OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

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March 1, 2006

Dr. Walter M. Polansky
U.S. Department of Energy
SC-21.2, Germantown Building
1000 Independence Avenue, S.W.
Washington, DC 20585

Dear Dr. Polansky:

Program Announcement LAB 06-04: Scientific Discovery through Advanced Computing (SciDAC): CANTIS: Center for Applications-Network Total-Integration for SciDAC

Enclosed please find the proposal entitled, CANTIS: Center for Applications-Network Total-Integration for SciDAC," for your consideration.

We propose to create the Center for Applications-Network Total-Integration for SciDAC (CANTIS) to address the totality of the problem space needed for end-to-end performance of SciDAC applications. The main goal of CANTIS is to serve as a comprehensive resource to provide SciDAC applications with high-performance network capabilities in an optimal and transparent manner. As an integral part of its charter, CANTIS will proactively engage SciDAC principal investigators, their developers, and science users in integrating the latest networking and related techniques with SciDAC applications and thus remove current network-related performance bottlenecks. This project addresses a broad spectrum of networking-related capabilities needed in various SciDAC applications by leveraging existing technologies and tools, and developing the missing ones.

The total request is $14,000,000 for five years.

Questions regarding this proposal should be directed to the Principal Investigator Nageswara Rao, 865-574-7517 or e-mail: raons@ornl.gov.

Sincerely,

Thomas Zacharia
Associate Laboratory Director
Computing and Computational Sciences

Enclosures

TZ:ddm

c: W. C. Lin
J. A. Nichols
T. Zacharia

DOE F 4650.2
Rev. (10-03)
(All Other Editions Are Obsolete)

Office of Science (SC)

Face Page

OMB Control No.
1910-1400
(OMB Burden Disclosure Statement on Back)

TITLE OF PROPOSED RESEARCH:
CANTIS: Center for Application-Network Total-Integration for SciDAC

1. CATALOG OF FEDERAL DOMESTIC ASSISTANCE #
81.049

2. CONGRESSIONAL DISTRICT:
Applicant Organization's District: 2nd & 3rd Districts
Project Site's District: 2nd & 3rd Districts

3A. I.R.S. ENTITY IDENTIFICATION OR SSN:
439551258

3B. DUNS Number:

4. AREA OF RESEARCH OR ANNOUNCEMENT TITLE/#:
LAB 06-04: Scientific Discovery through Advanced Computing

5. HAS THIS RESEARCH PROPOSAL BEEN SUBMITTED TO ANY OTHER FEDERAL AGENCY?
☐ YES ☑ NO

PLEASE LIST

6. DOE/OER PROGRAM STAFF CONTACT (if known):
Thomas D. Ndousse-Fetter 301-903-9960

7. TYPE OF APPLICATION:
- ☑ New
- ☐ Continuation
- ☐ Supplement
- ☐ Renewal
- ☐ Revision

8. ORGANIZATION TYPE:
- ☐ Local Govt.
- ☐ Non-Profit
- ☐ Indian Tribal Govt.
- ☑ Other
- ☐ For-Profit
  - ☐ Small Business
  - ☐ Women-Owned
- ☐ State Govt.
- ☐ Hospital
- ☐ Individual
- ☐ Inst. of Higher Educ.
- ☐ Disadvan. Business
- ☐ 8(a)

9. CURRENT DOE AWARD # (IF APPLICABLE):
None

10. WILL THIS RESEARCH INVOLVE:
10A. Human Subjects ☑ No ☐ If yes
Exemption No. ________ or
IRB Approval Date ________
Assurance of Compliance No: ________
10B. Vertebrate Animals ☑ No ☐ If yes
IACUC Approval Date ________ or
Animal Welfare Assurance No: ________

11. AMOUNT REQUESTED FROM DOE FOR ENTIRE PROJECT PERIOD $ 3,000,000

12. DURATION OF ENTIRE PROJECT PERIOD:
07/01/06 to 06/30/11
MM/DD/YY MM/DD/YY

13. REQUESTED AWARD START DATE
07/01/06
MM/DD/YY

14. IS APPLICANT DELINQUENT ON ANY FEDERAL DEBT?
☐ Yes (attach an explanation) ☑ No

15. PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR
NAME Nageswara S. Rao
TITLE Distinguished R&D Staff
ADDRESS P.O. Box 2008
Oak Ridge, TN 37831-6016
PHONE NUMBER 865-574-7517

16. ORGANIZATION'S NAME Oak Ridge National Laboratory
ADDRESS P.O. Box 2008
Oak Ridge, TN 37831-6163

CERTIFYING REPRESENTATIVE'S
NAME Thomas Zacharia
TITLE Associate Laboratory Director
PHONE NUMBER (865) 574-4897

SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROGRAM DIRECTOR
(please type in full name if electronically submitted)
Date

PI/PD ASSURANCE: 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 submission. Willful provision of false information is a criminal offense. (U.S. Code, Title 18, Section 1001).

SIGNATURE OF ORGANIZATION'S CERTIFYING REPRESENTATIVE
(please type in full name if electronically submitted)
Date

CERTIFICATION and ACCEPTANCE: I certify that the statements herein are true and complete to the best of my knowledge, and accept the obligation to comply with DOE terms and conditions if an award is made as the result of this submission. A willfully false certification is a criminal offense. (U.S. Code, Title 18, Section 1001).

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U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS

FIELD WORK PROPOSAL

PROGRAM: KJ Computational and Technology Research

1. WORK PROPOSAL NO. ERKJD10	2. REVISION NO. 0	3. DATE PREPARED 04-15-2006	12

4. WORK PROPOSAL TITLE: CANTIS: Ctr for App-Network Total-Intergration for SciDAC	5. BUDGET AND REPORTING CODE KJ 01 02 00 0

6. WORK PROPOSAL TERM BEGIN: 07-01-2006 END: OPEN	PATENT STATUS This proposal is being transmitted in advance of patent review for evaluation purposes only. No further dissemination or publication shall be made without prior approval of the Assistant General Counsel for Patents, DOE.	7. Is This Work Proposal Included in the Institutional Plan? ☒ Yes ☐ No

NAME: (Last, First, MI) (Phone Number)

8. HEADQUARTERS/OPERATIONS OFFICE PROGRAM MANAGER: Ndousse-Fetter, Thomas D. (301)903-9960	11. HEADQUARTERS ORGANIZATIONS: **Office of Science**	14. DOE ORGANIZATION CODE: **SC**
9. OPERATIONS OFFICE WORK PROPOSAL REVIEWER: Lin, Wayne C. (865)576-0639	12. FIELD OFFICE: **Oak Ridge Operations**	15. DOE ORGANIZATION CODE: **ON**
10. CONTRACTOR WORK PROPOSAL PRINCIPAL INVESTIGATOR(S)/MANAGER: Rao, Nageswara S. (865)574-7517	13. CONTRACTOR NAME: **Oak Ridge National Laboratory** **Managed by UT-Battelle, LLC** **For the U.S. Department of Energy** **Post Office Box 2008** **Oak Ridge, TN 37831**	16. DOE CONTRACTOR CODE: **41**

17. WORK PROPOSAL DESCRIPTION (Approach, anticipated benefits in 200 words or less)

We propose to create the Center for Applications-Network Total-Integration for SciDAC (CANTIS). It will proactively engage the Scientific Discovery through Advanced Computing (SciDAC) principal investigators, their developers, and science users to integrate the latest networking and related techniques with SciDAC applications and thus remove current network-related performance bottlenecks. Realizing the network capabilities needed in SciDAC applications requires the vertical integration and optimization of the entire Application-Middleware-Networking (AMN) stack so that the provisioned capacities and capabilities are available to the applications in a transparent, optimal manner.

The main goal of CANTIS is to serve as a comprehensive resource to equip SciDAC applications with high-performance network capabilities in an optimal and transparent manner. We propose to develop tools specifically tailored to SciDAC to generate application-level connection profiles, and identify potential components of an end-to-end AMN solution. We will develop in-situ optimization tools that can be dropped in-place along with the application to identify the optimal AMN configurations such as an optimal number of transport streams for application-to-application transfers, decomposition and mapping of a visualization pipeline, and transparent and agile operation over hybrid circuit/packet-switched or IPv4/v6 networks. We will also develop application-programming interfaces and libraries customized to SciDAC for various AMN technologies.

18. CONTRACTOR WORK PROPOSAL MANAGER: (Name and Phone No.) Thomas Zacharia (865)574-4897 Signature: Date: 04-15-2006	19. OPERATIONS OFFICE REVIEW OFFICIAL (Signature) (Date)

20. DETAIL ATTACHMENTS: (See instructions for page 3)

☐ a. Facility Requirements	☐ e. Approach	☐ i. NEPA Requirements	☒ m. ES&H Considerations
☐ b. Publications	☐ f. Technical Progress	☐ j. Milestones	☒ n. Human/Animal Subjects
☐ c. Purpose	☐ g. Future Accomplishments	☐ k. Deliverables	☒ o. Other (Specify)
☐ d. Background	☐ h. Relationships To Other Projects	☐ l. Perform Measures/Expectations	

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(1-96)

WORK PROPOSAL REQUIREMENTS FOR OPERATING/EQUIPMENT OBLIGATIONS AND COSTS

PROGRAM: KJ Computational and Technology Research

CONTRACTOR NAME:	WORK PROPOSAL TITLE:		
UT-BATTELLE, LLC	CANTIS: Ctr for App-Network Total-Intergration for SciDAC		
	WORK PROPOSAL NO. ERKJD10	REVISION NO. 0	DATE PREPARED 04-15-2006

21. STAFFING (in staff years)	FY 2006	FY 2007	FY 2008 REQUEST	FY 2008 AUTHOR.	FY 2009	FY 2010	TOTAL TO COMPLETE
a. SCIENTIFIC / OTHER DIRECT - ORNL	1.8	1.7	1.7				
b. OTHER DIRECT - OTHER SITES							
c. TOTAL DIRECT	1.8	1.7	1.7				
22. OPERATING EXPENSE (in Thousands)							
a. TOTAL OBLIGATIONS	610	611	622				
COSTS:							
1) WAGE POOL AND ORG. BURDEN	406	408	408				
2) MATERIALS AND SERVICES	28	28	28				
3) SUBCONTRACTS AND CONSULTANTS							
4) INDIRECT COSTS	176	175	186				
b. TOTAL COSTS	610	611	622				
23. EQUIPMENT (in Thousands)							
a. EQUIPMENT OBLIGATIONS							
b. EQUIPMENT COSTS							

24. MILESTONE SCHEDULE (TASKS:)	DOLLARS (in Thousands) PROPOSED	DOLLARS (in Thousands) AUTHORIZED	SCHEDULE (DATE) PROPOSED	SCHEDULE (DATE) AUTHORIZED
High performance data transport for memory transfers	200		09/06	
Support of single visualization streams over wide-area connections	200		09/06	
Computational monitoring and steering over network connections single clients	200		09/06	
High performance data transport for file transfers	200		09/07	
Support of multiple visualization streams over wide-area connections	200		09/07	
Computational monitoring and steering over network connections for multiple clients	200		09/07	
Coordinated multiple file and memory transfers	200		09/08	
Decomposition and mapping of coordinated visualization pipelines	200		09/08	
Coordinated computations monitoring and steering	200		09/08	

25. REPORTING REQUIREMENTS (DESCRIPTION:)

Results will be reported in periodic highlights to the U.S. Department of Energy and in peer-reviewed journals and conference proceedings.

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(1-96)

WORK PROPOSAL REQUIREMENTS FOR OPERATING/EQUIPMENT OBLIGATIONS AND COSTS

PROGRAM: KJ Computational and Technology Research

CONTRACTOR NAME:	WORK PROPOSAL TITLE:		
UT-BATTELLE, LLC	CANTIS: Ctr for App-Network Total-Intergration for SciDAC		
	WORK PROPOSAL NO. ERKJD10	REVISION NO. 0	DATE PREPARED 04-15-2006

20. DETAIL ATTACHMENT CONTINUED:

m. ES&H Considerations

Paper studies only.

n. Human/Animal Subjects

No human or animal subjects involved.

o. Other

(1) OBLIGATIONS FOR OPERATING EXPENSES-Budget Authority (B/A)

	Obligation Estimates FY 2006	FY 2007	FY 2008
Cost (B/O) Estimates	610	611	622
Less: Uncosted Balance (--) at 10/01			
Plus: Commitments for Continued Operations			
Outstanding Commitment Balance 10/08			
TOTAL OBLIGATIONS--CHANGE	610	611	622

(2) CAPITAL EQUIPMENT OBLIGATIONS AND COSTS - None

CANTIS: Center for Application-Network Total-Integration for SciDAC

Scientific Discovery through Advanced Computing - Enabling Computational Technologies
DOE Office of Science Program Announcement LAB 06-04

Oak Ridge National Laboratory

Principal Investigator (coordinator and point of contact)**:**

Nageswara S. Rao
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Co-Principal Investigators**:**

Steven M. Carter, William R. Wing, Qishi Wu, *Oak Ridge National Laboratory*
Dantong Yu, *Brookhaven National Laboratory*
Matt Crawford, *Fermi National Accelerator Laboratory*
Karsten Schwan, *Georgia Institute of Technology*
Tom McKenna, *Pacific Northwest National Laboratory*
Les Cottrell, *Stanford Linear Accelerator Center*
Biswanath Mukherjee, Dipak Ghosal, *University of California, Davis*

Official Signing for Oak Ridge National Laboratory:

Thomas Zacharia
Associate Laboratory Director, Computing and Computational Sciences
Oak Ridge National Laboratory
Phone: 865 574-4897; Fax: 865 574-4839
E-Mail: zachariat@ornl.gov

Requested Funding ($K):

Institution	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Brookhaven National Laboratory	400	400	400	400	400	**2,000**
Fermi National Accelerator Laboratory	400	400	400	400	400	**2,000**
Georgia Institute of Technology	300	300	300	300	300	**1,500**
Pacific Northwest National Laboratory	400	400	400	400	400	**2,000**
Oak Ridge National Laboratory	600	600	600	600	600	**3,000**
Stanford Linear Accelerator Center	400	400	400	400	400	**2,000**
University of California, Davis	300	300	300	300	300	**1,500**
Total	**2,800**	**2,800**	**2,800**	**2,800**	**2,800**	**14,000**

Use of human subjects in proposed project: No
Use of vertebrate animals in proposed project: No

Principal Investigator Signature/Date

Laboratory Official Signature/Date

TABLE OF CONTENTS

ABSTRACT

Large-scale SciDAC computations and experiments require unprecedented wide-area network capabilities in the form of high throughputs and/or jitter-free connections to support large data transfers, network-based visualizations, computational monitoring and steering, and remote instrument control. Current network-related limitations have proven to be a serious impediment to a number of large-scale SciDAC applications. Realizing the needed wide-area capabilities requires the vertical integration and optimization of the entire application-middleware-networking stack so that the provisioned network capacities and capabilities are available to the applications in a transparent, optimal manner. The technologies required to accomplish such tasks transcend the solution space of traditional networking or middleware areas, and require an active engagement with application scientists.

