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PI/PD Name: Edward D Lipson

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other _____
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

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PI/PD Name: Sheryl Burgstahler

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other _____
- ☒ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

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PI/PD Name: Geoffrey C Fox

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other _____
- ☐ None

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PI/PD Name: Corinna E Lathan

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
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- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other _____
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PI/PD Name: Gregg C Vanderheiden

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
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Disability Status: (Select one or more)
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- ☐ Other _____
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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 99-2

NSF 99-29 **02/01/99**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

9976281

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				002257350	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

150532081

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYMS(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Syracuse University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0028829000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Syracuse University
113 Bowne Hall
Syracuse, NY. 132441200

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply)
(See GPG II.D.1 For Definitions) ☐ FOR-PROFIT ORGANIZATION ☐ SMALL BUSINESS ☐ MINORITY BUSINESS ☐ WOMAN-OWNED BUSINESS

TITLE OF PROPOSED PROJECT **A Cross-Disability-Accessible Knowledge Network for Education and Collaboration in Science and Technology**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PREPROPOSAL NO., IF APPLICABLE
$ **2,556,752**	**36** months	**10/01/99**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG 1.A.3)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.D.1)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG II.D.10)
☐ NATIONAL ENVIRONMENTAL POLICY ACT (GPG II.D.10)
☐ HISTORIC PLACES (GPG II.D.10)
☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.12)
☐ GROUP PROPOSAL (GPG II.D.12)
☐ VERTEBRATE ANIMALS (GPG II.D.12) IACUC App. Date _____
☐ HUMAN SUBJECTS (GPG II.D.12)
Exemption Subsection _____ or IRB App. Date _____
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES _____
☐ FACILITATION FOR SCIENTISTS/ENGINEERS WITH DISABILITIES (GPG V.G.)
☐ RESEARCH OPPORTUNITY AWARD (GPG V.H)

PI/PD DEPARTMENT
Department of Physics

PI/PD FAX NUMBER
315-443-9103

PI/PD POSTAL ADDRESS

Syracuse University
Syracuse, NY 132441130
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Edward D Lipson**	**Ph.D.**	**1971**	**315-443-9107**	**edlipson@syr.edu**
CO-PI/PD **Sheryl Burgstahler**	**Ph.D.**	**1992**	**205-543-0622**	**sherylb@cac.washington.edu**
CO-PI/PD **Geoffrey C Fox**	**Ph.D.**	**1967**	**315-443-2163**	**gcf@cs.fsu.edu**
CO-PI/PD **Corinna E Lathan**	**PhD**	**1994**	**202-319-5095**	**lathan@cua.edu**
CO-PI/PD **Gregg C Vanderheiden**	**PhD**	**1984**	**608-262-6966**	**gv@trace.wisc.edu**

CERTIFICATION PAGE

Certification for Principal Investigators and Co-Principal Investigators:

I certify to the best of my knowledge that:

(1) the statements herein (excluding scientific hypotheses and scientific opinions) are true and complete, and
(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 required progress reports if an award is made as a result of this application.

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 offense (U.S.Code, Title 18, Section 1001).

Name (Typed)	Signature	Social Security No.*	Date
PI/PD **Edward D Lipson**		**SSN's are confidential and are not displayed *ON FASTLANE SUBMISSIONS***	
Co-PI/PD **Sheryl Burgstahler**			
Co-PI/PD **Geoffrey C Fox**			
Co-PI/PD **Corinna E Lathan**			
Co-PI/PD **Gregg C Vanderheiden**			

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding Federal debt status, debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 99-2. Willful provision of false information in this application and its supporting documents or in reports required under an ensuring award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflict which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Debt and Debarment Certifications

(If answer "yes" to either, please provide explanation.)

Is the organization delinquent on any Federal debt? Yes ☐ No ☒

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure Form to Report Lobbying,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME/TITLE (TYPED) **Mary Ann Holmquist, Research Admin. II**		**02/01/99**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
315-443-9358	**maholmqu@syr.edu**	**315-443-9361**

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION'S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

A Cross-Disability-Accessible Knowledge Network for Education and Collaboration in Science and Technology

