０１－Ｅ－００５

先進的情報処理教育システム
に関する調査研究報告書

平　成　２　年　３　月

㈶日本情報処理開発協会
中央情報教育研究所

この報告書は、日本自転車振興会から競輪収益の一部である機械工業振興資金の補助を受けて平成元年度に実施した「情報処理教育に関する調査研究」の成果をとりまとめたものであります。

先進的情報処理教育システム
に関する調査研究報告書

は　じ　め　に

本報告書は、わが国における情報処理教育の一層の充実に向けて、中央情報教育研究所が平成元年度事業として実施した先進的情報処理教育システム等に関する実態調査結果をとりまとめたものである。

本年度の調査は昨年度の欧州に引続き、１９９０年２月に実施したものであり、米国、欧州２ケ国の情報処理教育関連機関を対象として、教育の内容、方法等の実態状況さらに当該国における情報処理教育を取り巻く施策について最新動向を把握した。なお、本年度では、情報処理教育の基盤となる技術研究動向も含め調査を実施した。

短期間の訪問による調査のため必ずしも十分な成果とは言えないが、資料編のデータを含め多くの関係方面の方々の参考となれば幸いである。

なお、本調査の実施に際して、ご協力をいただいた、エデュコ教育研究所の井上哲夫先生をはじめ訪問先諸機関の関係各位に対しここに深く謝意を表する次第である。

平成２年３月

財団法人　日本情報処理開発協会
中　央　情　報　教　育　研　究　所

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第1章　調査概要

１－１　調査の目的

わが国における情報処理教育の質的向上に向けて、欧米諸国に調査団を派遣し、欧米の大学・企業および教育機関等における先進的な教育システムの現状、研究動向を調査し、今後の情報処理教育事業に資することを目的として今回の調査を行った。

１－２　調査時期と調査訪問機関

調査日程、訪問先等は次のとおり。

訪問月日	訪　問　機　関	面　会　者	所　在　地
1990年 ２月１日 （木）	Stanford University Graduate School of Education ｽﾀﾝﾌｫｰﾄﾞ大学教育大学院	Professor Walker	Education Building Stanford University Stanford, CA 94305 （ｻﾝﾌﾗﾝｼｽｺ）
	Stanford University CIFE:Center for Integrated Facility Engineering ｽﾀﾝﾌｫｰﾄﾞ大学　総合技術設備工学ｾﾝﾀｰ	Paul M. Teicholz CIFE Director	Terman Engineerring Center Stanford University Stanford, CA 94305-4020 （ｻﾝﾌﾗﾝｼｽｺ）
	Stanford University AIR:Academic Information Resources ｽﾀﾝﾌｫｰﾄﾞ大学ｺﾝﾋﾟｭｰﾀｾﾝﾀｰ	Steven J. Loving Academic Information Resources , System Development	Sweet Hall Stanford, CA 94305-3090 （ｻﾝﾌﾗﾝｼｽｺ）

訪問月日	訪 問 機 関	面 会 者	所 在 地
2月5日 (月)	Applied Learning, Ltd. アプライド・ラーニング社(ボストン)	Harry M. Lasker , ph. D. Vice President Strategic Development Charles Biebighauser Senior Vice President	9 Oak Park Drive Bedford, MA 01730 (ボストン)
2月5日 (月)	Massatusetts Institute of Technology (MIT) Media Laboratory マサチューセッツ工科大学 メディア・ラボラトリー	Catherine R. Avrill (Athena project) Information Officer	1 Amherst street Cambridge, MA 02139 Room E40-358f (ボストン)
		Carol Strohecker (Daedalus project) Research Assistant Learning & Epistemology Group (Media Lab. E15-390)	295 Harvard Street, #702 Cambridge, MA 02139 (ボストン)
2月6日 (火)	Harvard University Graduate School of Education ハーバード大学教育大学院	Arthur C. Johnson Doctoral Candidate Teaching Fellow	Media Center, Gutman Library , Appian Way , Cambridge, MA 02138 (ボストン)
2月7日 (水)	ボストン公共放送局 WGBH	Thodore Sicker Director, Interactive Projects Telecommunications (Interactive Nova)	WGBH Educational Fundation 125 Western Avenue Boston, MA 02134 (ボストン)

訪問月日	訪　問　機　関	面　会　者	所　在　地
2月9日 (金)	Applied Learning, International Ltd. アプライド・ラーニング社(ロンドン)	Charles W. Gould Director , International Distributor operations	1 Hogarth Business Park Burlington Lane, Chiswick, London W42TJ. (ロンドン)
		Mike Pope Consultancy Services	
2月12日 (月)	INRIA Institute Natinale de Recherche en Informatique et en Automatique 公益情報処理研究機関	Helene Gans Deleguee aux Relations Scientifiques Internationales	Domaine de Voluceau-Rocquencourt-B. P. 105-78153 Le Chesnay CEDEX (FRANCE) (パリ)
		George Nissen Directeur Relation Industrielles Internationales	
		Michel Bernadou Adjoint au President Charge de la Formation	

1－3　調　査　員

井上　哲夫　（エデュコ教育研究所　所長）

橋本　一俊　（中央情報教育研究所　教務部　教務第一課　課長）

成海　　洋　（　　　〃　　　　　教務部　教務第二課　主任）

第2章　調査内容

欧米における情報処理教育システム、とくにインタラクティブ教育システムの現状

2－1 スタンフォード大学教育大学院

2－1－1　概　要

スタンフォード大学教育大学院　ウォーカー教授との会見が主な内容であった。

内容のポイントは以下のとおり。

① 教育はマンツーマン、フェイスツーフェイスが基本であり、それを補助するものとして、各種メディアの活用がある。効果的なメディアの利用のためには、教育の専門家とコンピュータ等の専門家との間に協力的な関係、協同的な作業が必要である。

② メディアの有用性
・教育の質的向上が図れる
・教育の柔軟性の向上が図れる

③ メディアの効果的利用のためには、教師の役割の変化が必要。
講義自体はメディアが行ってくれるので、その代わりに教師はメディア学習後に理解を深めるためのディスカッション等が行われる。その際の進行役・コーチ役が必要となる。（コーディネーション機能）

④ ＯＨＰ、ＶＴＲ、ビデオディスク（ＶＤ）、ＣＡＩ、衛星通信等の各種メディアの評価の観点
ＶＴＲ（ビデオ）は学習者自身が主体的に参画できるために、有用性が高いメディアである。
インタラクティブなビデオディスク（ＶＤ）の活用にはもう少し時間がかかるであろう。
ＯＨＰは、教師自らが手元で操作できるので効果的な授業が展開できる。

２－１－２　インタラクティブ教育システムの現状と課題

～ウォーカー教授との一問一答より～

まず先に、私自身（ウォーカー教授）について簡単にお話をしておきたいと思います。

私が教育にコンピュータを導入してみようと考えたのは、７～８年位前です。当時は、ヘス教授（心理学）と共同で研究しており、学生と一緒に研究プロジェクトをおこなっておりました。当時は主として音楽や数学系統の学生を中心に実験をしておりました。それが２年前、ヘス教授が健康上の理由で引退され、プロジェクトは中止になってしまったのです。この大学（スタンフォード大学）では、学生とのプロジェクトを成立させるためには２人以上の教授の監督が必要とされるのです。ヘス教授の後任の教授はこの方面には全く興味が無く、他の教授も多忙でしたので、学生には悪いと思いながらも中止となってしまいました。他の大学を見てもこの種の研究が現在行われているのは数校しかないでしょう。

実際の現場を見てみますと、高校位の段階ですともうコンピュータを何らかの形で導入している所がほとんどです。その中で、現在の利用法ですでに満足している先生もいらっしゃいますが、もっと他のことができないものかと考えていらっしゃる先生が大半を占めていると思われます。

では、質問事項に移りましょう。

Ｑ１．メディアを利用した教育の基本コンセプトの確認

教育は、マンツーマン、フェイスツーフェイスが基本であり、それを補助するものとしてメディアを利用する、と考えるが、ウォーカー教授はメディアを利用した教育についてどうお考えか。

基本的な所に関しては全く同じです。

教育におけるメディアの有用性については主として２つの点が挙げられると思います。第１点は教育の質の向上です。そして第２点は教育における柔軟性の向上です。ここでいう柔軟性というのは、説明等をある点で止めて、巻き戻したりできるということです。しかし、これらの点を本当の意味で有効にするためには、教師の役割の変化が必要だと考えています。現在のように教師が説明したり、講義をする必要性が全くなくなります。それはメディアがやってくれますから。その代わり、学生達がそれを見終わった後で、理解度を深めるために討論が行われると考えますが、それの進行役となる人、つまり、コーチの役割をしてくれる人が必要となります。また、そのコーチは特定の科目の専門家でなくても勤まることになります。

Q２．教育の現場で利用するメディアの評価ポイントについて

ＯＨＰ、ＶＴＲ、ビデオディスク（ＶＤ）、ＣＡＩ、衛星通信等を利用した遠隔地教育、衛星通信等の各メディアについての評価ポイントをお聞きしたい。

メディアを利用した教育を評価する上で最も重要なのは、教育を受ける本人がそれを操作できるか否かという点です。その意味合いでは放送よりはＶＴＲの方が上に来ます。

また、先程申し上げたようにメディアを最大限利用するためにはある種の社会性が必要だと考えます。社会性というのは、価値観の相違等を討論できる場です。同じことを学んでいる者同士が集まって討論できる場が必要なわけです。

放送による教育では、それを受ける側が散在していたり、忙しくて特定の場所に来れないというのが前提となりますから、自ずとその評価は低いものです。どちらかといえば、その放送を見るために集まって来るような環境、つまり第３世界の方が有用性が高いと考えます。

恐らく、現段階で最も有用性が高いメディアがＶＴＲだと思います。操作性、コスト等様々な面から見て、現在最も高く評価されてしかるべきです。これにコンピュータを接続して、教育の補助をしたり、理解度を確認するためにテストしたりすればもっと良いものになるでしょう。

インタラクティブのＶＤが実際に登場するにはもう少し時間がかかると思います。

通信衛星に関しては、別の意味で期待するものがあります。このメディアの最大の特長は、情報の伝達速度です。その意味では、話題性に富んだものの伝達にその有用性があると考えます。例えば現在、多くの鯨には発信機が取り付けられていますが、その行動に関するデータは、衛星を通じて収集しています。今、鯨の行動習性に関するレポートを書きたい人がいたとすると、その情報は新しいほど良いわけですから、利用価値が高いわけです。

将来的に最も活躍すると思われるのが、次に挙げるＯＨＰです。これは非常に価値があります。集団を相手に使えるのが何よりです。また、教師が手元で全ての操作ができるというのも魅力です。例えば学生の書いた作文等を即座に校正することも可能ですし、またそれをスクリーン上でできるわけですから、今までとは違った授業ができるはずです。

Q３．複数のメディアを複合した教育環境での効果的教育について。

衛星通信等を利用した遠隔地教育の場面で、ＯＨＰ、ＶＴＲ、ＶＤ等のメディアを利用した教育が行われると考えられるが、教室での教育環境と、遠隔地の教育環境　（教育の受け側の環境の違い、教える側の環境の違い）があるが、この２つの環境で各メディア毎の最も効果的な利用方法についてのお考えをお聞きしたい。

どのメディアを使うにしても、それを最も効果的に利用するためには教師の役割をはっきりさせておかなければなりません。今まで教師は、その専門的な知識が教師としての役割でした。今後メディアがそこに介在すると教師の専門家としての役割が次第に薄れるでしょう。先程申し上げたように、メディアを通じた教育を受ける生徒のコーチが必要となってきます。それが今後の教師に与えられる役割なのです。

また、生徒の評価という問題があります。どのような教育を行うにしても、生徒は評価する必要があります。特に遠隔地教育を行う上で、教育を受ける側の生徒からすると、その評価の基準となる試験は全く見ず知らずの人から出題されるわけですから違和感があるはずです。ここでは最初に挙げたマンツーマン、フェイスツーフェイスという基本が崩れているわけですから仕方がないのですが、それを補うためにはできるだけ生徒側の役割を増やし、できるだけ生徒が積極的に教育に参加できる体制を作ることが重要であると考えます。

Q４．ハードウェアのコスト・パフォーマンスについて

教育の現場で利用するメディアのハードウェアは高価である。日本では、ＯＨＰ、ＶＴＲ等のハードウェアは以前より安価になっているが、他のパーソナルコンピュータ、ＶＤ、遠隔地教育の機材は大変高価である。

現状のメディアでコスト・パフォーマンスの良い順序をつけて、その理由をあげて頂きたい。また、今後各メディアのハードウェアのコストはどうなるとお考えかお聞きしたい。

現段階で最もコスト・パフォーマンスが高いメディアはＶＴＲでしょう。ハードウェア自体の価格も下げてきている上、ユーザー自身にとっても利用価値の高いメディアです。これに先程から申し上げているように討論のリーダー役を勤める人がいればもっと効果的だと思います。また、テープ自体の価格も低下してきていますので、よりコスト・パフォーマンスが高いと思います。

ＣＡＩＴもそうでしょうが、ＯＨＰに関していえば、非常に柔軟性のあるハードウェアの１つだと思います。教師の使い方１つで様々な用途に使えるのがこれらの機器ですが、コスト的にはまだ相当な値段がしますので、パフォーマンスとしてはまだＶＴＲと比べる段階には来ていません。また、ＣＡＩの方は生徒１人にたいしての効果しかありませんので、パフォーマンスという面では劣ります。

衛星通信による遠隔地教育は、ＶＴＲとの併用を考えれば柔軟性もでてきますが、今後はこれをより発展させたシステムで相互に会話ができるものが主流になることでしょう。ただし、このシステムは非常に高価なものですので、実現には相当時間がかかると思います。

Q５．ソフトウェアについて

メディアで利用されるソフトウェアの開発体制についてお考えをお聞きしたい。アメリカでは、どのようなチームを組んでＯＨＰ、ＶＴＲ、ＶＤ、遠隔地教育等のメディアで利用されるソフトウェアを開発しているかをお聞きしたい。（インストラクタ本人が作る場合、ソフトウェア開発の企業が作る場合等）

アメリカでは企業が関連しているソフトウェアが多いと思います。企業はＮＳＦや政府資金をスポンサーとして開発を進めているのが通常です。

しかし、最近では数名のプログラマが集まって共同開発するソフトウェアも増えつつあります。また中には内容に関するスペシャリストを交えての開発も進んできています。

ウォーカー教授には、予め質問項目を提示しミーティングに臨んだ。

質問項目は下記の通り。

ウォーカー教授への質問項目

Questions to Prof. Walker

① A confirmation on the basic concepts of education:

The basic of education should always be man-to-man, or face-to-face, and media should just be supplementry.

Question:

(Based on the above promise.) What is your opinion on education using media ?)

② About the evaluation points of media used in the field of education.

Question:

We would like to ask your evaluation points on each of the following media used in long-distance education, broadcast sattelites etc.

(a) Over head projectors.
(b) Video tapes.
(c) CAI.
(d) Sattelites.

③ Effective education in an education environment where a number of media are integrated.
It is thought that media such as OHPs, VTRs, Video Discs etc. will be used in the long-distance education via broadcasting sattelites.

Question: (a)

What are the differences between a classroom environment and environments that exist through long-distance education? (The difference to the recepiant of the education, and the differences from the teachers' point of view.)

Question: (b)

What would be the most effective way to utilize each media in both of the above environments?

④ Cost/Performance of hardware.
Hardware used in the field of education is expensive. In Japan, OHPs and VTRs have become cheaper than bofore, but other machinery used in long-distance education. such as personal computer and Video Disc Players remain very expensive.

Question: (a)

Under this situation please try to list the apparatus, listed in Question 2 (and any other apparatus that comes to mind) in order of cost-performance (better → worse)

Question: (b)

We would also like to hear your views on how the costs on each media hardware will fluctuete in the future.

⑤ About the software.

We would like to learn your views on the development system of softwar used in media.

Question:

What kind of team is formal in the U. S. in the development of software used in media for long-distance education. (OHPs, VTRs, Video-Discs etc...)

2－1－3　コンピュータセンター

スタンフォード大学のコンピュータセンターでは、Mr.ロビング（Steven J. Loving; System Development,Academic Information Resources)に同センターを案内していただいた。

概　要

地上３階、地下１階の同センターは、建物中のコンピュータを同大学内キャンパスネットワークであるＳｕｎＮＥＴに接続しており、学生、大学院生、教授陣、スタッフの２４時間の利用が可能になっている。学生、大学院生に人気が高い機種は、ＡＰＰＬＥ社のＭＡＣⅡとＮＥＸＴ社のＮＥＸＴである。サンマイクロシステム社のＳＵＮ３が２年前に同センターに導入されたが、前２機種にくらべると人気の点で格段に落ちるという。専用端末機は地下１階の廊下に山積みされており、今後これらの専用端末はＭＡＣⅡもしくはＩＢＭ　ＰＣに置き換えていく予定とのことであった。センター内の幾つかの部屋を見学したので以下に概略を述べる。

研究開発室

ＭＡＣⅡ、ＮＥＸＴが計１０台設置された部屋で、学生、大学院生、教授、スタッフを問わず開放されている。もっぱらソフトウェアの開発用として、自分のアイディアをコンピュータ上で実現するためのプラットフォームとしてＡＰＰＬＥ社、ＮＥＸＴ社より提供されている。

実習教室

ＭＡＣⅡ２１台（教師用１台）が教室にセットされ、教師用のＭＡＣⅡのディスプレイがそのままビデオプロジェクターから教室正面のホワイトボードに投影される仕組みになっている。また、教師用のディスプレイに任意の生徒の画面を呼び出すことも可能になっている。　全体がＬＡＮで繋がっており、ＭＡＣⅡの他にビデオディスク装置、ビデオテープ装置も接続されており、この情報（音と映像）は２１台のＭＡＣⅡのディスプレイに出力できるようになっている。（中央情報教育研究所では、ビデオプロジェクタではなく電子ＯＨＰを使用した実習を行っている）。

ただし、我々が訪問した時は、この実習教室の設計・運営上の中心スタッフが大学を退職して、ＡＰＰＬＥ社に移ったため、同センターのスタッフの中にこの教室のシステムを理解している人がいないため、稼働していないとのことである。

メディア研究室

ＭＡＣⅡとＮＥＸＴにビデオディスク（ＶＤ）、コンパクトディスク（ＣＤ－ＲＯＭ）ビデオテープ装置（ＶＴＲ）を接続し、コンピュータを中心にインタラクティブに活用する実験教室。我々が訪問した日に、ＭＡＣⅡとＣＤ－ＲＯＭを接続してミュージックＣＤの音を自分の好きな部分だけ取り出して、ソフトウェアに組み込む実験のデモンストレーションが学生、大学院生向けに行われた。コンピュータが作る電子音ではなく、ミュー

ジックＣＤの音楽を情報として扱うもので、ＭＡＣⅡのハイパーカードで利用するようになっている。デモンストレーションは音のみを利用するものであったが、同研究室にはＶＤの音と映像をコンピュータで必要な部分だけ取り出して活用する実験用システムが合計５セットほど用意されており、音と映像を活用するマルチメディアのアイデアを実際にパソコン上で実現させるための研究室である。

2－1－4　エンジニアリングセンター

スタンフォード大学のエンジニアリングセンター（ＣＩＦＥ；CENTER of INTEGRATED FACILITY ENGINEERING）では所長の Mr.タイシュルツ（Paul M. Teicholz;Director)にお会いし、ＣＩＦＥの運営と研究プロジェクト、教育の方針についてお話しを伺った。

ＣＩＦＥ概要

ＣＩＦＥはマサチューセッツ工科大学のメディアラボのように民間企業からの委託研究資金により運営されている。

ＣＩＦＥの研究テーマは建築、土木関連が中心であり、研究資金を出資しているのは日本の大手建設会社を中心に３０数社である。修士課程と博士課程の大学院生を中心に、出資している企業からの研究生等も受け入れている。

研究プロジェクトの設定はまず、企業研究生、大学院生、教授のディスカッションの中から将来発生しそうな技術的問題、経営問題等を洗いだす。このディスカッションで上がってきたテーマを、企業にたいする基本調査項目として企業に対する調査を実施し、企業にとって興味のありそうなテーマを探りだす。最終的には、ＣＩＦＥー教授、技術者のディスカッションでテーマを絞り込み企業から、４ランク（10万ドル、５万ドル、2.5万ドル、１万ドル）の出資を募って研究プロジェクトを開始する。幾多のディスカッションを経て、研究テーマを設定するが、教授の得意分野に偏ることと、企業ニーズが短期的な成果を期待することは、現状ではしかたのないことであると、所長はお考えのようである。ただし、将来的にもこの考えが正しいとは考えておられず、ＣＩＦＥ以外のスタンフォード大学の各センターを巻き込んだ協同研究等による、優れた研究結果を世の中に問うことで、企業に対しては時間の余裕を貰いたいと話していた。

教育の基本方針

ＣＩＦＥの教育の基本は、「教える側の都合で研究テーマを選択するのではなく、企業や社会の必要性から研究テーマを決定する」の一言に要約される。

つまり技術的な専門家を育てることよりも、企業が現実に直面している、或いは将来的に発生するであろう問題解決に役立つ経営感覚を持った技術者を育てることであり、研究プロジェクトを決定する過程で企業ニーズを重要視する点に見て取れる。

また、博士過課程大学院生の研究についても、理論だけでなく今現実に行われているものから将来を展望し、これから問題になることの解決をめざした研究が行われる。

企業からは今の問題を調査し、その中から大学院生は最先端の研究テーマをみつける方法で、産学協同研究が実践されている。

テクニカルな専門分野（ＡＩ、ＤＢ等）だけしか分からない、大学の中でしか役に立たない専門家より、マネジメントの感覚を併せ持ち、各種の業種、業態の特性を十分理解できる柔軟で応用力のある専門家を育成することが、ＣＩＦＥの目的のようである。

研究成果については、レポートのみでなくＶＴＲも成果物としている。

ＣＩＦＥのこのような教育に対する基本方針は、大学の研究機関としての機能が、政府の補助に対するレポート提出のみで終わっていたのでは、現実の企業ニーズから乖離されてしまい、社会のニーズに応えられる研究者を育成できなくなる恐れから、考え出されたものであると、今回の訪問で感じられた。

2－2 アプライド・ラーニング社(ボストン)

2－2－1　概　要

①　アプライド・ラーニング社は欧米の主要企業の社内教育用ソフトを開発している。その開発責任者が今回面会したハリー・ラスカー教授である。

ラスカー教授はハーバード大学で教鞭をとり、子供向けのテレビ番組「セサミストリート」の教育効果を中心に番組開発に携わった経験をもっている。

その過程で教育用のビデオやビデオディスク（ＶＤ）の開発ノウハウを得ている。

②　効果的な教育ソフト開発のカギは現場の徹底したニーズリサーチ（インタビュー）である。

③　教育・ハードウェア・ソフトウェア・映像・音声等の各種分野の専門家の協同作業による教育ソフト開発が重要である。

２－２－２　インタラクティブ教育システムの現状と課題

～ハリー・ラスカー副社長とのミーティングから～

アプライド・ラーニング社（米国・ボストン）では、Mr.ハリー・ラスカー（Harry M.Lasker,PH.D,;Vice President)にお会いして、パーソナルコンピュータを利用した教育システムについてお話を伺った。

Mr.ハリー・ラスカーの経歴

ハーバード大学の教授時代にアメリカの子供番組「セサミストリート」の教育効果を中心に番組開発に関わり、この時の経験から教育用ＶＴＲ、ビデオディスク（ＶＤ）の開発ノウハウを得た。その後８０年代にＶＤとパソコンを融合した新しい教育システム開発のため、大学を辞め会社を設立。その後アプライド・ラーニング社に合併され現在に至る。

現在はアプライド・ラーニング社で、教育システムのデザインの最高責任者である。

当初は、子供向けにＶＤとパソコンを融合した教育システムの開発を目指していたが、コストの関係から、企業向けの教育システムの開発をおこなっている。

アプライド・ラーニング社の教育システムの開発概要

一つの教育用システムを開発するために、チームを組んで開発している。開発に当たっては、教育ニーズのリサーチから始まり、ハードウェア、ソフトウェア、ビデオ制作、教育心理学の各専門スタッフからなる、チームにより開発される。

企業向け教育システムとして、アプライド・ラーニング社では２つの方法を考えている。スペシャル・パーパスとラーニング・コンサルティングである。前者は、特定の目的に対するマルチメディア・インタラクティブ教育システムの提案であり、後者は、企業の教育システム全体のデザイン提案である。（基本的な開発過程は以下の図に示す）

行動目的明確化は、人間が「見て、聞いて、やってみたい」ことを発展できることを教育システムによって実現できるよう、人間のポテンシャルを向上する方向で考える。

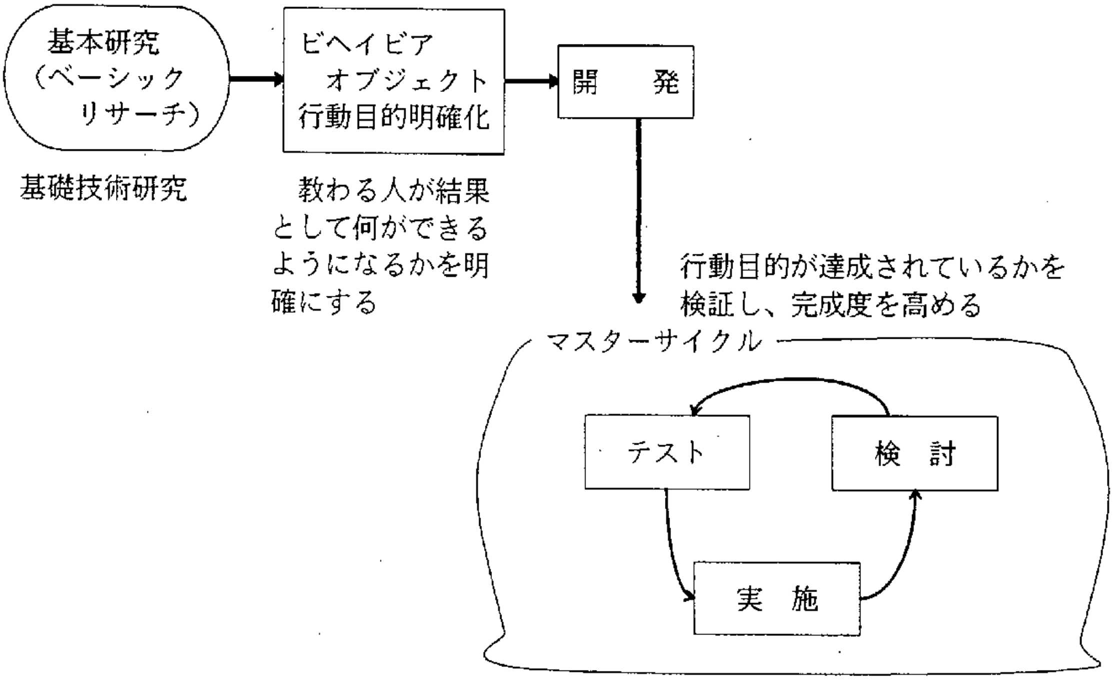
人間のポテンシャルは、1.ベース、2.オペレーショナル、3.トランスフォーメーショナルの３つに分けて考える。１は学校教育で育成される人としての基本能力である、２は行動して道具を使うための専門能力である、３はクリエーティブな能力である。アメリカの企業の教育ニーズはまさに３のクリエーティブな能力の向上にあり、アプライド・ラーニング社もこの部分にたいするコンピュータとＶＴＲ、ＶＤを活用した教育システムの開発を目指しており、開発体制もそれに沿ったものである。

ハードウェア

ＩＢＭ社のパソコン（ＩＢＭ―ＰＣ　ＡＴ）に、ソニー社のＶＤとテレビを接続したものが基本セットである。

アプライド・ラーニング社が販売を始めた頃には、企業内にＶＴＲが導入され教育にも利用されていた。そのＶＴＲによる教育システムに替わるものとして、ＶＤとパソコンによる教育システムを売り込んだ。そのために、ハードウェア（ＩＢＭ社のパソコンとＶＤ

図　教育システムの開発過程



を接続するボード）とソフトウェアの両方の開発が必要であった。

ソフトウェア

一つの教育システムを開発するために、まずお客企業の業務の処理能力の高い人と低い人に対する８時間に渡るヒアリング調査を実施し、仕事を進める上での心理状態を含めて具体的に解明する。ヒアリング対象の２人を比較することにより、処理能力の高い人の優れた部分をソフトウェアに反映させる。この過程が最も重要であり、ソフトウェアがお客企業に役立つかどうかを決める決定的ポイントである。

お客企業に対しては、この過程をへて作成されたソフトウェアを中心としたシステム全体を導入することで、仕事に与えるメリットを具体的イメージとして訴えることで採用していただいている。

コンピュータを利用して教育システムを作成する場合のメリットは、データ蓄積の手段のみではなく、人間の知識、能力の向上を補助するようなシステムをコンピュータを中心に作成することが可能となるという点である。

ＶＴＲ、ＶＤをコンピュータと組み合わせるのは、現状では人間の知識、能力の向上のためには欠かせないためである。

2－3 マサチューセッツ工科大学

2－3－1　概　要

①　アテナプロジェクト

コンピュータを研究、教育に利用するための環境作りと、その結果について実際にアテナプロジェクトの成果を活用した、人力飛行機の作成について、ビデオテープを参考に説明を受けた。

②　メディア・ラボ

アテナプロジェクトにも参画した、ストロヘッカー女史が実際に作成し、現在も使用されている、コンピュータとビデオディスクを接続し、教育効果を上げるための、ソフトウェアについてデモンストレーションと説明を受けた。

2－3－2　インタラクティブ教育システムの開発

マサチューセッツ工科大学では、インタラクティブ・ビデオディスクの作成と研究をしている、ストロヘッカー女史（Carol Strohecker;Research Assistant Learning & Epistemology Group)にお会いし、実際にストロヘッカー女史が作成に関連した、３本のインタラクティブ・ビデオディスクのデモンストレーションを見学した。以下に概要を示す。

(1)　A Different Train of Thought

教育を目的として作成されたものではないが、教育利用の目的で見ても大変示唆に富んだビデオディスクである。大きな特長は、メインストリームとサブストリームの考え方である。画面上では通常メインストリームの画面が流れているが、同時進行でサブストリームも裏で流れている。このビデオディスクの場合メインストリームは本編にあたり、サブストリームは登場人物それぞれのメインストリームの現在の場面での心情を描いたストーリーである。

メインストリームだけを見ていても映画として充分であるが、普通の映画と違う点は登場人物がその場面で何を考えているかは、見る人が感じるしかないがこのインタラクティブ・ビデオディスクでは、登場人物を示すウィンドウが画面下部にあり、そこを指でタッチすることで画面が指した人物の心情に画面が切り換わる点が大きく違う。

(2)　United States Golf Association Museum 展示用インタラクティブ・ビデオディスク

米国のゴルフの歴史を紹介したビデオディスクである。ゴルフ博物館の展示品の中に並んで博物館に来たお客様の興味を引きつける展示品の一つである。

ビデオディスクの特長であるランダム・アクセスを上手く活用し、ある大会の歴史を見ていて興味のわいた選手のプロフィールを画面に動画（選手のフィルムが残っている時代のみであるが）を表示して見せたり、その中でまた興味のわいた大会の詳細を画面に出したり出来、見る人の興味が尽きるまで米国のゴルフに関する情報を画面に引き出すことがきるようになっている。

(3)　The National Weather Service（ＮＷＳ）　天気予報官再教育用インタラクティブ・ビデオディスク

本インタラクティブ・ビデオディスクは、ＮＷＳの予報官の再教育用に開発されたものである。従来のＮＷＳの予報システムは、気象衛星の情報をコンピュータセンターで解析した情報を各サテライトを経由してお客様に提供していたが、直接サテライトが気象衛星の情報を解析しリアルタイムな気象情報をお客様に提供できるように予報システムをグレードアップする時に、ＮＷＳの要請によって開発されたものである。目的は、新システムに移行するに当たって発生するであろう習熟不足による能力ダウンを無くすことである。

このため、実際に新システムで使用される機器と気象データを使用して、教育用のインタラクティブ・ビデオディスクが開発された。教育される予報官にとっても自分達が実際

に使用する機器で教育を受けることで、移行後の不安を無くす効果があること、また実際に気象衛星から送られてくるデータを使用することで、考えられるあらゆる状況に対応する訓練ができる。ＥＷＳとしても全米各地に散らばるサテライトから予報官全員を集めて教育するコストを考えると、インタラクティブ・ビデオディスクを作成する方が効率的であると判断し依頼があったという。

実際に本インタラクティブ・ビデオディスクによる教育効果はＥＷＳの期待に充分応えるものであった。

総括

今回マサチューセッツ工科大学（ＭＩＴ）では３本のインタラクティブ・ビデオディスクのデモンストレーションを見学した。ＭＩＴではこの種の研究の歴史は古く、メディアラボが出来る前から研究をしていた。本格化したのはＭＩＴでアテナ・プロジェクトが始まってからのようである。（アテネ・プロジェクトについては別途記述）

３本のインタラクティブ・ビデオディスクに共通しているのは、ハイパー・テキストの考え方で、ある画面の情報に関連している情報が簡単に、次から次と画面に呼び出せるようになっていることである。使用する人が、自分の考えや興味で情報を引っ張り出す。コンピュータから自然に流れてくる情報を受け取るだけで進まないようになっていることである。

２－３－３　アテナプロジェクト

マサチューセッツ工科大学（Massachusetts Institute of Technology)では、アテナプロジェクト（Project Athena）について、概要の説明を受けた。

アテナプロジェクト概要

本プロジェクトは、７年前に始まったコンピュータを統合した環境での学生、修士課程の大学院生、教授の研究、教育環境に関する研究からスタートしたものであり、当初プロジェクトの名称を「ギリシャ女神の知恵（Greak Goddess of Wisdom)」と言った。

今回の訪問では、人力飛行機の制作から実際に飛行するまでの過程で、このコンピュータを統合した環境で、飛行機の設計から軽くて丈夫な素材選び、強度計算、パイロットの体力チェック等の必要な全ての情報をこの環境の中から引き出し、人力飛行機の飛行成功へ導いた過程を収めたビデオテープを見学した。

この例に見られるように、学生たちのより創造的で、効果の高い研究環境にコンピュータを活用することが本プロジェクトの目的である。

実際に、本プロジェクトの最初の５年で、ＭＩＴの研究、教育へのコンピュータ利用を含んだカリキュラムを１２５以上開発した。本プロジェクトが成功した要因として、大規模な範囲のネットワークに接続された、多数のワークステーションで一気に多くのソフトウェアの開発と利用がされたことをあげていた。

また、１９８８年から８９年にかけて、１２０名以上の要員が本プロジェクトに参加しており、これらの要員はＩＢＭ社、ＤＥＣ社といったハードウェア・ベンダーを中心に、多くのソフトウェア開発会社、メンテナンス会社から集まっており、本プロジェクトが終了する１９９１年5月までの資金総額としては、１０億ドルを超えるかなり大規模なプロジェクトである。

2－4 ハーバード大学教育大学院

2－4－1　概　要

教育システムのデモンストレーション —— Authur C. Johnson

ジョンソン氏（同大学院）がドクター論文のテーマとして、Ａｐｐｌｅ社から援助を得て研究した「コンピュータからの大量情報と人間の処理能力の差」について、デモンストレーションを見学した。

2－4－2　インタラクティブ教育システムの開発

Mr. ジョンソンがドクター論文のテーマとして、「コンピュータからの大量情報と、人の処理能力の差」について、ＡＰＰＬＥ社より援助を受けて研究しているものを今回見学した。

ハードウェア構成

ＡＰＰＬＥ社　ＭＡＣＩⅡｃｘとディジタイザをＲＳ２３２Ｃで接続し、ディジタイザにＣＤ－ＲＯＭ、ＶＴＲ、写真機を接続してある。

ソフトウェア概要

開発しているソフトウェアの名称「Ｐｅｒｓｏｎａｌ　Ｍｅｄｉａ　Ｓｔｕｄｉｏ」
ＭＡＣ上のハイパーカードに、音声、ＶＴＲ、写真機、ＣＤ－ＲＯＭよりデータを入力し使用する個人が、自分専用のデータベースを構築するためのソフトウェアである。

Mr. ジョンソンは、自分用のデータベースをＶＴＲ、ＣＤ－ＲＯＭ等のメディアを利用して作成することで、他の人がそのデータベースを使用しても作った本人がそこにいて、本人と会って話をしているような、本人（自分）そのものであるような個人用データベースの作成を目的としている。

データ収集のためアメリカ国内の高校に本ソフトウェアの試用を依頼しており、高校では生徒が、レポートをまとめるのに利用している。

生徒の使用を前提としているので、ふだん生徒が使用しているノートと同じフォーマットをＭＡＣに表示し、文字・描画だけでなく、音声・画像をも含んだレポートを作成することが可能になっている。始めは生徒も慣れないため、雑多な思いつきのデータを入力しているが、慣れるに従って本人の現時点の興味を入力しはじめ、本人の個性がデータベース化されていく。

今後は大学生、大学院生にも使用してもらって、データを収集する予定である。

ソフトウェア開発の狙い

従来のコンピュータの利用形態は、膨大な情報をコンピュータから引き出すことが中心であったが、Mr. ジョンソンは、個人の知識・行動様式をコンピュータに入力し、そこから自分の考えをまとめ新しい知識・行動を引き出すための道具として、複数のニューメディア（ＶＴＲ、ＣＤ－ＲＯＭ等）をコンピュータに接続して活用するためのプロトタイプとして開発した。

2－5 ボストン公共放送局（ＷＧＢＨ）

2－5－1　概　要

ボストン公共放送局では、ディレクターで以下に述べる「ＮＯＶＡ」プロジェクトの中心メンバーであった Mr,シッカー（Theodore Sicker;Director）にお話しを伺い、「ＮＯＶＡ」についての説明とデモンストレーションを見学した。

同放送局はボストン市内を中心にテレビ２チャンネル、ラジオ１チャンネルの放送をおこなっている。事業内容は日本の放送大学のような教育番組、子供向け教育番組、情報伝達手段の研究等である。教育番組は通常の放送であるが、情報伝達手段の研究は、放送のみならず他のメディアの登場による、新しい伝達手段が出現した場合（最近ではビデオディスク、コンピュータ等の登場）に、最も効果的な情報伝達手段の研究開発を目的としており、ハンデキャッパ向けの放送技術の開発、そして今回の主目的のＰＣインタラクティブも研究課題である。

2－5－2　インタラクティブ教育システムの開発

プロジェクト「インタラクティブ　ＮＯＶＡ」

概　要

科学ドキュメント番組を、パソコン（ＡＰＰＬＥ社マッキントッシュ）でインタラクティブに使用できるように編集し直し、４～５名のグループが学校の教室、図書館等に教材として利用するソフトウェア。

答えが一つ以上ある柔軟で一般的な問題について考えるソフトウェアを教育用に作成するアイディアは１０年以上前からあったが、ＡＰＰＬＥ社のハイパーカードが発売されて、学校で使用できる程度までコストが下がり、始めて実現可能になった。（ソフトウェア開発に関してＡＰＰＬＥ社の援助がある）

構成機器

標準的なハードウェア構成は、以下のとおり。

①　パソコン　　ＡＰＰＬＥ　　マッキントッシュＰＬＵＳ
（学校の予算で購入可能なハードウェア）
②　周辺装置　　パイオニア　　ビデオディスク装置
③　ソニー　　ビデオテープ装置
④　ソニー　　カラーテレビ

学校に導入されているパソコンで、ハイパーカードが使用可能なパソコンは上記パソコンが最も多いため、これを対象にソフトウェアが開発されている。

ソフトウェアとして提供されるものは、３．５インチフロッピーディスク１０枚、ビデオディスク１枚、フロッピーディスクにはハイパーカード用の資料情報（文字情報等）が入っており、ビデオディスクには音声と画像情報が入っている。

開発体制

ビデオディスクの技術者、パソコン用グラフィックの技術者、文字情報のテキストライタ、ハイパーカードのプログラマ、教育専門家等の１０名のチーム。

開発期間の２／３をリサーチ＆ディベロップメントにあて、残り１／３で製作した。

開発に当たって最大のネックは、教育専門家とコンピュータ技術者の考え方の相違であったという。（この話しは、ボストンのアプライド・ラーニング社でも聞くことができた）

ネックの中心点は、以下のとおり。

教育専門家　：　コンピュータを使う人の考える力を引き出し、伸ばすことを考えた操作性、画面をつくろうとする。

コンピュータ技術者　：　コンピュータに多くの情報を入力し、きれいに伝えようとする。

この違いがはっきりでるのは、画面をカラーにするかモノクロにするか、動画を多くするか静止画を多くするかにあらわれてくるという。
カラー・動画で見易く＝コンピュータ技術者、モノクロで色を想像させる・静止画で動きを想像させる＝教育専門家。といった違いになって、開発時に議論が深夜までおよんだことも度々あったという。

デモンストレーション概要

今回の訪問で実際に見学したＮＯＶＡのソフトウェアは、中学校、高校の学生向けに作成されたもの２本であった。
最初に見学したソフトウェアは、全米の水辺の特徴とそこに生息する生物について、ビデオディスクの音と画像情報により分りやすく解説したものであった。パソコンの画面に全米の地図が表示され、例えば五大湖の水辺について情報を得たい場合、五大湖をマウスでクリックすることで、ビデオディスクから五大湖の水辺についての音声と画像の情報をカラーテレビに表示するものである。ビデオディスクの情報はもともとＷＧＢＨで放送した番組を編集しなおしたものである。
学生が、図書等で調べていた水辺の生物についての情報を音声と画像を見ながら、このＮＯＶＡを動かしているパソコンでレポートを作成することも可能になっている（そのレポートにビデオディスクの情報を入力しておくことも可能）。学生はレポートを紙ではなくフロッピーで提出する時代が近い将来やってこよう。
もう一つのソフトウェアは、環境保護問題についてのソフトウェアで、フロリダの海岸に産卵にやってくる海亀を守ろうとする、ロールプレイングゲームのようになっていて、学生がボストンからフロリダへ行ってそこで現場（フロリダの海岸）がどうなっているのかを調査してくるものである。物語の途中で、例えばパソコンの画面上のテレビをマウスでクリックすると、ビデオテープ装置が自動的に動きだしてカラーテレビに海亀についての情報を映し出すようになっている。
このソフトウェアを使用する学生が、自分で考えなければ次へ進めないようになっており、パソコンから情報が流れ出てきて、それを学生が覚えるというものではない。受け身では使えないようになっている。

2－6 アプライド・ラーニング社(ロンドン)

2－6－1　概　要

ボストンのアプライド・ラーニング社ではハリー・ラスカー教授にお会いし、アプライド・ラーニング社で作成している教育用ソフトウェアの開発理念をお伺いしたが、ロンドンでは、実際にアプライド・ラーニング社が開発した教育用ソフトウェアを利用し、最も成果をあげている事例について概要を伺い、ＣＤＩを活用した最新の教育用ソフトウェアについてのデモンストレーションを見学した。

2－6－2　インタラクティブ教育システムの開発

アプライド・ラーニング社ロンドン支社では、Mr.ゴールド（Charles W.Gould; Director）とMr.ポップ（Mike Pope;Consultancy Services）にお会いし、教育システムの作成概要、実際の事例、最新の教育システムについてお話しを伺い、デモンストレーションを見学した。

概　要

アプライド・ラーニング社ロンドン支社では、アメリカ以外の国に対するＣＡＩの販売を担当しており、日本に対する販売のパートナを選び、既に拠点を設けている（日本国内においては、ＶＴＲのみ販売している）。

教育システム

お客企業の戦略目的のために、お客企業の人材教育（人材のパフォーマンスの向上）。そのために以下の３つの方法を実施している。

1．コンサルティング
　お客企業の人材がその戦略目的達成に必要な質・量ともにいるかどうかを評価し、質の問題に対しては、自社の教育システムを提案する。また、教育部門を持たない企業に対しては、アプライド・ラーニング社自体が、教育部門の業務を代行することもある。
2．コースウェア
　資料編にあるとおり、ＶＴＲ、ＣＡＩ、集合研修を含めた、多種多様な教育システムを備えている。
3．アフターケア
　ビデオディスク、ＣＤ－ＲＯＭを活用した、インタラクティブＣＡＩ。

上記の３つの方法で、特に有効な事例としては、お客企業が新しい商品・新しいシステムを販売・利用を始める時に従来では逃れられなかった、一時的なパフォーマンスの低下（習熟期間のパワーロス）を、コースウェアの活用等によりなくすことが可能になる。
お客企業の評価は、導入した企業の業績がどれだけ伸びたかによってはかられる。業績のみが、目に見える基準である。と考えているようである。
ただし効果は、企業のやる気、社員のやる気によって左右されると考えている点は、日本と同じようであるが、いかに社員がやる気を出す仕組み、環境を作ってコンサルティングするかが、ノウハウのようである。

ハードウェア構成

アプライド・ラーニング社は、世界各国（ヨーロッパを中心）に教育システムを販売しているが、基本的なハードウェア構成は、ソニーのビデオディスクとテレビ、ＩＢＭ社の

パーソナルコンピュータである。
技術的な開発は、アメリカで行っているが、言語（母国語）や文化の違いを考慮して、具体的なお客企業への適用は、各国の支社で実施している。
教育システムの適用（特に技術教育について）
技術教育に関しては、基本的に国による変化はないが、ＶＴＲ、ＣＤ－ＲＯＭの音声をその国の母国語に変えるだけであるが、それ以外のセールスやマネージメントの教育に関しては、コンサルテーションを実施し、オーダーメイドで作成することになる。

① 技術教育の例（ＵＮＩＸの教育）
コンピュータを利用して教育を実施する（ＣＡＩ）が、コンピュータに使われていると、絶対に感じさせない工夫が必要になる。例えば、何時でも何処からでも使う人が自由に好きな所から始めて、終われるようにする。また、ＵＮＩＸの教育に必要なカリキュラムについては、事前のコンサルティングによって、お客企業ごとに決定される。
② ＶＴＲを活用した教育システムの例
ＶＴＲの利点は、お客企業の社員が、自宅に持ち帰り自分の好きな時間に利用できること（アメリカとイギリスを比べるとイギリスの方が自宅に持ち帰る社員が多い）と、まったく知識のない人でも、繰り返し見ることで理解できることである。ただし使用した人の評価は、個人差が大きい。

最新の教育システム

ＣＤ－ＲＯＭの新規格として、ＣＤ－ＲＯＭ　ＸＡ（Compact Disc Read Only Memoryの拡張として音声の入力を規定したもの）、ＤＶＩ（Digital Video Interactive)、ＣＤＩ（Compact Disc Interactive media）といった機器が、日本や欧米の企業により提唱されている。アプライド・ラーニング社においても、今後出てくるであろう新規格に対応するため開発しているものがある。今回はその中で、ＤＶＩについて見学することができた。
デモンストレーションでは、西ドイツの化学会社の新製品のコマーシャルをＤＶＩで開発したものであり、同一の画像に英語、ドイツ語、フランス語、イタリア語で解説をしたもので、見る人が理解できる言語を選択できるようになっている。
ＤＶＩは、パソコンの制御が必要であるが、今後製品化されるであろうＣＤＩは、ＣＤＩの本体にＣＰＵが内蔵され、パソコンなしで利用が可能になるため、ＣＤＩ向けの教育システムは、ＶＴＲ以上の教育効果を上げることができると考えられている。

2－7 インリア（ＩＮＲＩＡ）

2－7－1 概 要

ＩＮＲＩＡ（Institut National de Informatique et en Automatique)はフランス文部省の情報処理の最先端分野の調査研究機関である。今回の訪問では、ガンス女史（Helen Gans;Deleguee aux Relations Scientifiques Internationaler)にＩＮＲＩＡの概要と現在行われている研究等の概要についてお話を伺った。

ＩＮＲＩＡはフランスの公的な科学・技術等の研究機関である。ＩＮＲＩＡはフランス国内に４カ所の研究センターを持っており、今回パリ郊外の研究センターを訪問した。

フランスでは、文部省傘下にＩＮＲＩＡと同じように産業に関する調査研究を実施している研究機関が３つある。

(1) 産業、分野を問わず全体的な調査研究を行っているＣＮＲＳ（Center National de la Recherch Scientifiqu)
(2) テレコミュニケーションを中心に調査研究しているＣＮＥＴ
(3) 製造業を中心に調査研究しているＩＮＲＡ

である。ＩＮＲＩＡと他３つの研究機関の中で最も関係が強いのは、ＣＮＲＳである。

ＣＮＲＳは産業全体の調査研究を実施しており、この調査研究成果を３つの研究機関に研究開発の依頼をおこなっている。

今回訪問したＩＮＲＩＡはその中にあって、情報処理に関する最先端分野、

(1) ＡＩ（Artificial Intelligence)
(2) 次世代コンピュータ開発
(3) ネットワーク
(4) データベース
(5) オートメーション
(6) ロボット
(7) 科学技術計算
(8) マン・マシン・インタフェース

の上記８項目について、調査研究を実施している。

ＩＮＲＩＡのマンパワー及びコンピュータリソースの概要は以下の通り。

(1) ６００名以上の科学研究者を含め、全体で９００名。
　科学研究者６００名の内訳
　　２２０名　フルタイムの研究者
　　２２０名　外部研修生
　　　８０名　公的研究所等からの研究者
　　　４０名　企業からのエンジニア
　　　４０名　海外からの出向研究者
(2) これらの研究者たちは、次のようなリソースを使って研究を進めている。
　　１５０台以上のマイクロコンピュータ
　　２００台以上のＵＮＩＸワークステーション
　　　（SUN 、BULL 、 Apollo etc ）
　　ＣＲＡＹⅡへのアクセス

これらはすべて　Ethernet、Ｘ２５でリンクされている。
ＩＮＲＩＡの研究開発に対する取り組み方の基本として、「一つのテーマに対して多くの人間が集まって研究した方が、より成果が上がる」としており、人種、国籍を問わず自由な雰囲気の施設の中に多くの研究員が集まっている。
今回訪問したパリ郊外の研究施設の他に、フランス国内に３つ（レンヌ、ナンシー、ニース）研究施設がある。

ＩＮＲＩＡは先に述べたように、ＣＮＲＳから来た研究テーマについて研究開発を行う以外にも独自に調査を実施し、社会的ニーズが高いが、一般の企業が研究開発を行うにはリスクの大き過ぎるテーマについても、研究開発を多数行っている。研究資金については、国家の資金の他に研究開発に成功したテーマを一般の企業にライセンスを供与しそのライセンス料も研究資金としている。割合としては８８年で全体の２０％をライセンス料が占めている。
国際間の研究協力についても、積極的に行っており、ＥＣ、アメリカ等の研究項目が関連する国際会議には必ず参加している。
日本では、ＩＣＯＴ（新世代コンピュータ技術開発機構）や日本情報処理開発協会との関連が深い。

教育研修について

今回の訪問の目的は、情報処理の最先端の研究機関が、どのような形でシステム・エンジニア等の教育を実施しているかを調査するために訪問したが、ＩＮＲＩＡの研究者に対する教育は、研究開発に関する発表会を中心としており、ＩＮＲＩＡの中で一から教育を実施しているわけではない。ただし、ＩＮＲＩＡの研究者の多くは国内の大学の教授を兼任している方が多く、ＩＮＲＩＡで研究した成果を大学の教育に反映させているとのことであった。
一般企業の研究所の情報処理関連の研究員を受入れ、半年から１年教育するためのカリキュラムがあるとのことであった。
このカリキュラムは、ＩＮＲＩＡで研究開発したＡＩ等のソフトウェア、ハードウェアを企業がライセンスを受けて、市場で販売するために必要な知識、技術の取得を目的としたものである。

第3章　調査結果

わが国の情報処理教育における課題

第３章　調査結果　：　わが国における課題

今回の海外視察において、参考になったポイントを下記に挙げ、今後の情報処理コースウェアにおけるインタラクティブ・ビデオ教材の効果的開発のあり方を、効果的制作・運用の点から検討し、次に効果的学習の諸条件を学習に際してのインストラクタ（教育側）の役割の点から、さらにビデオ教材の今後のあり方として、学習者の主体的参画による教育の重要性及び、ビデオの他メディアとの融合活用にふれ、最後にビデオ教育の今後の課題と、それに伴う教育観の転換の必要性を述べる。

・　教育の専門家とコンピュータの専門家との協動ワークによる教育ソフトの企画開発（スタンフォード大学教育大学院ウォーカー教授）
・　教育内容（情報）はコンピュータ情報に任せ、教師は教授機能をはたすのではなくコーチ機能をはたすべきである（同上）
・　教師のコーチ機能としてとりわけ重要なことはチームディスカッションのコーディネイトである。（同上）
・　ビデオ活用は〔自分が操作できる〕すなわち主体的に参画できるが故に教育的価値が大きい（同上）
・　衛星利用は学習側も操作参画できれば効果大であろう（同上）
・　これからの時代は教師の存在が不明確となり学習者の役割が増大する時代、したがって学習者の反応の確認・引きだし・再反応が重要（同上）
・　特定しない時間・場所で教育可能な手段としてのビデオ（同上）
・　教師がソフトウェアを開発する時代（同上）
・　ニーズを〔安く早く〕把握する必要性（同上）
・　企業とのジョイントによる教育システムの開発：企業にもメリットのあるテーマを提案し資金と人材を提供させ問題解決と人材育成に資するシステム（スタンフォード大学エンジニアリングセンター、タイシュルツ教授）
・　光ディスク・音響機器・コンピュータを連動させたシステム（スタンフォード大学コンピュータセンター）
・　ゆとりある教育ソフト作成スペース（同上）
・　マッキントッシュ・ハイパーカードの徹底活用（同上）
・　現場への皮膚感覚と徹底した現場ニーズリサーチが効果的教育ソフトづくりのカギ（アプライド・ラーニング社：ハリー・ラスカー副社長）
・　自己応答型・深化応答型（ループ）システムがポイント（同上）
・　ニーズリサーチにおける徹底インタビューの大切さ（同上）
・　プレゼンテーションそのものの見事さ（同上）
・　系統だったマニュアル（同上）
・　学習者が操作しやすい教育ソフト（同上）
・　経営コンサルティングを先行させた教育システムの導入の大切さ（同上）
・　教育専門家・ハード専門家・ソフト専門家・映像専門家・音声専門家・パフォーマンス専門家による教育ソフトづくり（同上）

・　これからの効果的教育ソフトは各専門家のノウハウの挑戦的融合から産出される（同上）
・　サジェスチョンに富んだ映像づくり（マサチューセッツ工科大学メディア・ラボ：ストロヘッカー女史）
・　学習者に与える効果が第一とのソフト作成姿勢（同上）
・　〔与える〕教育ソフトではなく〔自ら考えてテーマ設定〕する教育ソフトが重要（ハーバード大学教育大学院生：ジョンソン氏）
・　専門家として満足する教育ソフトではなく学習者が意欲的に取り組めることが重要（同上）
・　各専門家によるプロジェクトは実際には〔融合〕が難しく疲れきるまで議論している（ボストン公共放送局：シッカー氏）
・　日本の提携先は形を変える（日本語化する）だけだ（アプライド・ラーニング社：ゴールド氏）
・　日本のハード機器は素晴らしいが異分野機器との統合活用を期待したい（同上）
・　教育メニューは絶えず見直されその２０％は1年でメンテされる（同上）
・　教育メニューは〔現場で簡単に利用できる〕ことが大前提（同上）

3－1　インタラクティブ・ビデオ教材の効果的制作と運用

効果的な制作と運用において、もっとも重視されなければならないことは、学習者に与える効果であることは言うまでもない。ここでは学習者に与える効果と、そのための制作・運用について検討したい。

(1)　学習者に与える効果

学習者に与える効果の条件をまず考えてみたい。

条件１：学習意欲が喚起されること
　１）学習テーマおよび学習そのものに親和感を感じる
　２）役立つ予感度が高い
　３）学習テーマに対する達成可能性を感じる

条件２：学習理解を促進できること
　１）内容の平易性（分かりやすい）
　２）内容の再確認性（繰り返し確認できる）
　３）応答性（教師と応答できる）

条件３：行動化・運用化を促進できること
　１）行動イメージの明示性（学習した結果をイメージできる）
　２）行動ステップの明確度（まず何から身に付けるか分かる）

条件４：学習を自律化できること
　１）自己学習が容易にできる（あるいは復習がしやすい）
　２）学習結果を自己確認できる

条件５：コスト・パフォーマンス
　１）学習に時間がかからない
　２）学習に労力がかからない
　３）学習に費用がかからない

条件６：学習情報密度が高いこと
　１）情報量が多い
　２）情報圧縮度が高い
　３）個別的情報が入手できる

(2)　各効果条件におけるビデオ効果と制作・運用上の留意点

（ａ）条件１：学習意欲が喚起されること

特に若い世代にあっては、映像はますます日常的なものとなっている。親和感は日常性に比例するという考えに立つならば、ビデオはメディアとして、もっと活用されてよい。しかしビデオが普及すればする程、比較に耐えるだけの映像が期待されることになる。役立つ予感度に関しては、ビデオの実写性・具体性は大きな要因である。ビデオを学習者が見る前に、ビデオ内容の狙いを明確にしておく必要があろう。ビデオの初回視聴印象は強く、問題意識をもって視聴することは役立ちの期待を高める。達成可能性について、視聴することは、活字を読んだり、コンピュータを操作するよりは簡単であるが、努力を伴わないだけに視聴前に意欲喚起のガイドは必要である。

（b）条件2：学習理解を促進できること

平易性すなわち分かりやすさはビデオの大きな優位性である。ただし映像的にはそうであっても、内容の企画・制作に難があると不自然さ・矛盾感が前面に出てしまう。＜企画・制作は、視聴者の目で＞が大切である。内容の再確認性は映像的には問題ないが、操作の点で再確認しやすさがポイントになろう。コンピュータとの連動、ディジタル・ビデオの活用が望ましい。応答性については、内容上の工夫、インストラクタの参加が必要である。しかし学習理解の面でのビデオは、基礎の補完において最も効果を発揮すると言えよう。

（c）条件3：行動化を促進できること

行動イメージの明示度の点でのビデオ効果は他の追随を許さない。ただしこの点も、企画・制作と大きく係わる。とくに人物演技における出演者のパフォーマンスのレベルに大きく左右される。したがってビデオを視聴するだけではなく実際の行動演習を添えることは大切である。行動ステップの明確度についても同様である。行動化に関して、ビデオならではの優位性は、カメラの活用に負うところが大きい。すなわちいわゆる＜かがみの効果＞の活用である。カメラにより、学習者の行動を撮影し、その映像を確認することによって、行動のイメージ、行動のステップを実感する効果の活用である。障害対処情報入手度も、生き生きとしたイメージで可能である。しかし、この点は、特に企画・制作において、あらかじめ障害に関する現場調査をふまえた内容づくりが重要となろう。

（d）条件4：学習を自律化できること

この点でのビデオの優位性も高い。操作性に困難な問題がない。コンピュータの操作には若干の準備が必要であるが、ビデオは皆無と言える。自己学習可能性もきわめて大きい。時間・場所を選ばない。しかし効果確認性に関しては、自己学習の場合、応答性が低いことによる難点がある。内容に応答性をあらかじめ組み込む必要があるが、行動面での効果確認は、カメラの活用により、補完し得る。すなわち自己学習した後、自分の行動をカメラで撮影し、映像化し

て効果を確認する方法である。

（e）条件5：コスト・パフォーマンス

コスト・パフォーマンスの点での優位性は、自己学習ビデオの場合、教室での学習と比較するならばきわめて高い。学習者は移動時間・移動労力が皆無となる。ただしビデオの教室での学習では、この点での効果はない。教育側コストは教室での学習においても効果がある。講師の時間・労力は、放映時に関してだけでなく、ビデオの実写性・網羅性による講義時間・講義労力の短縮・節減につながる。メディア・コストに関して、ハード面では、コンピュータと比較すれば安くつく。またソフト面でも、制作にあたって、手作り性を高くする工夫によって低コスト化は可能である。

（f）条件6：学習情報密度が高いこと

ビデオの単位時間あたりの情報密度が高いことは言及するまでもない。情報量と情報圧縮度に関して、ビデオは、特に行動面の情報において優位である。表情・しぐさ・行動のいきいきしたイメージは、まさにビデオの真骨頂である。またビデオは遠隔地の情景あるいはカメラが撮影可能な範囲ならば、映像化が可能である。時空を越えて行動のイメージを再現してくれる。しかし個別的情報入手時においては、まず映像化しておかなければならないこと、あるいはカメラ配置との関連で、必ずしも効果的とは言えない。この点は、副教材等による補完が必要である。

3－2　教育システム開発における教育側の役割

映像を＜核＞とした教育におけるインストラクタの役割について検討したい。教室学習と自己学習の場合とに分けて考えてみたい。教室学習においてのインストラクタの重要な役割は、映像ならではの効果を教室環境面とコースウェアおよびインストラクションの上で、いかに確実にするかである。また自己学習においての教育側の役割は、特に応答性をいかに映像に組み込むか、自己学習時の心理に密着する映像上の配慮、もしあるとするならば、であろう。ここでは、インストラクションにおける役割、応答性の組み込み、自己学習心理と映像に関してふれたい。

(1)　インストラクションにおける役割

映像はインストラクションの代替ではなく、むしろインストラクション効果をより高次なものとするための補完機能と考えたい。映像により意欲喚起・具体的理解・行動のイメージ化が促進されるのを受けて、意欲の喚起に加えての方向づけ、具体的理解に加えての理解の応用・深化・発展、行動イメージに加えてのストーリー化・行動の体内化、等々、レベルアップされたインストラクションを期待したい。インストラクタは、映像が負担を軽減してくれる絶好の代替機能と考えるか、それともより一層の期待を課す補完機能と考えるかによって、今後の役割の明暗を分けるのではなかろうか。

(2)　応答性の組み込み

教室学習においては、インストラクタが応答性を補完できるが、自己学習の場合には、何らかの方法で応答性を高める必要がある。１つには、応答性をいかに映像そのものに組み込むかであり、もう１つはインストラクタとの効果的応答手段の採用である。応答性の映像への組み込みの方法としては、映像ストーリーの＜Ｑ＆Ａ方式＞、特に行動面テーマにおいては＜わるい例・よい例対比方式＞、映像にインストラクタ（ナレーター）を登場させ対面臨場感を盛り込む方法、問題喚起／一時停止／解答推測の方法、等がある。効果的応答手段としては、電話・ファクシミリ・パソコン通信等による補完、映像とコンピュータを連動させ、応答情報を検索選択できるようにする、行動面テーマにては、さらにはカメラを活用し応答の答部分を自撮し自己確認するとともに映像結果をインストラクタに評価してもらう、等がある。

(3)　自己学習における配慮

自己学習の場合には、教室学習と異なりシナージー効果（協働協学効果）が低い。教室学習においては、他者という＜かがみ＞があるために、自己発見・自己変革の契機が多い。自己学習時にあっては、主観的判断が中心になりやすく、自己発見・自己変革の必然性がともすると薄まりやすい。また教室学習においては、評価される可能性が、達成感を増幅し新たな挑戦を引き出す（逆に達成感が減殺され意欲を削ぐ場合もある）。自己学習では達成感も手応えが揺らぐ。すなわち自己学習の場合は、学習

成果を客観的に評価し難く、達成感が満たされず、学習意欲の継続発展に困難を生じやすい心理状態が一般的とも言える。したがって自己学習における映像には、評価と達成感を意識的に組み込む、たとえば自己評価のためのあるいは達成度評価のための、＜まとめ＞の映像あるいはナレーションを節々に挿入する、等の必要があろう。コンピュータ、カメラと連動させて、操作の点での達成感を加えることも大切であろう。

(4) 効果促進のための副教材のあり方

副教材において、まず望ましいことは、自己学習用であれ教室学習後の復習用であれ、主要映像が盛り込まれ、ナレーション部分も活字化され、重要ポイントが明示され、インデックスも完備しているものである。ビデオ内容を極力ペーパー化したものが望ましい。そのことにより映像をより一層客観視でき余裕をもって＜そしゃく＞できる。しかしその効果にとどまっていては＜副＞としての効果とは言えない。さきにふれた学習者にとっての効果の条件に照らして検討するならば、ビデオの映像においては、効果の点で以下の補完が、特に必要であろう。

1．＜ビデオを観る事前に＞学習意欲が喚起されること
2．学習理解の促進において＜応答性が補完される＞
3．行動化・適用化の促進において＜障害克服個別情報が入手できる＞
4．学習の自律化が＜飽きずに無理なくできる＞
5．コスト・パフォーマンスの点で＜随時随所の学習を促進＞
6．学習情報密度が高いことに関して＜関連情報・個別的情報を入手＞

＜ビデオを観る前の意欲喚起＞に関しては、ビデオそのものに組み込むことも可能であるが、むしろ教材テーマに関する簡単なペーパー・テストにより学習目標を明確にすることが望ましい。＜応答性の補完＞については、各セッション毎に映像化されていない項目に関しての＜Q＆A＞コーナーを設け、さらには＜解答送付＞による添削、＜質問表＞による回答等の手だてがあるとよい。＜障害克服個別情報＞＜関連情報・個別的情報＞について、ガイドが必要。またガイドとともに、電話・ファックス等による＜情報提供システム＞の連動が望まれる。＜飽きずに無理なく自律学習＞に関しては、単に学習テーマに関連してだけでなく、自己学習そのものの環境設備が必要であろう。＜随時随所の学習を促進＞については、自動車あるいは交通機関の時間帯にて、あるいは3分間単位程度で学習が可能なカード等を添えるのも一案。

3－3　学習者の主体的参画の重視

(1) 教育研修スタイル

教育研修スタイルは、講義テーマによって担当講師によって特色を異にしている。ひとつの考え方として、大きくは情報提供型と情報創造型に分類できよう。情報提供型は、さらに情報伝達型と情報提案型に分けられる。情報創造型は、情報統合型と情報発案型に分けられる。情報伝達型において学習者は＜理解＞を主眼とし講師は情報の＜伝達＞を役割とする。情報提案型において学習者は＜選択＞を主眼とし講師は情報の＜提案＞を役割とする。情報統合型において学習者は＜思索＞を主眼とし講師は＜提起＞を役割とする。情報発案型において学習者は＜発見＞を主眼とし講師は＜援助＞を役割とする。

教育研修スタイル		学習者	講師役割	学習者主体的参画度
情報提供型	情報伝達型	理　解	伝　達	小
	情報提案型	選　択	提　案	中
情報創造型	情報統合型	思　索	提　起	大
	情報発案型	発　見	援　助	極　大

(2) 各教育研修スタイルとビデオ教材活用

＜情報伝達型＞の教育研修は、正確な均質な情報伝達が基本的に問われる。また学習者の教室までの移動コスト等から見て、＜実習＞を伴う教育内容以外の研修は、今後はビデオあるいはオーディオテープ、魅力ある印刷物、さらにはニューメディアにとって代わられるであろう。中でも特に視覚的効果のあるビデオは、このジャンルの教育研修の全面的かつ重要な教材となろう。しかもこのジャンルをビデオ化することは、学習者のとりわけ＜随時随所効果＞の観点からも、また余裕ある＜そしゃく＞の点からも学習者の主体的参画に資すると言えよう。

＜情報提案型＞の教育研修は、多くの情報を網羅し、学習者がニーズに合致した情報を取捨選択する場合である。＜情報伝達型＞研修が初心者・初歩テーマ・新テーマを多く対象にするのに対して、経験者向け・再確認テーマ・発展テーマが多く対象となろう。教材には情報の網羅性・圧縮性、さらには参照ガイド・検索性が必要となろう。講師も多様な情報を身に付けていることが問われ、また学習者の関心の把握・関心引き出し応答力・関心に的を絞っての提案型プレゼンテーション能力が期待される。情報の網羅性・圧縮性、さらには実写性の点から、一部をビデオに代替する方法は効果的である。応答性が確保されるならば、ニューメディアに取って代わられ可能性が

高い。この分野におけるビデオ化は選択情報の量質ともに増大という点からも、学習者の主体的参画に役立つと言えよう。

＜情報統合型＞のジャンルは、情報を与えるのではなく、一定の情報を手懸かりにして、これまでの経験や多くの情報を整理・統合する、あるいは役立つ情報を発見するための教育研修である。この狙いのためには、実際の事例、あるいは吟味して作成されたケース、示唆的なセンテンス、思索を誘導・深化させるための図・絵、等がふさわしい。実際事例のビデオ化、ケースのビデオによる提示、教育内容を立体化するための、他の教育メディアの融合活用は効果的である。講師は、問題提起力・目標提起力・発想転換誘導力・葛藤コーディネイト力等が問われることになるだろう。しかしこの情報統合という狙いの研修は、ソフト作成の複雑さ、高密度応答性の必要性から、トータルとしてはビデオあるいはビデオと他のメディアとの融合活用によって代替することは、早急には難しい要素が多いと考えられる。このスタイルにおけるビデオ活用は、統合のための情報提供という観点からも効果大と言えよう。