We propose to create the Center for Applications-Network Total-Integration for SciDAC (CANTIS) to address a broad spectrum of networking-related capabilities for these applications by leveraging existing technologies and tools, and developing the missing ones. The team liaison members proactively engage SciDAC scientists to work closely with them to derive requirements, develop solutions, and accomplish the needed optimizations, customization and tuning of solutions. We propose to provide end-to-end solutions and in-situ optimization modules for the tasks of (a) high performance data transport for file and memory transfers, (b) effective support of visualization streams over wide-area connections, (c) computational monitoring and steering over network connections, (d) remote monitoring and control of instruments including microscopes, and (e) higher-level data filtering for optimal application-network performance. The underlying technologies will be tested, tuned and packaged as CANTIS toolkit for installation, and in-situ tuning and optimization.

1. Background and Significance

Despite the thousand-fold increase in computational power that has been brought to bear on scientific modeling in the last decade, the well-known goal of computational science, "insight, not numbers" is actually receding. The reason is simple. The modeling of complex systems at higher and higher fidelity generates proportionately larger volumes of data that must be visualized, examined, and studied by widely dispersed scientists searching it for insight. Unfortunately, the amount of data now being created by major computational efforts exceeds both the capacity and capability of current network-based data distribution. *The obvious result is that much of the potential for scientific discovery through advanced computing is not being realized*. Several examples exist, including supernova simulation and combustion modeling where data distribution has been delayed or thwarted. However, one of the most dramatic examples surely must be that collecting the data for the current 5-year international normalization of climate models is being done using a large wheeled RAID (Redundant Array of Inexpensive Disks) array that is shipped to participating institutions, filled, and returned to Livermore where the effort is coordinated.

Until recently, this effect has not been due to any inherent bandwidth limitation in the national research and education backbones. Indeed, the 10Gbs backbones of either ESnet or Internet2 can currently offer half of that bandwidth to connect pairs of sites for extended periods. This corresponds to 500 Megabytes per second or 50 terabytes per day. The fact that science users neither see or use [ST01] this bandwidth is symptomatic of much deeper problems, which will only get worse with the next generation of SciDAC requirements. Unfortunately, there is no one single problem, and thus no single magic-bullet solution. Effectively coupling a SciDAC resource (file system or supercomputer) to a high-performance network is a complex exercise in both hardware and software. Because supercomputers are designed by engineers focused on computational performance not network throughput, the network interface, buffering, and software stack have all tended to be afterthoughts. In particular, the software has defaulted to TCP which, as a result of its success in general networks, is the basis for almost all science data network activity. FTP, Grid-FTP, bbcp, and even HTTP are all built on top of TCP.

The unprecedented demands that SciDAC applications are about to place on network infrastructure will push TCP well beyond its useful envelope. The fundamental problem with TCP ultimately reduces to its treatment of bandwidth as a shared resource. Eliminating this shared-resource paradigm is an obvious step, and solutions from network researchers in the form of dedicated, switched-circuit networks are at hand. However, although necessary, these do not provide a complete solution to the network problems of SciDAC applications. The other major bottleneck is associated with the fact that each SciDAC resource is unique. The supercomputers and disk systems are unique, each with a different architecture, different I/O buffering, and even different hardware interfaces. In addition, each major application tends to use its supercomputer in a unique way. The result is that for a SciDAC application to achieve good or even reasonable coupling to a high-performance network, it must be impedance-matched at all layers of the I/O system. This was dramatically illustrated in the course of coupling the Terascale Supernova Initiative (TSI) application to a dedicated network link between Oak Ridge National Laboratory (ORNL) and North Carolina State University (NCSU). The TSI hydrodynamics code is executed on the ORNL Cray X1 and the data sets are transferred to NCSU for further analysis. Using tuned bbcp (a multiple stream TCP-based transport package) over a 1Gbps connection on the production network, the throughput was initially limited to 200-300 Mbps. The shared nature of the connection was initially thought to be the main source of this throughput limitation. The proposed solution was to provide a dedicated 1Gbps connection over the NSF CHEETAH network [ZV05] from Cray X1 OS nodes to the target NCSU cluster, and use the Hurricane protocol, which could achieve 99% utilization on dedicated 1 Gbps connections [RW06]. Simultaneously, and coincidentally, the Cray X1 was upgraded to a Cray X1(E), which involved replacing the OS processors with more powerful ones. The combination of dedicated connection and Hurricane software was handed off to TSI scientists, who were expecting to see network throughputs of 1Gbps. Instead, throughputs were of the order of 20 Mbps. This problem was finally traced by a joint ORNL and Cray team to a bottleneck in the IP protocol stack on the Cray X1, which was later addressed. This process required a careful and systematic analysis of the components of end-to-end data and execution paths, and was possible only because the NSF CHEETAH and LDRD projects at ORNL had established a close collaboration between TSI scientists and computer scientists. **The goal of this proposal is to provide such a collaborative capability to all SciDAC projects for a wider spectrum of *Application-Middleware-Network* (ANM) tasks.**

We propose to create the **Center for Applications-Network Total-Integration for SciDAC *(CANTIS)*** to address the totality of the problem space needed for end-to-end performance of SciDAC applications. The primary goal is to serve as a comprehensive resource to equip SciDAC applications with high-performance network capabilities in an optimal and transparent manner. As an integral part of its charter, it will proactively engage SciDAC PI's and science users to integrate the latest networking and related techniques with SciDAC applications and thus remove current network-related performance bottlenecks. This project addresses a broad spectrum of networking-related capabilities needed in SciDAC applications by leveraging existing technologies, and where necessary, developing missing ones.

1.1 Networking Needs of Large-Scale SciDAC Applications

Supercomputers such as the new National Leadership Computing Facility (NLCF) and others being constructed for large-scale scientific computing are rapidly approaching 100 teraflops speeds, and are expected to play a critical role in a number of SciDAC science projects. They are crucial to several SciDAC fields including high energy and nuclear physics, astrophysics, climate modeling, nanoscale materials science, and genomics. These applications are expected to generate petabytes of data at the computing facilities, which must be transferred, visualized, and analyzed by geographically distributed teams of scientists. The computations themselves may have to be interactively monitored and actively steered by the scientist teams. In the area of experimental science, there are several extremely valuable experimental facilities, such as the Spallation Neutron Source (SNS), the Advanced Photon Source (APS), and the Relativistic Heavy Ion Collider (RHIC). At these facilities, the ability to conduct experiments remotely and then transfer the large measurement datasets for remote distributed analysis is critical to ensuring the productivity of both the facilities and the scientific teams utilizing them. Indeed, high-performance network capabilities add a whole new dimension to the usefulness of these computing and experimental facilities by eliminating the "single location, single time zone" bottlenecks that currently plague these valuable resources.

Science Areas	**Today End2End Throughput**	**5 years End2End**	**5-10 Years End2End**	**Remarks**
High Energy Physics	0.5 Gb/s	100 Gb/s	1000 Gb/s	high bulk throughput
Climate (Data & Computation)	0.5 Gb/s	160-200 Gb/s	N x 1000 Gb/s	high bulk throughput
SNS NanoScience	Not yet started	1 Gb/s	1000 Gb/s + QoS for control	remote control and time critical throughput
Fusion Energy	0.066 Gb/s (500 MB/s burst)	0.198 Gb/s (500MB/20 sec.)	N x 1000 Gb/s	time critical throughput
Astrophysics	0.013 Gb/s (1 TBy/week)	N*N multicast	1000 Gb/s	computational steering and collaborations
Genomics Data & Computation	0.091 Gb/s (1 TBy/day)	100s of users	1000 Gb/s + QoS for control	high throughput and steering

Table 1. Current, near- and long -term network bandwidth requirements form DOE Roadmap workshops.

Three DOE workshops were organized during 2002-2003 to define the networking requirements of large-scale science applications, discuss possible solutions, and describe a path forward. Experts from DOE science areas including high energy physics, nuclear physics, climate, nanoscience, fusion energy, astrophysics and genomics, worked closely with computer scientists and network experts to develop requirements at the first workshop [H02] (summarized in Table 1). Later, more focused workshops developed a road-map for DOE science networks [D03b] and research agendas for provisioning and protocols areas [D03a]. The networking requirements of several DOE applications, including SciDAC, fall into two broad categories: (a) high bandwidths, typically multiples of 10Gbps, to support bulk data transfers, and (b) stable bandwidths, typically at much lower bandwidths such as 100s of Mbps, to support interactive, steering and control operations. These requirements cut across a number of SciDAC enabling tasks: (i) file and memory data transfers; (ii) remote visualizations of datasets and on-going computations; (iii) computational monitoring and steering; and (iv) remote experimentation and control. We emphasize that these capabilities must be available to the scientists at the application level in a transparent, optimized manner. In the years since the workshops, it has become clear that network infrastructures with these data rates constitute only a part - albeit very important and essential part - of the overall solutions needed for enabling the applications, and particularly so for a number of SciDAC projects.

1.2. Limitations of Current Networks

It has been recognized for some time within DOE and National Science Foundation (NSF) that current networks and networking technologies are inadequate for supporting large-scale science applications [H02, N01]. First, the required bulk bandwidths are available only in the backbone, typically shared among a number of connections that are unaware of the demands of others. As can be seen from Table 1, the requirements for network throughput are expected to grow by a factor of 20-25 every two years. These requirements will overwhelm production IP networks that typically see bandwidth improvements by only a factor of 6-7. Second, due to the shared nature of packet switched networks, typical Internet connections often exhibit complicated dynamics, which preclude the low jitter connections needed for steering and control operations. These requirements are quite different from those of a typical Internet user that needs smaller bandwidths at much higher delays and jitter levels (typically for email, web browsing, etc.). As a result, industry is not expected to develop the required end-to-end solutions of the type and scale needed for these applications. Furthermore, the operating environments of SciDAC applications consisting of supercomputers, high-performance storage systems and high-precision instruments present a problem space that is not traditionally addressed by the main stream networking community. Indeed, focused efforts from multi-disciplinary teams are necessary to completely develop the required capabilities.

1.3. Application-Middleware-Network Integration

One important realization in several large-scale science applications is that increases in network bandwidth must be augmented with a careful design, smooth integration and optimization of the entire AMN stack. When connection bandwidths are increased, performance bottlenecks move to a different part of the AMN stack, typically from network core to end hosts or subnets. Consequently, SciDAC capabilities require a vertical integration and optimization of the entire AMN stack to make the provisioned capabilities available to applications. The phrase *AMN Total-Integration (AMNTI)* collectively refers to the spectrum of technologies needed for accomplishing these tasks, which transcend the solution space addressed by traditional networking or middleware areas.

At present, efforts to address SciDAC AMNTI challenges have been scattered among a number of science and networking projects, often carried out by ad hoc teams with duplicated efforts. For example, file transfer methods have been independantly developed in fusion energy, high energy physics and astrophysics projects. In addition, application scientists were sometimes forced to become networking experts or invest significant project funds to recruit experts, a distraction from their main science mission. Even when such efforts were successful, isolated technology solutions only resulted in limited application-level improvements. Considering the significant commonalities among SciDAC requirements, an integrated effort addressing all AMN components is crucial to efficiently achieving these capabilities.

1.4 CANTIS Concept and Organization

The center will focus on making high-performance networking capabilities available to a spectrum of SciDAC applications including the ones using DOE experimental and computing facilities. The center is based on two concepts: first, *Technology Experts* to address specific technical areas, and second, *Science Liaisons* with assigned science areas to work directly with SciDAC scientists. The center will leverage existing tools and techniques, particularly in application software, middleware and visualization areas. Simultaneously, the center will also develop nascent networking and interface technologies to provide the latest developments in high performance networking to enhance SciDAC applications. The science liaisons will actively engage scientists in their assigned areas, through regular meetings and interactions, to help the center stay abreast of SciDAC requirements, anticipate SciDAC needs and guide the development, transfer and optimization of appropriate performance-enhancing and "gap-filling" shims.

The center will serve as a one-stop resource for any SciDAC scientist with a high-performance network requirement. In addition to actively pursuing SciDAC network-related needs, it will also respond to requests initiation by scientists. In either case, a single science liaison will be assigned who would interface with technology experts to: (i) identify the technology components, (ii) develop comprehensive network-enabling solutions, and (iii) install, test and optimize the solutions. Each participant institution of this center is assigned science areas (Section 4) to act as a liaison based on their prior and on-going relationships with science projects. Also each institution will lead in specific technical AMN areas.

We propose to develop tools specifically tailored to SciDAC to generate application-level connection profiles, and identify potential components of an end-to-end AMN solution. We will develop in-situ optimization tools that can be dropped in-place along with the application to identify the optimal AMN configurations such as an optimal number of transport streams, decomposition and mapping of a visualization pipeline, and transparent and agile operation over hybrid circuit/packet-switched or IPv4/v6 networks. We will also develop libraries customized to SciDAC for various AMN technologies. These tools cut across a wide spectrum of SciDAC applications, but may not be necessarily optimal (or optimally configured) for a specific application environment. Team member liaisons will work closely with SciDAC scientists to accomplish any needed finer optimization, customization and tuning.

This center consists of subject-area experts from five national laboratories: Brookhaven National Laboratory (BNL), Fermi National Accelerator Laboratory (FNAL), Oak Ridge National Laboratory, Pacific Northwest National Laboratory (PNNL) and Stanford Linear Accelerator Center (SLAC); and two universities, Georgia Institute of Technology (GaTech) and University of California at Davis (UCDavis). The team members are active participants in SciDAC, NSF and other enabling technology projects for large scale science projects. They have been involved in the DOE workshops [H02,D03a,D03b] where they engaged scientists in the development of requirements and DOE networking roadmap. Some of them originally worked in science area such as high energy and nuclear physics.

Team members, together, have an extensive research and practical expertise in networking as well as in enabling applications and middleware to make optimal use of provisioned network capabilities. The specific technical AMN tasks and their institutional primary assignments are as follows:

- **BNL** is the primary repository for storage and dissemination of tools and work products of the project. It will also provide Terapaths software for automatic end-to-end, inter-domain operation.
- **FNAL** will provide Lambda Station and its IPv4/v6 expertise for massive file transport tasks. Also, it will address host performance issues including Linux operating system under load.
- **GaTech** will address the "impedance matching" of network-specific middleware to different transport technologies. It will provide expertise in middleware-based data filters to the project.
- **ORNL** will provide an overall coordination of the project, and will also provide the technologies for dedicated-channel reservation and provisioning, and optimized transport methods.
- **PNNL** will generalize and extend the remote instrument control software it is currently developing for remote control of its confocal microscope facility.
- **SLAC** will bring its expertise in network monitoring to the project, with a specific emphasis on end-to-end monitoring and dynamic matching of applications to network characteristics.
- **UC Davis** will focus on optimizing remote applications by distributing component functions, and they will particularly concentrate on remote visualization tasks.

