Curriculum Resources in Interactive Multimedia (CRIM)

Proposal for the NSF DUE CCD Program (97-29)

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May 30, 1997

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Curriculum Resources in Interactive Multimedia (CRIM)

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(2) the text and graphics herein as well as any accompanying publications or other documents, unless otherwise indicated, are the original work of the
signatories or individuals working under their supervision. I agree to accept responsibility for the scientific conduct of the project and to provide the
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I understand that the willful provision of false information or concealing a material fact in this proposal or any other communication submitted to NSF is
a criminal office (U.S. Code, Title 18, Section 1001).

Name (Typed)	Signature	Date
PI/PD Edward A. Fox		May 30, 1997
Co-PI/PD Rachelle Heller		
Co-PI/PD		
Co-PI/PD		
Co-PI/PD		

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NAME/TITLE/TYPED) **H. T. Hurd, Director, Sponsored Programs**		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
540/231-5281	**hurd@vt.edu**	**540/231-4384**

PROJECT SUMMARY

The Project Summary should include a statement of objectives, methods to be employed, and the significance of the proposed activity to the advancement of knowledge or education. Avoid use of first person to complete this summary. DO NOT EXCEED ONE PAGE. (Some Programs may impose more stringent limits.)

Curriculum resources in interactive multimedia (CRIM) will be developed to help meet the chronic shortage for trained workers in the areas of interactive multimedia applications, education, interfaces, production, programming, publishing, systems, technologies, and tools. Curriculum guidelines and courseware will be made available through a digital library accessible through the WWW, linking back to resources developed at sites around the nation that will be a part of the CRIM Consortium. With support by ACM (especially SIG Multimedia), IEEE CS (especially its TC on Multimedia), and AACE (especially through ED-MEDIA), CRIM curriculum guidelines will be published to facilitate the spread of new multimedia specializations, courses, and training programs, as well as small "knowledge modules" (that will fit into existing courses, e.g., graphics, HCI, operating systems, networking).

This project also will contribute a new methodology for preparing curricular resources in high technology fields. First, it will draw upon prior curriculum and courseware developed at Virginia Tech (VT) and The George Washington University (GW) that will serve as a strawman for future work. Second, it will couple an in-person decision support room workshop with other interested parties connected through satellite and networked videoconferencing, so a first (semester long) round of collaborative work can proceed along the lines of agreed upon curriculum development directions. Third, during that round, not only will VT and GW materials be re-worked, but small travel awards to other consortium members also will lead to broader preparation of knowledge modules that can be easily disseminated and re-used. Efforts will be monitored by the project coordination team, to ensure progress in accord with project guidelines. Server logs will provide quantitative data on adoption and use that will supplement qualitative evaluation through surveys and focus groups. Fourth, during the next academic term (semester), completed modules will be tried at sites other than where development took place, and carefully evaluated, at the same time as other new modules are built. Finally, this three-step pipeline of curriculum resource development, deployment, and evaluation will be institutionalized through the CRIM Consortium and its support by professional societies, so that periodic discussions, panels and workshops at multimedia conferences can further improve CRIM materials.

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*Proposers may select any numbering mechanism for the proposal. Complete both columns only if the proposal is numbered consecutively.

C. PROJECT DESCRIPTION

Motivation, Overview: A search of the World Wide Web, for multimedia jobs, indicates over 1,000,000 hits or places which discuss, provide or offer placement in a career which in some way incorporates the use of Interactive Multimedia. The sites range in discipline areas from space related jobs, to medical domains, to areas of security, and all technical pathways in-between. On the other hand, a search for courses or syllabi for materials on Interactive Multimedia yields only 1% of that number, based on a search of even the broadest terms for multimedia courseware. Furthermore, in the past 4 years over 200 computer science educators have participated in tutorials, birds-of-a-feather presentations and discussion groups in an effort to obtain information, support and direction related to materials for courses in interactive multimedia. The demand is overwhelming the supply.

Interactive Multimedia covers some of the most technologically important areas in the broad field of information technology, computing and communications. Enormous investment has been made in the last decade to develop faster networking, tailored computer systems, usable authoring software, edutainment packages and a wide variety of applications. Low cost storage and ubiquitous networking have moved multimedia access into the mainstream of the rapidly growing World Wide Web, and requirements for multimedia streams are helping drive our society toward Internet 2. Tens of billions of dollars of our economy relate to these technologies that now underlay the Information Age and flow over the Information Highway. Some of the most innovative work in the science/engineering world deals with solving hard multimedia-related problems in compression, processor design, computer interfaces, and communication with acceptable quality of service. The serious lack of trained personnel in this field is due in large part to the lack of education and training available at the undergraduate level. The reasons for this are manyfold. First, the typical computing curriculum, especially within CSAB accredited schools, is highly structured and it is not easy for new courses to make their way into the curriculum. Secondly, many of the faculty are not well versed in the issues related to interactive multimedia and even for those that are, there is little promotion and tenure incentive for new course development.

This proposal addresses the problem, using a number of innovative approaches, through a multi-institution team that will develop a series of knowledge modules and a repository (digital library) of courseware. Modules can be combined into a comprehensive curricula for interactive multimedia study at the undergraduate level, or can be incorporated into existing courses to extend the course coverage to multimedia related topics. This project builds upon extensive prior related work (see section C.2), which shows that WWW-accessible courseware leads to widespread dissemination and use.

C.1 Curriculum Resources in Interactive Multimedia

C.1.1. Problem: There is a drastic shortage of people with suitable educational background to work in the broad field of interactive multimedia (IM). There are no guidelines available for curricula in this field. Few universities have courses in the area, and those courses suffer from a severe lack of suitable textbooks. New instructors often start from scratch to construct course notes or to design laboratories that are important for hands-on experience with tools or to support group projects. There are no comprehensive readings volumes or bibliographies. There are few collections of case studies or projects, few sets of exercises, and no large test banks. Popular interest and curiosity has created a tremendous demand for knowledge that is largely unfulfilled, and many misconceptions or limited understandings have resulted. For example, developers of multimedia applications are unaware of key concepts and tools prepared by those researching into authoring systems, that would provide a framework and support for their efforts.

C.1.2. Goals and Objectives: As a result of this project:

- Universities will add modules to existing courses to introduce concepts from the IM field.
- Universities will add or enhance undergraduate level courses in or related to IM.
- Universities will add or enhance curricula and programs in the IM area.

- Universities will participate in a Curriculum Resources in Interactive Multimedia (CRIM) Consortium for sharing of courseware and refinement of curricula in the IM field.
- A new approach will be demonstrated for developing high tech area curricula/courseware.

The key objectives relate to curricula, digital library development, and evaluation.

