate the course lectures. Content development editors are used to develop content. Content must be designed to support self-paced, adaptive learning. We consider the technical facilities for developing and delivering video content separately as that requires special hardware / software.

Homeworks, Projects and Other "Off-Line" Assignments. These types of assignments are considered *off-line assignments*; i.e., the instructor *hands out* these assignments and they are done in the students' own time/space and *submitted* to the instructor at a later time. The functionality of these components include an editor for creating the assignments and uploading them to the class system, a *turnin* facility for students to upload their responses to the assignment and a grading environment to support grading of the assignments.

Quizzes and Exams. Quizzes and exams are treated in the same way (at the architecture level). These may be taken in a pseudo off-line mode (which corresponds to the traditional exam format: the student receives the entire exam at once) or in an on-line mode, where the examiner dynamically selects the next question based on the students responses so far. The latter is similar to the approach used in computerized GRE examinations, for example, currently. This subsystem consists of the exam editor for the instructor, the exam generator to generate the exam for off-line or on-line operation, the examiner to administer the exam to the student and the exam grader.

Help Center. The help center is an essential component of the classroom. This consists of a reference desk containing various useful information (including "How do I..." type information), a question and answer bulletin board type environment to allow students to ask questions from one another and the instructor (as well as to review previously asked questions and answers), a problem center to provide a repository of sample problems and solutions for the students to learn from and (access to) a digital library.

Teleconferencing. This facility enables both student-instructor and student-student interaction. In addition to standard audio/video/text/graphic teleconferencing facilities, a major component is a virtual group manager which supports creating communication groups to allow students to work in group projects. For basic telecommunications, we intend to use existing commercial off-the-shelf facilities such as Netscape CoolTalk or Microsoft NetMeeting.

Class Management. The class management subsystem supports all administration aspects of the class. Depending on the access level of the user, the level of functionality is varied. The overall facilities include a roster manager to administer the class roster, a grades manager to administer the class grade book, a policy manager to administer class policies (including grading policies) and an on-line student access system to allow students to browse their own records.

Master Database. The master database is really a collection of databases that contain all records for the class. These records include the class roster, the class grades, homework, project and other handouts, exams, sample problems and answers, turned in assignments and submitted exams.

7.0 Implementation of the POL Course Development and Delivery Environment

One of the first decisions that need to be made for implementation is whether to buy a fully-functional commercial system, to acquire and adapt/modify a commercial/university system or to develop a system on our own. We have done a preliminary search of available software and have concluded that there is no available system that meets all of our requirements. Hence, at least for the current prototype stage of POL, we have decided to design and build a course development and delivery environment ourselves.

The architecture described above is being implemented using four components: a client for user access, a Web browser, a Web server and a management server. Each of these components is briefly described below and their inter-relationships are shown in Figure 2 on page 11.

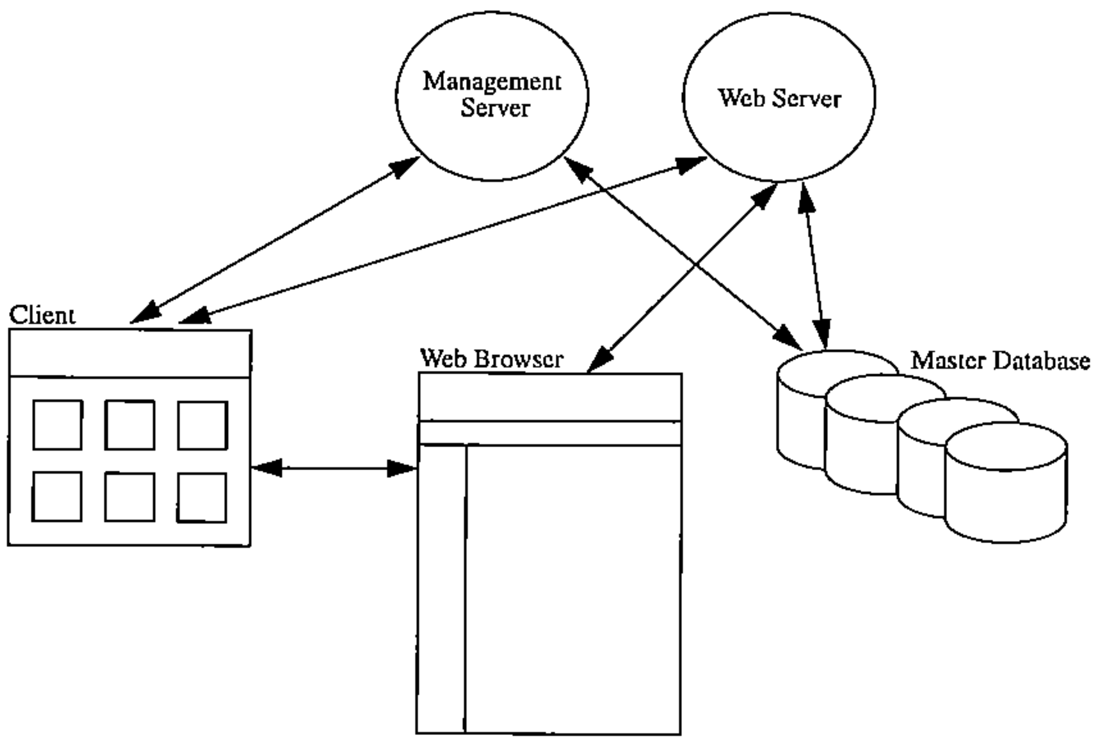
Client. The client environment is the access tool for all users of the course development and delivery environment. Depending on the type of user currently logged in, the capabilities of the client will differ. There are several choices for the architecture of this client: as an applet, as a traditional application or as a Castanet channel [3].

Web Browser. A standard Web browser is used to access and navigate "normal" Web content (HTML and other documents, course schedules, help center, etc.). The browser will be initially controlled by the client and then by the user.

Management Server. This server performs several important POL tasks such as access control, on-line records access, exam generation and administration and overall database management. The client uses this server as its secure counterpart and also to authenticate new users into the system.

Web Server. A standard Web server (with optimized support for accessing external code) is used to deliver "normal" Web content to the client and to the Web browser. All content will be access controlled using a fully secure mechanism (based on personal access codes and single-session keys).

FIGURE 2. Architecture of the POL Virtual Classroom Environment: Functional View



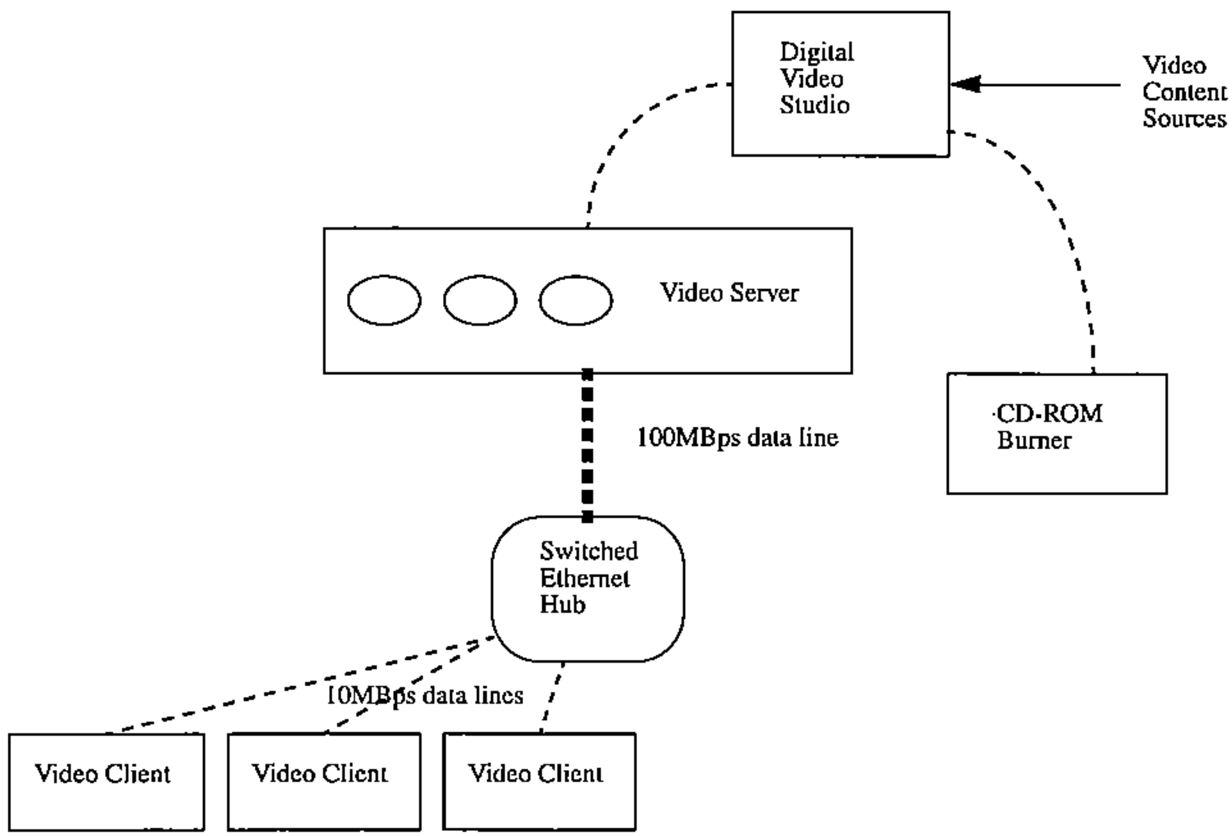
7.1 Video Content Development and Delivery

The development of video content must be done by the individual instructors. POL will have a digital video editing facility to convert VHS and SVHS format video content to digital MPEG-1 format. The resulting files will then be transferred to the POL video server for delivery.

While each course server will keep track of the video contents of each class, the video itself will be delivered by one or more video servers. We consider video needs for both intranet and internet use. Video on the current public Internet is not realistic at this point due to the high rate of congestion on the Internet. However, several key technologies are emerging rapidly currently (based on RTP (Real Time Protocol)) and we expect to adopt these at the earliest possible time. In the mean time, an alternative is discussed in the next section.

For intranet video, i.e., for virtual courses offered within the Purdue Data Network, we are setting up an Oracle Video Server on the machine pol.cs.purdue.edu. Even within the current intranet, video delivered across multiple networks is unusably slow and/or choppy. Hence, for initial prototying, we are setting up a special laboratory with custom switched ethernet networking to support the delivery of video content from a video server. Figure 3 on page 12 illustrates the architecture of the POL video environment.

FIGURE 3. Architecture of the POL Video Environment



7.2 Virtual Course Content on CD-ROM Media

As mentioned above, video content delivery via the Internet is not yet feasible. An alternative is to burn CD-ROMs with the video content and deliver that via regular mail to course participants and have Web-based content refer to the local CD-ROM for video material. We are purchasing a CD-ROM burner to support this activity.