Project Summary

This multidisciplinary collaboration will develop and research a knowledge network that is accessible to individuals with a wide range of disabilities. We combine expertise in collaboration, object Web, human computer interfaces, education and cross disability access. We will use the concept of a Cross-Disability-Accessible Document Object Model (DOM) as the underlying theoretical framework. However our approach will involve building an operational Cross-Disability-Accessible Knowledge Network (CDAKN) based on iterative improvement of existing technologies for collaboration and interfaces. This Knowledge Network (KN) will initially be used by the project team as a collaboratory both to build the KN itself and to design and prepare cross-disability versions of existing successful Web-based educational material. The same testbed will be used to deliver distance education with both computer-science and natural-sciences curricula and will so extend the testing of the KN and develop further important capabilities. The research issues addressed in this project include the architecture of CDAKN and implications for a CDADOM; the integration of knowledge agents with collaboration and human-interface technology; and the design of customizable interfaces. The major outcome of the proposed research will be knowledge on how easy or difficult it is to create CDAKNs, how to identify barriers, and how to overcome them. This will be quantified through the CDADOM design principles that we will develop. The main practical outcome of this project will be the creation of the CDAKN itself, which would serve as a model for further research and for widespread application of CDAKNs.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

Section		Total No. of Pages in Section	Page No.* (Optional)*
Cover Sheet (NSF Form 1207 - Submit Page 2 with original proposal only)			
A	Project Summary (not to exceed 1 page)	1	
B	Table of Contents (NSF Form 1359)	1	
C	Project Description (including Results from Prior NSF Support) (not to exceed 15 pages) **(Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**	5	
D	References Cited		
E	Biographical Sketches (Not to exceed 2 pages each)	0	
F	Budget (NSF Form 1030, including up to 3 pages of budget justification)	3	
G	Current and Pending Support (NSF Form 1239)	0	
H	Facilities, Equipment and Other Resources (NSF Form 1363)	0	
I	Special Information/Supplementary Documentation	0	
J	Appendix (List below.) **(Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**		
	Appendix Items:		

*Proposers may select any numbering mechanism for the proposal, however, the entire proposal must be paginated. Complete both columns only if the proposal is numbered consecutively.

Project Description

The basic goal of the proposed work is to build a Cross-Disability-Accessible Knowledge Network (CDAKN) and then evaluate and advance its effectiveness a) in distance education in science and technology curricula and b) for scientific collaboration. This goal and the project are based on the following principles:

1. People need to be integrated into society and its activities irrespective of physical disabilities.
2. Web technologies and pervasive communication infrastructure provide a universal backbone for which one can build more effective cross-disability access (CDA) with specialized perception and expression capabilities optimized for individuals.
3. The 'anyplace' characteristic of the Internet is particularly attractive for individuals with disabilities, who may find their geographical location limited. Thus Internet collaboration is especially important for building knowledge networks involving individuals with disabilities.
4. Syracuse University has developed state-of-the-art collaboration (TangoInteractive) and universal-interface (NeatTools/TNG[serial interface box]/sensor/transducer) technologies.
5. The Trace Research and Development Center (trace.wisc.edu) in Wisconsin has pioneered the principles of universal design for computer interfaces and brings a broad national knowledge network to augment the prototype communities built at Syracuse. The CDAKN will be based largely on technology developed at Syracuse for "interactive collaborative environments," combined with accessibility strategies developed by the Trace Center.
6. Science, mathematics, engineering and technology (SMET) education is a national priority, for which universal participation is highly desirable.
7. Distance education, including both teachers and students with disabilities, exemplifies the general goal of implementing societal functions in a way that allows universal participation.
8. Distance education provides an attractive early testbed for new technology, because it has a natural structure that puts less stress on base hardware and software technologies. We have shown this in our successful distance education experiments between Syracuse and Jackson State (historically black college in Jackson, Mississippi) using TangoInteractive.
9. Scientific research collaborations increasingly depend on electronic communication. TangoInteractive is fundamentally a collaboratory system that is optimal for long-distance collaboration among researchers. A CDAKN based on Tango and NeatTools can advance science by inclusion of team members regardless of geographical location or (dis)ability.