- Curriculum will be developed for IM in cooperation with the leading computer professional societies: AACE, ACM and IEEE Computer Society. (See letters in Section I from AACE, ACM, the ACM Special Interest Group on Multimedia - SIGMM - as well as the IEEE-CS Multimedia Computing Technical Committee.) We will help develop a unified curriculum during the term of this project, to be co-published by these groups and widely disseminated.
- A decision support room based workshop, coupled with satellite and networked videoconferencing, will launch a Curriculum Resources in Interactive Multimedia (CRIM) Consortium, that will work on curriculum and on accompanying educational resources.
- A digital library (courseware repository with suitable cataloging, linking, searching, and annotation) will be created for the IM field, to include:
    - animations (including of algorithms and processes) and multimedia presentations;
    - articles, bibliographies, technical reports, theses, and other publications/pointers;
    - case studies, real-life project reports;
    - data collections for all media forms (text, image, audio, video);
    - demonstrations (interactive when possible, else slide shows or scripted sequences of screen dumps);
    - exercises, assignments, problem sets, quiz/test banks;
    - laboratory session documentation;
    - simulations;
    - software packages (with documentation and test suites);
    - syllabi, course calendars, lecture notes, tutorials; and
    - Web based training / computer aided instruction.
- Mechanisms will be put in place for the project staff to “prime” the digital library with educational materials, starting with their own works, those of the CRIM Consortium, and extending to include others’ works they are aware of and rate highly.
- Collection development mechanisms will be put in place for the digital library to expand in a self-sustaining fashion, as part of the normal efforts of the professional societies --- a novel approach to coupling associations with education. The CRIM Consortium will hold regular meetings at each of the major conferences in the IM field so face-to-face discussion can reinforce ongoing online collaboration. These mechanisms will make it easy to add to the repository even after the grant period is over. The Consortium will employ schemes for multi-institution collaboration, assessment, and dissemination.
- Evaluation mechanisms will be put in place so that logs, usage records, remote evaluation data, user ratings and comments regarding the digital library and its content will be collected, analyzed, and made available. Evaluation will encompass formative efforts to improve the quality of “documents” in the digital library, as well as summative studies of their value. Special mechanisms will be provided so that those interested in coop, intern, and hiring programs can provide criteria, direction, and post-graduation data to guide the evaluation, covering both the digital library and the curriculum.
- A pipeline methodology will be perfected for leveraging existing course materials; establishing a permanent consortium to handle curriculum and courseware development; building upon meetings at professional conferences to supplement online collaboration; and

improving materials through discussion, dissemination, evaluation, and iterative refinement by the originators/users.

C.1.3. Approach

C.1.3.1. Building Consensus on Need

Working toward curriculum in the IM area now seems appropriate, based on four years of consensus building discussions. For example, PI Fox was asked to critique the EUROIEmasters effort of the European Community which proposed a curriculum for Information Engineering (including several multimedia courses - see also Appendix letter from S. Pantry). Other activities include the 1993 NSF Information Engineering Task Force (involving Fox), tutorials (Heller) and birds-of-a-feather (Fox) at ED-MEDIA 96, tutorials (Heller) at ACM MM '94 and 95, panels at SIGCSE 95 and 96 (Heller and Fox) and ICMCS'97 (Fox), and a workshop at ACM MM '96 (Fox). It would seem appropriate for the U.S. to move forward in somewhat similar direction to plans in Europe; we propose that curriculum development for IM is the most important priority in the broader area of Multimedia, Hypermedia, and Information Access (see http://ei.cs.vt.edu/~fox/MHIA/).

C.1.3.2. Curriculum Development Units

Some universities are interested in adding a little about IM to their curriculum; others will offer full programs. Our approach is to handle all such requirements. Based on the results of discussions at previous workshops, we may classify possible offerings (courses, and smaller "chunks", down to the level of a lab module or 1 week course unit) in the IM area using the following taxonomy:

A. Level: {Introductory, Advanced}
B. Disciplinary Focus:
{Arts, Computer Science, Computer Engineering, Education,
Information Systems, Library and Information Science, ...}
C. Depth:
{1-3 week-long "knowledge module", 1-credit overview course, 3-credit course,
6+ credit sequence, concentration, major}
D. Pedagogical Style:
{Lecture, Lab-based, Self-study, Case-study, Group project, Seminar}
E. Approach: {Theory, Design, Application Development, Tool Use}

C.1.3.3. Innovative Aspects of our Approach

Because of the complex taxonomy above, the fact that IM covers the domain of at least three professional groups, and the rapid evolution of new technology in this area, innovative approaches are needed if this project is to achieve adequate coverage.

- Encourage re-use. If courseware can be developed in small, modular chunks (as is done with WWW pages), then it can be used by the same instructor in other courses, by other instructors, or even by people in other institutions. Re-use can work with an "approximate match" to needs, instead of the exact fit that makes software re-use so difficult.
- Adopt a 3-level model. Rather than function only at the program and course levels, also have a lower level, of "knowledge modules". If these are small enough, they can be self-contained and can be re-used more easily. If developed for self-study, they can be learned or reviewed when needed, fitting well into the requirements of life-long learning. For each unit, issues will be identified, learning objectives specified, readings selected, interactive exercises (e.g., using a testbed) devised, and an introduction prepared. A lecture outline will be prepared and extra notes added for instructors or those with keener interest. Using the QUIZIT system

(developed in the Interactive Learning project - see Section C.2), 3 versions of a 2-part quiz for each unit can be prepared, facilitating automated testing of mastery.

- Apply concepts of technology transfer to education. In high tech areas like IM, technology transfer can enhance learning since students can be motivated by new ideas, and better prepared for work or advanced study by being exposed to the state-of-the-art. Especially regarding industry-university collaboration, a great deal of contact and interaction is needed [FOLE96]. All these points indicate that students should: be exposed to prototypes and demonstrations, work together as in project teams, and that a good social support structure is very important for learning.
- Leverage activities of professional societies to afford sustainable enhancement to curricula. Professional meetings are good places for working groups to meet to continue curriculum development activities. Also, since conferences in the IM area often have demonstrations, or presentations of prototypes, or videotape overviews, we propose to work closely with conference groups so that good demonstrations be "canned" and made available.
- Use digital libraries to implement the old notion of courseware repository. We propose to build upon our various digital library activities, and to extend the notion of sharing facilitated with the WWW, by having a digital library of IM content, to include especially demonstrations, test data, multimedia objects, programs, animations, etc. These will be carefully cataloged using appropriate metadata, and be safeguarded with intellectual property right sensitive access tools.
- Use the technology studied to help students learn about it. Since multimedia content is often motivational, and/or provides alternate ways of access so that people with different preferences can be accommodated better, it will be used as much as possible to help learning. Students will learn both about IM and about how to apply or use it.

C.1.3.4. Following the ACM SIGCHI Model

ACM SIGCHI commissioned a group to work on curricula in the human-computer interaction field, which led to very influential guidelines [ACMS92]. Those serve as a model for parts of this proposed effort. It is noteworthy that there are a number of types of overlap between HCI and IM issues. For example, the human sensory systems (e.g., human visual and auditory systems) are of interest to both fields and. multimedia concepts of quality of service relate directly to HCI issues of usability. At the ACM Multimedia '96 Workshop on curriculum, Ron Baecker, of the University of Toronto Knowledge Media Design Institute, a leading HCI researcher, offered to assist with IM curricular efforts. Thus, with the help of several people from the HCI area, who will participate in the CRIM Consortium, IM guidelines will be developed and will be related to the already developed HCI curriculum.

C.1.3.5. Integration with Existing Curriculum

IM curricula must fit in with various currently existing curricula, particularly those related to computer science and engineering, e.g., that for HCI as discussed above. In many cases, the approach will be to add a small number of knowledge modules to existing courses, such as:

- architecture,
- artificial intelligence,
- computer architecture,
- data structures,
- database management,
- graphics,
- human-computer interaction,
- networking (data communication),
- operating systems, and

- programming languages (e.g., scripting).

C.1.3.6. Building the CRIM Consortium

This project is led by PI Fox at Virginia Tech, with co-PI Heller at George Washington. PI Fox has written extensively in this area [FOXE89, FOXE91a, FOXE91b, FOXE94a, FOXE94b], and served as executive producer for a related videotape documentary [FOXE90a]. PI Fox is co-chair of ACM SIGMM's education committee [FOXE95e]. He founded both the ACM Multimedia conference series and the ACM Digital Libraries conference series. He chaired the ACM MM'96 workshop on curriculum and courseware.