8.0 CS158a: A new Paradigm for Teaching Computer Programming

Computer technology has already become an integral part of several aspects of life. It supports the management of our personal and business activities, and can be found in almost every human artifact. It is used as a learning aid and enabling technology in every social, scientific, and engineering discipline. Taking advantage of the opportunities and potential that this technology offers, either as users or as developers, requires some basic understanding of the underlying "computer science". This is regardless of the field of intellectual or professional endeavor of the user. Unfortunately, there is a big gap between current availability of computer technology and computer science education. One can argue convincingly that computer science courses in K-12 are considered as secondary intellectual material, something that "nerdy" students like. Even at the university level, we continue to teach students programming-in-the small in some one-to-many (usually more than 300 students) setting, using primarily text and plastic foils without taking advantages of our own technologies. This is inspite of the promising "ease-of-use" and "plug-and-play" technologies, the plethora of available applications and the rich, high-level functionality and concepts supported by application programs. The effective use of these technologies requires a new form of programming education that can be described as "programming-in-the-large." This involves teaching students the art of problem solving using high level computational tools, besides just teaching them details of some imperative language. The rapid exponential changes in computer technology demands continuing education even for reasonably knowledgeable professionals, and underscores the need for effective software tools and laboratories dedicated to such education.

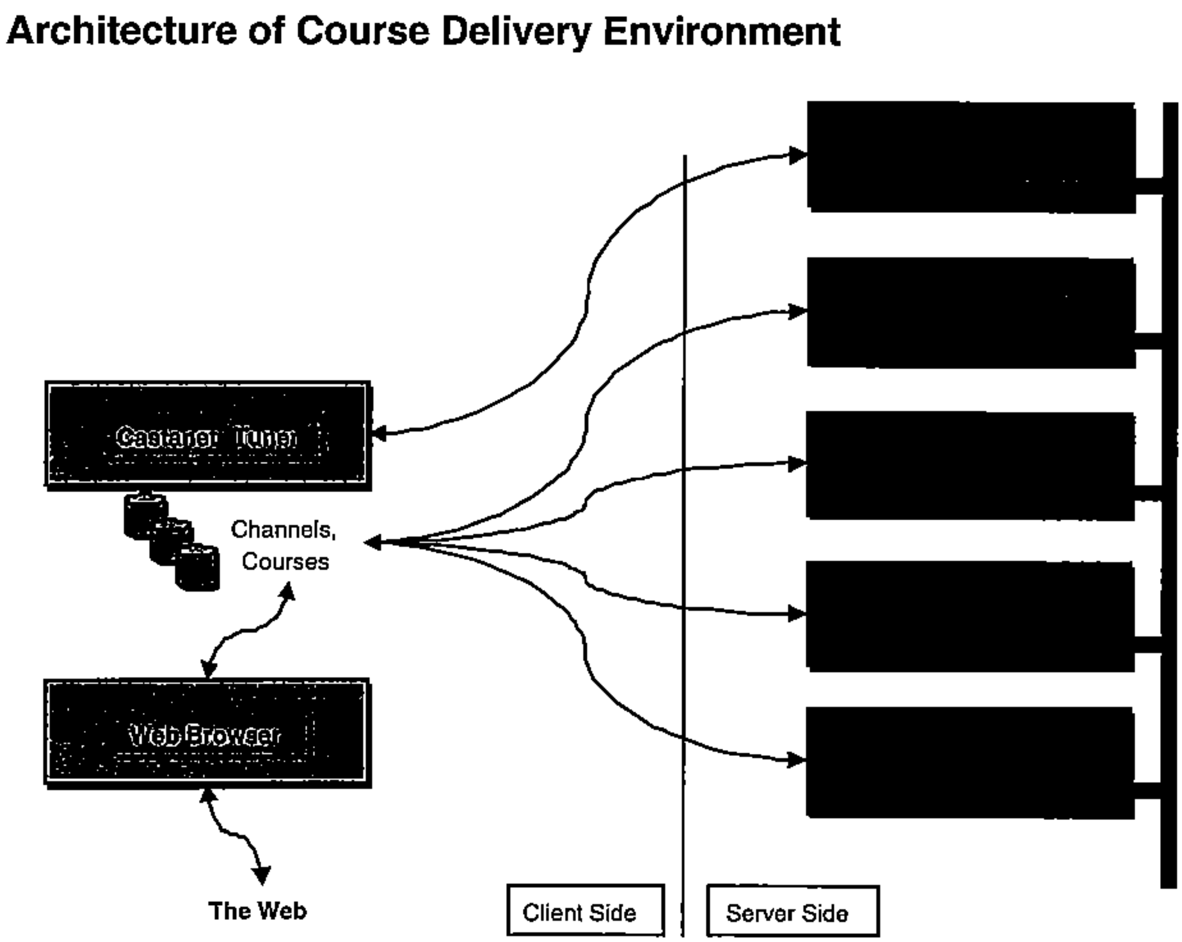
In the CS158a project we attempt to address the following research issues: a) **develop new paradigms for teaching computer programming and computer science courses in general using information technology, b) redesign the classroom & laboratory and make it available in some virtual form, c) develop software environments for delivering courses "anytime" and "everywhere" using such facilities, and, d) develop and evaluate an introductory computer science programming course material suitable for telelearning using this labware.**

9.0 CS158a: A virtual course in "Programming in C and Java"

The course objectives are to train and educate students in the following subject areas and associated technologies:

- PC Window environment, file system, Word processing and tools.
- Introduction to Internet, Web environment, and Web tools.
- Electronic communication: E-mail and electronic forums.
- *Mathematica* Programming Simulator.
- Study of Computer Techniques and Problem-Solving Methods for Applications in Engineering and the Physical Sciences.
- Unix fundamentals and Programming in C and Java (This activity is supported by a special tutor implemented in Java and runs on multiplatforms. The tutor allows users to rlogin to Unix servers).

FIGURE 4. Architecture of Course Delivery Environment



9.1 The PC computer and communication environment

- Basic familiarity with windows and system tools (file system, printing etc.).
- Internet, email, news as information gathering and sharing tools.
- Web related material, use of a Web browser (e.g. Netscape) as an integrated environment to access HTTP, Gopher, Mail, News, Wais protocol based material.
- Basic familiarity with tools for word processing and presentation.

9.2 The *Mathematica Symbolic and Numeric Simulator*

It includes the training of operating this powerful problem-solving environment (PSE) and computer science concepts and methods such as

- Computer Systems
- Basic Problem-Solving Techniques (Algorithm Design, Programming Constructs)
- Non-Numerical Algorithms and Data Structures (List Structures, Sorting, Searching, etc.)
- Computer Graphics (Graphs, Charts, CAD Methods, etc.)
- Numerical techniques (Solving Systems of Linear Equations, Solving Nonlinear Equations, Data-Fitting Methods, Numerical Integration, Other Numerical Applications)
- Statistical techniques
- Problem-Solving Methods using modular programming

In addition the students have access to a tutoring system for Mathematica.

9.3 Mathematica To C Intepreter

External intepreter for use with Mathematica clients to convert mathematica code to 'C' based code. Useful for teaching students with knowledge on Mathematica code to program in 'C'.

9.4 Programming in C and Java

The programming concepts and techniques demonstrated using *Mathematica* are revisited in C&C++ and Java. The students use the CD-ROM materials by Deitel & Deitel, Prentice Hall and a question and answer sessions corresponding to lectures.

9.5 Course Implementation And Delivery

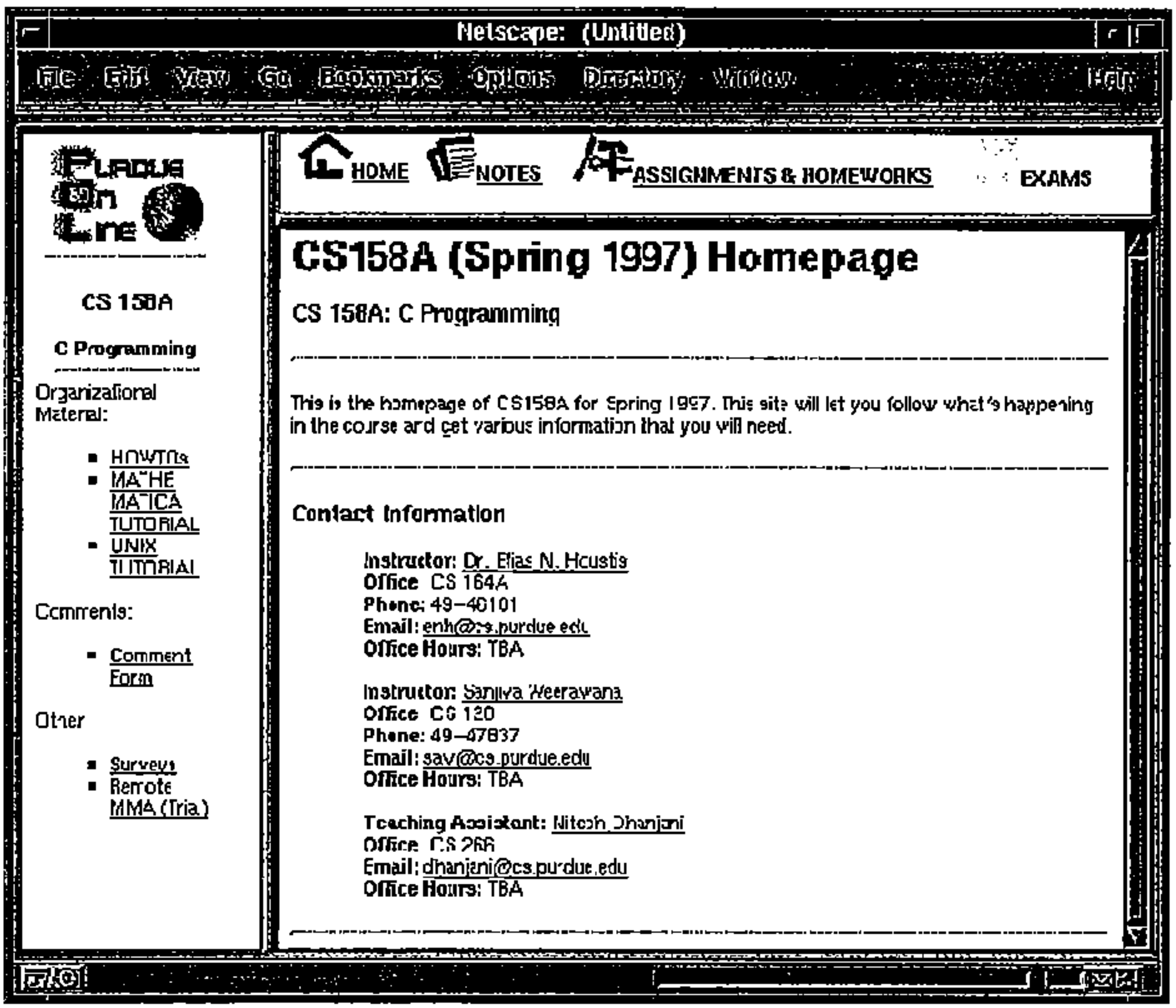
The course material (live lectures, video lectures, slides, assignments, and tests) will be available through some form of videoconferencing, CD-ROM, Web server, and Video server. For the delivery of the course we assume that the students has access to a workstation with CD-ROM drive, Internet connection, videoconferencing support.