＜情報発案型＞の分野、すなわち新しい役立つ情報を既存の情報にとらわれずに創造的に発見することを狙いとする、たとえば新しいソフトの開発・現業部門の個別業務に密着した個別システムの開発・組織の個別性を勘案してのプロジェクト管理スタイルの構築・自社独自の人材開発、等々をテーマとする場合である。時代変化は既存の情報だけでの対応では難しい。このジャンルにおいて必要な情報は、創造的発見に関する情報である。とくに「発見学習」あるいは創造的発見事例（結果よりもプロセス情報）そして、それらの実際的活用に関する情報であろう。講師は援助型コーディネイタであり、ディスカッションのカタライザーである。また状況に即して、必要情報の提供者でもある。いわば講師自体が教育研修の教材そのものの重要な一部となる。このジャンルの教育研修・講師は、ニューメディアの時代にあって、ニューメディアに代替し難い重要性を増すであろう。その中でビデオは援助情報機能として役割を大きくはたすであろう。

3－4　マルチ・メディアとしての融合活用

ビデオの他メディアとの融合活用について検討したい。各種メディアは単独で活用するよりも、各特性を相互補完させ<融合活用>することにより教育効果が高まる。では、いかなる融合がどのような効果をもたらすであろうか、重点的に見てみよう。

(1)　ＯＨＰおよび電子ＯＨＰとビデオとの融合活用

ＯＨＰは自作が簡単にできる。ビデオは制作に時間・労力・コストがかかる。またＯＨＰは追加記入・オーバーレイ・マスキング等により多様な使用法が可能である。この点の柔軟性はビデオをはるかに凌ぐ。機器の移動性・操作性・普及性もビデオの比ではない。しかし、ビデオの実写性・動画性はＯＨＰの得手ではない。電子ＯＨＰは複雑な動画の可能性を持つが、まだモノクロが現状である。

ビデオに実写・動画役割を担わせ、解説部分はＯＨＰの随時自作機能と追加記入等機能を活用する。さらには従来ビデオに組み込まれてきたフリップ部分をＯＨＰに任せれば、ビデオの制作コスト節減に役立つ。

ハイビジョンの映像の鮮明さは、電子ＯＨＰとビデオの融合活用を促進する要因となっている。同一映写面において、ごく自然にＯＨＰとビデオ映像の融合が可能になってきている。そのためにも電子ＯＨＰのソフトのより一層の開発と、検索しやすさのため、ビデオから光ディスクへの移行が迫られている。

(2)　ビデオ（光ディスク）とパソコンとの融合活用

ビデオ（光ディスク）をパソコンでコントロールすることは日常的になってきているが、単に操作の便利さとしての相互補完では惜しい。ビデオは制作内容次第ではあるが、視聴者との応答性をもっと補完する必要がある。実写性・動画性は注意・興味を引き寄せるが、ともすると情報圧縮度の高い画面を注視する余りに画面との対話が不十分になりやすい。パソコンにより再確認・関連情報提示・深度理解の誘導等の補完が望ましい。さらには視聴者がキーボードを持ちながら（複数のキーボードを連動させることは可能）画面をコントロールすることによる<対話型視聴>が望まれる。

(3)　ＣＡＩとビデオとの融合活用

ＣＡＩにおける、コンピュータとの対話形式による学習の個別化、および主体的にコンピュータに働きかけての学習は、教育の質確保・教育の機会創出・脱専門講師化とあいまって、ますます重要な要請となろう。またシミュレーションによる体験学習や、アニメーションによる演示実験は学習意欲の向上にもつながる。しかしながら学習テーマが学習者の個別的関心に合致している場合は別としても、他の学習者とのシナージーの欠落・持続的学習姿勢の強化は大きな課題といえる。学習初期段階における達成イメージの描写、学習途次における応答型の映像、映像によるシナージーの補塡、等におけるビデオの活用は効果的である。とりわけシミュレーションにおける実写性・動画性・ドラマ性の付加はビデオの面目躍如たるところである。

パソコンと光ディスクとを融合してのマルチメディア型ＣＡＩは、音声・音響の活用、タッチパネルの利用を含めて今後の教育的活用がまたれるところである。またパソコン通信、あるいはファックス利用による指導依頼・他学習者との交流も融合効果がある。

(4) 遠隔教育における融合利用

遠隔教育においては当然のことながら、複数のメディアが融合的に活用される。とくにＩＳＤＮ利用の遠隔教育システムは実用化の緒についたとはいえ、注目される。教育において最も重要な双方向コミュニケーションが可能なビデオ動画・静止画の活用、スタジオ等の設備の不要、衛星利用に比較してのランニングコストの節減、パソコン通信・ＣＡＩとの組み合せ活用を内容とした教育方法は、経済性・簡便性、そして、何よりもメディアの総合的な融合活用による教育効果の点から期待される。

パソコン通信による遠隔教育の場合は、上記(3)の融合効果が参考となろう。衛星通信による遠隔教育における複数メディア融合活用も注目される。音声・映像を伴っての質疑応答が可能である教育効果は大きい。ロールプレイ等もカメラワーク・スキル次第で効果的である。回線コストの低減、広域同時同報ニーズとあいまって注目されるところである。

3－5　インタラクティブ教育（とくにビデオ教材を主としての）における課題

ビデオを中心とした教育においては、いかなる課題が考えられるであろうか。主要な課題として、学習環境の整備、ソフトの開発を重点的に取り上げてみたい。

(1)　学習環境の設備

集合教育での学習環境に関しては、教室における遮光性・静粛性あるいは映像機器・音響機器の適切な配置、画面の大きさ・高さ・見やすさ等に配慮が必要であることは言うまでもない。しかし学習環境の整備が、とりわけ重要なのは、自己学習においてである。自己学習における好環境づくりについて、以下の諸点が特に望まれよう。

（ａ）随時随所学習効果のために、映像機器のコンパクト化および可搬性（現在ハード的には可能になっている）しかもコンピュータとの融合活用も含めてコンパクト化・一体化が望まれる。

（ｂ）活用できるソフトが現在少ない。多くは教室対応型である。多様なテーマの、しかも廉価なソフトが、手軽に入手出来るようでありたい。ソフトのコンパクト化の点からもテープよりもディスクがよい。

（ｃ）入手しやすさ、ニーズに適するソフトの選択しやすさの点で、いわば＜ビデオ図書館・ビデオ司書＞が必要となろう。さらにはソフトを購入しなくともコンピュータ通信でソフトを検索・受信できるシステムの確立が望まれる。

(2)　ソフトの開発

ビデオソフト開発は、日本においてもますます熱心に取り組まれている。工夫がこらされているソフトが多くなっている。しかし情報処理分野においては、全般的指向と比較するとまだまだ努力の余地が大きいと考えられる。特に映像が効果を発揮しうるコミュニケーション分野におけるテーマがもっと多くなってよい。情報処理技術に関する情報解説型ビデオが多いのが現状。以下に、今後のソフト開発における、特に望まれる諸点をあげたい。

（ａ）ソフトの多くは、必ずしも教育ニーズ調査に基づいているとは限らない。研修企画担当者の要望を取り入れての制作主導型でソフトが作成されている場合が多く見られる。したがって、研修企画担当者の満足度は高くとも学習者の評価は低い結果となることが実際に多い。教室活用型の場合は、インストラクタのフォローにより不十分な点を補うことが可能であるが、自己学習用においては、制作的には様々な工夫が凝らされてはいても、学習効果が少ないであろうと感じさせるソフトが結構多い。教育ニーズ調査は単に制作上の参考になるばかりでなく、制作されたソフトに対する参画意識が高まり、ソフト活用の動機づけにつながる。はじめにニーズありき、を原則としたソフト開発が大切であろう。

（b）今後の効果的映像の制作は、各種専門家の相互補完協力によってなされよう。調査の専門家による現場面接および調査結果の適切な分析、研修企画担当者による研修ニーズの整理および教育的強調点の明確化、教育専門家による教育効果のデザイン、映像化の専門家による効果的映像のデザイン、制作の専門家による学習者の視線からの撮影、音響・カラー専門家の協力、さらにコンピュータのハード・ソフト専門家による操作性の検討、・・・関連専門家集団のプロジェクトによるビデオソフトの開発が期待される。

（c）効果的なビデオソフト開発にあたって重要なことは、決して関連機器の技術・価格の問題ではなく、むしろ関連専門家間のプロジェクトの問題であろう。専門家同士が相互の持てる専門性を発揮しつつ、同時にその枠を越えて協力の価値ある成果物を生み出すための習慣を確立する必要があろう。異質を統合する感覚および統合的議論、そして自己の専門的クオリティ（品質）よりも学習者にとってのヴァリュー（価値）を優先させる、いわばマーケティング・マインドが要求されることになるだろう。

3－6　迫られる教育パラダイムの転換

「根本的に異なる教育理論は二つ、そしてたった二つしか存在しない。一つの理論は、教育とは長い期間を通じて人間が蓄積してきた重要な事実を手短かに概観すべきと考えている。もう一つの他の方法は、およそ教育とは日々変遷する周囲の情勢下に生み出される、新しい条件に対処するための諸問題に、個人個人の学習者がその行動において主体的に取り組むことが出来るような態勢を養う訓練の機会を提供するようなものでなければならない、と考えている。どうすれば人間は知識を得るように教育され得るかではなく、どうすれば状況に対して最適な行動をし得るようになるかが問題なのである・・・」ハーバード・ビジネススクールのまだ初期の時代、デューイング教授（A.S.Dewing）の言葉であるが、情報処理技術者教育において、基礎的な知識・技術に関して、＜長い期間を通じて人間が蓄積してきた重要な事実を手短かに概観すべき＞とする教育が、当然必要な教育であることは言うまでもないが、中心に行われ、ややもすると、その必要性は認めつつも＜日々変遷する周囲の情勢下に生み出される新しい条件に対処するための諸問題に、個人個人の学習者がその行動において主体的に取り組むことが出来るような態勢を養う訓練の機会を提供する＞ことが不十分であったとの反省は大方の教育関係者が感じているところであろう。

また、シャノン（C.E.Shannon）に代表されるメディアに関する工学的立場からのコミュニケーションモデル（1948）、すなわち正確かつ迅速な情報伝達という工学的制御の立場を軸とした枠組みの教育への反映と、他方において教育学側からの「発見学習」（discovery learning）の提起とは対比的である。ブルーナー（J.S.Bruner）によれば、「発見学習」の要点は、問題開発能力および問題開発態度の育成、外発的動機づけから内発的動機づけへの移行、発見の仕方の学習、さらに自分の環境を探索する方法の学習、環境の中で与えられた情報を越えて進む方法の学習であり、またウィットロック（M.C.Wittrock）によるならば、科学的な態度をもって行動し、機能的な様式で思考する仕方を学ぶことである。

情報処理技術者教育において、基礎的知識・技術に関しての情報伝達型の教育は必要であるが、今後ますます問題を発見・開発する能力および問題を発見・開発する態度の育成、外発的動機づけから内発的動機づけへの移行、発見の仕方の学習、さらに自分の環境を探索し改革する方法の学習、環境の中で与えられた情報を越えて進む方法の学習が大切であり、科学的な態度をもって行動し、機能的な様式で思考する仕方を学ぶことが大いに期待されていると言えよう。その期待に応えた教育を充実させるためにも、教育観の転換は重要であると考える。ビデオの活用も教育観の変換を伴ってはじめて効果をあげ得るのではなかろうか。

第4章　関 連 資 料

わが国の情報処理教育における課題

4 − 1　関連資料１(入手資料)

資料	資　　　料　　　名
1	スタンフォード大学教育大学院 Using Computers to Communicate : Connection Alternatives for Data Communication at Stanford , (Stanford University, AIR) August 1989
2	スタンフォード大学コンピュータセンター ①Computer Instruction Facilities　(AIR)　October 1989 ②Guidelines For Choosing A Microcomputer　(AIR) September 1987 ③Academic Data Service − Users' Guide　(AIR) January 1989 ④Off-Campus Computer Networks　February 1989 ⑤About Computing At Stanford(A guide For Faculty & Students) (Stanford University, AIR) September 1989
3	アプライド・ラーニング社 ①Applied Learning , Performance Through People　July 1989 ②Applied Learning International, Meeting the Performance Challenge
4	マサチューセッツ工科大学メディア・ラボ（アテナ・プロジェクト） ①A Second Wind for ATHENA ,The Experiment Scheduled to Finish in 1988 is in Some Ways Just Beginning , by SIMSON L. Garfinkel 1987 ②Project Athena As A Distributed System, by George A. Champine, DEC April 27, 1989 ③The Athena Service Management System , Mark A. Rosenstein, 1988 ④Project ATHENA ,　Visual Computing Group , September 1988 ⑤ A Construction Set for Multimedia Applications, IEEE Software 89 ⑥The MIT Report , Dec/Jan 1989-90 ,Volume 17 Number 10
5	マサチューセッツ工科大学メディア・ラボ（インタラクティブ・ビデオ） ①Videodiscs and Education : Four Views , Carol Strohecker, June 1989 ②A Sampler of Multimedia Applications , Carol Strohecker ③Prospectives , Carol Strohecker , Media Laborotory MIT ④ATHENA MUSE : Hypermedia in Action , by David R. Lampe, MIT Report
6	ハーバード大学教育大学院 Multimedia What The excitement's All About, by Robert McCARTHY , Electronic Learning・June1989
7	インリア NEWS LETTER No.2 , October 1989 (INRIA・GMD・CWI)

Using Computers to Communicate:

Connection Alternatives for Data Communication at Stanford

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Academic Information Resources
A division of Information Resources

Stanford University

Additional copies may be obtained from AIR, Third Floor, Sweet Hall, 723-1055

Using Computers to Communicate:

Connection Alternatives for Data Communication at Stanford

Table of Contents

1. Introduction

As a member of the Stanford community, you probably have used a computer as part of your work or study, whether it be for preparing a paper, completing a homework assignment, or exchanging ideas with a colleague. Using a computer often involves communicating—that is, sharing information—among computers. For example, you could use a microcomputer to search the electronic library card catalog on another computer on campus or send the latest chapter of your book to your colleague's computer.

At Stanford, computer users can take advantage of a variety of communication facilities and services. Just finding out about the available services may involve considering many alternatives and mastering technical jargon. Once you choose the services you need, you must select the necessary equipment and software and then learn to use them. This document should make the process easier.

About This Document

Using Computers to Communicate summarizes computer communications at Stanford. It includes examples of why you might want to communicate, describes the communication alternatives and the communication services available at Stanford, summarizes the equipment and software you need, and provides references for obtaining more information and assistance. A glossary includes definitions of technical terms.

This document is intended for members of the Stanford community who want general information about computer communication on campus, as well as for those who must make decisions about connecting computers for communication. Part of a series called *Connection Alternatives for Data Communication at Stanford,* this document offers an overview of communication alternatives. Each of the other documents in the series focuses on alternatives for a specific computer or on a specific aspect of computer communication (e.g., off-campus computer networks). See the section *Other Documentation* on page 14 for a list of these documents.

Using Computers to Communicate was prepared by Academic Information Resources in cooperation with Networking and Communication Systems. (Both groups are part of Information Resources, the campus computing organization.)

Why Use a Computer to Communicate?

Communicating via a computer offers a fast, reliable way to exchange information. Sending letters or other documents via U.S. or inter-office mail is often too slow. Telephoning can cause delays (the person you are trying to contact may not be available), and it can be expensive when it is long distance. Hand delivery also can be expensive and it is not always an option. A single message sent from a computer can reach many people, at their convenience.

Computer communication may not always be preferable to other forms of communication, but it is a natural extension to your work with computers, and it does offer the following advantages.

Provides Access to Information: Communicating via a computer provides access to information that otherwise may not be easily accessible. Examples include finding reference material by searching Socrates, Stanford's library catalog; reading a bulletin board on a campus computer for information about an IBM PC software vendor; receiving homework assignments on your departmental computer that your students completed on an Apple Macintosh; and accessing databases of medical information using the Medical School's Lane-Medline.

Allows Resource Sharing: Computer communication allows the sharing of resources such as remote computers and printers. For example, you could send a file from a Stanford computer to be processed on the CRAY supercomputer at the San Diego Supercomputer Center and then retrieve the results. A department could put software on a computer for everyone to use from their personal computers. A student could search the library catalog from a microcomputer and print the results of that search on a departmental printer.

Enhances Collaborative Work: Those who use a computer to communicate have found that they can share work more easily with colleagues across campus and throughout the world. Such work includes preparing research proposals, participating in joint research efforts, and sharing computer programs.

2. What Are Computer Networks?

Networks make computer communication possible. A network can be small or large, that is, anything from microcomputers connected to each other in a department or a campus cluster to a multi-country system such as EARN, a European computer network. All networks provide for uniform, regular communication among their member computers, and they have rules about who can join the network and how information is transmitted.

Some Basic Networking Terms

In this document you will come across the following terminology associated with computer communication. (The *Glossary of Technical Terms* on page 19 includes these and additional definitions of computer communication terminology.)

A ***personal computer*** (as used in this document) refers to both microcomputers (e.g., IBM PC and Apple Macintosh systems) and workstations (e.g., Sun and NeXT systems). A personal computer can operate on its own, or it can access the services of other computers.

A ***host computer*** is a multi-user computer that provides services both to users logged on to it and to other computers on the network. Portia, a VAX 8800 mainframe computer operated by AIR, is a host computer.

A ***terminal*** has a keyboard and display screen like a personal computer, but it cannot run programs by itself; it is used to access the services of a host computer.

A ***workstation*** is a computer that is similar to a microcomputer, but it can do more than one thing at a time (multi-tasking) or support more than one user at a time (multi-user). Workstations can operate as a personal computer or as a host computer. Examples of workstations include the Sun-4, DEC VAXstations, and the NEXT systems.

A ***node*** is any computer on a network.

A ***gateway*** (also called a *router*) is a special-purpose computer that connects two or more parts of a network, or two different kinds of networks.

A ***local area network*** (*LAN*) is a network that operates in a limited area, such as a single building.

A ***wide area network*** (WAN) is a network that covers distances from one hundred to several thousand miles, and generally includes hundreds or thousands of nodes. Examples of wide area networks are BITNET, NSFNET, and Telenet. (See *Off-Campus Computer Networks* on page 11 for more information about wide area networks.)

A Network's Components

Following are the basic components in any network:

- the medium (e.g., cable, telephone line) that carries information between computers,
- the hardware that attaches a computer to the network,
- the communication software (also called *protocols*) that manages a computer's communication activities on the network, and
- the applications software that allows a computer user to access network facilities.

Most computer manufacturers combine the hardware that attaches a computer to the network, the communication software, and the applications software in one package called ***network architecture***. Examples of network architectures are Digital Equipment Corporation's DECnet, Apple Computer's AppleTalk, IBM's Systems Network Architecture (SNA), and Xerox Corporation's Network Services (XNS). Networks at Stanford include some elements from all these architectures, and many others as well.

3. Networks at Stanford

If you are using a computer to communicate at Stanford, you are connected via SUNet, the Stanford University Network, or via the telephone system. These networks are managed by the two divisions of Networking and Communication Systems: SUNet by Networking Systems; the telephone system by Communication Services.

SUNet, the Stanford University Network

SUNet, Stanford's campus-wide, high-speed computer and video network, connects most of the host computers on campus and many personal computers. As of May 1989, SUNet had over 2000 nodes. SUNet also has connections to several wide-area computer networks, which connect in turn to universities, corporations, and research institutions around the country and the world.

SUNet is a network that uses ***packet switching***. In a packet-switched network, all computers share a common network cable. When a computer has data to send, it bundles up the data in a "packet" that includes the address of the destination computer and sends it over the network. This simple technique allows remarkable flexibility, efficiency, and speed in communication. A packet-switched network uses complex hardware and software in each node and a simple, shared communication medium.

SUNet takes advantage of two primary technologies: the Ethernet hardware standard and the Internet Protocols communication software standard (usually called TCP/IP). Both are described in the following sections.

The Physical Structure of SUNet: Physically, SUNet is a network of networks. Local area networks within most campus buildings are connected by the SUNet Spine network to form the campus-wide SUNet network. As of May 1989, SUNet had 107 local area networks connected by 44 gateways.

Both the local area networks within buildings and the SUNet Spine network use the Ethernet networking standard. Originally developed by Xerox Corporation, the Ethernet standard specifies the type of cable to be used, the way a computer attaches to the cable, the speed of data transmission, and the signaling method and format of the data that is sent. Ethernet connections now are available for most kinds of computers. Although the nominal speed of Ethernet transmission is very fast (10 million bits per second), the actual transfer speed is limited by the speed of the communicating computers, and will usually be between 100,000 and 1 million bits per second. (One million bits per second is about 100,000 characters of text or data per second.)

The SUNet Spine network is managed by Networking Systems. It consists of Ethernet cables that connect between most campus buildings, and the gateways that connect to local area networks within buildings. See the *Appendix* on page 17 for a campus map indicating buildings with Ethernet network connections. The SUNet video network, a broadband network that mostly carries television signals around campus, is also used to a lesser extent for data transmission as part of the Spine network. Just as the SUNet Spine connects local networks on campus, regional and national networks such as BARRNET (the Bay Area Regional Research Network) and NSFNET (the National Science Foundation Network) connect SUNet to networks at other institutions.

Connecting to SUNet: To use SUNet, a Stanford department or organization must first install a local area network in its building and then attach its computers to that network. Management of a local area network is the responsibility of the department or organization that uses it. If multiple groups share a building, they usually share the costs and management of its local area network as well. For more information about obtaining a SUNet connection, contact Networking Systems at 723-3909.

SUNet Protocols: Protocols are a set of rules incorporated in a software program that govern how information is exchanged over a network. Computers must use the same protocols to communicate, just as people must speak the same language to understand each other. The standard chosen for SUNet is a series of protocols known as TCP/IP or Transmission Control Protocol/Internet Procotol. TCP/IP was originally developed for the Department of Defense's nationwide network, ARPANET. One of the most widely-used series of protocols in university and research networking, TCP/IP has been implemented on most hosts connected to SUNet.

TCP/IP allows the interconnection of Stanford local area networks, SUNet, regional networks such as BARRNET, the nationwide NSFNET, and the worldwide Internet. Users can issue the same commands to connect across the country as they would to connect across the building.

TCP/IP defines a standard network interface. It allows programmers who prepare communication software for individual host computers to tailor the user interface to the local system's conventions. Almost all TCP/IP hosts implement two standard user protocols:

- Telnet, a basic remote login protocol and
- FTP, or File Transfer Protocol.

SUNet host computers use communication software based on these protocols to provide communication services. (See the section *Computer Communication Services at Stanford* on page 5 for more information.)

Other Protocols: Protocols other than TCP/IP can be used between computers on the same local area network. DECnet, XNS, and AppleTalk protocols are all commonly used on campus. It is not unusual for a computer to use multiple protocols. For example, a Digital Equipment Corporation VAX computer might use both the DECnet and TCP/IP protocols. An Apple Macintosh might use both AppleTalk and TCP/IP.

The Telephone System

Stanford's telephone system includes a twisted-pair cable system that connects to most buildings on campus, a Northern Telecom SL-100 central switching system for ordinary telephone communication, and a Gandalf data switch for terminal-oriented computer communication. Since the telephone system is a terminal-oriented network, it provides a slower, simpler connection than SUNet, and it does not use protocol software such as TCP/IP.

In a ***terminal-oriented*** network (also called a point-to-point network), each node—which can be a computer or a terminal—is connected to a large central switching system. A connection can be made to only one other computer at a time, so transmission speed is slower than it is on a packet-switched network. A terminal-oriented network has much simpler hardware and software in each node than a packet-switched network, but it uses a complex communication medium and switching system.

Stanford's telephone system supports communication via a computer in one of two ways: using a modem on a standard telephone voice line or using a circuit to the Gandalf data switch. Both are described below. For more information on ordering a voice line for a modem connection or a Gandalf connection, contact Communication Services at 725-HELP.

Connecting via a Modem: A modem is a device that connects to a computer or a terminal and acts as a translator. It converts data from the computer or terminal into tones that can be transmitted over telephone lines. A dial-up modem provides a low speed connection to the Stanford computer networks from an on-campus location not connected to SUNet or from an off-campus location (e.g., your home). Information transmitted via a modem travels at speeds ranging from 300 to 2400 bits per second (about 30 to 240 characters per second). Note that if both your telephone and modem are connected on the same phone line, you cannot use the phone and a modem simultaneously.

Connecting via the Gandalf Data Switch: The Gandalf data switch allows a personal computer or terminal located on campus to connect to Stanford's computer networks. Terminals—or personal computers acting as terminals—connect to the Gandalf data switch via a special-purpose circuit called a *Gandalf line*. This connection is more reliable and faster than a connection via a modem. Generally, the Gandalf connects terminals to Forsythe, the Stanford Data Center's IBM 3090 mainframe computer. Although a Gandalf connection is slower than a SUNet connection, it also connects terminals to other campus host computers. Information transmitted via the Gandalf travels at up to 9600 bits per second (960 characters per second).

4. Computer Communication Services at Stanford

Once your computer is connected to a network, you have access to the services that allow you to communicate. For example, electronic mail allows you to communicate with a colleague across campus; file transfer allows you to transfer a text file you created on your microcomputer for storage on your departmental computer.

This section includes descriptions of the most common communication services at Stanford; they can be used on most host computers (e.g., AIR's Portia, the Stanford Data Center's Forsythe), as well as on most personal computers. Each descripton includes an overview of the service, examples of how you might use it, and the required software. (The section *For More Information and Assistance* on page 12 lists those you can contact about acquiring or using the software.)

The SU-PC/IP and the SU-Mac/IP communication software mentioned in the following descriptions of communication services was developed at Stanford for use on IBM Personal Computer and Apple Macintosh systems, respectively. Each is available with documentation for $10 from Networking Systems, 323-3909. (SU-PC/IP stands for the Stanford University Personal Computer/Internet Protocol and SU-Mac/IP stands for Stanford University Macintosh/Internet Protocol.)

Electronic Mail

The most commonly-used and widely-connected service, electronic mail (also called e-mail) allows you to send and receive messages between computers on campus, across the nation, and around the world. Using electronic mail can replace some of your paper memos or telephone calls, and it allows you to keep copies of the messages you send and receive.

You may use electronic mail to keep in touch with a colleague on the East Coast, to check with another department about an upcoming meeting, or to ask a computer consulting group about a problem you are having with your microcomputer. Electronic mail also offers access to mailing lists that provide useful information on a specific topic. (For example, you may put your name on a supercomputer mailing list so you can receive campus supercomputing news).

When you send an electronic mail message to someone, you do so by using software called a mail program. It helps you compose your message, address it, send it through the electronic mail system, and deposit it in the electronic mailbox of your correspondent. Following is a list of the most commonly-used electronic mail programs at Stanford.

CMS Mail is on IBM 4300 series computers using the VM/CMS Operating System, for example, CDRVMA and Watson.

Contact EMS is on Forsythe, the Data Center's IBM 3090 computer using the MVS Operating System.

MH (Mail Handler) can be used on Apple Macintosh and IBM Personal Computer systems. It is available with SU-Mac/IP software (Version 3.0 and all later versions) and with SU-PC/IP software for IBM PC, XT, AT, and PS/2 systems (Version 3.0 and all later versions).

MM is on DEC-20 computers using the TOPS-20 operating system, for example, CSLI, GSB HOW and WHY, Macbeth, SCORE, Sumex-Aim, Sierra.

UNIX MAIL and **MH** are on computers using the UNIX operating system, for example, Ararat, Polya, Portia, and Sun workstations.

WYLBUR Mail is on Forsythe, the Data Center's IBM 3090 computer using the MVS Operating System.

VMS Mail is on DEC VAX computers using the VMS Operating System, for example, GSB-WHAT, Star, and DEC VAXstations.

Remote Login

This service allows remote login to on- and off-campus computers through the Stanford computer networks. Remote login means that from one computer you can initiate login to another computer. In most cases, you must have an account on the remote computer you want to access.

Once you log in, you can use the services on that computer. For example, you may log in to AIR's Portia from your microcomputer to complete a homework assignment. Perhaps you have already logged in to a Stanford computer such as Watson and want to log in to the CRAY at the San Diego Supercomputer Center to access its supercomputing facilities. Or, you may want to use your microcomputer to log in to your departmental computer and read your electronic mail.

Two types of software provide remote login: Telnet and terminal emulation software. Both allow a personal computer to emulate or "act like" a terminal (e.g., a DEC VT100) that is appropriate for the computer you want to access.

Telnet provides remote login access across SUNet and other TCP/IP networks. It is available on most host computers connected to SUNet (e.g., Portia, a VAX 8800; Watson, an IBM 4381), and it is part of both SU-PC/IP and SU-Mac/IP.

Terminal emulation software enables a personal computer to connect to a host computer using a terminal-oriented connection through the personal computer's serial port. Examples of terminal emulation software used at Stanford are: Kermit for IBM Personal Computer and Apple Macintosh systems, and Sun workstations; Red Ryder for Apple Macintosh systems; and Samson for microcomputers connecting to Forsythe, the Stanford Data Center's IBM 3090.

File Transfer

This commonly-used communication service allows you to transfer text or data files between your local computer (e.g., your microcomputer or your departmental computer) and remote on- and off-campus host computers. In most cases, you must have an account on the remote host. *Anonymous* or *guest* connections are sometimes available on host computers to allow those without accounts to access or transfer public files.

File transfer allows you to accomplish tasks such as transferring a text file created on your microcomputer for storage on your departmental computer, incorporating the results of a computation on a host computer into a document created on your microcomputer, or preparing data on your departmental computer and sending it to a supercomputer for processing.

Two types of software provide file transfer: FTP (file transfer protocol) and terminal emulation software. Both allow a personal computer to emulate or "act like" a terminal that is appropriate for the remote computer you want to access.

FTP, which makes use of the TCP/IP protocol for error-free file transmission, is on most host computers connected to SUNet (e.g., Portia, a VAX 8800; Watson, an IBM 4381); it is also part of SU-PC/IP and of SU-Mac/IP.

Terminal emulation software provides file transfer by enabling a personal computer to behave like a computer terminal connected to a host computer. Examples of terminal emulation software used at Stanford are: MacTerminal and Red Ryder for Apple Macintosh computers, Kermit for IBM Personal Computers and Sun workstations, and Samson for those with microcomputers who want access to Forsythe, the Stanford Data Center's IBM 3090.

Note that special software programs called *file transfer protocols* are required to ensure error-free transmission of files. The file transfer protocol must be available on both of the computers involved in a file transfer. MacTerminal and Red Ryder support the Xmodem file transfer protocol. X-Modem is on most UNIX and TOPS-20 host computers (e.g., Portia, Macbeth). Kermit supports a file transfer protocol, also called Kermit, that is the most widely available file transfer protocol for use with IBM Personal Computers. MacKermit and Red Ryder include Kermit support for Macintosh systems. The Kermit file transfer protocol is also supported by most UNIX, TOPS-20 and VM/CMS hosts.

Network Directory Information

Once computer networks span an entire campus, it becomes useful to provide a directory that includes the names, electronic mail addresses, and locations of the network computers and those who are using them. At Stanford, the directory is Whois. Managed and updated by Networking and Communication Systems, Whois is an online version of the campus telephone directories (faculty, staff, and student). It includes a person's electronic mail address, department, position at Stanford, and campus and home addresses and phone numbers. In addition, Whois includes the location, owner (campus department), and operating system for each host computer connected to SUNet.

Another service, Finger, allows you to access information about a user of a specific host computer. To use Finger, you must know the electronic mail address of the person about whom you are requesting information. The information Finger provides varies depending on the host computer, but generally it includes a person's electronic mail address, when that person last logged on to the host computer, and when that person last read his or her electronic mail. Anyone represented in a Finger database can usually insert a "plan" that includes information such as the hours the person can be reached or his/her field of interest.

Whois and Finger are on many of the campus host computers such as Portia, Macbeth, and Forsythe. They are also part of both SU-PC/IP and SU-Mac/IP.

File and Print Services

Currently, file and print services at Stanford are available through public and residential computer clusters, or through departments or organizations within a particular building. File service allows one computer (usually a microcomputer or workstation) to use the disk space on another computer (usually a larger workstation or mainframe computer) as though the disk were directly attached to the smaller machine. Users of the service can store files on that disk, access software stored on it, and share documents between computers.

Print service allows many computers on a network to share a printer. Users of this service can send files from their personal computer for printing on a printer attached to their network. Often, a larger computer acts as both a file and a print server for a cluster of personal computers.

The Network File System (NFS), developed by Sun Microsystems, is a TCP/IP-based file service that is used by many UNIX hosts and IBM PC systems at Stanford. 3Com's 3Plus system is used to provide file and print service to IBM PC systems in many Stanford departments. Apple's AppleShare provides file service for Apple Macintosh computers.

Bulletin Boards

Electronic bulletin boards (also called *bboards)* offer a convenient way for you to communicate with others—across campus or across the country—who share your interests. You can use bulletin boards to post or obtain information about almost any subject you could imagine.

A wide variety of bulletin boards are available via Stanford's computer networks. Currently, you must login to a host computer to access bboards, although direct personal computer access is under development. Following are descriptions of two popular bboard systems on campus: SU bboards and Usenet bboards.

SU Bboard System: You can access the SU bboards on many campus host computers (e.g., Macbeth, Polya, GSB-How, Sierra, Forsythe). These bulletin boards cover a variety of topics including computing, upcoming events, employment listings, and items for sale. Following is a list of some of the SU bboards and their subject areas.

SU-Computers	Comments or questions concerning computer software and services
SU-Events	Announcements of seminars, concerts, and other events on or off campus
SU-Jobs	Help wanted and offered listings
SU-Macintosh	Questions, answers, and comments about the Apple Macintosh
SU-Market	Items for sale; comments on merchants and services
SU-Etc	Notices not appropriate for the other SU bulletin boards

Usenet Bboard System: Usenet is a worldwide computer network for UNIX systems. Its bboard system is available through Stanford UNIX systems such as Portia. Through Usenet you can access some 600 bboards (also called *newsgroups* on UNIX systems), which cover a wide variety of information. For example, the **comp** topic area covers discussions related to computer issues. Examples of bboards under the **comp** area are: **comp.sys.sun** and **comp.unix.ultrix**. These bboards are related to discussions of Sun workstations and the Ultrix operating system, respectively. Note that it is possible to access the SU bboard system through the **su** topic area.

5. Communication Hardware and Software

This section summarizes the hardware and software required for computer communication at Stanford. It describes the two ways to connect for computer communication at Stanford—via a local area network or via a terminal connection—and the hardware and software required in each instance.

If you have a personal computer or a larger host computer, you can attach it to a local area network in your building. This allows you to take advantage of local area network services such as file and print service, and to use the more widespread SUNet services such as remote login, file transfer, and electronic mail.

If you are using a terminal or you do not have a local area network in your building, then a terminal-oriented connection is your only choice. The lower speed and lack of software protocols to support sophisticated communication make this type of connection less flexible.

The section *Other Documentation* on page 14 lists the documents in the *Connection Alternatives for Data Communication at Stanford* series that provide more detailed information (including installation and purchase costs) about these alternatives.

Connecting to a Local Area Network

At Stanford, there are two kinds of local area networks: Ethernet and LocalTalk. While Ethernet is faster, LocalTalk is less expensive.

Ethernet: Ethernet is a local area network cabling system and signaling method, which operates at 10 million bits per second. Any computer connecting to an Ethernet needs special hardware components and Ethernet cables. You must install an Ethernet adapter in an IBM PC system or in a Macintosh II or Macintosh SE system. Most workstations and larger computers have Ethernet adapters as standard components.

There are two common types of Ethernet cabling: thin and standard. If you are using thin Ethernet cabling, make sure the Ethernet adapter in your computer is thin-Ethernet-compatible (as are those for all IBM PC and Apple Macintosh systems and many workstations). Then attach the cable to the Ethernet adapter. If you are using standard Ethernet cabling, you need a transceiver and a transceiver cable. Attach the transceiver to the Ethernet cable and use the transceiver cable to connect the transceiver and the Ethernet adapter.

To connect an Ethernet network to SUNet, you extend the cabling of the network to the nearest SUNet connection. (Most buildings on campus have SUNet connections).

LocalTalk: LocalTalk is an inexpensive local area network cabling system and signaling method designed by Apple Computer for Macintosh computers. It operates at 230,000 bits per second. All Apple Macintosh systems and LaserWriter printers include a LocalTalk interface. If you install a LocalTalk interface board in an IBM PC, you can connect it to a LocalTalk network.

To implement a LocalTalk-type network, Networking and Communication Systems recommends using PhoneNET, a LocalTalk-compatible cabling scheme from Farallon Computing. PhoneNET operates at the same speed as LocalTalk, and it enables you to create a network using existing telephone wire. You do not always have to install new cable, as you do when using Apple's LocalTalk product.

To connect a LocalTalk-compatible network to SUNet, you use a FastPath gateway from Kinetics, Inc. This device has one connection on a LocalTalk and one connection on SUNet, and it passes information between the two.

Software for Ethernet or LocalTalk: To communicate over an Ethernet or LocalTalk network, your computer needs TCP/IP protocol software and the applications that make use of the protocols, such as mail, file transfer, and remote login. With IBM PC and Apple Macintosh systems, you can use SU-PC/IP and SU-Mac/IP. These programs provide Telnet (remote login), FTP (file transfer), mail, and directory service. TCP/IP protocols and applications are standard with UNIX systems, and are available for most other computers and operating systems.

Terminal Connections

At Stanford, you use a terminal connection to computer networks if you are using a traditional terminal. A ***terminal*** has a keyboard and display like a personal computer but it cannot run programs by itself; it is used to access the services of a host computer. You can also use a terminal connection for a personal computer that you want to use as a terminal. Following are the types of terminal connections that are possible at Stanford.

Connecting to a Local Host: If you have a host computer in your department or building, you can connect a terminal by running your own cable from the terminal to the host. Communication Services charges for cabling on a time and materials basis. For more information, contact Communication Services at 725-HELP.

Connecting to a TIP: If you have a TIP in your department or building, you can arrange to connect a terminal to it by contacting your department administrator about installing a circuit to connect to the TIP. A ***TIP*** (Terminal Interface Processor) is a specialized device that allows terminals connected to it to log in to host computers on the network.

Connecting to the Gandalf Data Switch: You usually connect a terminal to the Gandalf data switch to access Forsythe, the Stanford Data Center's IBM mainframe computer. You can also connect to other SUNet host computers through a Gandalf connection. Contact Communication Services at 725-HELP for information about ordering a Gandalf data switch connection.

Using a Modem: You can purchase a modem for use with your terminal or personal computer. After connecting the modem to your computer and to the telephone line in your office, dormitory, or home, you can use it to connect to campus host computers that are equipped to receive modem communication. (Most campus host computers have this capability.)

Software for Terminal Connections: If you have a terminal, you don't need additional software for computer communication. But if you want a personal computer to act as a terminal, you need terminal-emulation software. A wide variety of software exists, including Kermit for the IBM PC systems and Sun workstations and MacTerminal, Red Ryder or MacKermit for Apple Macintosh systems. Those with IBM PC and Apple Macintosh systems who want to access Forsythe should use Samson, terminal-emulation software produced by the Stanford Data Center.

6. Off-Campus Computer Networks

By connecting your computer or local area network to SUNet, you gain access to a great number of computers on campus and to computers on other wide area networks—large off-campus networks with hundreds or thousands of host computers. This section provides summary information about the kinds of off-campus computer networks that are accessible to computers connected to SUNet.

The document *Off-Campus Computer Networks* provides more detailed information, including a list of the off-campus networks accessible to SUNet computers. The list includes general information about each network and its administration, the services it provides, and any costs or restrictions involved in its use. Copies of this document are available in the AIR document racks on the third floor of Sweet Hall.

Off-campus networks are categorized in terms of their administration and intended purpose.

- **Research networks** are designed to facilitate research in various fields. Often research networks are supported by the government and are centrally administered. Examples of such networks are: BARRNET, CSNET, and NSFNET.

- **Cooperative networks** are made up of various institutions that often bear the cost of administering the network. Examples of such networks are: BITNET, EARN, and Usenet.

- **Company networks** are administered and funded by commercial organizations such as IBM, for internal use.

- **Public networks** are commercial enterprises that provide computer connections and on-line services to paying customers; they are operated by communication companies. Some private networks buy services from public network suppliers. Examples of public networks are: Telenet, Tymnet, and Datapac (Canada).

SUNet has active connections to the BARRNET and NSFNET research networks, and to the BITNET and Usenet cooperative networks.

7. For More Information and Assistance

The material in this document should help you define your communication needs and determine the equipment and software you must have to use your computer for communication. This section describes additional sources of information and assistance; it also references other documentation about computer communication.

On-Campus Sources

Various sources on campus offer the information and assistance you may need when learning about and using your computer for communication.

Local Experts: Often a *local expert* in an area such as a department, office, or computer cluster on campus serves as a source of computing help and information for others using computers in that area. The local expert may be someone who just has an interest in computing, not necessarily someone hired in a computing capacity. On the other hand, some schools or departments on campus provide a full-time consulting staff (e.g., the Graduate School of Business, the Medical School).

Contacting your local expert about your computing communication needs and any related problems can save time and effort. That person has computing knowledge and information unique to your area.

In addition, each campus department or office with a local area network should have a ***local network administrator*** who works with Network Systems to provide network planning, information, installation, and troubleshooting for their group.

Expert Partners Program: If your local expert is also participating in the Expert Partners Program offered by Information Resources (IR), he or she has special access to IR computing resources and training and can often provide the information and assistance you need more quickly than if you pursued other consulting resources on campus. Local experts in your area who may be interested in participating in the Expert Partners Program can contact David Lumadue of the Stanford Data Center at 5-1422, ge.wiz@forsythe or Tom Goodrich of AIR at 4-4747, ephelp@jessica.

Academic Information Resources (AIR): This group offers faculty, students, and staff a broad range of free technical advice and consulting about academic computing applications at Stanford. This includes information on microcomputers, workstations, on-campus mainframe computers, and supercomputing. AIR consultants can provide:

- assistance in selecting a computer or software,
- assistance in solving problems with a computer or a program you are using, and
- advice about using your computer in the Stanford academic environment and with other computing systems at Stanford.

Consultants are available on a scheduled basis to help you with brief computing questions; more complex or lengthy questions are handled by an appropriate specialist. You can also send computing questions to AIR consultants via computer, using the electronic mail address consult@air. For more information about AIR consulting services, contact AIR at 723-1055.

If you have a computing question, but are not sure where to go for an answer, begin with the consultants in Sweet Hall. They are available Monday through Friday, 9:00 a.m. to 5:00 p.m. to address general and specific computing questions.

To assist you with using AIR computers (mainframes, workstations, and microcomputers), student consultants are available in Sweet Hall, 723-0325 and in the AIR Tresidder Union Macintosh Cluster, 723-1315. These consultants handle questions regarding AIR introductory classes; accounts for the AIR mainframes and workstations; and sponsorships for disk space and additional computer resource allocations. They also support faculty and teaching assistants using the AIR computer systems for Stanford courses.

If you are a UNIX system manager or developer at Stanford you may want to take advantage of the services provided by an AIR initiative, SPUDS (the Stanford Program for UNIX Development and Support). SPUDS provides development, licensing, and support for widely-used versions of UNIX. This includes advising UNIX system managers on network procedures and problems. For more information, see the SPUDS flier in the document racks on the third floor of Sweet Hall or contact Liz Hayes, 723-5754 (ehayes@jessica) or Felix Limcaoco, 723-4942 (flk@jessica).

Networking Systems: Stanford departments and offices who are planning and installing computer network connections can contact Networking Systems for assistance. Consultants in Networking Systems work in cooperation with consultants at AIR and the Stanford Data Center to offer such services as preparing bid packages, coordinating equipment orders, and overseeing cabling contractors' work. Consulting is available by appointment. There is no charge to academic departments for these services, except for very large or extended network projects. For more information, call Networking Systems at 723-3909.

Networking Systems also provides copies of SU-Mac/IP and SU-PC/IP, Stanford-developed communication software for the Apple Macintosh and IBM PC systems, respectively. Each program costs $10 and comes with an administrator's manual and a user's manual.

Communication Services: This organization can provide dedicated data connections to the Gandalf data switch, specially conditioned telephone lines for use with modems, and point-to-point circuits for local area networks. Communication Services can also provide estimates and installation management for specialized data cabling projects. Any Stanford department's authorized telecommunications representative (known as a STAR) can request these services with the Communication Service Order (CSO) form. Trouble reports can be made twenty-four hours a day, seven days a week to the Systems Control Center at 723-1611. For consulting and information, call 725-HELP.

Stanford Data Center: The Stanford Data Center provides consulting advice about the software and services on its IBM 3090 mainframe computer (Forsythe), as well as the administrative applications of computers. These services are available to members of the Stanford community who use Forsythe or who work in administrative departments. Walk-in consulting hours are from 10:00 a.m. to noon and 2:00 p.m. to 4:00 p.m., Monday through Friday, at the Consulting Office in Forsythe Hall. Phone consulting (723-2046) is also offered during these days and times, although it begins at 9:00 a.m. You can use the CONSULT command on Forsythe for on-line questions.

You can get free copies of Samson, the Stanford Data Center's communication software for IBM PC and Apple Macintosh systems in exchange for a blank diskette at the Forsythe Hall Information Desk.

Other Documentation

The following documentation provides more information about computer communications at Stanford. Copies of the documents are available in the AIR document racks on the third floor of Sweet Hall or from Networking Systems at 723-3909.

Note that *Using Computers to Communicate* is part of the series of documents, *Connection Alternatives for Data Communication at Stanford,* which describe computer communication alternatives at Stanford. The other documents in the series are preceded by an asterisk in the following list. A summary of the information in these indicated documents is included in the section *Communication Hardware and Software* on page 9.

A Quick Guide to Electronic Mail. September 1988, 2 pp. Describes how to use electronic mail to correspond with off-campus colleagues. Available from AIR.

Acquiring a Local Network at Stanford. November 1985, 14 pp. Steps involved in local network acquisition as illustrated by three case studies. Available from Networking Systems.

***Apple Macintosh Computers—Connection Alternatives for Data Communication at Stanford.** March 1989, 21 pp. Provides IR recommendations for the hardware and software needed to use an Apple Macintosh computer to communicate at Stanford. Available from AIR and Networking Systems.

Catalogue of Networking Materials: Documents, Video Tapes, and Software. March 1989, 8 pp. A bibliography of materials distributed by Networking Systems and of documents distributed by AIR as part of their program for UNIX development and support. Available from Networking Systems and AIR.

Electronic Mail Across SUNet. Revised February 1989, 9 pp. A brief summary of the electronic mail systems accessible via SUNet. Available from AIR and Networking Systems.

***IBM Personal Computers—Connection Alternatives for Data Communication at Stanford.** March 1989, 16 pp. Provides IR recommendations for the hardware and software needed to use an IBM Personal Computer to communicate at Stanford. Available from AIR and Networking Systems.

***Local Area Networks (LANs) Compatible with SUNet—Connection Alternatives for Data Communication at Stanford.** In progress.

***Off-Campus Computer Networks.** February 1989, 9 pp. Summary of external networks accessible to campus computers connected to SUNet. Available from AIR and Networking Systems.

Stanford University—Macintosh/Internet Protocol (SU-Mac/IP), Version 3.0 with the Macintosh Mail Handler (Mac/MH) Version 1.0, User's Manual, September 1988, 111 pp. and **Administrator's Manual,** 64 pp. Manuals for SU-Mac/IP users and local network administrators inside and outside Stanford. One paper copy of each manual is included in SU-Mac/IP software package; additional copies of the manuals cost $2 each. Available from Networking Systems only.

Stanford University—Personal Computer/Internet Protocol (SU-PC/IP), Version 3.1: A Communication Program for IBM Personal Computers, May 1989, 101 pp., **Administrators Manual,** May 1989, 40 pp., and **Quick Reference Guide,** May 1989, 2 pp. Manuals and a reference card for SU-PC/IP users and local network administrators inside and outside Stanford. One paper copy of each manual and one copy of the reference card are included in the SU-PC/IP software package; additional copies of the manuals cost $2 each. Available from Networking Systems only.

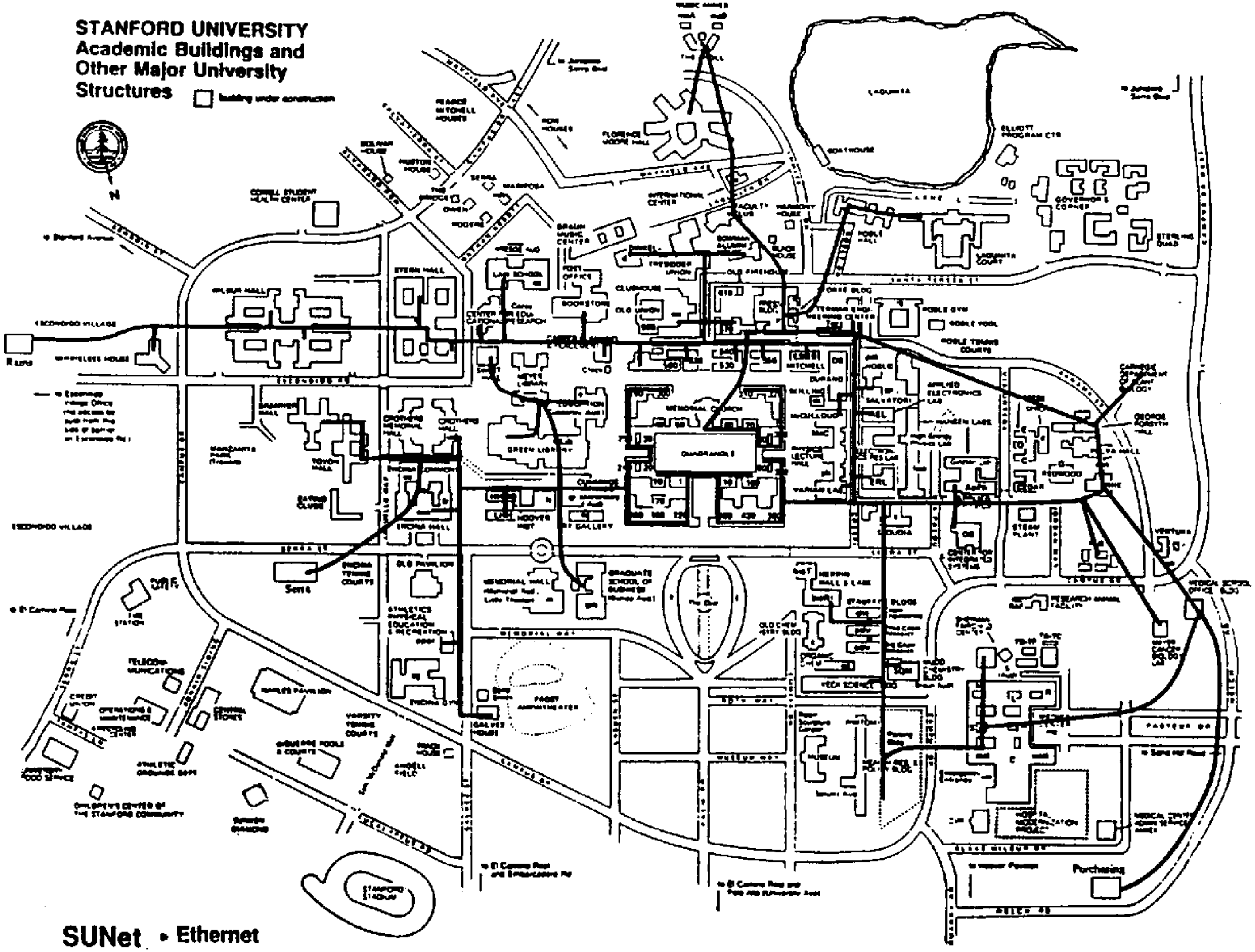
***Terminals and Terminal Emulation—Connection Alternatives for Data Communication at Stanford.** In progress.

The SUNet Connection—Brochure. Revised September 1988. A brochure explaining what SUNet is, the services it offers, who provides SUNet connections, what SUNet services are available from Networking Systems, what costs are involved, and how to get more information. Available from AIR and Networking Systems.

Using Electronic Mail: the mm Program. April 1989, 22 pp. An overview of how to use the mm program on Hamlet and Macbeth, TOPS-20 systems operated by AIR.

Where to Find Help with Networking at Stanford. Revised March 1989, 2 pp. A summary of sources of help for users of Stanford's data, video, and voice communication systems. Available from AIR and Networking Systems.

***Workstations and Host Computers (Mainframes and Minicomputers)—Connection Alternatives for Data Communication at Stanford.** In progress.



SUNet • Ethernet

August 1989

Glossary of Technical Terms

This glossary contains terms used both in this document and in the other documents in the series *Connection Alternatives for Data Communication at Stanford*. (See the section *Other Documentation* on page 14 for a list of the other documents in the series.)

Adapter: A printed circuit board that is inserted into a computer to add some function to it, such as networking capability. An adapter is also called a *board* or a *card*.

AppleTalk: Apple Computer's name for its network architecture. The name was formerly used for Apple's cabling system, which is now called LocalTalk. See also ***EtherTalk, LocalTalk,*** and ***Network Architecture.***

Application: A software program, such as a word processor, spreadsheet, or electronic mail program, that is actually used by a computer user, as opposed to lower-level programs that are part of the computer system itself.

ARPANET: The nationwide network established by the Advanced Research Projects Agency of the United States Department of Defense in the early 1970's to support research in computer resource sharing. The ARPANET network is part of the Internet. See also ***Internet.***

BARRNET: The Bay Area Regional Research Network is a cooperative network, using the TCP/IP protocols, that connects SUNet with Bay Area universities, corporations, and research centers. BARRNET is part of the Internet. See also ***Internet.***

Baseband: A system of cabling that allows only one signal at a time (only one channel of network traffic). Also called Ethernet, baseband systems are easy to install and support high data transmission rates. See also ***Ethernet, Broadband.***

BITNET: A worldwide network of computers in University computer centers, mostly consisting of large IBM mainframe computers. BITNET stands for Because Its Time NETwork.

Bits per second: The basic measurement for the speed of data communication. Since one character normally takes eight bits (one byte), you can calculate characters per second by dividing the bits per second rate by eight. See also ***Byte.***

BNC: The name for the type of twist-on, locking connector used with thin Ethernet coaxial cable.

Broadband: A system of cabling that supports multiple channels of network traffic. For example, an entire baseband network such as an Ethernet computer network can be carried on a single broadband channel, while video signals or other forms of data are carried on other channels. Broadband systems are more expensive to install and maintain than baseband systems. Broadband is also used for cable TV systems. See also ***Baseband.***

Bulletin board: An electronic message system that you can use to post or obtain information about a variety of subjects. A bulletin board is also called a *bboard.*

Byte: A unit of information processed by a computer that is equal to eight bits. A byte is often equivalent to one character. The letter "A," for example, can be represented by the eight binary digits 01000001. See also ***Bits per second.***

Coaxial cable: A type of communication cable used for networks and for connecting some terminals to mainframe computers. Used in most high-speed networks, coaxial cable consists of a central, insulated conductor around which is wrapped a braid or foil (sharing the same axis). This concentric design allows coaxial cables to carry high-frequency signals, and the foil or braid on the outside protects the signal from interference from outside fields. See also ***Twisted pair cable.***

Data switch: A piece of equipment that allows a terminal or a personal computer to connect to a computer network. Stanford terminals and personal computers use the Gandalf data switch to connect to the Stanford telephone system for communication among computers. See also ***Gandalf.***

DECnet: Digital Equipment Corporation's name for its network architecture. See also ***Network Architecture.***

EtherTalk: Apple Computer's name for its AppleTalk protocols when they are used on an Ethernet network. See also ***AppleTalk, Ethernet.***

Ethernet: A local area network cabling system and signaling method designed by Xerox Corporation and now supported by most computer manufacturers. Ethernet is a standard for high-speed computer networking; it operates at 10 million bits per second over distances up to 1500 feet. SUNet is made up of Ethernet networks. See also ***Baseband.***

Gandalf: The manufacturer of terminal-oriented communication equipment that supplied the data switch in use at Stanford. Gandalf also supplies the line interface devices through which terminals and personal computers on campus connect to the data switch. See also ***Data switch.***

Gateway: A special-purpose computer that connects two or more parts of a network, or two different kinds of networks. A gateway can also be called a *router*.

Hardware: Any piece of equipment in a computer system, e.g., printer, cable, modem.

Host computer: A multi-user computer that provides services both to users logged on to the system and to other computers on the network.

Interface: In the network hardware sense, an interface is a connector that meets the requirements of a specific communication standard, such as Ethernet.

Internet: An interconnected set of networks, mostly funded by agencies of the U.S. government for research purposes, all using the TCP/IP protocols. The Internet is mostly within the United States, but does have connections to Europe and Asia. SUNet is connected to the Internet.

Local area network (LAN): A network that operates in a limited area, such as a single building. A LAN consists of a transmission medium (cables) and the machines connected to it.

LocalTalk: Apple Computer's name for the cabling system and signaling method it designed for use with Macintosh computers. LocalTalk operates at a speed of 230,000 bits per second. See also ***AppleTalk, PhoneNET.***

Mainframe computer: A computer that is larger and usually more powerful than a microcomputer or a workstation. It can run large programs and handle many users simultaneously. Examples of Stanford mainframe computers are: Forsythe, an IBM 3090 operated by the Stanford Data Center, and Portia, a VAX 8800 operated by Academic Information Resources.

Microcomputer: A small computer designed to serve a single user. Examples of microcomputers include the IBM Personal Computer and the Apple Macintosh systems.

Modem: A modem is a device that connects to a computer or a terminal and acts as a translator. It converts data from the computer or terminal into tones that can be transmitted over telephone lines and converts tones sent over telephone lines into data that can be understood by the receiving computer. The modem is connected to the phone line; many can be used without a telephone instrument.

Network: The wiring, hardware, and software that connect devices such as host computers, personal computers, and printers so that they can share information.

Network architecture: The set of hardware, protocols, and applications that has been defined by a computer manufacturer or other organization for adding networking capability to a computer system.

Node: Any computer on a network.

NSFNET: A nationwide network established by the National Science Foundation to promote computer communication between science researchers. The NSFNET network is part of the Internet. See also ***Internet.***

Operating system: A program that directs all the activities of a computer and its peripheral devices (e.g., printers, terminals, disks). Examples of commonly-used operating systems at Stanford are: UNIX, TOPS-20, and VM/CMS.

OSI (Open Systems Interconnect): A proposed international standartd for network architecture which is expected to become widely used in the next few years.

Packet-switching: A method of computer communication in which all computers share a common network cable. When a computer has data to send, it bundles up the data in a "packet" that includes the address of the destination computer and sends it over the network. Packet switching allows for remarkable flexibility, efficiency, and speed in communication.

Personal computer: A computer (as used in this document) refers to both microcomputers (e.g., IBM PC and Apple Macintosh systems) and workstations (e.g., Sun and NeXT systems). A personal computer can operate on its own, or it can access the services of other computers.

PhoneNET: Farallon Computing, Inc.'s wiring and and signaling method that is used in a local area network of Apple Macintosh computers. An alternative to Apple Computer's LocalTalk system, PhoneNET operates at the same speed as LocalTalk (230,000 bits per second), but uses standard telephone cable and connectors. See also ***LocalTalk.***

Port: In the networking sense, any hardware communication interface that allows a computer to send and receive data.

Protocol: A set of rules incorporated into a software program that govern how information is exchanged over a network. Protocols provide for sharing a communication medium, addressing the nodes on a network, and achieving reliable communication between nodes. See also ***TCP/IP.***

Repeater: A device that amplifies an Ethernet signal, allowing an Ethernet network to cover a longer distance. A *multi-port repeater* allows multiple Ethernet segments to be combined into a single network.

Router: See ***Gateway.***

Serial communication port: A kind of communication interface found on almost all personal computers and most larger computers that allows low-speed terminal-oriented communication. These ports usually conform to the standard known as EIA RS-232-C. See also ***Port.***

Server: A computer that provides services such as file storage and printing to other computers on a network.

Software: The name given to a program (a set of sequenced instructions) that directs the operation of a computer, e.g., an operating system, protocols, or application software. See also ***Operating System, Protocol,*** and ***Application.***

SNA (Systems Network Architecture): IBM's name for its network architecture.

SUNet: Stanford's computer and video communication network, composed of the SUNet Spine network, the SUNet video network, and all local-area networks connected to the SUNet Spine. See also ***SUNet Spine.***

SUNet Spine: A high-speed computer and video network at Stanford that connects to almost all buildings on campus. Managed by Networking and Communication Systems, SUNet is an Ethernet network; it is part of Internet, a larger nationwide network. See also ***SUNet.***

TCP/IP: Transmission Control Protocol/Internet Protocol or TCP/IP is a series of protocols originally developed for the Department of Defense's nationwide computer network, ARPANET. TCP/IP is the protocol standard for SUNet and NSFNET. See also ***Protocol.***

Terminal: A device used to access the services of a host computer. A terminal has a keyboard and display screen like a personal computer, but it cannot run programs by itself. See also ***Mainframe Computer.***

Terminal emulation software: A type of software program that allows a personal computer to behave like a particular computer terminal (e.g., the DEC VT-100) and access the services of a host computer. See also ***terminal.***

Terminal-oriented: A method of computer communication that is based on a fixed connection between two communicating computers. In a terminal-oriented network (also called a point-to-point network), each node (which can be a computer or a terminal) is connected to a large central switching system. A connection can be made to only one other computer at a time. Terminal-oriented communication provides simple, low-speed services.

Thick Ethernet: Coaxial cable with a diameter of about 1/2 inch, the type of cable used for SUNet trunk lines.

Thin Ethernet: Coaxial cable with a diameter of about 1/4 inch. It can be used to connect computers to local-area networks and to connect local-area networks to SUNet.

TIP: A Terminal Interface Processor is a specialized network device that allows terminals (or personal computers acting as terminals) that are connected to it to use remote login to connect to host computers on a network.

Transceiver: A small device that attaches directly to an Ethernet cable to allow a single computer to connect to an Ethernet network. Most Ethernet adapter boards for personal computers contain built-in transceivers.

Transceiver cable: A cable that connects a transceiver (attached to an Ethernet cable) to the Ethernet interface connector on a computer.

Twisted pair cable: A type of wiring used in computer networks that consists of two stranded wires separately insulated and twisted together. Twisted pair cable is less expensive and easier to install than coaxial cable, but it cannot normally carry data at rates as high, and it is more susceptible to interference. See also ***Coaxial cable.***

Usenet: A worldwide network of cooperating computers using the UNIX operating system.

UUCP: A file transfer protocol specific to UNIX computers. UUCP is used to communicate over Usenet.

Wide area network (WAN): A computer network that covers distances from one hundred to several thousand miles and generally includes hundreds or thousands of nodes. Examples of wide area networks include BITNET, NSFNET, and Telenet.

Workstation: A computer similar to a microcomputer that can do more than one thing at a time (multi-tasking) or support more than one user (multi-user). Workstations usually run the UNIX operating system or some variant of it. Examples of workstations include the Sun-4, DEC VAXstations, and the NeXT systems.

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Computer Instruction Facilities

Have You Heard the News?

Over the past year, changes have taken place on The Farm. Computers and other instructional technologies are making their way into many Stanford classrooms, and faculty can now use several on-campus computer facilities for course-related instruction. On the next pages are descriptions of computer facilities where faculty may choose to teach classes.

And this Autumn...

This Autumn, two pilot projects are due from the Office of the Registrar. For details about either project, please contact the Office of the Registrar at 725-1884.

The first project is the introduction of overhead projectors into all classrooms in History Corner and in the Mitchell Earth Sciences building. This year, the Registrar's Office will monitor faculty use of the projectors. Depending on the results of this project, the Registrar's Office will decide if wider distribution of overhead projectors in classrooms is advantageous.

Secondly, the Office of the Registrar has initiated a pilot project to determine faculty demand for microcomputer and liquid crystal display technology as classroom teaching tools. The Office of the Registrar will loan on a short-term basis:

- a portable Macintosh IIcx microcomputer,
- a connected Chisholm Looking Glass LCD panel, and
- an overhead projector.

This equipment allows projection of the computer's display on a large screen at the front of the room.

Classroom for Freshman English, Building 60

The Classroom for Freshman English in Building 60 on the Quad is specially furnished with eighteen Apple Macintosh II computers with two-page monochrome monitors. The instructor's Macintosh is connected to an LCD projector. An AppleShare file server and access to SUNet are also available.

For details, call Course Scheduling, Office of the Registrar at 725-1892.

Computer-Projection Classrooms, Building 50

Two computer-projection classrooms in Building 50 on the Quad are now equipped with Macintosh SE systems, overhead projectors, and liquid crystal displays (LCD's). The LCD's allow instructors to project computer images from the Mac SE computers on large projection screens. Although this equipment is the property of Computer Science, other departments may arrange to use it.

For details, call Course Scheduling, Office of the Registrar at 725-1892.

ICE Facilities, Sweet Hall

The Interactive Classroom Experiment (ICE) facility is located on the ground floor of Sweet Hall and maintained by AIR. Currently available is a multi-media classroom with dual projectors (video and data) and a network of twenty Apple Macintosh II computers with access to SUNet. Five of the Macintosh IIs are set up as multi-media stations, each controlling a laser disk player; these systems are used to introduce videodisc-based courseware. Seven Sun 4/110 and seven NeXT computers are available in another classroom.

For details, call Steve Loving of AIR at 723-9214.

The Meyer Library Forum Room

The Meyer Library Forum Room, Room 124 has a seating capacity of 120. This room contains a Macintosh SE and an IBM AT, both connected to SUNet. The images from the microcomputers go through a ceiling-mounted video/data projector and onto a large screen in front of the room. Instructors using the equipment in the Forum Room operate in a self-service mode. They receive some introductory training, but regular operation of the various machines is the instructor's responsibility.

Besides the two microcomputers, equipment in the Forum Room includes:

- a 16 mm film projector,
- a carousel slide projector,
- an overhead projector,
- an opaque projector,
- a VHS video cassette recorder,
- a three-quarter-inch video cassette recorder, and
- a sound system with microphones.

For details, call Course Scheduling, Office of the Registrar at 725-1892.

Rooms 040 and 041, Jordan Hall

Rooms 040 and 041 in Jordan Hall are auditoriums with capacities of 297 and 180, respectively. These auditoriums have twin installations of computer/video projection systems. Tentative plans include the installation in each room of a Macintosh IIcx, an IBM AT, a laser disc player, a VHS VCR, a new public address and sound system, and a ceiling-mounted color data/video projector—in addition to the more traditional film and slide projectors.

For details, call Course Scheduling, Office of the Registrar at 725-1892.

Room 263, Language/Engineering Corner

Room 263 in the Language/Engineering Corner, has a video data projection system with a special VCR that handles both videotapes in the European PAL and SECAM formats and videotapes recorded in the American standard (NTSC). The equipment is for foreign language instruction, but is also available for other courses. Although this classroom is not currently equipped with computer hardware, its ceiling mounted projector handles images from microcomputers.

For details, call Course Scheduling, Office of the Registrar at 725-1892.

Room 320, Geology Corner

The upgrade of Room 320 in Geology Corner is the result of a collaborative effort of the Office of the Registrar and the Stanford Instructional Television Network (SITN). The complete face-lift includes installation of special lighting, a sound system, and equipment for the production of high-quality videos.

For details, call Course Scheduling, Office of the Registrar at 725-1892.

Room 410, Meyer Library

Room 410 in Meyer Library is a computerized classroom. It is a special-purpose computer facility with sixteen student stations, each with an IBM XT microcomputer connected to SUNet. This room has a video/data projector, which allows the instructor to project images from his or her computer onto a large screen visible to the entire class. Homework machines for classes taught in this room are available in the Meyer Microcomputer Cluster.

For details, call Course Scheduling, Office of the Registrar at 725-1892.

GUIDELINES FOR CHOOSING A MICROCOMPUTER

Deciding which microcomputer to purchase can be a frustrating and time-consuming process. There are many products from which to choose and many questions to be answered. This handout provides information that can help make the selection process easier.

Before you begin choosing a microcomputer system, consider answers to the following questions.

Do you need a microcomputer?

You may want to purchase a microcomputer for any number of reasons:

- Typing papers and completing homework assignments
- Organizing data for a research project
- Writing a dissertation or a book
- Learning about computer technology

Does your reason justify the cost of a microcomputer system, the time it takes to find the right combination of software and hardware for that system, and the time it takes to learn how to use it? (A "software" program is a set of instructions for the computer; "hardware" is the physical equipment that makes up a microcomputer system.) Is a computer available that you could use (e.g., a computer system on campus, microcomputer clusters on campus, or the microcomputer of a friend or colleague)?

How do you plan to use it?

Do you have a specific task (or tasks) and can you complete it more quickly and efficiently using a microcomputer? If your task is complex, time-consuming, or repetitive, the answer is probably "yes." If your work could just as easily be completed using tools you already have or that are less expensive to purchase (e.g., a typewriter or a calculator), you may want to reconsider.

How often will you use it?

Using a microcomputer frequently means that you won't have to think about how it works. (Just as you don't have to think about how to drive a car when you drive it regularly.) You also won't have to spend time re-learning how to use it.

If you decide to purchase a microcomputer, follow these steps. (Each step includes a page number, indicating the section in this handout that contains information to help you complete that step.)

- Determine your microcomputer needs (p.2).
- Consider some selection guidelines (p. 3).
- Choose software programs that meet your needs (p. 3).
- Choose hardware that can be used with your software (p. 4).

The final sections of this handout describe other sources of information and assistance and where to purchase a system.

DETERMINING YOUR MICROCOMPUTER NEEDS

Following are descriptions of some tasks that can be completed on a microcomputer, as well as the types of software programs that are necessary to complete these tasks. These descriptions should help you identify your immediate microcomputer needs, as well as what your future needs may be.