Research Program

We intend to contribute to research in collaboration technologies, the design and architecture of CDAKNs, and new approaches to cross-disability interfaces for multimedia material. Our approach is to use a testbed that will implement a CDAKN, and then evaluate and iteratively improve it. We will use the testbed both as collaboratory among the project team members, and to deliver cross-disability education. This program will be implemented stepwise as follows. First, we will gather initial requirements for CDAKN from both user, content and technology aspects. We will use the concept of a CDA Document Object Model (DOM) to categorize the information flowing in the CDAKN. A major result of our project will be new design principles for such a DOM which will provide important extensions to the current World Wide Web Consortium (W3C) DOM which does not have cross disability built into it. Although we will use the CDAKN to guide the project, it would be too ambitious to fully implement such an extended DOM. Our research and testbed experience will, however, help in the future revision

of current document object models in order to become truly CDA. We will integrate universal interface design (Wisconsin) implemented as a knowledge agent linking the interface technology and collaboration software (Syracuse) to produce prototype CDAKN for particular disabilities. Again, the knowledge agent will initially be simple and will be refined as the project progresses.

We will first set up a general collaboratory starting with project members, and their natural contacts through NCSA Alliance/NPACI/EOT, Trace Center, Center for Applied Special Technology (CAST, in Boston area), Catholic University (Corinna Lathan et al., and National Rehab Hospital; their new "Telerehab" Rehab. Engineering Research Center grant explicitly included NeatTools in proposal; Trace director Gregg Vanderheiden serves as advisor for this new RERC), and DO-IT (Disabilities, Opportunities, Internetworking, and Technology) at University of Washington (Sheryl Burgstahler, director). This team will plan and implement the broader use of the CDAKN, which will involve specific educational activities in both computer science and the natural sciences. This will use material already developed, but not universally accessible at present. Our first area is Internetics, which is a curriculum developed by co-PI Geoffrey Fox that combines computational science and modern information/communication technologies. Our major focus is *Science for 21st Century*, a large- enrollment course at Syracuse developed by PI and others with modular approach to teaching science in an integrated way to non-science majors. Two current NSF grants, associated with this course, support development of interactive Web-based educational modules; see http://www.simscience.org and www.phy.syr.edu/courses/CCD_NEW/. We will start with the *Science for 21st Century* modules, as these are broadly useable at both high school, undergraduate and general science literacy levels. Note that Gregg Vanderheiden and Geoffrey Fox are team leaders in the joint Alliance/NPACI EOT (Education, Outreach and Training) activity in areas of universal access, learning technologies and graduate education.

Participants on this project—including students and scientists with various disabilities—will use the CDAKN both to attend these courses and, within the core group, to actually research and develop the CDA technologies and educational material in a process of bootstrap and progressive optimization. We will hold conventional and CDAKN workshops to involve others in this area, disseminate lessons, and provide training in universal interface and collaboration methods. We will also produce research publications and presentations, and continually post results and issues on our Web sites for communication, feedback, and dissemination.

The research issues include: a) architecture of CDAKN and implications for a CDADOM, b) integration of knowledge agents with collaboration and human-interface technology, and c) determination of customizable interface approaches and effectiveness using visual programming environments and modular interface hardware.

Methodology

The representative core technologies on this project include TangoInteractive and NeatTools/TNG/devices (see below). Both systems are, in general, highly modular and adaptable, and can work very well together. An early technical objective will be to integrate Tango and NeatTools and then do preliminary multimodal testing of the emerging CDAKN.

We will leverage the new NEC Foundation grant (Syracuse) to include students with disabilities in Syracuse, Washington DC, Minneapolis, Seattle (DO-IT), Madison (Trace), and Boston (CAST; www.cast.org; consultant here). Further, we will adapt interactive Java-based science education modules (see URLs above; some already in Tango) from two NSF-funded grants at Syracuse to become CDA. These are associated with *Science for the 21st Century* course offered by the Syracuse Physics Department. Meanwhile, the Trace Center will address the

issues that arise in creating CDA multimedia interactive environments. Catholic University will co-develop interface technology with Syracuse team, and will develop assessment 'instruments' for formative evaluation. CAST (Boston) and DO-IT (U Washington) will begin testing by diverse users. Besides its core role in the CDAKN, Tango will be used for project communication, design, and bootstrapping/optimization of CDAKN. We will also set up representative CDA distance-learning courses (or, at least, exemplary class sessions, such as seminars) in SMET fields.

The research emphasis throughout the project will be based on hypotheses concerning CDA, KN (functionality, effectiveness, usability) and formative evaluation with consequent refinement. For example, can users who are abled, blind, deaf, or quadriplegic access the CDAKN and keep up with one another in interactive sessions? We will identify problems and take corrective design actions in an iterative fashion. The project will include quantitative performance assessment in Tango and in NeatTools interface programs (event tracking, database recording, data analysis). In this way we can strive toward developing a CDA-multimedia-interactive KN.