As an overall lead for this project, ORNL will coordinate various liaison and research activities.

2. Preliminary Studies

We present in this section a brief account of previous work by team members that will contribute to CANTIS technologies. These works, at various stages of development, together form the building blocks of CANTIS. We first describe our experiences with TSI to motivate the technical areas.

2.1. TSI Experiences and Genesis of CANTIS

The Petascale Supernova Initiative (PSI), previously TSI, is a large-scale multi-disciplinary SciDAC project that involves core collapse supernova computations on supercomputers. It requires a close collaboration from a team of domain experts who are distributed at various national laboratories and universities to carry out the computations, visualizations and analysis. Currently, TSI scientists utilize the supercomputers at ORNL and National Energy Research Scientific Computing Center (NERSC) for computations, and archive at local high-performance storage systems (HPSS). A hydrodynamics-based TSI computation currently generates a terabyte dataset in about 8 hours on ORNL Cray X1. The data are then transferred to remote nodes to be locally visualized and analyzed. Collaborative visualizations or computational steering across wide-area networks are currently not carried out for lack of required capabilities. This TSI model computes a small number of supernova variables, and runaway computations are discovered only during post processing.

PSI is expected to take into account several important additional variables which will result in petabyte datasets. PSI's enabling tasks range from cooperative remote visualization of massive archival data through the distribution of large amounts of simulation data, to the interactive evolution of supernova computation through computational steering. Together, these PSI capabilities would enable the group of scientists to carry out coordinated analysis, and avoid runaway computations by steering on-line. The networks over which such collaborations will be carried out could be quite varied, with national laboratories connected over the ESnet, and the universities connected via Internet2 or other regional networks. In addition to the need for massive data transfers, PSI also illustrates the requirement for precise control channels and is an exemplar of broad spectrum network needs in large-scale science computations.

ORNL PIs have been actively involved in TSI requirements analysis and AMN technology support [RC05] which provided us valuable hands-on experience. Our specific contributions include: provisioning dedicated channels between Cray X1(E) and NCSU clusters; identifying and diagnosing wide-area throughput problems of Cray X1(E); tuning bbcp transport modules [BBCP] and developing Hurricane protocol [RW06]; developing optimal decomposition and mapping of visualization pipelines for wide-area operations [WZ06]. These efforts have been supported by three networking projects funded by DOE, LDRD and NSF with TSI as a target example; these projects end in FY06. They required a significant amount of initiative, coordination and efforts both by TSI scientists and ORNL PI's. In some respect, the concept of CANTIS grew out of these experiences combined with the interest expressed by scientists from other science areas including climate, combustion and fusion energy for such collaborations. The broad-based, integrated CANTIS approach eliminates the need for separate efforts across multiple SciDAC science projects.

2.2. Network Provisioning

SciDAC scientists are distributed across various national laboratories and universities, with quite varied network connections, including ESnet, Internet2 and other infrastructures. It is generally believed that networking demands of large-scale sciences can be effectively addressed by providing on-demand dedicated channels of the required bandwidths directly to end users or applications. ORNL PIs are involved in two such projects. The UltraScience Net (USN) is commissioned by DOE to facilitate the development of these constituent technologies specifically targeting the large-scale science [RW05]. Its main objective is to provide developmental and testing environments for a wide spectrum of network technologies that can lead to production-level deployments within next few years. USN has a larger backbone bandwidth (20-40 Gbps) and footprint (several thousands of miles) compared to other testbeds, and has a close proximity to several DOE facilities. USN provides on-demand dedicated channels: (a) 10

Gbps channels for large data transfers, and (b) high-precision channels for fine control operations. User sites can be connected to USN through its edge switches, and can utilize the provisioned dedicated channels during the allocated time slots. Its data plane consists of dual 10 Gbps lambdas connecting ORNL to Chicago to Seattle to Sunnyvale. Circuit-switched High-speed End-to-End Transport ArcHitecture (CHEETAH) [ZV05] is an NSF project to develop and demonstrate a network infrastructure for provisioning dedicated bandwidth channels and the associated transport, middleware and application technologies to support large data transfers and interactive visualizations for eScience applications, particularly TSI. Its footprint spans NCSU and ORNL with a possible extension to University of Virginia and City University of New York. Both these networks are developing control plane technologies to support connection setup requests from application modules and end users.

The TeraPaths project at BNL investigates the use of LAN Quality of Service (QoS) and Multiprotocol Label Switching (MPLS) in enabling data transfers with guaranteed speed and reliability that are crucial to applications. BNL needs to carry out RHIC production data transfers and LHC (Large Hadon Collider) Monte Carlo datasets between BNL and the remote collaborators, whose aggregate peak network requirement exceeds BNL network capacity. To address this limitation, TeraPaths technologies modulate LHC data transfers to opportunistically utilize available bandwidth to ensure that RHIC production data transfer is not impacted. During 2005, about 270 Terabyte of data (3.5 billion proton-proton events) were moved to Japan over a period of 11 weeks. We integrated the capability to configure dedicated fractions of bandwidth via QoS and limit their disruptive impact upon each other. These QoS capabilities are implemented by a web-service which allows the applications to reserve bandwidth from LAN. We are collaborating with OSCAR project [OSCA] over ESnet and BRUW project over Internet2 [BRUW] to configure end-to-end paths with guaranteed bandwidth.

FNL initiated the LambdaStation project [B06] to enable production network facilities to exploit advanced research network facilities. The objective is to forward designated data transfers across these advanced wide-area networks on a per-flow basis, making use of the production-use storage systems connected to the local campus network. To accomplish this, we developed a dynamically provisioned forwarding service to provide alternate path forwarding onto available wide area advanced research networks. The service dynamically reconfigures the forwarding of specific flows within our local production-use network facilities, as well as provides an interface to enable applications to utilize the service. LambdaStation is also being integrated into dCache/SRM [DC06], and interesting behaviors of TCP data flows due to dynamic paths switching [BC06] are being investigated.

More generally, MPLS tunnels provide dedicated bandwidth channels over IP networks such as ESnet and Internet2. Their wide-spread deployment and availability to SciDAC applications will depend on technology maturation and footprints of these networks and connectivity to the sites. Together, CANTIS team from USN, CHEETAH, TeraPaths and LambdaStation projects has an extensive expertise in provisioning and effectively utilizing both the shared IP connections and various dedicated channels. Our plans are to empower applications and CANTIS tools with the control plane interfaces for setting up on demand network connections and dynamically adapting flows to optimize application-level performance.

2.3. Host Performance Issues

In addition to the connection properties, a number of host components play a critical role in deciding the achieved throughputs or jitter levels experienced by the application, and their effects become particularly important at 1-10 Gbps or higher data rates [WP05]. A majority of scientific computing on commodity or "white box" computers uses the Linux Operating System (OS). Furthermore, powerful computing clusters are built using Linux OS, and more recently a number of supercomputers are utilizing Linux OS, for example as I/O nodes by IBM BlueGene [IBM] and processing nodes by SGI Altix [SGI] and Cray XD1 [CXD]. From a network performance perspective, Linux represents an opportunity since it is amenable to optimization and tuning due to its open source support and projects such as web100 [W100] and net100 [DM02] that enable tuning of network stack parameters.

Single stream throughputs between Linux host systems, outfitted with top-of-the-line hardware and expertly tuned operating parameters, have achieved rates very near 1 Gbps throughput over production wide-area IP networks. However, similar machines running a scientific computational workload fall far short of such network throughputs, by a greater factor than might reasonably be expected. FNL PIs have instrumented recent Linux kernels to monitor packet movement and queue occupancies under various loads. They identified points at which orders of queuing and processing could be rearranged to reduce the impact of system load on network throughput [WC06]. The combined host and network effects on application throughputs can be visualized by the throughput profiles [RWI04], and the host parameters can be tuned to optimize the utilization of channels.

SLAC has extensive research and real-life experience with identifying and resolving the host based bottlenecks for high throughput network transfers. With the advances in technological hardware such as 10 Gbps network interface cards and PCI-X2, more and more emphasis is being put on the performance between network elements. Low level OS parameters such as queue sizes and TCP congestion control algorithms are often the cause of low throughput performances experienced by 10 Gbps NICs and connections. This is especially apparent when we consider the shared nature of the wide area network where users compete for bandwidth. In particular, we have extensively tested the performances of new TCP algorithms that promise effective and fair network resource utilization. We also experimented with UDP-based transport algorithms that can fully utilize lambda and QoS/DiffServ network paths and are currently working closely with BNL to monitor QoS paths effectively.

Another important host-related expertise is GaTech's prior work on efficient methods for kernel-level data streaming and online message scheduling, implemented in the Linux OS kernel. Our experience with kernel-level support for high performance data streaming is derived from the KStreams [KS04] kernel facility implemented in 2.4.22 Linux kernel. KStreams was used to create (1) data streams that arrive on multiple incoming sockets and are forwarded to multiple outgoing sockets [PS02] and (2) to mirror a single incoming data stream to multiple remote sites [GS02]. Other examples include dynamic data stream manipulations, such as data down sampling [FG99], format conversion [GS03], and similar "lightweight" data transformations. We developed the Dynamic Window-Constrained scheduler for real-time and best-effort packet Streams (DWCS) packet scheduler [WP00] to maximize network bandwidth usage in the presence of multiple packets, each with their own delay constraints and loss-tolerances. The per-packet delay and loss allowances are provided as attributes, generated from higher-level application constraints. Given the presence of some underlying bandwidth reservation scheme (such as USN scheduler or OSCARS), the DWCS algorithm has the ability to share bandwidth among competing clients in a strict proportion of their deadlines and loss-tolerances. The DWCS packet scheduler is currently being used in an ongoing DOE-funded SBIR effort.

2.4. Network Measurements

Effective network monitoring enables the strategic management, problem tracking (and thus solving), and informed engineering of both local and wide area networks. Generally, there are two aspects of network monitoring, namely performance of routers, switches and computers, and the usage and performance between the nodes. It is important to understand both aspects to be able to successfully monitor the complete end-to-end path and thus diagnose problems and or reduce the effect of end-to-end congestion.

SLAC's primary projects involve Pinger [PINR] and IEPM-BW [IEPM] which actively monitor the end-to-end network performance patterns across several academic and commercial networks. SLAC has over 14 years of experience in monitoring computer networks over the wide area. Currently, SLAC provides network monitoring with regular active and passive measurement methods to provide a detail representation and trends of Internet usage patterns and performances. Using monitoring tools such as OWAMP [OWAM], ping, traceroute, iperf, thrulay [THRU], pathchirp [PACH] and pathneck [PANE], we have extensively studied the accuracy and effectiveness of network monitoring tools and have collected several GBytes of network performance data. Of particular interest are the extremes of network performance. Our recent paper [DIGI] on the digital divide studies the growth of network usage patterns around the world over the last decade of not only the technologically advanced nations, but also that of growing nations. We have shown that the trends in performance are associated with advances in the underlying technology available to those countries. SLAC, in collaboration with other High Energy Physics institutions, holds the previous three consecutive year's record in being able to push the boundaries of network throughput and utilization during SuperComputing Bandwidth Challenge. Our current record stands at over 150Gbps, with the transfer of over 1 TB of data within 24 hours [SC05].

2.5. Data Transport Methods

For low bandwidth requirements over shared connections current TCP methods could be sufficient or could be tuned using tools such as net100 and parallel TCP. The problem of transporting data through "fat" dedicated pipes with large Delay Bandwidth Product (DBP) is not adequately solved by TCP [HJ04,F03]. These problems have been addressed by several researchers. For example, GridFTP [Wu04] sets up multiple TCP connections between the source and destination to achieve higher aggregate bandwidth compared to a single TCP stream; bbcp employs a similar scheme without the grid-related modules. UCDavis PIs proposed a lightweight end-system for probing end-system performance metrics such as the dynamic priority of various tasks at the receiving end-system, to detect congestion early, and send feedback to take action to avoid packet losses. One example of such action is to suspend transmissions during congested periods. These features have been integrated into a prototype protocol called RAPID (Rate Adaptive Protocol for Intelligent Delivery) [B206]. In our preliminary studies demonstrate that RAPID reduces file-transfer time, and hence, improves end-to-end throughput.

Channel	Provisioned bandwidth	Peak Hurricane throughput	Bottleneck segment	Network infrastructure
A	1 Gb/s	990 Mb/s	N/A	Production network
B	10 Gb/s	2.4 Gb/s	Disk/file throughput	UltraScience Net
C	450 Mb/s	434 Mb/s	N/A	Production network
D	1 Gb/s	480 Mb/s	Processor time	CHEETAH

Table 2 – Hurricane throughput on various channels.

The effects of shared IP connections on network throughputs have been studied extensively [FF03,HJ04]; but such studies on dedicated channels are limited [RW6,ZV05,RWC04]. ORNL PI's have developed a new class of protocols for maximizing the utilization of dedicated channels and achieving stable dynamics for control channels. A UDP-based protocol, Hurricane, was developed which utilizes host level optimization to adjust data flows. Hurricane's overall structure is quite similar to other UDP-based protocols, in particular UDT [GG04] and SABUL [GH04]. However, certain unique ad hoc optimizations are incorporated into the protocol. The low loss rate at which high throughput is achieved motivated a NACK-based scheme since a large number of ACKS would otherwise consume significant bandwidth and CPU time. The initial source sending rate in Hurricane is derived from the throughput profile of the channel, and is further tuned manually to achieve high throughput. Experimental results on application-level throughputs achieved by Hurricane for file transfers using workstations, a cluster, Cray X1 and Cray X1E as end hosts are presented in Table 2. On 1 Gbps wide-area channel between two Linux hosts we achieved 99% utilization of the connection-bandwidth.

For implementing stable flows, TCP is inherently ill-suited because by default it attempts to infer and occupy the available bandwidth, which is the entire channel capacity in case of a dedicated channel. While the sending rate of TCP can be clipped to a desired level by suitably restricting the flow window sizes, the non-zero loss rates at peak sending rates results in TCP underflows. Furthermore, small amount of random packet losses can drive TCP dynamics into chaotic regimes [RG05] wherein it is very difficult to use it for controlling remote processes or devices. A throughput stabilization protocol using flow control based on the Robbins-Monro stochastic approximation method was developed by us [RWI04]. It was analytically shown that this protocol achieves stable goodput under random losses, and it performs robustly over both shaded and dedicated connections.