Word Processing: A word processing program allows you to enter, edit, format, and print text. If your work involves considerable typing and editing, such a program can increase your speed and efficiency. Note that if you decide to get a word processing program, you will also need a printer (unless you have access to a printer that is compatible with the program and the microcomputer you choose).

Graphics: Many use graphics to turn lists of numbers into diagrams that make it easier to understand or compare the data. If you use such charts or graphs for presentations or to illustrate text, you may want to consider graphics software. With such software, you may also need a specialized video display screen and a printer or plotter to adequately display your graphics.

Communicating with other Computers: Communications software allows you to communicate with other computers on campus (and worldwide) and to transfer information among these computers. More specifically, you could use your microcomputer for tasks such as searching Socrates (the computerized version of the Stanford Libraries' card catalog), communicating with a distant colleague, and exploring bulletin boards available on various computer systems. With communications programs, you may also need a modem (described in the section, *Choosing Hardware*).

Financial Planning and Analysis: If your work involves financial planning and analysis requiring complex and repetitive calculations, a spreadsheet program provides added power, versatility, and speed. You enter numerical data and formulas into a grid of rows and columns; you can subsequently change some values and the rest will be automatically recalculated.

Filing Information: If you want to collect, organize, and manipulate large amounts of information quickly and efficiently, consider a database management program. A database is simply a collection of information, organized for easy retrieval. Examples of databases used in everyday life include an encyclopedia, a telephone book, or a library catalog.

Statistical Analysis: Statistical software allows you to explore, describe, and summarize numerical data, and to test hypotheses about patterns in the data. Although you don't need an extensive knowledge of statistics to run statistical software, you should know enough about statistical methods to plan your analyses and to interpret the results meaningfully.

Programming: Programming is writing your own programs (or sets of instructions) for a computer in a specific programming language such as BASIC, Pascal, or C. To write your own programs, you must not only know (or learn) a programming language but also learn at least some technical information about the microcomputer you choose.

Education: You may want to use a microcomputer as an educational tool. There are programs for almost any subject, covering material from kindergarten through graduate courses. Examples include drills for typing, spelling, and languages, as well as tutorial programs for history, architecture, and biology.

Recreation: There are game programs for most microcomputers that are similar to those found in video arcades, as well as other more sophisticated games and simulations.

SELECTION GUIDELINES

Keep the following guidelines in mind as you choose the hardware and software for your microcomputer system.

Personal Preference: Although the recommendations of others may help you make a decision, it is important to choose the microcomputer that *you* prefer; the one that you feel most comfortable using.

Working Environment: Consider where you will be using your microcomputer and if others will be using it. If you want to share files with a colleague or classmate who has a microcomputer, be sure that the two systems are compatible. Additionally, think about the software you may want to include for your family or friends.

Learning Curve: Try out the software programs you need, as well as the microcomputers you are considering, to see if you can learn the basics quickly.

Ease of Use: Will you have to spend so much time "using" your system that you won't be able to concentrate on your work?

Cost: Decide how much you want to spend for a microcomputer system now and how much you would consider spending on that system in the future. (Once you have used your system, you may need additional software programs, the system may need repair, or you may want to purchase additional equipment.) Be sure to include the cost of the basic system, the software programs, and any add-on equipment that you need (such as a printer).

CHOOSING SOFTWARE

When choosing software programs in general, consider the following guidelines.

Features: Be sure that the program you choose has the features you require. Examples: You may want a word processing program that handles large documents, a table of contents, indexes, and footnotes. If your work involves the use of special foreign characters, diacritics, or complex mathematical formulas, you may want a word processing program that handles them. You may want graphics software to plot research data or just for presentation or business graphics.

Evaluation: Be sure to "test drive" the software you are considering, preferably with some of your own work. Any reputable software dealer welcomes prospective buyers who want to try out various programs. Some programs are available in the Microcomputer Consulting Lab, co-located with the AIR/IRIS consulting service on the third floor of Sweet Hall. (See the section, *Other Sources of Information and Assistance*, for details about the microcomputer lab.) You can also check the software reviews that appear in computer magazines.

Menus or Commands: Those new to computing usually find a menu-driven software package easier to learn and use. Menus allow you to choose from a selection of actions to be taken by the computer; you don't have to remember commands. Some more experienced computer users prefer command-driven software programs because they offer more flexibility and direct control of the computer. You initiate an action by typing a command on the keyboard. Some software packages are based on menus that you can bypass for commands, once you become more experienced.

Documentation/Support: The more complete, clearly-written, and well-organized the documentation is, the less time it takes to learn and become proficient in using the software. Many software companies also provide support for program owners by notifying them of updates to the software. Many companies have a customer support phone number which is staffed by those who know the software and the computers on which it runs.

Memory Requirements: The memory needed to store and use software is a temporary storage area in the microcomputer called Random Access Memory or RAM. Check to see how much memory the software requires to operate. Sometimes the amount of RAM determines the amount of data or information that can be conveniently handled by the software. In general, the more complex the software, the more memory it will need.

Compatibility: Consider the following to ensure that each software program you purchase is compatible with the rest of your microcomputer system and with other microcomputers that you may want to share information with.

- Does the software require the same operating system as the microcomputer you want to purchase? (An operating system is the software program that controls the basic operations in a microcomputer. It is necessary for the other software to work.)

- Is the software compatible with the other software you might use with it? For example, can text created with your word processing program be transferred to another computer using your communications program or can the graphics you create with one program be inserted into text created with your word processing software? It is difficult to anticipate the uses you might make of a microcomputer that would raise these compatibility questions. On the other hand, the more they can be anticipated, the more likely you will be satisfied with your choices.

- What peripherals can be used with the software? (A peripheral is a piece of equipment such as a printer, a display screen, or a disk drive that can be added to a basic microcomputer system.) For example, you should find out whether a graphics program needs a color display screen or whether a word processing program works with the printer you are considering.

- Is the software compatible with the software used by your friends and colleagues who have microcomputers? If you plan to share files created on your microcomputer with others who have microcomputers, this is an important consideration. Additionally, if you have the same software as your friends or colleagues, it may be easier to get help or advice on using the program.

CHOOSING HARDWARE

Following is a list of the types of hardware you should be familiar with when choosing a system. (You may or may not need all of them.) A basic system usually consists of the first five items.

Keyboard; other input devices	for entering information and controlling the computer
Display screen	for displaying data
Central Processing Unit (CPU)	where the processing of data and instructions occurs
Internal memory	for temporary storage of software and data; RAM
Disk storage device	for permanent storage of software and data
Printer	for printing copies of your data on paper
Modem	for communicating with other computers
Cables and connectors	for printer, modem, display screen, etc.
Optional internal boards	for communications, color graphics, additional internal memory, etc.
Additional disk storage	to accommodate software or data that requires more disk storage than your microcomputer has
Power supply enhancements	to protect against electrical fluctuations and blackouts that can cause a loss of data

When choosing your basic microcomputer system and its components, consider the following guidelines.

Keyboard: As you try out the keyboards of various systems, notice the following:

Size : Is it a full-size, typewriter-style keyboard and do your fingers fit comfortably on the keys? (Can you type without accidentally pressing keys next to the key you want to press?)

Layout : Are the keys that you will be using frequently located so that they are not difficult to reach? For example: Are the Shift keys in the same position as typewriter Shift keys? Are the cursor movement keys positioned so that their use is almost intuitive? A good setup would be four keys arranged in a "cross" so that the key that moves the cursor left is on the left, and so on. (The cursor is a visual indicator, usually a small rectangle, that indicates your actual working point on the microcomputer screen.)

Touch : Notice as you type whether the keys' resistance to your touch is comfortable for you.

Special Keys : Are there function keys that can be programmed for specific functions by software or by instructions stored in the system? Some people find that function keys can make a microcomputer easier to use.

Flexibility: Is the keyboard detached? Can it be tilted? Is the cable unobtrusive?

Other Input Devices: There are other devices, besides the keyboard, for entering information and controlling a microcomputer. Examples are the mouse (a small hand-held device, with one or more buttons, that is moved around on a flat surface), a graphics tablet (a combination mouse and electronic drawing board), and a touch display screen that allows you to control your system by touching the screen. You may want to consider one of these devices if it is necessary for your work or if you find it easier to use than the keyboard.

Display Screen: The most common display screen for a microcomputer system is a video screen using a cathode-ray tube (similar to a TV). Monochrome (one-color) displays are usually sufficient for textual and simple graphics displays; color displays are most useful for sophisticated graphics systems but they may not have the resolution preferred for extended word processing sessions.

Monochrome displays are usually referred to by the color of their display: amber, green, or white. You can usually choose whether to have the image displayed in black against the background color or as the display color against a black background. Try out the various display combinations to see which is most comfortable for you.

When trying out display screens, be sure to notice if the image is clear and sharp. Also find out how many characters can be displayed on the screen. For word processing, a format of at least 25 lines of 80 characters is preferable.

Internal Memory: The internal memory you can temporarily store data in and make changes, additions, or deletions to is called random-access memory or RAM. You should know how much RAM comes with your microcomputer system and how much you can add. The amount of RAM you need largely depends on the memory requirements for the software programs you plan to use.

Note that when a microcomputer is referred to as a "512K system" it means that it has 512 kilobytes of RAM. (A kilobyte is equal to 1024 bytes. A byte is a unit for storing data in a computer; it is usually equal to one typed character. A single page of double-spaced typewritten words will take up approximately 1500 bytes or 1.5K.)

Disk Storage Device: A disk storage device allows you to store information (e.g., the text you prepare using a word processing program or the data you enter into a spreadsheet). There are two kinds of disk storage devices for microcomputers: the floppy disk drive and the hard disk drive. The one most commonly used is the floppy disk drive. Information is stored on a disk (also called "floppy disk" or "diskette") that is removable. Most microcomputer users agree that two floppy disk drives are preferable to one, since dual drives cut down on the amount of disk-swapping that is necessary when using a microcomputer.

The other storage device for microcomputers is a hard disk drive (also called a "fixed disk drive"). Information is stored on a hard disk that is not removable. Although hard disks drives are more expensive than floppy disk drives, they hold much more data and operate at a much higher speed. To make backup copies of your data on a hard disk drive, you use floppy disks or you have to purchase another hard disk or a piece of equipment to backup your data on magnetic tape.

Printers: Most microcomputer users want printed copies of the text, graphics, or data they produce with their software. Consider the following when choosing a printer:

Print quality: Do you want draft, letter-quality, or camera-ready output? Do you want graphics capability? When comparing printers, you should print samples of the kinds of output you require.

Features: Do you want to print on single sheets (such as letterhead) at times? Do you want to print on envelopes? Do you need superscripts, subscripts, foreign characters, multiple fonts? Do you need various paper widths?

Speed: How fast do you want your output to be printed? Many printers are rated at a print speed in characters per second (cps), although such ratings are usually higher than the actual speed. Some printers print faster at draft-quality than at letter-quality.

Compatibility: Be sure that the printer you choose is supported by the software programs you require. (Such information should be included in the documentation for the software.)

Ease of Use: How easy is it to change paper, ribbons, and other parts? Does the paper feed without jamming? Do you need a printer stand?

Noise level: How much noise does the printer make? Will it need a sound cover?

Communications: In addition to communications software, you may need a modem to communicate with other computers. A modem is a piece of hardware that translates a computer's digital signals into modulated audio tones that travel on a telephone line, and translates audio tones from a distant computer and modem back into digital form. (The word "modem" is a contraction of "modulator/demodulator", the technical term for this type of device.) A modem is either a small box, separate from the microcomputer, or a circuit board that is inserted into an expansion slot inside the computer.

Connecting Hardware Components: The external components of a microcomputer system, such as display screens and printers, often require cable connections to operate. When purchasing cable connections for the components of your microcomputer, test your software to be sure that your basic system and the external components are communicating properly.

Potential for Expansion: Can you add additional memory and components to your microcomputer as your computing needs change? Check to see if there are expansion slots in your system for such additions. Also find out how many types of expansion boards are available for your microcomputer.

Documentation/Support: Is the documentation easy to understand and to use? Does the manufacturer provide a toll-free number that you can call for information and assistance? Does the manufacturer or the computer dealer provide a service arrangement for the microcomputer you want to purchase? How long is the warranty? Most hardware comes with a 90-day warranty. Computer dealers (or a computer maintenance center) offer maintenance contracts that cover the equipment after the warranty expires.

Physical Dimensions (also called "footprint"): Be sure that the system you choose will fit comfortably in your work area. If you want a system that is portable (e.g., so you can use it at home and at your office), be sure that it is not too cumbersome or too heavy for you to transport.

OTHER SOURCES OF INFORMATION AND ASSISTANCE

The following sources of information and assistance may prove useful when deciding which microcomputer to purchase.

Instruction and Research Information Services (IRIS): Instruction and Research Information Services, a division of Academic Information Resources (AIR), provides information about microcomputers to the Stanford academic community. IRIS consultants are available to help you with technical problems and questions, and with choosing a computer system. For more information, contact the IRIS office at 723-1055, or come to the third floor of Sweet Hall.

IRIS Microcomputer Consulting Lab: Members of the Stanford academic community can evaluate hardware and software appropriate for academic applications at the IRIS Microcomputer Consulting Lab. A variety of software is available for evaluation, as well as IBM PC AT personal computers, and an Apple Macintosh SE and a Macintosh Plus. The lab is co-located with the IRIS consulting service on the third floor of Sweet Hall; it is open Monday through Friday from 9:00 a.m. to 5:00 p.m.

Friends and Colleagues: Often your best sources of information are computer enthusiasts in your dorm or department, or friends who are using microcomputers.

Users Groups: A microcomputer users group is usually formed by owners of a specific type of microcomputer who want to share information and experiences with other users of that system. Most users groups have regular meetings and they welcome non-members. You can attend the meetings of several different groups to get firsthand advice and recommendations from those using the systems you are considering. There are several users groups on campus; for more information, contact IRIS at 723-1055. *Computer Currents,* a bi-weekly computer periodical, contains a list of current microcomputer users groups. It is distributed free around campus and wherever magazines are sold.

WHERE YOU CAN PURCHASE A SYSTEM

Microdisc: Eligible members of the Stanford community can get substantial price reductions on selected microcomputer systems and some software through Microdisc, a discount purchase program located on the second floor of the Stanford Bookstore. Many products from Apple, Hewlett-Packard, and IBM are currently available, and consultants are on duty during normal business hours to help you choose a system to suit your needs. For more information, faculty, students, and staff should contact the Bookstore at 329-1217.

Computer Dealers: As you try out various microcomputer systems, go to several computer dealers. Find one you feel comfortable with, just as you would when choosing a mechanic. A computer dealer who is an excellent source of information and assistance may be the one to purchase your system from, even if that dealer's prices are not the lowest. You may want to ask others who own systems like the one you are considering to recommend a local dealer.

Mail Order: If you purchase through mail order, you can save money on your microcomputer system and software programs. However, there is some risk associated with mail order purchases; the level of support for the products may be substantially lower than that provided by a dealer. Because of Stanford's proximity to Silicon Valley, many large mail order houses have retail locations within easy driving distance. Check computer magazines that focus on the system you are considering for mail order ads.

ACADEMIC DATA SERVICE

Users' Guide

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A joint publication of the Systems Development (SyD) Division of
Academic Information Resources (AIR) and Stanford University Libraries.

ACADEMIC DATA SERVICE USERS' GUIDE

TABLE OF CONTENTS

INTRODUCTION

The Academic Data Service (ADS), a joint endeavor of Stanford University Libraries (SUL) and Academic Information Resources (AIR), is a coordinated service program for the acquisition and use of research materials in machine readable form (Machine Readable Data Files, or MRDFs). These are distributed to Stanford by the Inter-university Consortium for Political and Social Research (ICPSR), the Roper Center, and other national and international archives, and include census records, election returns, public opinion polls, and statistics and other information covering a wide variety of topics.

This guide is intended to assist you, the faculty, students, and staff researchers at Stanford, in using data files through the service. It describes the steps you typically go through to use the service, from knowing about a desired data file, to using the data file on the ADS host computer.

FINDING DATA FILES AT THE STANFORD LIBRARIES

Knowing About A Data File

Computer files are part of the Stanford University Libraries collection. Researchers affiliated with Stanford University and interested in accessing computer data files usually come to the Libraries with a certain amount of information about the data file they want. Some individuals are very knowledgeable about the data files made available by data archives and approach reference staff with a specific citation for the data file they want to use at Stanford. Computer files are catalogued in Socrates, the on-line catalog. Individuals who have located records for a specific data file or codebook then approach reference staff or a bibliographer to find out what they should do next.

Other researchers have a very general idea of the kind of data they need—they consult with the reference staff to determine if a data file that meets their needs exists in the Library's collection or elsewhere. You might know, perhaps from a colleague who has used the file before, that the University Libraries have already acquired a data file you want to use, or that it is available from an outside agency. Contact reference staff or the bibliographer who works with your department or school to find out how to get access to the data file.

Looking up Data Files in Socrates

Stanford University Libraries have been acquiring data files for many years. The *Computer Files* file in Socrates lists all the data files acquired by the Libraries. Reference Librarians can assist you in searching this file in Socrates, or for on-line assistance you can type:

HELP DATA FILES

Most data files have accompanying documentation. These codebooks are also cataloged in Socrates and shelved in one of the Stanford University Libraries (most often Green Library). One copy of each codebook will circulate to individuals with valid borrowing privileges.

Once you have located the data file you desire, you can request that it be made available to you. See "Requesting a Data File", below, or use the **HELP DATA FILES** command in Socrates, for instructions on making the request.

Data Files Not Among Current Library Holdings

There are data files not currently in the Library's collection that may be obtained from various organizations. The Library's acquisition decisions are based on support for the graduate academic and research programs at Stanford, individual doctoral research support, cost of acquiring the data file, and the assumption that any data file purchased will become part of the Academic Data Service and be accessible to the Stanford community. Some sources of data files are described here.

Stanford is a member of the Inter-university Consortium for Political and Social Research (ICPSR), and Eddy Hogan, at the General Reference Desk in Green Library, is the Official Representative. This large data archive organization produces a yearly listing of its data file holdings, the Guide to Resources and Services (H61.G85, at the General Reference Desk, Green Library; Jonsson Library of Government Documents; Cubberley Education Library; and there is a circulating copy in Green Library stack).

Data files from the ICPSR may be requested directly through Eddy Hogan or Eric Heath of General Reference. Librarians in other locations may verify that the data files desired by their clients are listed in the ICPSR Guide and make order referrals to Eric.

Stanford is also a member of the Roper Center for Public Opinion Research and data files may be acquired through this center. The Roper Center produces some documentation about its data file holdings, but it is not as detailed as the ICPSR guide. If you are interested in a study conducted by the Roper Center, contact Eddy Hogan or Eric Heath to verify the availability and cost of the data file.

Generally, acquiring ICPSR data files is inexpensive compared to data files from Roper. Roper will also produce reports especially tailored for the individual researcher, thus eliminating the need for the researcher to process data. These reports are very expensive and are approved only after serious consultation, negotiation with Roper, and written support by a Stanford faculty member. See Eddy Hogan for more information.

Often agencies of the United States Federal government have produced data files that are not made available through ICPSR or the Roper Center. See Joan Loftus in the Jonsson Library of Government Documents.

International governmental agencies, such as the World Bank, may also produce data files not made available through ICPSR or Roper. See David Rozcuszka in the Jonsson Library of Government Documents.

You may know of more elusive data files that are not included in the categories mentioned above. Consult with Eddy Hogan about acquiring these. The General Reference Department has a collection of data archive catalogs which may be helpful in locating the data file you need.

Sometimes a scholar or group of scholars have produced a data file as part of a research project sometime in the past. No attempt will be made by Library staff to locate such data files. As a general principle, data files produced by individual scholars that are not well documented and not formatted according to specifications acceptable to the Academic Data Service will not be acquired.

When Your Data File Arrives

After your data files are received by the Stanford University Libraries, you will be informed that the data files have been sent for processing into the ADS Library. When these have been processed, an entry for the new data files is made in Socrates, providing you with the information needed to request the files be made available for personal use. (The following section, "Requesting a Data File," provides instructions for making this request.) The codebook for the data file will be rush cataloged and the requestor will be notified when it becomes available at the Loan Desk of the library where the book will reside.

REQUESTING AN ADS DATA FILE

The ADS Host Computer: WATSON

Data that you request through the ADS are made available on the AIR IBM 4381 VM/CMS ccomputer, WATSON. You can work with the data on WATSON (using the statistics, graphics, and other software there) or transfer the data from WATSON to another computer for processing. When you request a data file, you are provided an account on WATSON and the data file is loaded onto disk for you there.

The Academic Data Service may be used only by Stanford University faculty members, students and staff. The WATSON computer may not be used for research that is sponsored (funded) by any agency external to Stanford (i.e., government or industry sponsored research). WATSON accounts are granted to individuals. You may use only your own account. You may not grant permission to any other person to use your account.

The ADS Request Form

Once you have located the desired data file in Socrates, you need to request that it be loaded onto disk and an ADS WATSON account be created for your use. In Socrates, typing

HELP DATA FILES

or

HELP REQUESTING

will give you general information on requesting data files through the ADS. From the Socrates entry, note the following three pieces of information for each file you will request:

(1) the File Title,
(2) the Tape Number, and
(3) the File Number.

You request a data file by completing and handing in an Academic Data Service Data File Request Form. This form is available at the Reference Desk of Green Library, the Jonsson Library of Government Documents, and the Cubberly Education Library. See Appendix A for a sample filled-out form. If you already have a WATSON account, you may make the request electronically by copying a Request Form Template, modifying this template file to include the request information, and sending it to the WATSON account ADS. To do this, type

COPYFILE *ADS REQUEST P ADS REQUEST A*
XEDIT *ADS REQUEST A*

SENDFILE *ADS REQUEST A* **TO** *ADS*

Requests are processed daily, Monday-Friday, and an account is generally created within one working day. Data files may take longer depending on the availability of disk space.

PLEASE NOTE: Although you may already have a WATSON account as an affiliate of the departments of Communications, Economics, Political Science, Sociology, the Law School or IMSSS, a separate account will be created for ADS use. A separate account is provided because of the large amount of disk space typically needed for working with the characteristically large data files, and to enable the ADS to record computer usage rates and patterns.

Loan Periods

ADS data files are library holdings, and as such, are provided to you on a loan basis. You are given access to the data files and WATSON for specified "loan periods". The loan period for a data file is five weeks; the loan period for your WATSON account is ten weeks. These dates are displayed on your terminal when you log in. The assumption is that the early stages of processing a raw data file include the generation of files containing the data in forms used for all subsequent processing (e.g., data file samples or subsets, SAS data sets, $SPSS^{X}$ system files); such files derived from the original data are stored on the private disk of your WATSON account and remain available for the entire account loan period.

Loan Renewals

You may request loan renewals toward the end of the five week data file loan period, or the ten week period of your WATSON account by sending electronic mail to account ADS or by sending an ADS Request Form through the Library. Such requests are considered on a case-by-case basis, and approval depends on the availability of ADS resources on WATSON.

USING YOUR ADS DATA FILES ON WATSON

Getting Started with WATSON and VM/CMS

WATSON is host to a number of statistical packages and programming languages, including SAS, $SPSS^{X}$, BMDP, Minitab, VSFortran, Pascal/VS and PL/1. Terminals for access to WATSON are located on the 2nd Floor of Sweet Hall. Other terminals and terminal emulators connected to the Stanford network, or those with modems, can be used to work on WATSON.

WATSON uses the VM/CMS operating system. The AIR documents entitled, "Introduction to VM/CMS Services", and, "VM/CMS - WATSON Connections" (available on the 3rd Floor of Sweet Hall) provide background information on subjects such as connecting to WATSON from a terminal or dial-in, and use of the text editor, XEDIT. Once you are logged onto WATSON, an extensive on-line help facility is available for your use. To see an overview of how the help system works, use the command:

HELP *INTRO*

Another good place to begin learning about WATSON is by using the on-line news system. Use the command:

NEWS

Classes on VM/CMS use are scheduled on a quarterly basis. To see the current schedule, use the NEWS command and select the *Intro Classes* topic. A printed schedule is also available on the 2nd Floor of Sweet Hall.

The WATSON text editor, XEDIT is used to create and save files. XEDIT instruction is available through an on-line tutorial. To access this tutorial use the command:

SLFTEACH

Consulting Services

Consultants are available to help you with general and specific questions regarding the use of WATSON and VM/CMS. To find out who these consultants are and their schedules, use the command:

HELP *CONSULT*

Statistical package consultants are also available to help you with questions regarding statistical software such as SAS and SPSS^X ; call 723-1055 or visit Sweet Hall, 3rd Floor.

For assistance with an ADS WATSON account or an ADS data file, contact Felix Limcaoco, 3rd Floor, Sweet Hall, 723-4942 (electronic mail: ADS@WATSON).

ADS Disk Space Information

There are three storage areas that you should be familiar with while using your ADS WATSON account: your default minidisk A (A-disk), the ADS data disk(s) which stores your requested data files (C-disk), and temporary disk space (T-disk).

A-Disk

Your A-disk allows you unrestricted READ and WRITE privileges and is created at the same time as your ADS account. You should be able to use the A-disk to store all the working files, data extractions, statistical package system files, listings, logs, and programs, that you create while working with your data file. This disk remains available as long as your account is active.

C-Disk

Your requested data file is loaded onto a separate data disk, a C-disk. You have READ ONLY privileges for the files on the C-disk. This means that you cannot write to the disk, preventing you from corrupting the data file in any way with editors or programs. Depending on the files you request, you may be given the READ ONLY link to more than one disk, and these additional disks will have filemode letters other than "C". In addition to your account and disk access due dates, the contents of all of your ADS READ ONLY disks are also summarized when you log in. These disks remain available for 5 weeks. Directing the software you use to read data in from your data disks and to route output to your A-disk will be discussed in a later section.

T-Disks

Although space provided by your A-disk should generally suffice, you may need to access temporary disk storage for short periods of time. More information on setting up and using T-Disks will follow later in this document. If you find that you need to access a temporary disk please remember to release the disk space at the end of your CMS session. BE CAREFUL: As the name implies, files on the T-disk are erased at the end of your session. Copy any files needed later to a permanent READ/WRITE disk, like your A-disk, before logging off.

Statistical Software on WATSON

To see a list of software available on WATSON, use the command:

HELP *PRODUCTS*

On-line help for SPSS^X, SAS, BMDP, and Minitab are found by using the command:

HELP

and selecting the desired topic.

Programs such as SAS and SPSS^X can be run in both interactive and batch mode. BATCH processing can be of particular use to the ADS user. When working with long programs or extremely large ADS data files, batch processing may be the only reasonable method for processing your programs. For more information on batch processing use the command:

HELP *BATCH*

An example of using batch processing on SAS and SPSS^X jobs is also given and discussed within the appropriate on-line help file. Use the commands

HELP *SAS*

or

HELP *SPSSX*

to view these help files.

Further information on the use of the statistical packages in the VM/CMS environment can be found in the following AIR documents: "Using SPSS^X on the VM/CMS System", "Using BMDP on the VM/CMS System", "Using SAS on the VM/CMS System", and "Using MINITAB on the VM/CMS System." These documents also point you to consultants and other sources of more detailed information.

File Naming in VM/CMS

In the VM/CMS operating system each file is named using a three part name:

filename filetype filemode

These specifications are often abbreviated *fn ft fm*. You give all files an arbitrary filename, however the filetype and filemode names may have special significance. The filetype can name the application or type of file. Some applications require specific filetypes such as: SAS, SPSSX or EXEC. The filemode names the minidisk where the file is stored. Your ADS data files are normally stored on a disk your CMS session accesses as the C-disk, so you will specify C for the filemode when naming these files. If other data disks are linked and accessed by your account, use the appropriate filemode letter to access the data files on them. All files that you create, like programs or system files, are generally stored on the disk accessed as the A-disk, so the filemode is A. If the filemode is not specified on the command line the default, A-disk, is used.

SAS And Your ADS Data File

To access an ADS data file which has been loaded into your C-disk, you need to issue a FILEDEF command within the SAS program. The CMS FILEDEF is used to link the SAS System through the operating system to the location of permanently stored files. The syntax of the FILEDEF statement as used in a SAS program is:

CMS FILEDEF *DDname* DISK *fn ft fm;*

In constructing the FILEDEF statement you will use a *DDname,* an arbitrary name for raw data files (or a LIBREF when referring to SAS system files) and the *fn ft fm* of the file to be used. For example, if a raw data file on your ADS C-disk is named *SURVEY84 DATA* , the *DDname* can be arbitrarily chosen to be *rawdata* and the FILEDEF statement in your SAS program would be:

CMS FILEDEF *rawdata* DISK *SURVEY DATA C;*

You are then able to access this file through the standard INFILE statement by pointing to the DDname *rawdata* from the FILEDEF.

INFILE *rawdata;*

SPSS^x And Your ADS Data File

To access an ADS data file which has been loaded into your C-disk, you need to use the SPSS^X FILE HANDLE command within your SPSS^X program. This command is used to define the location and the name of the file to be read or written by the SPSS^X program. To use the FILE HANDLE statement an arbitrary *nickname*, or *handle* is used. The syntax of the FILE HANDLE statement as used in a SPSS^X program is:

FILE HANDLE *nickname* / NAME = '*fn ft fm* '

The file is defined by specifying the *fn ft fm* of the file to be used. For example, if your ADS data file on your C-disk is named *SURVEY84 DATA* and the *handle* is arbitrarily chosen to be *rawdata*, the corresponding FILE HANDLE statement in your SPSS^X program would be:

FILE HANDLE *rawdata* / NAME = '*SURVEY84 DATA C*'

You are then able to access this file through the standard DATA LIST statement by pointing to the handle *rawdata* from the FILE HANDLE:

DATA LIST FILE = *rawdata*

Scratch Files

Both SAS and SPSS^X create and use temporary system files during execution. These files are normally written to your A-disk and are erased after completion of a program. They are generally never seen by you; however, if the program is unable to write these temporary files to the disk because of insufficient room on the A-disk, an error message similar to the following will appear:

DISK 'A(0191)' IS FULL

This means you would then need to make room on your A-disk by using the ERASE command to delete files no longer needed, or acquire a temporary disk (T-disk) for the temporary storage of these files.

LISTING Files

If you submit a noninteractive SAS program residing on your A-disk to SAS, after execution the A-disk will contain the SASLOG and LISTING files under the filename of your SAS program. Similarly, SPSS^X will place the listing file on the same disk as the program file, and will use the same filename as that of the command file with the filetype of LISTING. You should be aware that these LISTING files can be quite large if you request many procedures within a single run. If they are not required on-line it is suggested that you print the files and erase them from your A-disk.

If SAS or SPSS^X tries to write a LISTING file to your A-disk and the disk is full, you will receive a message on your terminal screen.

Temporary Disk Storage

If you are unable to write either system files or output files to your A-disk, and you have erased any files that are no longer needed, you may want to use a temporary minidisk. The temporary disk is a valuable resource allowing you to expand the available minidisk space. For more information on how to obtain a T-disk use the command:

HELP *TDISK*

Perhaps the easiest way to utilize the T-disk is to follow these steps:

1. Copy your program file onto the T-disk using the COPYFILE command:

   COPYFILE *fn ft* A *fn ft* T

2. Rename the program file left on the A-disk using the RENAME command:

   RENAME *fn ft* A *newname newtype* A

3. Execute the program named on the T-disk.
4. Look for the output files generated by the program on the T-disk.

Please note that if you do not RENAME the original program file still on the A-disk as suggested in step 2, when you run the program, you will run the copy of the program file on the A-disk, not the T-disk copy where all additional available space is located.

Programs that are copied to the T-disk can still point to files on the A- or C-disks using either the FILEDEF or FILE HANDLE statements. The location of the file to be read or written must be coded on these statements using the appropriate filemode.

After you have obtained a T-disk you need to be aware that when you LOGOFF the CMS session the T-DISK and ALL of its contents are erased. If you want to store any of the files for future use, you can copy them to another permanent disk or to tape.

USING ADS FILES ON OTHER COMPUTERS

You are encouraged to use WATSON's up-to-date software facilities for analyzing your ADS data. If you prefer to use ADS files on another computer, you will have to transfer your files from the WATSON account to it. Even if you indicate on your request form that you will be using another computer for your work on ADS files, you will be given a WATSON account. Since you will not be processing data files on WATSON, however, a smaller A-disk will be assigned to you. Your account and disk links will be active long enough for the file transfers to be made, expiring 2 weeks after your account is opened.

<u>Transferring ADS Data Files</u>

Please note the files requested through the ADS are typically quite large; before moving the data to another computer, be sure it can handle the storage demands.

To another host computer

The File Transfer Protocol (FTP) is one method to electronically transfer files from WATSON to another SUNet host (e.g., Lear, Othello, How) which supports the same protocol. Type:

HELP *FTP*

to obtain a description of the procedures and options for using this program.

To a microcomputer on SUNet

FTP may be used to transfer data from WATSON to a microcomputer which is connected to SUNet. The programs, SU-PC/IP and SU-MAC/IP (available from Networking, Pine Hall) are used on the IBM PC and Apple Macintosh respectively. Each program comes with a guide to its use.

To a microcomputer that is not on SUNet

The file transfer protocol, KERMIT, which is supported by WATSON, can be used for copying files to and from microcomputer disks. Documentation for this software can be found by typing:

HELP *KERMIT*

Another CMS command,

KERMIT DOC

lets you browse the KERMIT documentation in the XEDIT environment.

By Magnetic Tape

It may be more convenient or even necessary to transfer the data file to another host via magnetic tape. The WATSON tape drives are self-service, and are located in the tape drive room in the CERAS building. You must supply your own tapes; they are available from most stores that sell data processing supplies. To find more information on creating tapes in the VM/CMS environment use the command:

HELP *TAPES*

When creating copies of any data file on tape be sure that the tape you create is readable by the alternate host machine. The tape facilities and tools on WATSON allow you to create tapes at either 1600 or 6250 BPI, and in either CMS, unlabeled, or IBM Standard Label format. Check with the systems staff of the alternate host machine to learn the tape formats supported there.

APPENDIX A: Sample ADS Request Form

ACADEMIC DATA SERVICE
DATA FILE REQUEST

Please leave completed forms at the Reference Desk

Name: *Ronald Research* **Date:** *1/10/89*

Stanford Department: *Stanford Center For Chicano Studies*

Check One:

[ ] Faculty [x] Doctoral [ ] Masters [ ] Post Doc
[ ] Undergrad [ ] Visiting Scholar [ ] Staff

Phone Number(s): *home ( ) ###-#### work ( ) ###-####*

A new account on the WATSON computer will be created for you exclusively for use with your data files. If you have an existing WATSON account, please choose a different Account Name for this.

Account Name: *RONRES*
(not more than 8 alphanumeric characters, no spaces, the first character must be a letter.)

Password: *SOMEPASS*
(between 4 and 8 characters long; any characters are allowed, make sure that you remember it.)

You can try loggin on to WATSON using the Account Name and Password you've supplied in 1-2 working days. A message will be displayed when you log on telling you how to access your data files, when your link to these files expires, and when your account expires. If you are unable to log on please contact a WATSON consultant.

Will you be using your ADS files on WATSON or transferring them to another computer?

[x] WATSON [ ] Other

Data File Request:
Obtain the information requested below from the Data File Directory entry for the file. Ask the Reference Desk for help if needed.

FILE TITLE	TAPE NO.	FILE NO.
Current Population Survey: 1980	*AS2506*	*1*
Current Population Survey: 1983	*AS2879*	*1*

FOR OFFICE USE ONLY

Created:______ C Size:______
C Expire:______ C Number:______
Acct Expire:______ Renewal:______

Off-Campus Computer Networks

This paper gives a brief summary of the off-campus networks accessible to computers connected to the Stanford University Network (SUNet). Specific information on connecting to these networks is not covered here; Section 3 lists sources of more information.

1. AN INTRODUCTION TO OFF-CAMPUS NETWORKS

SUNet is Stanford's cross-campus computer network. By connecting your computer or local area network to SUNet, you gain access to a great number of Stanford's computers. In addition, SUNet links you to computers on large off-campus networks with hundreds or thousands of host computers. This document describes some of those off-campus networks.

Off-campus networks fall into several categories in terms of their administration and intended purpose:

1. **Research networks:** Designed to facilitate research in various fields. Often research networks are supported by the government and are centrally administered.
2. **Cooperative networks:** Costs are often borne by the institutional members of the network. BITNET, described in section 2, is a good example of a cooperative network.
3. **Company networks:** Administered and funded by commercial organizations, such as IBM, for internal use.
4. **Public networks:** Commercial enterprises that provide computer connections and online services to paying customers. They are operated by communication companies. Telenet is one example. Some private networks buy services from public network suppliers.

Every network has two basic components: the physical connection, a communication medium between the computers (hardware); and the rules or protocols (software) that the computers use to communicate over the connection.

Common communication media are coaxial cable, twisted pair, telephone lines, optical fiber, and satellite links. Many networks use a combination of these hardware items. Common protocols are TCP/IP, XNS, DECnet, and SNA. There are many other protocols as well.

This document does not generally mention the communication media or protocols a network uses, with one exception. The TCP/IP family of protocols is the protocol set used by SUNet and the Internet, a network of networks. TCP/IP networks are particularly widespread among campus networks. This document notes when a network runs these protocols because the services provided and the addressing schemes used will be similar to the methods used on SUNet, providing a general frame of reference.

Computer networking is a growing and changing field. As new protocols are designed and standards are approved, we are seeing a consolidation of protocols and greater connectivity between networks.

2. A LIST OF OFF-CAMPUS NETWORKS

The following is a list of some of the important off-campus computer networks accessible to computers connected to SUNet. This list is by no means complete, but it does include the networks most commonly used or referred to at Stanford. Some of the networks described below can only be accessed via other networks. You may need to investigate communication paths to the various networks; see the section "Sources of Further Information" below.

Also, the networks listed below may have differing policies about who can use each network for what purpose. Check with potential correspondents about whether you can send mail through a network or use other services it provides.

Each entry includes general information about the network and its administration, what services it provides, any costs or restrictions for using the network, and possible sources of further information. The networks are divided into major groupings to help you find the information you need.

The Internet

The Internet is Stanford's main link to other universities and research institutes. The nationwide National Science Foundation Network (NSFNET) is the backbone network of the Internet. Many other government-sponsored, university, and corporate networks are part of the Internet. Internet networks all run the TCP/IP set of protocols and use the same naming and addressing conventions. The following networks are all part of the larger Internet.

ARPANET

ARPANET is the research branch of the U.S. Defense Data Network. Funded by the Defense Advanced Research Projects Agency (DARPA) at the U.S. Department of Defense, ARPANET is for non-military uses and is restricted to a small group of researchers at institutions doing projects funded by the government. Its military counterpart is MILNET.

ARPANET runs TCP/IP protocols, providing its users with remote login, file transfer, mail service, and other network information services. It is administered by the Network Information Center (NIC) at SRI and the Network Operations Center (NOC) at Bolt, Beranek and Newman (BBN).

BARRNET

The Bay Area Regional Research Network (BARRNET) provides high-speed connections between universities and research organizations in northern California. BARRNET also provides access to remote computing facilities, such as the NSF supercomputer centers. Currently, Stanford, the Universities of California at Berkeley, Davis, Santa Cruz and San Francisco, and eleven other research organizations are linked to BARRNET.

BARRNET runs TCP/IP protocols and supports electronic mail, remote login, and file transfer. It is funded by the National Science Foundation.

MILNET

MILNET is the military counterpart of ARPANET. It runs TCP/IP protocols. MILNET split off from the ARPANET in 1983, but gateways connect the two networks.

MILNET has a classified component. Like ARPANET, MILNET is funded by the Department of Defense.

NSFNET

NSFNET is a research network administered and funded by the Office of Advanced Scientific Computing at the National Science Foundation (NSF). NSFNET is actually a network of networks. It is the backbone of the Internet, linking NSF's six supercomputing centers and thirteen regional research networks in the United States, including BARRNET. By building on existing networks and adding new networks, NSFNET continues to expand and may grow to encompass other existing wide-area networks.

The objective of NSFNET is to provide high-speed supercomputer and general network access to the scientific and academic communities. NSFNET runs TCP/IP protocols; it provides electronic mail, remote login, and file transfer services.

Other U.S. Research Networks

The following are other research networks in the U.S. that are not part of the Internet.

CSNET

The Computer Science Network (CSNET) is a research network connecting academic, industrial, and governmental research organizations to one another, to the Internet, and to foreign academic research networks in Europe, Canada, Asia, and the Pacific.

CSNET membership is limited to organizations involved in research or advanced development in the sciences and engineering. Electronic mail is the baseline service provided to CSNET members; some members also have TCP/IP-based connections to the network and can perform file transfers, remote logins, and other interactive applications. CSNET is administered by a Coordination and Information Center (CIC) located at Bolt Beranek and Newman Inc. in Cambridge, MA. The possibility of merging CSNET and BITNET networks is under review.

MFENET

MFENET (the Magnetic Fusion Energy network) was designed to give supercomputer access to physics departments doing research in nuclear fusion. Funded by the U.S. Department of Energy, MFENET maintains gateways to the Internet and other networks.

MFENET provides electronic mail, file transfer, remote command execution, and remote login services.

BITNET Networks

The following networks are all based on BITNET protocols and together make a large international BITNET network.

BITNET

Because It's Time Network (BITNET) is a cooperative network of colleges, universities and research institutions. Started in 1981, BITNET currently links over 2000 computers at member institutions. BITNET was originally based on IBM software and is available to SUNet through the Forsythe, SLACVM, and Watson computers. BITNET has associated networks in Canada (NETNORTH) and Europe (EARN).

EDUCOM and the City University of New York (CUNY) jointly operate the BITNET Network Support Center. Electronic mail services are available (through Forsythe) to all computers connected to SUNet; interactive messages and file transfers are available directly to users of Forsythe, SLACVM, and Watson, which are registered BITNET hosts.

EARN

The European Academic Research Network (EARN) is the European branch of BITNET. It is an integral part of BITNET, and EARN hosts are considered BITNET hosts from any BITNET site.

EARN provides the same services as BITNET: electronic mail, file transfer, remote login, and remote job execution. Each country has an EARN administrator.

NETNORTH

NETNORTH is the Canadian branch of BITNET, linking Canadian colleges and universities and running the BITNET protocols. It has direct links to EARN and BITNET in the United States.

Like BITNET in the United States, NETNORTH provides electronic mail, remote login, file transfer, and remote job execution services.

UNIX networks

The following are networks of computers that run the UNIX operating system.

EUNET

The European UNIX Network (EUNET) is a cooperative network based on the UUCP and Usenet networks in the United States. EUNET has gateways to EARN, JANET, CSNET, UUCP, Usenet, and ACSNET, among others.

EUNET provides mail and news services to its members. Mail is charged to originating hosts; mail originating outside of Europe may be charged to central administrative hosts.

JUNET

The Japanese UNIX Network (JUNET) is a cooperative network of universities and research institutions in Japan. JUNET supports English, Japanese in Roman characters, and Japanese in Kanji characters.

JUNET provides electronic mail and news services. It is primarily administered by students at the Tokyo Institute of Technology.

UUCP/Usenet

UUCP is an international network of computers running the UNIX operating system. Usenet was built on UUCP but uses the Internet for a large portion of its communications. UUCP/Usenet has thousands of hosts in the United States, Europe, and Asia.

Mail is the only service provided across the entire UUCP network, and Usenet provides the distribution of news. People send news items to specific news groups (bulletin boards), which are sometimes moderated. The set of news groups is sent to all Usenet hosts, where the groups are posted as bulletin boards. Topics vary widely, ranging from gardening to science fiction. UUCP/Usenet mail can be slow and unreliable. There is no central administration.

Foreign Research Networks

The following are major research networks in other countries.

ACSNET

ACSNET is the Australian Computer Science Network, connecting research, academic and industry users across the Australian continent. It has links to UUCP and CSNET in the United States, and to networks in Europe and Canada.

ACSNET provides mail and file transfer services. There is currently no central administration for this network.

CDNNET

CDNNET is a Canadian network linking research, development, and educational institutions in Canada. In 1986 it had approximately 65 hosts. It is referred to as an EAN network because of the protocols it runs. CDNNET has gateways to CSNET, BITNET, UUCP, and other networks.

CDNNET provides electronic mail, remote login and news services. The Canadian government has funded the network, but CDNNET is to become self-sufficient.

JANET

The Joint Academic Network (JANET) is a research network connecting universities and academic research centers in the United Kingdom. JANET has gateways to the Internet, BITNET, CSNET, and UUCP.

JANET provides electronic mail, file transfer and remote login services. It is funded by the British government, and administered by the Network Executive at Rutherford Appleton Laboratory.

Corporate Networks

The following are corporate networks.

DEC ENET (or Easynet)

DEC ENET is an internal engineering network in Digital Equipment Corporation (DEC). Like the company, the network is international in scope. DEC ENET has gateways to the Internet and UUCP.

DEC ENET provides electronic mail and file transfer services for DEC employees. It is funded and administered by DEC.

VNET

VNET is IBM's internal network. It provides mail, remote login and file transfer for registered company users.

For security reasons, IBM limits VNET access. Users on IBM's VNET must be registered to send and receive mail from outside networks. For more information, contact postmaster@IBM.COM.

XEROX

XEROX is Xerox's internal network. It provides mail, remote login, remote procedure call, file transfer, and distributed file system services for Xerox research and corporate personnel. For more information, contact postmaster@XEROX.COM.

Commercial Networks

Telenet

Telenet is a commercial network that provides remote login to a wide variety of computer systems and services, including Dialog, BRS, and CompuServe. Connections to host computers on foreign public networks such as Datapac (Canada), Transpac (France), and Datex-P (Germany) may also be made through Telenet.

File transfer and electronic mail exchange with SUNet computers are not generally available through Telenet, but Networking and Communication Systems is testing a service that would provide access from SUNet to external Public Data Networks like Telenet. Telenet is a commercial network operated by GTE Telenet.

3. SOURCES OF FURTHER INFORMATION

The following documents are good sources of further information:

Electronic Mail across SUNet, a Networking and Communication Systems document, describes how to send mail to many off-campus networks. Copies are available from Networking and Communication Systems (3-3909), from the document racks on the third floor of Sweet Hall, or from the PUBLISH utility on the Data Center (type PUBLISH.) You may also FTP an online copy from Jessica, file *netinfo/email.doc*, identification *anonymous*, and password *guest*; all must be typed in lowercase letters.

"Notable Computer Networks," an article by Quarterman and Hoskins, in *Communications of the ACM*, Vol. 29, No. 10, October 1986, is a good source of information on national and international networks.

Using BITNET, available from the PUBLISH utility on the Data Center, gives information on BITNET. An overview of BITNET is available on Macbeth in the file HLP:BITNET.HLP via anonymous FTP.

Information on accessing off-campus networks is available from AIR/IRIS at 723-1055.

Additional copies of *Off-Campus Computer Networks* are available from Networking and Communication Systems, 723-3909, or from the document racks on the third floor of Sweet Hall. An online copy of this document, *netinfo/offc.doc*, can be obtained from Jessica with the FTP program, identification *anonymous*, and password *guest*; all must be typed in lowercase letters.

4. NETWORK SERVICES AVAILABLE TO SUNET USERS

The following notes match the numbered items in the table of network services on the last page:

1. ARPANET services are restricted to government-funded research.
2. File transfer services are only available to Forsythe, SLACVM, and Watson, which are registered BITNET hosts.
3. Mail sent to EUNET from outside Europe is charged to central administrative hosts; bulk mailings to EUNET are therefore not advised.
4. Usenet also provides a news service.
5. Mail can only be sent to VNET users who are registered to send and receive mail from outside networks. Contact postmaster@IBM.COM for more information.

The following table summarizes network services available on each network to SUNet-connected computers. (These do not necessarily include all services available to registered hosts for each network.)

Network	Mail	Remote Login	File Transfer
ACSNET	x	-	-
ARPANET	x	x	x (1)
BARRNET	x	x	x
BITNET	x	-	x (2)
CDNNET	x	-	-
CSNET	x	-	-
DEC ENET	x	-	-
EARN	x	-	x
EUNET	x (3)	-	-
INTERNET	x	x	x
JANET	x	-	-
JUNET	x	-	-
MFENET	x	-	-
MILNET	x	x	x
NETNORTH	x	-	x
NSFNET	x	x	x
TELENET	-	x	-
UUCP/Usenet	x (4)	-	-
VNET	x (5)	-	-
XEROX	x	-	-

ABOUT COMPUTING AT STANFORD

SEPTEMBER 89

A GUIDE FOR FACULTY & STUDENTS

About Computing at Stanford:
A Guide for Faculty and Students

September 1989

Academic Information Resources
Stanford University

Responsible Use Policy

Stanford expects each person affiliated with the University to be a responsible user of its resources. Such resources include computer systems: computer hardware, software, and SUNet, the campus-wide computer network. Misappropriation of these resources can be prosecuted under applicable statutes. Students will be held accountable for their conduct under the Fundamental Standard. Complaints alleging a Stanford person's abuse of computing resources will be referred immediately to the University Judicial Affairs Office or the cognizant Staff Affairs Officer.

Additional copies may be obtained from AIR, Third Floor, Sweet Hall, 723-1055

Table of Contents

Introduction

This guide summarizes the computing facilities and services offered to Stanford faculty and students. Intended as a directory, *About Computing at Stanford* lists resources and provides references for additional information. See the map in the *Appendix* of this publication for the locations of offices and computing facilities mentioned in this document. Academic Information Resources (AIR) prepared *About Computing at Stanford;* AIR supports faculty, students, and staff in their computer-related academic endeavors.

As a member of Stanford's academic community, you may use computers for a wide variety of tasks. You may use a computer to teach a course or analyze data. You may send electronic mail messages, search library catalogs, or write scholarly articles on computers. Perhaps you analyze data or develop your own software on computers. In any case, you should find *About Computing at Stanford* useful.

Stanford University enjoys one of the most extensive and varied computing environments of any university campus in the country. The Stanford University Network, SUNet, connects over 2,500 mainframe computers, microcomputers, and advanced workstations, plus approximately 5,000 computer terminals. One of the largest campus-wide, Ethernet-based, high-speed computer networks currently in operation on a university campus, SUNet also provides access to off-campus computers—including national supercomputer centers.

Stanford furnishes diverse computing resources for its academic community. Various departments, schools, and research groups provide resources for their students, faculty and staff. Stanford's central computing organization, Information Resources (IR) also provides resources for public use.

General Information about Computing

Responsive to the Stanford academic community's computing needs, Academic Information Resources, the Undergraduate Advising Center, and the Office of Graduate Studies all seek to provide support in computer-related areas.

Academic Information Resources (AIR)

Sweet Hall, Third Floor, 723-1055
8:00 a.m. to 5:00 p.m.; Monday through Friday

AIR offers faculty, students, and staff a variety of computing support services. This includes providing information about on-campus computing alternatives and activities and advice about using microcomputers, workstations, and on-campus mainframe computers.

Undergraduate Advising Center (UAC)

Sweet Hall, First Floor, 723-2426
8:00 a.m. to 12:00 noon, 1:00 p.m.to 5:00 p.m.; Monday through Friday

As part of its role in assisting undergraduates with program planning and in setting long-term goals, the UAC helps students in the selection of introductory computer science coursework, supplies information regarding computer facilities and resources, and refers students to faculty and staff who work in computer-related areas.

Office of Graduate Studies

Bldg. 1, Bldg. 10, Bldg. 590
8:00 a.m. to 12:00 noon, 1:00 p.m. to 5:00 p.m.; Monday through Friday

The Office of Graduate Studies is generally responsible for policies concerning graduate instruction and financial aid within the University and advises graduate students about issues affecting graduate study. This office works with AIR to keep informed of graduate computing needs and to see that the University makes efforts to meet those needs. It also sponsors the graduate dissertation lab in Green Library.

Each School's Computing Resources

The program of instruction in the University is organized in seven schools. These schools operate and maintain a variety of computing equipment, in order to support the specific instruction and research requirements of their areas. In most cases, within an individual school, computing resources vary among the academic departments that comprise it. For information about computing equipment maintained by a specific school or department, contact that school or department. Following are general descriptions of the computing resources that each school offers.

Graduate School of Business

The Graduate School of Business operates a student computer laboratory for use by Business School students only. Students have access to IBM, IBM compatibles, and Apple Macintosh computers. Software includes a variety of word processors, spreadsheets, graphics, and statistical programs.

In addition to microcomputer facilities, students have access to a MicroVAX 3800 running VMS and a DEC-20 system. Consulting support is available during certain hours throughout the school year. For further information, contact Marlen Paez or Eliza Lim at 723-3833.

The School provides computing support for research. This includes a VAX 8550 computer, a DEC-20 system, and diverse personal computers, e.g., IBM PC/286 and PS2/80 computers, Apple Macintosh SE and II computers, and DECstations. For more information, contact Mike Cummins at 725-7254.

School of Earth Sciences

The School of Earth Sciences has a variety of computing resources spread throughout its departments and research groups. Normally, any faculty or student in a department can obtain an account on that department's computers; access to a research group's computers is controlled by the director of the research group.

These resources include:

- multi-user departmental computers for general use that run UNIX and connect to SUNet. Currently, these are VAX 750 systems, but an upgrade is planned to a new DECsystem 5810.
- multi-user research computers that run UNIX and connect to SUNet, e.g., a Convex C-1 and IBM RT, Sun 3, Apollo, and DECstation 3100 systems.

- public terminal rooms equipped with text or graphics terminals to connect to the multi-user computers, IBM PC or Apple Macintosh computers, and LaserWriter printers.
- specialized peripherals such as scanners, digitizers, and plotters.
- Apple Macintosh and IBM PC computers in research labs and offices.

While all computers are maintained by students, the School Computer Manager promotes integration of computer systems within the school and assists and trains individual managers of research machines. The manager also maintains system software and oversees hardware maintenance and acquisitions. For more information on the School of Earth Sciences' computer resources, contact Phillip Farrell, School Computer Manager, 723-9575, farrell@erebus.

School of Education

The School of Education operates a student microcomputer laboratory for use by its students only; all other use is prohibited. The laboratory has Macintosh SE and IBM PC XT, PC AT, and PS/2 systems. There are dot matrix and laser printing facilities. Software available includes WordPerfect, WordStar, Lotus 1-2-3, MacWrite, and MacDraw. Help from a Computer Technician RA is available during certain hours. For more information, contact Roger Beatty, Manager of Computer Systems, 723-5694.

Other resources available to students in Education include statistical consulting through the School of Education Math Methods Program. Consulting includes assistance with design and with selection of appropriate statistical software. The consultants are located in e326 in the School of Education Building. Check the door to see posted hours or to schedule an appointment.

Located on the second floor of the School of Education, the Cubberley Library has various software packages available for checkout. Check with the library information desk for more details.

School of Engineering

The School of Engineering has an array of computing resources available to students, faculty, and staff. The School operates two public clusters of microcomputers. The Engineering Microcomputer Cluster is located in Room 104 of the Terman Engineering Center and contains Apple Macintosh II and IBM PC XT computers, along with several printers. The Engineering Library Microcomputer Cluster, in the library on the second floor of the Terman Engineering Center, contains Macintosh Plus computers (with some upgrades to Macintosh II systems planned during the 1989-90 academic year). Both clusters are commonly used for engineering courses offered by all of the departments of the School. For more information about the clusters, stop by the cluster manager's office in Terman 10 or call 723-0523.

Most departments also provide computer clusters for research and teaching within the departments. Equipment ranges from basic IBM and Apple microcomputers to Sun or DEC workstations to mainframes to specialized computers and peripherals dedicated to particular courses or projects. Most research groups within the School also maintain computers and peripherals for members of the groups. Finally, almost every office and laboratory in the School contains at least one computer. Many, if not most, are connected to local networks and SUNet. For information about these local resources it is best to contact the department or laboratory directly. For more general information about computing in the School, please call 723-9106.

School of Humanities and Sciences

The School of Humanities and Sciences contains twenty-nine departments and approximately thirty programs; computing resources, needs, and interests vary greatly across the School. Some departments maintain clusters of microcomputers or workstations for their students and faculty. For example, each of the seven Social Science departments have computer clusters of IBM Personal Computers where students can do coursework. Other departments provide mainframe computer access for their students and faculty. The Departments of Chemistry, Communication, Economics, Political Science, and Sociology share access to two IBM 4381 systems. Some departments provide line printers or LaserWriters for their students and faculty. In addition, computerized classrooms are often used for classes in various departments. Freshman English, for example, uses a classroom of eighteen Macintosh II systems in Building 60 on the Quad. For details on computing resources provided by a particular academic department, contact the department administrator.

To facilitate the use of computers in scholarly text analysis, the School of Humanities and Sciences has recently purchased a text scanner, the Kurzweil Model 4000. Under an operator's supervision, the Kurzweil is taught to recognize the characters of printed material and record them in a computer file. This file can then be used in any word processing or database program on any computer system. Although the scanning service is available to faculty and graduate students in the School of Humanities and Sciences, faculty and graduate students in the Humanities have top priority. The cost of scanning a book is roughly equivalent to the purchase price of the book. To acquire more information or to use the scanning service, contact Malcolm Brown, AIR, 723-1248, mbb@air.

School of Law

The School of Law provides a student microcomputer laboratory for law students exclusively; all other use is prohibited. In the laboratory, the following hardware and accompanying software are available for students to use in conjunction with law school courses:

- 1 Macintosh II, with Expert Systems Development support;
- 2 IBM AT computers, with Expert Systems Development support;
- 1 IBM AT used for development of Interactive Video programs; and
- 1 IBM AT with SPSS, Lotus 1-2-3, and miscellaneous Computer Assisted Legal Instruction programs;

In the laboratory, for word processing, law students can use:

- 3 Macintosh SE systems with Microsoft Word;
- 8 IBM XT systems with WordPerfect 4.2;
- an Apple LaserWriter, shared by Apple computers, and an IBM Pageprinter shared among the IBM systems; and
- a 2-floppy IBM PC with letter quality printer, with which students may use their own software.

Presently, computing fees and consulting support are in the process of review. For more information, contact Joan Galle, 723-5470, rg.jxg@forsythe.

Various student organizations within the School of Law have word processing requirements, e.g., student-edited journals, Moot Court. These organizations have either IBM or Apple SE computers; their use is restricted to organization members and organization business.

Most law faculty use computers for word processing, as opposed to analysis of data. The School of Law partially subsidizes its faculty members in purchases of IBM or Apple Macintosh personal computers.

School of Medicine

Information Systems Group (ISG) provides a variety of computing support services to faculty, staff, and students in the School of Medicine. These include electronic mail and/or telephone support for quick advice about computing or communications; guidance for systems, hardware, and software planning and procurement decisions; PC software and hardware installation; and computer skills training. ISG operates an evaluation lab with popular Apple Macintosh, IBM PC, and UNIX workstation configurations. In addition, it maintains MedNet, the portion of SUNet within the Medical School. For more information, send electronic mail to consult@med-isg or call 723-8390.

Lane Medical Library maintains two microcomputer clusters for use by Medical School students and faculty. The Medical Informatics Training Lab (MITL) has IBM systems, including software for medical computer assisted instruction and telecommunications. The Fleischmann Learning Resource Center (FLRC) has Macintosh computers, including a collection of general application software and medical computer assisted instruction. There is also a variety of interactive videodisc/computer systems. The Library's Lane-Medline service, by arrangement with Dialog Information Services, provides SUNet access to the National Library of Medicine's bibliographic databases for the Medical Center community. For more information, call 723-6831.

Stanford's Computing Organization: Information Resources

As Vice President for Information Resources, Robert Street has responsibility for both academic and administrative computing at Stanford. In addition, the University Libraries report to him on those aspects of the Libraries related to technology, such as the computerized card catalog. Information Resource has four divisions, as described below.

Academic Information Resources

Directed by Ralph Gorin, Academic Information Resources (AIR) seeks to support and enhance instruction and research through the application of computer technology. It provides the Stanford academic community with access to computers and software. Through courses, publications, and consulting, AIR educates and assists community members so they may become knowledgeable users of computers. By developing and supporting applications of computer technologies for learning, AIR supports Stanford faculty, students, and staff in their computer-related academic endeavors. In addition, AIR develops system software environments for distribution on campus. For more information about AIR programs, call 723-1055.

Networking and Communication Systems

Directed by Bill Yundt, Networking and Communication Systems supports data, video, and voice communication for Stanford. This division operates the campus telephone system and SUNet, the University-wide computer and video network. It offers seminars, publications, videotaped courses, and consulting services. In addition, it evaluates networking products and provides hardware and software that allow access to SUNet services. For more information, contact Networking and Communication Systems at 723-3909.

The Stanford Data Center

Directed by John Sack, the Stanford Data Center (SDC) supports administrative systems in the University's central and academic departments and assists in the movement of information among these systems. SDC provides support for:

- the Forsythe mainframe computer (an IBM 3090);
- databases of University information, developed and maintained by offices throughout the University; and
- programs such as Folio that run on the mainframe.

The Cooperative for Linked Administrative Systems at Stanford (CLASS) is a joint effort of SDC and various University departments. It ensures that all departments have the computer access, skills, and tools necessary to use central administrative systems on the Forsythe mainframe computer. For more information, contact the SDC Director's Office at 725-8686.

Library Information Systems

This division allows IR and the Stanford University Libraries to collaborate on planning strategy and support for the technological aspects of the library system. Bruce Jones, Associate Director of Administrative Services in the Libraries, is also the Director of Library Information Systems. For more information, contact Bruce Jones at 723-2018.

Mainframes, Workstations, and Microcomputers

Apart from those offered through the various Schools and their departments, Stanford has a variety of public computing resources for the academic community. They range from microcomputers (e.g., Apple Macintosh and IBM PC systems) to advanced workstations (e.g., Sun SPARCstation 1 and DEC VAXstation) to mainframes computers (e.g., IBM 4381 and VAX 8800).

Mainframe Computers

Academic Information Resources operates several mainframe computers for the Stanford academic community. In general, Stanford students and faculty can use the computers free of charge, for purposes of instruction and unsponsored research only; sponsored research and commercial use are prohibited. Users receive allocations of computer resources in proportion to their coursework and research needs.

The time sharing services on the AIR mainframe computers are:

- UNIX,
- VM/CMS, and
- TOPS-20.

These services are also introduced in separate handouts, which include information about opening an account; they are found in the document racks on the second and third floors of Sweet Hall. For more information about the AIR computers, call AIR at 723-1055.

UNIX time sharing services are available on a VAX 8800, called Portia. Interactive services include text editors; statistical packages such as isp and S; and programming languages such as Pascal, FORTRAN, C, and Kyoto Common LISP.

VM/CMS interactive time sharing services are available on two IBM 4381 computers, called Watson and Oberon. Interactive services include the graphical display manager GDDM, statistical packages such as BMP, SAS and SPSS^{X}, and programming languages such as FORTRAN and Pascal/VS. Because these computers were made available through a grant from IBM, their use is limited primarily to research and instruction in the School of Humanities and Sciences, in particular the departments of Chemistry, Communication, Economics, Political Science, and Sociology. The Law School, the School of Education, and the Institute for Mathematical Studies in the Social Sciences also use the VM/CMS computers. In addition, Stanford researchers can use these systems for vector program development and simulation prior to execution on the IBM 3090 at the Stanford Data Center. Other users with special needs for the statistical and numerical analysis programs under VM/CMS may apply for access to these systems; for more information, contact AIR at 723-1055.

TOPS-20 time sharing services are available on a DECSYSTEM 2065 and a Systems Concepts SC30M computer. The two systems are called Macbeth and Hamlet, respectively. Interactive services include text editors and many programming languages such as Pascal, FORTRAN, BASIC, APL, and LISP, and statistical packages such as SPSS^{X}, BMDP, and Minitab. The NAG and IMSL subroutine libraries are also available.

The Stanford Data Center operates an IBM 3090-400eVF mainframe computer called Forsythe, located in Forsythe Hall. Forsythe is comprised of four CPUs and three vector processors. Although this computer is dedicated primarily to administrative computing, it may also be used for instructional and research computing. Batch and interactive services are available; software includes WYLBUR, SPIRES, SCRIPT, APL, FORTRAN, PL/I, SAS, and SPSS^{X}. Also on Forsythe are Folio and Prism. An online information resource for academic and public information, Folio includes the online catalog of the Stanford Libraries called Socrates. Prism is an online system for using University information much like Folio, but it is directed more toward the use of administrative computing.

To open an account on Forsythe, contact Data Center Account Services in Spruce Hall, 723-4795. Depending on the type of work you plan, there may be a charge for using the IBM 3090. However, faculty and students can often obtain funds to defray these costs; some departments have computing funds allocated for these purposes. To investigate computing funds, contact your department administrator.

For more information about the services and software provided at the Data Center, contact the Information Desk in Forsythe Hall, 723-4392.

Public Clusters

Members of the Stanford community can use the public clusters of microcomputers or workstations on campus. Note that the equipment in these clusters changes so only summary information is provided below. *Public Computer Clusters at Stanford University* is in the document racks on the third floor of Sweet Hall; this brochure describes each cluster: its hardware, software, priority for use, and hours.

AIR Terminals and Workstations in Sweet Hall: Located on the second floor of Sweet Hall, this cluster is open twenty-four hours a day for Stanford faculty, students, and staff. The terminals located here are used to access the UNIX, VM/CMS, and TOPS-20 mainframes operated by AIR. In addition, at this location printers are available for the AIR mainframes. UNIX workstations such as Suns and VAXstations are provided currently in Sweet Hall, and NeXT computer systems and Sun SPARCstations are planned for the upcoming academic year. Software unique to workstations will become available at this location during the upcoming year.

AIRport, the Tresidder Union Macintosh Cluster: Located on the second floor of Tresidder Union, AIRport contains approximately 70 Apple Macintosh II and Macintosh IIcx personal computer systems. These systems connect to the AIR mainframe computers and other University computing resources via SUNet. Printing facilities are available in the cluster. Priority for use of the Macintosh II systems goes to students in selected courses. Instructors wishing priority access for their courses should send electronic mail to tresidder-request@air. Any cluster user must obtain a cluster ID from the monitor at the entrance desk. For more, contact the cluster via phone at 723-1315 or via the electronic mail address tresidder@air.

Meyer Microcomputer Cluster: Located on the second floor of Meyer Library, this cluster contains Apple Macintosh II and IBM PC XT systems. Access to SUNet is provided. Software is available at the Loan Desk. Priority for the use of the Macintosh II computers goes to students in the Freshman English Program, and the IBM PC XT computers are homework machines for classes taught in Room 410 of Meyer. Printing facilities are available in the cluster. Faculty members who want to make their courseware available at the cluster should contact the cluster consultant. The Meyer Cluster also provides access to MedLine, a database of Medical Journal articles through AppleShare and a CD ROM drive. For more information about the cluster, contact the cluster consultant at 723-9760.

EMCC, the Engineering Microcomputer Cluster: Located in Room 104 of the Terman building, this cluster has Apple Macintosh II and IBM PC XT computers. Access to SUNet is provided. Priority for the use of the computers is given to students required to use course software placed on reserve in the cluster. Printing facilities are available in the cluster. Software is available in exchange for a Stanford ID. For more information, contact EMCC at 723-0523.

Engineering Library Microcomputer Cluster: Located on the second floor of the Terman building, this cluster contains Apple Macintosh Plus computers, with some upgrades to Macintosh II systems planned during this academic year. Printing facilities are available in the cluster. and access to SUNet is provided. Folio accounts are available at the Engineering Library Reference Desk. Priority for use of the computers is given to students required to use course software placed on reserve in the cluster by Engineering or Computer Science instructors. Software is available upon presentation of a Stanford ID. For more information, call the cluster, 723-0001.

Green Library: Two clusters of IBM microcomputers are located in Green Library: The IBM PC Cluster and the Dissertation Lab. Stanford students, faculty, and staff can use the IBM PC Cluster by presenting a Stanford ID. Since software is not available at the cluster, you must bring your own. There are no printing facilities in this cluster. The Dissertation Lab consists of IBM PC AT personal computers, Word

Perfect software, and printing facilities. It is dedicated to Stanford graduate students who are writing their dissertations. Printing facilities are available in the cluster. To use this lab, students present a Doctoral Borrower's Card, obtained from the Green Library Privileges Desk. Doctoral candidates in the schools of Education and Humanities and Sciences receive priority use of the lab.

In addition, there are three terminals in the Green Library communications rooms which members of the academic community can use to access their Data Center or Folio accounts.

Miscellaneous Terminals: Terminals to access on-campus mainframes are also found in the Terman Engineering Center and Forsythe Hall.

Residential Electronic Classrooms

As part of the Residential Electronic Classroom Project, some Stanford dormitories have electronic classrooms with computing and teaching facilities. Offering a variety of learning opportunities for students, these facilities contain primarily Apple Macintosh systems and some IBM PC systems. Students can use Apple Macintosh microcomputers for activities such as writing compositions for Freshman English or analyzing research data with the aid of a spreadsheet.

The classrooms offer access to SUNet, Stanford's computer network. Students in those dormitories can access a campus mainframe computer for tasks such as reading or sending electronic mail, completing a programming assignment, or using Folio.

The public Macintosh clusters in Meyer, Terman, and Tresidder, the interactive classroom in Sweet Hall, and the Residential Electronic Classrooms are configured so they are visible to each other across SUNet. Macintosh computers in any of these locations have access to AppleShare servers and other resources in any of these clusters or classrooms. This allows students to accomplish tasks such as accessing courseware that an instructor has made available in the classroom from a public cluster or submitting assignments electronically.