Outcomes

The fundamental outcome of the proposed research will be *knowledge* on how easy or difficult it is to create CDAKNs, how to identify barriers, and how to overcome them. The main practical outcome will be the creation of the CDAKN itself – the first of its kind. This will serve as a model for further research and for widespread application of CDAKNs.

Another substantial outcome will be our KDI research on this CDAKN to evaluate its effectiveness and continually improve it during and beyond the proposed work. This will serve as foundation for continued research (KDI/CDA/KN). We intend to sustain the project and its results for the long term, and will seek continued funding from NSF and other sources, while bringing in additional partners for broader implementation and testing.

We will make extensive use of the Web for dissemination of project information and free software (Tango and NeatTools). Information on how to obtain low cost modular interface hardware will also be provided. This would include our computer interface boxes and sensor kits and other commercial components listed in the Trace Resource Book, as appropriate. Project results will also be disseminated by traditional-style presentations, publications, and workshops.

A final major outcome of this CDAKN research and development project will be that users with disabilities will have far greater opportunities for SMET education (active learning in constructivist paradigm; lab participation; lifelong learning) and SMET careers.

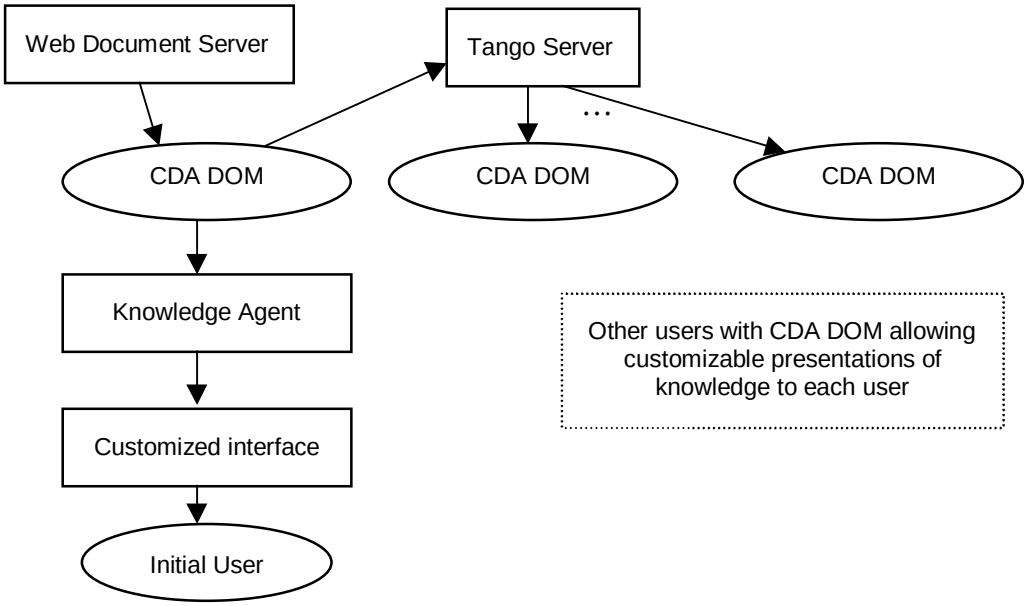
Knowledge of the CDAKN

The CDAKN will be used in two distinct roles: a) initially by team of content and technology developers (Syracuse/CUA/NRH), designers (Trace) and outreach sites (CAST, DO-IT) to develop initial CDA educational modules, starting with *Science for the 21st Century* course material (note that we have 2 NSF funded grants for this work; see above); and b) at outreach sites, to deliver material of increasing sophistication in both education and literacy modes.

Technology of the CDAKN

Overall Architecture. We will describe information as stored in the client computer in terms of a (generalized) document object model CDADOM, based initially on the current W3C proposals (www.w3.org/DOM/). The architecture is shown below. The capability of TangoInteractive to support client-dependent views of information will be used to produce optimized displays for

each user, depending in general on both physical capabilities and prior knowledge. This customization is supported in two ways. First, a traditional knowledge agent employs a user profile to broker the custom conversion of information (stored in CDADOM) to client-dependent



knowledge. This essentially involves processing text and images in the original document. Second, we process the event handlers for user interaction and convert abstract content appropriately (e.g. text and images to audio for the blind). Event handlers are typically specified by “onclick” or “onkeydown,” but this is clearly not in CDA form. Initially, we will map, in the Tango (which traps all DOM events for sharing with its JavaScript interface) interface to NeatTools, such classic input devices to those appropriate on this client. As a result of this study, we will propose a more abstract CDADOM where content and events are specified abstractly and on conventional machines mapped to text, images, onclick, etc.