Direct laboratory Delivery Model. We are currently experimenting the development of this course on a learning environment consisting of two laboratories of multimedia Pendium based PCs, connected to the PUCC network all running Window NT system, Mathematica, Netscape 3.0, Microsoft Office, Visual C++ and Java. The classrooms are equipped with projection systems connected to the instructor's PC. In addition these students have been provided for the duration of the course with a ThinkPad notebook equipped with wireless technology which he/she can take home and still be connected with the cyber classroom.

Asynchronous Delivery Model.

Synchronous Delivery Model. The synchronous on-line model will be supported by two-way video utilizing Intel ProShare videoconferencing technology, LearnLinc and Purdue-On-Line software, and Internet/Intranet/ISDN communication technologies. Figure 1 displays the architecture of this synchronous learning model using ProShare. In addition, the Purdue-On-Line (POL) group is exploring collaboration with Hughes Corporation to use satellite broadcasting and DirecPC technologies to deliver on-line courses. Figure 2 depicts the architecture of the satellite based synchronous learning model.

FIGURE 5. Web page of CS158a on-line course.



10.0 Available Tools for Implementing POL

There are many tools available for realizing (part of) POL. In this section we briefly summarize important tools available under the categories of conferencing software (for multimedia conferencing), multimedia delivery software, synchronous course management systems, asynchronous course management systems and virtual university systems.

FIGURE 6. Current hardware supporting POL facility

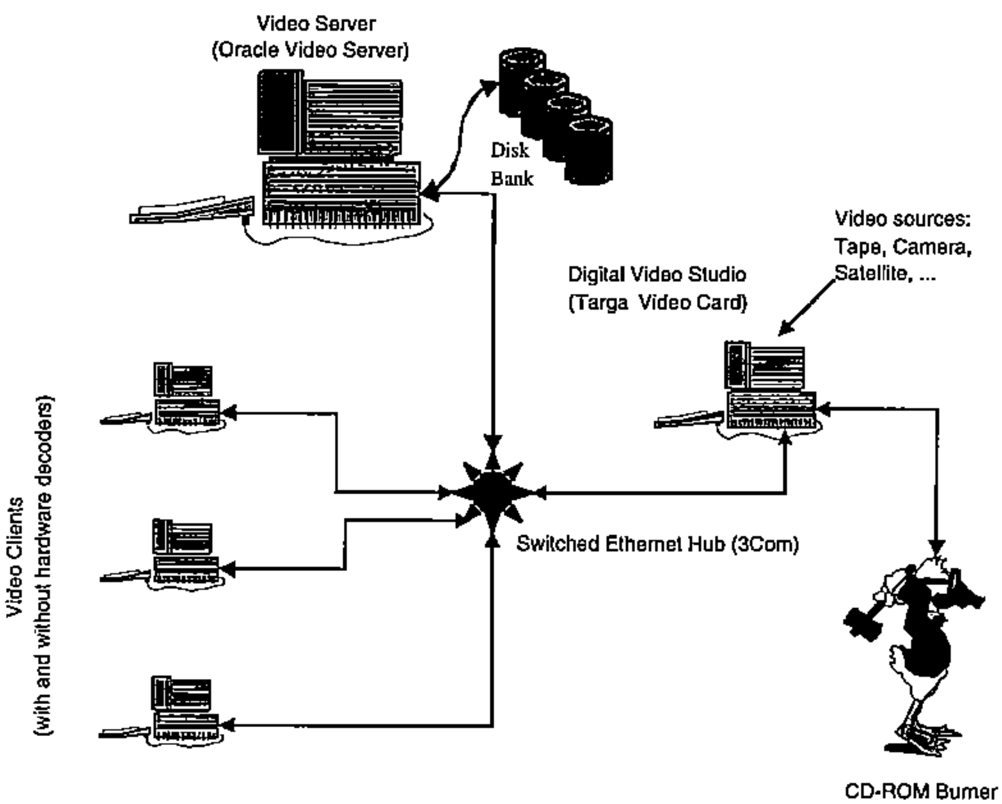
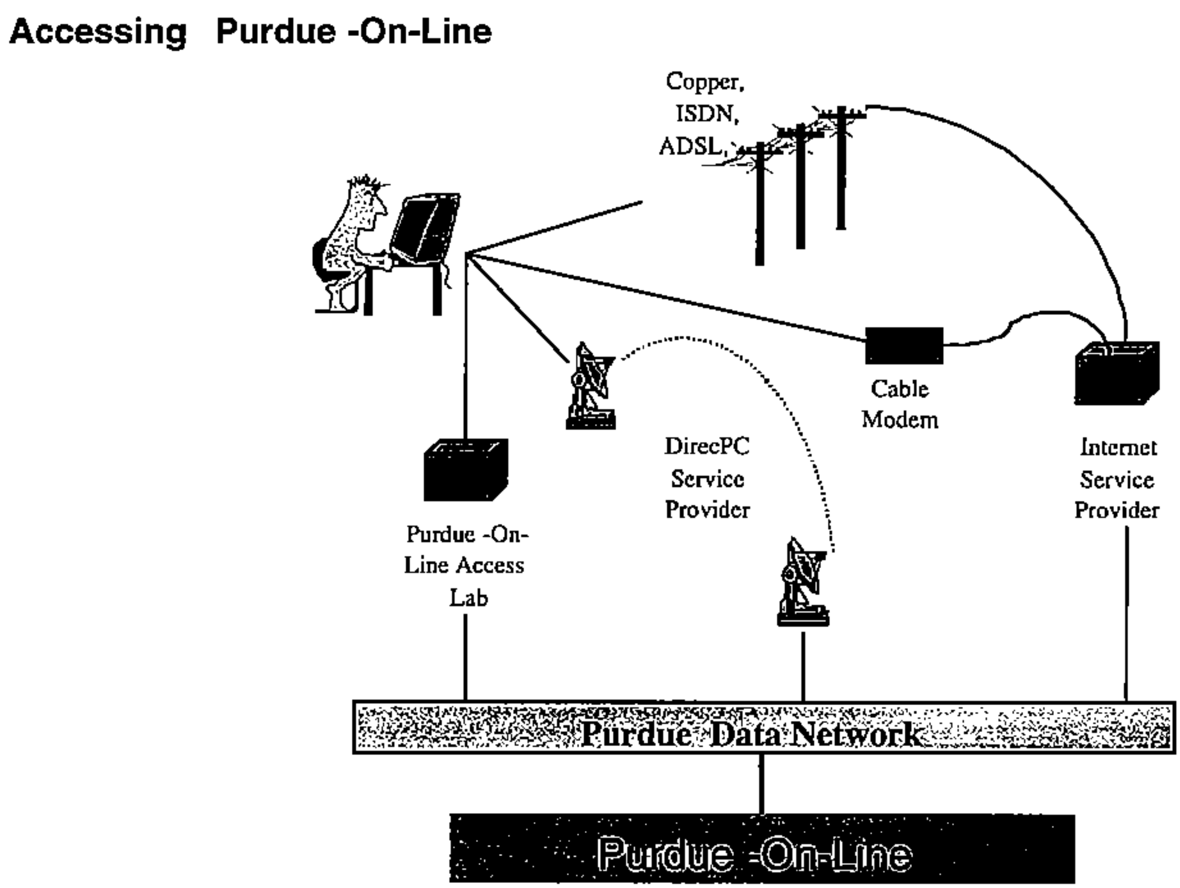


FIGURE 7. Hardware facilities foraccessing Purdue-On-Line server and courses.



10.1 Conferencing Software

The table below summarizes available conferencing systems. Key for "Type": Audio, Video,Text, Whiteboard, Messaging (e-mail), Bulletin Board.

TABLE 1. List of available conferencing systems.

Product	Type	Platforms	Cost	Comments
Netscape Cooltalk	A, T, W	Most	0 for academic	Audio communication tool, embedded in Navigator releases. http://www.netscape.com
Netscape Communicator	A, T, W, M, B	Most	0 for academic	Latest web browser by Netscape. http://www.netscape.com More security features added in its Java Virtual Machine implementation.
Netscape Gold 3.01	A, T, W, M, B	Most	0 for academic	Popular web browser by Netscape. Can run Vxtreme client
Microsoft Netmeeting	A, T, W	WinNT, Win95	0	http://www.microsoft.com/netmeeting Audio communication tool with the ability to share applications.
H.320 products	A, V	Most	Unknown	New standard for teleconferencing which is being adopted by various proprietary vendors. http://www.aeta.com/html/interview.html
FirstClass	T, M, B	Win95, WinNT, MacOS	0	http://www.softarc.com/FC/FC.HTM FirstClass is a high performance e-mail collaboration system that's easier and more fun to use than traditional groupware or intranet software.
POP-based mail	M	Most	0	
Usenet	B	Most	0	
Proshare	A, V, T, W	Windows 3.x, WinNT, Win95	$1200	Video Conferencing tool with application sharing capability. http://www.intel.com/proshare/videophone.
CuSeeMe	A, V, T, W	Most	$69 for client. $1298 for server.	http://www.cuseeme.com Popular video conferencing tool. Applicable for modem use also.

10.2 Media Delivery

The table below summarizes available media delivery systems. Key for "Type": Streaming Video (includes audio), Streaming Audio, Video File Format.

TABLE 2.

Product	Type	Platforms	Cost	Comments
Oracle Video Client/ Server	SV	Win3.11, WinNT, Win95, Solaris	low for academic, high for others	Provides full-screen MPEG-1/2 quality video. Useful for intranet. http://www.oracle.com/products/ oracle7/oracle7.3/html/ video_opt.html
VXtreme	SV	Most	$50 per stream	Video streaming with synchronous html flipping. Need Java enabled browser. http://www.vxtreme.com
RealPlayer / RealVideo	SV	Most	$29.99 for client. $995 for server supporting 60 streams	Live and archived streaming of audio and video. http://www.realaudio.com

10.3 Collaborating Software

The table below summarizes available application sharing and desktop mirroring tools. Key for "Type": Application Sharing, Desktop Mirroring

TABLE 3. List of available application sharing and desktop mirroring tools

Product	Type	Platforms	Cost	Comments
ProShare	AS	Windows 3.x, WinNT, Win95	$1200	Video Conferencing tool which has the capability of sharing applications. http://www.microsoft.com/netmeeting

TABLE 3. List of available application sharing and desktop mirroring tools

Product	Type	Platforms	Cost	Comments
Microsoft Netmeeting	AS	WinNT, Win95	0	Audio Conferencing tool which has the capability of sharing applications. http://www.microsoft.com/netmeeting
PC Anywhere	DM	WinNT, Win95	$149.95	Mirrors Desktop of remote machine, useful tool for debugging. http://www.symantec.com/pcanywhere/index_product.html

10.4 Content Delivery Sources

The list of existing organizations supporting some form of on-line education cab be found in

TABLE 4. Organizations involved in some form of on-line education.