Stanford faculty and staff are becoming increasingly involved in the use of these electronic classrooms. In the past few years, faculty have created software for course assignments and demonstrations. During the 1989–90 academic year, instructors will use the classrooms to teach such diverse subjects as Computer Science, Economics, French, English, and Philosophy.

A number of campus organizations and departments provide instruction and consulting services for the classrooms, including the Office of Residential Affairs, Academic Information Resources, and the Computer Science Department. In addition, Resident Computer Coordinators, students living in the dormitories, serve as tutors and support staff for the classrooms.

For more information about residence-based computing, contact Jeff Merriman at Residential Affairs, 725-2800.

Computer Instructional Facilities

Computers and other instructional technologies have been making their way into a number of Stanford classrooms over the past year. Stanford faculty can use several on-campus computer facilities for course-related instruction. Unless otherwise noted, faculty interested in arranging for the use of any of the equipment or facilities described here should call Course Scheduling, Office of the Registrar at 725-1892.

The Meyer Library Forum Room, Room 124 is the most ambitious presentation equipment installation; it has a seating capacity of 120. The computer hardware in this room is a Macintosh SE and an IBM AT, both connected to SUNet. The images from the microcomputers go through a ceiling-mounted video/data projector and onto a large screen in front of the room. Instructors using the equipment in the Forum Room operate in a self-service mode. They receive some introductory training, but regular operation of the various machines is the instructor's responsibility.

In addition to the two microcomputers, other equipment in the Forum Room includes:

- a 16 mm film projector,
- a carousel slide projector,
- an overhead projector,
- an opaque projector,
- a VHS video cassette recorder,
- a three-quarter-inch video cassette recorder, and
- a sound system with microphones.

Room 410 in Meyer Library is a computerized classroom. It has been converted to a special-purpose computer facility with sixteen student stations, each with an IBM XT microcomputer connected to SUNet. This room is also equipped with a video/data projector, which allows the instructor to project images from his or her computer onto a large screen visible to the entire class. Homework machines for classes taught in this room are available in the Meyer Microcomputer Cluster.

The Eugene McDermott Room is located in Green Library and maintained by the Stanford University Libraries. The McDermott Room is not a drop-in, public facility but a classroom reserved for instructional use. It can provide up to ten people with hands-on access to Apple Macintosh Plus computers. The computers can also be used as terminals connected via modem to other computer systems. The room is equipped with a projection system for displaying information from the instructor's station. To reserve the McDermott Room, contact the General Reference Department, Green Library, 723-1811.

Room 263 in Language/Engineering Corner has a video/data projection system including a special VCR that has the capability of handling videotapes in the European PAL and SECAM formats as well as tapes recorded in the American standard (NTSC). This equipment is intended specifically for foreign language instruction, although it is also available for other courses or one-time events. And although this classroom is not currently equipped with computer hardware, the ceiling-mounted projector is capable of handling images from microcomputers. If demand is sufficient, the Registrar's Office will equip the classroom with a computer to meet faculty needs. A system similar to the one in Room 263 is in **Classroom 241A of the German Studies Department**.

Two Computer Science Classrooms in Building 50 on the Quad are now equipped with Macintosh SE systems, overhead projectors, and liquid crystal displays (LCD's) that will allow instructors to project computer images from the Mac SE computers on large projection screens. Although this equipment is the property of Computer Science, other departments may arrange to use it through Course Scheduling in the Office of the Registrar.

Rooms 040 and 041 Jordan Hall, auditoriums with capacities of 297 and 180, respectively, have twin installations of computer/video projection systems. Tentative plans include the installation in each room of a Macintosh IIcx, an IBM PC AT, a laser disc player, a VHS VCR, a new public address and sound system, and a ceiling-mounted color data/video projector—in addition to the more traditional film and slide projectors.

The Classroom for Freshman English in Building 60 on the Quad is specially furnished with Apple Macintosh II computers. In a cooperative effort, Freshman

English, Academic Information Resources, the Dean of Undergraduate Studies, and the Office of the Registrar have installed eighteen Macintosh II computers here.

Room 320 in Geology Corner is the result of another collaborative classroom improvement effort. The upgrade of Room 320, which was done in close cooperation between the Office of the Registrar and Stanford Instructional Television Network (SITN), included a complete face-lift and the installation of special lighting, a sound system, and equipment for the production of high-quality videos.

The Interactive Classroom Experiment (ICE) facility is located on the ground floor of Sweet Hall and maintained by AIR. In the past few years, the classrooms have been used for classes taught with interactive courseware, that is, instructional software that allows a student to give input and receive immediate feedback. Currently available is a multi-media classroom with a network of twenty Apple Macintosh II computers with access to SUNet. Five of the computers have been set up as multi-media stations, each controlling a laser disk player. These multi-media systems are used to introduce videodisc-based courseware. Advanced function, UNIX-based workstations are found in two classrooms; Sun 4/110 workstations are in the first classroom, and NeXT computers are in the other. Faculty interested in using ICE should contact Steve Loving of AIR at 723-9214.

New in Autumn: Two pilot projects are due from the Office of the Registrar during Autumn of 1989. For details about either project, contact the Office of the Registrar.

The first project is introduction of overhead projectors into all classrooms in History Corner and in the Mitchell Earth Sciences building. This year, the Registrar's Office will monitor faculty use of the projectors. Depending on the results of this project, the Registrar's Office will decide if wider distribution of overhead projectors in classrooms is advantageous.

Secondly, the Office of the Registrar has initiated a pilot project to determine faculty demand for microcomputer and liquid crystal display technology as classroom teaching tools. Beginning Autumn Quarter, the Office of the Registrar will permit short-term loan of a portable Macintosh IIcx microcomputer, a connected Chisholm Looking Glass LCD panel, and an overhead projector. This equipment allows the projection of the computer's display on a large screen at the front of the room.

AIR Labs: Consulting, Development, and Multi-Media

As an adjunct to some of their services, AIR provides several labs.

AIR Consulting Lab: As part of their consulting service, AIR operates a lab located in Sweet Hall. Faculty, students, and staff may experiment with a variety of microcomputers and software such as word processing programs, spreadsheets, programming languages, and graphics packages. The lab also provides a facility used to transfer files between:

- an Apple Macintosh and an IBM Personal Computer and
- an Apple Macintosh computer or IBM PC and a campus mainframe computer.

Production work other than file transfer is not permitted. Lab hours are concurrent with consulting hours: Monday through Friday, 9:00 a.m. to 5:00 p.m. For more information, contact AIR at 723-1055.

Courseware Development Lab: AIR provides the Courseware Development Lab on the ground floor of Sweet Hall where faculty and students can design and build academic microcomputer software or "courseware." The lab provides advanced development systems for special projects. If a professor or a student has an idea for software development and can provide the programmer(s), AIR can provide space, hardware, software, and advice. The facility contains Apple Macintosh, IBM PC, and NeXT development environments. Faculty and students interested in using the lab should contact Steve Loving, 723-9214 (loving@air).

The Lab for Authoring Multimedia Programs (LAMP) enables faculty members to create a new type of instructional software: computer programs that use video and a combination of slides, computer graphics, and clips from existing films.

Examples of projects include a tutorial in American Sign Language for the Special Language Program, an exploration of the circulatory system for the Human Biology Department, and an interactive story set in Paris for teaching French. For more information about this lab or about developing videodisc-based courseware, contact Barbara Jasinski at 725-3153, bjj@air.

Supercomputing Resources

Both off-campus and on-campus supercomputing resources are offered to Stanford faculty members and researchers.

Off-Campus Resources

Faculty members and researchers can access several supercomputers through Stanford's institutional memberships in the following supercomputing organizations:

- San Diego Supercomputer Center (SDSC)
- National Center for Supercomputer Applications (NCSA)
- Cornell National Supercomputer Facility (CNSF)

Stanford has a limited amount of "seedtime" for using the facilities. Seedtime is available to Stanford faculty members and their graduate students for the following purposes:

- gaining supercomputing experience;
- investigating projects while a larger grant proposal is under review by a granting agency;
- teaching a course; or
- completing certain projects of limited duration.

On a quarterly basis, faculty members of the Supercomputer/Communications Working Group review applications for seedtime. To acquire larger blocks of time, faculty members can apply directly to one of the above supercomputing facilities or to the National Science Foundation. For application forms, send mail to supercomputer-request@air; for more information, contact Randy Melen, 723-5359.

For help in accessing or using these remote supercomputing facilities, send electronic mail to supercomputer-help@air or call AIR at 723-1055.

On-Campus Resources

AIR provides a vector service and a supercomputing mailing list for Stanford supercomputer users.

Vector Service: With vector processing, supercomputers can greatly decrease calculation time. AIR has arranged for access to a vector processing service on the

Stanford Data Center's IBM 3090 mainframe. For those with research grants, CPU time is priced at extremely low rates; for those pursuing unsponsored research, grants of CPU time are available. In either case, allocations are made after peer review of a proposal application. Contact Randy Melen, 723-5359 for more information.

Supercomputing Mailing List: Supercomputer users at Stanford can use a supercomputing mailing list in the same way they would use an electronic bulletin board: to post messages about supercomputing and read messages about supercomputing activities at Stanford. Unlike an electronic bulletin board, the messages are sent via electronic mail addresses. Typical messages include:

- announcements of grants for supercomputing time,
- information on using supercomputers at the facilities mentioned above, and
- information about supercomputer workshops or publications.

To distribute a message using this mailing list, send it to the electronic mail address, supercomputer@air. To add your name to the mailing list, send your request to supercomputer-request@air.

Computer Education and Assistance

There are many on-campus alternatives for learning both about computing in general and about Stanford's computing resources. They include:

- education,
- publications,
- consulting services,
- microcomputer users' groups,
- UNIX support and development, and
- instructional applications development.

Education

Courses: AIR introductory classes about how to use the AIR computer systems are scheduled during the first few weeks of the quarter. These short, no-credit courses do not require registration.

Typical courses provide introductory information on:

- the AIR mainframe systems: TOPS-20, UNIX;, and VM/CMS;
- the text editor EMACS;
- AIRport, the Macintosh cluster in Tresidder Union; and
- the X Window System (available on many workstations).

The *AIR Introductory Classes* schedule describes each course, including dates, times, and locations; it is found in the document racks on the second and third floors of Sweet Hall and in AIRport, the Macintosh cluster in Tresidder Union.

If you prefer, you may watch videotapes of some of the classes either at home, in certain libraries, or on SUNet. Faculty may want to borrow these videotapes to show to their classes. All videotapes are available in the Math/Computer Science, Terman Engineering, and Meyer Libraries. For more information on viewing the tapes on SUNet, consult the flier called *Enjoy the View: Computer Training Videotapes on SUNet*. Found in the document racks in AIRport and on the second and third floors of Sweet Hall, this flier gives the broadcast schedule.

The Computer Science Department offers introductory computing courses for students with non-technical majors. Taken for credit, these courses cover the basic concepts of computing and offer hands-on use of microcomputers. In CS1C, *Using the Macintosh Microcomputer*, non-computer science majors can learn how to use the Macintosh. The course covers the basic functions of the system, including word processing, communications, and other software applications. For further details and descriptions of other CS courses, see *Courses and Degrees 1989-1990*, or contact the Computer Science Department at 723-2273.

Lane Medical Library offers courses about computerized searching of medical literature, telecommunications, and reprint file management. For more information about eligibility for enrollment, course content, and schedules, call 723-6831 or stop by the Lane Medical Library Reference Desk.

The Stanford Data Center offers short, non-credit courses on using its IBM 3090 mainframe computer and the Apple Macintosh and the IBM PC microcomputers. Topics include vector FORTRAN, word processing and text formatting, database management, statistical application packages, graphics, communications and networks, and specific applications. All courses are open to faculty, staff, and students. Most courses are offered at no charge, but some microcomputer courses do require a fee. The schedule and course descriptions for the current quarter are at the Forsythe Hall Information Desk, 723-4391.

Videotapes and Tutorials: If you want more information about how to use SUNet, the Stanford University Network, you may be interested in the instructional videotapes on this subject. You may borrow them from AIR or from Networking and Communication Systems. Or you can watch them on SUNet cable television. Broadcast over SUNet, the videotapes air on Channel 48 of the on-campus universal cable and on Channel 11 on the residential cable in dormitories. The flier called *Enjoy the View: Computer Training Videotapes on SUNet* gives the broadcast schedule for the current academic quarter and describes each videotape. It is available in the document racks in AIRport, the Macintosh cluster in Tresidder Union and on the second and third floors of Sweet Hall.

AIR has a variety of tutorials and videotapes that students, faculty, and staff may be interested in borrowing to study at their leisure. Faculty in particular may be interested in showing these videotapes to their students. The topics cover software applications, information for Stanford network administrators, and mainframe, microcomputer, and supercomputer systems. These materials are described in the *Self-Paced Computer Training Materials* flier that can be found in the document racks on the second and third floors of Sweet Hall. For more information, call AIR at 723-1055. Networking and Communication Systems also offers self-paced tutorials and seminars on local network administration, current services, and new developments in networking. For more information, call 723-3909.

Presentations and Seminars: Networking and Communication Systems offers presentations to academic departments and conducts a series of meetings and training sessions for system and network administrators. These sessions typically cover networking within the departments, links to SUNet and external networks, and future networking services. For more information, contact Networking and Communication Systems at 723-3909.

AIR offers seminars designed to keep the Stanford community up-to-date on developments in computing. Check the calendar sections of the *Campus Report* and the *Stanford Daily* for announcements of these seminars. AIR also provides seminars by special arrangement for Stanford instructors, departments, or academic groups who wish to familiarize students, faculty, or staff with the computing software and services available on AIR mainframes and workstations. For details, contact Janet Lasher at 723-1518.

Publications

You may be interested in acquiring computing documentation produced by various organizations on campus.

Academic Information Resources: AIR prepares a rich variety of computing documentation to assist faculty and students using computers at Stanford.

Published quarterly, *Speaking of Computers* is a newsletter about campus computing activities. *Speaking of Computers* covers Stanford's computing resources and includes articles about campus computer clusters, classrooms, projects, and courses. It also describes new and upgraded products relevant to the academic community. Copies are distributed to the faculty, on-campus student residences, academic departments, and key distribution points such as Meyer Library and Sweet Hall. In addition, the newsletter is online in Folio on the Forsythe computer.

Documentation about the various AIR computer systems is found in the document racks on the second floor of Sweet Hall. These include publications about opening accounts on the different AIR computers. Other documents cover using electronic mail, the text editor Emacs, and the X Window System.

In the document racks on the third floor of Sweet Hall, there is a variety of other documents providing information about computing. For example, *Public Computer Clusters at Stanford University* describes the public computer clusters located on campus. *Guidelines for Choosing a Microcomputer* helps you select microcomputer hardware and software. *Traveling Abroad with Your Microcomputer* furnishes advice about taking your microcomputer on trips outside the United States. *Revenge of the Macintosh* helps you prevent, detect, and remove virus infections on your Macintosh.

The Stanford Data Center: Documentation describing services and software on the Data Center mainframe is available through an online printing facility, PUBLISH. A free handout about how to use PUBLISH and some introductory documentation about the Data Center is at the Document Distribution Center, behind the Information Desk in Forsythe Hall. The Data Center also provides production support for *Around the Office*, a monthly publication written by Stanford staff. *Around the Office* contains information about administrative and automation matters, such as the latest computer hardware and software for the office, training opportunities, and administrative tips. This newsletter is online in Folio on the Forsythe computer.

Networking and Communication Systems: Networking contributes articles to Stanford publications and distributes documents that provide information on the campus-wide Stanford University Network (SUNet), local networks on campus, and networking software. These items are described in the *Catalogue of Networking Materials: Documents, Video Tapes, and Software.* Copies are available in the document racks on the third floor of Sweet Hall or at Networking, 723-3909.

Others: The ***Stanford Daily*** and the ***Campus Report*** include news about computer courses and seminars, Microdisc activities, and recent computing acquisitions. In addition to computer supplies, the **Stanford Bookstore** carries a variety of books, periodicals and other publications about computing.

Consulting

Faculty, students, and staff who need computing consulting services can contact the local expert in their area or these divisions of Information Resources: Academic Information Resources, Networking and Communication Systems, and the Stanford Data Center.

A "Local Expert" is a student or a member of the faculty or staff in an area such as a department, office, or computer cluster on campus who serves as a source of computing help and information for others using computers in that area. Contacting the local expert in your area about your computing needs and problems can save time and effort. If that person is also participating in the **Expert Partners Program** offered by Information Resources, he or she has special access to IR computing resources and training. As a result, you may receive information and assistance more quickly than if you pursued other consulting resources.

The Expert Partners Program: Anyone who supports other computer users within a working group can be an Expert Partner. The Expert Partners Program is a way of helping these local experts do their jobs more effectively; it enhances the flow of information about academic and administrative computing issues on campus. Whenever computing problems arise in a department or office, the Expert Partner can direct their questions through dedicated online mail accounts and phone lines. In addition, IR develops training opportunities and vendor demonstrations for Expert Partners. Students, faculty or staff, formally trained professionals or seat-of-the-pants beginners are all welcome to join. For more information about participating in the Expert Partners Program, contact Tom Goodrich, AIR, 4-4747, ep-help@air.

Academic Information Resources offers faculty, students, and staff a broad range of free technical advice and consulting about academic computing applications at Stanford. This includes information on microcomputers, workstations, on-campus mainframe computers, and supercomputing. AIR consultants can help with:

- selecting a computer or software,
- solving problems with a computer or a program you are using,
- applying computers to courses and research, and
- using your computer in the Stanford academic environment and with other computing systems at Stanford.

Consultants are available on a scheduled basis to help you with brief computing questions; more complex or lengthy questions are handled by an appropriate specialist. You can send computing questions to AIR consultants via computer, using the electronic mail address consult@air. You can stop by Sweet Hall to ask a computing question in person. Or you can telephone AIR consultants at 723-1055.

If you have a computing question, but are not sure where to go for an answer, begin with the consultants in Sweet Hall. They are available Monday through Friday, 9:00 a.m. to 5:00 p.m. to address general and specific computing questions.

To assist you with using AIR computers (mainframes, workstations, and microcomputers), student consultants are available in Sweet Hall, 723-0325 and in AIRport, the Macintosh cluster in Tresidder Union. These consultants handle questions regarding AIR introductory computer classes; accounts for the AIR mainframes and workstations; and sponsorships for disk space and additional computer resource allocations. They also support faculty and teaching assistants using the AIR computer systems for Stanford courses.

Networking and Communication Systems offers consulting assistance to academic organizations that are planning and installing network connections for data and instructional video applications. With respect to data applications, Networking consultants work in cooperation with other IR consultants; with respect to instructional video applications, they work in cooperation with the Stanford Instructional Television Network (SITN) staff. Consulting services include:

- preparing bid packages,
- coordinating equipment orders, and
- overseeing cabling contractors' work.

Consulting is by appointment. There is no charge for the consulting services, except in the case of very large or extended network projects. For more information, call Networking at 723-3909.

Communication Services, a division of Networking and Communication Systems, provides information on ordering data communication links such as the Gandalf data switch, local area networks, or modems. For more information, call 725-HELP.

The Stanford Data Center offers consulting advice about the software and services on its IBM 3090 mainframe and about the administrative applications of computers. Walk-in consulting is from 10:00 a.m. to noon and 2:00 p.m. to 4:00 p.m., Monday through Friday, at the Consulting Office in Forsythe Hall. Phone consulting (723-2046) takes place from 9:00 a.m. to noon and 2:00 p.m. to 4:00 p.m., Monday through Friday. The CONSULT command is available on the Forsythe mainframe computer for online questions.

Microcomputer Users' Groups

If you are a microcomputer owner or user, you may choose to join a users' group to learn from and share experiences with other users of your system. Users' groups that meet on campus include one for Apple Macintosh users and one for IBM PC users. For information on other users' groups, call AIR at 723-1055.

Stanford Macintosh Users' Group (SMUG) is chartered under the ASSU (Associated Students of Stanford University), so it is a student volunteer organization. However, anyone who uses an Apple Macintosh is welcome, including non-Stanford people. The membership fee is $25 a year to members of the Stanford community and $35 a year to others. It includes admission to all meetings, one software distribution disk, a newsletter, periodic bulk purchases of hardware and software, and other benefits (e.g., members can purchase shareware program disks through SMUG). Open to all SMUG members are special interest groups in a variety of areas including novice users, development, music, and desktop publishing. SMUG also sponsors an electronic bulletin board connected to FIDOnet for those who have modems. The regular SMUG meeting is usually held on the first Monday of each month at 7:00 p.m.; admission to non-members is $3. For more information, contact SMUG at 723-7684.

Stanford/Palo Alto PC Users' Group is also affiliated with the ASSU. However, anyone who uses an IBM PC or compatible is welcome, including non-Stanford people. Membership is $10 a year for students, $25 a year for others. It includes a monthly newsletter, a library of public domain software, an electronic bulletin board, and access to various special interest groups. This users' group meets on campus the last Wednesday of each month; meetings are held at 7:30 p.m. in Turing Auditorium, Polya Hall. For more information, contact Beverly Altman at 329-8252.

UNIX Support and Development

AIR provides a wide range of support services for owners of UNIX computers. The services include acquiring campus-wide licenses for widely used versions of UNIX, distributing these versions of UNIX for use on campus computers, and providing UNIX system managers with Stanford specific installation and setup instructions. AIR provides advice to UNIX system managers about operating system, networking, and system administration procedures and problems. It also addresses UNIX system security, providing secure versions of UNIX utilities. AIR ports and distributes site-licensed and public domain utility software, maintains electronic distribution lists for UNIX information exchange, and coordinates Usenet network news distribution to the campus. These services are part of the AIR initiative, the Stanford Program for UNIX Development and Support (SPUDS). For more information, contact Liz Hayes, 723-5457, ehayes@air, or Felix Limcaoco, 723-4942, fkl@air.

SPUDS furnishes advice to UNIX systems programmers, and undertakes small and large scale development projects to enhance the functionality of UNIX implementations. Currently, major efforts are ongoing in the areas of security and distributed services through SUNet. For further information, contact Dan Kolkowitz, 723-5414, kolk@air.

Instructional Applications Development

Through the Courseware Authoring Tools Project (CAT), AIR provides Stanford faculty with an array of authoring tools which minimize the programming effort required to develop courseware, i.e., instructional software support. CAT team members meet with faculty to discuss and formalize their courseware ideas, determine which tools would be appropriate for their applications, demonstrate these tools, and train the faculty and/or their student programmers to use them. CAT further supports faculty projects with consulting advice and programming support for selected projects using CAT development tools.

Development tools include *Alias*, a HyperCard-based toolkit for generating simulations in the social sciences; *YOW!*, a software erector set for applications in the engineering-related disciplines and a collection of multi-media authoring tools for developing videodisc-based applications. For more information about the project, contact Barbara Jasinski, CAT Project Manager, 723-1542.

In addition, there are two development labs: the Courseware Development Lab where faculty and students can develop their applications and the Lab for Authoring MultiMedia Programs (LAMP) for faculty who want to develop videodisc-based courseware. Faculty also can use the Interactive Classroom Experiment (ICE) facilities to deliver their courseware to students.

Communicating with Computers

Using a computer often involves communicating, i.e., sharing information among computers. For example, you may send a message from your microcomputer to your department's computer to check on an upcoming meeting, or you may transfer public domain software stored on a large campus computer to your microcomputer.

A brief overview of computer communication at Stanford follows. The AIR document *Using Computers to Communicate* provides more detail. It describes the communication alternatives and the communication services at Stanford, summarizes the equipment and software required, and lists references for more information and assistance. Copies of this document are in the AIR document racks on the third floor of Sweet Hall.

If you are using a computer to communicate at Stanford, you are connected to other computers via SUNet, the Stanford University Network or via the telephone system. Computers connected via SUNet have access to such services as file transfer, remote login, electronic mail, and video transmission for instructional television and image retrieval. Computers connected via telephone connections have access to such services as file transfer, remote login, and electronic mail.

Using SUNet to Communicate

Physically, SUNet is a network of networks; local area networks within most campus buildings are connected by the SUNet Spine network to form the campus-wide SUNet network. SUNet connects almost all buildings on campus and offers high-speed communication among all of the campus computers generally available to faculty and students. The nominal speed of data transmission is very fast, usually between 100,000 and 1 million bits per second. One million bits per second translates into about 100, 000 characters of text or data per second. The actual speed depends upon the speed of the communicating computer.

To use SUNet, a Stanford department must first install a local area network in its building and then attach its computers to that network. SUNet connections for student-owned, properly-equipped microcomputers are provided in an increasing number of locations, e.g., dormitories and clusters. If you would like to order a SUNet connection or to obtain information on current or planned SUNet access, contact Networking and Communication Systems at 723-3909.

Networking and Communication Systems has developed two programs for microcomputer communication with on-campus mainframe computers directly connected to SUNet, e.g., AIR mainframes Watson or Portia. The programs are: SU-PC/IP for use with IBM PC models and SU-Mac/IP for use with Apple Macintosh computers. For a Stanford user, a copy of SU-PC/IP or SU-Mac/IP with documentation costs $10.00 at Networking and Communication Systems, 723-3909.

The Stanford Data Center has developed Samson/IP, a version of SU-PC/IP that features commands for use with Forsythe. It is available at the Forsythe Hall Information Desk. Samson/IP for the Macintosh is under development.

AIR publishes guides, which describe how UNIX system managers should configure their systems for communicating via SUNet. Distributed with the UNIX operating systems from the Stanford Program for UNIX Development and Support (SPUDS), the guides are also found in the document racks on the third floor of Sweet Hall. Electronic copies are also available via anonymous ftp from Alleyn (36.83.0.22). UNIX system managers can address questions about UNIX system network configuration to Liz Hayes, 723-5457, ehayes@air or to Felix Limcaoco, 723-4942, fkl@air.

Using the Telephone System to Communicate

Stanford's telephone system permits communication between computers in two ways: through a dial-up voice line or through a circuit to the Gandalf data switch. For more information on ordering a standard voice line for a dial-up connection or a Gandalf connection, contact Communication Services at 725-HELP.

Telephone Connections to On-Campus Computers: You can use dial-up telephone lines to access many on-campus computers. You must have an account for the computer you want to access, a properly equipped microcomputer or terminal, and a standard telephone line. Information is transmitted at speeds ranging from 300 to 2400 bits per second or 30 to 240 characters per second.

Listed below are the telephone numbers for the AIR mainframe computers (e.g., Macbeth, Portia, and Watson) and Forsythe, the IBM 3090 operated by the Data Center:

AIR mainframes:	723-8643 (300, 1200, or 2400 bps) 723-8511 (300, 1200, or 2400 bps)
Forsythe:	723-8012 (300 or 1200 bps) 723-8000 (2400 bps)

The AIR mainframes and Forsythe allow access at 300 bps, 1200 bps, or 2400 bps. That is, data can be transmitted across the phone line at 30 characters per second (300 bps), 120 characters per second (1200 bps), or 240 characters per second

(2400 bps). For more information about connecting via a dial-up telephone line, contact AIR at 723-1055.

Gandalf Connections: The Gandalf data switch allows a personal computer or terminal located on campus to connect to Stanford's computer networks. This connection is more reliable and faster than a connection via a dial-up telephone line. Information is transmitted at speeds up to 9600 bits per second or 960 characters per second. While the Gandalf generally connects terminals to Forsythe, the Stanford Data Center's IBM 3090 mainframe computer, it can also connect terminals to other campus mainframe computers.

Electronic Mail

One of the most commonly-used computer communication services, electronic mail is available to Stanford faculty, students, and staff who use computers in their work or study. Electronic mail or e-mail allows you to send and receive messages between computers on campus, across the nation, and around the world. Using electronic mail can replace some of your paper memos or telephone calls, and it allows you to keep copies of the messages you send and receive.

You may use electronic mail to keep in touch with a colleague on the East Coast, to check with another department about an upcoming meeting, or to ask a computer consulting group about a problem you are having with your microcomputer. Electronic mail also offers access to mailing lists that provide useful information on a specific topic. For example, you may put your name on a supercomputer mailing list so you can receive campus supercomputing news.

When you send an electronic mail message to someone, you do so by using software called a mail program. It helps you compose your message, address it, send it through the mail system, and deposit it in the electronic mailbox of your correspondent. Following is a list of the most commonly-used electronic mail programs at Stanford:

- **CMS Mail** is on IBM 4300 series computers using the VM/CMS Operating System, e.g., CDRVMA and Watson.
- **Contact EMS** is on Forsythe, the Data Center's IBM 3090 computer using the MVS Operating System.
- **MH** or Mail Handler can be used on Apple Macintosh and IBM Personal Computer systems. It is available with SU-Mac/IP software (Version 3.0 and all later versions). It is also available with SU-PC/IP software for IBM PC, XT, AT, and PS/2 systems (Version 3.0 and all later versions).
- **MM** is on DEC-20 computers using the TOPS-20 operating system, e.g., CSLI, GSB HOW and WHY, Macbeth, SCORE, Sierra.
- **UNIX MAIL** and **MH** are on computers using the UNIX operating system, e.g., Ararat, Polya, Portia, and Sun workstations.
- **VMS Mail** is on DEC VAX computers using the VMS Operating System, e.g., GSB-WHAT, Star, and DEC VAXstations.
- **WYLBUR Mail** is on Forsythe, the Data Center's IBM 3090 computer using the MVS Operating System.

Faculty and students can obtain free accounts on AIR computer systems for electronic mail purposes.

AIR consultants can provide advice and information about using electronic mail. To find out about obtaining an account or more information about using electronic mail, contact AIR at 723-1055.

UNIX system managers needing system assistance in setting up their systems for electronic mail can contact Liz Hayes, AIR, 723-5754 or Felix Limcaoco, AIR, 723-4942. Sendmail configuration files appropriate for the Stanford environment are available via anonymous ftp from Alleyn (36.83.0.22).

The documents *Electronic Mail Across SUNet* and *Off-Campus Computer Networks* summarize the electronic mail systems that the Stanford community can use. *A Quick Guide to Electronic Mail* describes how to use electronic mail to communicate with off-campus colleagues. Copies are available in the document racks on the third floor of Sweet Hall.

Buying, Renting and Repairing Hardware

As a member of the Stanford community, you may buy some microcomputers and workstations at discounted prices or you may qualify for a student loan program. Through your affiliation with the University, you may also utilize on-campus alternatives for computer rental, installation, maintenance, and repair. Information about these opportunities follows.

Microdisc: On-Campus Discount Program

Stanford students, faculty, and staff may make personal purchases of selected microcomputer products through the Stanford Microdisc plan at the Stanford Bookstore. Microdisc currently offers selected hardware and software products from Apple, IBM, and NeXT, as well as third-party hardware and software. Located on the second floor of the Bookstore, Microdisc features a computer demonstration area for experimentation, staff to assist you in choosing a computer, and an authorized Apple service center that offers warranty and non-warranty service. In addition, some vendors periodically offer special promotions on packages of hardware and software. For more information, drop by the Bookstore or call 329-1217, Monday through Friday, 9:00 a.m. to 5:00 p.m.

Academic departments wishing to place orders through Microdisc should contact Procurement at 723-1034 for more information.

Educational Discounts and Student Loans

Many vendors offer educational programs to university faculty, staff, and students. These educational programs may include substantial discounts or student computer loan programs. If you are planning to purchase hardware or software not carried at Microdisc, contact the vendor directly to inquire about educational discounts or loans. Microage is an alternate source for the same IBM products and discounts that Microdisc offers to Stanford students, faculty, and staff. Microage is located at 1910 W. El Camino Real in Mountain View, 964-5555.

The Apple Student Loan-to-Own Program is a plan to help college students purchase Macintosh computers. The program is designed primarily for parents of students who do not qualify for traditional student assistance programs or need to supplement federally-sponsored aid. To receive more information or to request an application, call or drop by Microdisc in the Stanford Bookstcre, 329-1217.

Zenith Data Systems' educational program includes substantial discounts to Stanford students, faculty, and staff and a student loan program similar to that offered by

Apple. Discounts range from forty-five to fifty percent off at the Heath Zenith Store in Redwood City. For more information, call 365-8155 or visit the store at 2001 Middlefield in Redwood City.

Computer Hardware Rental

Communication Services Field Operations is a group within Networking and Communication Systems that provides rental of personal computers and printers from Apple. Besides a few terminals and IBM PC's, some printers from Hewlett-Packard, DEC, or IBM may be available. As Field Operations focuses increasingly on Apple products, it will not replace non-Apple rental equipment that wears out. For more information, call 723-0577.

Installation, Maintenance, and Repair of Computer Hardware

Microcomputers and terminals may require installation or data connection service or occasional maintenance and repair. Several groups on campus provide these services.

Data and Video Connection Services: Networking and Communication Systems is the division of Information Resources that provides data connection services to SUNet, the Stanford University Network. Networking and Communication Systems installs, moves, and repairs SUNet connections for equipment such as mainframe computers, terminals, microcomputers, and printers. For details, call 723-3909.

Communication Services is a division within Networking and Communication Systems that handles all requests for data connection services via telephone lines and the Gandalf data switch. Besides maintaining all telephone voice lines, Communication Services installs, moves, and maintains telephone data lines that connect equipment such as terminals, microcomputers, and printers to mainframe computers. For installation requests, contact your department's Stanford Telecommunications Representative or STAR. For repairs, call the Systems Control Center at 723-1611.

Maintenance and Repair: Two groups on campus provide maintenance and repair for Apple Macintosh systems. The Stanford Bookstore provides Apple Macintosh computer maintenance and repair services, both warranty and non-warranty. For more information, contact the Bookstore at 329-1217. Communication Services Field Operations also provides warranty and non-warranty maintenance and repair for Apple Macintosh family of computers, printers, and other related peripherals. You drop off your Apple equipment for repair. If you request it, once the repair is finished, Field Operations will deliver it to you free of charge. For more information, call 723-0577.

For a sampling of maintenance options for a printer, personal computer, or terminal from other vendors, you may want to consult the flier *Maintenance Alternatives for Personal Computers and Peripherals*. Found in the documents racks on the third floor of Sweet Hall, this flier covers both maintenance contracts and time and materials maintenance services available from off-campus facilities.

Acquiring Software

With software such as word processors, databases, and spreadsheets, you can accomplish many kinds of work on a computer. Generally, when you use a Stanford computer system, the software you require is provided. However, you must purchase the software you need for your own microcomputer or workstation.

Stanford's Software Copying Policy

Stanford's policy on copying computer software states that "unlawful software copying is not permitted." The policy applies to all Stanford faculty, students, and staff and pertains equally to "software for microcomputers, minicomputers, mainframes, or any other device." Details about the policy are presented in a handout, *Guidelines and Information on Software Copying*. Included is a description of your responsibility as a member of the Stanford community to comply with laws and contractual obligations in connection with software, and an outline of the sanctions for violation. These sanctions can be as severe as termination of employment or student status. For a copy of *Guidelines and Information on Software Copying*, contact AIR, Sweet Hall, Third Floor, 723-1055. The guidelines are also found online by typing **help copyright** in response to the @ prompt when connected to Macbeth; or Hamlet. You do not need an account on the computer.

Discounted Microcomputer Software

Discounted software for microcomputers is available through Microdisc, located on the second floor of the Bookstore. This includes software from Apple, Claris , and Microsoft for the Apple Macintosh and software from Microsoft and Lotus for IBM PC's and compatibles. See Microdisc for their software product and price lists. For more information, drop by the Bookstore or call 329-1217, Monday through Friday, 9:00 a.m. to 5:00 p.m. Stanford students, faculty, and staff can make personal software purchases through Microdisc, and departmental software purchases can be made through Microdisc. To order software through Microdisc, academic departments should contact Procurement at 723-1034.

Departments can make direct purchases of discounted software for Apple and IBM personal computer systems and a full line of computer supplies through Stanford Central Stores, 330 Bonair Siding, 723-9606. Hours are Monday through Friday, 8:00 a.m. to 4:30 p.m. All purchases must be charged to a University or Hospital account.

Through Electrical Engineering Stores, Stanford students, faculty, and staff can purchase discounted software and computer supplies for use in University research or academic programs. Payment is by cash, check, or charge to a University or Hospital account. You can stop by EE Stores in the Electrical Research Laboratory or call 723-1791. Hours are Monday through Friday, 8:00 a.m. to 4:30 p.m.

Many vendors do offer educational discounts to faculty, students, and staff. Therefore, if you are considering purchasing personal purchases of software not available through Microdisc, contact the vendor directly to inquire about discounts.

Software Licenses

AIR participates in the negotiation of software licenses to aid the Stanford community in identifying software available at a cost savings. Licenses range from those that allow Stanford faculty, staff, and students to acquire commercially-available software for their personal use to those for software used on campus mainframe computers. Licenses are available for software used on microcomputers, for UNIX operating system and utility software, and for software used on DEC computers. For details about software licenses at Stanford, contact AIR, 723-1055.

Microcomputer Software Licenses: The Stanford Bookstore; has site licenses for the following microcomputer software:

- **Notebook II** from ProTem, a text-oriented database for IBM PCs;
- **PC TeX** from Personal TeX, Inc., a computer typesetting program for IBM PCs;

- **TeXtures** from Blue Sky Research, a computer typesetting program for Apple Macintosh computers;

These programs are available at Microdisc in the Stanford Bookstore. You can see demonstrations of the software there. For details, contact the Bookstore at 329-1217.

Stanford University has a site license for the statistical analysis package SAS PC. SAS PC runs under the DOS operating system on IBM PC's and compatibles. A full function statistical package, SAS PC is a complete implementation of the SAS system available on other mainframe computers on campus. The following products are included in the site license: Base SAS, SAS/Stat, SAS/Graph, SAS/IML, SAS/FSP, SAS/ETS, and SAS/AF. Microdisc handles purchases of the license, and AIR distributes the software and coordinates updates. The license must be renewed annually. For details, contact Janet Lasher, AIR, 723-1518, janet@air.

UNIX Operating System and Utility Software: AIR acquires campus-wide licenses for the most popular releases of UNIX; currently, these are: SunOS, ULTRIX, IBM AOS 4.3, the NeXT OS, Apple A/UX, Berkeley 4.3. Generally, AIR handles on-campus distribution of the different flavors of the UNIX operating system and utility software. Licensing arrangements include rights to new operating system releases. AIR also distributes important site licensed and public domain utility software for UNIX systems. For licensing information, contact Cathy Smith, 723-4378, csmith@air.

Software from DEC: Information Resources has made arrangements with Digital Equipment Corporation (DEC) to participate in three DEC programs that significantly reduce the costs of Digital software for the VMS and ULTRIX environments:

- The Campus Software License Grant Program (CSLG)
- The Education Market Basket (EMB)
- The Education Software Library (ESL)

The Campus Software License Grant Program grants licenses for more than 160 VAX software products at no charge to campus owners of DEC computers. The license portfolio includes the VMS operating system, and VMS and ULTRIX layered products. The ULTRIX operating system is also granted to VAX processors under Stanford's AT&T site license agreement. The Education Market Basket includes many additional licenses not included in the CSLG. The EMB offers program licenses at specially reduced prices. The CSLG and EMB provide licenses for VAX software; media, documentation and support for the licensed software products are available through either the Education Software Library or through the purchase of media/documentation kits and support services from Digital.

The Education Software Library provides media, documentation, support, and software updates for 42 VAX software products including the VMS and ULTRIX operating systems, VAX compilers, and many VMS layered products. Campus DEC computers may be enrolled in the ESL for a very modest annual subscription fee which varies depending on the central processing unit type. Enrollment provides access to software media, including updates, local technical support with access to Digital technical support, and documentation purchases at a 50 percent discount.

Many Stanford DEC computer owners are already taking advantage of these programs, enabling them to run new programs, and newer versions of old programs, at very reduced costs. To join or find out more about these programs, VMS system owners can contact Mike Durket, Stanford Data Center, 723-2866, gg.mpd@forsythe; ULTRIX system owners can contact Cathy Smith, Academic Information Resources, 723-4378, csmith@air.

Software Distribution: The Office of Technology Licensing

The Office of Technology Licensing (OTL) provides a means to distribute software created by Stanford faculty, students, and staff. Currently there are approximately 75 programs distributed through OTL in the following manner.

The Software Distribution Center handles direct licensing of software to academic and commercial organizations for internal use only. The center maintains a catalog of Stanford software currently available. It also provides distribution, tape production, mailings, appropriate license agreements and other services. If you are interested in utilizing the Software Distribution Center's services, please contact Jane McLean at OTL, 723-0651 or via electronic mail, cs.jml@forsythe.

Commercial licenses allow a company to distribute Stanford software as one of its own products. The form that distribution takes depends on the agreement reached with the company. The company may provide technical support and marketing or supplement it with other commercial application programs. In return for the right to distribute the software commercially, a royalty bearing license agreement is arranged. For more information, contact Dave Charron at OTL, 723-0651, or via electronic mail, ca.dav@forsythe.

Library Computer Services

The Stanford University Libraries provide several computerized services for faculty and students.

Socrates

Socrates is the computerized online catalog of the Libraries of Stanford University. It contains records of approximately half of the Libraries' collections: all items in the Meyer Memorial Library and records for items acquired since 1973 for the Green Library and branch libraries. It also holds records of materials acquired since 1977 in the coordinate libraries: the Hoover Institution Library, the Jackson Business Library, the Lane Medical Library, and the Robert Crown Law Library. The SU Libraries are working to add records for pre-1973 acquisitions to Socrates.

Socrates is available through the Folio system 24 hours a day, except for early morning hours on weekends and Thursdays. Through the Folio system, you can electronically mail or copy Socrates citations to most other campus computers. You can also print citations or save them to a disk on your microcomputer.

Socrates terminals can be found at Green and Meyer Libraries, all the branch libraries, the Law Library, and the Hoover Institution Library. Socrates terminals are always logged on to Folio and ready to use. Currently, there are printing facilities at Green and Meyer. You can also use a personal Folio account to search Socrates from terminals or microcomputers in your home or office, or in public terminal areas on campus. To obtain a Folio account, present your Stanford ID at the service desks in the libraries where Socrates terminals are located. Use of Socrates is free to the Stanford community.

Although Socrates is self-teaching and easy to use, the Libraries provide workshops for faculty and students to learn about the system. Green Library offers hands-on, introductory Socrates workshops using Apple Macintosh computers and a workshop for advanced Socrates users. Other libraries on campus also provide introductory Socrates instruction on a one-to-one or group basis, upon request or as part of a scheduled series. For more information, contact the General Reference Department at

Green Library, 725-1065. *Socrates: A User Guide to the Online Catalog of the Stanford Libraries* and a two-page *Reference Guide to Socrates* are available at library reference and service desks.

Computer Search Service

The Computer Search Service provides faculty, students, and staff with access to hundreds of databases covering virtually all fields—engineering and technology, life and physical sciences, social and behavioral sciences, humanities, business, law, and current events. These databases contain references to journal and newspaper articles, technical reports, conference proceedings, patents, dissertations, government documents, books, and statistics. Many databases include summaries of items and some offer full text. Often you can have your results downloaded to a microcomputer diskette. Your options for access include searches of:

- online databases that the library staff do for you,
- online databases that you do yourself, and
- CD-ROM (Compact Disk Read Only Memory) databases that you do yourself.

Costs for these searches vary; some searches are free, some cost a $5 flat-fee, and others are based on a sliding scale. The Support for Online Searching (SOS) program enables library staff to accomplish an online search on any topic for qualified Stanford students for a flat-fee of $5. To qualify for the reduced rate, students need to complete a form and obtain the signature of a faculty member who attests that the search is in support of the student's honor's thesis, master's thesis, dissertation, or other significant research. These forms are available at most libraries.

Unlimited online access to the Physics Briefs database is furnished free of charge through the Physics, Engineering, and Earth Sciences Libraries. Online access to the Chemical Abstracts database is provided by the Chemistry, Engineering, and Earth Sciences Libraries at 15 percent of the normal cost.

Meyer Library offers a free, easy-to-use, do-it-yourself online option to Stanford students and faculty. Over 70 databases covering a wide range of subject areas are available for searching on a system called Knowledge Index. There is a limit of three thirty-minute search appointments per quarter. Many libraries offer free, easy, do-it-yourself access to CD-ROM databases such as Dissertation Abstracts, Modern Language Association Bibliography, Medline, Life Sciences Collection, LegalTrac, Hydrodata, IEE/IEEE Publications, NTIS, and ERIC. Hours of availability and length of search appointments vary. Library staff throughout campus or the Data and Information Services Librarian at Green Library (725-1054, cn.dat@forsythe) can answer questions about the Computer Search Service.

Academic Data Service

The Academic Data Service (ADS), a joint endeavor of Stanford University Libraries (SUL) and Academic Information Resources (AIR), is a coördinated service program for the acquisition and use of research materials in machine-readable form. Over a period of years, SUL has acquired diverse data for the Stanford community from the Inter-university Consortium for Political and Social Research (ICPSR), the Roper Center, other data archives, and government agencies. There are now more than 700 data files. They cover a wide range of topics and time periods and include census records, election returns, public opinion polls, and international financial statistics. All data files obtained by SUL are listed in Socrates, the online catalog.

Stanford faculty and students may access the machine-readable data files of the Academic Data Service, and process the data with statistical packages such as SAS and SPSS^x by using Watson, the IBM VM/CMS system operated by AIR. For complete details about locating and using ADS data files, see the document, *Academic Data Service Users' Guide*, available from the Green Library Reference Desk or the document racks on the third floor of Sweet Hall. For more information about the Academic Data Service, call Eddy Hogan, Green Library, 725-1054, cn.dat@forsythe or Felix Limcaoco, AIR, 723-4942, fkl@air.

Online Information Sources

At Stanford there are a variety of information sources available through mainframe computers. These sources provide an easy way to share or obtain a variety of information and to communicate with other computer users.

Folio

Folio is an online system that gives Stanford faculty, students, and staff easy and convenient access to a variety of information at Stanford. Folio is available on the Forsythe computer all day, every day. It gives more up-to-date and complete access to information than is possible in traditional paper files. Although experts can omit them, instructions guide novices at every step.

Folio includes the following files of information. New files are added periodically.

- **Socrates** (Online catalog of the Libraries of Stanford)
- **Other Bibliographic Files**

HBR	Abstracts and full text from recent articles in the Harvard Business Review
Hoover Posters	Hoover Poster Collection
IR Newsletters	Articles from various Information Resources newsletters, including *Speaking of Computers* and *Around the Office*
MLK Bibliography	Martin Luther King, Jr., bibliography
Reserves	Reserved reading at Meyer Library
Stanford Bookstore	Catalog of the Stanford Bookstore

- **Academic/Advising Files**

Awards	Graduate and undergraduate scholarships and fellowships
Course Guide	ASSU Course Guide
Faculty Interests	Research interests of the Stanford faculty
Odyssey	Student internships and research opportunities
Student Activities	Voluntary student organizations

- **General Public Information**

Community Info	Services available to San Mateo County residents
Investments	Stanford University investment information
JOBS	Job opportunities bulletin for staff
Off-Campus Housing	Off-campus rental housing listings
Public Events	Public events calendar
Student Jobs	Jobs available to students on financial aid

You may search these information files at public Folio terminals in:

- most campus libraries,
- the Career Planning and Placement Center on White Plaza,
- the Off-Campus Housing Office in Old Union,
- the Public Service Center in Owen House,
- the Stanford Bookstore,
- the Undergraduate Research Office in Sweet Hall,
- the Undergraduate Advising Center in Sweet Hall, and
- Bechtel International Center.

You can also use a free Personal Folio Account to log on to Folio from terminals, microcomputers, or workstations in your dorm, home, or office, or in public terminal areas on campus. To obtain a Folio account, present your Stanford ID at one of the locations listed above, or at the service desk at most campus libraries.

Folio is a cooperative effort between Information Resources, the Libraries of Stanford, and other campus offices. For more information about Folio, contact Tony Navarrete at the Stanford Data Center, 723-1662.

On-Campus Electronic Bulletin Boards

Electronic bulletin boards, often called bboards, offer a convenient way for you to communicate with others—across campus or across the country. You can use electronic bulletin boards to convey or obtain information about almost any subject you could imagine. Electronic bulletin boards are similar to non-computerized bulletin boards; they both allow you to read or post notices. But electronic bulletin boards offer greater freedom: wherever there is a terminal, microcomputer or workstation that connects to Stanford University's computer networks, the bulletin board comes to you.

A wide variety of bulletin boards are available via Stanford's computer networks. Although direct personal computer access is under development, you must currently login to a mainframe computer to access bboards. To find out how to access a bulletin board on a TOPS-20 system operated by AIR, type **help bboard** in response to the @ prompt. To find out how to access a bulletin board on the Forsythe computer operated by SDC, type **help bboard** in response to the *Command* > prompt. For information about bulletin board access on other on-campus mainframes, contact the department or system administrator responsible for the mainframe.

There are two popular bboard systems on campus: SU bboards and Usenet bboards.

SU Bboard System: You can access the SU bboards on many campus computers (e.g., Macbeth, Polya, GSB-How, Sierra, Forsythe). These bulletin boards cover a variety of topics including computing, upcoming events, employment listings, and items for sale. Following is a list of some of the SU bboards and their subject areas.

• SU-Computers	Comments or questions concerning computer software and services
• SU-Events	Announcements of seminars, concerts, and other events on or off campus
• SU-Jobs	Help wanted and offered listings
• SU-Macintosh	Questions, answers, comments on the Apple Macintosh

- SU-Market — Items for sale; comments on merchants and services
- SU-Etc — Notices not appropriate for other SU bulletin boards

Usenet Bboard System: Usenet is a worldwide computer network for UNIX systems. Its bboard system is available through Stanford UNIX systems such as Portia. The way you access the Usenet Bboard System varies, depending on which UNIX system you are using. To access this bboard system on Portia, type **rn** at the *Portia>* prompt.

Through Usenet you can access some 600 bboards (also called newsgroups on UNIX systems), which cover a wide variety of information. For example, the ***comp*** topic area covers discussions related to computer issues. Examples of bboards under the comp area are: ***comp.sys.sun*** and ***comp.unix.ultrix***. These bboards are related to discussions of Sun workstations and the Ultrix operating system, respectively. Note that it is possible to access the SU Bboard system through the ***su*** topic area.

Consortia

This a sampling of the consortia in which Stanford University holds membership. It is not intended as an exhaustive list.

Apple University Consortium (AUC)

Begun in December 1983, the AUC consists of 33 colleges and universities chosen by Apple to integrate the use of the Macintosh computer into higher education. Besides Stanford, the consortium includes schools such as Carnegie-Mellon, Harvard, Dartmouth, and the University of Chicago.

AUC members exchange information about their Macintosh development activities on campus and compare ways to integrate microcomputers into the academic curriculum. At Stanford, equipment and software provided by Apple through the AUC have allowed the faculty to author instructional materials on microcomputers and students to complete class assignments requiring the use of microcomputer software. For more information about the Apple University Consortium, contact AIR at 723-1055.

DEC University VAXstation Consortium

Stanford is a member of the DEC University VAXstation Consortium. It is a forum by which universities express their needs in terms of Digital Equipment Corporation's VAXstation product direction. As a result of Stanford's participation in this consortium, academic departments can purchase DEC workstations off the Consortium's price list. This list reflects averages of 50 percent discount on regular retail prices for both VAXstations and DECstations. For details, call AIR, 723-1055.

EDUCOM

Founded in 1964, EDUCOM is a non-profit consortium of over 500 colleges, universities, and other institutions committed to the introduction, use, and management of information technology in higher education. EDUCOM is funded by membership dues, service fees, and grants from foundations, corporations, and government. The organization is governed by a member council and a board of trustees, and maintains a staff in Princeton, New Jersey.

As a member of EDUCOM, Stanford can take advantage of services that include an EDUCOM Consulting Group that provides evaluation and recommendation on uses of information technology; the BITNET international computer-to-computer communications network for higher education and research; and the activities of the Educational Software Initiative, a series of task groups working toward the encouragement of educational software development use, software accessibility, and the effective delivery and pricing of instructional software.

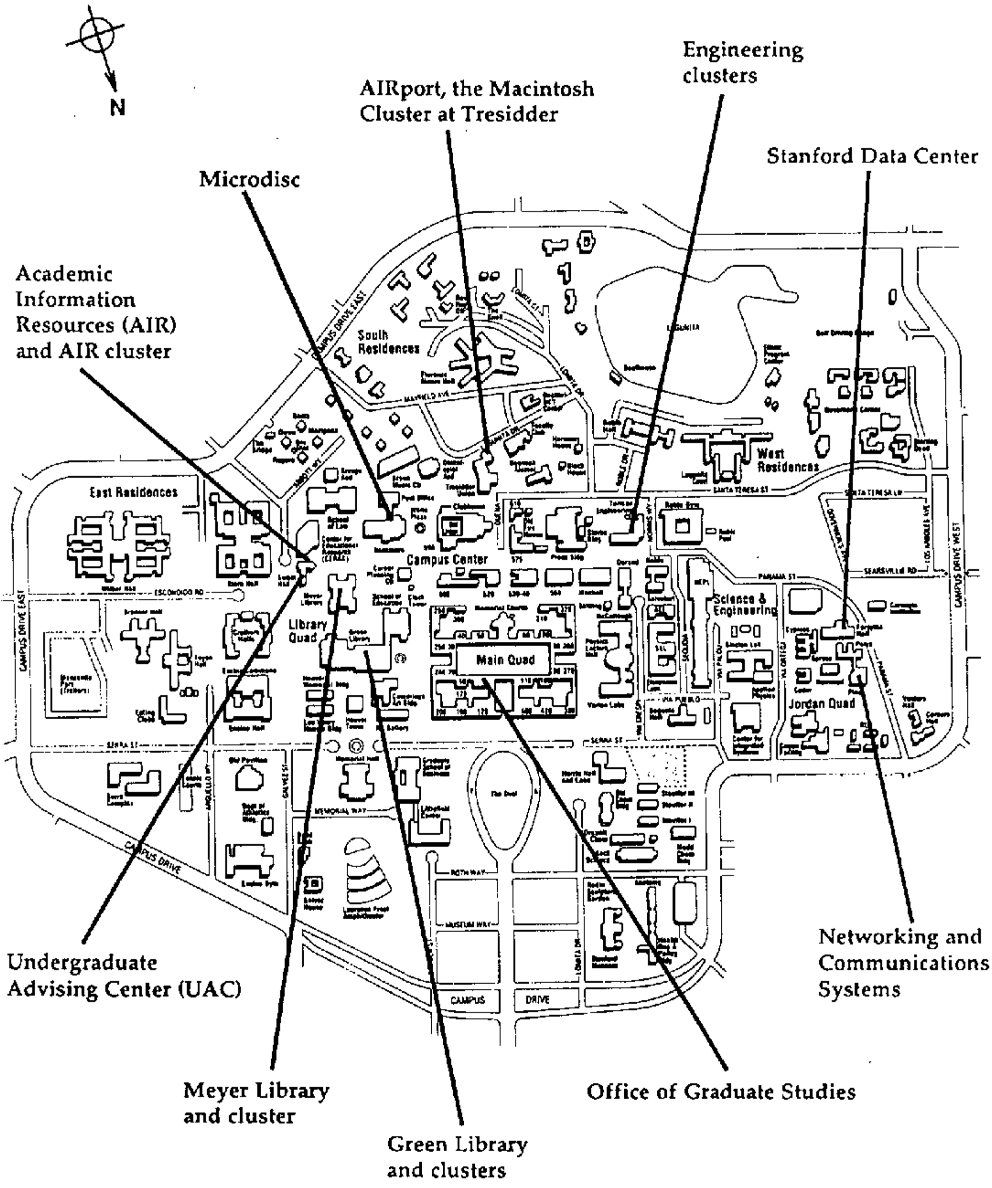
Inter-University Consortium for Political and Social Research (ICPSR)

Stanford is one of 300 members of ICPSR, which is headquartered at the University of Michigan in Ann Arbor. For more than two decades, ICPSR has served social scientists around the world by providing:

- a central repository and dissemination service for machine-readable social science data;
- training facilities in basic and advanced techniques of quantitative social analysis; and
- resources that facilitate the use of advanced computer technology by social scientists.

As an institutional member of the consortium, Stanford can request data files and codebooks from ICPSR's extensive tape archive and can send representatives to institutes and workshops in Ann Arbor. For more information, contact the Stanford ICPSR liaison, Eddy Hogan, General Reference Department, Green Library, 725-1054, cn.dat@forsythe.

Appendix: Stanford University Map



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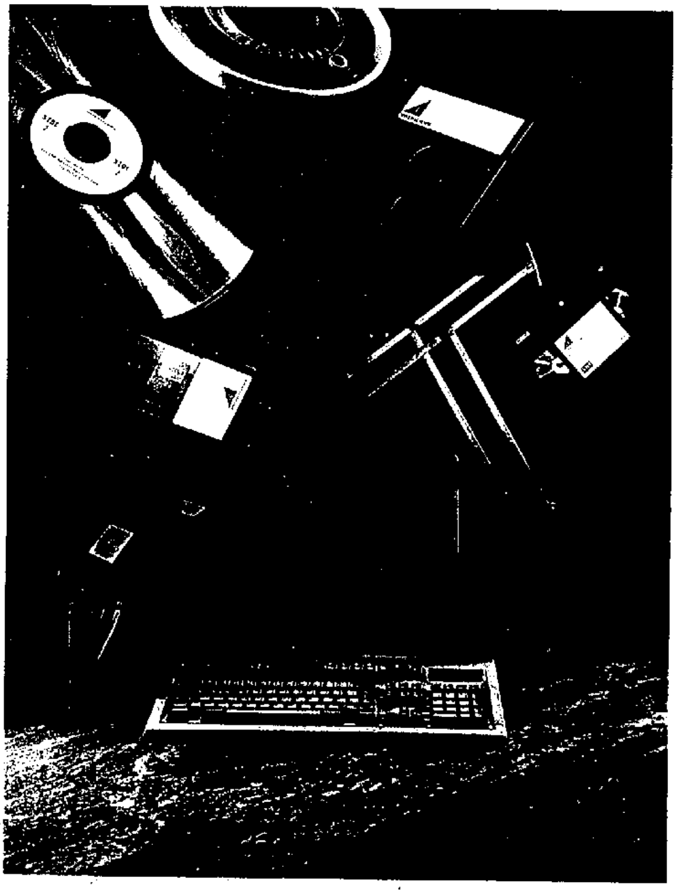
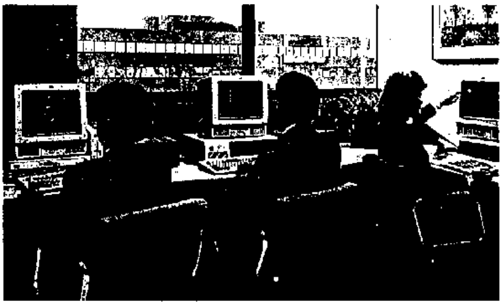
ABOUT COMPUTING AT STANFORD

STRATEGY FOR WINNING



Applied Learning is the world's largest training organization. Our unique combination of consulting services, courseware and custom development capabilities develops the skills necessary to implement our clients' strategic objectives.

PERFORMANCE THROUGH PEOPLE



As competition intensifies in the 1990s, fueled by a growing worldwide market, investment in people will be a major contributor to gaining competitive advantage.

More than ever before, employees will need to be ready to perform to a standard of excellence for their companies and customers. Organizations will need to use their technology to achieve that critical advantage over rivals – by making it easier for customers to do business with them, by improving their quality of service and by paring down their operational costs. In short, the challenge facing business and industry is one of competitive readiness. Applied Learning works in partnership with clients to develop a vision for the future – a vision that provides the strategies and methods to ensure their readiness to compete and to improve their performance through people.

"Information technology is a tool that keeps us ahead of the competition. Applied Learning helps us keep pace with the high demands we place on our computers and our data processing professionals. Applied Learning's interactive videodisc instruction helps us provide the best and fastest training for our applications programmers."

Transamerica Insurance Services

THE APPLIED LEARNING SOLUTION

A new economic framework is emerging. It is dominated by a shift to a service economy where the scarce resource will be knowledge' rather than people.

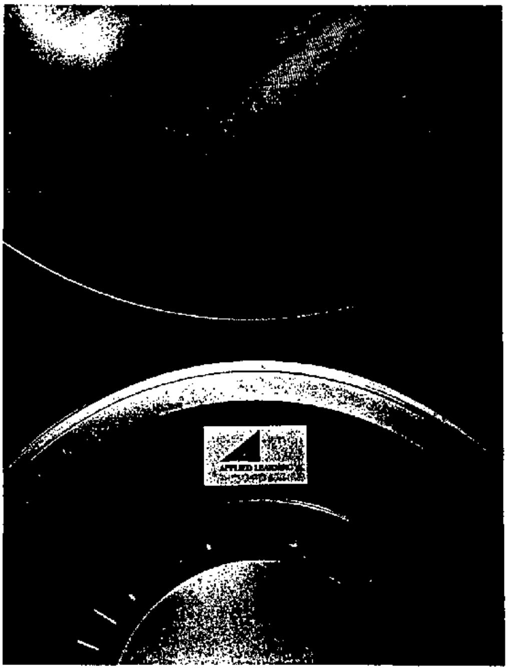
The evidence is overwhelming that people are the driving force behind economic growth. Unfortunately, too many workers lack the skills to perform more demanding jobs and haven't yet acquired the new skills necessary to replace those that are outdated. In other words, our ability to compete is threatened by inadequate investment in human capital.

Applied Learning specifically targets this problem. We help clients move away from a "fragmented" approach where training is a peripheral activity, to a "focused" approach where the development of people is the lifeblood of the organization.

This approach emphasizes that much of the training is done in the workplace, with learning becoming a totally continuous activity. Line managers and individuals themselves assume the main responsibility for development, while trainers adopt a wider role as agents of change.

Improved performance through people is made possible by our unique combination of consulting services, courseware and custom development capabilities. Applied Learning is the world's largest training resource, working in partnership with over 7000 clients through a network of 81 worldwide locations. We are ideally positioned to ensure your people have the skills of excellence and your organization achieves a state of competitive readiness.

SKILLS FOR THE FUTURE



"We turn to Applied Learning to help us increase the productivity of our human and capital resources. Applied Learning found what skills we needed, built training centers in New York and Chicago, and is keeping them on target with on-site facilities management consultants. They are helping us reach a key strategic goal: maximizing our investment in technology."

Dean Witter

The Applied Learning program includes an outstanding range of interactive courseware to help organizations get the best return on investment in people and technology. A partnership with Applied Learning gives you the opportunity to access our state-of-the-art training library – over 10,000 hours of training. This resource is designed to bridge almost every skills gap in your organization.

Technology Management – an innovative range of Information Technology perspectives to spark the vision of senior management. The series includes objective information about new technologies, planning technology strategies to meet business objectives and equipping your organization to take advantage of the changes in IT.

Information Processing Skills – a dynamic series to build skills in every discipline in the information processing environment. This unrivaled selection of courses will trigger the faster and more effective implementation of your systems.

End User Computing – training to satisfy the demands of both advanced and inexperienced users in every department in your organization, using IT to improve productivity and performance.

Human Resource Development – courses to develop individuals to their highest possible performance level. Practical and lively training covering management and supervisory skills, sales and marketing, interpersonal and business skills.

Manufacturing and Industrial Skills – training to cut the time it takes to manufacture a product and to integrate quality into every aspect of production.

TECHNOLOGY-BASED TRAINING

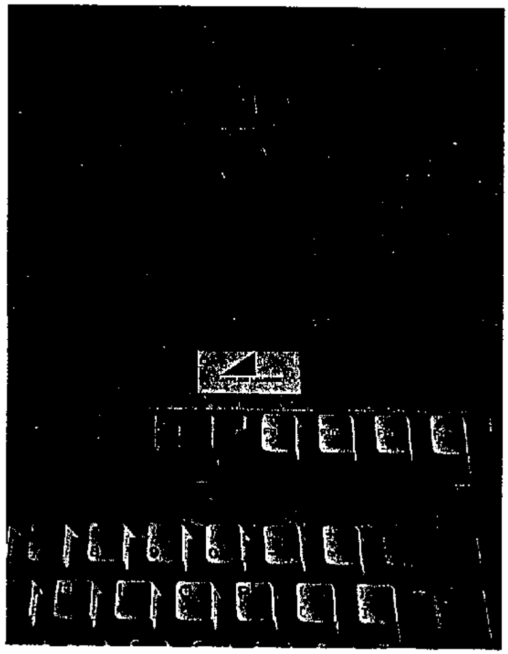
The personal computer on many desks, the mini-computer serving various departments and the mainframe at the heart of the organization are poised to provide the power to transfer skills directly to each learner.

Applied Learning is a world leader in the development of Technology-Based Training – Interactive Video Instruction (IVI) and Computer-Based Training (CBT). These techniques are collectively known as Distance Learning because there is no need for an instructor to be there all the time.

Applied Learning has pioneered the application of the latest interactive technology to learning and we are committed to maintaining this position. Our product development includes constant modifications and refinements that extend far beyond the initial release of courses.

Sound instructional design by our team of over 250 training and subject experts ensures that the training achieves its objectives. A six-step product development process and quality assurance team certifies every course for accuracy of content and software integrity.

In addition to our in-house expertise, Applied Learning has established relationships with acknowledged subject and industry experts. This results in a constant flow of high quality Distance Learning courses that reflect the changing skills requirements of our clients.

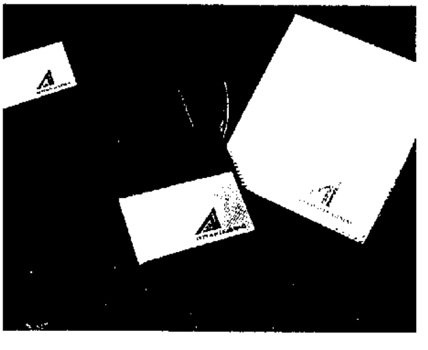


A BETTER WAY TO LEARN

PERSONALIZED	Offers each individual a personal training path by assessing existing knowledge – so they don't get out of their depth or go over ground already covered.	CONSISTENT	Guarantees uniformity of training throughout the organization. Your message is communicated in the same way every time.
INTERACTIVE	Simulates live experiences with opportunities for exercise and practice. Errors are made in simulated situations, not real ones.	INVOLVING	Employs a range of effects not practical with any other single presentation (moving pictures, still pictures, voices, music and graphics).
EXCITING	Combines the flexibility of computers with the impact of television.	MEASURABLE	Progress can be evaluated and results measured.
COST EFFECTIVE	Based on the principle of learning by doing – so employees learn faster and retain more.		

"We developed a training path for each job and looked for suitable material to support it. Distance Learning is one of the techniques we use to deliver the training we've selected. It allows us to be flexible – someone can arrive on Monday morning and start training by Monday afternoon – regardless of their skills level. Applied Learning proved to have the best courseware and provided a strong team to help us set it up."

Ford Motor Company



CONSULTING SERVICES

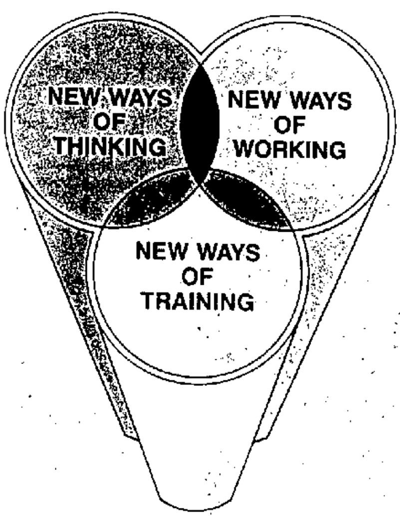
The Consulting Services division helps organizations to develop a vision for the future.

We design performance strategies and build training programs to meet the overall objectives of the organization, to implement the resulting change through each department and to improve the performance of each individual.

New Ways of Thinking – Consulting Services identifies the culture and attitude changes necessary to accommodate new ways of working and to improve performance through people.

New Ways of Working – We enable you to implement and manage the changes throughout the organization by gaining department-wide adoption of change through the commitment of each individual.

New Ways of Training – We are uniquely placed to design and develop tailor-made training programs to clients' specific needs. This unrivaled position is possible because of our 20 years experience of building state-of-the-art training solutions.



INITIATIVES FOR CHANGE

Through our work with Fortune 1000 corporations, Applied Learning has an in-depth perspective on the business challenges facing organizations today.

We know how corporate training initiatives can be used to fulfill a planned strategy because we have a thorough understanding of our clients and the markets in which they operate. Financial Services, Manufacturing, Retailing, Government and the IT sector are just some of the areas where Applied Learning has designed a variety of business solutions.

Applied Learning consulting teams work in close partnership with client management to develop the technology, skills and organizational strategies needed for total performance readiness.

By studying **your** needs and identifying **your** priorities our consultants will work with you to develop initiatives for change and subsequently to implement them.

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"We decided to launch a major partnership with Applied Learning's Consulting Services division because of its expertise in training for high-tech manufacturing technology. This division is overseeing the entire project from planning to implementation, and is able to offer us a total training service with a seamless join between custom training, off-the-shelf training and consulting."