TangoInteractive Background. TangoInteractive (or Tango; http://www.npac.syr.edu/tango) is an advanced, powerful, and extensible Web collaboratory, and is perhaps the most flexible of systems of its type. It is not aimed at exploring research issues in collaborative system design, but rather at exploring applications such as those proposed here. In this regard, great effort has been put into making the base infrastructure quite robust, so that it can be used outside a tolerant research environment.

Tango is written in Java, but supports collaborative applications in any language. Further Tango is fully integrated with Web browsers, and this provides the basis of convenient, familiar interfaces. To run Tango, one starts the system from a browser and connects to a Tango server. Both the client and server code for Tango are freely available on CD-ROM or from our Web site, which also contains the well documented API’s for C++, Java, Java Beans, and JavaScript. Once in the system, the user can select from over 25 collaboratory applications to work on projects with partners, play a game of Bridge or Chess, take a class at a virtual university, create and use a public or private chat room, conduct a videoconference, view a movie, or surf with friends using the powerful shared browser. It is possible to do all this at the same time, in any combination, and multiple copies of applications such as chat rooms can be launched. Further, Tango can provide shared sessions for either client- or server-side applications. The latter include

both shared (Web-linked) databases (as in Oracle-based WebWisdom curriculum management system) and shared CGI scripts (as in our integration of NCSA's Biology Workbench with Tango). We believe that no other collaboratory system, public domain or commercial, gives you so many applications under such consistent and simple session and floor control.

Besides running Java applets under Tango, one can run JavaScript-based client-side Web applications. Moreover, in Tango the user can take an arbitrary HTML page and automatically turn it into a shared entity. To build a 3D VRML world, populate it with avatars, and let them interact, Tango provides support via two integration modes: VRML JavaScript nodes and External Authoring Interface. Applications written in C or C++ (e.g. PowerPoint) can also be readily adapted to run collaboratively under the Tango API. In this proposal, we will use the C++ interface of Tango to link the NeatTools specialized interfaces. Note that the shared collaboration model of Tango allows each client to have different views of the same shared application, and this is essential for universal access. Shared display systems such as Microsoft's NetMeeting are less flexible.

NeatTools Background. We have been developing NeatTools, a visual-programming and runtime environment, for interfacing humans and computers (www.pulsar.org; http://www.pulsar.org/ed/manuscripts/mmvr7/MMVR99_paper_5.htm). It enables users to input information to a computer through various kinds of sensors and devices and, among other things, displays the information in the form of text, graphics, audio, video, or other methods. One constructs a dataflow network (visual program) in this environment by dragging and dropping objects (modules) from an on-screen toolbox to the desktop workspace and then connecting these with input or output controls and control of parametric lines. Editing and execution of programs occur simultaneously, so that no compilation is necessary.

NeatTools is written in C++ on top of a Java-like cross-platform application programming interface (API) so that it can run on multiple platforms including Windows 95/98/NT, Unix, Irix, and Linux. Macintosh will be supported once its multithreaded operating system is released. NeatTools is simple, object-oriented, network-ready, robust, secure, architecture neutral, portable, high-performance, multi-threaded, extensible, and dynamic. It can interface with serial, parallel, and joystick devices (and see below). Other significant features include Internet connectivity; display of time signals; mathematical and logic functions; character generation; multimedia; Musical Instrument Device Interface (MIDI) controls; and a visual relational database with multimedia functions. A developer's kit, for writing new external modules, is also available online for those proficient in object-oriented programming in C++.

Devices Background. We have also developed the palm-sized TNG-3 hardware interface box, which detects signals from sensors and switches. Both TNG-3 and the latest version, TNG-3B, have 8 analog and 8 digital input channels and stream data to the serial port of a personal computer at 19200 baud. We also have a working bench prototype of TNG-4, which has more capacity and versatility, with 8 analog and 22 digital lines that are dynamically bidirectional. In other words, each digital line can serve as an input or an output, and this can be dynamically reconfigured at any time within NeatTools by manual or automatic control. We have used *NeatTools* to interface various types of hardware devices to TNG-3, including displacement potentiometers, photocells, magnetic sensors (Hall Effect transducers), pressure transducers, and bend sensors. The customizable and extensible features of these modular hardware and software systems are important for the project goal of extending such technology to accommodate users with a broad range of disabilities.

