COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

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NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE **Syracuse University**	ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE **Syracuse University** **113 Bowne Hall** **Syracuse, NY. 132441200**
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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 ________
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- ☐ FACILITATION FOR SCIENTISTS/ENGINEERS WITH DISABILITIES (GPG V.G.)
- ☐ RESEARCH OPPORTUNITY AWARD (GPG V.H)

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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.

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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.

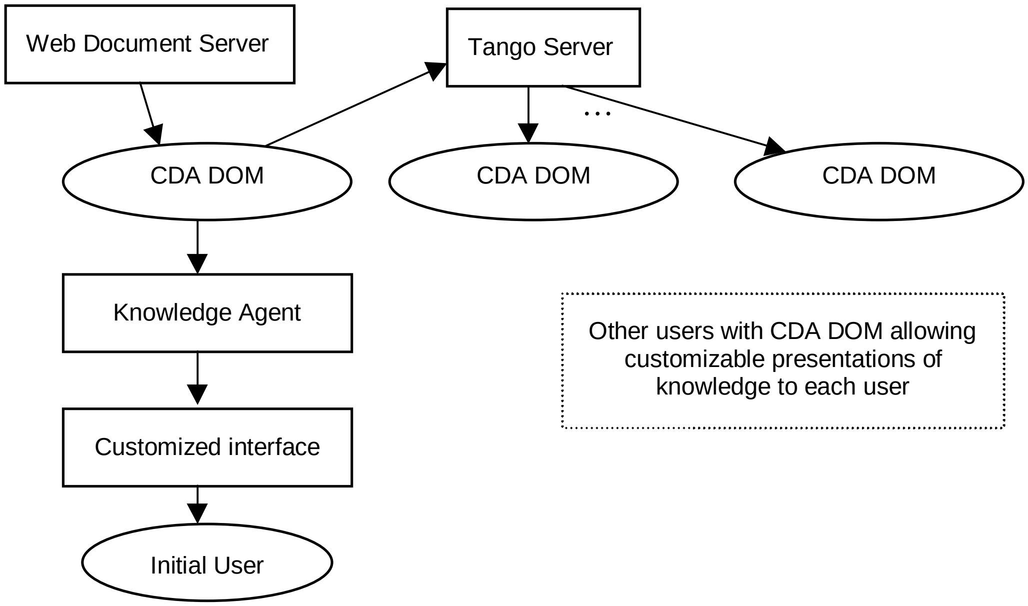
A final major outcome of this CDAKN research and development project will be that users with disabilities will have far greater opportunities for SMET education (active learning in constructivist paradigm; lab participation; lifelong learning) and SMET careers.

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.