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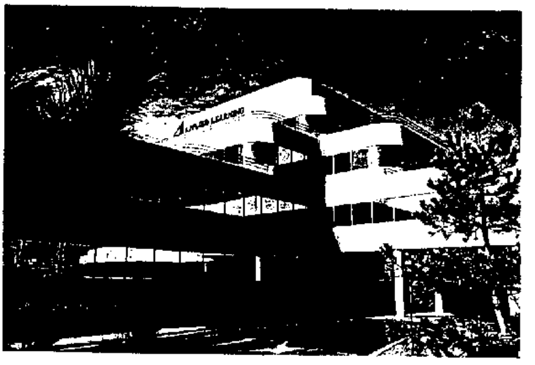
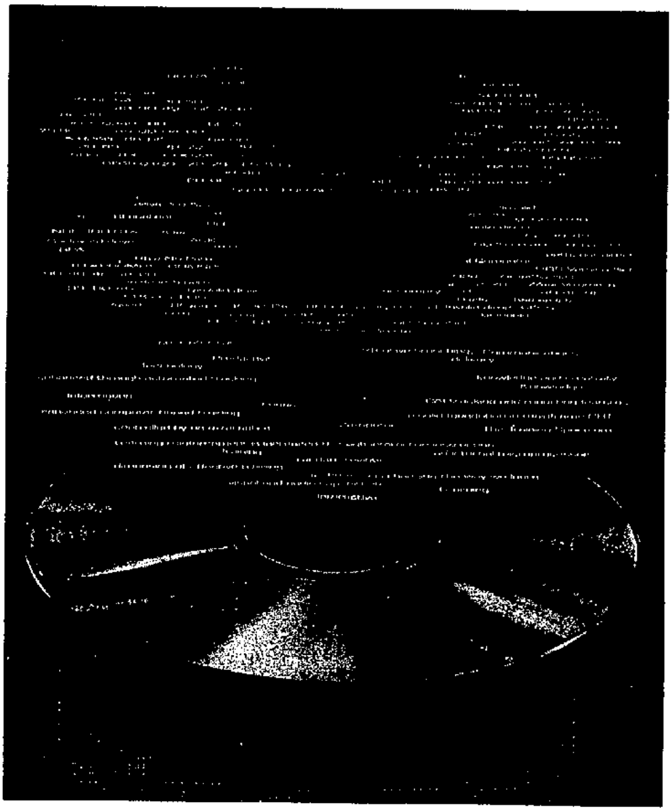
Our commitment as your **strategic training partner** is to offer the best in-depth client service and support in the training industry.



APPLIED LEARNING

HOW TO MAKE IT HAPPEN



To find out more about how to improve performance through people, please contact your nearest Applied Learning office.

"Applied Learning helps us align technology training with our overall business plan. They've helped us to establish Learning Centers and provided consulting support to ensure that we capitalize fully on our investments in new technology. As a result, we maximize our competitiveness in the world airline market."

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Applied
Learning
International

Meeting the Performance Challenge

Closing the gap between worker competence and workplace requirements will be the major issue in organizational development throughout the 1990s. Demographics show that fewer entry-level workers will be available; many of them will lack the skills needed to handle complex tasks of sales, manufacturing, and service work. And yet *worker productivity* will be the prime determinant of competitive success in the global economy of the 21st century.

Applied Learning International is committed to helping corporations meet the productivity challenge. We have more than 50 years of leadership experience in the development of innovative training systems for improving employee performance. Building on that experience, we began in the mid-80s to design and implement what we call "*Performance Systems.*" Unique in both approach and effectiveness, these systems provide our clients with a continuing process for developing and maintaining employee performance.

At the core of a Performance System is our ability to forge a synergistic link between client strategies and technology-based learning environments. Working in partnership with our clients, we tailor a cost-effective system that assures worker competence as well as the consistency and currency of worker skills. The result is increased productivity and enhanced readiness to perform—with measurable benefits to profitability.

Applied Learning's Performance Systems have been designed for numerous Fortune 500 companies in diverse industries, including financial services, manufacturing, and transportation. Each of these clients was driven by a vision of individual and corporate excellence. We are pleased to have been their partner, sharing in and helping them achieve this vision.

In the pages that follow, we invite you to consider this proven approach to achieving performance through people.

Kenneth G. Riedlinger

Kenneth G. Riedlinger, President
Applied Learning International

The Applied Learning Performance System

Over the past three decades, information systems have revolutionized American business by coordinating and transforming *data* into a valuable strategic asset. Technology made storing and distributing information economical, and corporations implemented ever more powerful means of bringing timely and accurate information to their workers.

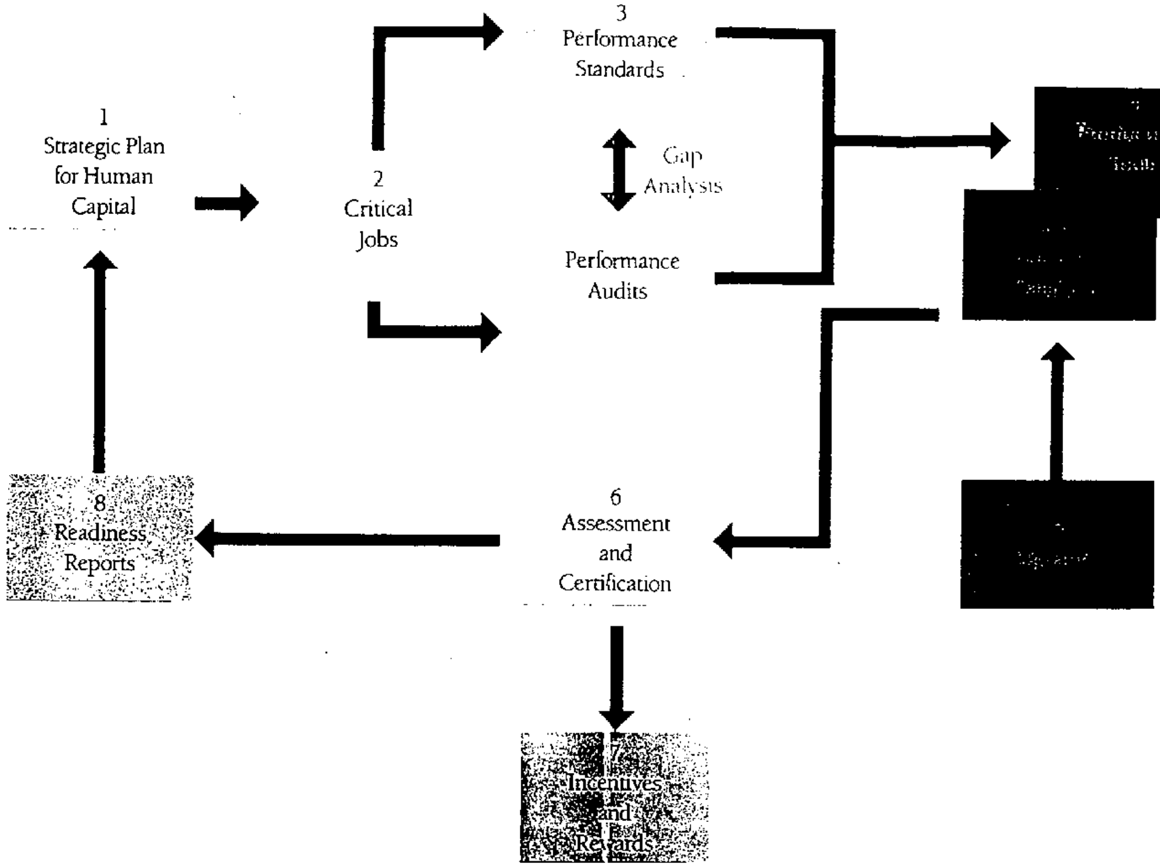
If companies are to close the widening "competence gap," the next generation of information systems must develop and distribute not just data, but *knowledge and skills*. Most corporations to date have found few economies of scale for what has traditionally been considered the labor-intensive "training problem." Even fewer companies link human resource development to strategy: historically, corporations assess performance only in terms of "training days delivered," not the "readiness" of employees to do their job.

For many corporations, meeting the performance challenge seems too complex, too time-consuming, and too expensive to tackle with the same creativity and determination required to overcome other large-scale, strategic problems. What has been fundamentally missing is an approach—one that is performance-based, cost-effective, and capable of keeping pace with changes in strategy, products, and processes.

The cost-efficient linkage of strategy to performance forms the basis for Applied Learning's next-generation information system, which we call the *Performance System*. Each element within the system gains in focus and value from the elements that precede it. This closed-loop model generates a self-renewing dynamic of continual improvement and relevance to current needs. The result is an economical, well defined process that enables our clients to:

> Better assess their human resource requirements.
> More quickly respond to changes in their products, processes, and markets.
> Improve their ability to define and motivate superior performance.
> Effectively monitor and evaluate individual skills in terms of readiness to perform at superior levels.

In short, to make their strategies fully operational in today's dynamic international markets.



The Performance System model optimizes productivity through the following eight elements:

1. Strategic Plan: We work closely with our clients to define the human capital requirements for success in realizing short- and long-term business objectives.

2. Critical Jobs: We help identify the critical jobs needed to implement the strategic plan.

3. Performance Standards and Audits: We then define excellence in these critical jobs in terms of the knowledge and skills of superior performers. We conduct baseline audits to learn where employee performance falls short of the standards of excellence. "Gap analysis" targets specific areas requiring additional performance improvements.

4. Technology-Based Courseware and Productivity Tools: Our performance experts develop a knowledge and skill database that can be accessed by individual employees. We integrate proven instructional design technology with a selection of appropriate delivery media to ensure that employees receive only the information they need, when they need it. And, to protect our clients' information systems investment, we analyze their technology infrastructure so our systems can link to existing information networks.

In addition to technology-based performance improvement programs, Applied Learning designs workflow-based productivity tools, such as desk-top sales aids and expert systems.

5. Updating: Courseware updating is a critical factor in assuring that the learning experience meets ever-changing corporate strategies. New information must be periodically fed into the system, and update briefings should be available to inform employees about the existence of new material. Despite constant changes to the learning environment, the system should always provide the employee with quick access to critical refresher material as needed.

6. Assessment and Certification: We develop procedures to assess and certify that the performance improvement program and tools are in fact bringing skills and knowledge up to the desired standards of excellence. These procedures include measures of actual *performance benefits* that result from training and tools (for example, an increase in sales commissions) as well as measures of *performance readiness*, or the capacity to perform. Mastery tests are created within learning materials to indicate when the employee has successfully met course objectives.

7. Incentives and Rewards: Motivation is an essential element of performance. By linking incentives and rewards to readiness, the model ensures that employees will have the motivation to maintain the current knowledge and skills required to achieve desired levels of productivity.

8. Readiness Reports: The feedback loop is closed with readiness reports that detail employee preparedness in key areas such as product knowledge, technical knowledge, and interpersonal skill levels. Performance can be managed if it can be measured, and readiness reports provide the needed measurement feedback.

System Staging and Rollout

Performance Systems are often implemented in three stages to minimize workplace disruptions and to allow opportunities for progressive evaluations. In the first stage, employees receive training based on individual needs. In the second stage, clients add updating mechanisms and processes for certification and monitoring. In the third stage, the assessment of readiness is linked to a performance appraisal and monitoring system and expert system tools are created. In this way, the Performance System is introduced in an evolutionary manner and smoothly integrated into the company's operating procedures.

Measuring Results

As a Performance System is implemented, clients can expect to see significant results. For each client, we develop a return on investment model so bottom line improvements can be projected and tracked. As the accompanying table shows, return on investment flows from three primary sources: increased revenues, decreased costs, and improved quality. The resulting effects on profitability are sustainable due to the constant updating and feedback built into the system.

Sources of Return on Investment from Performance Systems

Increased Revenue
> Shorter learning curves for earlier productivity
> Increased productivity through focused training
> Sustained productivity through updates and reviews
Decreased Costs
> Fewer hiring mistakes
> Lower turnover
> Reduced errors and rework
> Better deployment of training resources
Improved Quality
> Greater customer satisfaction
> Consistency of product/service delivery
> Improved responsiveness due to linkage of strategies and performance

If you have a vision of your company as the preeminent provider in your industry, if you believe your employees are the greatest potential source of competitive strength, if you know that the key to excellent performance is proper preparation and tools, and if you can see the link between today's information technology and the distribution of knowledge and skill, then you are already thinking about a Performance System. Let the experts at Applied Learning be your guide.

Partial Client List

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ATHENA REPORT
PART I

A Second Wind for ATHENA

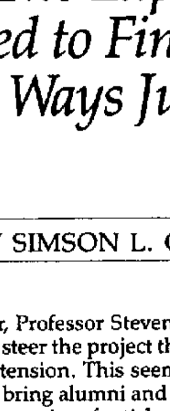
The Experiment Scheduled to Finish in 1988 is in Some Ways Just Beginning

BY SIMSON L. GARFINKEL, '87

When M.I.T. announced the launch of Project Athena in the spring of 1983, it was clearly labeled an experimental undertaking. Digital Equipment Corp. and IBM would provide $50 million in hardware, maintenance, and expertise; M.I.T. would provide faculty, students, technical staff, and $20 million in development support. Together they would find out if a network of high-performance computer workstations could be used to help undergraduates learn better.

That was an ambitious enough project, even for so impressive an alliance. But the question first posed didn't compare to the questions that were actually confronted: Could one campus system serve the needs of everyone from aeronautical engineers to students of Spanish? Could incompatible products from two or more vendors be integrated into a single system so that the differences were irrelevant to users? If so, what was the practical strategy for accomplishing that? How do you administer a system that includes 5,000 user accounts on 1,000 workstations, plus file servers, printers, and oodles of special-function hardware and special-purpose software seeping in at the sides? For that matter, how do you manage the logistics of just getting 1,000 workstations out of the boxes and running?

In July, Professor Earll M. Murman took up the reins from Athena's founding director, Professor Steven Lerman, '72, ready to steer the project through its three-year extension. This seems like a logical time to bring alumni and alumnae up to date. In a series of articles beginning here and continuing in future editions of *Technology Review,* Simson L. Garfinkel, '87, will report on what faculty, students, Athena staff, and M.I.T.'s industrial partners have to say about the project.



In 1983, there were primarily two kinds of computers at M.I.T.: mainframe "time-sharing" machines, and a growing number of desktop microcomputers, such as the IBM PC and the Apple Macintosh, that often featured interactive graphics but lacked the power required for large numerical calculations.

Project Athena envisioned using a new kind of computer—a "workstation"—with the power of a time-sharing machine on a desktop, completely at the disposal of one user at a time. In addition to high speed and compact size, these machines would have exceptional graphics, able to display whole pages of textbooks, complete with equations and drawings.

Because the fabled workstations were not available in 1983, Project Athena was broken into two discrete phases. During the first phase, says Lerman, Athena built a campus-wide fiber-optic network and operated 63 Digital VAX 11/750 minicomputers as time-sharing machines. Phase I also called for 500 experimental workstations from IBM. Terminal rooms called clusters—that would later house workstations—were carved out of every possible space. This set-up gave students and software developers a feel for how the new computer environment would eventually operate.

Phase II, in which the time-sharing VAXes and the experimental IBM machines would be replaced with workstations, was originally supposed to commence in August 1985, Lerman says. Instead, delays in hardware and software held it off until 1987.

Athena's mission was always to develop educational software that would be used

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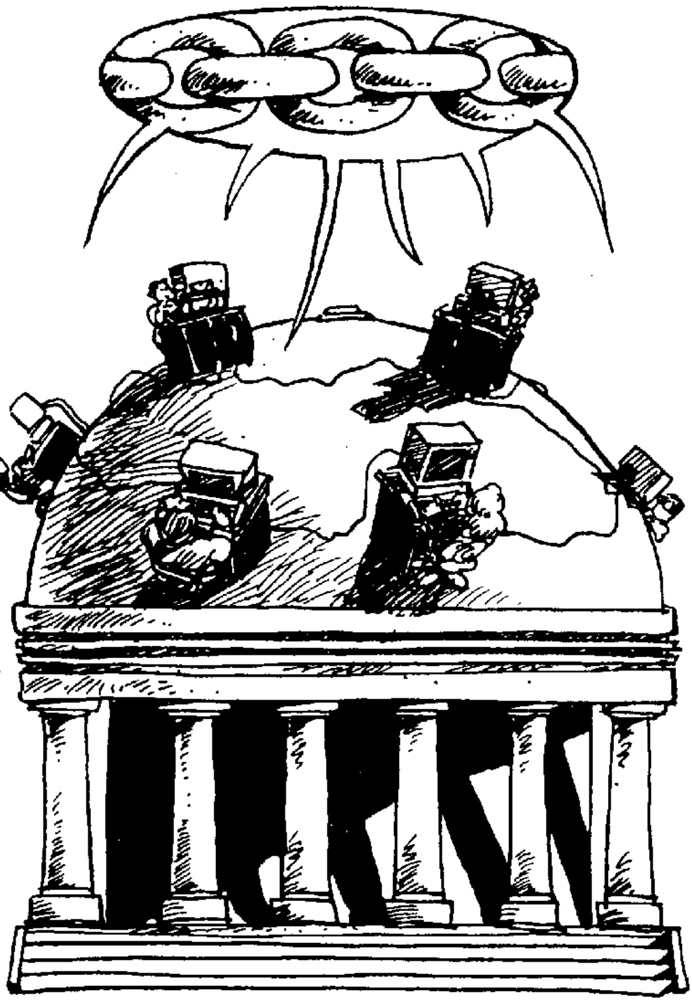


by undergraduates, not to do basic computer science research. "The purpose of Athena is to deliver computing to students to do homework," says Technical Director Jerome H. Saltzer, '61. But those involved in the project soon learned that many fundamental software developments were prerequisites to the operation of a large network of workstations. From the operating system to the screen-management system, a lot of underlying work had to be accomplished before the educational software could be developed and deployed.

Says Lerman: "[M.I.T. and its industrial partners] were talking about workstations that were in the development labs at the time. We overestimated our ability to take these and [in a relatively short time] turn them into networked workstations."

Today, Lerman proudly points to some of those basic developments as Athena's main accomplishments. The X-Window System, a program for managing text and graphic "windows" on the workstation, has become a standard throughout the computer industry. Kerberos, a system for enforcing rigorous computer security over a public computer network, has attracted interest from DEC and IBM. SMS, a database system that manages the accounts of Athena's 5000 users, and Hesiod, a system that lets any user sit down at any Athena workstation and automatically access his or her files and electronic mail, are also beginning to attract outside attention.

These are also the results that seem to have pleased Athena's sponsors the most.

"From the technical standpoint—how do you set up a large, complex, distributed system—we've learned a great deal," says Carol Crothers, manager of IBM's University Development Products, which oversees IBM's grant to Athena.

"The X-Window System has been very valuable to us. Because of our close working relationship with Athena, we were able to ship the first commercial release of X11 [an advanced version of X] on the marketplace," she adds. Next year, Saltzer says, X—in conjunction with IBM's own version of the Unix operating system—will be available on the full line of IBM's mainframe computers.

Digital, meanwhile, has incorporated the X-Window System, which it calls DEC Windows, into its entire line of VAX products. Some sources inside DEC say privately that the development of the window system alone was worth DEC's donation to M.I.T.

So far, however, the impressive technical developments haven't had a big impact on students, who continue to use the equipment primarily for word processing. According to a 1988 survey by Project Athena, students use the system an average of 1.95 hours per week for word processing, 1.41 hours for writing programs, and 1.34 hours for doing problem sets. However, as more course-specific software goes from the hands of the developers in the academic departments into the classroom, and as professors assign more problem sets that depend on Athena, the patterns of usage can't help but change.

Lerman notes that the Athena programs, or "modules," in Course XVI have been so successful that the faculty members in the Department of Aeronautics and Astronautics have virtually reworked the curriculum around Athena.

In the Beginning, There Were the Engineers

Gerald L. Wilson '61, dean of the School of Engineering, traces Athena's roots to a 1979 report from the director of the Laboratory of Computer Science, Michael L. Dertouzos. In that report, Wilson says, Dertouzos recommended "that the administration begin to think about networking a large set of mainframe computers in order to broaden the availability of computers to students, both graduate and undergraduate."

"That report was submitted at the time that [Jerome B.] Wiesner was president," says Wilson. "It died. Nothing ever happened to it."

After several years of waiting, Wilson

says, the School of Engineering decided to go ahead: "We in the school decided not to wait for M.I.T., but to make it our highest priority to [create] an environment in which we could explore the uses of computers in education." The school wanted to focus on undergraduates, Wilson says, because at the time undergraduates had no access to computers unless they were enrolled in Course VI subjects that specifically used the machines. Wilson thought that undergraduates were not being given a realistic education, because at the same time computers were being used all over M.I.T. in a variety of research applications.

In 1982, Wilson wrote a proposal to the major computer manufacturers looking for a partner for his school's project. Then he went to the Academic Council and spoke with the deans of other schools. "There was relatively little interest in some schools and none in others," reports Wilson. "Some of them said outright that computers are not a new tool for teaching." Frustrated by the lack of interest on the part of their colleagues, the engineers decided to go it alone.

The School of Engineering finally settled on Digital as the sole equipment supplier for its project. "When that started happening . . . the Corporation—particularly the Executive Committee—wanted to hear what we were proposing. [President] Paul Gray ['54] thought that we really should do this for all of M.I.T. . . . We were asked to go back and see if we could get additional resources to do all of M.I.T." So began a long series of negotiations with IBM, which had just formed its Academic Information Systems (ACIS), a branch of the corporate giant that had the potential to be the kind of collaborator M.I.T. would require.

As a result of those negotiations, Athena became a project for the entire Institute rather than one for only the School of Engineering. Because DEC had already made commitments to the School of Engineering, Wilson says, it was decided that IBM would have responsibility for providing equipment for use by all the other schools. (At the time, about 70 percent of the undergraduate students were majoring in engineering. The figure is about 62 percent now.)

Out of this intentional mix of hardware manufacturers was born the idea of "coherence," meaning that there would be no perceivable difference between running programs on an IBM workstation or a DEC workstation. The screens might be larger or smaller, the keyboards might have a different layout, but programs would run basically the same.

Although computer science research and technical development were never the objectives of Athena, it became obvious that Athena's requirements by way of workstations and a network could not be met until a lot of fundamental work was completed.

In 1983, coherence seemed like a radical proposal. With a few minor exceptions, computers manufactured by the two companies had never been compatible. Programs developed on an IBM mainframe simply would not run on a DEC minicomputer. Even the computers' "operating systems"—the basic programs that allow the user to instruct the computer what to do—have different vocabularies, command sets, and ways of approaching the equipment.

By developing a standard workstation environment, Athena was going to change that. "There was also some sense," Lerman recalls, "of not wanting to come out at the end of five years and find ourselves wedded to [one vendor]."

Digital's initial shipment of 63 VAX 11/750 computers (serving a total of more than 240 users at a time) was to be matched by the shipment of 500 experimental workstations from IBM that would each consist of "a coprocessor on a PC/XT with an experimental display," and would run the Unix operating system, Lerman says. The machine would hold IBM's place on campus while IBM developed its workstation, which eventually became known as the RT PC.

Due to technical difficulties, Lerman says, the experimental machine was never produced. "The ship date for the experimental box and the RT were getting awfully close [together]," Lerman recalls. Eventually, Athena decided to simply wait for the RT and accepted a large delivery of high-performance IBM PC/AT computers

In the beginning, Digital served the School of Engineering (at the time it enrolled about 70 percent of the undergraduates); IBM was to serve undergraduates in all the other schools. Removing that division was one of many steps in the right direction.

in the meantime.

"It was our idea," Lerman says. "It let us expand the base of PCs and get some experience with something that is *sort of* a workstation." Even though the machines could only support a single user running a single program at a time, they were networked and they were "relatively high-performance." (Today, the ATs are being used to monitor and run experiments in laboratories, and some have been made available to student organizations.)

Meanwhile, a growing number of VAX-based clusters had been set up for use by students in the School of Engineering. The idea that students would use the intermediate system was at the very heart of the Athena experiment. That meant that students used prototype hardware and software. And because of the vendors' different delivery schedules and the decision to split the Institute, inequities were inevitable.

Because programs for designated Athena-assisted subjects were installed on particular time-sharing machines, students enrolled in those subjects were restricted to working in a specific cluster. These students were then free to use the equipment for word processing, to write papers for their "non-Athena" subjects. Students who were not enrolled in any Athena-sponsored classes were initially confined to the Student Center cluster, where there were often long lines to use overburdened, very slow computers and printers.

"We had a network but we didn't have a central distribution of software," Technical Director Saltzer explains. To make matters worse, at the times the lines at the Student Center were longest, students were aware that Athena computers in other clusters were often idle many hours of the day.

When the workstations began arriving in 1986, a new problem cropped up: moving programs from the time-sharing machines to the new DEC machines was trivial, but a lot of basic software had to be rewritten for the IBM RTs. The gap was further widened because Athena received the RTs six months after receiving the MicroVAXes, Lerman says; the software on the IBMs took two years to catch up with the DEC workstations.

In March 1987, the first IBM workstation cluster began operation, and by that September the entire Athena system had been shifted over to "Phase II." At that time, the last of the VAX 750s were taken out of time-sharing service and set up instead to provide files to workstations over the M.I.T. Campus Network. Because any workstation can use any fileserver on campus, the restrictions that prevented most students from using clusters other than the Student Center were removed.

"Phase I to Phase II was a very important transition," Saltzer says, "from scarcity to plenty." One student, responding to an Athena survey, wrote: "I used to complain to anyone who would listen about how bad Athena was, but the new workstations are a great improvement."

Today a student can sit down at any Athena workstation located anywhere on campus, type his or her user name and a password, and immediately begin accessing files or reading mail. According to Athena's survey, 92 percent of M.I.T.'s undergraduates have used an Athena workstation at least once—and at least 25 percent of the undergraduate community uses it every day, Saltzer says.

Also gone with Phase I was the idea of dividing the Institute between the two vendors. "It didn't make sense," Lerman says. Project Athena's new video cluster, in which IBM color monitors are attached to DEC workstations, illustrates the degree to which equipment from the two manufacturers is now being blended, he adds.

Today there are 722 workstations on and off campus that students can use, in 12 public clusters and 21 clusters reserved for departmental, living group, or other private use. "The main reason why there aren't more workstations on campus is real estate," Saltzer contends. "If someone were to wander in magically

and say 'you can have 10,000 square feet in this building,' we would have 200 more workstations out in six to 12 months."

But the emphasis of Project Athena from now on will be more expansion into private settings, such as the living groups and the offices of faculty, Saltzer says. And with the cabling that is accompanying the installation of the new M.I.T. campus phone system, Saltzer says, it will be a lot easier to put workstations off in remote corners of the Institute.

Other changes from the original plan include Athena's definition of "coherence." "One of the things I found when I came on board was that there were five definitions of coherence," Saltzer recalls. "Some of the original goals of coherence were research problems," he says, and not prerequisites for an educational computer environment.

One such objective was to be able to write large programs in a variety of languages—such as Lisp, C, and FORTRAN—simultaneously, using each language for what it does best. "We decided that was not an important educational goal," Lerman explains.

"The biggest contribution to coherence has been [the X-Window System]," Saltzer continues. "It has always been the case that a Unix program written in C is mildly portable [from one brand of hardware to another]. The place you get in trouble is where you try to put things on the display." With the X-Window System to standardize display interaction, Saltzer says, "all of a sudden you discover that most programs are portable."

X has even masked seemingly insurmountable differences between DEC and IBM hardware. The DEC workstation's mouse—a handheld device that the user rolls around on the table to move a pointer on the workstation's screen—has three buttons on its top, while IBM's mouse has two. Athena's solution: DEC's middle button can be simulated by pressing both of the IBM buttons together.

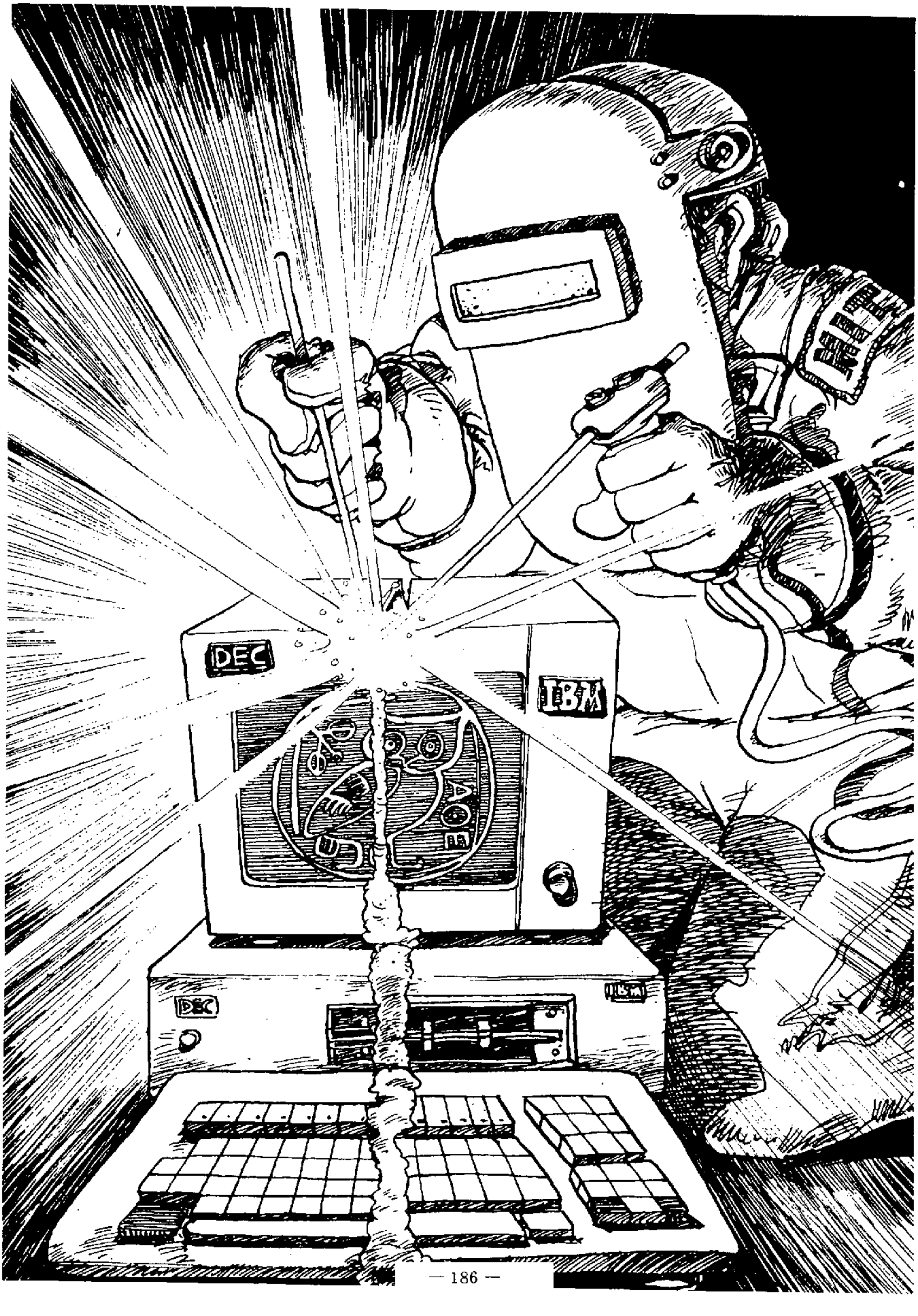
If so much has been accomplished, why extend the project for another three years?

"We had more work to do," Lerman answers. Under the initial plan, M.I.T. was to have had two or three years experience with the workstation environment before having to make a decision about Athena's success. "Realistically, we only turned it on in September 1987."

While software could be developed and used by students on the time-sharing machines, programs that were originally envisioned for the project needed the power of a workstation to perform the necessary calculations. One example Lerman points to is Professor Earll M. Murman's Computational Fluid Dynamics programs, in which a student can watch the flow of a fluid over an airfoil. "Simulating what is going on with the movement of fluids really requires high performance," Lerman says.

"We're just beginning the more extensive use of color," Lerman adds. The "fish bowl"—the glass-walled cluster along the Infinite Corridor that is often ringed with campus visitors—has become the definitive video cluster, where up to 12 students can work, each with his or her own high-resolution color display and laser disc player. Video disc projects are under development in biology, civil engineering, and foreign languages, Lerman says.

And so, at least three more classes of M.I.T. students will participate in this experiment. In a sense, the challenges ahead are much more complicated than the ones that have been solved: Professors can require that students use computers to solve their problem sets, but do the students actually learn better as a result of the exercise? Will that be equally true for non-technical subjects? Will the aptitudes of most students be sufficiently improved to justify the continued maintenance expense of such an elaborate network, let alone the cost of any future upgrading? Will what has been learned at M.I.T. be applicable to other colleges at reasonable cost? In the final analysis, it is these issues, rather than the success of the window system, that will determine the project's eventual impact on education. □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Project Athena As A Distributed System

by

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Abstract

Project Athena was initiated six years ago as a vision to provide ubiquitous and high quality computing for education on the MIT campus. Athena is now a distributed workstation system in use 24 hours per day with 7000 users and 900 workstations. The Athena model of computing is that of a unified distributed system where a single login provides access to a variety of authenticated network services. The distributed services supported by Athena convert the timesharing model of computing supported by Unix into a distributed system operating environment.

Other network services supported include a name server, a real time notification server, a mail system, an electronic conferencing system, a network file system, and an on-line consulting system. The system has extensive failsoft capabilities that permit continuous operation in spite of equipment failures. The system is designed to scale to support 10 000 workstations by minimizing the use of the scarce resources of network bandwidth, mass storage, and manpower. The centralized management approach also helps to minimize support and operations cost.

The workstation types presently supported include the Digital VAXstation and the IBM RT/PC.

Communications is provided by a campus-wide local area network. The backbone is a 10 MHz fiber optic token ring. Attached to the backbone are 23 IP routers, each of which supports an Ethernet subnet using TCP/IP.

The system provides a coherent model of computing in which all applications can run on all supported workstations independent of architecture. Because of the strong level of coherence, the human interface to the system is independent of the type of workstations being used: therefore only one training program and one set of documentation is needed no matter what workstation hardware is used. Students need to learn only one system during their stay at MIT, thus improving their productivity.

Project Athena was established in 1983 to improve the quality of education at MIT by providing ubiquitous and high quality computing based on a large network of workstations. The two major sponsors of Athena in addition to MIT are Digital Equipment Corp. and IBM. The early vision and technical plans for the system are documented in [Balkovich 84].

The purpose of this paper to to document the design of the distributed workstation system that resulted from the project implementation effort. The project is a large undertaking, and this paper describes only the distributed system aspects of Athena. Other activities of the project not described here include the multimedia workstation development [Hodges 89], the human interface activities, the X Window System [Schiefler 87], and the pedagogical aspects of the project [Cohen 87].

Although the approximate outline of the system was understood very early in the project, the design evolved to a considerable extent over the first few years as the requirements became more clear.

Today, Athena has met its system design goals and is a fully operational production system. There are 16 public clusters of workstations for use by students. These public clusters include 20-65 workstations each, and are open 24 hours per day. One of the 16 public clusters is an electronic classroom. In addition to the public clusters, there are nine development (usually department) clusters and two projection-equipped facilities. Workstation clusters have been installed in five independent living group facilities, with some having workstations in the bedrooms and others having them in common areas. A total of 900 workstations is now in use, with the number increasing daily.

Presently there are 32 Network File System (NFS) file servers, 17 Remote Virtual Disk (RVD) file servers, about 30 printers, three each of name servers and post office servers, and two authentication servers. In addition to the "generic" Athena monochrome workstations, there are 15 multimedia workstations which can support full motion color video. The system has 40 G bytes of rotating storage in the workstations, and an additional 30 G bytes of rotating storage in network file servers.

There are presently about 7000 active user accounts. These accounts generate 4000 logins and about 9000 mail messages per day. The average student uses the system eight hours per week. In aggregate, the users generated 12 000 questions for the on-line consulting system, and printed 3 million pages during the past year. Excluding first semester freshmen, about 86 percent of all undergraduate students use the system. The usage of Athena is increasing about 15 percent per year.

The project is probably unique in that it is one of the largest educational workstation networks that is centrally managed. A major benefit to students is that they need learn only one system for educational computing.

The initial equipment deployment for Athena was a timesharing environment installed in late 1983, utilizing about 55 VAX 11/750 and associated ASCII terminals running Berkeley Unix. The first workstations were introduced in early 1985 for staff use. The first public cluster of workstations for student use opened in March of 1985. Deployment continued on an aggressive basis from that time on. As workstations became more plentiful, the timesharing system was used less and less. It was phased out entirely in September, 1987 in favor of a completely workstation environment, and the time sharing main frames were converted to file servers. The following considers only the workstation environment.

1 Requirements

Initial work on Athena considered the requirements of the system. Some of the requirements established were generic to campus computing in general. Other requirements were unique to MIT. In order to meet the needs of instructional computing on campus, the following requirements relative to distributed systems were identified.

- Scalability--the system must scale to support 10,000 workstations.
- Reliability--the system must be available on a continuous basis 24 hours per day even though equipment failures would occur frequently in a system this size.
- Support public workstations--any user could use any workstation.
- Security--the system services must be secure even though the workstations were not.
- Heterogeneity--the system must support a variety of hardware platforms.
- Coherency--All applications software must run on all workstations.
- Affordability--the cost to operate should not exceed ten percent of tuition on a sustaining basis.

The support of public workstations is necessary because workstations are too expensive to be purchased by an individual. The plan is to allow (but not require) the purchase of workstations by individuals when they became affordable.

There was early concern about the complexity of the system that might result because of its size. Therefore a policy of eliminating needless complexity has been followed throughout the project.

2 Definitions

The following definitions will be used.

A *user* is a human who uses a subsystem (e.g. workstation), program, or service. A *client* is a generalized entity which uses services. A client can be a user or a program acting for a user. A *server* is a provider of services or resources. A *service* is a set of actions to be performed.

An object is referenced by its *name*. The object is located by its address or (more generally) by its path. A *binding* of the name to the object occurs when the name is associated with the address. Often part of the address is contained in a context of the name. Some systems use an address for a name. While this may simplify system development, it can cause problems in binding a name to a different object. *Resolving* a name means identifying the address related to a name.

Coherence refers to the ability of two distinct hardware architectures to compile and run the same software.

Interoperability is the ability of two subsystems to cooperate in the execution of a single task. For example, two subsystems supporting the X Window system can cooperate on a single task as client and server since they support the same network protocol.

Security has two major aspects: authentication and authorization. *Authentication* is determining the identity of the user. *Authorization* is determining if the user has legitimate access to the requested resources.

Failsoft refers to the ability of a system to continue to operate in spite of the failure of a subsystem, possibly with degraded performance.

3 Models of Distributed Systems

Many different models of distributed systems have been proposed. One extreme model might be called the "main frame" model. In this model, each workstation or other node in the distributed system can exchange files with other nodes subject to security restrictions, but nodes cannot work together in any other manner. In this model, all resource allocation, security access, and functional access are handled on a per-node basis.

If a user in a distributed system based on the main frame model wants access to a printer on another node, the user must log in to that node, gain security authorization on that node, move the file to be printed to that node, and then command the print function.

A major benefit of the main frame model is that presently available time sharing operating systems (such as Unix) support this model, and can be used to implement it with minimal development.

Another extreme model could be called the "unified" distributed system. In this model, all nodes in the distributed system are considered part of one logically unified system. Resource allocation, security, and access to function are handled at the system or network level, not at the node level.

If a user in a distributed system based on the unified model wanted to do the same print function, the user would simply issue the print command, logical printer name (if not the default), and file name. By logging in on the local workstation the user becomes logged into all services provided anywhere in the distributed system, and all resources in the entire system are accessible transparently.

The major benefit of the unified model is that it automates much of the user control that must be supplied manually in the main frame model.

Although the time sharing system model would have been easier to implement, it would have serious drawbacks in the Athena distributed system environment. The time sharing model maintains system integrity by preventing users from obtaining access to the kernel of the operating system. In the Athena environment, users can get access to the kernel of the workstation by either obtaining the superuser password, or by booting their own operating system. Thus, workstation integrity cannot be assured. Since users can corrupt the kernel of the operating system, they could (for example) masquerade as others or as a system service. The user can also "infect" the workstation with a Trojan horse, virus, worm, or other undesirable code. Of course the user can monitor all Ethernet messages on the local net.

Also, with the workstation physically available to the user, the user can boot the workstation in a single user mode. The user may therefore corrupt the operating system without knowing the root password. Because of these problems, the workstations must therefore be assumed to be insecure.

The time sharing model also assumes that users are attached to a particular machine. User files exist on that machine, and mail is sent to the user on that machine. Since in the Athena environment the objective was to let any student use any workstation, neither of these was desirable. Instead, the objective was to provide mail and file access as network services, accessible from any workstation independent of location.

Network access to these services has security implications. If user files or the system software were stored on a public workstation, the previous user could have damaged (or deleted) files. They could have corrupted the operating system, perhaps by inserting a Trojan horse that would capture passwords of subsequent users. Since any user could use any workstation, the concept of sending mail to a machine was not suitable for the Athena environment. Instead, the objective was to send mail to "username" using a network service, and allow mail to be read, written, and filed from any workstation.

The time sharing model also had undesirable support implications. The classical support model for time sharing is that there is a system manager per system. At a scale of the order of 10,000 systems, this was clearly not appropriate. The objective is to have a "system manager" per 1000 workstations, requiring a three order of magnitude improvement over conventional approaches. (Presently, five operations programmers support 900 workstations.)

4 Existing Distributed Operating Systems

Several other distributed operating system projects have addressed requirements similar in some respects to Athena. These include Amoeba [Tannenbaum 85, Mullender 86], Andrew [Morris 85], Dash [Anderson 87], Eden [Black 85], Emerald [Jul 88], Grapevine [Birrel 82, Schroeder 84], HCS [Black 85], ISIS [Birman 85], Locus [Walker 83], Mach [Rashid 87], Sprite [Ousterhout 88], and V [Cheriton 88]. Although Amoeba and Grapevine are designed for larger environments than a single campus, they have addressed many of the same issues that Athena has.

Amoeba is designed to run in both a local and extended network environment. A typical local environment might consist of perhaps 16 processors connected to a pool of several tens of workstations. Beyond that, multiple Amoeba sites can be interconnected through a wide area network to form a single system. The research focuses on the use and management of the processor set in addition to communications and protection as well. An extended system currently exists which inteconnects local Amoeba systems in a wide area network extending through several countries in western Europe.

Andrew is a system for support of instructional and research computing at Carnegie-Mellon University, with objectives very similar to Athena. Both systems support on the order of 1000 midrange workstations in a Unix and Ethernet environment, with plans to scale to 10,000 workstations. Both assume that the user has complete control over workstation functions, with a central mechanism controlling and supporting network services. A distributed file system called *Vice* was developed as part of Andrew, and is now being used as the basis of a nation-wide file system experiment. The *Vice* file space is separated into two parts: local and shared space. The local space is accessible to the user (generally on a local disk) but not publicly shared. The shared space can exist anywhere in the network and is publicly accessible.

In contrast to the systems described above, Dash is designed for very large future hardware and systems rather than the present or past. It is designed for far faster and cheaper processors and networks, implemented in numbers of thousands to millions, with dimensions of scale world-wide.

Eden is an object-oriented operating system based on a single remote procedure call mechanism. It has a single, uniform system-wide namespace spanning multiple machines. An *object* is a set of processes that is referenced by capabilities and can migrate freely among systems. All objects have a data part, which includes short and long term data. Objects can checkpoint autonomously.

The objective of HCS is to integrate different hardware/software combinations into a unified system. It is based on TCP/IP and uses a single global name space for the entire heterogeneous environment along with remote procedure calls. The network services supported are remote computation, mailing, and filing.

Grapevine is an older system design for much larger geographic distribution. It has rapidly come to be used throughout the Xerox internet, with nodes located in clusters around the world. Resources are accessed within the local cluster, but access is allowed to any other Grapevine system in the Xerox internet. Grapevine consists of about 1500 computers and 17 servers in 50 local area networks.

Locus is a distributed operating system which supports transparent access to data through a network-wide filesystem. It permits automatic replication of storage and transparent distributed process execution.

Mach provides support for both tightly coupled and loosely coupled general purpose multiprocessors. It also supports transparent remote file access between autonomous systems. It has a large, sparse virtual address spaces, copy-on-write virtual copy operations, and memory mapped files. Multiple threads of control are provided within a single address space. Large amounts of information can be transferred by the interprocess communications facility by using copy-on-write techniques. Mach has a binary applications program interface compatible with Berkeley Unix 4.3.

Sprite is an operating system that supports multiprocessing and distributed files. The user level facilities are identical to BSD Unix. All files and I/O devices are uniformly accessible to all systems, and they appear as a single shared hierarchy. There are no private partitions to manage and devices can be accessed remotely as well as files. Complete Unix file semantics are provided, including locking and consistent access.

V is a testbed for distributed system research. The four logical parts are: the distributed Unix kernel; the service modules; the runtime support libraries; and the added user-level commands. It manages a cluster of workstations and servers, providing the resources and information sharing facilities of a conventional single machine.

At the beginning of Athena, these and other distributed operating systems were reviewed, but none was found to be suitable for Athena, often because they were in the early stages of research.

5 Issues in Distributed Systems

Several issues arise immediately in the design of such a distributed system. Among the most important of these are naming, authentication, and compatibility.

5.1 Naming

A name service in a distributed system converts a logical name into a physical address by an algorithm, a table lookup, or a combination of the two. The purpose of a name service is to decouple the logical support of a function (such as printing) from the physical implementation of that function. This makes it far easier to change the configuration of a system. It is only necessary to change the logical to physical mapping, not all of the code that references the function.

System objects that can be named include:

- main frames
- printers
- services
- files
- users

Factors affecting the design of name servers include the number of object types, number of objects, frequency of queries, and update frequency.

The simplest implementation of a name server is by means of a centralized service. If that is inappropriate for reasons of network bandwidth, distance, or load, the service can be distributed. If the implementation is by means of a data base, the usual methods of data distribution can be used. These include replication or partitioning.

A replicated data base is created in multiple copies. Replication has the advantage of providing good performance and reliability, but update is difficult because of synchronization requirements. Replication also uses considerable storage.

In partitioning, the data base is split into multiple, disjoint data bases. Some means must be provided to identify the correct partition holding the data of interest. This can be done through a directory or with a broadcast search. The advantage of a partitioned data base is that only one copy of the data exists, thus saving storage and simplifying update. The drawback is that the correct partition must be found for the access, and in some cases multiple partitions must be accessed to resolve the name.

Most of the systems referenced above use a combination of replication and partitioning to achieve a balance between performance and storage requirements. Most name servers also use caching of frequently-used names.

5.2 Scalability

Design approaches that work well with a few nodes in a distributed system may not be usable with many nodes. For example, protocols using broadcasting work well for small numbers of nodes but do not scale well to large numbers. More generally, any design approach where a scarce resource such as storage or manpower scales linearly with the number of nodes is likely to be too costly to implement. Thus, techniques such as putting complete system configuration lists on every workstation (storage intensive), or making all workstation software configurations different (labor intensive), are not usable for large configurations (e.g. order of 100 workstations). Issues of scale are addressed in [Neuman 88].

5.3 Security

Two issues that must be considered in security design are root passwords and user passwords.

On a distributed system of more than a few dozen workstations, the root password cannot be different on each workstation because the support task quickly becomes unmanageable. Therefore, Athena has made all root passwords the same.

For user passwords, Unix systems store encrypted passwords for all users on each workstation. It is very difficult to maintain passwords for users for of the order of 100 workstations and completely impractical to provide complete password and group files for each machine in a large network. This (replicated data base) approach to authorization does not scale well, and suffers from the usual problems of replicated data bases. A natural alternative is to provide a centralized password checking service. In order to access remote services, passwords must be sent over the net. This makes the system vulnerable to eavesdroppers who can steal passwords.

A solution to problems in sending passwords across the net is to encrypt the passwords. Two approaches have been developed to implementing encryption-based authentication: public key cryptography and key distribution servers.

With public key cryptography, the keys come in pairs. Each key in the pair is used to decrypt messages encrypted in the other. Therefore one key of the pair can be given to the servers and the other (secret) key can be given to the user. The user uses the secret key to become authenticated.

A key distribution server can be used to assign secure keys to be used between a user and a server. This approach scales well but requires a third party. The method generally used employs private keys and a trusted third party. It was developed by Needham and Schroeder [Needham 78].

Authorization can be handled in many ways. One way is to delegate the function to the servers and implement it by access control lists showing membership in groups (used in Grapevine). A second way is to use capabilities implemented as a bit pattern passed to the server showing that the user is authorized to perform a particular operation (used in Amoeba). Capabilities are usually encrypted to prevent forgery.

5.4 Compatibility

Various levels of system compatibility are possible, including the binary level, execution level, and protocol level.

In binary compatibility, all processors execute the same binary instruction repertoire and are compatible at the binary level with differences only in performance and input/output. Emerald and VAX systems exhibit this level of compatibility. Although this greatly simplifies system development, it restricts the source and architecture of systems greatly, and is not often used in large systems for this reason.

A more common level is to provide system compatibility at the next level up; the execution abstraction (called "coherence" in Athena"). A common execution level abstraction exists if the same source code can be compiled and executed properly on the two systems. Andrew and Athena both support the Unix execution abstraction.

The least restrictive form of compatibility is one that achieves interoperability by requiring all system components to support a common set of protocols. The X Window System [Scheifler 87] is an example of this level of compatibility. The protocol level of compatibility allows a distributed system to be built based on common protocols for essential system services such as naming and authentication. Athena supports this level of abstraction as well. The execution abstraction could be given up and diverse operating systems could still be supported within Athena through the protocol compatibility.

6 The Athena Model of Distributed Systems

The distributed systems model for Athena has three major components:

- workstations
- network
- servers

The Athena approach is to implement a set of network services to replace equivalent time sharing services, in essence converting the time sharing model of Unix into a distributed operating system.

The network is invisible to the user. All services appear to be local and are available to the user with only a single submission of a password at login time. The actual delivery of the services is physically distributed over the system and communicated to the user over the network in a transparent manner.

In concept, any operating system can be used on components (workstations or servers) in Athena. To achieve interoperability with the other system components (and gain access to the distributed services) the components need only support the Athena protocols for authentication service, name services, file access, and print service.

In order to minimize development cost, the protocols to date have been implemented in only Berkeley Unix on all hardware platforms. A side benefit of supporting only Berkeley Unix is the minimization of training and support cost.

The computational model seen by the users, therefore, is Berkeley Unix.

To meet the Athena objectives, the following strategy was used.

- Scalability--partitioned network, centralized servers, identical workstation software.
- Reliability--redundancy of all system elements required for operation.
- Support public workstations--deployment of public clusters.
- Security--development of a trusted third party authentication facility.
- Heterogeneity--standard interfaces to workstations.
- Coherency--the same operating system is used on all workstations.
- System Management--tools were developed to allow dynamic change of the system configuration through the use of a service management system.
- Affordability--Centralized operations, development, and maintenance. Development of software tools to allow remote installation and maintenance.

Each of these will be discussed in greater detail below.

6.1 Scalability

Design approaches have been used to improve scalability by minimizing the demands on scarce resources in three areas. These are network bandwidth, mass storage, and labor.

The campus network [Schiller 88] was designed with a backbone using optical fiber and a token ring protocol running at 10 MHz. Network routers are attached to the backbone, with each router supporting one Ethernet. Because of the routers, traffic local to a subnet does not load the backbone. This approach gives a good measure of growth capability, because as more workstations are added, more Ethernet subnets can be added to the backbone.

All workstations have local hard disks which are used to eliminate paging traffic on the net. System software libraries are replicated on all subnets, so communications traffic for loading of system software remains local to a subnet.

To minimize mass storage, files that would normally be replicated on a per-workstation basis are centralized. These include password files and most configuration files.

To minimize labor requirements, all workstations are anonymous and interchangeable. They all have the same root password and the same software configuration. The only unique items are the workstation name and net address. Initial loading of the software is done over the net.

6.2 Reliability

In order to improve reliability, no systems other than network routers are attached to the backbone. This limited the number and types of problems that could bring the entire net down. All other systems are attached to the Ethernet subnets. As a general rule, a hardware failure may prevent the updating of master files for adding new user accounts or changing the hardware configuration. However, system operation can still continue. Hardware subsystems whose failure would stop system operation, such as authentication service, name service, or access to system software are replicated with automatic cut-over.

6.3 Public Workstations

Clusters of workstations are provided in about 16 locations around campus, located so that students will not have to walk more than about 5-10 minutes from any location to get to a workstation. In addition to the clusters for student use, there are several dedicated to development of departmental instructional software.

Any user can log into any workstation and gain immediate access to private files and environments.

Public workstations have no retained state between sessions. Therefore the operations staff can reload the system at any time with no adverse consequences. By default, the workstations refuse remote services such as login or *rsh*.

6.4 Security

The assumption is made that the security of the workstations cannot be maintained. To obtain system security with insecure workstations after login, an authentication server called Kerberos was developed. This is described in much greater detail below.

The Kerberos authentication server [Steiner 88] is a trusted third party private key network encryption system that validates the identity of individuals to network servers. It is based on the model developed by Needham and Schroeder [Needham 78]. Each user and network server has a key known only to it and the Kerberos authentication server. Timestamps have been added to that model to assist in the detection and prevention of replay. Kerberos operates without imposing any additional burden on the user as a part of the normal login process.

Kerberos establishes a secure session key for servers and clients. The server then has the responsibility to use the key in an appropriate manner, ranging from ignoring it to encrypting all transactions.

6.5 Heterogeneity

Since there were two major sponsors of the project along with MIT, it was assured that there would be at least two incompatible workstation platforms supported by the system. In addition, there are multiple generations of hardware from each vendor. The following minimum workstation requirements were imposed to bound heterogeneity and thereby the range of hardware for which instructional courseware must be developed.

- Ethernet interface
- one million instructions per second processing speed
- one million pixel display (monochrome)
- local hard disk of at least 40 MByte
- four Mbytes of main memory
- pointer device (mouse)

At this time, personal computers and other 300 000 pixel devices are not supported. However, some level of support is planned for the future.

6.6 Interoperability and Coherency

Athena supports both interoperability and coherency. As with the X Window System, the subsystems in Athena interoperate by using a common network protocol

provides a high level of coherency so that the same source code code can be compiled and executed on all workstations regardless of architecture.

Coherency at Athena included standardization of three lower level interfaces [Balkovich 85]. They are:

- system interface, between the applications and the operating system

- applications interface, the interface between applications
- user interface, the interface presented by applications to the users.

To obtain system coherence, the same operating system and the same communications protocol were used on both hardware platforms. Operating system options considered were MS-DOS and Unix. Berkeley Unix was selected based on functional power and multi-tasking capability. It provides the same virtual machine interface to applications on all workstations. About 85 percent of the source code for the operating system is common for the two workstations. Essentially all of the source code is common for applications. Separate binaries complied from the same sources are supported for the two workstations. To obtain communications coherency, TCP/IP was selected to implement the same virtual network interface to all applications.

Applications coherency is a much more difficult problem. It has been approached in part by supporting a small number of languages on Athena. Presently supported languages are C, PASCAL, Lisp, and FORTRAN. PASCAL may be dropped from support due to lack of use.

Another part of the problem is solved by using a standard windowing system. The X Window System was developed at the MIT Laboratory for Computer Science and Athena to meet this need. In a similar manner, standard applications including a 2-D drawing package (GKS), a text editor (Gnu EMACS), a spread sheet, a laboratory data management system, and a document formatter have been adopted.

The user interfaces for the two types of workstations are as identical as the keyboards and mouses will allow. The X Window System was developed at Athena and the MIT Laboratory for Computer Science to provide applications coherency to the human interface. However, X solved only part of this difficult problem. Recently, the MOTIF human interface development environment from Open Software Foundation has been installed to provide a more powerful level of abstraction in obtaining user interface coherency.

Since the two different workstation architectures supported two different floating point and byte orders to represent integers, the system must handle these differences in a method transparent to the users. Each workstation knows its own type (VAX or IBM RT). Separate sets of binaries are stored for each system type. Text file formats are the same for both hardware platforms. When binary data are accessed, each workstation type accesses its own type based on data from the name server.

6.7 Affordability

It was realized at the beginning of the project that any support approach where the labor requirement scaled linearly with the number of workstations was doomed to failure. To achieve affordability, the decision was made to use centralized management and support of the system even though the hardware was distributed. Athena experience indicates that centralized management and support provides significant benefits in reduced support cost and improved quality of services compared to distributed management and support. (It is true however, that distributed management can solve political and organizational problems that the centralized approach cannot solve as easily).

7 Athena System Design

The system design that was developed views the entire hardware complex of (up to 10,000) workstations, file servers, communications servers, and printers as a single unified distributed system (as described earlier).

A block diagram of the Athena distributed system is shown in Figure 1. The system is network oriented. Workstations attached to the network are all identical in software configuration. These communicate with a variety of network servers that provide services to the users. Because all services provided are network services, they are available to all users without regard to location. These network services include:

- service management system
- name service
- file service
- printing
- mail
- real time notification.

Files that would normally be provided for the entire system at every workstation are centralized, normally with a small number of copies to provide fail soft capability and improved performance.

Figure 1 here

7.1 Service Management System

The configuration management of large numbers of workstations and servers is very labor intensive and cannot be done effectively by manual means. Therefore, Athena has developed the Service Management System (called Moira) [Levine 87, Rosenstein 88] to automate much of the management task. Moira includes a central data base of system information, tools for manipulating that information, and tools for updating the services from the data base. The use of a centralized data base has proven to be both effective and economical because each piece of data is stored only once and is easily updated.

7.2 Name Service

In timesharing systems, names are translated into addresses by using configuration files. These files tend to be relatively static and reside in each node. In order to meet system needs for dynamic reconfiguration, this static approach is not appropriate for workstation networks. Also, it is wasteful of storage if replicated on all workstations.

The purpose of the Athena name server, called Hesiod [Dyer 88], is to allow centralized, dynamic linkage between names and objects. For example, Postscript printing for building E40 third floor might initially be provided by a printer named NIL at address PS.MIT.EDU. At some later time this service is moved to a different printer at address LQP.MIT.EDU. It would not be feasible to update a configuration file on each of 10 000 workstations to reflect the change. Instead, the name server provides a single, centralized location for the configuration file for all workstations, thus providing very significant savings in storage and making changes in system configuration manageable with minimal manpower.

Hesiod includes the Berkeley *bind* name server [Bloom 86] with some extensions. It provides information on users, location of user private files, mail delivery addresses, and locations for network services such as authentication and printing.

Hesiod is updated by Moira every few hours.

7.3 Authentication Service

To validate the integrity of the system software at login, the system software (except for the kernel) is purged on each logout. When the next user logs in, new system software is down-loaded from a secure network file server, thus assuring a validated initial operating system.

When no one is logged in at a workstation, it automatically goes to a "deactivated" state after a short timeout. No network connections (for example to external files) are retained, and the window system is not running. A program called *Toehold* solicits a key depression from the user. When the key depression is received, Toehold executes a shell script that attaches the system libraries from RVD (described in the next section) and starts the X Window System. A login window then is activated for the user and login is solicited.

Login proceeds with the user submitting username and password. The user is authenticated by the Kerberos authentication server (see discussion below) in a transparent manner. Information about the user is obtained from the Hesiod name server. The user home directory is then attached from the appropriate NFS file server (described in the next section). The Zephyr real time notification service is activated and a Zephyr windowgram client is started. Login continues with the usual execution of the login files.

When the user logs out, Toehold "deactivates" the workstation. All attached filesystems are detached insuring that remote access is impossible. All temporary storage areas are cleaned out and the window system is terminated. Finally, the next login is solicited by a "Press any key" prompt. If a new system library is loaded onto a server while the workstation is deactivated, it will be used at the next login.

Subsequently, Kerberos authenticates the identity of the user to the desired service in a fully transparent manner through the use of "electronic credentials". Kerberos only establishes identity (authentication) and does not become involved in the decision of whether an individual is allowed to use a specific service (authorization). The normal Unix mechanisms are used for authorization.

The general information flow in Kerberos is shown in Figure 2.

Figure 2 here

Two types of credentials are generated by Kerberos: *tickets* and *authenticators*. A ticket is used to transmit the identity of an individual to a server in a secure manner. The authenticator contains additional information that can be compared by a server to the ticket to prove that the user presenting the ticket is the same one to whom the ticket was issued.

7.4 Athena File System

Athena has two different file systems. One file system, called Remote Virtual Disk (RVD) is used to hold read-only files such as system software libraries and some applications software. The other file system, Network File System (NFS) developed by Sun Microsystems, is used for read/write files.

Additional file system can be mounted upon user request via the *attach* command. Also, RVD and NFS file systems are named objects. The names are resolved to {location, type, mount point} by Hesiod.

7.4.1 RVD

Workstation software includes a considerable amount of library software. Storing this software of each individual workstation would give good performance, but would lead to excessive cost. In addition, it would greatly complicate the software update and software integrity problems.

To solve these problems, Athena uses RVD [Greenwald 86] to store system software libraries. RVD was originally developed at the MIT Laboratory for Computer Science and subsequently enhanced at Athena. RVD supports "packs" on network server machines that appear to a workstation to be the same as local physical disk packs. All file system information is maintained by the workstation, and the RVD servers simply delivers requested disk blocks. An RVD pack may be used by many workstations in a read-only mode, or by a single workstation in a exclusive read/write mode. Because of the efficiency of the block level service, an RVD server can support about ten times as many users as a generalized file server.

7.4.2 NFS

An Athena requirement is that any user can use any workstation. NFS [Sandberg 85, Sun 87] provides the capability for private user files to be available at any workstation. Private files are stored in "lockers". Lockers are stored on network file servers distributed across the system, but they appear to the user in a single, local file directory. The files must be attached to the workstation directory, but this is usually done in a transparent manner in the *.login* file. Normal NFS security and privacy facilities are provided.

7.5 Printing

Conventional timesharing systems provide centralized printing. The use of this model in a workstation environment creates two problems: print queueing and printer configuration.

Unix normally queues the print file on the workstation, with no indication of whether the requested printer is accepting jobs. The possibilities exist that if the user logs off, the next user may trash the spooled file before it gets printed. The possibility also exists that the spooled file may never get printed because the printer is not accepting jobs.

In Athena, *lpr* has been modified to queue the print file at the remote print server. If the print server is not available, an immediate error message is generated.

A second problem is similar to the password problem. The *printcap* file would normally be stored on every workstation in a static form. Athena has moved the *printcap* function to the Hesiod name server.

7.6 Electronic Mail

In a timesharing system, users send mail to remote individuals using a mail address of *username@machinename*, or to local individuals using an address of simply *username* with the remainder of the address as a default. An Athena requirement is that any user can use any workstation. Therefore the remote address is not appropriate because individuals are not limited to one system.

The approach developed by Athena, shown in Figure 3, combines the best of local and remote approaches. All individuals are addressed as though they were local, without using a machine name. The mail is sent to a central *mail hub* and then to a "post office" where the mail is queued until the addressee decides to pick it up. When the mail is "picked up", it is transferred to the private (NFS) mail file for that individual (based on information from the name server), who can then read, write, and edit mail just as if everything were actually local from any workstation.

Figure 3 here

To accomplish this, Athena uses the MH mail system [Rand 85]. An improved graphical front end has been added to MH (called XMH) based on the X Toolkit [Swick 88] so that all commands are entered through mouse selection of active objects instead of the command line interface. The Post Office Protocol [Rose 85] utilized by MH has been retained and is modified to use the Kerberos authentication server. Multiple post office servers are supported to improve performance and reliability. The proper post office for each individual is selected using information in the Hesiod name server. All changes to MH to support a distributed system are transparent to the user, and the user uses the software the same as if it were on a single centralized time sharing system.

Users outside of Athena can also send mail to individuals within Athena as if it were a single, centralized system. They send mail to address *username@athena.mit.edu*. This mail goes to the mail hub and is distributed by the same mechanism as internal mail.

The mail hub also handles distribution lists within Athena. At this time there are three post office servers supporting the 7000 users.

7.7 Real time notification

There are occasions when real time notification of an individual is useful, for example when new mail has arrived or when a file server is going to be taken out of service temporarily. This is easily accomplished on a centralize timesharing system because the identity of all individuals logged in is available in a single location. In a distributed system this is much more difficult because there is no central file holding this information.

To meet this need, Athena has developed a real time notification server called Zephyr [DellaFera 88]. Using this system, a message can be sent to an individual immediately by using a single command and without knowing the location of the individual (or even if the user is logged in.) Zephyr searches the active workstations to locate the individual, and if the user is logged in it creates a popup window immediately with the message. The user can select classes of Zephyr messages of interest and suppress the rest. This capability operates within the constraints of privacy and permission.

7.8 On Line Consulting

An on-line consulting system (OLC) [Coppeto 89] has been developed where users can direct questions to consultants or other expert users logged in elsewhere on the network. A set of stock answers is maintained for quick response to common questions. If the consultant is not available, questions are automatically queued. Answers are often returned by electronic mail if the questions are difficult, or if the question remains unsolved when the user logs out.

7.9 Discuss

Discuss [Raeburn 89] is an electronic conferencing system that allows Athena users to communicate easily and effectively on specific subjects. The approach used is to support the "meeting" model, and there are presently about 100 concurrent meetings in progress. *Discuss* is authenticated by Kerberos and uses Zephyr to send real time messages. The system evolved from an earlier system called *Forum* supported on Multics.

8 System Software Development

Because of coherence, much of the source code for the operating environments is the same on the two different workstation platforms. The source code is partitioned into a machine-independent section (e.g. the applications and most of the operating system) and a machine-dependent section to simplify the system building process.

The basic operating system software used on all Athena workstations and servers at this time is BSD 4.3, with machine-dependent software (e.g. device drivers) supplied by the manufacturers. All workstations include the NFS client support and use the X Window System. The standard Berkeley distribution is augmented by several third party software packages and local Athena modifications and additions.

To maintain control of the software configuration, all software is completely built from source code about once each year. Module updates are provided 3-4 times a year.

The new source code for the Athena distributed services is about 20 M bytes [Davis 89]. The total amount of source code for the Athena system, including Unix, the Athena distributed services, and applications amounts to 400 M bytes. This source code is structured into a hierarchy of about 1300 *makefiles* and generates 12 000 binary modules.

To control the labor content and quality of the development, management, and support of this large amount of source code, a number of software tools were developed. These include [Davis 89]:

- Prot_sources--to manage access privileges
- Track (like *rdist* [Nachbar 86])--to manage distributed files
- Maksrv--a script set to convert workstation software to servers.

Prot_sources is a tool that manages access privileges so that system builds are not aborted by lack of privileges for access, but which provides some measure of protection. It allows software developers to start a build at any time without using *root* access. It traverses the 400 M bytes of source code in about 1.5 hours.

Track creates a local file containing the update status of all of the distributed files used for the system build. After the local file is complete, the system build process can compare local copies to the update status contained in *track* instead of comparing against remote files, thus saving thousands of remote file accesses.

Ideally, all software update should be entirely automatic, and should propagate to all workstations essentially simultaneously. Tools to do this at Athena are available for non-kernel code, but not for kernel code. Presently, changes to the kernel require that each individual workstation be visited and the kernel loaded from a floppy disk (the "rollerskate" approach). Work is proceeding to largely automate workstation kernel software update.

Server systems (e.g. printers, name servers) are built as modifications from a standard workstation system using a tool called *makesrv*. The workstation software is initially installed on servers. Building a server from a workstation then becomes a standard operation. *Makesrv* presently can build the server types of NFS, Hesiod, Kerberos, Moira, On-line Consulting, RVD, Zephyr, Discuss, and Printer.

9 Future Plans

Because of the significant value of Project Athena to its two industrial sponsors, funding has been committed through June, 1991. The new initiatives planned for the distributed systems area during the next two years are as follows.

- Move to private ownership model. To date, all Athena workstations are owned by MIT and are made available to students and faculty at no cost. When prices for a workstation meeting Athena standards drop to an appropriate level (currently seen as $2500), MIT may sell workstation to students and faculty through the Microcomputer Store. Eventually the number of workstations supported (primarily privately owned) will approach 10 000. The network, servers, and infrastructure must scale in accordance with the number of workstations in a transparent manner.

- Shift to supported software. The strategy of Athena is to move away from the Berkeley Unix to a vendor supported Unix. Since both major sponsors belong to the Open Software Foundation, the use of the OSF/1 operating system looks attractive. (Project Athena also belongs to the Open Software Foundation and has a research grant relationship with them).

- Automatic software update and integrity check. Installation of a major new version of the system software is a major undertaking because it requires a visit to every workstation. Tools are now being developed to install a new version of the system software over the network and to verify its integrity after installation.

- Dynamic network reconfiguration. One of the most common current problems for Athena workstation installation is the installation of an incorrect Internet address. Experiments are underway to assign this address at boot time. In addition, when Athena begins to allow privately-owned workstations, it must be possible for a user to unplug from one network connection and reconnect at a new location without notifying the network administration. Work on dynamic reconfiguration is also in process.

- Support of personal computers. The widespread availability of personal computers with screen resolution of 300 000 pixels makes support of them attractive. The degree support and methods of support and now being investigated.

- Deploy to other universities. Part of the original vision of Athena was to make it available at no cost to other research labs and universities once it was fully operational. Parts of the system have been installed and are in use at the University of Karlsruhe, Germany. In late 1988, the system was installed at the Cambridge Research Lab of Digital Equipment Corp. During early 1989 the entire distributed system was installed at Bond University, a new, private university in Australia. Other installations are now being considered.

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RT/PC is a trademark of IBM

MS/DOS is a trademark of Microsoft Inc.

Unix is a trademark of AT&T.

NFS is a trademark of Sun Microsystems, Inc.