Co-PI Heller has established a series of courses and special topics at The George Washington University. A four course series addresses all aspects of interactive multimedia from compression algorithms to cost analysis. The specific syllabi and materials can be found on the WWW (http://www.seas.gwu.edu/seas/projects/multimedia/). Key to the course set, and the basis of four very successful tutorials at ACM MM'94 and '95, IEEE MM'95 as well as ED-Media '96, are the concepts of a Media Taxonomy [HELL95] and multimedia evaluation [HELL96]. In addition, Heller and faculty from the English Department have developed and taught Reading and Writing in Cyberspace [HELL97]. The details of this course in non-sequential writing and use of media to enhance writing can be found at http://www.seas.gwu.edu/faculty/sheller2/cs751/.

In addition, 10 other institutions will be selected to participate. Each must identify a distinguished investigator to help with curriculum development and courseware refinement. Each institution must agree to add or refine at least two courses in the IM field, or at least 10 knowledge modules. Funding at the level of $500/year for the 3 years of the project will be allocated to cover travel to a workshop during the first year, and relevant conferences (which will have CRIM Consortium meetings) during the latter years. Each institution must have adequate infrastructure to allow networked videoconferencing with other consortium members. Charter members of the Consortium will include: Boston University (Tom Little), CMU (Scott Stephens), Cornell (Brian Smith), U.C. Berkeley (Larry Rowe), and University Texas at Austin (Harrick Vin).

In addition to the 10 members who receive travel support, another 10 will be selected that will participate with only support during year 1 to attend the inaugural workshop. Thus, there will be 20 institutions involved from the onset, and others will be encouraged to join as well even though support cannot be provided.

C.1.3.7. Starting with Existing Curriculum and Courses

The CRIM Consortium will get off to a rapid start as a result of strawman proposals from VT and GW that will be developed during the first semester of the project. Through a series of in-person and network meetings, the co-PIs will discuss their own courses, those at other institutions, and prepare several strawman curricula, syllabi, and lists of content for the digital library. For example, taken from the Computer Science domain, the following illustrate typical courses now offered at institutions involved in the Consortium.

Virginia Tech's **CS4624** (http://ei.cs.vt.edu/~mm) is a senior level course on Multimedia, Hypertext and Information Access. **CS4624 Catalog Listing:** Introduces the architectures, concepts, data, hardware, methods, models, software, standards, structures, technologies, and issues involved with: multimedia information and systems; hypertext and hypermedia; networked information; electronic publishing; virtual reality; and information access. Students will learn how to capture, represent, store, compress, manipulate, interact with, and present text, drawings, still images, animations, audio and video. They will work with video conferencing, authoring systems, and digital libraries. **CS4624 Additional Description:** This course is

designed for seniors to become familiar with a range of information technologies, much like Database Systems covers certain types of data, and Artificial Intelligence covers certain types of knowledge. Coverage includes text, electronic publishing, search, retrieval, browsing and related issues of information access. Other media types are considered separately and in combination, when synchronization and time-based performance are crucial to achieve adequate quality of service. Linking, hierarchical structures, streams, layers, and similar organizations and views will be considered. A wide variety of hardware, software and application demonstrations will be given. Students will gain expertise working with key packages such as AuthorWare, Mosaic/Netscape, and Storyspace.

GW has a total of 4 courses in the IM area (Introduction to Interactive Multimedia, Design and Implementation of Educational Software, Evaluating Interactive Multimedia and Interactive Multimedia Project Development). The course coverage in the Introduction to Interactive Multimedia takes the unique approach of examining each medium, one by one, from three points of discussion: The science of the medium, the psychology of the medium and the technology of the medium. For example, in discussing the science of sound, the course reviews the physics of sound waves, the anatomy of the ear and other related topics. Under the psychology of sound, for example, the course reviews how humans understand sound effects as well as how they are manipulated by the type and pace of music. In the technology of sound the students come to understand the computer based tools for capturing, sampling, compressing, storing, manipulating, retrieving and playing sound. For details see http://www.seas.gwu.edu/seas/projects/multimedia. The additional courses identify aspects of multimedia that bridge the fields of interface design and evaluation, research design and evaluation, as well as team work and cost analysis.

Cornell University's **CS631** is a graduate course that discusses enabling technologies and advanced applications in multimedia. Topics include analog image, audio, and video, sampling theory, color and perception, compression techniques for image, audio, and video data (JPEG, Musicam, MPEG, and H.261), compressed domain processing, image and video processing (morphing, mosaicing, object tracking, image comparison, cut detection), networking for multimedia (multicast, guaranteed quality of service), video storage systems (admission control, disk buffering and scheduling, and storage hierarchies), operating system scheduling, and toolkits for multimedia. **Note:** While this is a graduate course, some aspects may fit into undergraduate courses, or suggest what must be covered to prepare students to take such a course.

C.1.3.8. Inaugural Workshop

Co-PI Heller will coordinate the year 1 decision support system (DSS) based organizing workshop for the CRIM project. To facilitate travel, the workshop will be held at The George Washington University (GW) in Washington, D.C. Its schedule and the questions addressed are shown in Table 1.

This agenda setting workshop will identify the modules to be developed based on the input of attendees representing colleges and universities as well as businesses. This wide range of stakeholders are positioned to consider undergraduate education needs and resources in technical areas at liberal arts colleges and research universities as well as the needs of industry as they employ these students.

Schedule	**Questions**
Day 1 AM: Overview of conference	1. What are the IM threads necessary for technically
Information on participants	oriented undergraduate

	education?
Use of decision support room	2. What is the content of each thread?
Data collection on questions 1, 2, 6	3. What are techniques of good practice to present this
Lunch	information?
PM: Expansion of results of AM	4. Resources available?
Data collection on questions 3, 4	5. Topics for research?
Break / Supper	6. Needs of employers?
Evening: Review of day's direction	7. Appropriate evaluation?
Data collection on questions 5, 7, 8	8. Additional dissemination techniques?
Day 2 AM: Assignment of teams, target dates, Satellite presentation of workshop efforts	9. Needed /enhanced site resources?
Lunch	10. Was this workshop successful?
PM: Revise and review of direction in light of satellite and workshop evaluation	

Table 1. Schedule for Inaugual Workshop, Year 1

The workshop conducted at a decision support center will involve brainstorming, goal setting and making a priority of recommendations about the topics to be included in the undergraduate education. This is particularly necessary because there is no clear direction, as yet, for IM. IM claims many ancestors and each of these presses for different focus in the classroom. For example, if IM is seen as having network communication as its parent, then an appropriate topic of study is data compression for reduced bandwidth demands. On the other hand, if IM is the offshoot of HCI then issues of interface design, functionality and navigation are prime. Alternatively if IM is considered related to information processing then issues of media messages, abstracting and indexing for retrieval are key points.

The DSS technique has been shown to be an efficient and effective [HELL91e; HUFF95] environment for soliciting, refining and coordinating ideas from disparate groups. The computer supported environment assures that all individuals are heard (via keyed input), anonymity is maintained and a detailed transcript of the discussion is maintained. The result of this workshop will be a detailed list of modules to be prepared for an IM curriculum. Taken together these modules could constitute an entire course in IM. Taken as individual modules they can be included as units in specific courses such as data communications or information processing.

The satellite broadcast, while the workshop is underway, will allow a wide effort for immediate dissemination and discussion of brainstorming and direction for the project. The outline generated by the workshop will be tempered by this immediate review process. The potential impact of this unique format is improved communication about the project, a wide feeling of ownership in the results and a motivation to continue participation.

C.1.3.9. Roles of Lead Institutions

VT serves as coordinating body for the project:

- housing a large digital library server;
- creating a liaison with associations and publishers;
- monitoring assignments, reports, and progress on tasks;

- bringing the project team together monthly for a video-conference to discuss progress, solve problems, and make plans;
- coordinating in-person meetings at IM-related conferences;
- handling all finances related to travel;
- providing courseware and in other ways participating as an implementation team;
- coordinating editing of the curricula and syllabi; and
- preparing reports to NSF.