Organization	Description
RealEducation	Builder and manager of complete on-line campuses and continuing education centers while using various available tools. http://www.realeducation.com
Asymetrix	Consultant on howto efficiently author, deploy, and manage learning applications via the internet and the intranet using various multimedia applications. http://www.asymetrix.com
IBM Global Campus	An education and business framework that helps colleges and universities use computer networks to redesign learning, teaching and administration. http://ike.engr.washington.edu/igc
NovaNET	An on-line computer based education and communications network with instructional material in more than 150 subject areas. NovaNET currently delivers more than 2.5 million hours of instruction each year to adult and young adult students throughout the United States. http://www.novanet.com
Centra	A comprehensive resource center with links to various distant learning education sites and a collection of its own material. http://www.centra.com/DISTANCE/INDEX.HTML

TABLE 4. Organizations involved in some form of on-line education.

Organization	Description
ILINC	ILINC(Interactive Learning International Corporation) develops distance learning software that increases learning quality through a combination of instructor led and self-paced , interactive, multimedia learning tools. http://www.ilinc.com
IRI at Old Dominion University	IRI(Interactive Remote Instruction) melds high speed networking, television, and computer technologies to allow for distance learning over the internet. http://www.cs.odu.edu/~tele/ini

10.5 Asynchronous Content Delivery

The table below summarizes available course content managers .Key for "Type": Grading Facility, Misc. Content Delivery

TABLE 5. List of available course content managers.

Product	Type	Platforms	Cost	Comments
Lotus Learningspace	GF, MCD	Most	$23 for one client. $580 for Domino Server	Lotus Notes and Domino integrated Asynchronous distance learning tool Web-based and Lotus Notes client based. http://198.114.68.60
Mallard	GF, MCD	Unix	0 for academic	Interactive Web-based educational software system developed at the University of Illinois. http://www.cen.uiuc.edu/Mallard/Mallard_nest.html
Cyberprof	GF, MCD	Unix	0 for academic	Interactive Web-based educational software system developed at the University of Illinois. http://www.cyber.ccsr.uiuc.edu/cyberprof/general/homepage/New-page/toplevel/welcome.html

10.6 Selected Tools for Implementing POL

Based on our evaluation of the various tools we have selected to base the implementation of the POL

TABLE 6. The tools selected to implement the first version of POL

Functionality	Product
Browsing, E-mail, and audioconferencing	Netscape Gold 3.01
Videoconferencing	ProShare and CuSeeMe
Asynchronous content delivery	Lotus Learning Space
Synchronous content delivery	LearnLinc
Video on demand	Vxtreme, Oracle Video Server/Client

on the tools listed in the Table 6 on page 23.

10.7 Selected Tools for Implementing CS158a

The on-line environment for delivering CS158a consisits of the tools listed in Table 7 on page 23.

TABLE 7. The asynchronous distributed learning environment for CS158a will be supported by the listed tools.

Functionality	Product
Browsing, E-mail, and audioconferencing	Netscape Gold 3.01
Videoconferencing	CuSeeMe
Asynchronous content delivery	Lotus Learning Space
Video on demand	Vxtreme, Oracle Video Server/Client
Compilers	Microsoft Visual C/C++ and Java++
Mathematica to C interpreter	Purdue's MtoC tool
Multimedia Material in C/C++ and Java	CD-ROM materials by Deitel & Deitel, Prentice Hall
Talking head lectures with slides	Vxtreme
Test on demand	Purdue's tool
Unix environment	Java based Unix environment
Tutorials	Web tutorial's on tools

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Video Applications in the Era of Computer Networks
- Computer & Video = Multimedia? -

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Abstract

The areas of television, telecommunication, and information technology are converging, new application areas are arising and new services are being established. Aside from the traditional delivery channels, computer networks play an increasing role in providing the new services.

An important part of these services is based on video. However, in order to develop and establish such services, the differences between traditional video and multimedia applications as well as the requirements, limitations, and possibilities for an integrational use of both have to be understood. The question arises in which way video can be included to fulfill the requirements for newer, more valuable services, different and more powerful than existing services such as TV, electronic mail or CD-ROM applications.

This paper presents a classification scheme together with a requirements analysis regarding communication channels, interaction mechanisms, quality, and parameter settings for a useful development of new computer-based multimedia applications. The use of "still video" for Internet-based applications and the integrational use of static information, e.g. on CD-ROM, are presented, as new multimedia and hypermedia application concepts.

The discussion concerning requirements and applications for multimedia systems leads to the definition of "High-Definition Multimedia". Aspects of High-Definition Multimedia Systems will be discussed at the end of this paper.

1 Introduction

As the areas of television, telecommunication, and information technology fuse, new services are being established and new application areas are arising. Many of these new services are computer-based and the computer is used as a "general purpose" device for the processing and presentation of multimedia information. Furthermore, computer networks together with traditional delivery channels are used for the delivery of these new services. On the other side, TV-sets will also be used for the presentation of multimedia information. The ongoing research and current activities in the area of "Interactive TV" are an example of this development.

Multimedia presentations are characterized by the integral use of different monomedia information types. To reach the communicative goal and to be accepted by the user, these monomedia have to satisfy specific quality requirements which are seldom addressed by today's applications [GeMü 94]. A central issue in the development of multimedia systems is the complete integration of video. In this context, an adaptation of traditional video technology is not sufficient to solve the specific requirements of computer-based applications. In multimedia systems - in contrast to TV with its fixed set of parameters and delivery mechanisms - video can be presented over very different communication channels and display devices and with very different communicative goals in mind. Consequently, video in multimedia systems needs to be more flexible than its traditional - analogue - counterpart. This aspect will be discussed in more detail later.

The following questions arise:

- What are the differences between traditional TV and multimedia applications and what are the requirements for integrational use?
- In which way can video be included to fulfill the requirements for newer, more valuable services, different and more powerful than existing services such as TV, electronic mail or CD-ROM applications?

1.1 What is Multimedia?

To point out the differences between traditional video services and new multimedia applications, it is necessary to determine the basics of multimedia. Multimedia is the processing and presentation of multimedia information. Multimedia information is characterized by the integrational use of different mono-media types. To reach the communicative goal for a specific multimedia application, the *quality* of the mono-media data streams as well as the *integration* of these media have to be sufficient for the specific application. *Quality* and *integration* are two major aspects of useful multimedia systems and applications. In general, the following factors determine the quality of each multimedia presentation as well as that of mono-media presentations:

- the visual abilities of the human observer,
- the information to be coded,
- the communicative goal,
- the application area with its metaphors and application-specific requirements,
- the presentation and interaction devices and tools.

Multimedia can integrate different media components as shown in figure 1. Not every possible media component is integrated in each application. Many multimedia applications only include text, image, and video/audio. Each media can be represented at different levels, starting from the optical/analog-electrical representation, through the digital pixel representation and the geometry and feature representation, up to the symbolic representation which is the most abstract representation level [GeKr 93]. Often, different representation levels are chosen to achieve different levels of quality or functionality. For instance, the user can operate with graphics in different ways if they are represented as bitmap images (digital pixel representation) compared to the operation methods he has at his disposal if graphics are represented as higher level primitives (geometry and feature representation). Hence, other combinations of media and used representation levels as shown in figure 1 are possible [Kröm 94]. We define the rate at which a combination of media and representation levels is supported as the *completeness* of a multimedia system.

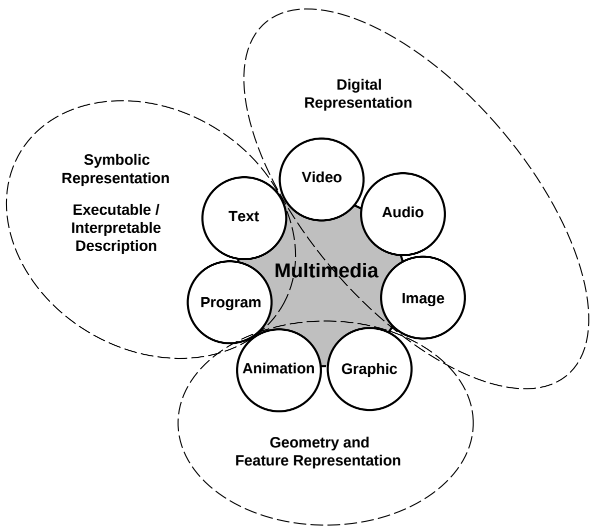

Fig. 1: Mono-media in multimedia systems

A central part in today's multimedia development is the integration of video data and functionality. Through the use of video in computer applications, much information can be represented in a more adequate way due to the addition of the factor movement. The main professional application areas for this kind of multimedia system are:

- Conferencing and negotiations
- Presentations and training
- Information kiosks and catalogues

Since video is the central media component of today's television services, the question arises in which way these data, delivery channels and methods, and devices can be used in multimedia systems and applications.

1.2 Traditional Video Services and Multimedia Applications - What are the Differences?

Computer-based video services and multimedia applications are no longer fixed applications using determined components for video acquisition and generation, distribution, and presentation. As shown in figure 2, in multimedia systems, different data "servers" can use numerous communication channels to connect to various "clients".

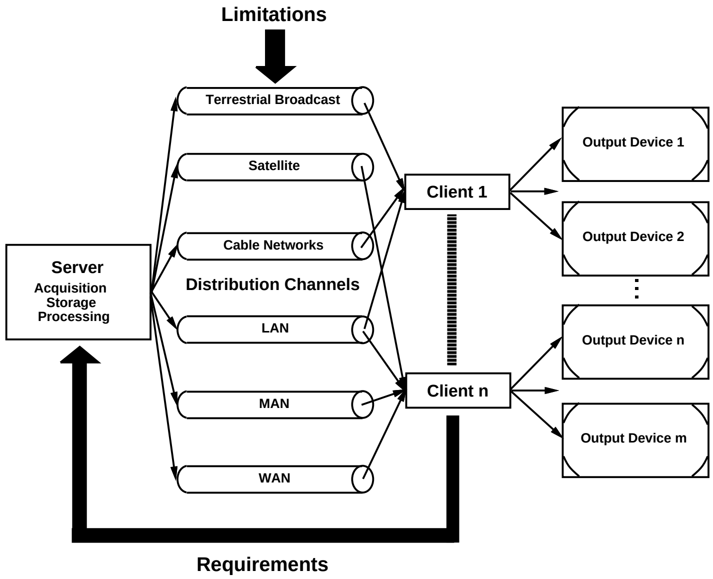

Fig. 2: Communication model for distributed multimedia systems

In contrast to computer-based systems, server, distribution channels and clients in classical applications - such as television systems - are characterized by fixed parameter sets and formats as well as fixed channel bandwidth. The communication model of these classical systems is shown in figure 3.