SLAC has extensive experience in the testing and analysis of new transport applications. Programs such as bbcp [BBCP] and xrootd [XROO] have been proven in both high-performance experiments (at the recent SuperComputing 2005 conference) and in large scale production systems. As networks become more intelligent and incorporate advanced technologies, it will be even more useful to be able to interface with the network services. Through a close collaboration with both SciDAC projects and internal SLAC initiatives, we propose to integrate the two into one cohesive and effective package.

Our overall CANTIS approach is to test various available transport methods using the measurement infrastructure and select suitable candidates using profiling tools and optimize the application performance using in-situ optimization tools proposed in the next section.

2.6. Connections to Supercomputers

Supercomputers present wide-area performance challenges that are not typically addressed by the mainstream networking community mainly due to the complexity of data and execution paths inside those machines and their interconnections to wide-area networks. This is illustrated by ORNL's analysis and preliminary work in this area. Data from a Cray X1 node traverses a System Port Channel (SPC) channel and then transits to a FiberChannel (FC) connection to the CNS (Cray Network Subsystem). The CNS converts FC frames to Ethernet LAN segments and sends them on to a GigE NIC. These Ethernet frames are then mapped at the ORNL gateway router onto a SONET long-haul connection to NCSU, where they transit to an Ethernet LAN and finally arrive at the cluster node via GigE NIC's. Thus the data path consists of a sequence of different segments: SPC, FC, Ethernet LAN, SONET long-haul, and Ethernet LAN. The TCP stack optimized for usual network connections consisting of wide-area SONET connections terminated at Ethernet LANs does not perform well for this complex data connection, as evidenced by the observed 50 Mbps throughput of TCP over a 1 Gbps connection. Subsequently we adapted bbpc for the Cray X1 and achieved throughputs in the range of 200-300Mbps depending on the traffic conditions. Hurricane protocol tuned for this connection consistently achieved throughputs of the order of 400Mps [RW06].

Since the capacity of Cray X1's NIC is limited to 1Gbps, we developed an interconnection configuration to yield network throughputs higher than 1 Gbps [RC05]. In place of its native CNS we utilized USN-CNS (UCNS) which is a dual Opteron host containing two pairs of PCI-X slots; it is equipped with two FC (Emulex 9802DC) cards each with two 2Gbps FC ports, and a Chelsio 10GigE NIC. A similar host with a 10GigE NIC is used as a data sink. Then channel bonding was disabled on UCNS, and parallel streams were sent through the individual channels. In this configuration, memory-to-memory transfers reached 3Gbps for writes and 4.8Gbps for reads between Cray X1 and UCNS. These are among the highest throughputs reported from Cray X1 to external hosts over local and wide-area connections. However, when Cray X1 was upgraded to a X1(E) such performance could no longer be achieved due the host-level performance bottleneck described in Section 1. Nevertheless, this experience has been extremely valuable in analyzing and developing AMN technologies for supercomputers. We note that the architectures of supercomputers are varied and must be explicitly studied in-depth to develop the needed AMN technologies.

2.7. Optimal Network Realizations of Visualization Pipelines

Remote visualization is considered a critical enabling technology for a number of large-scale scientific computations that involve visualizing large datasets on storage systems using remote high-end visualization clusters. Such systems of different types and scales have been a topic of focused research for many years by the visualization community. In general, a remote visualization system forms a pipeline consisting of a server at one end holding the dataset, and a client at the other end providing rendering and display. In between, zero or more hosts perform a variety of intermediate processing and/or caching and prefetching operations. A wide area network typically connects all the participating nodes. The goal is to achieve interactive visualization on the client-end without transferring the whole dataset to it. ORNL PIs developed an approach to dynamically decompose and map a visualization pipeline onto wide-area network nodes for achieving fast interactions between users and applications in a distributed remote visualization environment [WZ06]. This scheme is realized using modules that implement various visualization and networking subtasks to enable the selection and aggregation of nodes with disparate capabilities as well as connections with varying bandwidths. We estimated the transport and processing times of various subtasks, and developed a polynomial-time algorithm to compute decomposition and mapping that achieves minimum end-to-end delay. Our experimental results based on an implementation deployed at several geographically distributed nodes illustrated the efficiency of this system [WZ06].

In another direction the UCDavis team addressed the problem of aggregating files needed for visualizations from distributed databases by identifying concurrent routes in the lambda grid network and scheduling the transfers. We adopted a hybrid approach that combines off-line and on-line scheduling. We defined the Time Path Scheduling Problem (TPSP) for off-line scheduling and proved it to be NP-complete using Integer Linear Program (ILP) formulation; then we proposed a greedy approach to solve it. We have compared the performance of the greedy algorithms on sample lambda grid topologies. We have also studied online reconfiguration algorithms, so that, as files are transferred, the off-line schedule may be dynamically modified depending on actual file transfer times. This helps to improve link utilization and reduce the download times [B04]. Together, ORNL and UCDavis provide an extensive expertise in optimally executing remote visualization tasks over different wide-area connections.

2.8. Application-Middleware Filtering

GaTech's IQ-Echo project deals with the interoperability and QoS across heterogeneous hardware/software platforms and created network-aware middleware for high performance applications [GK06]. IQ-ECho addresses the increasing heterogeneity of hardware/software platforms on which teams of researchers conduct scientific collaborations, which makes it difficult to guarantee the timely transport of data and execution of software required for seamless remote collaboration. The key contribution of the IQ-ECho middleware is its ability to act in a network-aware fashion, (i) by permitting applications to associate application-specific services with data transport middleware, and (ii) by controlling the way in which such data filters or data selectors operate with dynamic performance attributes. These attributes capture current application requirements and current network conditions, the latter extracted from the underlying network with passive or active measurement techniques. Performance improvements from using IQ-Echo can be substantial, including up to 25% improvements in message delivery rates when information sources "pace" the data offered in conjunction with available network bandwidth, and almost threefold improvements in message rates when a client-specific data down-sampling service is used to control the amounts of data sent from data server to client. In addition to applying IQ-ECho to remote data visualization and online application monitoring, its principles were also used to create IQ-GridFTP, a network-aware version of the popular GridFTP package [GK06].

2.9. Remote Control of Microscopes

PNNL developed a system to support remote control of confocal microscopes, and completed a proof of concept demonstration. This system ties in existing microscope control systems with two new components, namely a client application and network layer daemon. The new client application can run on a remote workstation. Currently, on the machine local to the microscope, there is a production grade Graphical User Interface (GUI) called CaMatic. The existing microscope control system is written as a Visual Basic application, and uses an OCX C++ application to control the two cameras of the microscope. The OCX application also provides the visual feedback of the positioning imagery and any image capture playback. The new client application presents the same GUI as the current production system; it is written in Visual Basic and provides that same look and feel. Moreover, it has an OCX C++ application to provide the visual feedback of positioning control and of image captures remotely. The new client works in conjunction with the CaMatic application that is local to the microscope. It supports all the functionality of the local system in conjunction with the local CaMatic system over network connections. We propose to further develop this system to optimize the performance over various network connections, generalize it to other microscopes used in SciDAC applications, and integrate it into CANTIS toolkit to be available to science applications.

3. Research Design and Methods

The technical focus areas of CANTIS are: (a) high performance data transport for file and memory transfers, (b) effective support of visualization streams over wide-area network connections, (c) computational monitoring and steering over network connections with an emphasis on leadership-class applications, (d) remote monitoring and control of instruments including microscopes, and (e) higher-level data filtering for optimal application-network performance. Each of these areas is supported by a number of technical tasks described in this section, which are based on the building blocks from previous section. All these underlying technologies will be integrated into CANTIS toolkit.

3.1. CANTIS Toolkit

We propose to develop two types of tools, end-user tools and system tools, which facilitate the utilization and integration of various CANTIS technologies. The end-user tools will enable science users to utilize CANTIS technologies in a transparent manner, and the system tools collect measurements, generate profiles, and facilitate the configuration and optimization of component technologies.

3.1.1 End-User Tools

The end-user tools will integrate modules to support the automatic selection, in-situ optimization and configuration of various component technologies. We propose to develop a unified CANTIS user interfaces with options for executing different modules including data transfer, visualizations, computational monitoring and steering, and remote control. We propose a system for computational tasks which will enable scientists to remotely launch their computations on supercomputers or visualization codes on remote clusters through GUI. Similarly, we propose a system for control applications to enable scientists to connect to remote microscopes, conduct experiments and archive the images at remote storage sites. The tool will be capable of requesting and setting up the needed connections, choosing appropriate transport modules and their parameters, and setting up and optimizing the needed end-to-end connections; this entire process will be carried out transparently to the user. This toolkit will be gradually built during the course of this project by progressive integration of component technologies as they mature.

3.1.2 System Tools

The systems tools encompass a collection of existing tools and three new tools that integrate a number of lower-level tools.

(A) Channel Profiling: We propose a Channel Profiling Tool (CPT) that generates the application-to-application throughput profiles (described in Section 3.2.5) by utilizing send/receive modules specific to the hosts and the connections between them; these module may range from simple TCP socket calls to customized application-level data transfer systems. These tools will be further enhanced using network models of the end-systems including models for receivers [C93, M98] and disk I/O systems [G98,A01].

(B) In-Situ Optimization: We propose to develop In-situ Optimization Tools (IOT) that will utilize the profiles generated by CPT. By utilizing various host and connection measurements and flow control parameters that are communicated to the sender, these tools optimize the end-to-end application performance.

(C) Performance Monitoring: The Performance Modeling Tool (PMT) integrates a collection of existing tools to monitor the CPU, memory, and I/O systems load and the network throughput and delay, and provides feedback on the location and the intensity of performance bottlenecks. PMT includes network monitoring tools such as pathchirp [PACH] pathload [PALO] and Iperf [IPER], and also tools that monitor end-system kernel level events such as MAGNET [G03].

In addition to the tools, CANTIS technologies will be implemented as a number of independent libraries, and their functionalities will be provided to scientists as a set of well-defined Application Programming Interface (API) functions. The liaisons will work with scientists to analyze their workflows to identify the best locations to deploy the tools and integrate the API functions.

3.2. Component Technical Areas

Due to the wide variety of CANTIS tasks, the underlying technical components are quite extensive and varied, and due to page limits we will only briefly describe them in this section.

3.2.1 Network Provisioning

Within next five years, it is expected that the bandwidth of IP networks will be significantly enhanced, and there will be an increasing availability networks that can provide dedicated bandwidth channels to applications either on-demand or through advanced reservation. Furthermore, the network control-planes will be enhanced to accept messages, such as MPLS or Generalized MPLS (GMPLS) [YS06], to dynamically setup the required paths. The CANTIS framework will vertically integrate hybrid networks along with control-plane signaling methods into the AMN stack. We will harvest results from the existing DOE projects, such as USN, OSCARS, TeraPaths and LambdaStation (Section 2.2) to provision the required connections on-demand or in advance and dynamically adjust the flows. In addition, we will also closely collaborate with non-DOE network research projects such as CHEETAH [ZV05], DRAGON [DRA] and HOPI [HOPI], to peer with their networks and exchange the technologies. Currently, there is a close collaboration between ORNL PIs and HOPI and DRAGON teams which will facilitate these efforts. In addition, we will also closely work with ESnet, Internet2 and LHCnet [LHC] infrastructure teams.

In meeting the SciDAC application-level requirements, there are some gaps between the functionalities provided by these individual projects that must be addressed in integrating these technologies into the AMN stack. CANTIS will build on these technologies by encapsulating and integrating them into the toolkit. It will utilize dynamic provisioning, monitoring and flow adaptation methods to enable applications to setup and operate the needed connections. The new bandwidth scheduling algorithm developed in USN will be enhanced and applied here to ensure efficient resource utilization and equitable sharing. End-to-end monitoring proposed in the previous section will be used to track the state of network and data flows, diagnose performance degradation and errors, and provide an automatic recovery mechanism to allow service continuation. We propose three research and development areas to bring end-to-end quality of service to the application level: 1) a network provisioning service that provides the substrate network management and schedule, 2) a network aware storage resource middleware, and 3) a data management and distributions system.

Most large institutions have multiple WAN connections provided by different Internet service providers (ISP's). For example, all participating DOE labs are connected to ESnet. In addition, PNNL, SLAC, FNAL, and ORNL are connected by USN, and BNL is connected by NYSERNET. The proposed network provisioning component will utilize multiple networks to provide higher availability and performance compared to any single one. This service will keep track of the status of end hosts, site LAN's, and site ISPs using data collected by the Datagrid WAN Network Monitoring Infrastructure [DWMI], PerfSonar [SONA] and Monalisa [MONO], and will interact with their management agent or web services. The service agents will have a database containing the current reservation status and resource monitoring information. It will use the USN scheduling algorithm for path computation and the Terapaths signaling system for path setup and teardown. The paths could be layer-2 or MPLS tunnels augmented by QoS attributes or a combination. We will integrate LambdaStation technologies into CANTIS tools to achieve robustness and graceful degradation under failure of the provisioned paths by steering traffic away from problematic paths through proactive monitoring. Under normal conditions, traffic will be forwarded via provisioned paths. When these connections experience problems, the monitoring system raises an alarm; then traffic will steered to alternative path(s) if available or best effort service otherwise. These provisioning technologies will be integrated into CANTIS tools to augment applications with capability to estimate bandwidth requirements and automatically signal the networks.

3.2.2. Channel Profiling and Optimization

Due to the wide variety of network connections, the application-level performance is not easily inferred from the lower level network measurements because of host effects (Section 2.3) or complex data and execution paths an in the case of supercomputers (Section 2.6). We propose the concept of an *application-level channel profile* that plots the data goodput at the receiver in response different sending rates. By utilizing actual application-level tools to build such channel profiles, one can gain an initial understanding of achievable application level performance. We will briefly outline a specific profile that enables the design and optimization of data transport methods described in Section 3.2.7. We collected throughput and loss measurements by sending UDP datagrams at varying sending rates, and plotted the *goodput* and loss-rate at the destination. The source rate is controlled by sending a number of datagrams, denoted by the *window size* $W(t)$, in a single burst, and then waiting for a time period called the *idle time* or *sleep time* $T(t)$. The sending rate is specified by a point in the horizontal plane, given by $(W(t); T(t))$, and its goodput measurements at the destination corresponding to various window size and sleep (idle) time pairs are shown in left plot of Figure 1, which is commonly known as the *throughput profile*.