GW also will participate in CRIM as an implementation team. The PI will work on inclusion of the curricular modules identified by the workshop and share this with students as they further their education into interactive multimedia. These modular materials will include detailed goals and objectives for the material, content levels of presentations, student exercises appropriate for lab or homework, test questions, suggestions for larger projects resources and reading lists. One key to the IM modules will be the IM nature of these modules. It is key that the media be the message at a variety of levels so that modules fit the pedagogic style of educators and learners. For example, for faculty used to lecturing and suggesting outside reading to students the module will have a text-only content presentation with detailed additional readings. However for faculty whose style includes an example driven or activity driven presentation, the IM module will include a layer to suit this style. This might include an animation of a data compression algorithm, or role play discussion among telecommunication systems managers and users. These various layers allow learners access to different learning modalities which may insure a deeper educational experience. As one of the design and implementation teams, GW will prepare the materials for a number of modules, make the materials available through the VT digital library, use the modules in one or more specific undergraduate technical courses and evaluate the outcome of each such instantiation.

C.1.4. Dissemination: Virginia Tech runs a courseware server (ei.cs.vt.edu) in connection with the Interactive Learning grant (see Section C.2), and a mirror server will soon run in the Computing Center, with an ATM connection. The courseware developed in this project will be made accessible nationwide using those digital library servers. Both PURLs and handles (two types of Universal Resource Names, to give permanence relative to URLs) for the new courseware will be recorded and widely advertised. In addition, in Fall 1999 a small number of CD-ROMs will be prepared for use at locations where network connectivity for multimedia information is not very rapid.

The digital library will handle most of the dissemination of courseware, and should serve well the needs of the project. However, if there is extraordinary growth, regional replication and other performance enhancing devices will be applied to ensure that dissemination will be possible to thousands of universities and tens of thousands of courses, involving hundreds of thousands of students. In addition to curriculum that will be prepared, and reports thereon, the main other deliverables will be digital library content objects supporting education and research in the IM field. The digital library systems will include complete documentation, metadata required for the catalog, and have each useful object fit into one or more knowledge modules.

Curriculum will be released through society publications (e.g., *CACM* and *IEEE Computer*) and presented at annual meetings of all relevant societies. Feedback will be solicited so that continuous refinement of the materials can take place. ACM and IEEE Computer Society have long been the key players in curriculum development for the computing field [ACMC68, ACMC77, ACMC79, ACMI91, ACMS92, DENN88, IEEE76, IEEE83]. From the support letters in the appendix (ACM, SIGMM, IEEE CS TC on Multimedia Computing) it is clear that this

project has support from interested parties in those societies. Further, close working relationships between those groups and project staff already exist.

Working with ACM and IEEE-CS will ensure that adequate discussion takes place regarding curricular proposals. Those societies' various publications will allow distribution of draft versions that can lead to final improvements to the set of guidelines that will emerge. Thus, early in the project, the IEEE-CS Technical Committee on Multimedia Computing Newsletter and several ACM newsletters will announce project plans and call for assistance. The second step will involve repeating this process after a draft curriculum is ready for comment, or after significant content in the IM area is in the digital library. Slots in the workshop, panel, paper and demonstration parts of all IM-related conferences will be sought, including those of ACM SIG Multimedia and the IEEE-CS International Conference on Multimedia Systems.

PI Fox serves as editor for a book series on Multimedia Information and Systems for Morgan Kaufman Publishers, that is providing coverage in this area. Thus, several researchers are working on a *Readings in Multimedia* project, to supplement the soon-to-be-published *Readings in Information Retrieval*, and a new book will appear shortly in the digital library area. These *Readings in ...* efforts can support the proposed curriculum project by putting key (early) articles in the hands of students, as well as researchers and developers.

C.1.5. Evaluation: GW will prepare an evaluation guideline for all development teams. The evaluation will include formative and summative analyses and will use a combination of qualitative and quantitative measures. Evaluating educational materials is a complex process requiring a novel set of tools and techniques [SALO91]. The formative evaluations, done during the design and creation of the materials, will include a collection of all artifacts collected and generated in the design creation process. These will be used as part of a cost analysis -- a cost can be both an analysis monitoring expenditure and a level of effort. The team will be queried as to their impressions of the process, where improvements could be made, which parts or resources were effective and which were ineffective. The semi-summative measures include both qualitative and quantitative measures at the implementation sites and the auxiliary sites. Each will be queried as to preparation time, content compatibility, flow and student reaction. Where possible, coders will visit classes to observe the use of the material. In those courses where the material had been covered through other forms or formats in previous years, faculty will be asked to compare the ease of preparation, curricular fit and student reaction to the module and previous material. Where available, grades in projects and/or test questions will be noted. This evaluation is termed semi-summative in that the module represents the first live test and the module will be refined based on responses from the analysis. In the presentation of the refined module, information will be compared from the first and second evaluation. The final GW participation will be to include the modules in two types of courses. The first will be in the already existing Introduction to IM, available to upper-level undergraduates and designed as part of a computer science concentration in IMM. The second attempt will be to include specific modules in specific courses, depending on the available modules. Possible courses are HCI, data communication and information processing, and this intent is supported by the attached letters.

Because of the digital library base for all project deliverables, assessment, dissemination, and evaluation will be greatly facilitated. All usage of the digital library will be logged, and those adopting the results of the project will sign agreements requiring local logging and evaluation. The VT project team will analyze who uses what resources (drawing upon tools in use on another 3-year NSF grant on WWW traffic). Evaluations of resources, knowledge modules, courses, course sequences, and curricula will be collected and used to improve the digital library content, with assistance from contributing authors whenever that is possible.

Selective detailed user studies also will be undertaken at VT. Because of the 1993-98 NSF Research Infrastructure grant on "Interactive Accessibility", there are six usability rooms along with powerful monitoring and logging software and hardware. New interactive materials added to the digital library will be tested by students in VT courses, and summaries of the resulting videotapes (showing user behavior and synchronized computer screens, along with a critical incident database) will be sent to developers of the materials to aid in their refinement. This in-depth evaluation will be supplemented with surveys as well as videotaped focus group discussions at the end of each semester.

Thus, our evaluation will be largely formative, which is appropriate for a project in which there is extensive development of materials and courseware. We will have summative evaluation through the surveys, focus groups and log-based analysis of actual use. In the case of two VT courses in the IM area which have been running for several years, we also will undertake comparative evaluations from year to year to measure the effectiveness of project-supplied enhancements.

C.1.6. Contributions/Impact: The goal of this CRIM proposal is to define, create, refine and evaluate curriculum and syllabi, along with with all curricular materials for instruction, about interactive multimedia, within a technical undergraduate degree. In order to promote the greatest possible impact and adoption, the coverage and content of the curriculum and all accompanying materials will be identified at a workshop and then they will be prepared by a consortium of educators working in this area. Packaging as a series of modules should facilitate flexible use.

This project should help meet the need for workers in the IM field by making it possible for educators to teach courses on IM, or to add modules about IM to existing courses. The extensive digital library of materials being prepared should make effected courses more interesting and promote class-focused as well as self-study. It is hoped that most computer science programs, as well as programs in many IM-related fields, will be effected by this project.

In addition, the methodology adopted by this project should be helpful in other related efforts to develop curriculum in high tech areas. If shown effective, it might be useful to emulate its approach that involves: a workshop, videoconferencing, establishment of a consortium, low-level financing of members by providing limited funds for travel, use of a digital library, and a careful program of evaluation (formative, semi-summative, and log-based).

C.1.7. Timeline: This project involves

Spring Year 1: Preparation of strawman curricula, syllabi, lists of desired courseware by the co-PIs

Summer Year 1: A 2-day workshop at GW launching the CRIM Consortium, to:

a) identify examples of need, direction and/or good practice within IM;

b) involve satellite discussants to analyze and assess impact of workshop recommendations;

c) select existing materials that can be posted to the digital library and deployed immediately;

d) outline a curriculum and assign writers for each part;

e) develop a detailed plan for the rest of project, assigning specific modules to implementation teams.