X Window System is a trademark of MIT.

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ATHENA SYSTEM MODEL

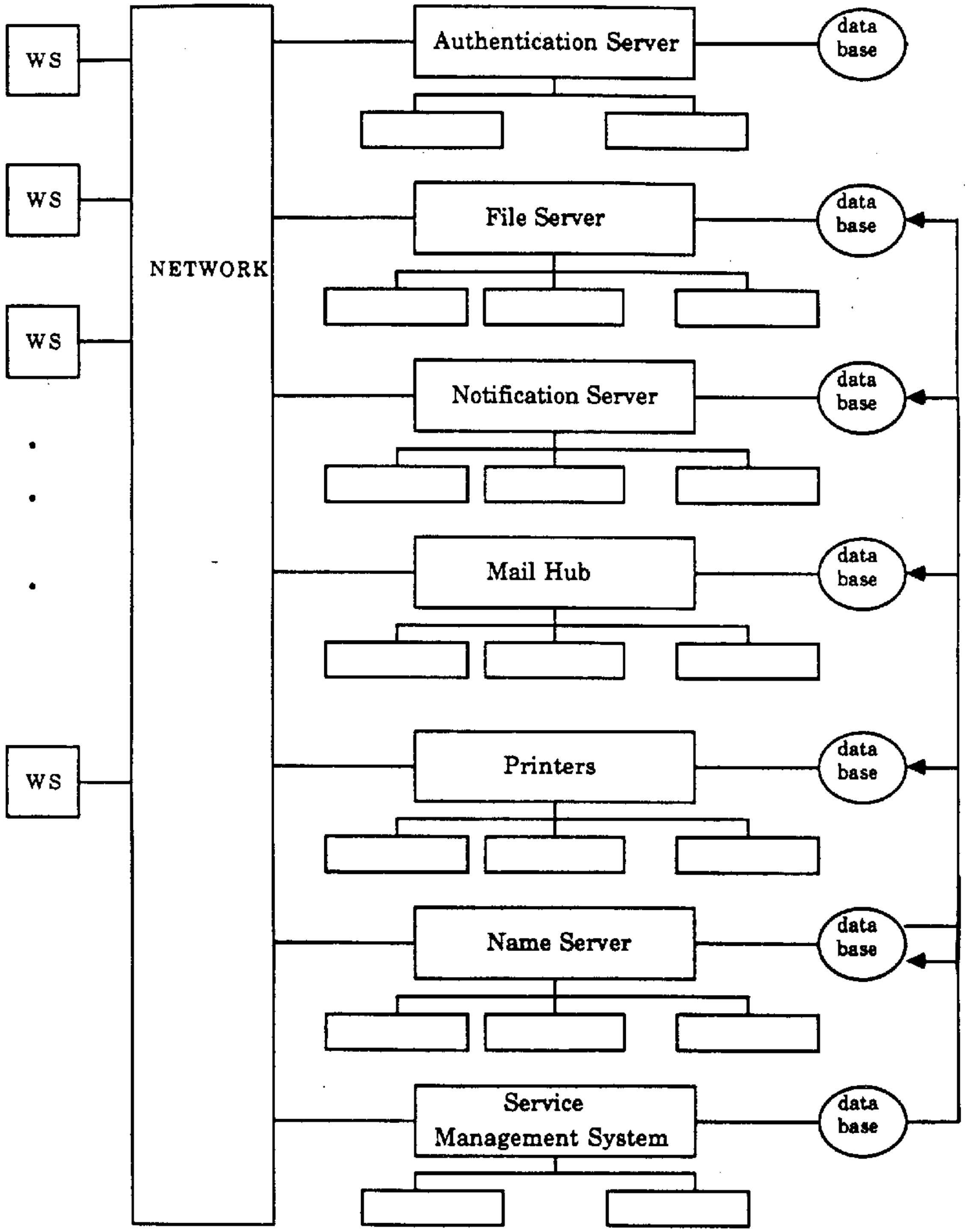

Figure 1

Kerberos Information Flow

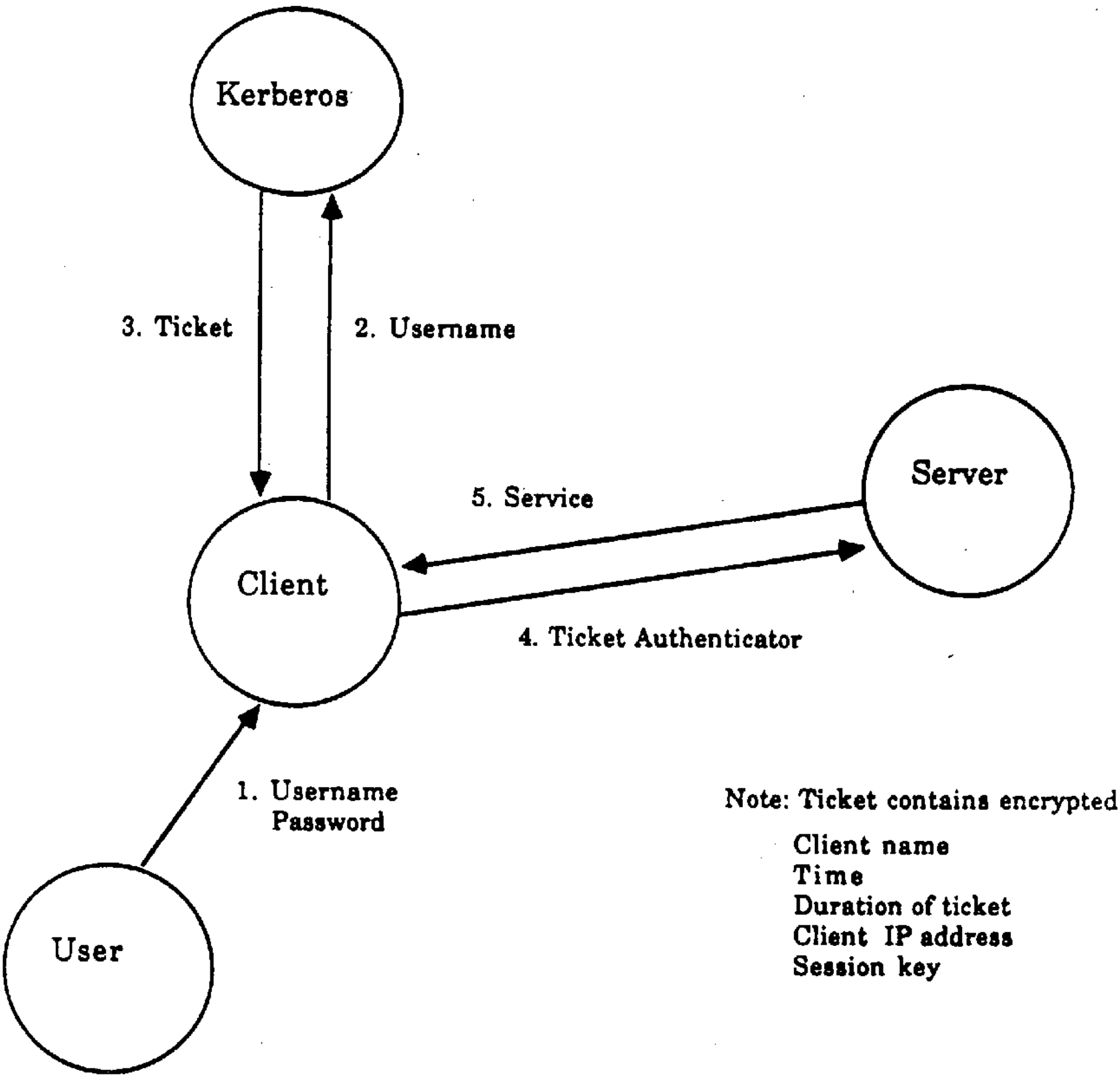

Figure 2

Athena Mail

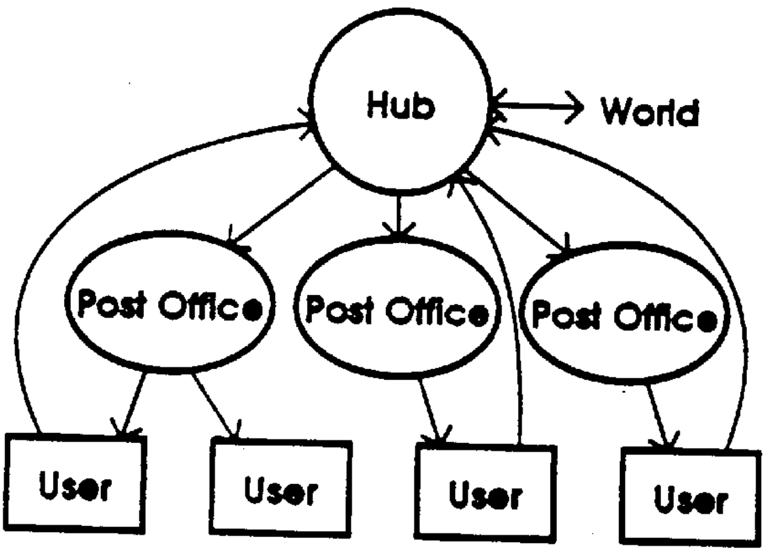

Figure 3

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The Athena Service Management System

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ABSTRACT

Maintaining, managing, and supporting an unbounded number of distributed network services on multiple server instances requires new solutions. The Athena Service Management System provides centralized control of data administration, a protocol for interface to the database, tools for accessing and modifying the database, and an automated mechanism for data distribution.

1. Introduction

The purpose of the Athena Service Management System (SMS) is to provide a single point of contact for authoritative information about resources and services in a distributed computing environment. SMS is a centralized data administrator providing network-based update and maintenance of system servers.†

- Conceptually, SMS provides mechanisms for managing servers and resources. This aspect comprises the fundamental design of SMS.
- Economically, SMS provides a replacement for labor-intensive hand-management of server configuration files.
- Technically, SMS consists of a database, a server and its protocol interface, a data distribution manager, and tools for accessing and modifying SMS data.

SMS provides coherent data access and data update. Access to data is provided through a standard application interface. Programs designed to reconfigure network servers, edit mailing lists, manage group membership, etc., all use this application interface. Applications used as administrative tools are invoked by users; applications that update servers are (automatically) invoked at regular intervals. Management reports and operational feedback are also provided.

1.1. Requirements

The requirements for the initial Athena SMS include:

- Management of 15,000 accounts, including individual users, course, and project accounts, and special accounts used by system services.
- Management of 1,000 workstations, timesharing machines, and network servers, including specification of default resource assignments.
- Allocation of controlled network services, such as creating and setting quotas for new users' home directories on network fileservers, consistent with load-balancing constraints.
- Maintenance of other control information,

† Care must be taken to distinguish among different senses of the word "server": the SMS server, which manages a database; the servers which provide system services and whose maintenance are SMS's reason for existence; and the update servers which allow SMS to affect these system services.

including user groups, mailing lists, access control lists, etc.

- Maintenance of resource directories, such as the location of printers, specialized file systems (including privately supported file systems), and other network services.

This must be accomplished with the utmost robustness.

The system must be easily expandable, both to support additional instances of a particular service and to offer additional services in the future. At this time, SMS is used to update three services (with RVD to be added shortly):

- *Hesiod:* The Athena Name Service, *Hesiod*, provides service-to-server and label translation. It can be thought of as a high-performance, read-only front-end to the SMS database. See the companion paper in this volume.[1]
- NFS: At Athena, most shared-access read-write file systems are provided by a locally modified form of the Network File System.[2] SMS manages the NFS server hosts, providing quota-based resource allocation, and load balancing. Also refer to the companion paper in this volume.[3]
- Mail Service: Athena's mail service is through a central routing hub to multiple post office servers (mail repositories) based on the Post Office Protocol[4] (POP) of the Rand Mail Handler[5] (MH) package. SMS allocates individual post office boxes to post office servers, and builds the */usr/lib/aliases* control file used on the central mail hub.
- RVD: At Athena, most shared-access read-only file systems are provided by a Remote Virtual Disk system. SMS manages the RVD server hosts, providing access control lists and server configuration files.

Each of these server hosts are controlled by some number of server-specific data files; over 50 separate files are required to support the services described above. SMS currently supports three *Hesiod* servers, 17 RVD file servers, 32 NFS file servers, one mail hub and three post offices. Each RVD server requires one file, and each server's file is different. A *Hesiod* server requires 9 separate files containing 64000 resolvable queries, but each *Hesiod* server receives the same 9 files. Each NFS server requires two files, one file identical across most NFS servers, one file different. The mail hub requires one file, */usr/lib/aliases*.

1.2. Design Points

There are five factors to be taken into account when making design decisions. In order of importance, to this project they are:

1. Reliability
2. Consistency
3. Flexibility
4. Time Efficiency
5. Space Efficiency

SMS must be reliable. In particular, it must be designed to allow straightforward recreation of SMS on replacement hardware from backups, should the need arise. The backup regime for SMS consists of frequent database backups in ASCII format, to redundant sites. All components of the SMS system are designed such that a duplicate configuration can be kept running as a test platform without interfering with normal, "real," operations. Service updates are verified by testing the server before calling an update successful. Failed operations ring alarms that are heard, disabling parts of the system if required, but without interactions with logically unconnected parts of the service management system. Services which are duplicated for availability are updated such that the service is always available; i.e., it is not permitted for server updates to drift into unwarranted synchrony, bringing down all instances at the same time. The entire life-cycle is considered part of the package, so tight change and source-code control (reviewing each change to source, running only what can be built from source) is part of the design.

In addition to having authoritative control of the data, SMS must see that the data is kept consistent. To guarantee internal consistency, SMS clients do not touch the database directly; they do not even see the database system used by SMS. Each application uses the application library to access the database. This library is a collection of functions allowing access to the database by communicating with the SMS server using the SMS protocol. Many of the database consistency constraints are handled by the library. A number of consistency verification applications also exist. To make this consistency reliable, the protocol is designed to be tamper-proof, withstanding both denial-of-service attacks and malicious attempts to corrupt the data. Security is provided with the help of authentication by the

Kerberos private-key authentication system. See the companion paper in this volume.[3]

Beyond these goals, SMS must be flexible in both its database underpinnings and the services it supports. As discussed later in the design section, the particular Database Management System used is insulated from SMS through a Global DataBase (GDB) library,[6] making SMS plug-compatible with other database foundations. It is independent of the individual services—while each service updated by SMS has its own particular data format and structure, the SMS database stores data in one coherent format. A separate program, the Data Control Manager (DCM), converts SMS database (internal) structure to server-appropriate structure (such as a configuration file). When a new service is supported, the database can be changed and only minimal updates are necessary in the SMS server, and a new module is added to the DCM specifying the additional specific output data format to be manufactured.

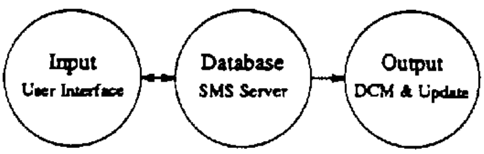
Also, in the interests of flexibility, no administrative policy decisions are coded into the design. These are determined only by the data in the database.

Simplicity of the design is more important than the speed of operation; other systems, such as the *Hesiod* name service, provide a high bandwidth read-only interface to the database. To this end, the server only supports simple queries. Processing efficiency for complex queries is maximized by local applications running on the workstation, not on the central server. Any set of changes that must be atomic to maintain database consistency are performed on the server; sets of non-atomic changes and complex lookup operations are supported in the server only through combining simpler queries.

2. System Design

There are three sides to the SMS system:

- The input side, which contains all of the user-interface programs, allowing the user to enter, examine, or modify data in the database.
- The database side, which consists of the actual database, the SMS server which manipulates the database, and utility programs to backup, restore, and verify the internal consistency of the database.
- The output side, which extracts information from the database, formats it into server-specific configuration files, and updates the various servers by propagating these files.



Various amounts of glue are required to connect these three sides. At the lowest level, there is the network protocol that client programs use to gain access to the database. This, however, depends on the actual model of how database queries are done, which is influenced by the organization of the database (but not its exact format, which is hidden through the protocol).

2.1. The SMS Protocol

The SMS protocol is the fundamental interface to SMS for client applications. It allows all clients of SMS to speak a common, network-transparent language.

The SMS protocol is a remote procedure call protocol based on the GDB library, which in turn uses a TCP stream. Each client program makes a connection to a well known port to contact the SMS server, sending requests and receiving replies over that stream. Each request consists of a major request number, and several counted strings of bytes. Each reply consists of a single status code followed by zero or more counted strings of bytes. Requests and replies also contain a protocol version number, to allow clean handling of version skew.

The following major requests are defined for SMS. It should be noted that each query defines its own signature of arguments and results. For some of these actions the server checks authorization based on the authenticated identity of the user making the request.

noop Do nothing. This is useful for testing and profiling of the server.

authenticate There is one argument, a *Kerberos*[7] authenticator. All requests received after this request are performed on behalf of the principal identified by the authenticator.

query The first argument is the name of a pre-defined query (a "query handle''), and the rest are arguments to that query. Queries may retrieve information or modify what is in the database. If the server query is allowed, any retrieved data are passed back as several return values. All but the last returned value will have a status code indicating more data, with the final one returning the real status code of the query.

access There are a variable number of arguments. The first is the name of a pre-defined query usable for the ''query'' request, and the rest are query arguments. The server returns a reply with a zero status code if the query would have been allowed, or a reply with a non-zero status code explaining why the query was rejected.

Normal use of the protocol consists of establishing a connection, providing authentication, then performing a series of queries. As long as the application only wants to retrieve data or perform simple updates, only an authenticate followed by queries are necessary. The access operation is useful for verifying that an operation with side effects will succeed before attempting it.

2.2. Queries

All access to the database by clients is provided by the application library via the SMS protocol. This interface provides a limited set of predefined, named queries, allowing tightly controlled access to database information. Queries fall into four classes: retrieve, update, delete, and append. An attempt has been made to define a set of queries that provide sufficient flexibility to meet all of the needs of the Data Control Manager as well as the individual application programs, since the DCM uses the same interface as the clients to read the database. Since the database can be modified and extended, the application library has been designed to allow the easy addition of queries.

The generalized layer of functions makes SMS independent of the underlying database. If a different database management system is required, the only change needed will be a new SMS server. It is made by linking the pre-defined queries to a set of data manipulation procedures provided by a version of GDB suited to the alternate DBMS.

At this time there are over 100 supported queries. See the complete technical description of SMS for a listing.[8] Some sample queries include:

get_nfs_quotas
Arguments: machine, device
Returns: list of login/quota tuples
Errors: no match, bad machine
Retrieves disk quota assignments for all users on the specified disk partition.

get_user_by_login
Arguments: login name
Returns: login, uid, shell, home, last, first, middle, status, ID number, year, expiration date, modification time
Errors: no match, not unique
Retrieves information about a particular user, searching by login name. Similar queries exist to search by last name, first name, user ID, and Registrar's ID number.

add_machine
Arguments: name, type, model, status, serial number, system type
Returns: nothing
Errors: already exists, bad type
Appends a new machine to the list of machines known by SMS.

update_server_info
Arguments: service, update interval, target file, script, dfgen
Returns: nothing
Errors: no match, not unique
Updates a service entry, allowing anything but the service name to be changed.

delete_filesys
Arguments: label
Returns: nothing
Errors: no match, not unique
Deletes the specified file system information from the database. Does not automatically reclaim the storage at this time.

Each query has two possible return status values in addition to any errors given above: **success** and **permission_denied**.

2.3. The Database Management System

The database is the core of SMS. It provides the storage mechanism for the complete system. SMS expects its database to consist of several tables of records with strings, integers, and dates. Tables are keyed on one or more fields in each record allowing efficient retrieval by key or wild cards.

The database currently in use at Athena is Ingres [9] from Relational Technology, Inc. Ingres provides a complete query system, a C library of routines, and a command interface language. Its advantages are that it is available and that it mostly works. By design, SMS does not depend on any special feature of Ingres so as to retain the option to utilize other relational database systems.

The database is an independent entity from the SMS system. The Ingres query bindings and database-specific routines are layered at the lower levels of the SMS server. All applications are independent of database-specific routines. An application passes query handles to the SMS server which then resolves the request into an appropriate database query.

The database contains several types of objects. Each object in the database has an access control list (ACL) associated with it indicating who is allowed to modify that object. Each object also has records who last modified it and when that modification was performed. The ACL's are just references to lists in the database. The database contains the following:

- User information: full name, login name, user ID, registrar's ID, login shell, home directory, class year, status, modification time, nickname, home address, home phone, office address, office phone, school affiliation, an ACL
- Machine information: name, type, model, status, serial number, system type, an ACL
- Cluster (mapping of machines to default printer and RVD server) information: name, description, location, default servers, machine assignments, an ACL
- General service information: service name to network port mapping
- File system configuration: name, type, server host, name on server host, mount point on client host, access mode, an ACL
- NFS information: host name, physical disk partition, quota by user on each partition, an ACL
- RVD information: host name, physical disk partition, virtual disks assigned to each partition, pack ID, access passwords, size, an ACL
- Printer information: name to */etc/printcap* entry mapping
- Post office location: for each user post office server and box on that server
- Lists: name, description, modification date, members (which can be users, other lists, or literal strings), attributes (mailing list, UNIX group and gid), an ACL
- Aliases: includes allowed keywords for certain fields in the database, alternate names for file systems, alternate names for services
- DCM information: services to be updated, hosts supporting each service, target files on each host, last update time, enable/override/success flags for updates
- Internal control information: next user ID, group ID, machine ID, and cluster ID to assign (these are just hints); an ACL for each query; usage statistics

2.4. SMS-to-Server Update Protocol

SMS provides a reliable mechanism for updating the servers it manages. The goals of the server update protocol are:

- Rational, automatic update for normal cases and expected kinds of failures.
- Ability to survive clean (target) server crashes.
- Ability to survive clean SMS crashes.
- Easily understood state so that straightforward recovery by hand is possible.

All actions are initiated by the SMS system. Updates of managed servers are performed such that a partially completed update is harmless. Updates not completed are simply rescheduled for retry until they succeed, or until an update can not be initiated. In the latter case, a human operator will be notified.

The update protocol is based on the GDB library just as is the SMS protocol itself. In the update protocol, there are four commands:

authenticate A *Kerberos* authenticator is sent. The update server on the target server uses this authenticator to verify that the entity contacting it is authorized to initiate updates.

transfer This command is used for sending information, usually entire files. The protocol is capable of efficiently sending a half-megabyte binary file.

instructions This sends over a command script, which when executed on the target server will install the new configuration files just sent.

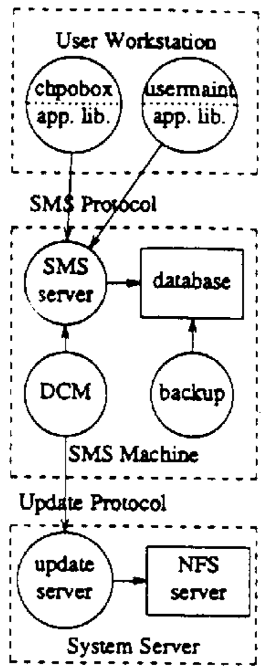
execute This instructs the update server to execute the instructions just sent.

In typical usage, all four commands are used in the order presented above. Multiple transfers may be necessary for some server types. Note that when data files are transfered, they do not directly overwrite the existing data files. Instead, they are put in a temporary position. When the update is executed, the old files are renamed to another temporary name, and the new files are given the correct names. This minimizes the interval during which a server system crash would leave an inconsistent set of configuration files. If all portions of the preparation are completed without error, the execution is then allowed. This usually consists of moving files around, then sending a signal to or restarting a server process. The update server then performs a plausibility check on the result by verifying the operation of the system server, and sends SMS an indicative return code.

3. System Components

Six software components make up the SMS system.

- The database, currently built on the commercial database system RTI Ingres.
- The SMS server, a program always running on the machine containing the database. It accesses the database for the client programs.
- The application library, a collection of routines implementing the SMS protocol. It is used by client programs to communicate with the SMS server.
- The client programs, a collection of programs that make up the user interface to the system.
- The data control manager, a program run periodically by *cron* and driven by data in the database. It constructs up-to-date server configuration files and installs these files on the servers.
- The update servers, which run on each machine containing a server that SMS updates. These are contacted by the data control manager to install the new configuration files and notify the real servers being managed by SMS.



Because SMS has a variety of interfaces, a distinction must be maintained between applications called clients that directly read and write to SMS (i.e., administrative programs) and services which use information distributed from SMS (i.e. a name server). In both cases the interface to the SMS database is through the SMS server, using the SMS protocol. The significant difference is that server update is handled automatically through the Data Control Manager; administrative programs are executed by users.

3.1. Clients

SMS includes a set of specialized management tools to grant system administrators overall control of system resources. For each system service there is an administrative interface. To accommodate novice and occasional users, a menu interface is the default. For regular users, a command-line switch is provided that will use a line-oriented interface. This provides speed and directness for users familiar with the system, while being reasonably helpful to novices and occasional users. A specialized menu building tool has been developed in order that new application programs can be developed quickly. This user interface does not depend on the X Window System.[10] It must be possible for system operators to use dumb terminals to correct resource problems, i.e. it cannot be a requirement that a high level of functionality be present before the service management system can operate.

Fields in the database have associated with them lists of legal values. A null list indicates that any value is possible. This is useful for fields such as *user_name*, *address*, and so forth. The application programs, before attempting to modify anything in the database, request this information, and compare it with the proposed new value. If an invalid value is discovered, it is reported to the user, who is given the opportunity to change the value, or "insist" that it is a new, legal value. (The ability to update data in the database does not necessarily indicate the ability to add new legal values to the database.)

Applications should be aware of the ramifications of their actions, and notify the user if appropriate. For example, an administrator deleting a user is informed of storage space that is being reclaimed, mailing lists that are being modified, and so forth. Objects that need to be modified at once (such as the ownership of a mailing list) present themselves to be dealt with.

The following list of client programs are currently in use at Project Athena. These are rewrites of standard UNIX programs, and are available to regular users:

- *chfn* - change finger information
- *chsh* - change default shell

These are new programs available to regular users:

- *register* - allow new students to claim an Athena account
- *mailmaint* - allow users to add/delete themselves to mailing lists

These are used by system administrators:

- *attachmaint* - map file system names to physical server configurations
- *chpobox* - change forwarding post office for a user
- *clustermaint* - associate a machine with a set of default servers
- *dcmmaint* - update DCM table entries, including service/machine mapping
- *listmaint* - create and maintain groups, mailing lists, and access control lists
- *nfsmaint* - configure NFS file servers
- *portmaint* - maintain the list of well known contact ports
- *regtape* - enter new students from the Registrar's tape
- *rvdmaint* - configure RVD servers
- *usermaint* - maintain user information including file service and post office location

Finally, this program is used only in debugging SMS:

- *smstest* - perform any query manually

3.1.1. New User Registration

A specialized client is the new user registration program. A new student must be able to claim an Athena account without any intervention from Athena user accounts staff. Without this the user accounts staff would be faced with manually creating hundreds of accounts at the beginning of each academic term.

Athena obtains a copy of the official list of registered students from the MIT Registrar shortly before the start of each term. The *regtape* client adds each student on the Registrar's tape who has not already been registered for an Athena account to the "users" relation of the database, and assigned a unique user ID; the student is not assigned a login name or any other resources at this time. A one-way encrypted form of the student's ID number is stored along with the name. No other database resources are allocated at that time. This ID number and the exact spelling of the student's full name as recorded by the Registrar are all that are needed for a student to claim an account. Thus the ID number is something of a password until a real account has been set up.

When the student decides to register with Athena, he or she walks up to any workstation and logs in using the username of "register". This produces a form-like interface prompting for the user's first name, middle initial, last name, and student ID number. The *register* program does not talk to the SMS server directly, but goes through a registration server first. The registration server deals with access control to the SMS server and the *Kerberos* administration server. Register encrypts the ID number, and sends a *verify_user* request to the registration server. The server responds with **already_registered**, **not_found**, or **OK**. After this the register server will do work on behalf of the user; the user still cannot contact SMS directly until he or she obtains a login name and user ID.

If the user has been validated, *register* then prompts the student for a choice in login names. It then goes through a two-step process to verify the login name: first, it simulates a login request for this user name with *Kerberos;* if this fails (indicating that the username is free and may be registered), it then sends a **grab_login** request. On receiving a **grab_login** request, the registration server then proceeds to register the login name with *Kerberos;* if the login name is already in use, it returns a failure code to *register*. Otherwise, it allocates a home directory for the user on the least-loaded fileserver, sets an initial disk quota for the user, builds a post office entry for the user on the least-loaded post office server, and returns a success code to *register*. SMS keeps track of loading on servers in the database, incrementing and decrementing its estimate of the load as it allocates and deallocates resources on each server.

Register then prompts the user for an initial password. It sends a **set_password** request to the registration server, which decrypts it and forwards it to *Kerberos*. At this point, pending propagation of information to the *Hesiod* name service, the central mail hub, and the user's home fileserver, the user's account has been established. These updates may take up to 12 hours to complete.

3.2. The SMS Server

As previously stated, all remote communication with the SMS database is done through the SMS server, using the SMS protocol. The SMS server runs as a single UNIX process on the SMS database machine. It listens for connections on a well known service port and processes remote procedure call requests on each connection it accepts.

GDB, through the use of BSD UNIX nonblocking I/O, allows the programmer to set up a single-process server that handles multiple simultaneous TCP connections. The SMS server will be able to make progress reading new RPC requests and sending old replies simultaneously, which is important if a reasonably large amount of data is to be sent back. The RPC system from Sun Microsystems was also considered for use in the RPC layer, but was rejected because it cannot handle large return values, such as might be returned by a complex query.

A major concern for efficiency in some DBMS's is the time it takes to begin accessing the database, sometimes requiring starting up a back-end process. Since this is a heavyweight operation, the SMS server will do this only once when it starts.

The server performs access control checks on all queries. An access control list (ACL) is associated with each query handle, and with many objects within the database. For instance, to add someone to a list, it is sufficient to either be on the ACL associated with the **add_member_to_list** query, or to be on the ACL of the list in question. In addition, lists, users, machines, and file systems have lists of additional users who are allowed to modify them. The concept of an all powerful database administrator is not necessary with SMS, although could be implemented by having the same ACL for all queries that affect the database.

Because one of the requests that the server supports is a request to check access to a particular query, it is expected that many access checks will have to be performed twice: once to allow the client to find out that it should prompt the user for information, and again when the query is actually executed. It is expected that some form of access caching will eventually be worked into the server for performance reasons.

3.2.1. Input Data Checking

Without proper checks on input values, a user could easily enter data of the wrong type or of a nonsensical value for that type into SMS. For example, consider the case of updating a user's mail address. If, instead of typing "athena-po-1" (a valid post office server), a user accounts administrator typed in "athena-po1" (a nonexistent machine), all the user's mail would be returned to sender as undeliverable.

Input checking is done by both the SMS server and by applications using SMS. Each query supported by the server may have a validation routine supplied which checks that the arguments to the query are legitimate. Queries that do not have side effects on the database do not need a validation routine.

Some checks are better done in applications programs; for example, the SMS server is not in a good position to tell if a user's new choice for a login shell exists. However, other checks, such as verifying that a user's home directory is a valid file system name, are conducted by the server. An error condition will be returned if the value specified is incorrect. The list of predefined queries defines those fields which require explicit data checking.

3.3. Backup

It is not critical that the SMS database be available 24 hours a day; what is important is that the database remain internally consistent and that the data never be lost. With that in mind, the database backup system for SMS has been set up to maximize recoverability if the database is damaged. Backup is done in a simple ASCII format to avoid dependence on the actual DBMS in use.

Two programs *(smsbackup* and *smsrestore)* are generated automatically (using an *awk* script) from the database description file. *smsbackup* copies each relation of the current SMS database into an ASCII file. *Smsbackup* is invoked nightly by a command file that maintains the last three backups on-line. These backups are put on a separate physical disk drive from the drive containing the actual database and copied over the network to other locations. *Smsrestore* does the inverse of *smsbackup*, taking a set of ASCII files and recreating the database. These backups by themselves provide recovery with the loss of no more than roughly a day's transactions. To obtain complete recovery, it is necessary to examine the log files of the servers. An automated procedure to do this has not been written since it is complicated and has not been needed yet.

3.4. The Data Control Manager

The Data Control Manager is a program responsible for distributing information to servers. The DCM is invoked by *cron* at regular, frequent intervals. The data that drives the DCM is read from the database, rather than being coded into the DCM or kept in separate configuration files. Each time the DCM is run, it scans the database to determine which servers need updating. Only those that need updating because their configuration has changed and their update interval has been reached will be updated.

The determination that it is time to check a service is based on information about that service in the database. Each service has an update interval, specifying how often providers of that service should be updated, and an enable flag. For each server/host tuple, the database stores the time of the last update attempt, whether or not it was successful, and an override flag. If the previous update attempt was not successful, the override flag will indicate when to try again. The administrative user's interface provides a mechanism to set the override flag manually, so as to update a server sooner than it otherwise would be updated.

Locking is also provided since an update may still be in progress the next time the DCM is invoked. Without this locking the new DCM process would attempt to update the same service that the older process is still working on.

If it is necessary to update a server, a separate program (also named in the database) is invoked to extract the information from the database and format into the server-specific files. The DCM then contacts the update server on the machine with the target server, sends the necessary data files and the shell script that is invoked on the server machine to install the new files. The success flag is set or cleared based on whether the update attempt succeeded. If the attempt failed, the override flag is set, requesting that another attempt be made to update this server sooner than indicated by the default update interval.

For performance reasons, some parts of the DCM currently touch the database directly rather than going through the SMS server. Nothing is being done that could not be done through the server. However, bypassing the server makes extracting large amounts of information much faster and avoids slowing down the server for these operations.

4. System Performance

The system is more reliable than the one previously in use at Athena. The old version had an update mechanism more suited to the scale of tens of timesharing hosts rather than thousands of workstations. System crashes have been rare. The speed of the system is fair, being fast enough to use interactively, although some queries do take a while to complete. The database currently occupies about 13 megabytes on the server.

Most of the system as described here has been in use for over six months. A few of the points mentioned here are just now being implemented and put into service. Note that this is the only management tool for 5000 active users, 650 workstations, and 65 servers.

4.1. Availability

The SMS server has nearly always been accessible. Some queries, such as listing all publicly accessible mailing lists, will tie up the server for a short period of time. Regular users are prohibited from the longer queries such as listing all users, which will lock up the server for several minutes. The server is occasionally down for safety when an SMS administrator wishes to modify the database directly through Ingres.

4.2. Security

Kerberos authentication on all network access and physical security of the machine have been sufficient to prevent breakins. However, the system has not had enough exposure to believe it is really resistant to concerted attacks.

One problem with the current implementation has to do with security and access control lists. It is difficult to administer the numerous ACL's in the system, and it is not always obvious when different queries are used to predict the effects of changing an ACL. Currently this problem is avoided by having two classes of queries: those that anyone can do, and those that only the database administrators can perform. There need to be more intermediate levels. For instance, it would be useful to allow some system operators to change the information describing public workstations, but not the timesharing machines and service hosts.

4.3. Consistency

The current database suffers from decay. The database grows indexes and reference counts that are wrong, post office boxes that do not belong to any user, and groups with no members. These are assumed to be caused by coding errors in the client library and clients. Any problem is potentially compounded by the very *raison d'être* of SMS. With hundreds of workstations in the field there is no guarantee that SMS client programs installed on them are all at current revision level. There are also a few problems suspected in the database system itself (Ingres), but these are difficult to pinpoint. However, the various data extraction programs used by the DCM are robust; they skip over any inconsistent records so these cause few problems.

A database consistency checker, in the spirit of *fsck*, is run regularly, but only for informational purposes. Because of the dangers involved in modifying the database outside the SMS server, it is not modified by this checker at this time.

A shortcoming of the current system is that it is occasionally necessary to use Ingres directly to make some modification to the database. For example, it was recently necessary to modify every instance of a particular login shell in the user account information. A special client could have been written to do this, but it would only be used once, so the operation was done interactively with the Ingres query interpreter. A large number of similar operations to be executed would normally imply a need for a generalized batch processor. This is is too complicated for our needs, hence such operations are either done by hand through the regular clients, or edited into a script that can be run through the raw Ingres interpreter. Availability of this interpreter makes such operations relatively easy; yet there is the temptation to fix too many things that way, bypassing the checks built in to the client library and SMS server.

Care must be taken to avoid hardcoding into the SMS design current policy decisions about accounts and resources here at Athena. Yet by maintaining this flexibility, it sometimes is too easy to break the rules. This is more often an error than an intentional breaking of the rules. For instance, there have been users who did not have a post office box because of administrative mistakes; they were unable to receive mail.

5. Conclusion

Systems for managing the otherwise unmanageable need to be designed well, burned in realistically, and provided with seamless upgrades. With the Athena SMS, we have an example of a system that is working for the scale of 1,000 workstations, but needs significant refinement to go to the 10,000 workstation level. The initial vision has proven correct; the remaining question is whether the design as we now have it will be capable of the next leap in scale. We believe it will and will be back to report to you with our results.

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PROJECT ATHENA
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Jud Harward has recently joined the Visual Computing Group from the Center for Remote Sensing at Boston University. There he served as Co-Director of the Perseus Project, a Macintosh based multimedia database project on Ancient Greek art and archaeology. Dr. Harward is working on building new Muse applications and is particularly interested in the creation of interactive editors and museum applications under the Muse environment. He holds a doctorate in Classical Archaeology from Harvard University.

Brian Michon is Visiting Scientist from Digital Equipment Corporation's International Engineering Group. At Athena he will continue his research in the design and interface evaluation of cinematic computing systems. Brian is a recent graduate of Stanford University, where he earned a Master's degree in Computer Science specializing in User Interface Design. He also holds a Bachelor's degree in Computer Science and Engineering from MIT.

Russell Sasnett is a Visiting Scientist from the GTE Laboratories. Mr. Sasnett has a broad background in video and computer graphics. He is an award-winning documentary filmmaker, and has co-produced an interactive videodisc on mediation. He has worked as a human interface developer for Lucasfilm's The Droid Works, and as a consultant on the design of graphic interfaces to video editing systems. He holds a Master's degree from the MIT Media Laboratory, where he researched future applications of video databases.

Roman Budzianowski provides system and programming support for educational software projects in the areas of Common Lisp, graphics, and user interface. Dr. Budzianowski holds a Ph.D. in Physics from the Polish Academy of Sciences/Institute of Geophyiscs and a Masters Degree in System Engineering from Warsaw Polytechnic Institute.

Paul Boutin does systems support of UNIX and related software including the INGRES Relational database management system. He is the principal implementor of the Visual Workstation hardware/software configuration.

Constantinos Doukas received his Bachelors Degree from National Technical University of Athens, Greece, in Electrical Engineering and Computer Science and a Masters Degree from Teachers College Columbia University in Computing and Educacation. At Project Athena he designs and programs interfaces for multimedia applications.

Evelyn Schlusselberg holds Masters Degree from the Harvard School of Education. Her undergraduate degree from Boston University is in Special Education. Evelyn's work involves interface evaluation, MUSE evaluation, prototyping applications and documentation.

In addition, several full-time Athena staff members devote significant attention to the work of the Visual Computing Group:

Jacqueline A. Stewart is Manager of Project Athena User Services and Applications Development, the parent group of the VCG. Formerly a manager at Digital Equipment Corporation, Ms. Stewart has responsibility for Athena's groups in documentation, applications programming, training, consulting, faculty liaison, and computer resources.

Dr. Dan Geer, Manager of Athena Systems Development, coordinates the standardization of the Athena Visual Workstation, X11 development, and the integration of visual computing into the Athena network.

Research Associates

Mark Ackerman, formerly a software engineer with the Visual Computing Group, is now a Ph.D. candidate in Information Technology at MIT. His major areas of interest are information retrieval, human-computer interaction, and reference systems.

Steven Wertheim is a Visiting Scientist in the Department of Brain and Cognitive Sciences at MIT. Dr. Wertheim's Neuroanatomy Learning Environment is one of the major projects in Visual Computing. He consults with the group on user interface and digital imaging issues. Dr. Wertheim is currently a Research Fellow at Children's Hospital in Boston.

Wendy Mackay is a doctoral candidate at MIT's Sloan School of Management, specializing in management of technological innovation. Prior to coming to Project Athena, Wendy Mackay managed Digital's Computer-Based Course Development Group and later established and managed the Educational Services Research and Development group. Wendy joined the Project Athena staff in 1986 to consult on multi-media user interfaces.

Solange Karsenty was a Visiting Scientist from INRIA (Institute Nationale de la Recherche en Informatique et Automatique, Paris). She is currently with the Digital Equipment Corporation in Paris and consults with the VCG on user interface issues in Muse.

Dany Guindi was a Visiting Scientist from Georgia Institute of Technology and continues to consult with the VCG on X11 Video Server issues and system development.

1 Visual Computing Initiatives

The Visual Computing Group (originally called the Visual Courseware Group) was begun in 1985 as an effort to accomodate certain MIT faculty who were interested in integrating video into computational courseware. This early effort has grown over the last three years into a development situation that now employs 8-10 people full-time, has created a Visual Workstation, has invested more than a million dollars in hardware and software, has created a public cluster of experimental visual workstations, has sought financial resources outside of the sponsors, and has become a world recognized leader in the field of *Visual Computing* that will have a **very significant impact on education and educational technology.** All this in addition to producing interactive videodiscs and evaluating/implementing image capture and storage technologies.

The Visual Computing Group at Project Athena is doing continued development in four basic areas: **interactive videodisc, visual reference, telecommunications, and image processing.**

These four uses of visual databases are orchestrated by developments in *Athena Muse*, an authoring langauge that will allow students and faculty to create, quickly and without programming skills, highly interactive multi-media curriculum applications. This language has been developed on the Athena Visual Workstation: DEC MicroVax and IBM RT/PC platforms running under the UNIX, XWindow System environment with 8 bit color graphics and full motion digitized video supported by the Parallax Graphics 1280 series boardset.

Currently, the design of *Athena Muse* is being shaped by ten applications already utilizing its basic tools. These include three foreign language **interactive videodisc** projects (*Athena Language Learning Project*) in French, Spanish, and Japanese. The Mechanical Engineering Project on *Bearings* also utilizes interactive videodisc, computer graphics, and expert system software. *New Orleans: A City in Transition* has a visual database of more than five hours of moving video concerned with urban planning, design, and the implementation of cultural change. The visual computing system for this project allows a student to respond to prepared questions by selecting information from libraries of maps, documents, moving interviews, documentary footage, still photographs, and graphics and actually using the system to edit and present the informtion on the workstation.

Visual reference projects include the *Boston Architecture Collection* from the Rotch Visual Collection. This videodisc and text database provide an in depth study of city planning, architecture, and transitional images from 1620 to the present. The *Neuroanatomy Learning Environment* combines an illustrated videodisc glossary, 3D computer graphics,a slide browser, and dissection film for exploration of the human brain. This project also plans to employ **image processing** to enhance areas of the brain for identification. *Introduction to Biology* is a set of basic learning modules written around existing videodiscs of Cell Biology that employ narrated audio tracks and still frame/motion video of molecular materials.

The *Image Delivery System* is designed to use **telecommuncation** technology to remotely serve the workstation visual images from the Boston Architecture videodisc. A student can call for still video images from the Rotch Library by using the MIT cable TV system connected to each workstation and associate the image with an on-line text database.

2 Additional Research Initiatives

Project Athena is also involved in a joint proposal to create a Collection Image System for the Native American Collections at the National Museum of Natural History at the Smithsonian Insititution in Washington, D.C. This project (MITSI) will initially provide Visual Workstation support for curators and researchers using the Southwest Collections. A subsystem will also be created for the Navajo Nation as a prototype for for other tribal museums. The use of Apple technology is anticipated as an appropriate vehicle for the dissemination of this project.

The Visual Computing Group also works with MIT's Center for Space Research Man Vehicle Laboratory "telescience" experiments. By adapting the Visual Workstation to receive digital data, voice, and live satellite video links to the Kennedy Space Center, faculty and students can monitor real time experiments anticipating the use of the multi-media workstation as a NASA system link to the Spacelab and Space Shuttle.

Other areas of interest include the use of image capture and storage devices like Write Once Read Many (WORM) optical media, CD-ROM databases, digital video camera input, networking of digital imagery, "jukebox" (videodisc, WORM, and CD-ROM) delivery systems, digital imagery file systems, digital audio, and high resolution graphics.

Project Athena: Multimedia Learning

Project Athena was launched in 1983 at the Massachusetts Institute of Technology (MIT) with $20 million funding from MIT and $50 million worth of hardware and technical support from DEC and IBM. The aim was to install a network of workstations throughout the MIT campus for the development and use of multimedia learning systems. Part of the network consists of a cluster of 32 bit visual workstations capable of combining full-motion colour video, cable television, digital audio, high resolution graphics and digital data from videodiscs, CD-ROMs, cable television and magnetic discs.

The aim of installing the networked workstations was to promote the use of new technologies to develop systems that would improve the quality of student learning. The Project Athena group is committed to exploring the ways visual information can be set free from its dependence on text. It is the belief of the team that the technology to do this will only reach its full teaching and learning potential when it is in the hands of dedicated educators. The Project Athena Visual Computing Group was formed to facilitate this process by providing the faculty and students with the tools on which to develop applications.

In all, Project Athena has seven interactive learning projects underway and is developing its own authoring language, Athena Muse. The aim of Athena Muse is to create a construction set for multimedia educational software, and to reduce the time and skill required to build educational projects. Athena Muse is based around a system of "packages" containing the different types of displayable material. Applications are developed by specifying the content of the packages and creating control links between them to form a network of packages. Athena Muse is capable of two systems of representation: a network system (eg semantic networks, associative networks, hypermedia webs), and a spatial and temporal scheme allowing descriptions of dynamic state changes.

Also in an experimental phase is the Athena Muse Reference Facility (AMFR) which examines two major issues of electronic information: how to formulate and implement a conceptual structure for indexing and retrieval, and how to allow dynamic and flexible presentations of visual and text materials. The AMFR provides the ability to display a selection of images as active windows, represented by reduced size icons that can be brought to full-screen by clicking the appropriate button. Unlike HyperCard, which links data objects to data objects, AMFR links concepts to concepts presenting information on a dynamic electronic page. The approach is an attempt to provide the aesthetic quality of the printed page with the flexibility of the computer.

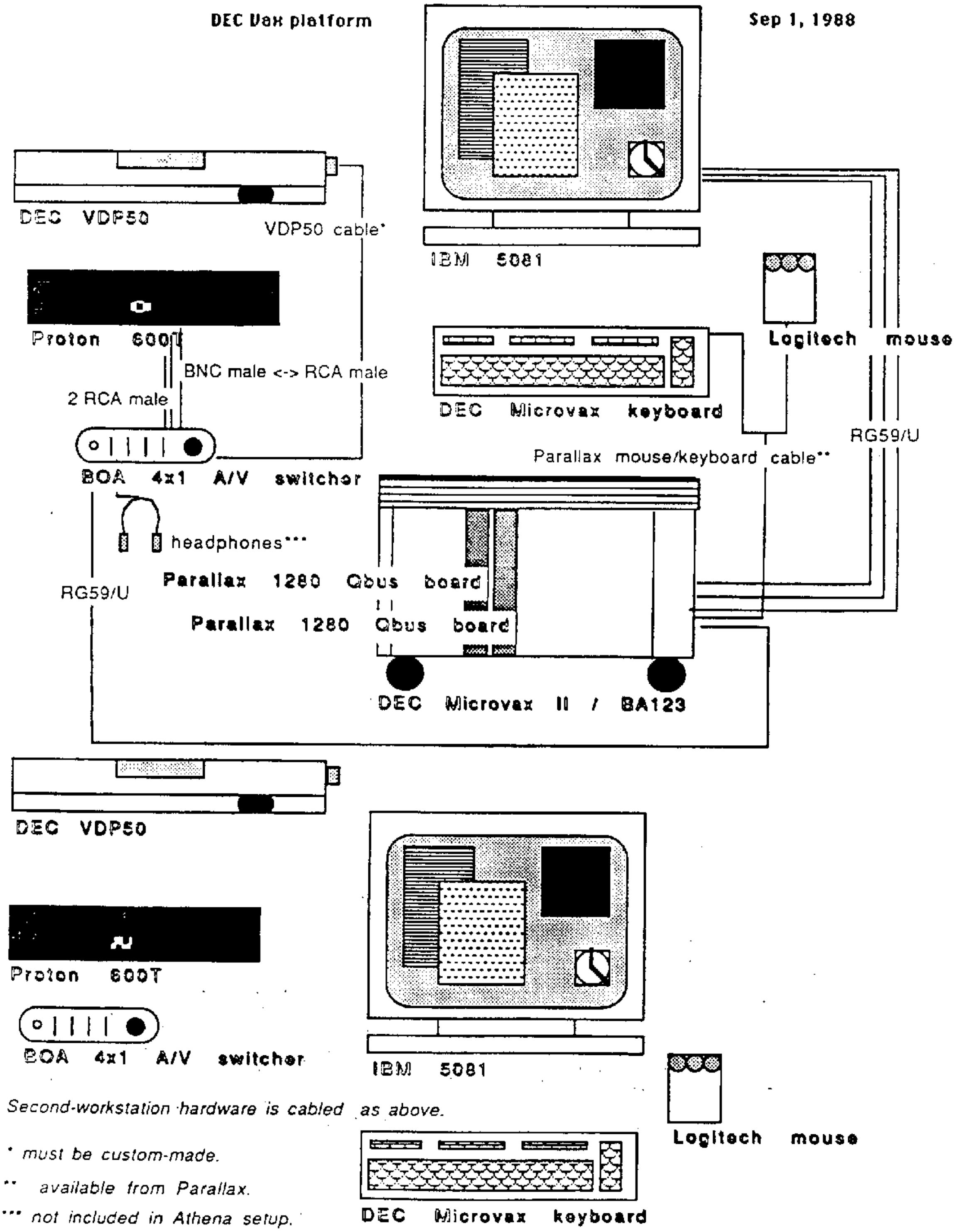
At the courseware development level, the Athena Visual Computing Group is doing research in four basic areas; interactive video, visual reference, telecommunications and image processing. The Athena Language Learning Program consists of three interactive video programmes teaching French, Spanish and Japanese. The Spanish programme, *NoRecuerdo* (I Don't Remember), has been developed as an interactive novella set in Bogota, Columbia. Similar to a computer adventure game, the student must guide a Spanish-speaking scientist who has lost his memory to a vial containing a genetically-engineered amnesia-causing micro-organism. The programme makes use of artificial intelligence to respond to user requests and actions. The *Introduction to Mechanical Engineering: Bearings* project uses computer graphics and expert system software alongside interactive video. In a similar vein, the *Introduction to Biology* project is creating a set of basic learning modules from a number of existing videodiscs on cell biology.

The visual reference programme concentrates on two projects: *New Orleans: A City in Transition* - an urban planning, design and cultural change programme including five hours of video - and the *Boston Architecture Collection* videodisc, from the Rotch Visual Collection, which comprises image and text databases for the in-depth study of city planning and architecture. The telecommunications project concentrates on the development of an Image Delivery System. The project is currently working with the *Boston Architecture* videodisc allowing students to call up images and text from remote servers via the MIT cable television system to which each workstation is linked. The image processing project provides the *Neuroanatomy Learning Environment*, a three-dimensional graphic representation of the brain with videodisc glossary, slide browser and film of a brain dissection.

With the hardware in place and courseware under development, Project Athena is exploring the gaps in our knowledge of the handling of multimedia information networks and courseware design and development. By involving "dedicated educators and learners" in the design and development process, Athena aims to further our knowledge of multimedia learning and communication while developing real applications and tools.

This feature is based on a report made by Ashly Pinnington of Henley Management College, following a visit to the Massachusetts Institute of Technology's Project Athena.

Athena Visual Workstation

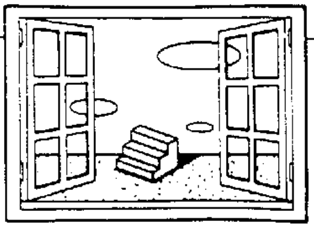


Second-workstation hardware is cabled as above.

* *must be custom-made.*

** *available from Parallax.*

*** *not included in Athena setup.*



IEEE Software

A Construction Set for Multimedia Applications

Matthew E. Hodges, Russell M. Sasnett, and **Mark S. Ackerman**
Project Athena

The Athena Muse system combines four representation schemes to simplify the construction of multimedia educational software that lets teachers and students explore subjects from many views.

"Content vanishes without form. We can have words without a world but no world without words or other symbols," wrote Nelson Goodman in his book *Ways of World Making*[1] In some respects, as Goodman points out, world making is a symbolic affair. Especially in the case of computer-based realities, worlds exist only as descriptions. World makers are confined to the expressive limits of their symbol systems, and so the range of possible worlds is limited by the available means for defining them.

With $100 million in funding primarily from Digital Equipment Corp. and IBM, the Massachusetts Institute of Technology established Project Athena as an eight-year research program to explore innovative uses of computing in the MIT curriculum. One focus is to create an experimental construction set for building multimedia learning environments. The system, called Athena Muse, was designed to support MIT faculty in developing worlds — fictional places for students to experience remote or intangible phenomena, to traverse conventional structures of knowledge, and to practice the skills of research.

The goal of Muse is to reduce the time and skill needed to construct such learning environments. The basic approach is to diversify the tools of symbolic representation available to the computer-based world maker. Rather than restrict the world's author to just one method, as most authoring systems do, our aim is to offer several complementary approaches to better match the patterns of human expression and representation.

To create the hardware platform for Muse, the project's Visual Computing Group modified a standard Athena workstation to support 256-color graphics as well as full-motion digitized video. The group, which focuses on the uses of still- and full-motion imagery in educational software, supports MIT faculty members

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ing of high-level abstractions rather than the simple linking of data objects.

To implement hypermedia applications, the Muse packages are linked in a network. Cross-references are fired by activation signals sent from one package to another. The display of information is controlled by the activation and deactivation of packages, so a whole chain of packages can be displayed as the cross-references are triggered.

• State-transition networks. In a different branch of educational computing — one related more to simulation than document management — the directed graph again emerges as a fundamental organizational structure. In the state-transition network, nodes of the directed graph represent a system's finite states and arcs indicate branching paths from one state to another.

The Language Learning Project uses two forms of this model. The first is a branching movie, which is a simulated interaction with a cast of fictional characters. Each scene occupies a node in the network. The order of scenes is based on input from the viewer, which is generally gathered at the end of each scene. The film's entire structure can be represented as a tree, where viewer choices determine which path through the tree is followed and, ultimately, which conclusion is reached.

The second example is a fixed-route surrogate travel system. In a French-language application, Direction Paris, students are asked to visit and explore apartments in Paris as part of the interactive story. The apartments are represented as sequences of photographs that step through the various rooms. In this case, each sequence of photographs becomes a node in the network. The branch points are intersections in the apartment where the student can choose to turn left or right, continue straight ahead, or turn around. Here, the graph does not follow a tree structure but is a network of nodes (see Figure 1).

Limitations. While using the directed-graph model extensively, the foreign-language projects also indicate some limitations that this approach has as a representational scheme. These projects' design calls for dynamic subtitling for the full-motion video. Subtitle texts are displayed on the screen phrase for phrase with the native speakers. Also, intermittent cultural flags appear when the speaker uses an idiomatic expression or references something of cultural interest.

Students control the video: They can stop at any point and back up an arbitrary amount to repeat the presentation. The problem, of course, is that with the subtitles and cultural flags, this means the text must be rewound to stay matched with the video.

We could have achieved this with a directed-graph model, but it would have been an awkward implementation. Instead, we used a second — and very different — system of representation, one that uses a spatial framework to organize information.

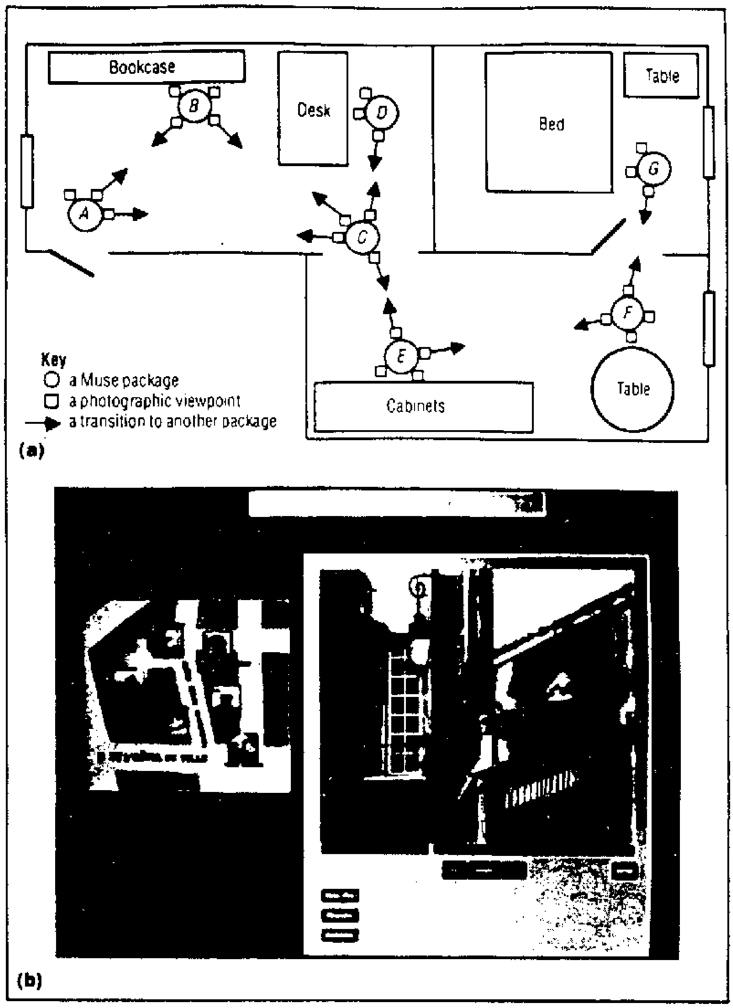

Figure 1. (a) This floor plan of an apartment in the Direction Paris application shows how Muse packages arranged in a directed graph can construct an interactive surrogate travel environment. Each package contains a series of photographs that show the passage from one point to another. The current position of the dimension determines which photograph is displayed at any time. **(b)** A Direction Paris photograph.

Multidimensional information

Information like that of the foreign-language subtitles is a matter of timing. In such cases, we use a conventional time line with onset and offset times for each information unit. The time line implies a structure fundamentally different from the spaceless web of nodes that make up a directed graph. In this case, time functions as a dimension, with information or-

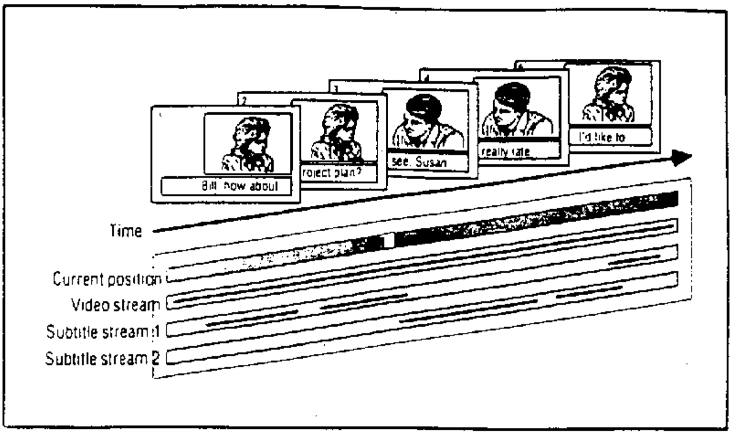

Figure 2. Internal structure of a package showing the synchronization of subtitles and full-motion video. The time dimension controls the choreographed display of text and video.

ganized by position. Muse lets spaces of arbitrary dimensionality exist within each package. Dimensions need not represent real time or physical space; they can represent any changing value in a dynamic system.

First dimension. The subtitles for foreign-language films described earlier are a good example of how to use dimensionality (in this case, one dimension). The easiest way to couple subtitles with video is to create links between frame numbers on the videodisc and text fragments in the subtitle stream. With this arrangement, the video stream becomes the representative of time in the display and the subtitles look directly to the video for timing information.

Instead of using frame numbers directly, we created a layer of abstraction between the two channels. We used an independent dimension of time and attached both the video and text to this abstraction separately. This way, no two components of the display are directly tied to one another, which makes it easy to add and remove channels of information without disrupting the whole presentation.

The dimensions themselves are bounded integer ranges, with maximum and minimum values. Each dimension maintains a current position in its range. Set-position signals adjust the current positions. User-interface controls, such as on-screen command buttons and scroll bars, can generate these signals, as can the system clock as it drives time forward and thus determines when the text and video appear and disappear. You can attach any number of channels to the dimensions, so a dimension of time can handle multiple streams of subtitles, cultural flags, and so on, in a complex display choreography (as Figure 2 shows).

This provides a general mechanism for annotating video material. With the spatial framework, it becomes possible to cut and paste video without losing the annotations. This capability has utility in several Project Athena target applications.

For example, the New Orleans: A City in Transition project has a database of three hours of full-motion documentary footage stored on videodisc. These materials were produced in 1983-84 and document the planning and development that took place for the New Orleans World's Fair. The video is being used in both urban planning and filmmaking classes. Students are asked to draw illustrations from this archive and to prepare small documentary pieces representing different interests and perspectives. It is important for the users to be able to attach annotations and data references to specific points in the video.

Second dimension. It's a small step from one to two dimensions, where x and y dimensions define a Cartesian space. Again, the dimensions function as an abstract spatial framework to organize and manipulate display data.

Such a space is commonly used to manipulate images on the screen — zooming and panning, for example. Once the image is mapped to the dimension space, these effects are achieved by manipulating the dimensions. Any change in the current position of x or y affects the image display. In this respect, the dimensions provide a coherent system for handling different kinds of display information.

The Muse prototype lets the x and y dimensions be defined as virtual coordinates, so the display window becomes a viewport into a larger space. Zooming and panning over an image become a matter of moving the viewport within this virtual space and changing the scope of its display. All the display materials, including still video images, are scaled and repositioned appropriately.

The neuroanatomy project uses this technique to view cross-sectional photographs of the brain. The student can zoom in on any region of an image. Because Muse defines the image in a virtual space, it can resolve the coordinates of anatomical features no matter where the features appear on the screen or at what scale they are displayed. This lets different areas be tagged as endpoints to a cross-reference while still letting the student manipulate the image.

You can apply the same technique to view more than one image. Consider the Boston Architecture Collection project, which has an archive of 30,000 images of Boston architecture from MIT's Rotch Visual Collection. These images are used for comparative analysis of architectural style; the teacher or student typically wants to select images and organize them into presentations.

A query to the Boston database will return a list of images, which can then be displayed and manipulated in a 2D virtual space. You can control these images the same way as in the neuroanatomy example, so you can view any subset of images at any scale. Muse allows multiple simultaneous views of this space, so you can create more than one viewport, each showing different regions at different scales. You can add text and graphic annotations and interface-control mechanisms such as scroll bars. As you work, you can organize these virtual light tables into the pages of a personal notebook.

***N*th dimension.** Muse does not limit the number of dimensions that can be created. Dimensions can represent not only phyical space and time but any changing parameter in a dynamic system. Dynamic systems are often modeled as a state space, which is a set of coordinates or dimensions that define the range of movement along each degree of freedom (dimension) in the system. A dynamic function or process governs how the position of the system changes and moves through its state space.

You can use dynamic systems of this kind to implement some forms of simulation. Because simulation is a classic method of using computers in education, it is a highly important focus of the Muse system.

In Muse, the dimensions are well-integrated into the indexing and cross-referencing machanisms. Taking advantage of this, a teacher can easily make cross-references directly into the state space of a dynamic system. This provides a generic method for querying the simulation state, changing the simulation state, and setting trigger conditions in the simulation that can change state in other nodes of the directed graph.

The Navigation Learning Environment project is an example of a time-driven simulation implemented with Muse. This project simulates a boat moving through two square miles of coastal waters in Maine, using a library of about 10,000 images to represent the environment. The entire simulation is implemented as a single interactive document and uses seven dimensions. Two dimensions represent the boat's x,yposition. Another two dimensions represent the boat's heading and speed (the systems uses these to compute the boat's position). A fifth dimension tracks the user's viewing angle, since you can look in any direction from the boat regardless of its heading. The sixth and seventh dimensions manage a simulated compass that can be positioned anywhere on the image.

The effect is that the user can steer through a virtual world, using command buttons and scroll bars to control the boat and a mouse to take compass bearings directly from the images. The simulation becomes active whenever the document is opened, and the user can choose whether to take control or simply watch. A system timer updates the boat's position every 0.1 seconds.

To implement such a simulation, a fairly high level of orchestration is needed among the various display elements. The directed graph and spatial framework provide a foundation for organizing and controlling the display elements, but you also need some facility to coordinate the behavior of these elements. In many cases, you can define the desired relationships as simple functions and thus implement them as declarative constraints.

Declarative constraints

Constraints are functional bindings within a system that define relationships among different components and automatically propagate change among them.[5] In Muse, constraints are limited to bidirectional equality relations: You can apply such bindings to attributes of the dimensions and display elements.

An example constraint is the relationship between a scroll bar and a dimension. It is usually important to have a visible representation of the dimension, either to control it or to see what state it is in. You can use a scroll bar for both operations: If you use the mouse to reposition the slide bar indicator, the change will be propagated to the dimension. Conversely, any changes in the dimension that occur from some other input or timing event will be propagated back to the scroll bar, as Figure 3 shows.

It is usually important to have a visible representation of the dimension, either to control it or to see what state it is in. You can use a scroll bar for both.

A similar case is a dynamic graphic object that modifies its appearance based on a constraint binding to a dimension. In the navigation project, we created a simulated hand-bearing compass by using constraints. The compass moves to the location of a mouse click in a water-level view of the environment and prints a value between 0 and 359. The system can compute the bearing because it knows the camera orientation for the panoramic views.

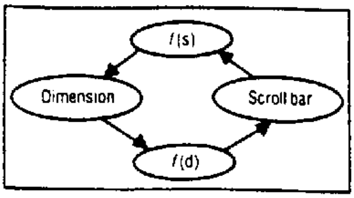

Figure 3. The appearance of scroll bar representing time is a function of the time dimension's current position. Conversely, you can control the current value of time by dragging the scroll bar.

This example uses three constraints, one each for the x and y locations on the screen and one for the text label that indicates compass direction. When a mouse click occurs, the system uses the mouse's x and y position to adjust the compasss's x and y directions in the simulation document. The changes in these dimensions are then propagated via the constraint to reposition the graphic object. The number printed on the screen is constrained to the compass x dimension, which ranges from 0 to 359.

Constraints are a common feature in Muse applications. They range from simple one-way bindings on a graphical object to complex interactions among a group of dimensions used to implement a simulation. They are declarative in that they generally consist of simple mathematical expressions that include references to dimensions and display attributes.

As an editing environment for such constraints, we have experimented with a modified spreadsheet calculator. Our aim is to embed small spreadsheets in the Muse environment as editing utilities for defining and managing constraints. A cell can directly reference a dimension in any package as its input value. Values can be picked up from one or more dimensions, processed through a series of mathematical functions on the spreadsheet, and output to other dimensions or display objects. In a simple case, the spreadsheet can act as a patch panel or routing switch, directing the propagation of data values to different components of the system. In a more complex case, the spreadsheet can maintain the constraint relations that form the core of a simulation.

The declarative constraints in Muse maintain reversible linear functions among the system components. In many cases, however, constraints are not sufficient to define all of the actions and be-

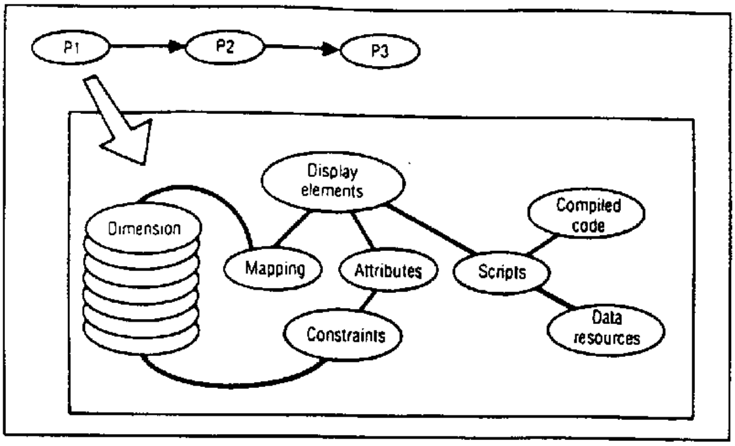

Figure 4. The Muse architecture. P1, P2, and P3 are packages in a directed graph. Each package contains bounded dimensions and display elements. You assign display elements to a position through mapping. You can link attributes of the display elements through unidirectional or bidirectional constraints. Display elements can also have interpreted scripts for specialized user actions. These scripts have access to external data and compiled procedural code.

haviors needed in an application. Procedural descriptions fill this need.

Procedural descriptions

In Muse, one design principle is to minimize the use of procedural code, since data specification tends to be quicker to create and to require less-specialized skill. However, any purely data-driven system is bound to fall short because there will be some application requirements, such as database queries and user interactions, that cannot be accommodated effectively with a strictly data-driven paradigm.