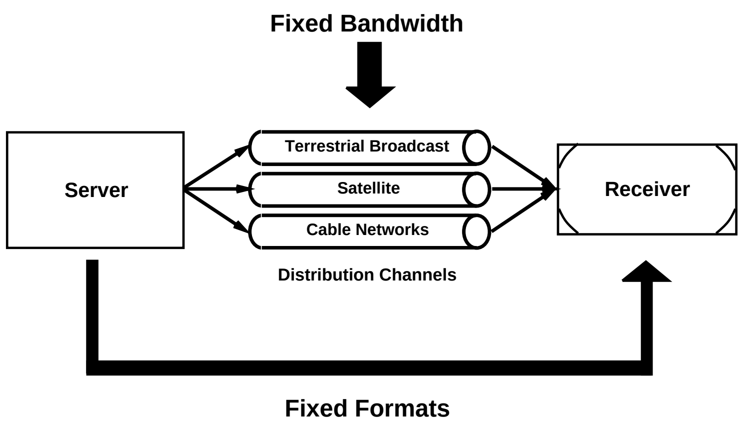

Fig. 3: Communication model for classical video systems

Furthermore, multimedia systems include, in contrast to today's television applications, the feature *interaction*. Interaction can be used for two main tasks. First, it allows content control, that is, the content and its presentation order can be changed. Second, interaction can also be used to determine and control the presentation quality, e.g. determine the bandwidth which should be used, the audio and video quality, etc. Especially the determination of quality levels for mono-media in multimedia applications represents a main difference to television. Due to the large variety of systems and application requirements, different quality levels are necessary to fulfill the various quality needs. In contrast only one level of quality is used in traditional television systems.

As technical differences between classical video and computer-based systems, the following aspects are of major importance:

	Television	*Computer*
Task and Environment	• "watch scenes" • large viewing distance • replaces the surrounding environment	• overview or study of details • small viewing distance • works with and complements the surrounding environment
Content	• fine details are limited • reduced artifacts for movements • limited up to digital representation	• very fine details • correspondence between framebuffer and display (rendering) • no limitation in used representation levels
Display	• large dot pitch allowed • bright display, variations allowed • geometry, convergence, and focus can decrease at corners • wide deflection angle (≥ 100^0)	• small dot pitch • constant brightness • geometry, convergence and focus have to be constant over all screen areas • small deflection angle (90^0 or less)

Tab. 1: Differences between television and computer

More detailed discussions concerning television and computer systems differences can be found in [Poyn 93], [Syme 94], and [TFDI 92].

Television and computer-based applications have important differences in the areas of tasks, contents, and devices, e.g. displays. In principal, two approaches can be taken to perform integration:

- First, integration of computer data, e.g. texts, graphics, etc. into existing television systems,
- Second, integration of video into computer systems.

Analyzing the differences, it is an open question which of the visions, "compuvision", television with computing capabilities, or "teleputer", computer with video capabilities, will become reality [Pres 90] [Pres 93].

Due to the heavy increase of the use of computer networks, e.g. the "Internet", for both commercial and academic use, network-based applications are of major interest [Gerf 95]. This direction of integration, that is, adding video to computer applications, and its use in computer networks will be discussed in more detail in the following chapter.

2 Integration of Video and Multimedia Applications

2.1 Service Classification

As described in chapter 1.1, multimedia covers many different applications and application areas. Each of them can have different requirements, therefore, a classification is necessary. The following classification is based on two aspects, the necessity of interaction capabilities and the delivery mechanisms and classes used.

One main feature of computer-based systems is *interaction*. For distributed applications, this means the bi-directional communication between server and client as shown in figure 4. Most of today's applications in the area of "Interactive TV", such as Video-on-Demand and home shopping, use different channels in both directions. Besides a data channel with medium or high bandwidth, only small to medium bandwidth return channels are used. Hence, these applications have only limited interaction capabilities.

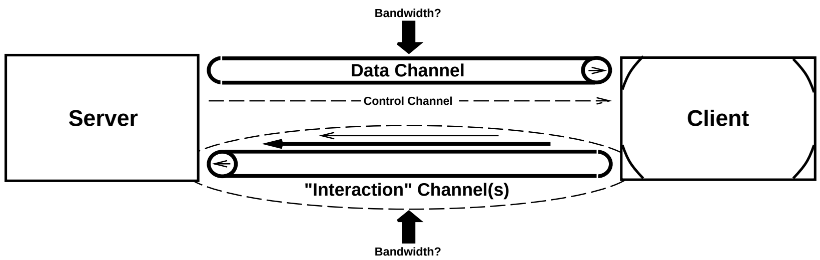

Fig. 4: Used channels in distributed multimedia systems

In general, we can distinguish between the following application classes:

- Applications *without a return channel*
    - Near Video on Demand (NVoD)
    - A/V multicast on the Internet (see MBone)
- Applications *with small bandwidth return channel*
    - VoD and home shopping
    - Configuration of distributed Internet services, e.g. AVWOD [Bönn 95]
- Applications *with large bandwidth return channel*
    - Interactive games
    - Video-conferencing, Video-Mail

Each of these application classes with its different interaction capabilities is used for different delivering mechanisms [GeKr 93]:

- *Singlecast / Unicast*
    - 1:1 connection. Interaction between both partners is possible; applications use a bi-directional channel; data and return channel are equal. The receiver is known and negotiations concerning parameter sets can take place.
- *Multicast*
    - 1:n connection (n is small). Applications with this kind of connection can have bi-directional channels, e.g. video-conferencing applications; depending on the application, the used return channel ranges from small to large bandwidth. The receiver can be known; in this case, negotiations concerning parameter sets can take place.

- *Broadcast*
    - 1:n connection (n is large). No interaction possible, therefore, a return channel is not necessary. The receiver is unknown - anonymous - parameter sets have to be pre-defined.

Figure 5 shows these different delivery classes. Using computer networks, in principle, all kinds of delivery mechanisms can be realized, since the return channel is not separate from the data channel. In practice, real broadcast applications are simulated by multicast sessions without making use of the return (see MBone description - chapter 2.2.1).

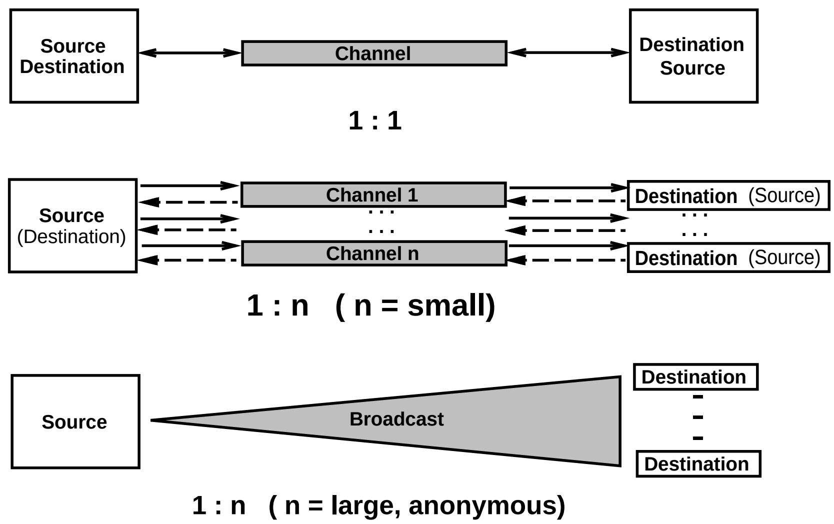

Fig. 5: Delivery classes

The delivery classes have different limitations and requirements, therefore, the concept "one size fits all" cannot be applied. A television system operates with fixed parameter sets, formats, bandwidth, and receiver. This is necessary, since it is a real broadcast application without the possibility of interaction concerning quality settings, etc.

For distributed interactive applications, the whole information processing should ideally take place on the client side. Hereby, a maximum of flexibility in fulfilling the quality needs, depending on the application requirements and the communicative goal, could be achieved. However, this solution can often not be applied due to channel limitations and the often limited processing capacity on the client side. Therefore, the bandwidth of the signal has often to be reduced on the server side. For the bandwidth reduction, two concepts can be used:

- different quality levels
    - parameter hierarchies are defined and, depending on limitations and requirements, information is delivered at the adequate quality level. Examples of video hierarchies can be found in the "Digital Image Architecture" Report or in the level and profile concept of MPEG II video [TFDI 92] [ITUT 95] [GeMü 94] [Gerf 95a].
- generation of low bandwidth data stream
    - depending on worth case bandwidth and client, an adequate information representation is generated. Using this concept, all possible clients are guaranteed to receive the same information. This concept is often used in multicast applications.

Moreover, combinations of both concepts are also possible. For instance, scaleable data streams provide the client with the option of only processing the information it can handle. Additionally, information can be coded at different priority levels, such that when data loss occurs, the highest priority information is still received.

In contrast to television, computer-based applications cover all three methods of delivery: unicast, multicast and broadcast. Furthermore, different levels of interactivity, or communication between server and client, are used. In the next chapter, some examples of these various applications are provided together with an analysis concerning the degree of video integration and the use of multimedia features, e.g. interactivity.

2.2 New Concepts and Applications

With the integration in multimedia and hypermedia systems, computer-based video systems are losing their status as stand-alone applications. A single video channel may be used in very different applications and application contexts with varying quality requirements. Examples of such new application areas are:

- Home Multimedia Systems
  - Advanced Video-on-Demand Systems ⇒ Real Interactive TV
  - Information Systems ⇒ "NII"
- Public Multimedia Systems
  - Multimedia systems in banking, real estate, museums, libraries
- Professional Systems
  - Multimedia office and conferencing systems
  - Professional information systems
  - Computer-supported cooperative work (CSCW)
  - Multimedia learning environments
  - Multimedia systems for medical applications

About three years ago, a new Internet service was established: *MBone*, the Multicast Backbone for the integration of video in multicast applications. In the next chapter, this "base" service will be described in more detail together with an analysis concerning restrictions and limitations; this leads to the proposal of a new concept to overcome some of the detected limitations.

2.2.1 MBone - Providing Video and Audio Across the Internet

The MBone is an outgrowth of the first two IETF (Internet Engineering Task Force) meetings, in which live audio and video were multicast from the IETF meeting site to destinations around the world [Kris 94] [MaBr 94].

MBone is a "virtual" network and is layered on top of portions of the physical Internet to support routing of IP (Internet protocol) multicast packets. The MBone network is composed of islands that can directly support IP multicast, linked by virtual point-to-point links called "tunnels". The tunnel endpoints are typically workstation-class machines with multicast support. MBone's key component is its bandwidth-efficiency, since one multicast packet can touch all workstations on the virtual network. Thus, a 128 kbit/sec video stream uses the same bandwidth whether it is received by one workstation or 200.

The MBone as the underlying network is used for more and more varied applications:

- Video-conferencing (1:1 - n:n)
- Meetings, conferences, teleteaching (1:n)
- Public information (satellite images, etc.) (1:n)
- Entertainment (Radio Free Vat) (1:n)
- "In-house" use ("CSCW, etc.) (1:1 - n:n)

For all these applications, a large variety of tools have been developed, from conference management tools and whiteboards, over video, audio tools, to the integration of "World Wide Web" applications [Deer 94]. Figure 6 shows an MBone in-house conferencing session using different MBone tools.