Fall Year 1: parallel activities

a) formative evaluation of materials previously selected for immediate deployment;

b) refinement by implementation teams of other materials, for deployment in Spring of Year 2;

c) preparation of draft curriculum and syllabi.

Spring Year 2:

a) refinement of materials based on formative evaluation in Fall of Year 1;

b) deployment of materials previously refined;

c) careful critique and refinement of draft curriculum and syllabi, including by those examining a WWW copy;

d) development of additional materials previously selected for delayed deployment.

Summer and Fall Year 2:

a) meetings at annual conferences for in-person discussions of CRIM Consortium and others interested;

b) release of draft curriculum and syllabi on WWW and into association newsletters;

c) continuing of the pipeline of development, deployment, refinement, re-deployment.

Year 3:

a) continuing of the pipeline of development, deployment, refinement, re-deployment;

b) release and publication of curriculum and syllabi, plus presentations of them at conferences;

c) widespread advertising of the digital library of course materials;

d) collecting and examining artifacts from formative evaluation and surveys of use of project materials;

e) final report, with semi-summative evaluation.

C.2 Results from Prior NSF Support

C.2.1. Institution: Virginia Tech, NSF CISE Instit. Infra. (Education) Grant CDA-9312611

C.2.1.1. Title of Project: Interactive Learning with a Digital Library in Computer Science

C.2.1.2. List of PIs: N. Dwight Barnette, Edward A. Fox (director), H. Rex Hartson, JAN Lee, Clifford Shaffer

C.2.1.3. Overview of Goals & Objectives: Key concepts of our project [FOXE95c] are to improve CS education by increasing interactivity and use of a digital library. The main objectives/accomplishments were to:

- expand the content and software (especially interfaces [NOWE84, NOWE96, WAKE95a]) initially developed with NSF support of our "Envision" digital library project, "A User-Centered Database from the Computer Science Literature" [HEAT95];
- develop/apply algorithm visualization tools that are easy for instructors to use in supplementing courses, and feasible for students to work with as an aid to program development and debugging [YANG95, SHAF96a, SHAF96b];
- incorporate use of specialized digital library systems like Netlib into related courses;
- add new courses related to human-computer interaction, multimedia, and a freshman level Introduction to Networked Information (later renamed Introduction to the Internet);
- significantly change courses like "Computer Professionalism," to make use of interactivity (e.g., asynchronous online debates) and digital library support (e.g., adding to a large History collection); and
- apply the key concepts to improve other courses.

C.2.1.4. Current Status and Accomplishments: In 1991 Virginia Tech began working with ACM through support from NSF on a "User-Centered Database from the Computer Science Literature" [HEAT95]. In 1993, Virginia Tech expanded its work on digital libraries to launch the NSF EI (Education Infrastructure / Innovation) project, partnering with Norfolk State University, which has developed extensive sets of laboratory manuals. Over 40 courses are available through WWW, leading to over 4.8M accesses from January 1995 through mid-May

1997. There are several gigabytes of ACM publications available. A server was installed at ACM Headquarters in NYC. The Virginia Tech server has been upgraded, and an IBM donation has provided a mirror machine with ATM connection in the Computing Center to ensure reliability. Ongoing collaboration with ACM has expanded to include IBM and their digital library systems, which also are helping Virginia Tech coordinate development of the National Digital Library of Theses and Dissertations (http://www.theses.org).

Several courses have all the on-line materials required for self-study available, and new programs are under development for distance learning and continuing education. In the new multimedia course, there was a dramatic increase in megabytes transferred because of more images, digital audio, and digital video: from 847 in 1995 to 1052 in 1996 to 2373 in 1997. Due to the development by Prof. Lee (editor of *Annals of the History of Computing*) of one of the largest repositories on computer history, with a unique image collection of the founders and early systems in our field, there is extensive additional traffic from throughout the nation. In 1996 --- with the help of NSF-funded digital video capture and editing facilities --- audio annotations, digital video movies, and animations to show interactive applications have been added. One of the courses developed under this effort, and extended through support from SUCCEED, is CS1604, Introduction to the Internet. A self-study version of this course was finalized in 1997, and is expected to be widely used throughout the Southeast and beyond by those interested in a freshman or beginner-level orientation to Internet, digital libraries, collaboration technologies, etc. This version has numerous audio and movie files to help learners, an automated real-time feedback facility (using our SGML-based QUIZIT tool [TINO96]), and a variety of illustrations and demonstrations.

In one old and two new courses, we have adapted Keller's Personalized System of Instruction [KELL68] to our networked environment. Students proceed at their own pace, study on their own, get help through asynchronous communication with peers and instructors, and in general have much greater flexibility in learning. Many students prefer this type of course, and in the case of CS1604 we simply could not accommodate the demand any other way, in this time of scarce resources. Students requested that we add interim deadlines, since they tend to procrastinate and require help with time management - doing so seems to have solves the major problem faced earlier. Pilot tests with courses like CS1604 are demonstrating how these subjects can be mastered through independent study courses.

C.2.1.5. Plans for Remainder of Project: A supplement to the original project is allowing addition of courseware on digital libraries, a June 1997 workshop to disseminate results, and development of a set of WWW pages for all the NSF CISE EI projects, cross-indexed and organized to aid access by CS instructors.

C.2.1.6. Materials that Have Been Developed: One result of our effort is the prototype Envision system. Its interface, being ported to Java, could be a very convenient means for accessing a variety of bibliographic collections, as well as richer digital libraries. A second result is the content converted from ACM. The most convenient portion is several hundred articles from *CACM* available now for those with permission using the Dienst system. A third result is the software created in increase interactivity of learning: SWAN (algorithm visualization) and QUIZIT. Finally, there are over 10,000 WWW pages of CS courseware.

C.2.1.7. Dissemination Activities:

C.2.1.7.1 Publications Summary (see D. References*)*

Project Overviews: FOXE94e, FOXE95c, FOXE96d, FOXE96f

Digital Library - General: CHEN96, DOUG95, FOXE93b, FOXE93d, FOXE93e, FOXE94d,

FOXE95a, FOXE96b
Digital Library - Architecture: FOXE94b, FOXE95f, FOXE96c, GLAD94a, GLAD94b
Digital Library - Capture, Conversion: DALA93
Digital Library - CS Technical Reports: FOXE95b, FREN95, MALY94a, MALY94b
Digital Library - Education: FOXE96a, FOXE96d, FOXE95e, FOXE96e, LAUG96
Digital Library - Interface: NOWE94, NOWE96, WAKE95a
Digital Library - System: FOXE93c, FOXE94c, HEAT95
Interactive Applications: WAKE95b, WAKE95c
Interactive Learning: SHAF96a, SHAF96b, TINO96, YANG95
Networking: ABRA95a, ABRA95b, FOXE94a, WILL96

C.2.1.7.2 Presentations by Project Director

Many presentations have been given over the course of the project, including 8 keynote/ distinguished lecture talks: Univ. Utah (3/7/96), UNC Chapel Hill (2/1/96), NORD-INFO (Helsinki, 11/94), Multimedia Systems (Ottawa, 10/94), ISMIS'94 (Charlotte, 10/94), EG-MM'94 (Graz, Austria, 6/94), CAIA'94 (San Antonio, 3/94), IR'93 (Regensburg, Germany, 9/93). Eight tutorials, 3 demonstrations, and > 20 other presentations also were given.