Thus, we included procedural descriptions as one of the four major resources provided to developers. You can incorporate two kinds of procedural materials in Muse applications:

- In the simplest case, single actions can be defined as attributes of Muse packages and their display elements. Often, a single action is sufficient, as in one package sending an activation signal to another. This forestalls the need to use a more formal procedural description.
- In more complex cases, you use an interpreted language called Event Script. Event Script was developed as the procedural component of Muse. It lets you attach special-purpose behaviors to individual display elements. Event Script is a simplified object-oriented language that is used primarily for creating user-interface event handlers. It is not meant to be a general-purpose programming environment.

Event Script follows an uncomplicated syntax, similar to Apple's Hypertalk language, using untyped variables and event-oriented construction.[6] In addition, Event Script permits transparent access to any C variables or functions in the program space. Thus, any object's methods can gain access to general system libraries or resources, providing an extension mechanism to Muse.

Delegation strategy. Event Script uses a variant of the delegation strategy for sharing object behavior.[7] In Event Script, you can specify an object to use the contents of one or more existing prototype objects. If a message handler is not found in the recipient object's methods, a search is begun in the recipient's prototypes (and in their prototypes) until the method is found or the chain is exhausted. If found, the method is then borrowed and executed in the scope of the original object. Event Script addresses the problem of preserving local context through an inheritance chain by built-in functions that return the name of the client and delegate objects, which can be used inside any method. (The client is the original recipient of a message; the delegate is the owner of the borrowed method.)

An important feature of delegation is that any existing object can be duplicated and given a new name. The duplicated object has its own local state variables but shares the method dictionary and prototype list of the original object. This permits great flexibility in defining new objects dynamically. Developers can duplicate and modify prototype objects for specialized applications and their interfaces.

Applications. The primary use of Event Script so far has been as a programmer's interface to X Windows. Objects can be bound to windows; thereafter any X Windows events occurring in that window are translated into messages to the Event Script object. Normally, an Event Script object is associated with a display element in a Muse package. When the display element's window is activated, the object is registered to handle all the window's events. Often the desired behavior is shared by many display elements, as in the case of window exposure events. This situation is well-suited to the method-borrowing form of delegation we have implemented.

Editing in Muse

The human interface begins with the data model. If the data model does not fulfill the purposes of the system as a whole, any efforts on the more superficial aspects of the interface will be largely wasted. Given a sound model to work from, the next step is to design efficient editors and make the development process easier.

One Muse design goal has been to write the editors that manipulate the data model in Muse itself. This work is continuing as a primary focus in the second version of Muse.

Muse uses a direct-manipulation style of editing. One example is a Muse video editor, which we have implemented as a test case. The editor is modeled after a two-buffer text editor, where two buffers of video are displayed on the screen side by side. The two buffers are defined as Muse packages, with time as the principal dimension. Cutting and pasting video segments is a matter of selecting a region of time in one buffer and then cutting all data resources referencing that part of the time dimension. You can then paste these cut materials into the other video stream, just as a text editor would paste text into another buffer. We implemented the cut and paste functions as compiled C functions, but they are controlled through the Event Script section of Muse.

To be useful, the four representations — directed graphs, dimensions, declarative constraints, and procedural descriptions — must be combined into a coherent framework. Muse integrates them into one data model, as Figure 4 shows. We have tried to achieve a system where the strengths and weaknesses of the various approaches complement one another and allow for free interaction so that the combination offers much greater potential than four separate systems would.

The prototype version of Muse has shown promise in speeding up the process of world making that is the basis for teachers and students to explore their subjects and encourage them to investigate many points of view. Muse has also shown promise in reducing the need for specialized programming skills. ❖

Acknowledgment

We thank the MIT faculty members who have carried out the projects for which we developed Athena Muse: Gloriana Davenport, Gilberte Furstenberg, Douglas Morganstern, Janet Murray, Merrill Smith, and Steven Wertheim.

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The MIT Report

Dec/Jan 1989-90
Massachusetts Institute
of Technology
Industrial Liaison Program
Volume XVII Number 10

WHAT'S NEW AT MIT

FUSION: HOT OR COLD?

Fusion was a hot area of research long before anyone thought that the phenomenon might occur at room temperature. Since the early 1960s, a major international effort has been under way to harness the enormous energy released when the nuclei of isotopes of hydrogen are made to fuse together at extremely high temperatures and pressures.

Funding for thermonuclear fusion power research got a shot in the arm after the oil crisis in 1973 highlighted the need for alternatives to fossil fuels, rising to about $500 million a year in the U.S. in 1980. But with oil prices falling back into line in recent years, support has slipped steadily down to just over $300 million. According to Professor Ronald R. Parker, Director of MIT's Plasma Fusion Center (PFC), this trend may have serious long-term consequences for our nation. "We are on the verge of a new energy crisis that is much more insidious than the last one," he warns. "It takes years for the effects of burning fossil fuels, including pollution, acid rain, and global warming, to produce visible damage to our environment. The sky isn't falling, but we know something is happening out there."

Thermonuclear fusion has extraordinary appeal as an energy source even aside from its role as the process that powers the sun. The hydrogen isotopes required as fuel are found in abundance in seawater, and a little more than 3 grams of the fuel produces the energy equivalent of 1,000 gallons of gasoline. Furthermore, a fusion plant would produce little long-lived nuclear waste and poses no threat of "meltdown." Although cold fusion may indeed exist, Parker explains, it is a distinctly different phenomenon from "hot" fusion, and it appears to have little potential as a major energy producer.

While the debate has raged on since last spring about cold fusion, the thermonuclear fusion community has quietly edged closer to the brink of a major milestone. The Joint European Torus (JET), a giant fusion research reactor in England, is now well positioned to be the first to reach breakeven -- a point where the energy produced by the fusion reaction equals the amount of power used to cause the reaction. This is the first step in the long road to building a commercially viable fusion power plant, a process of research and development expected to take about 20 more years.

Much of the fusion research at MIT today is aimed at the next step: ignition. ALCATOR C-MOD, a prototype for an ignition reactor, is now under construction at the PFC. Its research goal is to prove the feasibility of a relatively small, high-field tokamak to produce a self-sustaining fusion reaction. MIT's involvement in fusion power is an outgrowth of its basic research in the field of plasma physics as well as its work in high-field magnets, which are used to contain the ultra-hot clouds of randomly moving charged particles. Other research at the Center focuses on such diverse topics as space plasmas, free electron lasers, electron beam devices, and materials processing.

At present, major research efforts in the Soviet Union, Europe, the U.S., and Japan are exploring the potential of thermonuclear fusion. A joint project involving the cooperation of all four -- the International Thermonuclear Engineering Reactor -- has been proposed to integrate the expertise of these groups and to spur progress toward the goal of commercialization.

But Parker is concerned that slipping U.S. funding may preclude our ability to participate, or even to keep up the pace of research. "If the Japanese or the Europeans develop fusion technology first," he warns, "we will be buying it from them."

For more information on fusion research at MIT, circle number 53 on the Preprints Order Card.

MANAGEMENT IN THE 1990S

How to manage the organizations of the 1990s effectively, and what role the revolutionary capabilities of information technology can play in that process, is a people problem, not a technology problem. All functions of an organization and all levels of management will have to be reassessed and carefully coordinated in order to respond constructively to the changing nature of information technology and to take advantage of the ways it can transform the structure and the work of an organization.

This is one of the central messages

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The MIT Report Dec/Jan 1989-90

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THE MIT INDUSTRIAL LIAISON PROGRAM

Founded in 1948, the Industrial Liaison Program provides its member companies with convenient access to the expertise and resources of MIT. Through its various services, the Program works to build mutually beneficial relationships between MIT and the international industrial community. The purpose of *The MIT Report* is to present comprehensive information on the full scope of research and educational activities at the Institute.

arising from the Management in the 1990s Research Program, launched in the fall of 1984 by MIT's Sloan School of Management in conjunction with 12 diverse major international organizations. The broad purpose of the program was to begin to develop a factual and systematic base of understanding for both the practicing manager and the management educator on such issues as the potential of information technology and the types of skills needed by today's and tomorrow's managers.

Over the past four years, nearly 30 research projects have been carried out, involving 25 faculty drawn from throughout the Sloan School as well as MIT's Department of Economics and Department of Political Science. The 12 participating sponsors not only provided the funds to support the research, but they helped shape the research agenda by sharing their knowledge and insights into the issues faced by their organizations. Sponsors also provided field sites for researchers to examine leading edge applications of information technology, including strategy formulation, marketing, sales, manufacturing, engineering, purchasing, and human resources.

Four of the sponsors are vendors of information technology: Digital Equipment Corp., International Computers Ltd., MCI Communications, and BellSouth. Three are users of the technology in the manufacturing sector: British Petroleum, Eastman Kodak, and General Motors. And five apply the technology in services: American Express, Ernst & Young, CIGNA, the U.S. Internal Revenue Service, and the U.S. Army Headquarters.

Program research has shed light on effects ranging from those seen at the individual level to those that affect entire industries. Stepping back from the specific findings, six major trends emerge from the 90s Program.

The Changing Nature of Work–Until fairly recently, information technology has been used to reduce costs by automating jobs. Future applications will depend upon applications to support knowledge workers, a much larger and more diverse group. There has been little prior experience to guide how and where to apply the technology. Studies of early applications have shown that, when successful, they can have a profound and often unanticipated impact on task definitions and roles played by both professional and support staff.

Electronic Integration–Since the power and plummeting costs of information technology makes possible a much richer variety of ways to coordinate activity, firms should reassess the way both internal and external functions are managed. Such an evaluation requires some real mental stretching, because the basic patterns of coordination–between engineering and manufacturing, for example, or between a principal manufacturer and its suppliers–have not seen major change in nearly 50 years.

Changing Organizational Structures–For knowledge workers, the changing nature of work usually includes a broadening of skills. This effect, coupled with the introduction of electronic communication networks, is leading to the emergence of the "networked organization," an entity which is likely not only to be less hierarchical and more responsive but also to vary over time and and contain parts of legally separate entities.

New Competitive Climate–Although the competitive consequences of these changes will vary widely from industry to industry, they will be substantial in almost all businesses. Firms must respond strategically to this trend, re-examining long-established patterns of competition and collaboration in the light of the new capabilities of information technology.

Changes in Management Systems–New strategies, structures, and individual roles can live up to their potentials, only with corresponding changes in management systems. The traditional many-layered hierarchy is not likely to be effective when some critical team members are not even employees of the firm. And traditional ways of monitoring employee performance break down when the work is being done by ad hoc, geographically dispersed teams, some of whom may be working at home for a significant portion of the work week.

The Challenge of Change–The 90s

Program has identified four conditions that can help make the process of change successful. First is leadership and a shared vision, a requirement that is especially critical when the changes are likely to be major and protracted. Second is the availability of the necessary information technology infrastructure. Third is the commitment to training and education needed to prepare for and motivate change. Fourth, human resource practices must not only be flexible, but they must be crafted to provide the proper incentives to encourage innovation and cooperation.

A book summarizing both the specific results and the broad trends uncovered by the Program is scheduled to be published by the Oxford University Press in late spring.

For more information on the Management in the 1990s Program, circle number 54 on the Preprints Order Card.

REAL ESTATE IN THE 1990S

Caution is the word for the next decade in most sectors of the real estate market, according to Professor William Wheaton who holds a joint appointment MIT's Department of Economics and the Department of Urban Studies and Planning.

Two significant factors are cutting back demand in U.S. commercial real estate markets in the the '90s , Wheaton explains. First of all, most economists are predicting a downturn in the economy around 1990, and commercial real estate is typically sensitive to general economic slowdowns. Moreover, Commerce Department projections show that the growth in the labor force that fueled the rapid expansion of real estate over the past two decades will grind to a halt by the year 2010.

To complicate matters, large institutions in the U.S. have embraced real estate as an investment, raising its share in their portfolios to as much as 15 percent today, up from insignificant levels in 1990. The influx of additional investment funds has led to overbuilding.

Institutional interest has been spurred by studies that have shown real estate to be a low risk investment with high returns. But Wheaton argues that since these studies typically rely on appraised values, their conclusions can be misleading. After taking a look at actual income data and applying factors to account for risk, Wheaton has concluded that real estate is not quite so ideal an investment.

The above comments were extracted from a talk presented at a recent meeting sponsored by MIT's Center for Real Estate Development. For more information on research on returns to real estate investment, circle number 55 on the Preprints Order Card.

BREAKTHROUGHS ON ICE

In the Arctic, ice is not only a raw material for sculpting ice islands that serve as offshore platforms but also a shifting, flowing hazard capable of destroying both conventional offshore structures and frozen ones. Engineers presently design arctic structures using empirical data about ice's properties, but that is insufficient to predict the full range of ice behavior. Now, MIT researchers under the direction of Professor S. Shyam Sunder of the Department of Civil Engineering are developing a more sophisticated theoretical model of ice behavior that will allow engineers to predict the formation and propagation of cracks in ice under mechanical load.

Sea ice is a surprisingly complex material. It is basically a jumble of randomly oriented crystals complicated by the presence of air bubbles, pores, and pockets of brine. Stresses applied to porous polycrystalline ice hit chaotically arranged crystal boundaries in chaotic directions, resulting in a mix of shearing, friction, and tension stresses.

Sunder has developed a new mathematical model of crack nucleation that can predict the influence of the stress state and the effect of pre-existing pores on crack nucleation. The theory predicts that the nucleation of crack in compression requires a significantly larger stress than in tension; that the tensile strength in ice depends on the size of the crystals; and that pores, which are present even in the relatively dense ice samples made in a laboratory, can significantly affect crack nucleation. The first two of these predictions have been recently confirmed in experiments in other labs, and the third resolves a major debate in ice research.

Further work is under way to develop equations to account for the evolution of tiny defects in ice and to develop techniques to track defects in ice by monitoring its acoustic emission response. Ultimately, the scientists' goal is to lay the foundations for the safe, reliable, and efficient design of a wide variety of arctic structures, ranging from icebreakers to offshore platforms.

For more information on this research, circle number 56 on the Preprints Order Card.

CONTROLLING MICROMOTORS

Micromotors are tiny electrical "motors-on-a-chip" that are produced using the techniques of integrated circuit fabrication technology. These devices have rotors that are just 50 to 200 microns across and they can whiz along at thousands of revolutions per minute. They hold great promise for applications requiring extremely precise motion control, such as aligning optical fibers, for example. There is also the possibility of producing "microtools" for holding, manipulating, and modifying micron-sized objects.

A number of barriers must be overcome, however, before this promise can be realized. One barrier is the design of appropriate control systems, which are required to guarantee stable, accurate performance. Professor Jeffrey Lang of MIT's Department of Electrical Engineering and Computer Science has recently developed a model of the electromechanical dynamics of a relatively general micromotor to test various control schemes.

His analysis has led to several conclusions. First, the strong similarities between the dynamics of micromotors and those of conventional-sized motors implies that the considerable accumulated knowledge of the dynamics and control of the latter is applicable to the former. Second, the least understood aspect of the dynamics of micromotors is the friction component of their load torques. Further research on the role of friction is essential to further progress in the control of micromotors.

Third, because of its particular dynamics, it is simpler to design a closed-loop control system for what is known as a variable-capacitance micromotor. And fourth, there is a likelihood that electric micromotors will display a performance-limiting instability under open-loop control, which is simpler to implement than closed-loop schemes.

Although closed-loop controls for micromotors are simple in principle, they may be a challenge to implement. In addition to the unknown complications due to friction torque, closed-loop schemes require motion microsensors, which have yet to be designed and fabricated.

For more information on this research, circle number 57 on the Preprints Order Card.

FIGHTING SCIENTIFIC ILLITERACY

Science and technology are inextricably interwoven into the fabric of our society. Not only are they the basis of our current quality of life, but a scientifically literate workforce is crucial to the competitiveness of our nation's industries in the global marketplace. Yet scientific illiteracy is on the rise in the U.S.

Now, an MIT program under the direction of Professor Ron Latanision of the Department of Materials Science and Engineering has sparked a grassroots movement to combat this problem. Last summer, 51 high school science teachers from around New England came to MIT for a week-long program of lectures, lab tours, and hands-on demonstrations designed to help convey the excitement of science to students and to address the problem of scientific illiteracy. Sponsored by MIT's Materials Processing Center (MPC), the program included talks by six academic department heads and four center directors.

While at MIT, the teachers drafted a statement on the problems behind scientific illiteracy and planned a follow-up meeting to brainstorm solutions. As a result, 43 of the teachers reconvened late last fall with MPC staff and formed a new organization--New England Science Teachers (NEST)--that they felt could assume a more active role in pursuing the issue than existing groups.

NEST's first initiative was to organize five committees to pursue five key follow-up initiatives. The committees are:

Briefing Package–NEST members plan to create a briefing package which will be sent along with a videotape of the original teacher program to other educators, news media, and government to help educate the public about the value of a science education.

Newsletter–To help bring the community of 6,000 New England science teachers together, members are creating a NEST newsletter.

Elementary Resource/Mentor–The object here is to encourage teachers to reach back to elementary schools to serve as mentors or to help with curriculum development.

Accreditation Review Critique–This initiative is aimed at providing advice to school administrators, who often don't understand or attach a high priority to science issues. A related aim is to relax teacher accreditation standards to make it possible for retired scientists to help overcome a projected nationwide shortfall of 300,000 science teachers in elementary and secondary schools by the turn of the century.

Government Affairs–This committee will develop a strategy for introducing NEST goals to all levels of government.

For more information on this effort, please circle number 58 on the Preprints Order Card.

PROJECT ATHENA REACHES MILESTONE

In mid-December, MIT's Project Athena, a $100 million joint educational project sponsored by IBM, Digital Equipment Corporation (DEC), and MIT, installed its 1,000th workstation. The Athena network, which has been designed to scale up to 10,000 workstations, is reputed to be the largest centrally managed single-site installation of workstations in the world.

The Athena system, developed through $80 million in grants from IBM and DEC and an additional $20 million investment by MIT, is a major computing resource for all MIT students and faculty. Project Athena users can go to any one of hundreds of networked IBM or DEC workstations in more than 40 locations about the campus, log in with their personal password, gain immediate access to their private files, and start working. The system is available 24 hours a day to its more than 10,000 active student, faculty, and staff users, who generate about 3,000 log-ins and 10,000 electronic mail messages a day. Last year, users printed out 3 million pages of text and graphics.

Nearly 3,000 visitors from around the world come to see the Athena system each year. It is being made available at no cost to universities and laboratories throughout the world. Athena systems have recently been installed at universities in West Germany and Australia, as well as at DEC's Cambridge laboratory.

The project has developed some industry standard software, such as X Windows and Kerberos, that is made available to the public at nominal cost. X Windows permits different computers to communicate with each other to display graphical output, as well as for an individual workstation to have an almost unlimited number of window panes of different program information on its monitor. Kerberos is a security system that authenticates all users. It aided in barring the November, 1988 national computer virus from infecting Project Athena machinery.

Athena users may access more than 40 special courseware lockers, including a cardiovascular simulator, modules for the teaching of fluid mechanics, thermodynamics software, a program for simulating and designing structures, and control theory packages. Over 100 subjects give assignments each semester on the Athena system. A newly installed Cray 2 supercomputer may also be accessed from any Athena workstation.

Headed by Professor Earll Murman, Athena has a staff of 50 programmers, consultants, and operational personnel.

For more information on Project Athena, circle number 59 on the Preprints Order Card.

RESEARCH OPPORTUNITY

DEFENSE AND ARMS CONTROL STUDIES PROGRAM

Revolutionary changes that are now sweeping through the countries of Eastern Europe, coupled with continuing reforms in the Soviet Union in the spirit of glasnost, have cast a new light on our current national security policy. Adapting our policies in a way that is responsive to these as well as other trends requires a full understanding of available options through a thorough and unbiased examination of defense strategies and defense technologies.

MIT's Defense and Arms Control Studies (DACS) Program has become a leading center for examining the complex issues of national security. Formally founded on the initiative of Prof. Jack Ruina in 1973, its antecedents date back to the early 1960s when Prof. William Kaufman, a pioneer in the field, joined the faculty. It has assembled a faculty of leading experts drawn from the natural sciences, engineering, and the social sciences, most with firsthand experience in policymaking. Its graduate-level training program is recognized as the most comprehensive in the country, producing specialists for government, industry, universities, and research organizations.

Industry, of course, plays a central role in maintaining national security. The DACS Program is now soliciting the participation and support of the defense industry for an expanded research effort aimed at helping to provide a sound base of knowledge and insight for informing the policy-making process.

American security is affected by a multitude of factors both here and abroad. Changes in the quality and quantity of military forces and weapons available to ourselves and our potential adversaries requires a continuing assessment of the effectivenes of established plans. Shifts in the national strategies of our allies or our putative adversaries may require innovative responses. Constant attention to the efficient organization and management of military capabilities has long been an important contributor to battlefield success, and will be increasingly important as all the developed countries, both friendly and potentially hostile, enter a new period of budgetary austerity.

The overlay of stability that nuclear weapons brought to the relationship between the superpowers is threatened by the diffusion of these weapons to other nations. The determination of the force structure needed to maintain adequate security is complicated by the rise of well-armed regional powers and by the growing challenge of terrorists. The ability to provide for defense is limited by economic strains brought on by shifts in international competitiveness. Changes in the perception of threats to national security, the policies of potential enemies, the contributions of allies, and domestic politics affect the willingness of the public to support defense.

The Program seeks the participation and support of the defense industry for an expanded research effort aimed at helping to provide a sound base for informing the policy-making process.

These and related issues have been examined by the DACS Program over the years with support from foundations and the government. The proposed expanded research effort will focus on four main lines of inquiry: (1) Soviet forces, doctrine, capabilities, and technologies; (2) U.S. conventional forces and the European balance; (3) Weapons technologies, trends, and capabilities; and (4) Defense politics, the impact of political trends on U.S. acquisition and force level decisions.

Complementing the central research themes will be the Program's on-going work in the structure of nuclear strategic forces and the analysis of arms control trends and proliferation issues.

Sponsoring firms will be asked for a three-year commitment of $20,000 per year, followed by an optional two-year rolling commitment. The funds will be used to support a broad program of faculty, post-doctoral, and graduate student studies, publications, research workshops, and annual MIT defense symposium.

Each sponsor will receive the Program's publications, including special serials and monographs, and lists of theses produced under Program supervision will be available. The Program will invite representatives of sponsoring agencies to all periodic research briefings, workshops, and symposia in addition to its usual weekly seminars. Sponsors will also be encouraged to suggest topics. It will also be possible to arrange on-site seminars by mutual agreement.

The Program's activities provide a forum for informed discussion of important trends affecting firms involved in defense. By working closely with MIT faculty and graduate students on a wide spectrum of compelling defense problems, participating firms will be able to provide their own input and perspectives on the crucial issues of national security.

The Defense and Arms Control Studies Program is located in MIT's Center for International Studies. The Center is especially strong in issues relating to development, competitiveness, and international migration. A collaborative project on the security issues of the North Pacific region is being initiated in collaboration with the Center's pioneering Japan Science and Technology Program.

MIT provides a natural setting for a major defense and arms control program, especially one that emphasizes technology and technical analysis. Not only has MIT long played a key advisory role in national security matters, but it is also a recognized leader in a wide range of relevant technologies.

For more information on the DACS Program, please contact directly Professor Harvey Sapolsky, Director, Defense and Arms Control Studies Program, MIT Room E38-603, 77 Massachusetts Avenue, Cambridge, MA 02139. Telephone: 617-253-5265.

NEW INVENTIONS

SURFACE-ACTIVE POLYSILOXANES AND DRUG RELEASING MATERIALS THEREOF

M.I.T. Case No. 4449

ANTITHROMBOGENIC DEVICES CONTAINING POLYSILOXANES

M.I.T. Case No. 4449A

Technology Licensing Officer:
Lita Nelsen

M.I.T. has received notice from the U.S. Patent Office that patents will issue shortly on the above-referenced technologies. These patents are based on a unique class of cross-linked polymer network based on a reaction product of polyethylene oxide and glycidoxypropylsiloxanes.

The resulting polymer structures have unique biocompatibility properties. Protein adsorption is extremely low, and the structure has good mechanical strength. The surfaces are nonthrombogenic in contact with blood. Potential applications based on these properties include contact lenses, vascular prostheses, blood-contacting extracorporeal medical devices, blood storage devices and others.

The polymer structures also have a unique blend of hydrophilic and hydrophobic properties allowing controlled release of certain classes of drugs. Specific drugs studied include a number of tricyclic antidepressants and leutinizing release hormone.

These patents are available for licensing. Exclusive licenses may be granted in certain fields of use.

ELECTROCHEMICAL MICROSENSORS

M.I.T. Case No. 4536
U.S. Patent No. 4,874,499
Technology Licensing Officer:
Christina Jansen

Our patent has just been issued for leading edge technology which could lead to inexpensive or even disposable electrochemical microsensors. These would be functionally equivalent to conventional Ion Sensing Electrodes (ISE). In general, the devices developed under this patent would be in the form of Chemical Field Effect Transistors (CHEMFET). The micromachined cavity structure is adhesively attached to an underlying substrate which contains the means for sensing potential or current. This allows for manufacturing by use of standard chip fabrication processes, either in-house or in chip foundries.

The microchemical sensors have an unusually wide range of potential applications. They may be used in vivo for measurements of hydrogen, sodium, potassium, and other ion levels as well as for measuring protein concentration. There are potential applications for online gas monitoring during industrial processing of products ranging from food to ceramics.

SURFACE RELIEF GRATING FOR LASER-BEAM INTENSITY-PROFILE SHAPING

M.I.T. Case No. LL79-26
Technology Licensing Officer:
Lori Pressman

Lasers typically emit energy in a spatially gaussian, that is, bell-shaped profile. Thus, the energy is smeared out in space. This has real disadvantages for any application that requires precise delivery of laser energy, such as laser printers, data recording on and acquisition from optical media, or laser annealing. Ideally, one would want a flat beam with no energy in any shoulders, and a completely flat and uniform distribution of energy in the beam itself.

The invention discloses a relief pattern of teeth which accomplishes such flattening. The teeth can be on a transparent object. A gaussian beam incident on the plate is transmitted with a flat spatial energy distribution. The teeth can also be on an opaque, reflective object. A gaussian beam incident on this corrugated mirror would be reflected as a flat one. The patent discloses the proper geometry of the teeth to produce the desired beam spatial flattening.

There are many ways of making such teeth. If the corrugations are completely radially symmetric, the grooves can be machined on a lathe. Straight lines can be ruled using the same methods that are used to make gratings in spectrometers. It is also possible, and easy, to use semiconductor fabrication techniques, in particular, lithography and etching to make the required patterns.

For Further Information *MIT owns rights to the inventions described in this section. The Institute is interested in licensing rights to these inventions and facilitating the commercial development of the technology. Please note that the Industrial Liaison Program does not file information on these inventions. If you would like further information on these or other inventions, please directly contact the Technology Licensing Office at the address below:*

Technology Licensing Office
77 Massachusetts Avenue
Room E32-300
Massachusetts Institute of Technology
Cambridge, MA 02139, USA
(617) 253-6966

BULLETIN BOARD

MADE IN AMERICA COMMISSION TO TOUR U.S.

Representative members of MIT's Commission on Productivity, a group of 16 faculty who published a major report in the spring of 1989 on the competitive stance of the U.S. industry in the global marketplace, will be visiting at least six U.S. cities this coming spring to encourage further public debate and action on this crucial issue.

In its study, entitled *Made in America: Regaining the Productive Edge* and published by the MIT Press, the Commission examined closely the productivity of eight industrial sectors in the U.S., Europe, and Japan. Most analysts have looked at the U.S. economy from the top down and prescribed macroeconomic cures. But the scientists, engineers, and economists on the MIT commission based their conclusions on hundreds of interviews conducted on three continents, focusing on the reorganization and effective integration of human resources and changing technologies within companies as the principal driving force for productivity growth. The book outlines specific strategies for industry, labor, government, and education that will lead to a substantial improvement in American industrial performance.

In each city, Commission members will be joined by selected local industry leaders to host a two-hour summary and discussion of the Commission's findings. The tentative schedule for the tour is as follows:

Seattle	February 22
Detroit	March 12
Chicago	March 13
Los Angeles	March 28
San Francisco	March 29
Houston	April 26

Additional events are being considered in Washington D.C., New York, and Boston. Attendance is open to all interested parties. The registration fee of $50 includes a copy of *Made in America*.

For more information on any of these meetings, please contact Mr. Robert Blake, MIT Room 10-122, 77 Massachusetts Avenue, Cambridge, MA 02139. Telephone: 617-253-8243.

BIOMEDICAL ENGINEERING AT MIT

Artificial skin, novel imaging techniques, sophisticated hearing aids, advanced limb prostheses, expert systems for aiding medical diagnoses, and studies of the use of such tools as lasers and ultrasound in medicine are just a few of the dozens of areas of biomedical engineering research at MIT. Every department in the School of Engineering includes research in bioengineering, and clusters of investigators may also be found in other departments, including Chemistry, Biology, Brain and Cognitive Sciences, and also in the Division of Health Sciences and Technolgy.

Because this work is so widely scattered about the MIT community, it has often been difficult to keep track conveniently of what work is in progress. To help overcome this problem, the Whitaker Health Sciences Fund, located in the Whitaker College of Health Sciences, Technology, and Management building at MIT, has compiled a list of nearly 60 faculty involved in biomedical engineering work on campus. The list includes a summary statement of the research interests of each investigator.

For a copy of the tally of bioengineering researchers at MIT, circle number 51 on the Preprints Order Card.

UPCOMING ILP SYMPOSIA

Two of the upcoming conferences in the Industrial Liaison Program Symposium Series are described below. Any representative from an ILP member company is invited to attend these meetings. There is no registration fee for ILP member companies. To obtain a copy of the agenda for either symposium, please contact Ms. Maria Clara Suva Martin, Conference Coordinator, MIT Industrial Liaison Program, Room E38-508, 77 Massachusetts Avenue, Cambridge, MA 02139, Telephone: (617) 253-0213, Telex: 921473 MIT CAM, Fax: (617) 253-0002.

Multifunctional Polymers

Date: February 13-14, 1990
Chair: Professor Edwin Thomas
Department of Materials Science and Engineering

Increased emphasis on value-added materials has brought polymeric materials to the attention of many scientists and engineers. Multifunctional polymeric materials provide more than one service role, as for example nonlinear optical and high temperature stable polymers. This symposium will present–through presentations, laboratory tours, and a poster session–a broad range of cross-disciplinary work in polymers at MIT.

America's Business Challenge: The New Europe

Date: March 1-2, 1990
Co-Chairs: Lester C. Thurow
Dean, MIT Sloan School of Management, and Suzanne Berger
Head, Department of Political Science

Europe is in the midst of a profound and far-reaching revolution that poses unprecedented challenges and opportunities for the international business community. The economic alliance of western European nations scheduled for 1992 will change the face of international competition, and it is possible in the light of recent events that the union will be strengthened further by the participation of the countries of eastern Europe. With speakers drawn from government and industry in the U.S. and Europe as well as from MIT faculty, this symposium will feature moderated sessions aimed at helping the business community explore the key issues surrounding the emergence of the new economic superpower. Sessions will focus on the new political and economic environment, the new European corporation, economics and finance, approaches to technology management, marketing, corporate strategy, and managing in a global environment.

NEW VIDEO COURSES RELEASED

Two new video courses produced by MIT's Center for Advanced Engineering Study are now available for purchase or rental. A 5-day executive preview of a single tape, along with the Video Course Manual, is available for $95. A 20% discount on the prices below is available to ILP member companies. *For further details, please contact Carolyn B. Johnson, Video Education Cordinator at 617-253-7444 or circle number 52 on the Preprints Order Card.*

Analysis of Welded Structures

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Carol Strohecker
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MIT Media Laboratory

Presentation for 7 June 1989:

Videodiscs and Education: Four Views

Abstract:

Four projects will be described, each of which represents a different approach in its use of the medium of computer-accessed videodisc for "educational" purposes.

Three of these projects provide a basis for discussion of the fourth, a work-in-progress. The projects are a training program for meteorologists, contracted by the National Weather Service; a museum exhibit, contracted by the United States Golf Association; an "interactive" movie produced by the author, which presents one story in a way that invites many interpretations; and the author's current production, a videodisc about MIT's Daedalus Project, which developed a human-powered aircraft that broke the distance and duration records of the Gossamer Albatross.

The presentation will include discussion of the terms "interactive" and "education."

Carol Strohecker

Videodiscs and Education: Four Views

These four projects represent different approaches to uses of the medium of computer-accessed videodisc. They are arranged roughly in a continuum, from more to less rigid in their educational purpose and design.

1. The **National Weather Service** demonstration of a training program for meteorologists

2. The **United States Golf Association** museum exhibit

3. An "interactive narrative" movie entitled *A Different Train of Thought*

4. A videodisc about MIT's **Daedalus Project**

"Education"
modelled in terms of self-direction and self-reflection

UN ENSEMBLE DE PROJETS

A Sampler of Multimedia Applications

Carol Strohecker
Media Laboratory
Massachusetts Institute of Technology

A usual approach to presenting a talk like this one would be to organize the projects according to categories for which the applications were developed, such as education, entertainment, or business and industry. But because the applications are realized through computerization, their contents are malleable, capable of being extended beyond these usual or traditional categories. The same base of images, sound, or information may be tailored for several different purposes. And because of the highly sensual nature of the presentations, the boundaries of the categories themselves seem to be blurring. The line between education and entertainment, for example, becomes more and more difficult to determine – and trying to determine it seems to be a less and less fruitful activity. In many cases, both functions can be well served by the same application. So, in seeking some other means of organization, I began looking at the work of some of the "major players" in the industry.

In the United States, the HyperCard (and SuperCard) softwares for the Macintosh have taken the multimedia world by a storm. Not only have they become so prevalent that they border on having achieved the status of a standard, but Apple Computer, Inc., has initiated partnerships recently with six leaders in the media industry to develop multimedia products based on HyperCard. These "information products," as they are called, are geared to categories defined by markets rather than by genre. Their focus is on the combination of specific information with "the navigating, organizing, and publishing tools available on the Macintosh" computer. Thus the Newsweek application, "Upheaval in China," is targeted for secondary schools, as well as libraries, as well as international business; and the Warner "Audio Notes" application is targeted for both home and education. A typical system configuration consists of a fully equipped Macintosh with a CD-ROM drive and speakers, or a videodisc player and video monitor. Here are the applications that are part of this project:

ABCNews InterActive
secondary education

include HyperCard software, "Documentary maker" software (for creating video sequences), often a second audio track in Spanish (most widely used second language in the US), and sometimes closed-captioning (for hearing-impaired users)

Martin Luther King Jr.: bio of the winner of the Nobel Peace Prize, uncut version of "I Have a Dream" speech

In the Holy Land: examines the roots of conflict in the Middle East. interviews of Arab and Israeli children. commentaries by historians and authorities.

The '88 Vote: Campaign for the White House: original 13 candidates, conventions, issues debated during the campaign

Datapro

business and professional

Datapro's Macintosh Consultant: electronic resource including applications in desktop publishing, Macintosh LANs, word processing, database management, spreadsheets, desktop presentation. updated quarterly to include AV critiques of of Macintosh software products, tables for locating and comparing specifications for hardware and software, & ratings for major products as determined by Datapro & its National Software Testing Laboratories division

Newsweek

secondary schools, libraries, international business

Upheaval in China: "instant history lesson on the revolution in China". videodisc has text, maps, & photos published in Newsweek from April to June 1989.

Harvard University/John F. Kennedy School of Government

government, business managers

The Harvard Interactive Series: interactive videodisc simulation games – executives & students can "play the roles of decision makers during historical moments of crisis and controversy"

Three Mile Island: case of crisis management and the public's right to know

Warner New Media

home and education

Music Discovery series: *Audio Notes*

The Magic Flute: 3 CD-ROM discs with HyperCard stacks and audio: music and commentary on the composition and the opera form

WGBH Television

education

Interactive NOVA: Animal Pathfinders: humdreds of slides, much text, several documentaries. viewers assume view of bee as seeks honey, conduct lab experiments to learn about animal migration, behavior, & habitats

Other players: (other times, other systems)

MIT Architecture Machine Group

Aspen

MIT Film/Video (Media Lab)

A Different Train of Thought

New Orleans

MIT Film/Video and Learning & Epistemology (Media Lab)

Learning Constellations

Daedalus Project (also Athena tie-in)

MIT/IBM/DEC Project Athena:

collaboration with Smithsonian

French language disc

Brown University

IRIS project – hypertext

J. Paul Getty Museum

Greek vases

Harvard Law School

14 lessons for law students or new lawyers who want to gain practical courtroom, interviewing, or negotiation skills. self-paced. courtroom experience in making objections, entering evidence, asking questions. negotiation skills. students can get course credit for writing video lessons.

driving under the influence of alcohol, bank robbery, motorcycle accident, real estate broker's fee, criminal line-up,welfare fraud, landlord/tenant, personal injury, shopping mall development

many corporate training groups

management, financial decision-making, organizational communication, etc.

Bank Street College

Palenque

primary education

boy travels to the Yucatan and learns about Mayan culture through a young tour guide

Tom Snyder Productions

Reading Magic library

home purchase

animated interactive storybooks for children: they choose paths of action

ACTV ("active television")

home subscription

viewers make choices, answer questions, or choose different camera angles for live sports events and pre-recorded shows. advertisers can target commercials based on subscriber demographics, interests and preferences. can run up to nine different commercials in same time slot, but only appropriate one will be shown to a specific viewer. viewer can interact with advertisement by selecting which information or products are received.

Le Groupe Videotron Ltee of Canada acquired a 50% interest in ACTV Domestic Corp. for $14million, used for programming, market evaluation, and national rollout. LGV has exclusive license to use the technology in Canada, Europe, & USSR

makes use of cable systems. modifications to the video signal (synchronization and computer commands in the vertical interval) allow local personalization so viewers nationwide can interact at the same time and get their own program. no return signal is sent: each TV set gets its own responses. (not a voting system). selections at hand-held remote are converted so the program switches at pre-determined intervals between segments of multiple signals. instant, frame-accurate (invisible) switch.

programs: exercise, self-help, discussion series, show business trivia, comedy

Mirror Systems

publishing subsidiary

medical education: animated graphics show the anatomy & physiology of the beating heart, synchronized to audio of heartbeats. interaction and feedback guide toward correct examination procedure.

CD-ROM as less costly than videodisc because full-motion video is not used. also, costs of CD playback equipment are not as high as for videodisc.

Little, Brown & Co.
medical publishers
Electronic Library: reference manuals on CD-ROM, accessed through windows-based software.

National Weather Service
in-house training
Interpreting Satellite Images with SWIS

Butler, Raila & Company
custom house

Smart Move!: New England Telephone trade show exhibit. a board game. solve business problems as you go along. correct solutions are NETelephone services.

Ben's Grille: Harvard Community Health Plan traveling exhibit (high schools, corporations, science museum). decide whether to serve alcoholic beverages to different patrons. much factual info about alcohol and its effects.

5 exhibits for National Scouting Museum. scout oath and laws. search for a lost child. history of scouting.

Diagnostic Radiology: hospital floorplan serves as a menu. physicians act as staff radiologist at imaginary hospital, use mediacl records, access treatment rooms, perform procedures. promotes a chemical compound used in radiology to dye arteries and veins for radiographs.

New England Technology Group
custom house

USIA exhibits:

- Design-A-Chair
- Housing in the US
- The American Kitchen
- Good Design (in advertising, for children, in sports, of buildings)

St. Louis Zoo

Burger King

Digital Techniques, Inc.
custom house

eyeglass selections – instead of racks of frames, stored in computer. sorted through data about frames by capturing info. about what kind of face (shape; eye & hair color; nose, chin, cheekbone structure) and weeding out a lot to yield possible frames

Signage, building directories

Stop & Shop – 35 stores in New England participating, about 3 systems per store – all tied together, updated every week with price and stock info.

I M Pei /JFK 2000 (new terminal in NY airport) – system for travelers to get ground transportation, etc.

Citicorp – InSite – has persona of financial counselor who guides through development of payroll savings plan...also other employee benefits and human resources applications

Earth Over Time: Boston science museum exhibit

Play Away, Please!: USGA museum exhibit

GTE
corporate research lab – telecommunications

Video Line service – list of TV shows and movies: you get a blurb about each one and a clip from it (like *Sneak Previews*). also you can order the program and watch it (replaces going to the video store). combines graphics and text, voice prompts.

TeleChess – mediates chess players in the process of correspondence chess. use the telephone keypad to indicate moves. keeps the history and passes onto the next player what the opponent; also can reconstruct the entire game at any time. each player can query the system for info at any time. The principles here are general – could be used for banking transactions, a history of stock trades, tax-return questions, health insurance claims, etc.

PROSPECTIVES

Carol Strohecker
Media Laboratory
Massachusetts Institute of Technology

The progress of current technology reviewed:

DTI as a technology provider that is now becoming a solutions provider.
Patrick deCavaignac on the state of multimedia applications now in the US:
The picture of how the technology is slowly coming to be accepted is shaped by the developers' search for appropriate markets, and their understanding of the users' reasons for accessing the applications. Outside of the training market, where employees are often "forced" to use certain applications, acceptance has been slow. In airports, for example, where everyone thought kiosks would do well, we have found that gift sales have not found their niche in interactive technologies, though ticket delivery for frequent flyers might be more likely to succeed. Why? People still aren't used to interacting with machines on their own time – developers, in order to be successful, have to find a way to change behavior. This is a fundamentally difficult thing! ATM is getting people into the practice of relying on a machine for transactions they consider to be important; there is a compelling reason for them to use the kiosk. So gradually, the everyday use of the technology is becomeing more and more common. Meanwhile, the technology has continued to evolve, so that the applications are more useful and inviting. Developers can now make use of the quick display of graphics and the exchange of information through telecommunications, so the possibilities for different types of applications is expanding. When you have access to a large information base, as telecommunications and storage media like CD-ROM allow, you can develop applications for which people have more of a need. And when you can update that information through telecommunications, the information can stay alive, growing with the public's ever-changing needs.

Aside from the areas of education and training, many of the failures of the past ten years can be attributed to the developers' lack of understanding the public's need for a compelling reason to use the technology. We don't need to regard it as a space-age play thing anymore; we can make good use of it.

The technology in development:

Clarification of terms: "interactive" technology.

As AI computational techniques become better understood, and as parallel processing on large machines is further explored, applications may become truly "interactive." But now, for the most part, they're not.

Research projects at the Media Lab:

Back Seat Driver

HDTV research

Newspeak was an electronic newspaper hindered by 525 interlaced scan lines

2000+ lines, progressively scanned, can allow lots of readable text

Paperback Movies

We have window systems with movies in them, running on a frame buffer.

(parallax board – digitized video stream)

But PM are different in that they are digital, not analog. Image sequences are stored digitally on hard disks or CD-ROMs. more flexible: can access the info in more interesting ways, processing hardware allows effects.

Video Finger

Range Camera

Hi-Res "Yellow Pages"

progress in computer animation, computer holograms for 3D displays

Information & Entertainment Technologies

technology being developed, but experimentation now with applications is the key to using future technology well.

ATHENA MUSE: HYPERMEDIA IN ACTION

by David R. Lampe

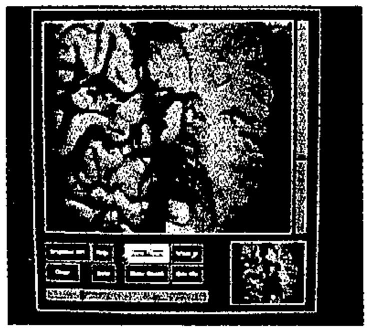
Although educators have long been fascinated with the prospect of using computers to enhance the learning process, a number of barriers have kept the promise from being fulfilled on a significant scale. Until recently, for example, computers have been too expensive for general use in an educational setting.

Now, however, the costs for more and more powerful computers are plummeting. These new machines are equipped with high resolution displays that are capable of presenting the sophisticated graphics and even digitized full-motion video along with the normal text and numeric data.

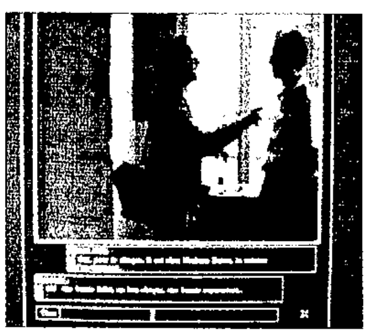
One of the greatest difficulties with these new "multi-media" workstations is the problem of manipulating and combining all of the resources that the system provides. A skilled programmer is needed to create even a simple application, and the time required is often prohibitive.

A team of researchers at MIT is working to address this problem by developing an experimental system called Athena Muse. Muse is a "construction set" designed primarily to help MIT faculty develop interactive video materials for undergraduate courses. It allows students and teachers to develop complex presentations that combine text, graphics, video, and audio. With Muse, the elements of a display are composed by writing them out like a parts list or a menu, rather than by following a complicated procedure. In the longer term, this approach, which minimizes the need for computer programming, has broad potential for expanding the use of multi-media workstations in a variety of fields.

Much of the work in educational software at MIT is conducted under the auspices of Project Athena, a major five-year initiative to explore the potential of networked high performance workstations in undergraduate education at MIT. The Project began in 1983 when Digital Equipment Corp. and IBM agreed to provide the Institute with $50 million worth of hardware, software, technical support staff, maintenance, and networking. In addition, MIT raised an extra $20 million to fund curriculum development.



In one hypermedia courseware system under development at MIT, not only can students of neuroanatomy ask the computer for detailed visual and textual information about the brain, but the computer can test the students' knowledge of the subject.
Photo: Ben Davis



Native French speakers in an interactive hypermedia program can enhance a student's understanding of the subtleties of the language. Subtitles, glossaries, and cultural notes stored in separate files are available to the student on command. *Photo: Ben Davis*

By the end of 1987, 135 projects were funded. Nearly 80% of the projects have called for some combination of computers with other media such as graphics or video for visualization of abstract concepts.

About 450 workstations are now in place in public work areas, student living groups, laboratories, libraries, departmental areas, and other special sites. These machines are interconnected via a campus-wide coherent network that allows the different types of computers on campus to communicate freely with one another. Among these workstations is a cluster of 32-bit "Visual Workstation" machines which are capable of combining full-motion digitized color videodisk, cable television, digital audio, high resolution graphics, and CD-ROM.

A number of specific courses are currently under development that will take advantage of these special machines. They span such diverse fields as language, neuroanatomy, mechanical design, basic biology, and architecture. This work is coordinated through Project Athena's Visual Courseware Group.

The common element in the various new courses is that they integrate several media. According to Matt Hodges, Visiting Scientist from Digital Equipment Corp., Athena Muse is a valuable software tool or "authoring environment" for piecing together this sophisticated courseware. "It's the equivalent of a multimedia word processor that allows freeform cross referencing," he explains. "It's like an erector set for building the most common forms of educational software."

The design of the system is based

Programs such as Muse can play a significant role in helping broader audiences tap the potential of the computer.

directly on the requirements of the MIT faculty projects. It uses the basic structure of the "hypertext" and "hypermedia" systems—those that allow extensive cross-referencing among a set of interconnected "documents" that can embrace such materials as video, audio, and graphics. This approach is not new; it was originally conceived in 1945 by Vannevar Bush, professor of Electrical Engineering at MIT. Researchers at Brown University have used the idea effectively for educational software, and in August, 1987, Apple Computer Company introduced their flagship "HyperCard" product built on some of the same techniques.

With Athena Muse, the MIT researchers have expanded the notion of a document by making them "active" instead of passive. This means that the user can control or interact with the material of any "document" presented on the screen. For example, a user may freeze a frame in a video sequence, make it go forward, backward, faster, or slower on command before moving on to another document. The documents can also pass messages back and forth among themselves.

Thus, each document is actually an independent dynamic system of arbitrary complexity. This means that certain classes of computer simulation can be included as documents in the same way as normal text, graphics, and video. In every case, the same cross-referencing facilities can be used, so a specific state or configuration of a mathematical model can be linked to a text or video document explaining that situation. Integrating simulation in this way with other forms of presentation materials is one of the main objectives of the Visual Courseware Group, since it is likely that such integrations will be the most popular—and fruitful—uses of the computer in undergraduate courses.

Several innovative applications of these dynamic hypermedia systems are underway in the area of language instruction at MIT. Four courseware projects—one each in German, French, Spanish, and Japanese—are being developed as part of the Athena Language Learning Project, under the direction of Dr. Janet H. Murray and funded by the Annenberg/Corporation for Public Broadcasting Project.

The Spanish courseware, for example, now being developed by Douglas Morgenstern of MIT's Foreign Languages and Literatures section, is actually an interactive video narrative which creates situations in which students can develop a deeper understanding of the practical use and cultural context of the language.

Entitled "No Recuerdo" (I don't remember), the story is set in Bogota, Colombia. The student must help a Spanish speaking scientist with amnesia locate a vial containing a genetically engineered amnesia-causing microorganism that poses a serious threat to all of Latin America. To do so, the student must query the people they meet as they wander through the city by typing questions on the keyboard. These questions, and instructions typed by the student based on his or her understanding of the spoken responses, determine the specific sequence of video clips presented, as well as the ultimate outcome of the narrative. The program uses artificial intelligence to parse these questions and commands, and thereby determine the flow of the action.

In a hypermedia courseware program being developed by Gilberte Furstenberg, students of French help a man locate a new apartment in Paris after his girlfriend throws him out. A videodisc contains a map of the quarter where he lives, sequences showing several apartments at various locations, floor plans of each apartment, and even sequences showing the route to the apartments. These segments allow the student to see and hear the language in action, presenting the gestures and facial expressions as well as the sound and intonation of French spoken by native French. In addition to traveling about, the student interacts with fictional characters, answers questions, and even listens to phone messages recorded by a phone answering machine.

Many of the video "documents" in the French courseware are themselves interactive. They can be stopped, reversed, replayed, or skipped at the whim of the user. Video sequences can also be accompanied by subtitles in French—or any other language—which are stored in a separate file. By flagging an unfamiliar word in the subtitles, it is possible to summon up definitions from a glossary contained in yet another file. At some points, there are also "cultural notes" that provide backup information on idiomatic expressions or historic locations, for example. These are synchronized with the video, and the student is offered the option of inquiring further if desired. All of the complex searching and rerouting among and within the various files and media is invisible to the student, who controls the flow of information by selecting various options on the screen via a "mouse."

Work is also under way in other fields. A program designed for medical and neuroscience students developed by Research Associate Dr. Steven Wertheim ties together an illustrated glossary, a 3-D model of the brain that makes it possible to view the various components of the brain from any angle, a video of a brain dissection, and a slide browser. In mechanical engineering, a program is being developed that will combine animations, motion segments, a still-frame library, and an expert system to teach the principles and applications of mechanical bearings.

One project in architecture will center on a videodisc containing over 30,000 images from MIT's Rotch Visual Collection of Boston Architecture. Students and faculty will be able to use the visual workstation as an

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Because they deal fundamentally with data and how it can be retrieved and organized, hypermedia systems have applications far beyond education.

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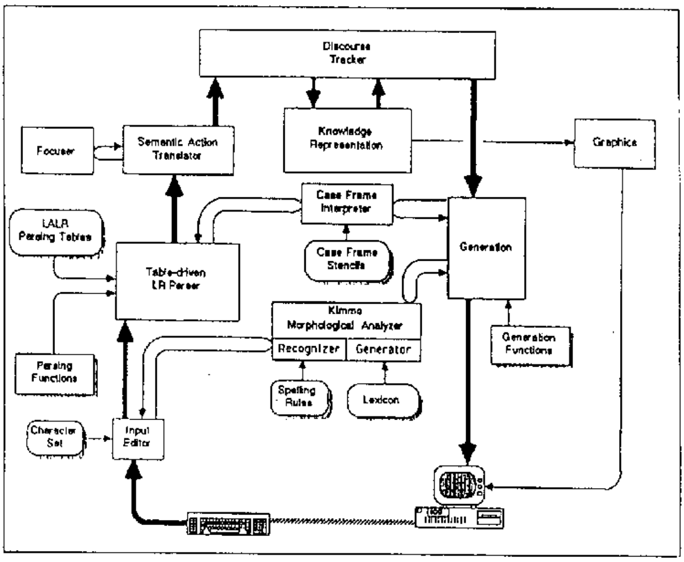
"electronic light table" that gives them instant access to any combination or sequence of images so they can make stylistic or historical comparisons, for example, of Boston architecture.

The goal of Athena Muse is to encourage the development of more of these highly flexible and versatile educational aids by eliminating what used to be a formidable programming task. According to Hodges, setting up a hypermedia program with Muse typically involves mainly filling in forms presented on the computer screen. To date, Hodges and his colleagues have developed a working prototype system that has already contributed to several projects. They are now in the process of refining and expanding the program to make it even more versatile.

Because they deal fundamentally with data and how it can be retrieved and organized, hypermedia systems have applications far beyond education. And programs such as Muse can play a significant role in helping broader audiences tap the potential of the computer. "In the broadest sense," Hodges says, "it gives someone with knowledge in any particular field entry into the unique and powerful means of expression that the computer offers." ■



Interactive programs must be able to "understand" questions and answers provided by students. This AI system for processing keyboard input is now being tested at MIT.

Drawing: Douglas Morgenstern

MULTIMEDIA TECHNOLOGY'S USE OF SOUND, STILL AND MOVING PICTURES, TEXT, AND MORE IS AN APPEALING EDUCATIONAL TOOL BECAUSE STUDENTS BECOME ACTIVE LEARNERS

MULTIMEDIA

WHAT THE EXCITEMENT'S ALL ABOUT

Multimedia is taking the educational technology community by storm. Apple Computer has made multimedia a major focus: It has established a research and development lab devoted to its study and last year published a book on the subject. IBM's education division also has announced that multimedia will be a primary concern. Several multimedia projects in education are receiving national attention. Even software publishers see it as an important area for development.

But what exactly is multimedia? That's not a question that can be answered quickly. Of course the concept of multimedia is hardly new; after all, lecture notes, a slide projector, and some overheads, when blended together, constitute multimedia. But as used by today's teachers, educational theorists, cognitive learning experimentalists, and computer hardware vendors, the term "multimedia" has taken on a whole new significance.

Definitions

Today, multimedia refers to (or can refer to) nothing less than the integration of text, audio, graphics, still image and moving pictures into a single, computer-controlled, multimedia product.

"That's probably the most sophisticated, high-tech version of what multimedia in education means today," says Fred D'Ignazio, the head of Multi-Media Classrooms Inc. (East Lansing, Mich.), the self-described "Johnny Appleseed of multimedia."

"But there's also a more low-tech concept," he says. "In low-tech multimedia, the computer is still an integral component, but not necessarily the controlling platform."

As an example of low-tech multimedia, D'Ignazio cites the following student project: first, using a video camera, the students shoot footage of a polluted river; next, using a computer and a word processing and a graphics program, the students create text and titles and visual special effects for the film footage. "By connecting the monitor output with the video input, you can even transfer screens to the video camera tape," he adds.

This low-tech multimedia — jokingly referred to by D'Ignazio as "scavanged multimedia" — starts with a computer ("any computer, even one as small as a Commodore 64") and begins to gather up other devices: tape recorders, TV monitors, video cameras, laser printers, music keyboards — anything, in fact, that you can plug a cord into and attach to something else.

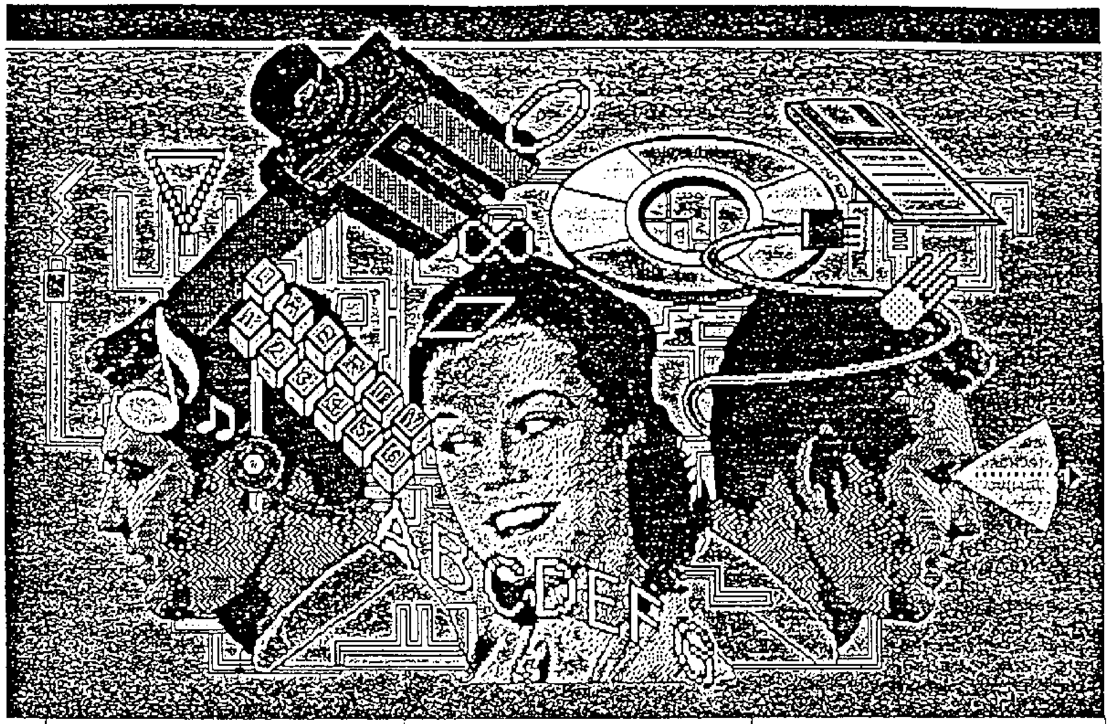
"The point," D'Ignazio explains, "is that not every school can afford a Macintosh lab. That's number one. Number two is that you don't need to wait until you *can* afford a Mac lab before you can start doing multimedia. That's why I emphasize that teachers and students be as inventive as possible in customizing multimedia to accord with available resources and with classroom needs."

No question that low-tech multimedia is multimedia. And yet (with due respect to Fred) something low-tech is not what many people have in mind when they envisage multimedia in the K-12 classroom. What they have in mind is some combination of: powerful computers (Macs, IBM PS/2s, Commodore Amigas, etc.), videodisc or compact disc players, TV monitors, optical scanners, audio cards, music synthesizers, etc., all linked together by powerful developmental software (for example, *LinkWay*, from IBM, or *HyperCard*, from Apple).

An Example

An example of an innovative multimedia project is at New York's Bank Street College, where researchers use customized software in the C language, an IBM PC AT, digitial video interactive boards, a CD-ROM player and more to provide users with a truly multimedia "experience."

The "Palenque" project is a prototype developed by The Center for Children and Technology at Bank Street



College of Education, in collaboration with the David Sarnoff Research Center in Princeton, N.J.

"Palenque," explains Kathleen Wilson, the director of the project at the college, "is the site of a Mayan ruin in the Yucatan. The first thing we did was go down to the site and film it — and not just a panoramic view, but from all different views and angles and paths. We filmed in 16mm mode, which means that for each step the cameraman took, he also took a shot. Then the film was digitized, which means it can be booted up on the computer. And because it is digitized, the film is completely in the control of the computer operator. It's like you're right inside the frame. The film can be stopped and started at any point, at any point the direction or path can be altered, at any point you can click-on objects that appear in your path — say, a Mayan temple, and call up more information [about the temple], both visual, audile, and text."

Palenque also has a map-overlay feature that can be called up to show the operator where he is in relation to the entire site; there's even a dynamic arrow that moves as the simulated walker moves. There are simulated tools, too, such as a camera. By clicking on the camera icon, students can "take a picture" of the screen, reduce it in size and store it in a simulated album.

There are animation video guides that can be clicked on: a little boy, who provides travel tips and fun facts; an archeologist, who has a fund of information on various aspects of the site; and a teacher, who is associated with the museum component of Palenque.

"In addition to the spatial aspect of the program — which allows the user to construct a simulated trek through the site," says Wilson, "there is also a thematic component, which is the museum. The museum has four rooms: a map room, a rain forest room, a Mayan language room and a history room."

Inside each room are various objects; monkeys, for example, in the rain forest room. By clicking on the monkey icon, a student can access in-depth information, such as the several types of monkeys that inhabit the rain forest canopy. The student can then choose one of these monkeys and receive more specific information in the form of text, still images, film, and even audio. By pressing the audio icon the student can hear how, for instance, the howler monkey sounds.

BY ROBERT McCARTHY

Without a doubt, a product like Palenque will generate a considerable amount of pedagogical excitement. Many teachers and educators cite the benefits of learning about something through a variety of media, each of which tends to reinforce the other's message. The flexibility and open-endedness of the technology is also noteworthy; teachers can customize their presentations as they deem fit, either adding or subtracting information, or varying the path by which the information is presented.

Perhaps most important, the new multimedia turns students into proactive learners, since it gives them a tool that allows them to immediately gratify their intellectual curiosity. And, as educators know, students are most disposed to learn when they've first been made curious.

Multimedia Vendors

Not unexpectedly, vendors of the multimedia technologies are, if anything, even more excited than educators.

The makers of videodiscs and videodisc players have been galvanized by the prospect of attaching themselves to the computer's coattails in the all-important education market. (Videodiscs are well suited to multimedia applications because one side of a 12-inch disc can store 54,000 pictures along with stereo audio and digital data.) Soundly trounced by the VCR in the

ILLUSTRATIONS BY DIDIER CRIMIEUX

home entertainment market several years ago, many videodisc vendors had been relegated to producing the hardware on which to play discs containing very elaborate slide repositories for K-12 life-science classrooms.

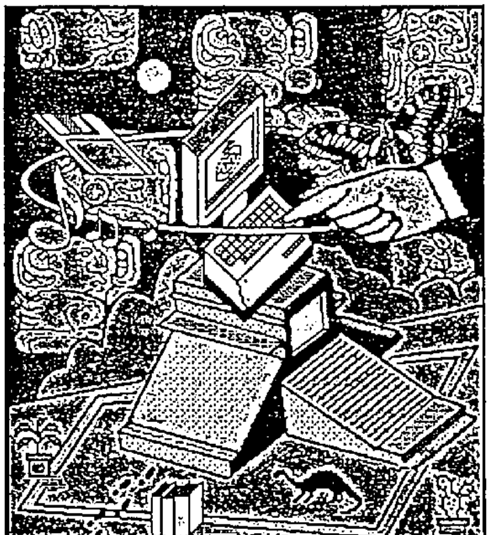
Suddenly the videodisc hardware companies are facing the happy prospect of vendor alliances with Apple, IBM, and other computer makers, while the disc makers are rushing to market with exciting new products — like *"The '88 Vote: Campaign for the White House"* — specifically designed for computer interaction. This disc contains ABC new film footage of the conventions and debates with anchorman Peter Jennings.

"One of the reasons videodisc technology is so beneficial in the classroom," says Pam Herber, communications director for Optical Data Corp., Warren, N.J., which, in conjunction with ABC News Interactive, has produced The '88 Vote, "is that the teacher has complete control over the medium. It's easy to start, stop, reverse, etc., and you can jump into the frames at whatever point you wish. And of course there's the visual learning component. Cognitive research has shown that presenting an image in conjunction with talk or text really reinforces the learning."

Software publishers, too, are looking into the possibilities of multimedia. "Multimedia is obviously a very hot application in the schools," says Diane Rapley, director of marketing services with Broderbund, "and we are interested in developing products appropriate to that area." Both *HyperCard*- and *LinkWay*-compatible products are in the works at Broderbund; already available are products like *VCR Companion*, which uses the computer to create titles and special effects for videotapes; and *The Whole Earth Catalog*, a CD-ROM product, which, in addition to text, features bird calls and various sound effects.

Scholastic Software has just published a number of products with multimedia applications, says Peter Kelman, vice president of software development. *"Slide Shop* and *Super Story Tree*," he says, "I would describe as low-tech multimedia applications. And by that I mean that they can run on Apple IIs [Scholastic is planning to introduce MS-DOS versions of these programs in the future], and you don't need a videodisc player.

"*Slide Shop* allows you to create presentation programs with text, sound, some voice, graphics, animation and special effects — the result is like a computer version of, say, a TV commercial with special effects. But the neat thing is you can replay the disk created in another computer — without the *Slide Shop* program. The other program, *Super Story Tree*, allows you to create individualized stories by branching through sequences of various scenes, graphics, and sound effects that are grouped under various themes. For instance, ghost stories."



COMPUTER-BASED, VIDEODISC MULTIMEDIA HAS CREATED A NEW CATEGORY OF VENDOR — THE "CONTENT VENDOR."

Computer-based, videodisc multimedia has also created an entirely new category of vendor — the "content vendor," a term used by some people interviewed for this article. Content vendors are the owners of all those images, film strips, movies, newsreels, etc., that will be used to provide filling for all those empty frames inside the videodisc. (Contrast that with the Palenque project at Bank Street, where researchers shot their own film.) Content vendors are going to come from all over, and Apple, reportedly, is already negotiating with a number of prime content suppliers (Lucas Films; NOVA, the PBS nature program, etc.). ABC News, with its *'88 Vote* product, seems to have found a profitable use for all those old news stories in its film libraries. If the multimedia technology really takes off, there may be a new answer to the age-old question: Who wants yesterday's paper?

The Computer Vendors

Of course the most excited group of vendors, perhaps, are IBM and Apple, rival developers of the media-linking software, *LinkWay* and *HyperCard*.

Although *LinkWay* was just released in February, Peter King, senior product administrator, IBM educational systems division, says it is already in place in about 60 schools sites. "Educators are exploring how the product can and will be used," says King, "and how use will affect the product. A number of commercial applications are also being developed by software publishers."

One such commercial application, from Alexandria, Va.-based Mobius Corp, a software developer, is called *KidsWay*. "*KidsWay*, which we are currently testing in a number of sites," says Baxter Burke, Mobius' director of business development, "supports a number of software packages — such as *Fantastic Animals*, from Bantam Software, and *Mixed-Up Mother Goose*, from Sierra — with voice and graphic cues, so that even a very young child can access and explore the software independently." The recommended configuration for *KidsWay* is two IBM PS/2 Model 25 computers with speech and color monitors set up side-by-side.

As for Apple, well, it's no exaggeration to say they've gone hyper over *HyperCard*. In fact, during the month of March, Apple's multimedia personnel were kept busy scurrying up and down the West Coast giving full-day seminars on the new technology: covering what multimedia means, what it does, the business implications, providing hands-on demonstration — but not for educators, for the commercial press!

Apple has also established a multimedia R&D lab in Sausalito, Calif.

"What the multimedia lab team is doing," says Paul Jurata, Apple's K-12 multimedia manager, "is creating what we call 'design examples' that will demonstrate how multimedia products can be integrated into both education and business. For a design example, for instance, we would be working with a content provider, say, NBC News. We would select from their content and then add to that selection pedagogical and curriculum tools. The end-product would be a commercial piece of stackware, with a data base, a personal authoring system, and some tools that would allow the user to go in and manipulate the data in various ways to generate reports, presentations and lectures."

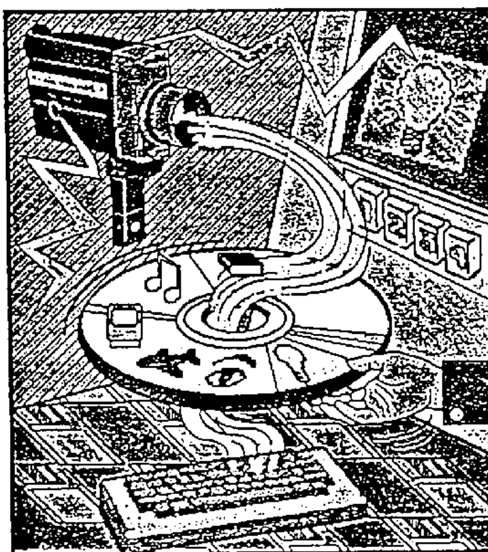
"Picture something very open-ended," he adds, "something easy to use, easy to change around the data base materials, easy to add your own materials."

Grapevine and Beyond

Grapevine, created by Pat Hanlon and Bob Campbell, teachers at Lowell High School in San Francisco, is one of the prototype multimedia stackware programs which the multimedia lab has had a hand in helping develop. Grapevine (see "Heard It, Read It, and Saw It on the Grapevine," *Electronic Learning*, May 1989) focuses on U.S. history in the 1930s. Using a Mac, a laserdisc player and *HyperCard*, Grapevine correlates some 30 Depression-era topics in the forms of essays, photographs, songs, text, film footage, and voice narration.

"Grapevine is one of the design models which the multimedia lab is currently looking at," says Jurata. "The point where we are with that product — as well as with a number of others — is trying to determine what it will take to bring it to market. For instance, what are the most appropriate distribution channels. What sort of training and support will the products require. And, perhaps most important, how do we go about securing the rights to some of the materials that are incorporated in Grapevine — materials which may not be in the public domain."

In other words, who are the content vendors of record and what will it take for them to release their property for presentation in the Grapevine product?



"MULTIMEDIA ALLOWS YOU TO REINVENT THE TERM PAPER — SOMETHING THAT . . . BADLY NEEDS REINVENTING."

The importance of dealing with content vendors up front, before the project gets off the ground, becomes obvious — which is precisely why Apple is currently negotiating with a number of important content vendors.

Once multimedia stackware becomes commercially available, says Jurata, teachers will have a multi-purpose tool from which they can either: 1) construct their own lessons and courses, using the authoring program and treating the data base as an enormous grab-bag of related materials in a variety of media; or, 2) present multimedia lessons which have been in effect pre-programmed into the commercial multimedia package.