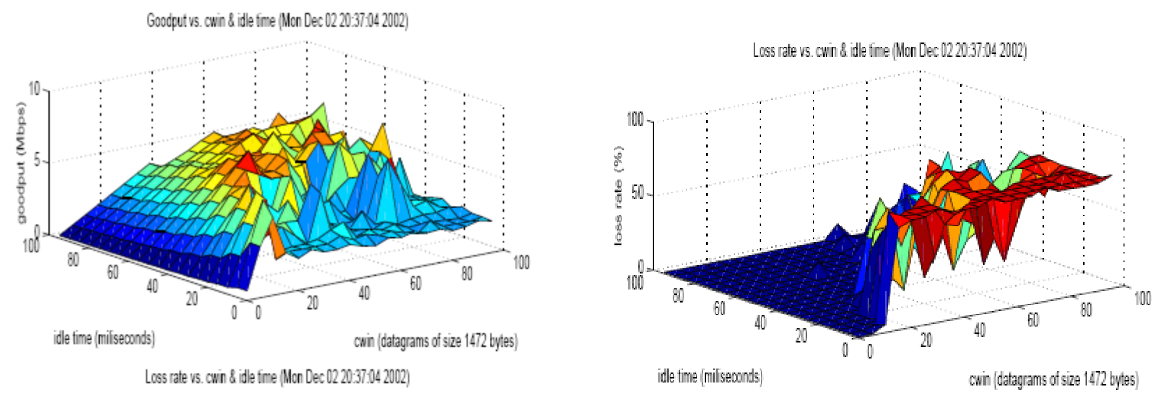

Figure 1. UDP goodput profile (left) and loss profile (right) of typical Internet connection.

The UDP throughput and loss profiles in Figure 1 between ORNL and Louisiana State University (LSU) Internet connection are typical of shared channels. There is an overall increasing trend followed by a decreasing trend in the goodput as sending rate increases. In contrast, the goodput profile for the dedicated channel reached a plateau and remained constant afterwards [RW06]. It is interesting to note that the goodput actually decreases for Internet connections when the sending rate increases beyond a certain level. The overall plot of the goodput profile is quite non-smooth mostly because of the randomness involved in packet delays and losses. The variation in the goodput is particularly high at high sending rates. We propose to generalize the concept of channel profiles to include all layers of AMN stack, and build profiles at multiple layers. At each layer the corresponding profiles indicate the achievable performance by taking into account all lower layers accounting for both host and connection properties. These profiles will requires a variety of host and network level measurements; some of the measurements may have to abstracted up to a suitable AMN layer to support the profile generation. Such profiles can be used in a number ways in matching the AMN modules to the connection at hand and in optimizing their parameters in-situ to maximize performance as will be described later in this section.

3.2.3 IPv4/IPv6 Networking

Within the next few years, we estimate that IPv6 will reach an important threshold due to a combination of many factors: availability of more and larger computing clusters, more overseas collaboration in open science computing, the restricted availability of new routable IPv4 address blocks, and the architectural penalties of using private address space. Wide-area networks with large research constituencies (such as ESnet and Abilene) are already prepared for IPv6 and are carrying token amounts of IPv6 traffic today. Site networks and operating systems are ready to handle IPv6 upon configuration since many Linux hosts have IPv6 enabled by default, awaiting configuration broadcast by routers on each subnet. Using experience gained by participation in IPv6 evolution and development from 1993 onward, FNAL PIs will assist SciDAC application developers in making their codes portable and interoperable between IPv4 and IPv6. In most cases, this consists of introducing IPv6 awareness into the codes and removing IPv4 specificity by working at an appropriate abstraction level.

3.2.4 Host Optimizations

The AMN components of a host play a critical role in deciding the achieved throughputs or jitter levels at the application level [WP05]. In typical workstations, data from an application is copied into kernel buffers and then onto the NIC output queue. Consequently, various buffer sizes, together with speeds and policies for clearing them can have an impact on the source rates and the resultant dynamics. At the receiver, the packets percolate from NIC to kernel buffer to application buffer. The application modules typically share the processor with other concurrently running applications and kernel processes. As a result, some of the newly arrived packets may be dropped at the NIC when the host processor is heavily loaded. Such unread packets are treated as losses by the application. Data paths inside supercomputers are generally more complicated, wherein the host effects could be much more pronounced as will be discussed in Section 3.2.7. Mismatches in NIC rates and bandwidths of provisioned connections can result in losses since most Ethernet cards do not support explicit rate controls. Traditional storage devices and file systems on a majority of PCs are not capable of supporting 1-10 Gbps rates, and thus result in bandwidth bottlenecks in file transfer applications. For example, typical IDE disks provide peak I/O rates of about 300 Mbps. However, higher data rates for file transfers can be achieved through striping data streams using clusters or RAID disks. Supercomputers such as Cray X1 employ stripped disk systems over FC connections that provide multiple 10s of Gbps I/O rates.

Our work will initially focus on improving the performance of Linux systems which are involved in both computational and network tasks concurrently such as computation requiring remote storage. Most work to date has focused on systems dedicated to one task: computation or communication. And network performance enhancement work to date has focused primarily on transmission strategies to operate as near as possible to the congestion limit. Our work will start primarily on the receiver side, where we have identified kernel design problems that arise under moderate load, and are crippling under heavy load. One of these problems, abrupt ARP cache flushing, affects both sides regardless of other load, and is most severe on the sending side. Through instrumenting the kernel to record queue occupancies, memory usage, and packet processing events we will isolate and solve, in turn, the most severe problems that limit network throughput under load. To put our improvements into the hands of SciDAC researchers, we will use the distribution and support channels already employed for "Scientific Linux" since 2003, and for "Fermi Linux" for five years before that. A beneficial spinoff of supporting an OS for SciDAC is that new installations begin from a secure configuration and later security updates are tested and made available very quickly to be installed on each workgroup's schedule. Scientific Linux, like its predecessor Fermi Linux, has an outstanding security record at Fermilab. Over 17,000 computers are currently obtaining system installations or updates through the Scientific Linux program, most of them without any formal support being provided.

3.2.5 Network Measurements

SLAC, through the DOE funded DWMI initiative, currently configures active network measurement including. iperf, ping, traceroute, and pipechar, and uses passive means such as SNMP, Netflow and host level solutions such as Web100 extensively. We will help to evaluate, federate and deploy network sensors at important SciDAC sites for monitoring and measurement. An important issue to consider for passive gathering of network performance information is that the physical and logical components are typically owned and managed by different network operators. Projects such as perfSONAR [SONA] and the Abilene Measurement Infrastructure (AMI) [AMI], with whom SLAC is involved, provide very detailed network performance related information through SNMP from network elements in unified and standardized way to both applications and end-users. However, such projects only provide a broad picture of the actual network usage, and other techniques must be used to extract useful information for applications. Through utilizing both NetFlow active end-to-end tests and passive monitoring of applications, we plan to provide rich data to help characterize and optimize application level performance.

But often the datasets are very large (typically several GBs per day), and require anonymizing the private information. We currently have methods for summarizing such data and efficiently processing the NetFlow records.

Through the DWMI initiative, we propose to support an end-to-end monitoring of SciDAC applications including end-systems and intermediate routers and switches; this information will help us diagnose the performance bottlenecks and trends of the connections. By abstracting network performance metrics from the measurements, we wish to develop additional services and provide information for profile generation in Section 3.2.2. By working closely with SciDAC application groups we will derive network requirements and provide federated and standardized web-services for measurements. By leveraging NMWG [NMWG] schema we will provide network monitoring capability to application programs and users. We propose to develop measurement approaches for bottleneck location identification [HCC], anomalous event detection [LC04] and network performance forecasting [FIEP].

3.2.6 High Performance Data Transport

The Internet has been the major driving force behind existing transport methods, particularly TCP. The networking functionalities needed in the large-scale SciDAC applications that require effective transport methods can be broadly classified into four overlapping categories: (a) high throughput data transfers, (b) network-based visualizations, (c) remote steering and control, and (d) collaborations and coordination over wide-area networks. The most widely deployed protocol, TCP, falls severely short of meeting these requirements: it is unable to provide stable high throughput [HJ04], and its complicated dynamics [RG05] make it unsuitable for supporting high precision control channels. There have been numerous efforts addressing item (a) particularly in scaling TCP over high bandwidth shared connections such as FAST TCP [Ji04], High-Speed TCP (HS-TCP) [F03], Scalable TCP [K], RUNAT [WR05] and BIC-TCP [X04] (a comprehensive account is presented in [HJ04]). A large number of transport protocols that either eliminate or minimize the effects of congestion control have been proposed over the past two years as replacements for TCP-like methods [GG05]. These include Reliable Blast UDP (RB-UDP) [He02], UDP-based data transport (UDT) [Gu04], Group Transport Protocol (GTP) [Wu04], FRTP [ZP05], Hurricane [RW06] and others (a survey is presented in [GG05]). These protocols have their unique strengths and often require in-situ customizations such as tuning of buffer sizes, flow and congestion parameters. It is difficult for scientists to test and decide which transport protocol is appropriate to use for a particular application. The combination of CPT and IOT will automatically accomplish these tasks.

ORNL has been developing a new class of transport methods based on stochastic approximation methods specifically targeting dedicated channels over USN, namely Hurricane [RW06] and RUNAT [WR05], which will be further developed. As described in Section 2.5, Hurricane has achieved record utilization on several dedicated connections [RW06]. While there are several protocols for achieving high throughputs, there are few that ensure the smooth dynamics needed for control connections. The stochastic approximation algorithms have been used [RW04] to maintain constant throughput at the destination by adapting the throughput rate in response to delays and retransmissions. Using this method a stable channel can be implemented so that control messages can be sent almost jitter-free. We will continue to develop this class of protocols to implement the control connections.

We propose to carry out a detailed measurement and comparative analysis of these protocols and prepare and maintain their performance summary, and this information will enable the liaisons to make a first selection of protocols. Second, we will integrate transport protocols into CPT so that the throughput profiles will lead to further down selection of protocols. Third, the protocol parameters will be exposed in OIT so that they will be optimized in-situ. We propose to develop in-situ optimization methods for protocol parameters based on connection properties and feedback from end application or user.

The transport protocols will be integrated into three generic middleware capabilities to support data transfers, interactive visualization and computational steering. In the first case, the data transfers are user driven, and the middleware sets up connections and invokes the transport modules. In the latter two cases, the middleware utilizes a combination of dedicated channels and transport methods to match the application needs. Once the connections are granted, it invokes the transport modules dynamically, for example using one channel for visualization data and the other for commands for interacting with visualization.

3.2.7 Connectiing Supercomputers

To achieve high network throughputs to/from supercomputers, it is essential that performance bottlenecks be eliminated at every part of the data flow including: (a) data paths from supercomputer nodes to user and storage nodes (internal, external, and intra-nodal); and (b) all levels of the AMN stack. ORNL PIs have designed and implemented a class of high-performance interconnects capable of providing the dedicated channel functionalities to Cray X1(E)-X2 class supercomputers to support the TSI application. These methods will be further expanded to other architectures, such as SGI and IBM BlueGene, and furthermore collaborations will be sought with NERSC for some similar efforts to support SciDAC.

Typically, data transfers between Cray compute nodes and disks are handled through service nodes that communicate over FC connections, each at a peak rate of 2 Gbps on X1. The close proximity and dedicated point-point connectivity to the disks make FC a natural choice in this case. But it is not well-suited for wide-area connectivity since FC is mainly designed for storage area networks that span a few miles. On the other hand, SciDAC computations, including PSI, can significantly benefit from a direct access to remote FC-connected disks to read and store data through a file system. We propose an architecture, where CNS may consist of several nodes with separate FC connections into the cross-connect and with separate external 1/10GigE connections. We propose similar architecture for more "cluster-like" machines such as SGI Altix wherein dedicated hosts (connected to the local cross-connect) will constitute an inter-connect to the dedicated high performance networks.

We expect that 10 Gbps FC and 10GigE cards installed on supercomputers machines will only result in effective throughputs of a few Gbps. A combination of protocols and end-to-end optimization would be required to effectively utilize these high bandwidth data paths. Our overall objective is to develop the technologies and expertise needed to provide dedicated network connections between applications running on supercomputers and remote users. There are two basic types of network connectivity requirements addressed in this project. First, the transfer of large datasets to and from the computations must be supported efficiently. Second, data streams with different requirements may have to be supported from the computation to remote users for on-line visualization, computational monitoring and steering. These diverse set of connection requirements necessitate a close scrutiny of data paths between the supercomputer and remote nodes both for the maximum achievable bandwidths and the dynamics of path properties such as losses and jitter which have a direct effect on the stability of transport streams. In addition to the network connections, we propose to provide the applications and users CANTIS tools for effective utilization of high-performance connections.

3.2.8 Optimal Networked Visualizations

We propose to develop a set of network-based visualization support tools to meet the visualization needs for SciDAC applications. Our goal is to efficiently support a visualization pipeline in an environment where the system resources such as simulation/experimental datasets, computing facilities, display devices, storage media, and network bandwidths are widely distributed in the network. For different applications running in such a distributed environment with time-varying system resource conditions, we adaptively partition a visualization pipeline and map visualization modules onto network nodes to minimize the total delay for fast interactions or maximize the frame rate for smooth animations.

Implementation of an optimal partitioning and mapping scheme requires a close examination of the pipeline composition, data objects, network nodes, and transport links, each of which have their own distinct characteristics. For example, visualization modules have different computational complexities; data objects transmitted between modules are of varied sizes; network nodes have built-in capabilities in diverse aspects; transport links have different bandwidths, end-to-end delays, and jitter levels. For a specific application in a certain system condition, different partitioning and mapping schemes will result in significant variations in the overall system performance. Fixed schemes, such as the one in a conventional client/server method, are not always optimized if running in a distributed environment over wide-area network connections.

We will establish analytical models for visualization modules, network nodes, and transport links, based on which, the objective function for each optimization problem will be derived. We will design and implement efficient algorithms to optimize the objective functions with rigorous analysis and mathematical proof. Timely and accurate cost estimation is a key to making a visualization system with an adaptive pipeline configuration successful in a practical scenario. In our preliminary studies, we have found it practically feasible to develop performance models for estimating runtime costs of both visualization computation and network transport. We will develop and validate performance models for common visualization techniques including marching cubes, raycasting, and streamlines, and for various TCP- or UDP-based transport methods used in the Internet or dedicated networks.

We will also study various formulations of this class of problems from the viewpoint of application performance. Based on the constraints on module grouping and node deployment, the problem of pipeline partitioning and network mapping can be classified into at least five categories. For each category of the problem, we will design and implement an appropriate algorithm to achieve the optimization goal. Due to the network bandwidth limitation, the datasets in our initial visualization experiments over Internet connections were restricted to several or hundreds of Mbytes. We will deploy and test a prototype of distributed visualization system employing CANTIS technologies over dedicated networks to evaluate possibilities to handle terabyte datasets for large-scale SciDAC applications. One focus in this regard involves incorporating latest progress in network transport protocols with optimized remote visualization algorithms. Although most visualization techniques employ a linear pipeline without branches or loops, other computational science applications may go beyond this assumption. Hence, we will further expand our work to address pipelines with branches and loops as well.