C.2.1.7.3 Outreach

Ongoing collaboration with Norfolk State University (NSU) has led to an increase in the use of laboratories to aid learning of CS students at Virginia Tech, and adaptation of many of the Virginia Tech materials and tools for use at NSU. Another systematic extension has been facilitated by additional funding from NSF through the Southeastern University and College Coalition for Engineering EDucation (SUCCEED). The SUCCEED Coalition Grant "Using Computers and Networked Information: Distance Learning with Networked Multimedia" is expanding through the use of digital video/audio tutorials, an alternative VRML (Virtual Reality Markup Language) interface, a Palace interface, multiple graphic pathways, an interactive collaboration medium for synchronous communication, and an online interactive real time testing component. Outreach work with a number of universities in the region is underway to help them apply this course to help them deal with increased interest in this field, and to more closely approach full "Information Literacy."

C.2.1.8. Evaluation Activities: Our evaluation involves typical traditional methods, e.g., pre- and post-tests, surveys, and focus groups. We performed usability studies of tools we developed or applied, and used formative evaluation methods to refine both our tools and courseware. Yet, our project still requires additional approaches to evaluation.

The investigators in our project are instructors who changed their allocation of time, behavior, pedagogy, course materials, and tools. To understand the effects of these changes, ethnographic practices are of great value - especially regarding use of asynchronous communication (i.e., online debates) [LAUG96].

Another shift in our evaluation has been to rely on network monitoring, logging, and analysis. Here we draw upon special tools for this purpose [ABRA95a]. Part of this work has helped improve our quality of service through caching [ABRA95b]. The rest has helped us understand what students really do, what course materials are accessed, how use of multimedia effects network traffic, and how both remote and local accesses increase over time. There has been a gradual increase in both remote and total access counts, if we ignore the valleys occurring during mid-semester, summer, and end-of-year breaks.

C.2.1.9. Benefits Seen and Expected: In summary, we have developed tools, expanded our digital library systems and content, and built over 10,000 "pages" of WWW-accessible courseware, increasing the interactivity and quality of learning about computer science.

Evaluation has shown that learning practices have changed, most students are happy with the emerging infrastructure and pedagogy, and there is steady growth in access to our server. Remote users now account for about one-third of the page requests, adding to the hundreds of students served locally. (In Fall 1997 the Department of Computer Science at Virginia Tech will have over 1000 majors. In recent years, the senior multimedia course has been the most popular senior elective.)

Our work has helped train hundreds of students, has aided the work of instructors interested in teaching courses for which we have developed useful materials, has developed tools (e.g., SWAN, QUIZIT) that can increase the interactivity of learning about computer science, and has helped with the construction of digital library systems and a content collection in CS (with ACM publications as well as technical reports).

C.2.2. Institution: George Washington University
C2.2.1 Title of Project(s): NSF Grant CDA-8954181: Bringing Young Minority Women to the Threshold of Science, 1989-1991, $199,000; Supplementary grant for $26,000; Extended through 1993 for $187,000 NSF Grant: HRD 94-44062: Did It Work? Followup Evaluation for Minority Women Project; $32,442.
C2.2.1.1. List of PIs: Rachelle S. Heller and C. Dianne Martin
C.2.2.1.2. Overview of Goals and Objectives: During each year of this four-year project, 24 minority female students in grades 9 or 10 were selected from the greater Washington, D.C. area to participate in a 10-month program to teach them computer skills as a vehicle to interest them in future careers in science and technology. Six high school science teachers were also selected to participate as mentor / participants on the project. The students and teachers worked in teams using hypermedia to develop computer-aided instruction in fields of science and technology. The objectives for the student participants were 1) to allow young minority women to interact with female scientists and university professors as role models for potential future careers in science and engineering, 2) to bring young minority women to a university setting to raise their sights toward higher education and to learn about the opportunities available for them, 3) to develop a peer network of young minority women in the greater Washington, D.C. area who have similar interests in studying math, science and engineering, and 4) to upgrade the skills and confidence level of young minority women to use computers as a tool to conduct research. The objectives for the teacher participants were 1) to upgrade the computer skills of the science teachers so that they can use computers as a tool to enhance their roles as teachers, 2) to provide the opportunity to develop a mentor / facilitator relationship with four students demonstrating potential in math and science, and 3) to provide the opportunity to establish a collegial relationship with university faculty.

C.2.2.1.3.Summary of results: A formal evaluation of the first two years of the project was conducted by an outside consultant. This evaluation was based upon the daily evaluations completed during the Saturday Seminars and the residential program, from questionnaires, and from informal interviews with the participants. Results from the evaluation reveal that all participants, both students and teachers, felt strongly that they have benefited from the project. The PIs continue to track all student participants through high school and into college as part of the evaluation process. Many of the students continued to use the university computers to do their homework projects. Several students each year have been accepted into science intern programs the summer following their experience in the GW project. Another measure of success of the project was the interest of the local media and private industry in the project. Local newspapers interviewed the girls and reported on the project. Without being solicited, several local companies called to inquire about how they can participate and to offer funding to the

project. One company indicated an interest in providing follow-up opportunities for the girls when they leave this project. IBM provided an IBM Visiting Scholar for two years to assist the Co-Principal Investigators with this project and other outreach programs in the local high schools. As a result of the success of the first two years of the project, funding was extended to two more years. In addition, a supplementary grant was awarded to the PI's to convene a conference of experts to examine programs targeted to attract young minority women to science and engineering and to determine characteristics of exemplary programs. Conference of Experts:

Twenty experts who direct or who are involved in programs that address the issue of attracting minorities and women to engineering and science were invited to participate in a two-day working conference held on October 14-15, 1991 at the IBM Decision Support Center (DSC) at Bethesda, Maryland. The panel members were drawn from corporations, educational institutions, professional associations, foundations, government institutions, and volunteer groups. The purpose of the working conference was twofold: to look at programs in general to determine what characteristics constitute exemplary programs and to look at the GW program in particular to investigate the possibilities of expanding the current program beyond the NSF grant period. Two major recommendations resulted from the conference: the development of a Program Planning and Self-Evaluation Guide that includes demographic and descriptive data and a checklist of characteristics necessary for an exemplary program; and 2) the need for a national clearinghouse of information about exemplary programs and funding sources. Another outcome of the project is that the PI's have been awarded a $43,500 grant from the US Department of Education to develop a professional quality video and implementation kit to be made available to groups interested in replicating the project at other sites. Did It Work: As a result of continued interest in this project, the National Science Foundation provided additional funds to conduct a follow-up study of the 100 student and 20 teacher participants in the project two years after the project ended. The purpose of the follow-up study was to track the participants and compare them to a similar population of minority high school girls who did not participate in the project. The report presents the results of the follow-up study, which shows that for participants the project raised their confidence level and ability to deal with the chilly climate often encountered by females in the classroom and workplace.

C.2.2.1.4. Dissemination Activities: The dissemination of information and products from these grants include publications [HELL92], [MART92a], [MART92b], [HELL94a], [HELL94b]; videotapes [HELLa]; technical reports [HELL91e], [HELL96]; keynotes/lectures [HELLb], [MART91]; and conference presentations [HELL91a], [HELL91b], [HELL91c], [HELL91d], [HELL92].

C.2.2.2. Title of Project: NSF Grant TPE 9055370: TEAMSS: Teacher Enhanced Applications for Middle School Science Using Multimedia, 1990-92, $318,000
C.2.2.2.1. **List of PIs**: Rachelle S. Heller and C. Dianne Martin
C.2.2.2.2. **Objectives**: This two-year project was designed to enhance the content knowledge and teaching skills of middle school science educators, to create a model for the innovative use of computer-aided, hypermedia technology in science classrooms, and to encourage increased collaboration between educators and scientists. The first year focused on the life sciences, and the second year focused on the physical sciences appropriate for the middle school science curriculum. Each year, teams, consisting of a science coordinator, a master science teacher and a novice science teacher, from public and independent school systems in the greater Washington, D.C., area were invited to a three-week summer workshop at GWU with school year follow-up sessions and site visits. The summer workshop featured skill-building through hands-on instruction in the use of computer-aided hypermedia, content enhancement through collaboration

with a science specialist and research scientists in residence, skill and content utilization through the integration of the new technical skills and science content into team projects to develop classroom lessons in life and physical sciences, and resource identification of technology resources in the greater Washington, D.C. area. School year follow-up included team meetings, implementation of the science lessons, Saturday sessions, site visits by the Principal Investigators, and participation in a regional science educators conference.