Fig. 6: In-house use of MBone tools for conferencing

The bandwidth used for MBone sessions is typically about 100-300 kbit/sec, with audio carried at 32 or 64 kbit/sec and video at up to 128 kbit/sec. For in-house use, a higher bandwidth can be selected. This relatively small bandwidth is achieved by the application of video and audio compression [Fred 94]. Here, the concept of generating a low bandwidth data stream is used; in general, the user cannot choose between different quality levels. Only about 1-4 video frames per second can be sent at this bandwidth. The question arises which quality levels for video have to be used? This leads to the proposal of using "still video" in environments with only small bandwidth availability.

2.2.2 The use of "Still Video"

At Fraunhofer-IGD, we have developed a new application which demonstrates audio and video delivery using MBone tools, together with synchronized delivery of World Wide Web (WWW) hypertext documents. The application is called "AVWOD", short for *Audio-Video-WWW-on-Demand* [Bönn 95]. Users can contact the AVWOD server and select an available session together with the media desired. In contrast to MBone applications, AVWOD uses standard unicast protocol with the same bandwidth limitations, that is up to 128 kbit/sec for video data.

Due to this bandwidth limitation, only a frame rate of about 1-4 frames/sec can be achieved. For in-house,, use we raised the bandwidth limitation to 1.5 Mbit/sec to achieve about 25 frames/sec.

In addition to frame rates from 1 frame/sec up to 25 frames/sec, we generated test sequences with picture changes only in situations when the image content changed. We call this content-dependent frame rate "still video". This means new frames were only generated when the presented slides were changed.

Subjective tests have shown an interesting result:

- high frame rate (≈ 15 - 25 frames/sec)
  - users accepted this frame rate; they could concentrate on all presented information: video, audio and hypertext documents
- low frame rate (≈ 1 - 4 frames/sec)
  - users did not accept this frame rate; the video demanded too much of their attention, thus, it was difficult for them to concentrate on the other presented information
- very low frame rate (much less than 1 frame/sec) ⇒ "still video"
  - users accepted this frame rate; they could again concentrate on all presented information: video, audio and hypertext documents

Together with experiments on image resolution and frame rate, these test have shown that, in cases of low bandwidth channels, a better subjective image quality can be achieved when the frame rate is reduced. This method can be used for all applications where the content changes at a low frequency. In the future, more intensive research has to be conducted in the field of automatic detection and interpretation of content changes [Stas 93].

The examples of MBone and the possible enhancement for several MBone-based applications show the possibility of video integration in existing applications and in the development of new ones. However, these examples also still show deficiencies in real multimedia applications. They provide real interactivity only up to a certain point.

In the following chapter we want to concentrate on "High-Definition Multimedia" and on all aspects which have to be taken into account for the development of "real" multimedia applications.

3 The Goal - High-Definition Multimedia

The integration of video data and functionality is a major issue in today's development of multimedia systems and applications. This integration can be seen as a positive improvement of multimedia systems; however other factors also have to be taken into account. Since man is "multimedia" and has the ability to use all his senses while communicating, this potential has to be considered in the development process. Table 2 shows the different human potentials for communication primitives. Only an optimal use of these potentials will lead to a future proof development. The main goal encompasses not only the inclusion of more and more mono-media, but also the user-oriented development of multimedia systems.

Communication Primitives	*Reception Potential*	*Action Potential*
Visual	very large	small
Acoustic	medium	medium
Tactile	rather small	large

Tab. 2: Human potential for reception and action [Kröm 94]

In the former chapters, we identified three major aspects which have to be considered in the user-oriented development of new systems:

- **Completeness**
  Consideration of different information and representation types
- **Quality**
  Quality settings and adaptation to communicative goals
- **Integration**
  Development of open, platform-independent systems

Obviously, these factors determine the acceptance and usefulness of multimedia systems. We want to call systems which take these three major aspects into account "*High-Definition Multimedia Systems*" (HDMM Systems). HDMM systems will make improved use of real world phenomena and lead to an optimal design in accordance with application and user requirements, leading from a technological point of view to a user-oriented development. As an example, discussion about technical aspects of video formats is important, but more important is the orientation toward user and application requirements for video data. This was illustrated, e.g. in the work of the SMPTE "Task Force on Digital Image Architecture" [TFDI 94].

In order to explain HDMM mre thoroughly, the three major aspects are discussed in more detail.

Completeness in HDMM systems means more than the combination of different mono-media such as text, graphics, audio and video. An ideal complete system allows the representation of all media at all different representation levels as well as the conversion between the representation levels and the communication primitives. Table 3 gives some examples of representations of the communication primitives at different levels of abstraction.

<table>
<tr><td rowspan="3">Representation Levels</td><td>Symbolic</td><td colspan="3">Text, Numbers, Tables, Functions</td></tr>
<tr><td>Feature</td><td>Graphical Primitives, Animation</td><td>Midi</td><td></td></tr>
<tr><td>Discrete</td><td>Raster Image, Digital Video</td><td>Language, Music</td><td>Key Pressure, Movement</td></tr>
<tr><td colspan="2">Communicative Primitives</td><td>Visual</td><td>Acoustic</td><td>Tactile</td></tr>
</table>

Tab. 3: Media representations on different levels of abstraction [Kröm 94]

As table 3 shows, it has to be possible to convert a symbolic representation of information to a visual, acoustic, or tactile representation depending on the communicative goal and system restrictions. Today, most work has been done on the conversion between different representation levels, e.g. from analog to digital, or from a feature representation to a digital pixel representation by rendering of graphics or animations. The conversion between the different communicative primitives is much more difficult. It includes such processes as image and speech understanding. Nonetheless, the possibility of using this kind of conversion in multimedia systems is very important for the user- and application-oriented development.

The precision and speed of perception as well as the certainty of perception are directly determined by the *quality* of the input features, the transmission of the information and the representation of the information. This is valid for all communicative primitives and methods of interaction. Aside from adhering to certain borderline values while representing mono-media information, the quality of communication and interaction is also affected by combination effects, such as synchronization requirements or system response times. Therefore, the achievement and control of adequate quality levels have to be related to the communicative goal and the application area of a specific multimedia application [GeMü 94].

Only the determination of and adherence to application- and situation-dependent quality criteria, with respect to coding, transmission and representation of information, will lead to an undisturbed, error-minimized, and efficiency-enhanced mode of man-computer interaction and man-to-man communication.

Table 4 gives some examples for the determination of quality levels in different application areas. These quality levels are not based on technical criteria, but on different communicative goals which have to be achieved.

Quality	*Application*	*Conferencing / Negotiations* (live)	*Presentation* (live)	*Kiosk / Catalogue* (pre-generated)
High	Goal	Recognizability of emotions	Recognizability of the audience	Complete assessment
Quality	Requirements	Size, Color, Frame rate	Color, Frame rate	Size, Color
Medium	Goal	Completeness of conference	Accompanying presentation of lecturer	
Quality	Requirements	Audio Synchronisation	Synchronization with data	
Low	Goal	Recognizability of partners	Recognizability of lecturer	Product identification
Quality	Requirements		Audio	Frame rate

Tab. 4: Application Scenarios and Quality Levels

The aspect of *integration* stands for the combination or addition of existing systems into multimedia applications. The broadness and complexity of existing stand-alone systems often prevent the re-implementation for use in new systems. This leads to the demand for "open systems", which allow the embedding of existing systems on one side, the opportunity for further improvements and adding of new technologies on the other. The development of open systems can be positively influenced in view of the following areas [Kröm 94]:

- Integration achieved by making platforms uniform
- Integration via exchange formats
- Integration by means of evolutionary databases

A survey of existing multimedia systems has shown that most of the existing multimedia authoring and presentation systems have large deficiencies in terms of completeness, support of quality levels and parameter control, and the possibility of adding new components, media, etc. [BöKK 94].

Fig. 7: View of the HDMM Lab and Demo Center with high-resolution display (2k x 2k) and rear projection for conferencing applications

At the Fraunhofer Institute for Computer Graphics, a Darmstadt, Germany-based research institute, we have established a lab and demo center for High-Definition Multimedia Systems. This center is used for the evaluation of both existing and new multimedia systems. Using high-resolution output devices up to 2k x 2k, it is possible, for example, to scale the used resolution and to perform subjective tests for quality judgment. Furthermore, a scaleable rear projection system is used for multimedia conferencing applications. Our application *AVWOD* was tested in this lab [Bönn 95]. Figure 7 shows a view of the main lab.

In the following section, two examples of new concepts for the development of HDMM applications are given. These two examples concentrate on the aspects *integration* and *completeness*.

- **Combination of Timely and Static Information**

Today's video systems - television - and network-based information systems, e.g. World Wide Web, only use remote servers for the delivery of information. When people watch the news, they have no way of getting additional information on a specific topic other than by using other non-integrated media such as books, newspapers, etc. The same situation applies for the World Wide Web; the user can only get additional information, if it is provided by the server.

The use of remote servers is only necessary in situations where, if information is changing rapidly. In all other cases, other delivery channels can be used. A practical example: TV news presents the newest information concerning the situation in Bosnia-Herzegovina. While viewing this news, the user decides he would like some background information about the history of this country and Yugoslavia.

In such situations, news and background information can be delivered by different communication channels. The news, since it is changing rapidly, is delivered through broadcast channels; the additional information is delivered through locally available CD-ROMs or additional computer networks.

The combination of different delivery channels can be done by adding "meta information" to the video signal. As it is done with "Videotext", this meta information can consist of keywords or overlay planes, which the user can select by remote control or mouse. After selection, the local CD-ROM is searched for additional information on the chosen topic. In addition to this locally available information, or, if information is not locally available, information can be sought on computer networks, e.g. using World Wide Web searching servers.

Using this concept, multimedia integration of different delivery channels could be achieved.

- **Overcoming Media Limitations - Software Migration across Networks**

Most of today's multimedia systems have a fixed set of built-in media types, protocol handlers, and presentation software. As an example, standard World Wide Web clients can only display two image formats internally, that is, spatially synchronized with text information. If other image formats are to be presented, so-called "external applications" have to be used. These external applications can display these images, but there is no more synchronization between these images and other information.

In 1995, SUN presented a new kind of World Wide Web browser, called HotJava™ [SUN 95]. This browser uses another concept of information processing. It does not include fixed functions, but it can interpret code; hence, new data types and functions to handle them can be added at any time, since they are received like data over the network. The software transparently migrates across the network. This transparent acquisition of applications frees developers from the boundaries of the fixed media types and applications. Furthermore, there are no more problems with updating systems; new software does not have to be installed, but is interpreted when needed.

This concept provides the possibility of completeness and integration at any given time. The interpretation of new media types, at any representation level, as well as of new applications, can be added depending on the requirements of the user or application context.

4 Conclusions

As shown in the previous chapters, it is possible to use video on computer-based networks. Video can be used as video services, e.g. video-conferencing, or together with other data types, e.g. AVWOD. However, due to large variety of applications, systems, and requirements, different levels of quality have to be provided. The concept "one size fits all", used in today's television systems, cannot be applied to network- and computer-based applications.