3.2.9 Computational Monitoring and Steering

Computational monitoring is the capability to expose some parameters or variables of an on-going computation to monitor their status, and steering refers to the capability to adjust parameters of an ongoing computation. For SciDAC environments such monitoring and steering capabilities of a computation taking place on a remote supercomputer are extremely valuable. For example, in the case of hydrodynamics TSI model, the computation takes place in time steps; using these capabilities the time evolution of supernova can be monitored and parameters can be adjusted to either slow it down by increasing time resolution if it proceeds too fast, or to expedite it if no significant changes are taking place. Such capability will eliminate wasted unproductive or runaway computations. ORNL has developed a primitive version of such a system [WZ06] that demonstrated this concept for VH-1 code on ORNL Cray X1; the velocity and density variables were rendered on-line on a remote client and time-steps could be adjusted on-line. For SciDAC environments, parameter control through visual feedback to identify appropriate parameter values for an on-going computation would be an important capability. We propose an integration of visualization capability into computational monitoring and steering. We will design a system to enable scientists to remotely launch their computations on supercomputers through GUI so that the dataset at each time step will be remotely rendered. Using this system, scientists will be able to monitor the computation and make corrective changes to the simulation and visualization parameters, which will take effect promptly on remote simulation and visualization. We propose to integrate automatic provisioning and transport optimization into this system.

3.3.10 Application-Middleware Optimizations

We propose to develop middleware and system-level technologies that will reduce the "impedance mismatch" between end user applications and the networks. The role of the proposed middleware is to continuously match application needs with the currently reserved connection capabilities. The intended outcome is to enable scientific teams to benefit from both shared and dedicated high speed connections. The specific technologies to be developed are the following. At the system level, we will create "bridging" technologies to: (1) effectively share bandwidth reservation between the different communication needs of a single, distributed application, and (2) balance the interaction between the constant bandwidth of dedicated channels and the variable capacity of the IP networks to improve application performance. We propose middleware to make the system-level mechanisms outlined in (1) and (2) accessible to end users with applications running over heterogeneous networks. We propose software infrastructures for data transport with enhanced capability derived from our system- and middleware-level technologies.

The current GridFtp and Storage Resource Manager (SRM) (i.e. dCache/SRM, xrootd) assume best effort IP networks and guarantee performance with a large number of TCP streams for long round trip connections. CANTIS tools will allow Grid-based storage manager and transfer tools to be made aware of advanced networking options, and provide the capability for dynamic reservation, status monitoring, and release. Furthermore, the internal data transfer scheduler can do fine grain optimization to the CPU, disk and network resources by grouping certain amounts of CPU and storage with the appropriate network resources. It will eventually enhance this Grid middleware to provide level of services ranging from cost-effective best effort service and on-demand data delivery to interactive analysis jobs.

We propose CANTIS technologies to enable unprecedented access to petascale distributed data storage for LHC, nuclear physics and Lattice QCD communities by providing scalable services. We plan to integrate into CANTIS toolkit the data management tools used by this community: LHC ATLAS Distributed Data Management System (DDM) and Data/File Transfer Service (FTS), LHC CMS Dataset Bookkeeping Services, Dataset Location Services, Data Placement and Transfer Services (e.g. PhEDEx); RHIC dCache/xrootd based data storage and placement tools; and Lattic QCD data management service. We will enhance these data management tools with proactive capability to monitor the progress of data transfers. The data management tools interact with site network provisioning service and enhanced Grid middleware for transparently interacting with services necessary to optimize the transfers within the context of all ongoing and scheduled network usage. We also proposed to integrate network and storage monitoring service into these data management tools.

3.2.11 Remote Instrument Control

PNNL has developed a wide range of imaging technologies to probe biochemical processes using both living and fixed cells. Traditional microscopes analyze samples using a single imaging modality, usually with a single wavelength of light. We are building instruments that combine the capabilities of multiple instruments, allowing different dimensions of information to be gathered simultaneously. We are also developing advanced algorithms to extract quantitative data from multispectral images. Advances in microscopy require not only the development of more sensitive and specific instruments, but also the creation of software to operate them and manage the large datasets they generate. Scientists at PNNL are currently building the data infrastructure for networking (access), storage, and analysis of imaging data with the goal of turning advanced cell imaging into routine laboratory techniques. We will leverage the technologies previously described in this section to support these activities.

Traditional network infrastructures and technologies are inherently limited in their ability to support real-time instrument control. To that end PNNL will be address remote microscope access. The main goal of this research is to develop and deploy networking technologies needed for remote instrument control and real-time streaming of large-scale data for genomics applications operating in the framework of SciDAC genomic applications. This goal will be accomplished through basic real-time control protocol research, application of other research efforts in visualization and data transport, and prototype implementation and testing using dedicated channel capabilities, for instance.

We propose to develop this remote instrument control system in steps. First, the current system will be made generic to handle other microscope systems used in SciDAC genomics applications, which will be identified using CANTIS liaisons. Second, we will expand the capability to handle datasets of hundreds of Gbytes to Terabyte range; this step requires that the network connections be adequately provisioned so that microscope image will appear promptly at remote clients. Third, we will integrate automatic channel setup and active visualization capability into this system.

3.3 Research Plan

The various component technologies described previously in this section will culminate in an integrated system for data transfer, remote visualization, computational monitoring and steering of computations, and remote instrument control. Various components of this integrated system will be gradually designed, tested and integrated over the span of this project; the individual tasks will be carried out according to the following yearly tasks and milestones:

Year 1:

1. Requirement analysis for all liaison areas; creation of web site and repository server;
2. Coordination with ESnet, UltraScienceNet, CHEETAH and other networks;
3. Development and testing of application-to-application channel profiling tools;
4. Testing and optimization of data and file transfer methods;
5. Measurement tasks including tool and site selections;
6. Analysis and testing of wide-area connectivity of supercomputers for data transfer applications;
7. Development of middleware components for transport awareness; and
8. Generalization of microscope client-server control system.

Year 2:

1. Refinement of requirements, and development of technical tasks for liaison science areas;
2. Development of in-situ tuning, kernel optimizations for data transfers;
3. Integration of channel signaling modules into data transfer systems;
4. Development of visualization pipeline decomposition and optimal wide-area mapping systems;
5. Development of modules for bottleneck location identification in connections and hosts;
6. Analysis and testing of wide-area connectivity of supercomputers for remote visualizations;
7. Middleware enhancements for integrated data transport over combination channels; and
8. Optimization of remote microscope controls task for combination of dedicated and shared channels.

Year 3:

1. Summary analysis of data transfer performance of all liaison science areas;
2. Development of computational monitoring and steering systems;
3. Integration of channel signaling modules into remote visualization systems;
4. Development of methods for measurement-based anomalous event detection;
5. Analysis and testing of wide-area connectivity of supercomputers for computational monitoring;
6. Middleware enhancements for visualization-aware modules; and
7. Integration of remote microscope controls with channel signaling capability.

Year 4:

1. Summary analysis of remote visualization performance in all liaison science areas;
2. Development of integrated visualization, monitoring and steering system;
3. Integration of channel signaling modules into computational monitoring and steering system;
4. Integration of higher levels measurements into transport and visualization tools including forecasting;
5. Analysis and testing of wide-area connectivity of supercomputers for computational steering;
6. Augmentation of middleware with automatic signaling and flow optimization; and
7. Integration of remote control, channel signaling and visualization capabilities.

Year 5:

1. Summary analysis of computational monitoring and steering performance in all liaison science areas;
2. Integration of signaling, transport, visualization, computational monitoring and steering methods;
3. Testing of integrated visualization, computational monitoring and steering for supercomputers;
4. Integration remote microscope control systems with dynamic transport optimizations;
5. Release of entire CANTIS toolkit for distribution to science community; and
6. Summary report of all CANTIS technologies and experiences.

4. Consortium Arrangements

This project is based on a close collaboration between five national laboratories, BNL, FNAL, ORNL, PNNL and SLAC and two universities, UC Davis and GaTech. Together they represent extensive breadth and depth in AMN technologies needed for SciDAC. Equally important are the collaborations of CANTIS team with various SciDAC scientific teams. These national laboratories have a long history of working with DOE application scientists in providing a wide range of networking and related services including provisioning of dedicated channels on USN and MPLS tunnels on ESnet. These national laboratories have direct connectivity to USN and have had a working relationship over past several years in connection with USN project. ORNL and GaTech have just completed an NSF project in the area of network-aware middleware. All these institutions have been active participants of DOE High-Performance Networking Program including the planning workshops.

The liaison activities constitute an integral part of CANTIS, and are extremely crucial to its success. Various team members have been involved in such activities or have initiated collaborations with members from several SciDAC science projects. The SciDAC application area liaison assignments are:

Accelerator Science and Simulation – SLAC, FNAL;
Astrophysics - ORNL, SLAC;
Climate Modeling and Simulation - ORNL;
Computational Biology – PNNL, GaTech;
Fusion Science – GaTech, ORNL;
Groundwater Modeling and Simulation - PNNL;
High-Energy Physics - FNAL, BNL;
High-Energy and Nuclear Physics - BNL, FNAL;
Nuclear Physics - BNL;
Combustion Science and Simulation –UCDavis, ORNL;
Quantum Chromodynamics - FNAL, BNL.

These assignments are chosen based on the prior involvement of institutions in respective science areas, and in specific SciDAC projects. Within each area, a single liaison is (or will be) designated to a SciDAC project with AMN requirements. The role of a liaison is to coordinate *all* aspects of the support for scientists by: (i) identifying various technology components for addressing the specific application needs, (ii) assembling and engaging suitable group of CANTIS technology experts, (iii) arranging for required teleconferences, face-to-face meetings and site visits as needed, (iv) ensuring that CANTIS technologies are installed, integrated and in-situ optimized, and (v) summarizing and presenting these activities and lessons learned to the entire CANTIS team. While a particular liaison may not be an expert in the technologies needed by the application, but will be familiar with the areas of CANTIS team to help develop an overall response. Based on the enclosed letters in the Appendix, the concept and specific liaison assignments are very positively received by SciDAC scientists.

The activities of this project will be coordinated by ORNL, and the website and repositories will be maintained by BNL with backups at ORNL. The center members will participate in weekly teleconferences and bi-annual face-to-face meetings. These meetings are very important as different liaisons will share their experience with the entire team. The technology areas may be appropriately adapted and scoped when needed to match the dynamic needs and progress reported by the liaisons. While the results in the technical domains will be published in peer-reviewed, open literature, the results of liaison activities will be produced as summary annual reports. The application scientists will be invited to CANTIS meetings to discuss their needs and interact with entire CANTIS team. Also, the liaisons will attend the appropriate meeting of SciDAC science projects.

A website will facilitate the dissemination of measurement summaries, software and tools to SciDAC community in general, whereas the activities of a specific project will be handled through the liaison. While the individual liaisons are in charge of assigned SciDAC projects, we will also provide an alternate web mechanism for a scientist to initiate communication with the center on specific AMN tasks. This mechanism will be used to make new liaison assignments to SciDAC projects.

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[IBM] IBM Research Blue Gene Project Page, http://www.research.ibm.com/bluegene/.

[IEPM] IEPM-BW Project, http://www-iepm.slac.stanford.edu/bw/.

[IPER] Iperf 1.7.0 available at http://dast.nlanr.net/Projects/Iperf/.

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[Lambda] LambdaGrid at http://www.calit2.net/lambdagrid/.

[LHC] LHCNet: Transatlantic Networking for the LHC and the U.S. HEP Community, **http://lhcnet.caltech.edu/right.html**.

[LC04] C. Logg, L. Cottrell, and J. Navratil, "Experiences in Traceroute and Available Bandwidth Change Analysis", in *Proc. Sigcomm workshop*, 2004, www.slac.stanford.edu/grp/scs/net/papers/sigcomm2004/nts26-logg.pdf.

[Lynx] LynxOS Real Time Operating System available at http://www.lynuxworks.com/.

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[MONO] MONitoring Agents using a Large Integrated Services Architecture, http://monalisa.cern.ch/monalisa.html.

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[N01] NSF Grand Challenges in eScience Workshop, 2001, Final Report: http://www.evl.uic.edu/activity/NSF/final.html.

[NLR] National LambdaRail Inc. at http://www.nlr.net.

[NMWG] GGF Network Measurement Working Group (NMWG), http://nmwg.internet2.edu/.

[NJ] E. Nielsen and J. Simone, "Lattice QCD Data and Metadata Archives at Fermilab and the International Lattice Data Grid," http://arxiv.org/ftp/cs/papers/0410/0410026.pdf.

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[OSCA] ESnet On-demand Secure Circuits and Advance Reservation System (OSCARS), http://www.es.net/oscars/index.html.

[OWAM] One-Way Ping, http://e2epi.internet2.edu/owamp/.

[PACH] Pathchirp available at http://www.spin.rice.edu/Software/pathChirp/.

[PANE] Locating Internet Bottlenecks: Algorithms, Measurements, and Implications, http://www.cs.cmu.edu/~hnn/pathneck/.

[Pathl] Pathload available at http://www.cc.gatech.edu/fac/Constantinos.Dovrolis/pathload.html.

[PING] Internet Control Message Protocol - DARPA Internet Program Protocol Specification, IETF RFC 792.

[PINR] The PingER Project, http://www-iepm.slac.stanford.edu/pinger/.

[PIPES] End-to-End Performance Initiative, http://e2epi.internet2.edu/.

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[RWI04] N.S.V. Rao, Q. Wu, and S.S. Iyengar, “On Throughput Stabilization of Network Transport,” *IEEE Communications Letters*, 8(1):66–68, 2004.

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[SGI] SGI Altix Clusters, http://www.sgi.com/products/servers/altix/clusters/.

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[SONA] perfSONAR: PERFormance Service Oriented Network Monitoring ARchitecture, http://monstera.man.poznan.pl/jra1-wiki/index.php/PerfSONAR_About .

[T] Terascale Supernova Initiative. http://www.phy.ornl.gov/tsi.

[TERA] TeraPaths: A QoS Enabled Collaborative Data Sharing Infrastructure for Peta-scale Computing Research, http://www.atlasgrid.bnl.gov/terapaths/.

[THRU] thrulay, network capacity tester, http://www.internet2.edu/~shalunov/thrulay/.

[TRAC] Traceroute: A tool for printing the route packets take to a network host, ftp.ee.lbl.gov/nrg.html.

[T06] L. Tuura et al., “PhEDEx High-Throughput Data Transfer Management System,” submitted to Computing in High Energy Physics, 2006 (see also: http://cms-project-phedex.web.cern.ch/cms-project-phedex/).