C.2.2.2.3. Summary of results: The first year there were 36 teacher and science coordinator participants who worked in 12 teams to produce 12 science modules during the summer workshop. In addition, they returned for an inservice day in November to work on developing a demonstration or inservice presentation for their schools or school districts. Some of them had already become involved in assisting with the training of other teachers in their schools and districts. Evaluation by an independent consultant revealed that the participants were overwhelmingly enthusiastic about their participation in the project and felt that it had a major impact on their teaching style in the classroom. There were 48 participants accepted for year two of the project held during the summer of 1992. Participants from that cohort were also extremely enthusiastic about the impact of the project on their professional development. In addition to the two summer sessions, there also were four special follow-up one-day workshops provided for all TEAMSS participants.

C.2.2.2.4 Dissemination Activities: The dissemination of information and products include conference presentations at [HELL92a], [HELL92b], [HELL92c], [LOWE92], and [MART92].

C.2.2.3. Title of Project. NSF ESI-9705033: Preparing for Teacher Enhancement in CS: A Two-Day Workshop; $50,509, Feb. 1, 1997 - Nov. 30, 1997;
C.2.2.3.1. List of PIs. Rachelle S. Heller and C. Dianne Martin
C.2.2.3.2. Objective: This two-day workshop was presented in conjunction with the 1997 SIGCSE Symposium to provide information to computer science faculty about the current state of the precollege computing curriculum and pedagogy to encourage the development and submission of Teacher Enhancement proposals. The workshop content included an explanation of the latest NSF guidelines and expectations for Teacher Enhancement proposals; several case studies of previously funded Teacher Enhancement projects; the current state of the precollege computing curriculum; the implications of recent changes to the university computing curriculum for the precollege curriculum in areas such as the choice of programming languages, the use of applications programs, the impact of the Internet, social and ethical concerns of computing; teacher training strategies; and program evaluation issues. The workshop was limited to 30 participants, each of whom received a $500 stipend to apply toward expenses to provide funds for food and hotel expenses for two extra days of attendance.

C.2.2.3.3. Results: A number of the participants submitted proposals under the Teacher Enhancement Program of NSF as a result of their participation in this workshop. The outcome of those proposals are still being decided.

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E. BIOGRAPHICAL SKETCH

Provide the following information for the senior personnel on the project. Begin with the Principal Investigator/Project Director (PI/PD).

DO NOT EXCEED 2 PAGES PER PERSON

A. Vitae, listing professional and academic essentials and mailing address.
B. List up to 5 publications most closely related to the proposed project and up to 5 other significant publications, including those being printed. Patents, copyrights or software systems developed may be substituted for publications. Do not include additional lists of publications, invited lectures, etc. Only the list of up to 10 will be used in merit review.
C. A list of persons, other than those cited in the publication list, who have collaborated on a project or a book, article, report or paper within the last 48 months, including collaborators on this proposal. If there are no other collaborators, please indicate so.
D. A list of the names of graduate students with whom this individual has had an association as thesis advisor and postdoctoral scholars sponsored by this individual over the past five years, with a summary of the total numbers of graduate students advised and postdoctoral scholars sponsored.
E. The names of this individualís own graduate and postdoctoral advisors.

The information in C, D, and E is used to help identify potential conflicts or bias in the selection of reviewers.

EDWARD A. FOX

fox@vt.edu http://fox.cs.vt.edu/

A. VITAE

EDUCATION:

8/83	Ph.D.	Computer Science, Cornell University
1/81	M.S.	Computer Science, Cornell University
2/72	B.S.	Electrical Engineering (Computer Science Option), M.I.T.

RECENT EMPLOYMENT:

6/90-	Associate Director for Research, VPI&SU Computing Center
4/95-	Professor, Dept. of Computer Science, VPI&SU (Virginia Tech), 660 McBryde Hall, Blacksburg VA 24061-0106 USA
5/88-4/95	Associate Professor, Dept. of Computer Science, VPI&SU
9/83-5/88	Assistant Professor, Dept. of Computer Science Virginia Polytechnic Institute and State University

PROFESSIONAL SERVICE:

CURRENT (Selected):

Member: OCLC Research Advisory Council; External Advisory Board of the Center for Research on Information Access at Columbia U.; SIGIR Education Comm., SIGIR Elect. Pub. Comm., SIGMM Education Comm. (co-chair)

Editor, Morgan Kaufmann Publishers, Inc. Series on Multimedia Info. and Systems

Editorial boards: The British Computer Society Journal of Digital Information; Electronic Publishing - Origination, Dissemination and Design Journal; Information Processing and Management; Journal of Educational Multimedia and Hypermedia; Journal for Universal Computer Science; Multimedia Systems; Multimedia Tools and Applications

RECENT (Selected):

Program chair, ACM Digital Libraries '96, Bethesda MD, March 20-23, 1996

Program chair, ACM SIGIR '95, Seattle, WA, July 9-13, 1995

Chair, ACM SIGIR (Special Interest Group on Information Retrieval), 1991-95

Vice Chair, ACM SIGIR (Special Interest Group on Information Retrieval), 1987-91

Editor-in-chief ACM Press Database and Electronic Products, 1988-91

Founder & Chair, ACM Multimedia Conferences Steering/Advisory Comm., 1992-94

Program committee member: ACM Multimedia '93-96; SIGIR '89-97; CIKM '94-95; ...

PROPOSALS: Over 55 proposals funded for over $7M since 1983.

TUTORIALS: Over 30 on digital libraries, hypertext, information retrieval, multimedia, etc.

B. PUBLICATIONS:

PUBLICATIONS (Selected Related):

E. Fox, ed. Sourcebook on Digital Libraries: Report for the National Science Foundation, TR-93-35, VPI&SU Computer Science Dept., Dec. 1993, Blacksburg, VA. Available by FTP from directory pub/DigitalLibrary on fox.cs.vt.edu

E. Fox and L. Kieffer. Multimedia Curricula, Courses and Knowledge Modules, *ACM Computing Surveys,* Dec. 1995, 27(4): 549-551.

E. Fox, R. Akscyn, R. Furuta, and J. Leggett. Guest Editors' Introduction to Digital Libraries. *Commun. ACM,* Apr. 1995, 38(4):22-28 (plus co-authored 3 other short articles in this issue).

L. Heath, D. Hix, L. Nowell, W. Wake, G. Averboch, and E. Fox. Envision: A User-Centered Database from the Computer Science Literature. Commun. of the ACM, Apr. 1995, 38(4):52-53.

E. Fox, D. Hix, L. Nowell, D. Brueni, W. Wake, L. Heath, and D. Rao. Users, User Interfaces, and Objects: Envision, a Digital Library. Journal of the American Society for Information Science (JASIS), Sept. 1993, 44(8): 480-491.

PUBLICATIONS (Other):

E. Fox, J. Eaton, G. McMillan, N. Kipp, L. Weiss, E. Arce, S. Guyer. National Digital Library of Theses and Dissertations: A Scalable and Sustainable Approach to Unlock University Resources. D-Lib Magazine, The Magazine of Digital Library Research, ISSN 1082-9873, Sep. 1996.