Video integration is only a first step toward real multimedia systems; it is only the integration of one - albeit a very important - media type. Hence, *Computer & Video ≠ Multimedia*. Only the consideration of the aspects *completeness*, *quality*, and *integration*, that is, High-Definition Multimedia, will make user-oriented and future proof multimedia systems and applications possible.

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NETWORKING BIOMEDICAL INFORMATION ON CD-ROM AT THE WALTER AND ELIZA HALL INSTITUTE OF MEDICAL RESEARCH

Josephine M Marshall

INTRODUCTION

Australian medical libraries are enthusiastic users of medical information on CD-ROM. At the Walter and Eliza Hall Institute of Medical Research we have successfully networked MEDLINE on CD-ROM to over 50 APPLE MACINTOSH computers. This paper will describe the rationale behind the decision to network, the technical aspects involved in the process, and discuss points for and against the concept of end-user searching on CD-ROM networks.

BACKGROUND

Australia has operated its own MEDLINE network since 1976. This has been run by the National Library of Australia in Canberra with tapes from the US National Library of Medicine run on the Australian Department of Health, Housing and Community Services computers. The network provides dial up access across the nation. In 1991 a review of network operations was held which resulted in an announcement in September 1991 that network operations would cease in June 1993. The major rationale for the decision was a dramatic decrease in connect hours by Australian users. Network connect hours peaked in 1988/89 at over 19,000 hours and has declined to under 13,000 hours in 1991/92 [1]. The sole reason for the decline in use is the availability of MEDLINE on CD-ROM. Australian medical libraries have enthusiastically adopted CD-ROM technology. A 1991 survey of the growth of CD-ROM usage in medical libraries conducted by the National Library of Australia showed that in 1989 15% had MEDLINE on CD-ROM. By 1991 53% had adopted the technology and a further 30% indicated they intended to acquire it during 1992 [2].

The Walter and Eliza Hall Institute of Medical Research is Australia's largest and oldest private medical research facility. A population of 350 comprises 80 scientists, their technical and administrative support staff and 50 postgraduate students. Principle investigations focus on the immune system, with an emphasis on cancer research, molecular biological studies, autoimmune diseases, transplantation and immunoparasitology. The library of such an institute must provide easy access to current information. We access a variety of data-bases on-line via DIALOG, however MEDLINE

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has always been the major source of bibliographic information. We have consistently been amongst the top 15 users of the Australian MEDLINE Network.

IMPLEMENTATION OF NETWORK

When the decision to cease network operations was announced we were in a position to commence development of our single work station CD-ROM drive into a network. Together with computer personnel the librarian evaluated other Australian networks and found all were based on MS-DOS systems. Our multi-vendor computer network comprises 15 MS-DOS, 7 VAX/VMS and 4 UNIX machines connected to 50 plus APPLE MACINTOSHES on a LOCALTALK network via ETHERNET with a WEBSTER MULTIGATEWAY. We connect to INTERNET via the University of Melbourne. After consultation it was decided that as APPLE MACINTOSH was the rapidly growing machine of choice with scientific staff for their everyday computing and that the LOCALTALK network was already in place we would attempt to network SILVER PLATTER MEDLINE with MacSPIRS software. We then proceeded to lobby and apply for the necessary funding.

A meeting of the Library Committee was held in December 1991 and it was unanimously agreed that we put forward a proposal for a special grant to develop the network. The librarian prepared a proposal explaining the rationale and outlining the advantages of providing 24 hour access for all users across the network. This proposal was presented to the institute's Internal Finance Advisory Committee in late December 1991 and following a positive response we were awarded $25,000 to purchase the necessary initial equipment to begin the service. We purchased a CD-ROM tower with the capacity for 14 CD drives with the intention of immediately networking the full set of SILVER PLATTER MEDLINE. An APPLE MACINTOSH QUADRA 900 was installed as the dedicated network server. Unfortunately at present only seven drives can be connected to the APPLE QUADRA. This limitation is due to the present unavailibility of an additional NUBUS SCSI adaptor card to operate CD-ROMS. On advice we purchased the QUICK SCSI card but this does not support CD-ROM drives as yet. The QUADRA uses APPLESHARE software version 3.0, running under System 7 to serve the CD-ROMS over LOCALTALK.

By the beginning of January 1992 we were able to offer the current 7 years of MEDLINE across the LOCALTALK network to 50 Apple MACINTOSH computers within the institute building. As part of our initial aims we hoped to include the 15 MS-DOS computers on the network. This has not proved possible as yet despite the efforts of our computer staff. We have run APPLESHARE for PC on an MS-DOS machine and have been able to connect the CD-ROM drives, however SPIRS for the PC will not operate on this arrangement, presumably because the volume label of the CD disk is not made available across the network. SILVER PLATTER, despite our requests, have not been willing to modify their software to overcome this problem. These technical difficulties have frustrated our efforts to network all years of MEDLINE, EXCEPTA MEDICA IMMUNOLOGY and AIDS, EXCEPTA MEDICA-NEUROSCIENCES, ENTREZ: Sequences and EMBL Sequence CD-ROMS. At present these are all available from a single drive in the library. By continual lobbying we also hope that SILVER PLATTER will take steps to upgrade MacSPIRS searching software to the level of PCSPIRS.

We are investigating the feasibility of changing the PC network from DEC pathworks to NOVELL NETWARE and placing the CD-ROM tower on the NOVEL file server. 20 CD drives should be available to both the PC network on ETHERNET and to the MACINTOSH APPLETALK network. Substantial cost and effort would be involved in this change and several other factors will need to be considered before a decision can be made. Another of our initial aims was to offer remote dial-up access to the network from the home of researchers. We have experimented with home connections to the CD-ROMS achieved by using APPLETALK Remote access software. Using the current 2,400 baud modems has proved too slow for MacSPIRS. Further tests using 9,600 baud and 14,400 baud modems may prove more usable for careful use of SILVER PLATTER software. It is worthwhile to note however that licensing issues related to accessing SILVER PLATTER data over the phone lines will have to be addressed.

USER EDUCATION AND RESPONSE

An intensive user education programme was begun in January 1992. Some CD-ROM users lack a basic concept of bibliographic systems, however we find that the friendly MacSPIRS retrieval system appeals to our end-users. The most effective training has proved to be individual tutorials with hands on experience. Library staff conduct all training with an average of 20-30 minutes per session. To maintain control and security over network usage, users are registered with a network password once basic training is completed. At August 1992 we had trained and registered 124 users, equalling approximately 62 hours training time. Our system currently supports up to 8 concurrent users. Continuing education is provided both on individual demand and by Librarian regularly attending user group meetings to demonstrate advanced searching techniques using specific examples.

User response has been particularly enthusiastic. MEDLINE subject searches performed on-line by librarians have dropped from 209 for period January to June 1991 to 87 for the same period this year. The highlights for users are the 24 hour access and the ability to download data directly into the ENDNOTE PLUS personal bibliographic software which is on all our MACINTOSH computers. This greatly facilitates preparation of theses and scientific papers.

CD-ROM ISSUES

Librarians must address the wider issues involved in CD-ROM technology. We must lobby data base providers and software and hardware suppliers alike. Particular areas of concern are licensing and the complex and high price structures involved in networking. Aspects of costing for medical data bases such as MEDLINE and CD-ROM must be rationalised [3]. Data bases vendors must realise that the intellectual input which makes up their product is actually the result of work at the very hospitals, universities and research institutions who are subsequently asked to pay to use the systems. With regard to licensing numbers of network users we must consider that no library is ever charged for a printed bibliography on the basis of how many users it may have. We must also continue to convince CD-ROM suppliers that, particularly in the health field, we must have access to the most current material. SILVER PLATTER MEDLINE, in particular, is consistently behind MEDLINE on-line in Australia.

Librarians in Australia, as in Europe, have indicated their enthusiasm for CD-ROM technology. Surely now it is time for closer liaison with suppliers to ensure our needs are met in the future.

Librarians must realise that in the information explosion we play a vital role in the accessing and effective dissemination of the information. We must not let ourselves be intimidated by the technology and end-user pressure. Librarians should prove their worth as effective players by maintaining close contact with computer staff in their institutions to become more technologically aware. We must make every effort to maintain our role as an integral part of the research or healthcare team by offering effective CD-ROM training programmes and publicising the options available in expert library based on-line data base searching.

CONCLUSION

The major rationale behind networking any information is to maximise the utilisation of resources and to minimise costs. At present I would have to say that networking information on CD-ROMS certainly offers efficient utilisation of resources, however, I think more work need to be done to rationalise costs before it becomes an economic decision.

Over the past nine months at the Walter and Eliza Hall Institute of Medical Research we have shown that it is possible for the library and Computer Centre to work together to quickly provide an efficient networked information system on CD-ROM. We will continue to work towards realising our initial aim to create a large networked information base and overcome the technical difficulties. In conclusion I have to say it has been a successful operation. Our users love it and it greatly facilitates their work. After all, in medical research what really matters is maximising resources towards achieving successful results for the health of the community at large.

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HELLO USERS: THIS IS CONTROL
or
CD-ROM ACCESS FOR ALL

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ABSTRACT

The University of Delaware Morris Library has long been a leader in supporting computerized access to catalogs both on campus as well as throughout the state. Its service took another step forward in the Summer of 1990 when a CD-ROM server was installed in the Reference Room. Although the service allowed access to several CD-ROM data bases and indexes, the access was only available in the Reference Room at a limited number of workstations. In December of 1991 the Library requested assistance from Computing and Network Services (CNS) in designing a proposal to upgrade the network and give wider access to the service not only throughout the central campus, but also through dial-in service. The proposal was submitted in March, 1992, to a government agency, but was not funded. The proposal was reworked (as technology continued to change) and submitted to a funding unit within the University of Delaware. Shortly after the first of the year, a grant was awarded. Now the details had to be worked out.

This paper will discuss the process from two perspectives: 1) the decisions that were made and why; 2) the cooperation that enabled the Library Information Systems group and the CNS staff to work together to prepare a successful proposal, set mutual goals, and finalize a workable design.

Deciding what environment should serve as the delivery vehicle was accomplished within the framework of the University-wide strategic plans, insuring compatibility in the future. Discussions covering specific needs of the Library, anticipated problems, and future goals served as a bridge for both departments to learn and grow.

INTRODUCTION: A BRIEF HISTORY OF OUR EXPANDING UNIVERSE

The Library's support of computerized access to catalogs from on campus as well as throughout the state dates back to the Fall of 1986, when an integrated automated library system (DELCAT) was implemented. In the Spring of 1989 two other major features were added to the system. Dial access to DELCAT from anywhere within the state at no charge to the user, and as a toll call from outside the state was initiated through a public data network (PDN). A new journal service, DELCAT Plus, was made available, wherein users could do an on-line search of four databases in the fields of business, arts and humanities, and science and technology. At this time the use of CD-ROM (Compact Disc-Read Only Memory) technology was available in the Reference Room of the library, but only in a stand-alone format. It was so popular that reservations had to be made by enthusiastic users.