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Budget and Budget Explanation

Budget Summary:
($K)

Institution	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Brookhaven National Laboratory	400	400	400	400	400	**2,000**
Fermi National Accelerator Laboratory	400	400	400	400	400	**2,000**
Georgia Institute of Technology	300	300	300	300	300	**1,500**
Pacific Northwest National Laboratory	400	400	400	400	400	**2,000**
Oak Ridge National Laboratory	600	600	600	600	600	**3,000**
Stanford Linear Accelerator Center	400	400	400	400	400	**2,000**
University of California, Davis	300	300	300	300	300	**1,500**
Total	**2,800**	**2,800**	**2,800**	**2,800**	**2,800**	**14,000**

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(Amounts in Thousands)

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1910-1400
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Statement on Reverse

ORGANIZATION: OAK RIDGE NATIONAL LABORATORY

Budget Page No: YEAR 1

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Amounts in Whole Dollars Funds Requested by Applicant	Funds Granted by DOE
1.	4.0			74,545	
2.	4.0			51,587	
3.	4.0			34,586	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	12.0			160,718	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				137,000	
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER (CRAFTS)					
TOTAL SALARIES AND WAGES (A+B)				297,718	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				56,860	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				354,578	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				8,250	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)					
2. FOREIGN					
TOTAL TRAVEL				20,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				299	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER Division Organization Burden and Labor Burden				81,138	
TOTAL OTHER DIRECT COSTS				81,437	
H. TOTAL DIRECT COSTS (A THROUGH G)				464,265	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) G&A 35.0%, Legacy Tax 4.8% Management Fee 2.90%					
TOTAL INDIRECT COSTS				135,735	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				600,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				600,000	

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Statement on Reverse

ORGANIZATION OAK RIDGE NATIONAL LABORATORY				**Budget Page No:** YEAR 2	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Amounts in Whole Dollars Funds Requested by Applicant	Funds Granted by DOE
	CAL	ACAD	SUMR		
1.	4.8			76,502	
2.	4.8			48,853	
3.	4.8			31,402	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	14.4			156,757	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				143,150	
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER (CRAFTS)					
TOTAL SALARIES AND WAGES (A+B)				299,907	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				56,229	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				356,136	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				8,338	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)					
2. FOREIGN					
TOTAL TRAVEL				20,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				223	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER Division Organization Burden and Labor Burden				78,870	
TOTAL OTHER DIRECT COSTS				79,093	
H. TOTAL DIRECT COSTS (A THROUGH G)				463,566	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) G&A 34.0%, Legacy Tax 4.8% Management Fee 2.90%					
TOTAL INDIRECT COSTS				136,433	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				600,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				600,000	

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ORGANIZATION: OAK RIDGE NATIONAL LABORATORY

Budget Page No: YEAR 3

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Amounts in Whole Dollars Funds Requested by Applicant	Funds Granted by DOE
1.	4.7			80,586	
2.	4.2			49,101	
3.	4.0			32,483	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	12.9			162,170	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				147,445	
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER (CRAFTS)					
TOTAL SALARIES AND WAGES (A+B)				309,614	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				58,381	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				367,995	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				2,338	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)					
2. FOREIGN					
TOTAL TRAVEL				20,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				181	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER Division Organization Burden and Labor Burden				69,061	
TOTAL OTHER DIRECT COSTS				69,242	
H. TOTAL DIRECT COSTS (A THROUGH G)				459,576	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) G&A 35.0%, Legacy Tax 2.9% Management Fee 2.50%					
TOTAL INDIRECT COSTS				140,425	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				600,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				600,000	

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ORGANIZATION
OAK RIDGE NATIONAL LABORATORY

Budget Page No: YEAR 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Amounts in Whole Dollars Funds Requested by Applicant	Funds Granted by DOE
1.	4.8			82,528	
2.	4.2			50,942	
3.	4.2			30,481	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (3) TOTAL SENIOR PERSONNEL (1-6)	13.2			163,950	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				151,868	
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER (CRAFTS)					
TOTAL SALARIES AND WAGES (A+B)				315,818	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				57,794	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				373,612	

	Funds Requested by Applicant	Funds Granted by DOE
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)		
TOTAL PERMANENT EQUIPMENT	1,500	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)		
2. FOREIGN		
TOTAL TRAVEL	20,000	
F. TRAINEE/PARTICIPANT COSTS		
1. STIPENDS (Itemize levels, types + totals on budget justification page)		
2. TUITION & FEES		
3. TRAINEE TRAVEL		
4. OTHER (fully explain on justification page)		
TOTAL PARTICIPANTS ( ) TOTAL COST		
G. OTHER DIRECT COSTS		
1. MATERIALS AND SUPPLIES	137	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION		
3. CONSULTANT SERVICES		
4. COMPUTER (ADPE) SERVICES		
5. SUBCONTRACTS		
6. OTHER Division Organization Burden and Labor Burden	63,557	
TOTAL OTHER DIRECT COSTS	63,693	
H. TOTAL DIRECT COSTS (A THROUGH G)	458,806	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) G&A 35.0%, Legacy Tax 2.9% Management Fee 2.50%		
TOTAL INDIRECT COSTS	141,194	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)	600,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES		
L. TOTAL COST OF PROJECT (J+K)	600,000	

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ORGANIZATION: OAK RIDGE NATIONAL LABORATORY

Budget Page No: YEAR 5

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Amounts in Whole Dollars Funds Requested by Applicant	Funds Granted by DOE
1.	4.7			84,356	
2.	4.2			49,570	
3.	3.6			28,083	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (3) TOTAL SENIOR PERSONNEL (1-6)	12.5			162,009	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				156,424	
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER (CRAFTS)					
TOTAL SALARIES AND WAGES (A+B)				318,433	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				56,703	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				375,136	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				1,328	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)					
2. FOREIGN					
TOTAL TRAVEL				20,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				26	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER Division Organization Burden and Labor Burden				61,515	
TOTAL OTHER DIRECT COSTS				61,540	
H. TOTAL DIRECT COSTS (A THROUGH G)				458,004	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) G&A 35.0%, Legacy Tax 2.9% Management Fee 2.50%					
TOTAL INDIRECT COSTS				141,996	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				600,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				600,000	

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ORGANIZATION: OAK RIDGE NATIONAL LABORATORY

Budget Page No: YRS 1 - 5

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR

Requested Duration: 60 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Amounts in Whole Dollars Funds Requested by Applicant	Funds Granted by DOE
1.	23.0			398,516	
2.	21.4			250,053	
3.	20.6			157,035	
4.					
5.					
6. (3) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	65.0			805,603	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				735,886	
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER (CRAFTS)					
TOTAL SALARIES AND WAGES (A+B)				1,541,490	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				285,968	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				1,827,458	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				21,754	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)					
2. FOREIGN					
TOTAL TRAVEL				100,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				865	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER Division Organization Burden and Labor Burden				354,140	
TOTAL OTHER DIRECT COSTS				355,005	
H. TOTAL DIRECT COSTS (A THROUGH G)				2,304,217	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) G&A 35.0%, Legacy Tax 2.9% Management Fee 2.50%					
TOTAL INDIRECT COSTS				695,783	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				3,000,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				3,000,000	

Budget Explanation

Budget Pages

Cost estimates presented in the “budget pages" of this proposal have been reclassified in order to be comparable to proposals submitted by other research institutions. At the Oak Ridge National Laboratory (ORNL), costs are collected and reported in accordance with approved Department of Energy (DOE) accounting guidelines. Although costs have been reclassified in this proposal, integrity has been maintained in total and between direct versus indirect costs.

A. (1-7) Senior Personnel

The ORNL’s cost accounting system utilizes wage pools based upon salary ranges. For purposes of this budget, the wage pool cost estimate is divided by the fringe benefits rate. The labor component is being reported in Item A and the fringe component is being reported in Item C.

Rao and Wing will coordinate various organizational tasks of CANTIS. In addition, Rao will carry out ORNL technical tasks in the area of data transport, visualization mappings, and computational monitoring and steering. Wing will carry out technical tasks in the areas of provisioning and network measurements. Carter will carry out technical tasks related to supercomputers.

B.1 Post-Doctoral Associates

Post-BS subcontractors, who work on the ORNL site, are assessed a $1,075 per month organization burden charge for FY2006, $1120 for FY2007 and $1130 for FY2008 and out years. This charge recovers the division’s costs associated with working on-site (primarily space and utilities). This is being reported in Item G.6.

A full-time post-doctoral fellow will be hired to contribute to various technical tasks.

C. Fringe Benefits

Fringe Benefits for ORNL employees are estimated to be 35.1% of labor costs for FY 2006, 35.5% for FY2007 and 36% for FY2008 and out years.

D. Permanent Equipment

A linux workstation will be purchased in year 1 to house CANTIS website and repository at a total cost of $8,250. Three laptop computers will be purchased for three senior personnel for supporting this project in year 2 at a total cost of $8,338. Disk hardware of linux workstation will be upgraded in years 3, 4 and 5 at costs of $2,338, $1500, and $1328, respectively. The cost of materials and supplies including poster reproductions are estimated to be $299, $223, $181, $137 and $26 for years 1, 2,3, 4 and 5 respectively.

E. (1-2) Travel

Travel funds are requested to attend two project meetings and two conferences/meetings by each investigator and post-doctoral fellow per year. Estimated cost per domestic travel is $1250 and includes plane fare, housing, meals, registration, and other allowable costs under government per diem rules.

G.6 Other - Organization Burden Administration

Use of cost collection centers in ORNL R&D divisions is the approved method for collection and distribution of organization burden costs. These accounts are established to collect costs associated with an R&D division. The types of costs which can be charged to organization burden cost collection centers are unfunded paid hours; division administration; and general materials/service costs, including, but not limited to telecommunications, space, utilities, word processing, and copying which are not directly attributable or chargeable to R&D projects. Division Administration costs include: *(i)* managerial, technical, and administrative oversight; and *(ii)* support personnel such as facilities and operations, environmental, safety, and health, finance and budget, quality, and health physics provided for the general benefit of a division.

For ORNL staff, the labor and fringe components have been estimated and reported in items A - C. For Post-BS subcontractors, the subcontract costs have been reported in Item B.1. For ORNL staff and Post-BS subcontractors, the organization burden component has been estimated and is being reported in Item G.6. Inclusion of these costs is necessary to provide a full accounting of estimated cost for the project period. All cost will be collected and reported in ORNL's cost accounting system.

I. Indirect Costs

Full General & Administrative (G&A), Legacy Charge, and Management Fee are assessed on ORNL labor costs (Items A, C, and G.6), Materials and Supplies, and Equipment less than $35,000 unit value. Full G&A is estimated to be 35.0% for FY2006, 34.0% for FY2007 and 36.50% for FY2008, with an estimated 3% increase each year after that for additional fiscal years. Legacy Charge is estimated to be 4.8% for each year. Management Fee is estimated to be 2.9% for FY2006, 3.2% for FY2007 and 3.5% for FY20081% each year.

Non-DOE-contractor subcontract costs are assessed Subcontract G&A and Management Fee. Subcontract G&A is estimated to be 1.1% each year. Management Fee is estimated to be 2.9% for FY2006, 3.2% for FY2007 and 3.5% for FY20081% each year.

Travel costs are assessed Travel G&A and Management Fee. Travel G&A is estimated to be 7.0% each year. Management Fee is estimated to be 2.9% for FY2006, 3.2% for FY2007 and 3.5% for FY20081% each year.

DOE F 4650.2
Rev. (10-03)
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Office of Science (SC)

Face Page

OMB Control No.
1910-1400
(OMB Burden Disclosure Statement on Back)

TITLE OF PROPOSED RESEARCH:
CANTIS: Center for Application-Network Total-Integration for SciDAC

1. CATALOG OF FEDERAL DOMESTIC ASSISTANCE #
81.049

2. CONGRESSIONAL DISTRICT:
Applicant Organization's District: District 1
Project Site's District: District 1

3A. I.R.S. ENTITY IDENTIFICATION OR SSN:
113-40-3915

3B. DUNS Number:
038150264

4. AREA OF RESEARCH OR ANNOUNCEMENT TITLE/#:
LAB 06-04 Scientific Discovery through Advanced Computing

5. HAS THIS RESEARCH PROPOSAL BEEN SUBMITTED TO ANY OTHER FEDERAL AGENCY?
☐ YES ☑ NO

PLEASE LIST

6. DOE/OER PROGRAM STAFF CONTACT (if known):
Dr. Thomas D. Ndousse (301)-903-9960

7. TYPE OF APPLICATION:
☑ New ☐ Renewal
☐ Continuation ☐ Revision
☐ Supplement

8. ORGANIZATION TYPE:
☐ Local Govt. ☑ State Govt.
☑ Non-Profit ☐ Hospital
☐ Indian Tribal Govt. ☐ Individual
☐ Other ☐ Inst. of Higher Educ.
☐ For-Profit
☐ Small Business ☐ Disadvan. Business
☐ Women-Owned ☐ 8(a)

9. CURRENT DOE AWARD # (IF APPLICABLE):

10. WILL THIS RESEARCH INVOLVE:
10A. Human Subjects ☑ No ☐ If yes
Exemption No. ______ or
IRB Approval Date ______
Assurance of Compliance No: ______
10B. Vertebrate Animals ☑ No ☐ If yes
IACUC Approval Date ______ or
Animal Welfare Assurance No: ______

11. AMOUNT REQUESTED FROM DOE FOR ENTIRE PROJECT PERIOD $ 1,875,958.00

12. DURATION OF ENTIRE PROJECT PERIOD:
07/01/06 to 06/30/11
MM/DD/YY MM/DD/YY

13. REQUESTED AWARD START DATE
07/01/06
MM/DD/YY

14. IS APPLICANT DELINQUENT ON ANY FEDERAL DEBT?
☐ Yes (attach an explanation) ☑ No

15. PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR
NAME Dantong Yu
TITLE Group Leader
ADDRESS Physics Department
Brookhaven National Lab
Building 510M
Upton, New York 11973
PHONE NUMBER 631-344-4064

16. ORGANIZATION'S NAME Brookhaven National Laboratory
ADDRESS Brookhaven National Laboratory
Building 460
Upton, New York 11973

CERTIFYING REPRESENTATIVE'S
NAME Richard Melucci
TITLE Budget Officer
PHONE NUMBER 631-344-2911

SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROGRAM DIRECTOR
(please type in full name if electronically submitted)
Date February/12/2006

PI/PD ASSURANCE: 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 submission. Willful provision of false information is a criminal offense. (U.S. Code, Title 18, Section 1001).

SIGNATURE OF ORGANIZATION'S CERTIFYING REPRESENTATIVE
(please type in full name if electronically submitted)
Date February/23/2006

CERTIFICATION and ACCEPTANCE: I certify that the statements herein are true and complete to the best of my knowledge, and accept the obligation to comply with DOE terms and conditions if an award is made as the result of this submission. A willfully false certification is a criminal offense. (U.S. Code, Title 18, Section 1001).