SUMMARY PROPOSAL BUDGET

YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Syracuse University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Edward D Lipson**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Edward D Lipson - Professor**	**0.00**	**0.00**	**1.95**	$ **54,340**	$
2. **Sheryl Burgstahler - Director, DO-IT**	**0.00**	**0.00**	**0.00**	**0**	
3. **Geoffrey C Fox - Professor, NPAC Director**	**0.00**	**0.00**	**0.00**	**0**	
4. **Corinna Lathan - Assistant Professor**	**3.00**	**0.00**	**0.00**	**0**	
5. **Marek Podgorny - Assoc. Director, NPAC**	**6.00**	**0.00**	**0.00**	**148,200**	
6. (**2**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**3.00**	**0.00**	**0.00**	**17,500**	
7. (**7**) TOTAL SENIOR PERSONNEL (1 - 6)	**12.00**	**0.00**	**1.95**	**220,040**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**2**) POST DOCTORAL ASSOCIATES	**72.00**	**0.00**	**0.00**	**240,000**	
2. (**2**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**72.00**	**0.00**	**0.00**	**240,000**	
3. (**3**) GRADUATE STUDENTS				**152,471**	
4. (**2**) UNDERGRADUATE STUDENTS				**21,000**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**873,511**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**251,064**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**1,124,575**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **computers** $ **60,000**					
TOTAL EQUIPMENT				**60,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				**36,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
(**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**90,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**30,000**	
3. CONSULTANT SERVICES				**90,000**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**360,000**	
6. OTHER				**28,935**	
TOTAL OTHER DIRECT COSTS				**598,935**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**1,819,510**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **FirstIndirectCostItem (Rate: 51.0000, Base: 1370575) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				**737,243**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**2,556,753**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **2,556,753**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI / PD TYPED NAME & SIGNATURE*	DATE	FOR NSF USE ONLY
Edward D Lipson		INDIRECT COST RATE VERIFICATION
ORG. REP. TYPED NAME & SIGNATURE*	DATE	Date Checked / Date Of Rate Sheet / Initials - ORG

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

Other Senior Personnel

Name - Title	Cal	Acad	Sumr	Funds Requested
Vanderheiden, Gregg - Professor, Trace Director	0.00	0.00	0.00	0
Warner, David J - NPAC Senior Scientist	3.00	0.00	0.00	17500

**** C- Fringe Benefits**
17.3%(A1+A2)+34.2%(A3+A7+B1+B2)+12.7%(B3)+7%(B4)
**** G-6 Other**
tuition ($643/cr hr)
**** I- Indirect Costs**
subawards (applied to $25k of each) (Rate: 51.0000, Base 75000)
IDC on 25k during year 1 only

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Syracuse University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Edward D Lipson**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-mos. CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
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3. **Geoffrey C Fox - Professor, NPAC Director**	**0.00**	**0.00**	**0.00**	**0**	
4. **Corinna Lathan - Assistant Professor**	**3.00**	**0.00**	**0.00**	**0**	
5. **Marek Podgorny - Assoc. Director, NPAC**	**6.00**	**0.00**	**0.00**	**148,200**	
6. (**2**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**3.00**	**0.00**	**0.00**	**17,500**	
7. (**7**) TOTAL SENIOR PERSONNEL (1 - 6)	**12.00**	**0.00**	**1.95**	**220,040**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
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4. (**2**) UNDERGRADUATE STUDENTS				**21,000**	
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6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**873,511**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**251,064**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**1,124,575**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ **60,000**					
TOTAL EQUIPMENT				**60,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				**36,000**	
2. FOREIGN				**0**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
(**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**90,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**30,000**	
3. CONSULTANT SERVICES				**90,000**	
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J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**2,556,753**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.D.7.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **2,556,753**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI / PD TYPED NAME & SIGNATURE*: **Edward D Lipson** DATE

ORG. REP. TYPED NAME & SIGNATURE* DATE

FOR NSF USE ONLY

INDIRECT COST RATE VERIFICATION

Date Checked	Date Of Rate Sheet	Initials - ORG

NSF Form 1030 (10/98) Supersedes all previous editions

C***SIGNATURES REQUIRED ONLY FOR REVISED BUDGET (GPG III.B)**