Late in 1989 the process of planning a local area network (LAN) to support the CD-ROM offerings began. Unfortunately, even on the network only four users could access CD discs simultaneously, whereas DELCAT Plus could handle up to 150 concurrent users. Use of the CD-ROM technology to facilitate self-searches did not diminish the use of the library in the traditional sense, but it did allow users to be more self-sufficient. Support issues became more complicated as the Federal government increased its use of electronic media by submitting databases such as census information on compact disc, not always in a consistent format. As more users became familiar with the capabilities and advantages of compact disc databases there was a major increase in usage, although access to the CD-ROM network was still only available on-site in the Reference Room.

While continued updates and new modules helped to improve the DELCATPlus system for the administrators as well as for the end users, it became evident that wider access was needed to the CD-ROM network. The technology that was available in 1991 did not offer as easy an interface for access as DELCAT did. Using the backbone to reach the existing library LAN which communicated with Novell's proprietary protocol (IPX) was not efficient, since Transmission Control Protocol/Internet Protocol (TCP/IP) was the only protocol used on the campus backbone. At the end of 1991 a proposal for upgrading the CD-ROM network was prepared and submitted to a Federal government agency. This proposal was put together by the professional staff in the Library with the assistance of staff from Computing and Network Services (CNS). Although this proposal was not accepted, it served as the basis for another proposal to be submitted to an "in-house" funding unit at the University. Rather than offering an itemized list of desired equipment, the proposal presented goals and ideas. That is, the primary goal was to make access to the CD-ROM databases more widely available, both on and off campus as licensing permitted. A grant was awarded in the Winter of 1992-93. Now the detailed planning had to proceed in earnest.

There were several issues to be considered within the context of the project, as well as keeping within the scope of the greater University strategic plans and directions. It became obvious that neither group (the Library staff nor the CNS staff) could provide all the answers independent of the other. Close cooperation would be necessary to complete the project successfully.

The future direction of computing on the University campus was at this time oriented toward a client/server configuration, with UNIX as its primary operating system. After several months and presentations by a variety of vendors, the basic framework for the new configuration was developed. It was definitely a different solution than that which had been part of the initial grant request. In fact, it was so new that the software to be used for one part of the solution was still in beta testing. The staff from the library had much to learn, concerning computing solutions, and there was an equally challenging amount to learn for the CNS staff about library needs and expectations.

CHOOSING "THE RIGHT STUFF"

The Morris Library Reference Room has had an Opti-Net CD-ROM network running for several years. In 1991, the server hardware was upgraded to a 386 PC clone and an additional 4-disc tower was made available. At that time there were five popular databases available on the network, as well as several others. The five databases used most frequently were:

1) CINAHL Nursing index 2) ERIC Education database 3) PsycLit Psychology database 4) Sociofile Sociology database 5) MLA Bibliography Humanities index

The Opti-Net server co-existed with a Novell network, sharing the same hardware. Novell Advanced NetWare (NW) 2.15c could run as a non-dedicated Novell network from which the Opti-Net server was loaded. Initially (while constructing the first proposal) merely upgrading the Novell network to the NW 3.x software, creating a new terminal server, and using LAN WorkPlace for DOS (or Windows) to facilitate access over the campus backbone appeared to be the solution. Experience with asynchronous communications to access a Novell network made it evident that opening that environment to the general public would undoubtedly lead to major dissatisfaction, since transmission would be discouragingly slow.

By the time the second proposal was being prepared in the Fall of 1992, CNS had made some major decisions regarding the strategic directions that the University would be pursuing. The one decision that directly influenced the choices for the new CD-ROM service was that of a client/server architecture within a UNIX environment. It was known that Novell was moving toward this direction, but the specifics were not yet available, and the search engines that were available on UNIX would not support the various databases and indexes that were most popular with the users. Rather than include explicit requests for hardware and software in the proposal, the decision was made to stress the goals. This allowed time for some of the vendors to catch up with the needs of the user community. When the grant was awarded, the investigation of what was specifically available began.

A number of vendors were invited to campus to show their products. The primary experience and support of the majority of the vendors centered around an Intel-based DOS environment, with some support for Apple products and some terminal emulation. SilverPlatter Information, Inc. made the best impression when they presented a new product called MultiPlatter ERL-1000. It was described in their literature as "a powerful UNIX client/server solution...ERL (Electronic Reference Library)...enables you to take advantage of your existing campus-wide network to provide wide-area access to databases." Since UNIX was to be our de facto standard for the future and since our campus backbone used the TCP/IP protocol, this solution looked exciting. It was also interesting because the majority of the databases already in use here were offered by SilverPlatter with their new program. Furthermore, there was support for multiple client architectures (DOS was ready, and Windows, Mac, and UNIX were due in the future.)

SilverPlatter offered a comparison of ERL to the typical technologies which are available today...mainframe tape loading, CD-ROM file servers and hard disk file servers. According to SilverPlatter, the advantages included:

ERL advantages over mainframe tape loading

- Lower cost hardware and software
- Small UNIX systems which are easier to administer than mainframes
- SilverPlatter databases are delivered pre-indexed
- Support for multiple, distributed servers (offers redundancy, local autonomy, traffic control)
- Equivalent capacity for simultaneous users
- More sophisticated search interface
- Larger database selection
- Non-proprietary clients possible (open architecture)
- Client/server architecture reduces burden on server (means more simultaneous users per server)
- Media independence (hard disk and CD-ROM supported)

Tape advantages over ERL

- Tape databases may have more frequent updates
- OPAC-based solutions may have direct access to holdings info.

ERL advantages over CD-ROM and hard disk file servers

- Much lower bandwidth requirements (Wide Area Network compatibility)
- Open architecture (client/server)
- Uses the same hardware more efficiently
- Client variety without redundant host hardware (gateways or pcAnywhere hosts supporting Macs, terminals and remote sites no longer needed)
- Better data security
- Superior usage statistics
- Choice of protocols (simultaneous support of TCP/IP and IPX)

Fileserver advantage over ERL

- In a LAN environment (large bandwidth) with powerful desktop machines (e.g. 486s), hard disk servers may be higher performance than ERL under certain simultaneous user conditions

SCO Unix (which is the foundation of the SilverPlatter application) offers native support for CD-ROM, support for Symmetric MultiProcessing (SMP), and a large catalog of third-party software. Operating on an Intel-based server allows for the use of either Ethernet or Token Ring architecture. Most Intel-based central processing units (CPUs) have more slots available than, for example, a Sun SPARC, with a large amount of third-party hardware and software available. The new EISA machines have a good price/performance ratio. And the staff at the library is familiar with Intel-based architecture...important, since they will ultimately be responsible for maintaining the systems.

The major stumbling block with this solution was the current status of the new software. Although it was suggested that the software would be ready in time for us to offer the service for the Fall semester, that time line was extended. Previous experience with this company leads us to believe that when they finally deliver the product, it will be ready for use, with few bugs or suspect features. This system will be used to present a large number of the current databases and indexes. But there are still others which will not be supported.

Another area of CD-ROM discs that is of interest is that of the government census information, as well as information from many other government agencies. This information takes up many discs, and is growing rapidly. Along with the need for more CD-ROM support, the use of the popular Gopher (University of Minnesota) software is becoming more important to the campus. With this in mind it was decided that another server would support both the miscellaneous CDs as well as become the Library's Gopher server and anonymous FTP site. For this purpose a Sun SPARC10 model 30 with 64 MB of RAM was proposed. Four 7-disc CD-ROM towers will be attached to the SPARC.

Along with the server/search engine changes from the present network, it was deemed necessary to upgrade the available workstations on the library network from IBM/PS/2 model 30s to 486 clones. Since two of the stations would be used for multi-media work, they were ordered with 66 MHz CPUs, sound boards, and video cards, compared to 33 MHz CPUs for the generic station. Several branch libraries were also to receive upgraded workstations.

The basic premise of the current solutions is to allow for future growth. From the traditional approach of most libraries where the focus is on what they have, the movement is toward "what we can point to". Access through the Internet is providing the pathway to information rather than the actual material. The Morris Library is already preparing itself for further technological advances, even as it deals with the present. Including two multi-media workstations in the proposal is an example of forethought. Although there are still problems with multi-media presentations (slow, requires large hard disk space and much memory), these issues are small hurdles which are disappearing rapidly.

WORKING ACROSS THE UNIVERSE (OF THE INTERDEPARTMENTAL GAP)

Ever since the early days of computerized library tools, there has been a need for cooperation between the library staff and the staff of the computing groups on campus, regardless of the administrative structure of the computing groups. Because of the need for close cooperation, any change in the structure of either organization strongly affects whatever projects are under way. The present configuration of CNS is three units: Management Information Services (MIS), Network and Systems Services (NSS), and User Services (US). Each of these three units is essential to the support of Library computing. Upgrading BRS software, interacting with Diamond State Telephone regarding problems or upgrades to the PDN, and supporting a help desk which answers the questions of users trying to access the system remotely are just a few of the services which CNS gives to the Library.

When the decision was made to proceed with a second proposal the first reaction was to merely update the cost information of the hardware and software which had been proposed initially. But after careful consideration the Assistant Director for Library Computing Systems decided that we should investigate some alternate solutions. At this point there were some misconceptions regarding who was responsible for what. That is, the staff of the Library had expected that CNS would do the investigation, winnow out unacceptable solutions, and present the Library with a turn-key answer. But several of the people involved from CNS had limited understanding of all the issues that were important to the Library. As a result, Library Computing Systems staff were pressed to learn more than they expected in order to communicate intelligently with the vendors during their search. In retrospect, this was probably a healthy task, since these same staff members will bear the bulk of the responsibility for the new systems.

Not only was the Library's perspective on issues different from some of the CNS staff, but there were also differences within the CNS staff. In early talks, UNIX was proposed by some in CNS, but the most popular databases and indexes were not necessarily available under that operating system. That caused other CNS staff to lean toward the Novell environment, in spite of the strategic direction of the University. After all, we already had years of experience with Novell networks (since 1987) and the DOS-based environment it supported (as well as supporting Mac and UNIX client access.) Fortunately for all concerned, a company with whom the Library already had successful dealings was working on something new...a UNIX-based application which would allow for access to all the current databases and indexes, in a client/server configuration. Their presentation offered an exciting alternative to current software, and they were eager to have us use their new product...as soon as it was released from beta testing. They were also willing to supply us with some of the client code so that we could speed up the process of getting a character-based client to use from our terminals. Most of the staff from both departments were pleased with this solution. All that remained was to select the hardware to support the decision. Again, much of the information gathering was performed by Library staff, with input from CNS staff regarding experience with existing hardware on campus.

CONCLUDING THE "FLIGHT"

The solutions that were chosen will meet the current needs of the Library in facilitating access to popular CD-ROM databases and indexes. Plans are in progress for a universal menu which will enable users to access the mainframe catalogs, use Gopher, perform anonymous FTP, and use the Sun as a PC-NFS file server, as well as to access the SilverPlatter offerings. This will give the Morris Library an opportunity to move in an evolutionary manner into the 21st century. The dream is the "Scholar's Workstation", whether local or world-wide, with a common user interface to access a choice of sources transparently. There will be full text at the desktop, full-motion imaging, and access to the accumulated knowledge of mankind within each person's fingertips.

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