"Most teachers won't have the time or the inclination to construct their own tours through the multimedia data base," says Jurata, "although for those teachers and students who want to, the tools will certainly be there. But for the teachers who don't want to do their own navigating, there will be pre-structured lessons already in place. And these lessons will also be modifiable, in case the teacher wants to change the lesson around a bit, or add some new material."

Jurata also suggests that the current, box-encumbered avatar of multimedia (computers, videodisc players, several kinds of monitors, scanners, etc.) may be merely a transitory stage.

"Ultimately," he says, "I'm not sure that the full-blown workstation [a computer attached to numerous devices, as mentioned above], with a student plugged into the center of all these flashing screens and keyboards, is the unavoidable destiny of the classroom. What will happen eventually is that all the multimedia effects will be ported to the computer — text, graphics, sound, images, even moving images and animation. The computer will handle these media just as it now handles text and graphics. That's a ways away of course, but the ultimate multimedia integration will occur inside the computer."

Term Papers

Computer-controlled multimedia sounds wonderfully exciting; it provides teachers with a wealth of information in a variety of formats which they can structure, add to, or simply play out in pre-structured forms. Teachers who have seen multimedia in action are properly enthusiastic and can usually rattle off a number of educational advantages directly linked to multimedia.

"For one thing," says Joe Holmeister, computer coordinator at Cincinnati Country Day School (Indian Hill, Ohio), "multimedia allows you to re-invent the term paper — which is something that both students and teachers agree badly needs re-inventing."

A prime example of the re-invented term paper is Craig Holmeister's (yes, Joe's 10th-grade son) "Hannibal Crossing the Alps," composed in the Day School's Mac lab using *HyperCard*. In addition to text concerning the intrepid Carthaginian's invasion of Italy (on elephants!), young Holmeister's "paper" features maps, graphics, moving arrows to show routes, and even sound effects — such as the trumpetings of well-chilled pachyderms.

Suddenly term papers at Day School became not only fun to do, but even fun to read, and correct. And not only fun, since the "stacks" (a computerized version of a card file used in *HyperCard*) of information in Holmeister's term paper aren't simply miscellanies of randomly gathered Hannibaliana; rather, the stacks are designed to explore issues in greater and greater depth as one proceeds through them.

When Apple personnel saw "Hannibal Crossing the Alps," they got so excited, says Joe Hofmeister, that they made 5,000 copies of the program for their account executives to use as demos.

Nancy Fogelson, a history teacher at the Country Day School, was also excited by Hannibal.

"Nancy Fogelson," says Holmeister, "who by the way is a battle-scarred veteran of the classroom wars and by no means a computerphile, was desperately looking for ways to get her kids excited about studying history. For too many of her students, history was pure torture — they just sat there dead in the water, day after day. But with *HyperCard* and multimedia, she saw a way to put power and tools into her students' hands, to help transform them from note-takers into historians."

Into a well-stocked multimedia lab (Macs, scanners, CD-ROMs, laserdisc players, digitizers) strode Fogelson's young history-phobes. Dividing the class into teams of three, she set them the task of compiling multimedia data on selected topics in the history of World War I.

"Suddenly," says Holmeister, "kids who had been sleeping through history became avid compilers of multimedia information. They actually get turned-on to doing research. And because the team's stack has to be more than a grab bag of information, the students are obliged to seek connections among the information nuggets. Stacking has become shaping."

Its Advantages

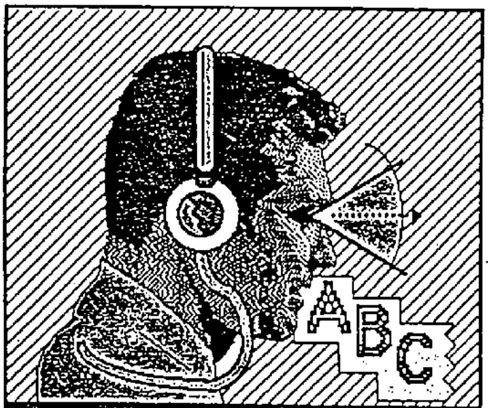
Similar instances of motivated students, excited teachers, and nifty applications can be multiplied in more and more classrooms with relative ease; and as that occurs, pedagogical excitement can only grow.

And with good reason. Multimedia technology offers traditional pedagogy some sorely needed pizzazz. For example, multimedia can, as Joe Hofmeister observes, take something that has become educationally moribund for some teachers and students, like the term paper, and make it not only exciting but a real learning experience. In addition, multimedia seems to make students into pro-active learners, not passive receptors — the kids, after all, have to take the initiative in following the paths, and clicking into the stacks. The multimedia format also means that multiple learning styles will be stimulated, with each reinforcing the others.

As Nancy Fogelson found, the technology both encourages research and helps develop research skills. And since students usually have to team up when they're building their stacks (at least until the day when the average school system can afford a workstation for each student), they are also learning cooperative problem-solving — a skill students may find of particular use during their work life.

"One of the most important developments that seems to be emerging from the accumulation of multimedia technologies in classrooms," says Fred D'Ignazio, "is the 'Tool School' concept, where the learning environment mimics the workplace environment as it will be in the 1990s. Unfortunately, most of the educational computing kids do now will not at all reflect the computing they will be doing on the job. Computing on the job in the '90s will be multimedia, it will be groups working together to problem-solve.

"What the workplace *won't* resemble is passive bodies sitting there while the boss tells them what to do, how to do it, and then watches them while they do it," D'Ignazio adds. "Since you're going to have to be proactive in your work-life, why not start out as a proactive learner in school? And multimedia is an ideal facilitator of proactive learning."



Didier Crimleux, the creater of the art on the cover and in this feature, used a Macintosh, a video camera with *Mac Vision* software, and a flatbed Apple scanner to scan and save the various images. He then composed each illustration, using the saved images, with *SuperPaint*. Each illustration was printed on a LaserWriter, and then painted by hand. A multimedia project in its own right!

Are There Problems?

But is multimedia therefore the perfect education technology? Is there nothing even slightly equivocal about it? Marginally disquieting? Or should we all just plug all our students right into multimedia?

What would happen, I wonder, should an educational curmudgeon, an educator of the old school, come upon a student plugged into a multimedia workstation? How would he interpret what he would be seeing: text, graphics, film snippets, still photographs, cartoon people talking in cartoon voices, sound effects, moving maps, the whole nine yards of bells and whistles? Would he say, our curmudgeon, "Wow! That's education!" Or would he say, "Well, it's all very impressive, but isn't it all just fooling? Is there really any educating going on here, any learning? Or isn't it all simply entertainment, just — gasp! — television?"

"Well, without conceding that your curmudgeon is correct," says Kathy Wilson of Bank Street, "let me offer this counter argument: One of the major difficulties teachers face is motivating their students. And that's the first thing that must be done if learning is to occur. Unquestionably, multimedia motivates kids — even the learner-phobic."

"In certain ways," says Rebecca Corwin, associate professor of education at Lesley College in Boston, "the curmudgeonly view may be true. True, in the sense that entertainment can be what multimedia is allowed to dwindle into. It's important, therefore, for the teacher to emphasize that using multimedia is not recess, but a way of learning.

"However," Corwin continues, "I think the analogy with TV is a bit off the mark. TV, basically, is a passive medium; you turn it on, and then TV does all the work. But multimedia, if it's really placed in the hands of the students, demands activity and the making of choices — or else everything just stops."

There are other caveats, as well, though these address the way the technology is implemented rather than the technology itself.

Some teachers are troubled, for example, by what other teachers see as multimedia's prime benefit: its appeal to visual learning. Especially troubling is the claim by some that multimedia helps students who don't like to read (or who don't learn from reading). By using multimedia the reader-phobe can produce some interesting and valuable work, from which he will have learned something. But if multimedia is allowed to substitute for the text and the library (a hypothetical situation that would probably never occur), then, far from solving a problem, it's abetting an educational dysfunction. Even in the multimedia workplace of the '90s, Johnny will still have to know how to read.

Another criticism addresses one of multimedia's glories: it's evident ability to stimulate and facilitate in-depth learning. Those student teams of Nancy Fogelson's, for instance, may end up knowing more about the Battle of the Marne, say, or about the evolution of the tank than even the teacher knows. But how much will they have grasped about World War I as a whole? In fostering depth of learning, which the technology does admirably, might it not sacrifice breadth?

"That may be something to watch for," Joe Hofmeister agrees. "In fact, when Fogelson gave her students a comprehensive exam at the end of term, she found that, on the whole, the kids did so-so. However, each student aced that particular portion of the exam that dealt with his particular stackware area."

Interactive Multimedia: Visions of Multimedia for Developers, Educators, and Information Providers ($24.95) provides a good overview of what multimedia is and how it can be used in education. Written by Sueann Ambron and Kristina Hooper of Apple, the book is published by Microsoft Press, Redmond, Wa., (206) 882-8080. ■

(It's fair to note, at this point, that Nancy Fogelson herself is under no illusions about multimedia as a simple substitute for comprehensive teaching.)

The message here, of course, is not that the technology is pedagogically invalid, but that the teacher must be a teacher, must exercise vigilance and make sure that every student is getting the comprehensive picture. The danger lies in getting caught up in the delightful concept of empowering students to do their own learning.

"Students should be the navigators through the multimedia package," agrees Mary Alice White, director of the Electronic Learning Laboratory at Teachers College, Columbia University, New York, but "what you don't want is just a lot of random learning about a given subject. You want a presentation that has some built-in direction; something that leads the student from one important piece of information to another."

It will be the job of educators who use this extraordinary tool — multimedia — to make sure students do comprehend the larger subject they are studying. Because if used properly, multimedia technology could have a very positive impact on learning. ■

— Robert McCarthy is a Weehawken, N.J.-based freelance writer.

NEWS LETTER
INRIA GMD CWI
NO. 2
OCTOBER 1989

EDITORIAL

The Scientific Community of Europe

I am happy to introduce the second issue of the common CWI-GMD-INRIA Newsletter. It is the evidence that our common will to strongly interact and coordinate our actions has led to a process which is entering into a mature phase.

Needless to stress the importance of common research actions in the building of this cooperation. The ESPRIT programme, by nature, is an excellent vehicle to carry such actions. Both in ESPRIT 2 and BRA, the three institutes are participating in common projects. A representative selection of them is briefly described in this issue. Many of them were already under way even before the decision of the three organizations to coordinate their scientific policy.

This shows that there was a deep and natural motivation among the research teams to cooperate. Thus, the desire of the institutes to strengthen their links is by no means artificial nor opportunistic. But the European Single Market brings a new challenge, namely that scientists of Europe consider themselves as members of the same scientific community. When this goal will be achieved, the European industry will have access to a major source of innovation as well as to a demanding market, exactly as the American industry in regard with the American scientific community.

We should go as fast as possible in this direction. The activities described in this issue are an important step to fulfill this objective, but a lot remains to be done. We are aware of this and we shall take new initiatives in the future. Issues to come will present them among other things.

Alain Bensoussan

COOPERATION

European National Research Centres in the Field of Computer Science Prepare for Europe 1992 and Beyond

Computer scientists from The Netherlands, the Federal Republic of Germany and from France have decided to increase their research impact by setting up a long-term European cooperation. Three national research Institutes, the Centrum voor Wiskunde en Informatica (CWI), Amsterdam, Netherlands, the Gesellschaft für Mathematik und Datenverarbeitung mbH (GMD), Sankt Augustin, Federal Republic of Germany, and the Institut National de Recherche en Informatique et en Automatique (INRIA), Rocquencourt, France, formally agreed on a long-term research cooperation on April 13, 1989 in Sankt Augustin, Schloss Birlinghoven.

The agreement outlines a joint understanding of CWI, GMD and

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INRIA in the fields of computer science, applied mathematics and information technology. It makes precise the objectives of a cooperative strategy for strengthening research and development in these fields. This joint action programme is initiated to indicate the relevance of the planned cooperation for technology and society, but also to meet the challenges and opportunities of the Single European Act. By 1993 the European Community will become even more a reality as a political and economic entity. This development at the government level will have a major impact on research management, strategies and structures in many fields of science.

The three organizations want to actively participate in this process. They are convinced that they will improve their ability to better cope with the changing environment by combining their efforts and complementing their fields of research. It will, at the same time, enhance their contribution to the research community and to the European nations in general.

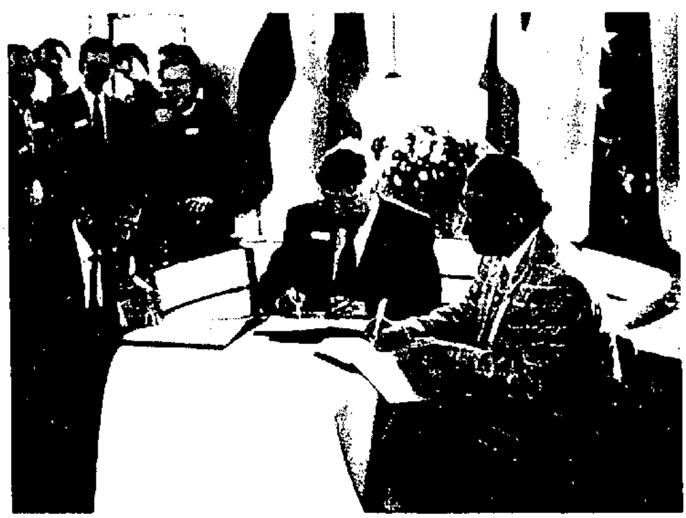
On the occasion of the second series of joint workshops held on April 13/14, 1989 (Programming, Graphic Interfaces, Concurrency) CWI, GMD and INRIA agreed to put into practice essential parts of their joint action programme by the end of this year:

- to offer a fellowship programme for outstanding scientists from European countries;
- to prepare an advanced training programme for special industrial/ academic target groups as a contribution to technology transfer from research to the industrial environment;
- to publish a joint quarterly newsletter, describing ongoing joint projects and other activities of the three partners.

The three partners also agreed on a new workshop series in December 7/8, 1989 at INRIA in Paris, focussing on security/cryptography, VLSI design and software for parallel computers.

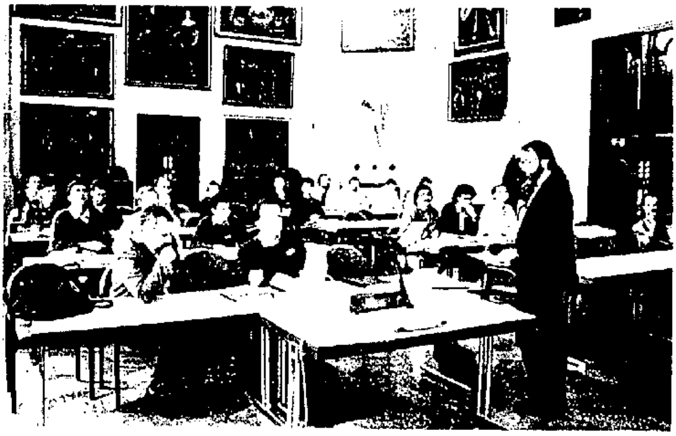
A Standing Committee and several task forces of the three partners were established to prepare and coordinate the various joint actions on an ongoing basis.

CWI, GMD and INRIA have pooled their resources to promote R & D in computer science, information technology and related mathematics to make a substantial contribution for shaping the future European research and technology market. They are open to similar research centres in other EC countries to join in and support their effort.



Signing the "Agreement on Scientific Cooperation": (from left) Prof. Alain Bensoussan (INRIA), Friedrich Winkelhage (GMD), Prof. Cor Baayen (CWI)

The members of the three working groups meet at Schloss Birlinghoven
Photos by Siegfried Münch



ATMOSPHERE – Improving Software Tool Production

GMD - The ESPRIT II ASEE project ATMOSPHERE was officially started on March 1, 1989. ATMOSPHERE (Advanced Techniques and Models of System Production in a Heterogeneous, Extensible, and Rigorous Environment) was approved by the EC for a one year definition phase. Total budget for ATMOSPHERE's first year is approximately 6 MECU, half of which is funded by the EEC.

From April 17 to 21, 1989 representatives of the participating companies and institutions from 13 nations (among them two EFTA countries) met in Garmisch-Partenkirchen for a startup workshop. It was intended for the coordination of the project work and for getting to know the partners.

The project goal is to support system engineering by the development of appropriate, standardized methods and tools. System engineering covers all tasks necessary for the design of a complete computer system including hard- and software. System engineering is the generic term for requirements engineering (ERAE, FOREST), design engineering (SDL, COLD, HOOD), software engineering (VDM), hardware engineering (DACAPO), system allocation and system integration. System Engineering is viewed as comprising three stages: system requirements analysis; high level functionality (both technologically independent) and transformation into implementable designs. The existing methods, given in parentheses above, are considered and advanced by the partners of the ATMOSPHERE consortium, consisting of seven main partners: Siemens, Bull, SFGL, ESF, GEC-Marconi, Nixdorf and Philips. System allocation focusses on the question whether to implement a component in hard- or in software.

Besides the more technical development ATMOSPHERE also addresses the organizational aspects of system engineering like project and product management, quality assurance, and documentation. The developed tools will be integrated into a system engineering environment on the basis of the PCTE operating system.

The GMD Research Group for Program Structures in Karlsruhe is in ATMOSPHERE subcontractor of Siemens and Philips. GMD contributes program generators for the construction of system engineering tools. First, this is G2F, an editor generator for two-dimensional graphical formulas. G2F is suitable for the construction of uniform graphical user interfaces. Secondly, these are the following newly developed compiler construction tools: the scanner generator Rex, the parser generators Lalr and Ell, the generator for abstract syntax trees Ast, and for semantic analysis the attribute grammar tool Ag. Within the project there will be a portation of the program generators to the PCTE operating system. They will be improved and validated by using them in several applications.

CWI Subcontractor

CWI - Starting March 1990, CWI will participate in ATMOSPHERE as a subcontractor of Philips with the following activities:

- Verification of SDL programs. We will use the algebraic framework ACP (Bergstra & Klop) in the verification of SDL programs; in particular a number of case studies will be performed on the basis of SDL programs supplied by industry.

- The study of modularization issues. Module Algebra (Bergstra, Heering & Klint) gives an axiomatic, algebraic calculus of modules which is based on the operators combination/union, export, renaming and taking the visible signature. We will investigate how modularization constructs can be added to or improved in VDM, SDL and COLD, using and extending Module Algebra.

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ITHACA – Integrated Toolkit for Highly Advanced Computer Application

INRIA - The ITHACA project aims to develop an integrated application support system, based on object-oriented techniques. The system will consist of the following components:

- a strictly typed object-oriented language, with its compiler and an interface with a database system allowing object persistency;

- a set of predefined classes allowing rapid development of office or CAD applications. It contains, among others, a generic office model.

- CASE tools, such as browsers, editors, and a User Interface Management System;

- an application support environment: task manager, support for collaborative work, support for multi-media communications, and a help and information system.

To demonstrate the usefulness of this environment for rapid development of applications, three different "demonstrators" will be developed in three different areas: CAD in chemical industry, financial managing and public administration.

INRIA participates in the design and development of User Interface tools (UIMS, interface editor) and is responsible for the design of the help and advice-giving systems for end-users.

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PHOENIX – Logic and Functional Programming Paradigms

GMD - The ESPRIT Basic Research Action PHOENIX was started in April 1989 at the GMD Research Group in Karlsruhe. It will carry out a coordinated research programme into the technologies involved in integrating and extending the logic and functional programming paradigms. In this project, GMD cooperates with the Imperial College of Science and Technology (Prof. John Darlington), London, and the University of Nijmegen (Prof. Cees Koster).

Functional and logic programming languages are typical exponents of so-called declarative languages. In contrast to imperative programming languages, they have many advantages: they are mathematically founded, show a great descriptive power and are very close to specification languages, programs are easy to analyze and to manipulate, and they are well suited for execution on parallel architectures. But software technology did not yet arrive at a full exploitation of these advantages.

The PHOENIX project aims at enhancing and integrating existing technologies towards a more effective and more efficient availability of both programming paradigms to software development. The approach is a hierarchical one which investigates three levels in parallel:

- At the language level, integrated language concepts including their formal description will be developed. They will unify different concepts of both paradigms into one language framework.

- At the transformation and refinement level, techniques for program analysis and transformation will be developed. Investigations will address transformations of programs into more efficient programs of the same language and into programs of a simpler subset of the language allowing a more efficient implementation.

- At the implementation level, implementation concepts for integrated functional/logic languages will be developed based on abstract machines. At all levels, aspects of parallelism will be considered. The hierarchical approach allows an optimal consideration of interdependencies and influences between the different levels.

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ICARUS – Incremental Construction and Analysis of ReqUirements Specifications

INRIA - The ESPRIT II project ICARUS is a project with a manpower of 120 m/y and is intented to last for 5 years. Four countries are involved, with 5 industrial and 3 academic partners:

- Philips Research Laboratory Brussels (PRLB), main contractor (project leader Pierre Wodon);
- Alcatel Standard Electrica (SESA), Madrid (with subcontractor TEICE, Madrid);
- Universidad Politecnica de Catalunya, Barcelona;
- Laboratoire de Marcoussis, groupe CGE, Orsay;
- RELEACE, Dublin;
- Faculté Universitaire Notre Dame de la Paix, Namur;
- INRIA-CRIN, Nancy;
- SEMA-GROUP, Montrouge.

The project is concerned with the study of formal methods and the definition of software tools for building and reusing requirement specifications.

In brief, requirement engineering (RE) is the activity of investigating the customer's needs in the context of a software development project. In order to be more precise, a distinction must be made between specification of the requirement, which describes functional and non-functional properties of the system and of its environment, and specification of the design, which describes the system alone for the benefit of the software engineers. There is no doubt that requirement engineering is a very sensitive area of software development, because it takes place early in the project's history and its errors are often discovered too late.

The study of formal methods for requirement specification distinguishes three levels of concerns:

- the specification product which is the description of the desired system in its environment ("what");
- the specification process which is the organized set of activities (choices, decisions, transformations, ...) by which the specification is produced ("how");
- the specification rationale which is the set of reasons that have led to the choice of a particular process ("why").

The aim of ICARUS is to propose an original approach to requirement specification, close to several projects, in particular the ESPRIT I projects TOOLUSE and REPLAY intended to study the derivation of products at the design and code level.

As the three-level problem in RE has not been addressed yet, some restriction on the scope has been made in considering functional and performance (e.g. real-time) requirements.

The development of the project will take place along the following lines:

- Study of the real world practice to get deep insights in the RE process and rationales. The experience of the industrial partner will be here very important.
- Formal concepts, formal languages and a theory for modelling specification products, processes and rationales at these three levels must be defined. It should be noted that a formal method is not a way of restricting the creativity of engineers. It aims at giving them means for reasoning on their work.
- Putting RE methods into practice will be ensured by the development of a prototype of an integrated RE environment supporting such methods actively and by the performance of realistic case studies. The environment will be based on a process-driven RE assistant integrating active analyst guidance, consistency / completeness checking, specification visualization and prototype generation. The development of software tools will try to reuse versions of existing tools like PCTE, PACT, GIPE or GRASPIN. Industrialization will proceed incrementally, using the particular procedures of each participant.

Participation of INRIA in ICARUS is estimated to 17 men/year. It concerns the central task of defining a formal and linguistic framework allowing to express the three levels, including real-time constraints. INRIA is also involved in the conception and design of the environment, in the development of some specialized tools and for a lesser part in case-studies.

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REX – Reconfigurable and Extensible Parallel and Distributed Systems

GMD - Within the EC ESPRIT Research Programme, the project REX was started at the GMD Research Group for Program Structures in Karlsruhe on May 1, 1989. Ten research organizations and industrial enterprises from France, the Federal Republic of Germany, Greece and Great Britain will cooperate in REX.

The REX project will develop a methodology and support tools for the development and management of parallel and distributed systems. The emphasis of this project is on the support for reconfiguration and extension in order to exploit the parallelism available in distributed and multiprocessor hardware and the parallelism inherent to the applications. The notion of the system as a configuration of modular software and hardware components will be used as the framework research objectives.

System specification and modelling

Development of a specification methodology to express structure and behaviour of distributed and parallel systems and to guide the activities to construct and (re)configure them.

System programming

Development of adequate linguistic support for the design of software components with a high degree of parallelism, for asynchronous communication and for real-time processing.

Methods

The provision of development methods for the systematic construction of software for distributed architectures.

Analysis and evaluation

The provision of techniques and tools for the analysis and validation of system behaviour and performance.

Dynamic configuration and reconfiguration

Graphical and linguistic support for the description, construction and evolution of systems based on the (re)configuration of software components, their interrelationships and allocation to the hardware configuration.

Runtime support

Tools to support software components and systems during runtime and to enable their (re)configuration, including monitoring tools for timing analysis, load balancing, and reconfiguration.

Demonstrator applications

Realistic examples from the industrial automation and telecommunications areas are integrated, thus showing the feasibility of the REX approach and the practicability of the developed tools. They will also serve as a basis for the interchange of technology and industrial requirements among research and industrial partners.

The GMD Research Group in Karlsruhe mainly will be involved in the research for specification techniques and language concepts with special emphasis on parallelism and on communication in cooperation with partners from industry and research institutes.

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DEMON – Basic Research for the Design of Concurrent Systems

GMD - The ESPRIT basic research project DEMON started in April 1989 and planned to end in September 1991 is part of the new EC programme for basic research in information technology. The objective of the project is to explore important theoretical issues involved in the formal reasoning about concurrent systems and to develop a formal framework supporting the design and verification of large concurrent and decentralized systems. Computer scientists from the GMD Institute for Foundations of Information Technology participate in this project. The basis for this work is the Petri net model which has the benefits of a graphical system representation and a supporting formal theory which captures the essential characteristics of concurrency and locality of state and action and is very general in that it subsumes virtually all other formal models of concurrent systems.

The focus of the project is to enhance Petri net theory by a maximum of concepts of modularity and composition required as aids for designing concurrent systems: refinement and abstraction techniques, algebras and proof rules, appropriate notions of equivalence, congruence and simulation, associated formal proving methods.

The work is organized into two strongly interrelated parts. The central part is concerned with the development of net classes showing the above characteristics of modularity. The second part involves case studies, language studies and other activities supporting the development of suitable net classes. It is the interface to the related approaches and projects.

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Type A – Machine Learning Toolbox

GMD - The ESPRIT-Project "Machine Learning Toolbox" aims at making machine learning available to a wide range of applications. Therefore, a system is developed that provides the users with several learning procedures. Moreover, the system helps the user to select and use the appropriate procedure.

Machine learning techniques have been successfully applied to a variety of problems. This requires, however, intimate knowledge of the field and a considerable effort to adapt scientific results to industrial environments. In general, it is not well known how to relate features of problem classes to those of learning procedures. Therefore, evaluating and characterizing the learning algorithm will be an important task of the Machine Learning Toolbox project. The Machine Learning Toolbox will create a wide range of learning procedures. Each of them will be evaluated using practical problems. Moreover, the procedures will be transferred to a common UNIX environment, thus enhancing availability.

Tasks of the GMD are to provide a model-based learning procedure, to evaluate and characterize it and to enhance it where it is necessary. Moreover, the GMD project group will take part in the development of a common knowledge representation for the Machine Learning Toolbox. Project duration will be from 1989 to 1993.

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CLICS – Categorical Logic in Computer Science

GMD - The ESPRIT Basic Research Action "Categorical Logic in Computer Science" aims at a unified theory of programming and specification based on methods of categorical logic. The project is motivated by the belief that category theory and the categorical approach to logic are extremely suitable for constructing mathematical explanations of the meaning of very many formal systems which are used in computer science. The strong unity of the concepts of category theory coupled with their wide applicability make the subject an invaluable tool for the application of mathematical techniques in computer science.

Categorical logic translates possibly complicated logical structures into formally simpler, categorical ones. This has proved feasible for a remarkably large number of the basic concepts underlying traditional logic (substitution, quantification, higher-order function, power set operation). However, many of the mathematical concepts which are of fundamental concern in computer science are not so well understood.

Translation into the categorical language should play a dynamic role suggesting new formal systems and sharpening our understanding of the original concept. Categorical logic has already given some deep insights into the mathematical nature of some new paradigms of programming such as type structures (polymorphism, dependent types and inheritance), concurrency and logic of programming. This work will be continued and broadened to provide a unified mathematical and logical basis of programming specification.

All partners will be involved in the development of a meta-language for denotational semantics. GMD will moreover focus on high level specification language and on languages and proof systems for parallel processes, while INRIA will particularly work on epistemic type theory and on implementations of formal systems.

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STRETCH

INRIA - This ESPRIT II project aims at integrating database and knowledge-base technology. The goal of the project is to develop a system that can handle large amounts of data, make inferences about stored data through logic programs and express the structural semantics of data in an object-oriented fashion. The envisioned approach relies on two main directions:

- Development of an extensible object server. This server will support multi-user access and update to large bases of complex objects (lists, trees, graphs,...) and execution of operations specific to these objects. These functionalities (typing system, access methods, operator) will be available in a primitive form, serving as basis for extensibility.

- Development of two languages for application programming: a rule based language and a persistent object oriented language. Each language will have an optimizer/compiler interfaced with the object server. The work performed by INRIA will consist of the design and development of main parts of the object server and the rule based language with its optimizer/ compiler. It will be a follow-up of the work already performed in the ESPRIT 1 project ISIDE.

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GRASPIN – Personal Environment for Incremental Graphical Specification and Formal Implementation of Non-Sequential Systems

GMD - As one of the first ESPRIT projects in the area of software technology, the GRASPIN project is concerned with improving current software development approaches to encourage their use on a wider industrial scale. The project is carried out by a number of industrial and research companies from Germany, Greece and Italy, GMD as the prime contractor.

The GRASPIN project, which started in September 1983 and will end in September 1989, aims at both, research and development goals.

Research activities are directed to improve current software development approaches and, where necessary, to develop new methods. Emphasis is placed on the most critical activities in the software life cycle, namely requirements analysis and specification as well as on validation and verification. A further goal is to combine these methods in a coherent way.

Development activities aim to systematically support the methods by appropriate tools. The tools shall be integrated into a personal software engineering environment prototype.

The environment is dedicated to the incremental development of distributed software systems. It provides a methodological support for specification and development of complex and reliable systems. Concepts, methods, and tools cover many technical activities in the software life cycle, and reflect the cyclic nature of software construction with the countercurrent validation processes.

The GMD team in GRASPIN is particularly involved with specification support and generator aspects of the environment kernel. Methodological improvements are expected, e.g. from combining Petri net theory with algebraic specification and from supporting different languages for different "phases" of the software life cycle. Technical improvements are expected, e.g. from syntax directed editing techniques and from object oriented programming techniques.

The project has developed prototypes of a personal software engineering environment to support the construction and verification of distributed and non-sequential software systems. Each of theses prototypes provides a flexible framework with extensive facilities for the incorporation of new methods and tools, and for the customization to a variety of languages, applications, and target systems. The prototypes are implemented on Lisp systems and PCTE-based machines.

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MULTIWORKS – Multimedia Integrated Workstation

INRIA - The aim of the ESPRIT II project MULTIWORKS is to define a low cost multimedia workstation. The project is oriented towards two main axes:

Hardware axis. Based on RISC architecture, MULTIWORKS will integrate the forthcoming VLSI technology. To minimize the costs remaining compatible with PC's costs, some multimedia functions will be integrated directly on silicon.

Software axis. The MULTIWORKS machine will be based on the UNIX system compatible with international standards. The software architecture will offer an object-oriented environment to develop some advanced management application for multimedia documents as an hypertext system. The main functionalities of the workstation will be a high resolution bitmap, a scanner, a voice treatment interface ; these functionalities will be compatible with X-Windows standard.

INRIA is involved in three major subtasks:

- Voice recognition. In the framework of MULTIWORKS, a Nancy research team will work in the project SYCO on software for automatic voice recognition: definition of the management system, and input of voice data.

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- Language for an hypermedia system. A second research group at Rocquencourt will define and implement the MULTITALK language for hypermedia systems, in which text, drawing, voice, video, graphics, etc., are integrated. This system will be connected by symbolic links allowing a non-linear access to the documents. MULTITALK will be based on the same concepts as Hypertalk of Apple and Notecards of Xerox. It will be adapted to the environments of hypermedia document editors proposed by Bull, Olivetti and ICL, which are partners in this project.

MULTITALK will be implemented on X-Windows with the help of SYNTAX and FNC-2 ; it will support tool kits such as ANDREW (IBM - CMU) and the HP - DEC toolkit adopted in OSF.

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- Management of ideas. The conception of a document does not only consist of the edition of texts, drawings and graphics. The main work is to elaborate the ideas. The productivity of the conceptor certainly can grow by offering him a strategy of generation, organization, evaluation and control of his ideas.

The objective of this subtask is the conception and implementation of such a tool and its integration in the hypermedia system of MULTIWORKS.

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CONCUR – Theories of concurrency: unification and extension

CWI - CONCUR is an ESPRIT II Basic Research Action. It will run from 1 Sept. 1989 to 1 Sept. 1991. CWI is coordinating partner. The other partners are the University of Edinburgh, Oxford University, the University of Sussex, INRIA (Sophia Antipolis), SICS (Swedish Institute for Computer Science), and the University of Amsterdam. Formal verification of software programs, protocols and chip designs, is becoming increasingly important, but up to now has been undertaken only on a very small scale, and with a multitude of techniques and formal theories. Normal academic interchange will slowly bring unity into the disparate world of concurrency theories, but collaboration of a more intense kind is needed to accelerate the process. Among the many formal approaches which exist for concurrent communicating systems, the important algebraic approaches are represented in this project. The principal aims of the project are to explore the relationships among these different approaches, and to develop a formalism applicable to a wide range of case studies. In addition to collaborating at the theoretical level, we will collaborate through the development, use and comparison of software reasoning tools. This latter collaboration will serve both to further unity and to enhance the theoretical collaboration. Several of the partners already have ongoing tool building activities. The action will coordinate the participants' well-established programmes of research into theories of concurrency.

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GIPE II – Generation of Interactive Programming Environments II

CWI / INRIA - GIPE II is an ESPRIT II project aiming both at advanced research in the area of interactive environments based on formal specifications and at design, implementation and experimentation of real size environments for industrial applications.

This project continues and extends the research carried out in the successful ESPRIT I project 348 (GIPE) which ends in November 1989. The main results of the ESPRIT I project are - apart from scientific publications - a prototype interactive programming environment generator called Centaur. Taking as input the complete formal description of a programming language, Centaur provides a toolkit of generic components and compilers for constructing a specific interactive environment for that language. This environment includes an editor, an interpreter/debugger and other tools, all of which have uniform graphic man-machine interfaces.

The main result of the GIPE project is that this technology is feasible. The GIPE II project aims at making it mature by several actions.

The research on interactive environments will address subjects like the construction and analysis of large formal language definitions. Functionality and performance of the generated environments are extended by studying incremental processing and concurrency, and by adding typographical and graphical facilities to the system. In addition to this, the Centaur system will be maintained, extended and distributed.

Furthermore, two demonstrator projects will evaluate the Centaur system in industrial applications. In the first project, a programming environment for scientific computing will be generated which aims at producing highly efficient Fortran code on a variety of pipelined and parallel architectures. In the second project, a prototype environment for the LOTOS specification language will be generated.

The GIPE II consortium consists of the following partners: ADV/ORGA, BULL, CWI, GIPSI, INRIA, PLANET and PTL. The University of Amsterdam will act as an associated partner of CWI.

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INTEGRATION

CWI - The ESPRIT Basic Research Action INTEGRATION aims at integrating the foundations of functional, logic and object-oriented programming. Functional programming has its mathematical foundations in the fields of lambda calculus and term rewriting, and logic programming is rooted in predicate logic and automatic theorem proving. Integrative efforts for these two programming styles have already vigorously been pursued for several years. For object-oriented programming it is generally felt that there is a strong need for a better understanding of its mathematical nature. Also, there is ample evidence that one may profit here from the insights from functional and logic programming, which justifies the organization of the integrative effort into three chapters: integration of the functional and logic, the functional and object-oriented, and the logic and object-oriented programming styles.

Participants in INTEGRATION are: CWI (coordinator), CAIMENS, Imperial College, UNINOVA, the University of Pisa, and Philips Research Labs (Eindhoven).

Altogether, the workplan consists of nine tasks, each task being allocated to a senior and a junior researcher from one of the partners , in close co-operation with a second senior researcher from one of the other partners. The duration of the action is thirty months, during which period crossfertilization between chapters is expected to increase. A final integrative effort is envisaged for a second phase after completion of the work of this action.

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LOGICAL FRAMEWORKS

INRIA - There has been a steady increase in recent years in research towards systems that can provide assistance with reasoning about a variety of problems, particularly in the development of hardware and software systems. Such systems must be usable by programmers and hardware designers who are not experts in logic and so must provide a comfortable, problem-specific environment for developing formal proofs.

A wide variety of formal systems is of interest to systems designers (operational semantics, lambda-calculi, sequent calculi, type theories, first- and higher-order logics). The task of implementing a proof development environment for a given logic is daunting, and there is considerable duplication between implementations of different logics. It is therefore desirable to develop a unifying theory of formal systems that allows one to give a concise specification of the object logic. The proof development environment can then be logic independent, accepting a specification of logic to be used. This eliminates, in large measure, the redundancy between implementations, and one can rapidly prototype systems for a variety of logics. A "logical framework" is such a unifying theory of formal systems; it provides a notation and a calculus for specifying logics.

The proposers are currently experimenting with various AUTOMATH - related type theories, with variants of Church's higher-order logic and with a general system of operational semantics as a framework in which to conduct formal proofs. One aspect of the proposed research is to understand the relationships among these systems. It appears, on present evidence, that some form of typed lambda-calculus is a basic component of such a framework. A common point of implementations is their ability to provide the user with proof-search procedures. It is expected that the experience gained in such endeavors will be among the principal results of the proposed collaboration. Most prototype software is written in ML (a functional programming language oriented towards symbolic computation). This will enhance collaboration among the participants. Besides scientific publications, the expected result is a demonstration of feasibility and usefulness of "developing certified software in the large".

LOGICAL FRAMEWORKS is an ESPRIT Basic Research Action, and involves mostly two INRIA projects:

- the CROAP project at INRIA Sophia is working on the User of logical formalisms for the specification of the semantics of programming languages. Through this Basic Research Action, the theoretical aspects of this field are studied as well as the setting up of an elaborate interaction system to build and operate mathematical proofs (interaction, tactics, semi-automatic proofs).

- through INRIA's FORMEL project, attention is focussed on the construction calculus designed by Th. Coquand and G. Huet. This is a higher-order typed lambda-calculus, including the so-called dependent types that are practically attractive. Its metatheory is very rich, which opens good prospects for concrete applications. A prototype already exists, written in CAML (INRIA's ML dialect). It includes a mathematical vernacular, and provides the user with program extraction from proofs procedures as well as partial proof synthesis algorithms. Another research direction followed by Ph. Le Chenadec consists of investigations concerning the problem dual to proof synthesis: type inference. In these two research trends, numerous partial results, both theoretical and practical, witness the practical value of a highly formal approach to programming activity.

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SEMAGRAPH

CWI - ESPRIT BRA project SemaGraph concerns the foundations of graph rewriting. Its main objective is to develop knowledge relevant to the semantics and pragmatics of generalized graph rewriting. Our rather general notion of graph rewriting theory extends term rewriting notions to include sharing, multiple non-root rewriting and explicit control of reduction order. These can be used for optimalized reduction, side effects and process communication and synchronization. Taken together, these extensions provide a potentially unifying framework for a variety of models of computation, including: functional languages, logical languages, object-oriented languages, and parallel generalizations of imperative languages. A computational model based on graph rewriting might provide the basis for a 'common virtual machine' to support European work on various symbolic and other languages.

Participants in SemaGraph are: CWI (Amsterdam), ICL (Manchester), ICST (London), the University of Nijmegen, LIENS (Paris), and UEA (Norwich) (main contractor). The project will bring together participants from various European IT programmes in a united attempt to further develop European foundational knowledge about graph rewriting. Industrial participation at observer level will aid in establishing priorities for the various investigations, and provide a channel via which relevant results can be rapidly fed to shorter term research projects.

SemaGraph started July 1, 1989, and will continue for 30 months. It will bring together and enhance knowledge in the following areas of generalized graph rewriting systems (GGRS): formal descriptions and abstract models, relating other models to GGRS, controlling reduction order and typing, static analysis, and efficiency of normalizing lambda graph reducers.

By identifying those results which carry over from the term world to the graph world, and by a better understanding of the constraints on a rule system necessary for efficient implementation, SemaGraph will be of direct interest to larger ESPRIT II projects, particularly those concerned with general and special purpose rewriting formulations of both symbolic and numeric problems for parallel machines.

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TROPICS

CWI - TROPICS is an (industrial) ESPRIT-II project, aimed at the development of a high performance parallel system for the office. The project is structured around eight subprojects including architecture, operating system, database management, and the construction of an office application. It re-uses and builds on the experience gained in several ESPRIT-1 projects (415,302,967,1588,28), and the PRISMA project funded by the Dutch computer science stimulation programme SPIN.

The TROPICS consortium consists of five main partners: Philips, Olivetti, Thomson, CAP-SESA, and Nixdorf. The project started in January 1989 and the first phase ends in June 1990. CWI will participate as a subcontractor of Philips with the following activities:

- Design of a datamodel for complex objects. In particular, we will extend the relational and NF2 models to deal with both multimedia and cartographic objects.

- Implement a prototype query processor for this model on top of the PRISMA architecture.

- Consult and aid the partners in extending the PRISMA DBMS architecture to efficiently support the two application areas mentioned above.

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ToolUse – An Advanced Support Environment for Method-Driven Development and Evolution of Packaged Software

GMD - The project aims at providing means for active assistance in the design, implementation and evolution of software.

The underlying hypothesis for the guidance of this project is that such an assistance should be obtained by describing the development of software in a formalized manner such that this description itself can be manipulated, e.g. for describing the development of a slightly modified piece of software. The development of such a formalized description can only be based on a thorough understanding and formal definition of methods driving the process of software construction from the first description within a framework of an application oriented specification language to the stages of implementation, use, and continued evolution. The use of a formalized description must rely on the existence of an advanced support environment. This support environment in turn must comprise tools relying on the understanding, acquisition, representation and reuse of knowledge and constraints related to information processing techniques depending on given application areas and on target systems.

The project is supposed to provide a prototype environment containing an adequate user interface supporting the use of the development language, an underlying database, and a set of tools supporting the whole development process.

GMD is participating in the tasks concerned with the development of a development language, a support environment and support for program development.

In addition to contributing to the current definition of Deva, GMD has developed the following support tools so far:

- A generator for graphical user interfaces (G^2F),

- a theorem prover for intuitionistic logic (TILT),

- a tool for semi-automatic complexity analysis (COMPLEXA),

- an implementation of the program development method of D. Smith (PROPER).

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Semiconductor devices

CWI - Two types of simulations are of prime importance for the development of semiconductor devices: 'process modeling' of the diffusion processes describing the etching processes which give the shape to the devices, and 'device modelling' of the electric field and the electric currents inside the semiconductor material. This simulation boils down to the solution of a system of three coupled, highly non-linear and terribly scaled elliptic partial differential equations.

In view of the coming submicron technology it is expected that the physical models have to be extended and that the numerical problems encountered will be correspondingly harder. But even with the present physical model, the available numerical techniques are felt to be inadequate. Although in industry several simulation programs are available, the applied methods are not yet sufficiently robust and efficient. The few efficient programs are applicable only for small sub-classes of the problems of interest. Numerical techniques for the device modeling are currently studied in CWI's Numerical Mathematics department. Research concentrates on fundamental issues: discretization methods for singularly perturbed problems and multigrid and adaptive methods for the non-linear algebraic equations resulting from the discretization.

Close contacts exist with Philips CFT Centre in Eindhoven; the research is supported by the national innovation programme IOP.

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EUROMATH

CWI - Euromath started up in 1987. It is an international project, initiated and monitored by the European Mathematical Trust under supervision of the European Mathematical Council, and sponsored by the European Commission. The aim is to stimulate the research potential of European mathematicians, by creating a research environment, the Euromath system, based on modern information technology specifically adapted to the needs of the mathematical community. CWI is one of the technical partners in the project with main responsibility for the functional design of the Euromath system.

Facilities envisaged are: electronic mail and conferencing, production and mailing of mathematical documents, mathematical databases with data on articles (published or to appear), mathematicians (addresses, specialisms, etc.), coferences, meetings, workshops, research facilities and their financial support, and other facilities such as a possible integration of computer algebra systems in Euromath. A number of these facilities is already available, but Euromath offers them in one integrated computer environment.

Driving force behind Euromath was (and is) the Danish mathematician F. Topsøe. At present 19 countries participate, representing a potential of 10.000 researchers in 500 centres. There are also contacts with the USA and Eastern Europe.

The Euromath project is due to be completed on December 31, 1992. During the last, operational phase the establishment of a permanent Euromath Centre for general services is envisaged.

The first phase of Euromath ended on June 30, 1989. GMD, INRIA and CWI, have expressed their great interest in the second phase of the project, in particular because Euromath II would be the first project in which all three institutions participate. The definitive decision about funding for the second phase is expected to be made in September.

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NANA – Novel Parallel Algorithms For New Real-Time VLSI Architectures

INRIA - The main theme addressed in this ESPRIT BRA project is the development of novel parallel algorithms and real-time VLSI architectures for multi-dimensional signal processing and their introduction in computer-aided synthesis environments.

The project is oriented towards the development of efficient multi-dimensional subsystems needed in application domains such as video, image processing, robotics, radar, sonar, seismic processing, telecommunication, factory automation, vision, advanced process control, biomedical technology, and so on.

The most important class of techniques needed in these domains are algebraic and numerical techniques for multi-dimensional problems such as linear system solving, least squares solution of overdetermined systems resulting from measurement data, eigen- or singular value computation, finite element modelling, coordinate transformations in robotics, etc.

The project will study and propose novel algorithms for these techniques. It will thoroughly investigate the implications of these algorithms on the choice of processing architectures. Synthesis strategies for making possible the future design of high-complexity applications in mega-chip technologies, will be an important research topic of the project.

The institutions involved in this project are IMEC (Leuven, Belgium), the Catholic University of Leuven (Belgium), Delft University (The Netherlands), IMAG / TIM 3 (Grenoble, France) and IRISA-INRIA (Rennes, France).

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RelaX – Reliable Distributed Applications Support on Unix

GMD - RelaX is a software layer on top of the UNIX kernel that provides system support for reliable distributed applications in form of a generalized transaction mechanism. Its functionality is available as a procedure library and relieves the programmer of dealing explicitly with concurrency control and error recovery in each distributed application. The transaction mechanism is isolated in a server and cooperates with an extensible set of resource managers which provide different kinds of persistent, sharable data (e.g. file systems, object management systems, specialized databases). It is designed to support a broad range of applications and thus incorporates significant extensions to the conventional transaction concept used in database systems. These extensions aim to make transactions flexible and efficient to use: they comprise extended nesting by independent recovery and synchronization levels, fast recovery in virtual memory, possible separation of the completion of a transaction from its commitment to allow efficient group commitment, premature release of uncommitted data achieved by non-strictly 2-phase locking. Dependencies between transactions that result from the use of uncommitted data are recorded by the transaction mechanism and taken into account when transactions commit or abort. The flexibility introduced by these extensions makes transactions applicable as a general programming tool for reliable distributed applications.

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STONE – A Structured and Open Environment

GMD - STONE is an EUREKA project to build a software engineering environment (SEE) for education purposes. "Education" means software engineering education as well as environment engineering education. This domain requires that the environment is extremely simple and easy to learn, open for a quick integration of methods that shall be taught, and well structured in order to teach environment engineering.

At present the STONE partners have started with the detailed definition of the desired environment and its interfaces. STONE will be developed with the contribution of French and German partners. The German partners started their work in May 1989. These partners are Forschungszentrum Informatik, Karlsruhe, Fraunhofer Gesellschaft IITB, Karlsruhe, Gesellschaft für Mathematik und Datenverarbeitung mbH, Sankt Augustin and Karlsruhe, Technische Universität Berlin and Zentrum für graphische Datenverarbeitung, Darmstadt. On the French side the proposed partners are AEROSPATIALE and the Centre d'Etudes et de Recherches de Toulouse (CERT). They will start with their work items by October 1989.

The GMD contributes to STONE in two ways. First, a number of tools are developed which will support the management of software documents, their versions and their interrelationships in a multi-user environment. Secondly, the support environment of the design language DEVA, which is developed in the ToolUse project, will be integrated into the STONE environment to provide a realistic education of formal methods in practice.

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Expertise Centre Computer Algebra gets off to a good start

CWI - A starting subsidy of 1,7 million Dfl was allocated by the Dutch Ministry of Education and Science in March, 1989, to the establishment of an expertise centre for computer algebra (CA) in The Netherlands. The centre will be located at the Centrum voor Wiskunde en Informatica (CWI) in Amsterdam. Scientific management comes under the foundation Computer Algebra Nederland (CAN), set up last December for the benefit and support of research and development in the field of computer algebra. Similar activities were already developed in other countries, e.g. France and West-Germany, because of the increasing number of researchers and users of CA. There exists also already for quite some time a European organization, SAME, which regularly organizes international conferences on CA in close cooperation with ACM-SIGSAM.

The subsidy, granted for a period of three years (1989-1991), will be used for the purchase of computers and the appointment of two staff members. Activities will concentrate on procuring researchers and users access to a central computer specially designed for CA-software, and providing them with workstations and software by means of which they can utilize this central facility through well-functioning communications (in this case SURFnet, the Dutch network of the Organization for Co-operation in Computer Support in Higher Education and Research SURF).

Moreover, the expertise centre will provide services including information about CA-systems (price and terms of delivery, documentation, required hardware, etc.), advice on the use of these systems, and if necessary expert consultation. Several CA-systems will become available through the SURF-network. At the university of Nijmegen, 'cana' - a Sun-4/280 with 32 MB main memory - is already operating within the CAN framework. Some of the installed programs are Reduce, Maple, Mathematica, Macaulay, and Lie. Activities also include the organization of meetings, workshops and courses.

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GMD Buys SUPRENUM Supercomputer

GMD - SUPRENUM, the first marketable supercomputer developed in the Federal Republic of Germany, was bought by GMD at a price of 21.5 mio deutschmarks. The purchase was financed by the Federal Government via special funding. These were the news presented by Prof. Dr. Gerhard Seegmüller, chairman of the executive board of GMD, and Prof. Dr. Ulrich Trottenberg, speaker of the SUPRENUM GmbH management.

The SUPRENUM supercomputer which is able to do five billion floating point operations per second (GFLOPS) will be used within the so-called Höchstleistungsrechenzentrum (supercomputing centre) operated by GMD, Kernforschungsanlage (KFA) in Jülich und Deutsches Elektronen-Synchrotron (DESY) in Hamburg to solve scientific problems considered so far unsolvable due to the lack of sufficient computing capacity. These are problems of high energy physics, aerodynamics and climatology on the one hand, but also problems of chip design and fundamental questions of numerical mathematics on the other. The SUPRENUM supercomputer developed for using new computing methods will again help to develop new computing methods. Since GMD continues to advance the SUPRENUM concept, the supercomputer will also be used to design its own successor model.

SUPRENUM GmbH hopes that more than half a dozen SUPRENUM systems will be installed in the German-speaking area by the end of 1990. This is a great lot if one considers that a total number of only 23 supercomputers have been installed in the Federal Republic of Germany during the last 15 years.

In 1990 SUPRENUM GmbH will intensify its activities on the European and extra-European markets. The first installation there is expected for 1991.The activities of SUPRENUM GmbH will however not be restricted to universities and publicly funded research, but will also be directed towards industry. It is hoped to sell the first SUPRENUM computer in the industrial sector in 1990/91. On medium term, SUPRENUM GmbH intends to sell every second supercomputer to industry. Thus, SUPRENUM will compete on this market with American and Japanese manufacturers.

Some weeks ago, the Commission of the European Communities approved the research project Genesis to be conducted jointly by several Member States. This project, which is to focus the development efforts of the participating Member States and institutions on a powerful supercomputer, is mainly based on the SUPRENUM concept which is thus recognized on a European basis. Therefore, the work on Genesis and that on SUPRENUM 2 will benefit from each other.

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INTERNATIONAL RELATIONS

Agreement with Columbia University

INRIA - An agreement was signed on March 17,1989 between INRIA and the Center for Telecommunication Research at Columbia Unversity. The aim of this agreement is to further the development of cooperation between the two research institutions in information processing technologies and telecommunications. This agreement encompasses:

- exchange of researchers,
- exchange of scientific publications,
- joint seminars,
- exchange of software for research purposes for the next three years in the following areas: image and speech processing, parallel and distributed algorithms, VLSI systems, artificial intelligence, modelling and performance evaluation, integrated communication networks, communication protocols, numerical and symbolic software, and computational complexity.

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European deputies at Sophia Antipolis

INRIA - A delegation of thirty European deputies, led by Mr. Adam, Vice-President of the Commission for Energy, Research and Technology, visited INRIA-Sophia Antipolis on March 21st.

Mr. P. Bernhard, director of the institute, gave a presentation of the institute, its international (particularly European) cooperative efforts, as well as its main industrial contacts.

Then followed the presentation of software developed by two new companies located in Sophia-Antipolis and founded by researchers: ISTAR, created by Laurent Renouard, who recently wrote his thesis while working in the project PASTIS (INRIA - Sophia Antipolis) and by other members of PASTIS ; and SOPHIATEC, cofounded by Serge Miranda, professor at Nice University.

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Visit of scientific counselors West-Germany and France

CWI - In the framework of the GMD-INRIA-CWI cooperation, the scientific counselors of the Federal Republic of Germany, Mr. H. von Graevenitz, and of France, prof. M. Girod, visited CWI on March 9. They were informed about CWI's science policy in general, and the co-operation with GMD and INRIA in particular, and attended some demonstrations of ongoing research in the field of computer graphics, distributed systems and cryptography. The meeting was also attended by Mr. E. Schenk of the Netherlands organization for scientific research (NWO), CWI's main sponsor. Mr. Schenk is responsible for NWO's international relations.

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Visit of Prof. Meng from Taiwan

CWI - Prof. Hsien-Chung Meng, member of the National Science Council of Taiwan and director of its Frankfurt-based European Office, visited in the middle of March a number of research institutes in The Netherlands, among which CWI. Purpose of the visit was to explore possibilities for contacts and exchanges between Taiwan and The Netherlands.

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Second International Conference on Japanese Information in Science, Technology and Commerce

GMD - From October 23 to 25, 1989, GMD will organize an international conference on various aspects of Japanese Information in Science, Technology and Commerce. The conference will be held at the new Japanese-German Centre in Berlin.

The conference will be sponsored by further organizations in the Federal Republic of Germany, Great Britain, the USA and Japan. More than 50 papers on the four main subjects have been received so far, i.e. on general problems of information flow, new information about information sources, state of the art of analysis and services as well as contributions to overcoming the language barrier.

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France-Japan symposium

INRIA - Dr. Iwata from the ICOT Institute has recently visited INRIA and met with Laurent Kott at the INRIA Research Center in Rennes. They organize together the next France-Japan symposium which is going to take place November 15-16-17 on Izu Peninsula (Japan).

The chair persons of this symposium are Laurent Kott (INRIA) and Kazuhiro Fuchi (ICOT). The major areas of this meeting will be:

- parallel languages and their semantics,
- all languages and architecture,
- software science and engineering,
- all applications (including natural language processing),
- automated deduction and symbolic computation.

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Conference on Very Large Databases

CWI - The Fifteenth International Conference on Very Large Data Bases, VLDB 89, was held on August 22-25, 1989, in Amsterdam. There were 500 participants. The programme included a tutorial part with five well-known speakers: C.J. Date (The foreign key Saga), K.R. Apt (Top down versus bottom up computing in deductive databases), G.M. Nijssen (An effective design method for relational databases), S.B. Zdonik (Research directions in object-oriented databases) and M.L. Brodie and J. Mylopoulos (Integrating AI and database technologies). The key-note speech was given by Hervé Gallaire, director of the European Computer Industry Research Centre.

The following topics were covered: logic, deductive and temporal databases; dependency theory and integrity enforcement; object-oriented and extensible databases; engineering-, design-, and multimedia databases; query languages and query optimization; storage management; database machines; and distributed systems.

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Workshop on Stereology & Spatial Statistics, Stochastic Geometry and Image Analysis

CWI - An international workshop on Stereology, Stochastic Geometry and Image Analysis was held at CWI on 10-12 September,

1989. This meeting was the fifth in a series initiated at the University of Aarhus (Denmark) in 1981 and held subsequently in Bath (UK) and Berne (Switzerland). These workshops are organized as a forum for specialists (applied and theoretical) to discuss new developments in the three fields.

Special themes for this meeting were: non-uniform sampling designs in stereology and image analysis, marked point process models of images and spatial data, and mathematical morphology from alternative viewpoints (algebraic formulations, statistical models). Also several demonstrations of software for image processing and spatial data analysis were given.

A number of distinguished researchers from abroad gave a talk at the workshop, including R.E. Miles (Canberra) and J. Mecke (Jena), world authorities on stochastic geometry. Researchers active in image processing were also strongly represented, the fields including stochastic image modelling (B.D. Ripley (Glasgow), P.J. Diggle (Lancaster), C. Jennison (Bath)) and morphology (members of the Fontainebleau group, C. Ronse (Philips, Brussels)).

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Second International Workshop on Protocol Test Systems

GMD - Design and implementation of protocol test systems is the subject of a workshop to be held from October 3 to 6, 1989 in Berlin. Experts from research and practice will be able to obtain information about new methods and techniques of protocol testing in systems such as OSI, ISDN and IBCN.

Available test tools will be presented, possible future developments and applications of test tools will be discussed. The workshop is organized by the GMD Research Center for Open Communication Systems in Berlin and the European Center for Network Research of IBM in cooperation with the Committee 6 of the International Federation for Information Processing.

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Summer course on constructive methods in fractal geometry

CWI - Based on Michael Barnsley's recent book 'Fractals everywhere' (Academic Press 1988), this course -held at the end of June at CWI for 80 participants-considered in particular two aspects of fractal geometry: iterative construction of fractals, and techniques for approximating given images by fractals. The course was given on a rather elementary level and treated subjects as metric spaces, contractions, construction of fractals, chaotic dynamics on fractals, fractal dimensions, fractal interpolation and measures on fractals.

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Intelligent CAD workshop

CWI - Thirty-five participants from eleven countries attended the third Eurographics workshop on Intelligent CAD, held on April 3-7, 1989, at Hotel Opduin on the island of Texel, The Netherlands. The workshop theme was "Practical Experience and Evaluation" and covered the following topics: design process, system architecture, languages, geometric reasoning, and user interfaces. The design process was treated theoretically in a logical and a psychological approach, and more practically using product modelling as a basis. Discussions on system architecture included database manipulation, constraint propagation and the application of a history mechanism. The session about languages treated IDDL - a programming language designed for ICAD systems - , as well as a logical and graphical language for representing CAD knowledge. For geometric reasoning, the value of constraint propagation was recognized. Concerning user interfaces for ICAD, it became clear that a lot of basic research still has to be done.

A selection from the papers presented will be published by Springer Verlag as "Intelligent CAD Systems 3 - Practical Experience and Evaluation" (editors: P.J.W. ten Hagen and P.J. Veerkamp) in the Eurographics Seminar series. Organizers of the next workshop (last week of April, 1990) are J.-P. Barthes and K. El Dahshan of the Université de Technologie de Compiègne, Dépt. de Génie Informatique, C.N.R.S. UA 817, BP 233, 60206 COMPIEGNE Cédex.

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GMD Forum "Expert Systems for Industry and Science"

GMD - From June 7 to 9, 1989, the GMD in Sankt Augustin held a forum presenting the most advanced industrial expert system developments to interested people from industry and science. The system range reached from systems for speech recognition via configuration and automatization systems to expert systems for vehicle optimization in the wind tunnet. The presented systems originated from VW, Siemens, Hewlett-Packard, Infodas and from the Research Institute of the German Bundespost. The choice of the system reflected an important new development trend towards technical task automatization, especially in construction and configuration. The forum has shown the development lead of technical expert systems over business or other expert systems.

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INDUSTRIAL TRANSFER

PLATO – Gate Assignment at Schiphol Airport

CWI - Some 500 aircraft land at Schiphol every day, they stay for given periods and depart again. The complex logistics at the airport have a major influence on economic viability, with aircraft location during sojourn playing a crucial role. Between 1986 and 1988, CWI helped develop a planning system for the seasonal planning of aircraft-stand allocation at Schiphol Airport. It is an interactive system, formulated mathematically as an interval scheduling problem or a resource constrained scheduling problem. For the time being it uses only a simple heuristic (priority rule). The system, named PLATO (a Dutch acronym), consists of a data module, developed by a team of Schiphol Airport, and a planning module, for which CWI bears responsibility. Presently a system for the daily planning is being developed.

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CAR – Computer Aided Routing

CWI - CAR (Computer Aided Routing) is an interactive software package which has been developed at CWI during the years 1985-1988 as a tool to support physical distribution management. CAR enables the user to construct economical vehicle routes and schedules in a simple way. During the design and development of CAR the co-operation and feedback from the Dutch road transportation company Van Gend & Loos (at the same time the first user) was indispensable. At present CAR is marketed by the Dutch logistics company Logion.

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Overload control

CWI - The team of J.H. van Schuppen and P.R. de Waal is studying overload control problems for communication systems. In case of overload at a telephone exchange, the delays cause angry reactions of customers and result in a decrease of the effective throughput of the exchange to unacceptable low levels. Therefore access control algorithms must be used which are sufficiently robust to be effective at several levels of overload. The approach to this problem is based on stochastic control theory and queueing theory.

This research is financially supported by the Stichting voor de Technische Wetenschappen (Technology Foundation), a government agency which tries to promote co-operation between academic institutes and industry. The project runs for a period of 4 years until January, 1990.

Knowledge transfer is promoted in several ways. The project has an advisory committee which meets twice a year with researchers from the companies Philips Telecommunication and Data Systems Nederland B.V. and AT&T Network Systems International, and from the national telephone company PTT and its main laboratory, the Dr. Neher Laboratorium. The task of the committee is to assist the research team and help it with making the results useful for practice. During the project frequent contacts were maintained with the companies mentioned.

A two-month visit of Peter de Waal to the INRIA Centre Sophia Antipolis for co-operation with Ph. Nain has been beneficial to the investigation. This visit funded in the framework of the separate twinning programme between INRIA and CWI.

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LE-LISP

INRIA - Since 1987, the LE-LISP club brings together software houses and computer manufacturers involved in LE-LISP. The last meetings pointed out the evolution of the normalization and the quality and quantity of the diffusions in France and abroad. The number of licences is increasing significantly year after year. INRIA has signed more than twenty provisions of LE-LISP on the machines for which INRIA did the ports (VAX / UNIX, SUN 3 and SEQUENT).

Version 16 of LE-LISP should appear in October. The kernel of this new version will be the starting point of the Eureka project ELSY (European Lisp SYstem) which brings together CRIL, BULL, ILOG and GMD.

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SPHINX Club created

INRIA - The SPHINX software was developed by the SCORE team at INRIA Rocquencourt. The aim of this system is to help the simulation of real time protocols. It is based on an "event-driven" simulation kernel. This software will, in the near future, be industrialized and commercialized by a French company.

In parallel, INRIA has created the SPHINX club, composed of universities and research institutes, to coordinate the conditions of the licences and the developments to be done on SPHINX. President of the club is P. Rolin, who was a researcher at INRIA and is now professor at the ENSTA. The first meeting took place on June 21 at INRIA Rocquencourt.

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Collaboration with CRAY Research

INRIA - INRIA and CRAY Research signed at the beginning of 1989 a collaboration agreement concerning the development of optimization techniques for vectorized programs. These techniques will allow gains of more than 50% in the program kernels. They will be extended to the CRAY3 machines.

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INRIA-GIPSI SA collaboration

INRIA - A. Lichnewsky 's project has collaborated with the Public and Industrial Group "GIPSI SM 90" and then with the company GIPSI SA for the development of a floating point vector processor (PVF) which considerably increases the performance of the BULL DPX 1000 workstation in the floating point mode. This processor is now commercialized by GIPSI SA.

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LIFE IN THE INSTITUTES

Symposium in honour of Piet J. van der Houwen

CWI - Prof. Piet van der Houwen, head of the department of Numerical Mathematics, joined CWI 25 years ago. This fact was celebrated with a symposium on the theme 'Construction of stable numerical methods for differential and integral equations'. Speakers included H. Brunner (Memorial University of Newfoundland), Th.J. Dekker (University of Amsterdam), M.N. Spijker (University of Leiden), and J.G. Verwer and B.P. Sommeijer (both CWI). Since 1975 Van der Houwen is also professor of numerical mathematics and computer science at the University of Amsterdam.

Symposium in honour of Jaco.W. de Bakker

CWI - Prof. Jaco de Bakker, head of the department of Software Technology, joined CWI 25 years ago. This fact was celebrated with a symposium under the title '25 years of semantics'. Speakers included J.V. Tucker (University of Leeds), A. Nijholt (University of Twente), P. America (Philips Research Laboratories Eindhoven), J.A. Bergstra (University of Amsterdam), D.S. Scott (Carnegie-Mellon University, Pittsburgh), W.P. de Roever (University of Eindhoven) and E.-R. Olderog (University of Kiel). Since 1973 De Bakker is also professor of computer science at the Free University of Amsterdam.

INRIA-Visit

INRIA - A delegation of thirty RPR deputies, lead by Mr. Jacques Chirac and Mr. Alain Devaquet, visited INRIA - Sophia Antipolis on March 31st. After a general presentation of INRIA and its research unit in Sophia-Antipolis, they visited the Robotics Laboratory, where Mr. Jean-Daniel Boissonnat, leader of the PRISME project, explained the scientific objectives and the accomplishments of his project.

PEOPLE ...

GMD - **Prof. Radu Popescu-Zeletin** has been appointed head of the GMD Research Center for Open Communication Systems (FOKUS), in Berlin. In this function he is successor to Prof. Karl Zander. Prof. Dr. Radu Popescu-Zeletin was also appointed professor for open communication systems at the Technical University of Berlin.

GMD - **Dr. Stefan Jähnichen**, head of the GMD Research Group for Program Structures, was appointed professor by the University of Karlsruhe. Jähnichen focusses his work on teaching and research in the field of program structures and data organization.

GMD - **Dr. Hans Martin Wacker**, formerly head of the Hauptabteilung Zentrale Datenverarbeitung der Deutschen Forschungsanstalt für Luft- und Raumfahrt, was appointed head of the GMD Institute for Computational Infrastructures on May 2, 1989.

GMD - **Dr. Eike Best**, member of the GMD Institute for Foundations of Information Technology, was appointed professor for theoretical informatics by the University of Hildesheim. Best focusses his work on research and teaching in the fields of formal semantics, Petri nets and concurrency.

GMD - **Ernst-Joachim Freiherr von Ledebur**, advisor on international affairs of GMD, has retired for age reasons. Before joining GMD, Freiherr von Ledebur was working in the field of technical information for the Gesellschaft für Information und Dokumentation.

CWI - **Prof. Jaco de Bakker**, head of the department of Software technology, has been elected a member of the Royal Netherlands Academy of Arts and Sciences. De Bakker's research concentrates on the semantics of programming languages.

CWI - **Ko Anthonisse**, researcher in the Department of Operations Research, Statistics, and System Theory, and associated with CWI since 1961, left on April 1, 1989, for a consultancy position in industry. At CWI he mainly worked on combinatorial optimization problems and decision support systems.

CWI - **Prof. Jan Karel Lenstra**, head of the Department of Operations Research, Statistics, and System Theory, left CWI on July 1, 1989, to accept a professorship in Mathematics, in particular Optimization and Planning, at the Technical University of Eindhoven. He is succeeded by Onno Boxma, who was a project leader in the department. Lenstra, member of a well-known family of Dutch mathematicians, came to work at CWI in 1969.

INRIA - **Bernard Lorho**, professor at Orléans University and Scientific Head of the project "Languages and Translation" at INRIA has been appointed Director of the Center of INRIA Rocquencourt.

INRIA - **Maurice Robin**, formerly Vice Director of INRIA, has been appointed responsible of the Department of Mathematics and Information Technology at the French Ministry for Research and Technology.

INRIA - **Patrick Valduriez** came back from the USA where he stayed four years at MCC - Austin. From September 1st he is Scientific Head of the project SABRE.

INRIA - The selection committee for the attribution of foreign fellowships has met at INRIA on the 29th of May. 42 candidates applied, 15 were selected and obtained a fellowship to spend a research stay in a foreign laboratory. 12 will stay in North America (USA and Canada), 1 in Japan and 2 in Great Britain.

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4 － 2 関連資料 2 (購入資料)

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4	THE PERSUASIVE EDGE	Myies Martel, PH. D.
5	USING COMPUTERS	Raymond S. Nickerson
6	HOW TO SPEAK LIKE A PRO	Leon Fletcher
7	The MEDIA LAB	Stewart Brand
8	Made in America	Michaei L. Dertouzos 他
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18	LEARNING and TEACHING with COMPUTERS (ARTIFICIAL INTELLIGENCE IN EDUCATION)	Tim O'Shea 他
19	MULTI-MEDIA COMPUTER ASSISTED LEARNING	Philip Barker