E. Fox. Advances in Interactive Digital Multimedia Systems. *IEEE Computer,* Oct. 1991, 24(10): 9-21. Reprinted in *Readings in Groupware and Computer Supported Cooperative Work,* ed. Ron Baecker, Morgan Kaufmann, San Mateo, CA, 1993, 342-354 and as Chapter 1 of *Multimedia Computing: Preparing for the 21st Century*, ed. Sorel Reisman, Idea Group Publishing, Harrisburg, PA, 1994, 3-33.

E. Fox. Standards and the Emergence of Digital Multimedia Systems. *Comm. ACM,* Apr. 1991, 34(4):26-29. Guest editor introduction, Special Section on Digital Multimedia.

E. Fox. The Coming Revolution in Interactive Digital Multimedia Systems. *Commun. of the ACM,* 1989, 32(7): 794-801. Guest ed. intro. Spec. Section on Interactive Technologies.

E. Fox. Digital libraries, WWW and educational technology - lessons learned. Invited paper for *Proc. ED-MEDIA 96, World Conference on Educational Multimedia and Hypermedia*, Boston, MA, June 17-22, 1996.

C. COLLABORATORS IN RECENT YEARS:

G. Abdulla, M. Abrams, Z. Ahmed, R. Akscyn, E. Arce, R. Ashany, G. Averboch, R. Baeza-Yates, N. Barnette, N. Belkin, S. Betrabet, E. Blythe, D. Brueni, J. Carroll, L. Carstensen, F. Can, Q. Chen, S. Chen, B. Cline, A. Cohill, B. Cross, J. Crowder, A. Daoud, S. Datta, N. Davis, G. Downey, J. Eaton, R. Ehrich, M. Evens, W. Farley, R. France, J. French, R. Furuta, J. Gaboury, P. Gherman, H. Gladney, J. Guidi, S. Guyer, D. Harman, H. Hartson, L. Heath, N. Herther, D. Hix, P. Kantor, L. Kieffer, M. Koll, M. Koushik, S. Kriss, M. Lambur, J. Lee, W. Lee, J. Leggett, J. Lundeen, L. Lunin, K. Maly, G. Marchionini, T. McAnge, G. McMillan, J. Menezes, J. Merola, S. Midkiff, M. Miller, V. Miranda, R. Modlin, R. Morrill, A. Narasimhan, S. Newcomb, L. Nowell, G. Nunn, J. Nutter, S. Patel, J. Pollard, G. Pulido, Y. Qian, D. Rao, M. B. Rosson, B. Rous, R. Quizon, E. Sahle, E. Schwartz, A. Selman, C. Shaffer, J. Shaw, A. Siochi, C. Snavely, P. Thompson, W. Wake, S. Wartik, M. Weaver, L. Weiss, J. Wiencko, R. Williges, L. Wilson, M. Zemankova

D. GRADUATE STUDENTS IN RECENT YEARS:

G. Abdulla, R. Barnhart, S. Betrabet, Q. Chen, A. Daoud, S. Datta, R. France, W. Heagy, N. Kipp, M. Koushik, S. Kriss, W. Lee, B. Liu, P. Mather, J. Menezes, A. Narasimhan, G. Nunn, S. Patel, D. Rao, R. Quizon, V. Riggins, E. Sahle, J. Shaw, M. Subhas, W. Wake, M. Weaver Smith, S. Winett

E. OWN ADVISOR:

G. Salton (deceased)

Current and Pending Support

See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Edward A. Fox (page 1 of 2)	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: Current x Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: (this proposal)

Curriculum Resources in Interactive Multimedia (CRIM)

Source of Support: NSF

Total Award Amount: $238,418 Total Award Period Covered: 1/1/98-12/31/99

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 5% Sumr: 1 month

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Support: x Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

A High Performance Connection for Research and Education Institutions and Facilities in Virginia

Source of Support: NSF

Total Award Amount: $350,000 Total Award Period Covered: 1/1/97-12/31/98

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: 5% Acad: Sumr:

Support: x Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Interactive Learning with a Digital Library in Computer Science

Source of Support: NSF

Total Award Amount: $449,088 Total Award Period Covered: 8/15/93-12/31/97

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 10% Sumr: 2 mos to 1996

Support: x Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Interactive Accessibility: Breaking Barriers to the Power of Computing

Source of Support: NSF

Total Award Amount: $1,375,000 Total Award Period Covered: 7/1/93-6/31/98

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 5% Sumr:

Support: x Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Using Computers and Networked Information: Distance Learning with Networked Multimedia

Source of Support: SUCCEED (from NSF)

Total Award Amount: $35,432 Total Award Period Covered: 5/15/95-6/30/97

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 5% Sumr:

Current and Pending Support

See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Edward A. Fox (page 2 of 2)	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: x Current Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

World-Wide Web Traffic Characterization with Application to In-network Caching and Prefetching

Source of Support: NSF

Total Award Amount: $320,559 Total Award Period Covered: 8/16/96-8/15/98

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 5% Sumr: .667 months

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Support: x Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Improving Graduate Education with a National Digital Library of Theses and Dissertations

Source of Support: US Dept. of Education (FIPSE)

Total Award Amount: $208,040 Total Award Period Covered: 9/1/96-8/31/99

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 10% Sumr: 1.333 months

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Support: x Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Development and Beta Testing of the Monticello Electronic Library Thesis and Dissertation Program

Source of Support: SURA (Southeastern Universities Research Association)

Total Award Amount: $90,117 Total Award Period Covered: 1/1/96-12/31/97

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 5% Sumr: 2 wks to 1996

Support: x Current Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: 3 supplements to "Interactive Learning with a Digital Library in Computer Science":

Workshop to Disseminate Results from "Interactive Learning with a Digital Library in CS",

WWW Pages to Support CS Education Innovation, Interactive Courseware on Digital Libraries

Source of Support: NSF

Total Award Amount: $66,846 Total Award Period Covered: 5/16/97-12/31/97

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 10% Sumr: 1 month

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Support: Current Pending x Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: subaward title:

A Digital Library Based Computer Science Teaching Center (CSTC)

Source of Support: NSF (subaward for proposal from D. Knox of TCNJ)

Total Award Amount: $72,820 Total Award Period Covered: 1/1/98-12/31/99

Location of Project: Blacksburg, VA

Person-Months Per Year Committed to the Project. Cal: Acad: 5% Sumr: 1 month

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. Use additional pages if necessary.

Laboratory: Interactive Accessibility

NSF Research Infrastructure Facilities funded for 1993-98, especially the Information Access Laboratory and the Usability Methods Research Laboratory.

Clinical:

Animal:

Computer: Computing Center

$650K worth of donated equipment from IBM late 1995 or 1996 to support digital library research, plus a handle or PURL server and DEC Alpha for development. Part of the donation involves a courseware server and another part covers a multimedia server with very ample storage, both ATM connected.

Office:

Other: _____

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate, identify the location and pertinent capabilities of each.

1. Information Access Lab: 1 large digital video editing facility with complete set of audio/ video devices, 5 RS/6000, 1 Sun 10, 1 Mac, 3 Pentiums, 3 X terminals, 2 scanners, networking.

2. CS department: a variety of machines for development and servers for WWW. The system ei.cs.vt.edu is our main courseware server and will be mirrored in Computing Center.

3. Interactive Accessibility: 7 rooms, with usability tools, 25 computers, networking.

4. Computing Center server: 6 processor IBM SMP, 512M RAM, 4 Tbytes storage; Alpha; Sun

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual/subaward arrangements with other organizations.

I. Supplementary Documentation

SUPPORT LETTERS

- ACM SIG Multimedia
- ACM Headquarters
- IEEE CS TC on Multimedia
- Interested Universities and other Organizations
- Virginia Tech

SUBAWARD PROPOSAL FROM THE GEORGE WASHINGTON UNIVERSITY