NOTICE FOR HANDLING PROPOSALS
This submission is to be used only for DOE evaluation purposes and this notice shall be affixed to any reproduction or abstract thereof. All Government and non-Government personnel handling this submission shall exercise extreme care to ensure that the information contained herein is not duplicated, used, or disclosed in whole or in part for any purpose other than evaluation without written permission except that if an award is made based on this submission, the terms of the award shall control disclosure and use. This notice does not limit the Government's right to use information contained in the submission if it is obtainable from another source without restriction. This is a Government notice, and shall not itself be construed to impose any liability upon the Government or Government personnel for any disclosure or use of data contained in this submission.

PRIVACY ACT STATEMENT
If applicable, you are requested, in accordance with 5 U.S.C., Sec. 562A, to voluntarily provide your Social Security Number (SSN). However, you will not be denied any right, benefit, or privilege provided by law because of a refusal to disclose your SSN. We request your SSN to aid in accurate identification, re erral and review of applications for research/training support for efficient management of Office of Science grant/contract programs.

DOE F 4620.1
(04-93)
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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

CANTIS: Center for Application-Network Total-Integration for SciDAC

ORGANIZATION Brookhaven National Laboratory				**Budget Page No:**	1
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Bruce Gibbard and Dantong Yu				Requested Duration: 12 (Months) FY 2006	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted by DOE
	CAL	ACAD	SUMR		
1. Bruce Gibbard					
2. Dantong Yu	1.00			$8,000	
3. Dimitrios Katramatos	1.00			$6,000	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	2.00			$14,000	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATE (80% from project budget, and 20% from BNL OH)					
2. (2) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	24.00			$135,000	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$149,000	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) Staff 41% ;Post Doc 31%				$61,090	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$210,090	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$8,000	
2. FOREIGN					
TOTAL TRAVEL				$8,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$4,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$1,000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				$2,000	
5. SUBCONTRACTS					
6. OTHER includes space organizational support and communication and power charges					
TOTAL OTHER DIRECT COSTS				$7,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$225,090	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) Indirect on travel.M&S @49.21%				$7,238	
Indirect composite rate on labor @56%				$117,650	
TOTAL INDIRECT COSTS				$124,888	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$349,978	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$349,978	

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

CANTIS: Center for Application-Network Total-Integration for SciDA(

ORGANIZATION Brookhaven National Laboratory				**Budget Page No:** 2	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Bruce Gibbard and Dantong Yu				Requested Duration: 12 (Months) FY 2007	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted
	CAL	ACAD	SUMR		by DOE
1. Bruce Gibbard					
2. Dantong Yu	1.00			$8,320	
3. Dimitrios Katramatos	1.00			$6,240	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	2.00			14560.00	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATE (50% support)					
2. (2) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	24.00			$140,400	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$154,960	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) Staff 41% ;Post Doc 31%				$63,534	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$218,494	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$7,000	
2. FOREIGN				$2,000	
TOTAL TRAVEL				$9,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$2,000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				$2,000	
5. SUBCONTRACTS					
6. OTHER includes space organizational support and communication and power charges					
TOTAL OTHER DIRECT COSTS				$5,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$232,494	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) Indirect on travel.M&S @49.21%				$6,755	
Indirect composite rate on labor @56%				$122,356	
TOTAL INDIRECT COSTS				$129,111	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$361,605	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$361,605	

DOE F 4620.1
(04-93)
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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

CANTIS: Center for Application-Network Total-Integration for SciDA(

ORGANIZATION: Brookhaven National Laboratory				**Budget Page No:** 3	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Bruce Gibbard and Dantong Yu				Requested Duration: 12 (Months) FY 2008	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted by DOE
	CAL	ACAD	SUMR		
1. Bruce Gibbard					
2. Dantong Yu	1.00			$8,653	
3. Dimitrios Katramatos	1.00			$6,490	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	2.00			15142.40	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATE (50% support)					
2. (2) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	24.00			$146,016	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$161,158	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) Staff 41% ;Post Doc 31%				$66,075	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$227,233	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$5,000	
2. FOREIGN				$4,000	
TOTAL TRAVEL				$9,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$2,000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				$2,000	
5. SUBCONTRACTS					
6. OTHER includes space organizational support and communication and power charges					
TOTAL OTHER DIRECT COSTS				$5,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$241,233	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) Indirect on travel.M&S @49.21%				$6,755	
Indirect composite rate on labor @56%				$127,251	
TOTAL INDIRECT COSTS				$134,006	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$375,239	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$375,239	

DOE F 4620.1
(04-93)
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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

CANTIS: Center for Application-Network Total-Integration for SciDA(

ORGANIZATION Brookhaven National Laboratory				**Budget Page No:** 4	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Bruce Gibbard and Dantong Yu				Requested Duration: 12 (Months) FY 2009	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested	Funds Granted by DOE
1. Bruce Gibbard					
2. Dantong Yu	1.00			$8,999	
3. Dimitrios Katramatos	1.00			$6,749	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	2.00			15748.10	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATE (50% support)					
2. (2) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	24.00			$151,857	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$167,605	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) Staff 41% ;Post Doc 31%				$68,718	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$236,323	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$4,000	
2. FOREIGN				$5,000	
TOTAL TRAVEL				$9,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$2,000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				$2,000	
5. SUBCONTRACTS					
6. OTHER includes space organizational support and communication and power charges					
TOTAL OTHER DIRECT COSTS				$5,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$250,323	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) Indirect on travel.M&S @49.21%				$6,755	
Indirect composite rate on labor @56%				$132,341	
TOTAL INDIRECT COSTS				$139,096	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$389,418	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$389,418	

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy
Budget Page
(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

CANTIS: Center for Application-Network Total-Integration for SciDA(

ORGANIZATION Brookhaven National Laboratory				**Budget Page No:** 5	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Bruce Gibbard and Dantong Yu				Requested Duration: 12 (Months) FY 2010	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted by DOE
	CAL	ACAD	SUMR		
1. Bruce Gibbard					
2. Dantong Yu	1.00			$9,359	
3. Dimitrios Katramatos	1.00			$7,019	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	2.00			16378.02	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATE (50% support)					
2. (2) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	24.00			$157,931	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$174,309	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) Staff 41% ;Post Doc 31%				$71,467	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$245,776	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$3,000	
2. FOREIGN				$3,000	
TOTAL TRAVEL				$6,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$2,000	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				$2,000	
5. SUBCONTRACTS					
6. OTHER includes space organizational support and communication and power charges					
TOTAL OTHER DIRECT COSTS				$5,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$256,776	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) Indirect on travel.M&S @49.21%				$5,308	
Indirect composite rate on labor @56%				$137,634	
TOTAL INDIRECT COSTS				$142,942	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$399,717	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$399,717	

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CANTIS: Center for Application-Network Total-Integration for SciDAC

ORGANIZATION Brookhaven National Laboratory	**Budget Page No:** 6 Total
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Bruce Gibbard and Dantong Yu	Requested Duration: 12 (Months) FY 2006~2010

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested	Funds Granted by DOE
1. Bruce Gibbard					
2. Dantong Yu	5.00			43330.58	
3. Dimitrios Katramatos	5.00			32497.94	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)	10.00			75828.52	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0.5) POST DOCTORAL ASSOCIATE (50% support)					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	120			731203.55	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$807,032	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS) Staff 41% ;Post Doc 31%				$330,883	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$1,137,915	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				27000.00	
2. FOREIGN				14000.00	
TOTAL TRAVEL				$41,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				8000.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				9000.00	
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				10000.00	
5. SUBCONTRACTS					
6. OTHER includes space organizational support and communication and power charges					
TOTAL OTHER DIRECT COSTS				$27,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$1,205,915	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) Indirect on travel.M&S @49.21%				$32,810	
Indirect composite rate on labor @56%				$637,233	
TOTAL INDIRECT COSTS				$670,043	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$1,875,958	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$1,875,958	

Budget Justification

Personnel: We request DOE funds for supporting 2 full-time employees to develop software and provide support to three SciDAC-sponsored physics application areas: High Energy Physics, Nuclear Physics, and Lattice QCD. The two employees will provide Brookhaven National Lab's deliverables in accordance with the work schedule of CANTIS. The deliverables will range from local area network bandwidth provisioning to service integration into high-level ATLAS applications. Some of these deliverables will leverage TeraPaths software modules.

BNL already has one FTE responsible for the USATLAS facility network operation, problem detection, and high-performance TCP data transfers. This employee is closely collaborating with us to ensure our software can be deployed on the BNL LAN. BNL's TeraPaths project supports one FTE responsible for the development of the network management system as defined by the scope of TeraPaths. This employee is collaborating with the SLAC network monitoring group and the UltraLight and OSCARS groups to design and implement end-to-end solutions for the LHC USATLAS data traffic. A percentage of the work of these two FTEs will be contributed to CANTIS.

Senior Personnel: Dantong Yu and Bruce Gibbard are PIs for the DOE TeraPaths project. Dimitrios Katramatos is senior personnel for the same project. One month of their FTE will be supported by the CANTIS project to ensure that the results of TeraPaths can be utilized in CANTIS. They will participate in the project meetings and act as liaisons with the three SciDAC physics programs.

Fringe Benefits: BNL fringe rate is 41.0% of salary.

Travel: The first year's travel will be dedicated to visiting SciDAC application sites to understand the needs the data management software will have to cover. The second year will include one trip to CERN to collect user specifications and data transfer statistics for LHC data transfers. For the remaining years, travel will be split between domestic and international destinations to participate in project meetings and disseminate the project results to workshops.

Publication Cost: The registration fees are needed for presenting results at leading conferences and project workshops. Publication costs are requested to assist in covering page charges and print costs to publish research results in journals.

Materials/Supplies: The first year we will purchase personal computers for newly hired employees working for CANTIS. For the following years, a modest amount ($1,000) is requested for materials and supplies in the form of software and licenses necessary for the project as well as for office supplies.

Other: Overall indirect cost: 56.0%, annual inflation rate: 4.0%.

Cover Page

Title of Proposed Project:
Enabling Computational Technologies – CANTIS: Center for Application-Network Total-Integration for SciDAC

Office of Science Announcement Title/#:

Scientific Discovery through Advanced Computing
LAB 06-04

Name of Lead Institution:

Oak Ridge National Laboratory (ORNL)

Principal Investigator(s):

Fermilab PI: Matt Crawford

Official signing for Fermi National Accelerator Laboratory:
Piermaria J. Oddone, Director

Requested funding for All ; total request

Year 1 $	400,000
Year 2 $	400,000
Year 3 $	400,000
Year 4 $	400,000
Year 5 $	400,000
Total: $	2,000,000

Duration of Entire Project Period:

07/01/2006 to 06/30/2011

Use of human subjects in proposed project: No

Use of vertebrate animals in proposed project: No

Signature of PI, Date of Signature:

____

Signature of Official, Date of Signature:

____

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Statement on Reverse

Year 1 Funding Proposal

ORGANIZATION FERMILAB Computing Division				**Budget Page No:** 1	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Matt Crawford				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Matt Crawford, Computer Professional	3.00			$30,350	
2. Wenji Wu, Computer Professional	6.00			$45,000	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)	9.00			$75,350	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (4) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	14.09			$100,378	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$175,728	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$62,032	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$237,760	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$24,000	
2. FOREIGN				$3,500	
TOTAL TRAVEL				$27,500	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST					
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$50,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				$50,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$315,260	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 10.5% on Travel expense and 16.58% on all other M&S expense; 30.94% on SWF					
TOTAL INDIRECT COSTS				$84,740	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$400,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$400,000	

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Year 2 Funding Proposal

ORGANIZATION FERMILAB Computing Division				Budget Page No: 2	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Matt Crawford				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested by Applpicant	Funds Granted by DOE
	CAL	ACAD	SUMR		
1. Matt Crawford, Computer Professional	3.00			$31,412	
2. Wenji Wu, Computer Professional	6.00			$46,575	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)	9.00			$77,987	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				$0	
2. (4) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	15.48			$114,192	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$192,179	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$67,839	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$260,018	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$24,000	
2. FOREIGN				$3,500	
TOTAL TRAVEL				$27,500	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS (0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$25,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				$25,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$312,518	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 10.5% on Travel expense and 16.58% on all other M&S expense; 30.94% on SWF					
TOTAL INDIRECT COSTS				$87,482	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$400,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$400,000	

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Year 3 Funding Proposal

ORGANIZATION FERMILAB Computing Division				**Budget Page No:** 3	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Matt Crawford				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Matt Crawford, Computer Professional	3.00			$32,512	
2. Wenji Wu, Computer Professional	6.00			$48,205	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)	9.00			$80,717	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES Graduate Student				$0	
2. (4) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	14.60			$111,462	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$192,179	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$67,839	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$260,018	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$24,000	
2. FOREIGN				$3,500	
TOTAL TRAVEL				$27,500	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$0	
2. TUITION & FEES				$0	
3. TRAINEE TRAVEL				$0	
4. OTHER (fully explain on justification page)				$0	
TOTAL PARTICIPANTS (0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$25,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$0	
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES				$0	
5. SUBCONTRACTS				$0	
6. OTHER				$0	
TOTAL OTHER DIRECT COSTS				$25,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$312,518	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 10.5% on Travel expense and 16.58% on all other M&S expense; 30.94% on SWF					
TOTAL INDIRECT COSTS				$87,482	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$400,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				$0	
L. TOTAL COST OF PROJECT (J+K)				$400,000	

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Year 4 Funding Proposal

ORGANIZATION: FERMILAB Computing Division

Budget Page No: 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Matt Crawford

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Matt Crawford, Computer Professional	3.00			$33,650	
2. Wenji Wu, Computer Professional	6.00			$49,892	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)	9.00			$83,542	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				$0	
2. (4) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	12.50			$98,766	
3. ( ) GRADUATE STUDENTS				$0	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$182,308	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$64,355	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$246,663	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$24,000	
2. FOREIGN				$3,500	
TOTAL TRAVEL				$27,500	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS (0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$40,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				$40,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$314,163	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 10.5% on Travel expense and 16.58% on all other M&S expense; 30.94% on SWF					
TOTAL INDIRECT COSTS				$85,837	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$400,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$400,000	

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Year 5 Funding Proposal

ORGANIZATION FERMILAB Computing Division				**Budget Page No:** 5	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Matt Crawford				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted
	CAL	ACAD	SUMR	by Applpicant	by DOE
1. Matt Crawford, Computer Professional	3.00			$34,827	
2. Wenji Wu, Computer Professional	6.00			$51,639	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)	9.00			$86,466	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES				$0	
2. (4) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	11.72			$95,842	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$182,308	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$64,355	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$246,663	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$24,000	
2. FOREIGN				$3,500	
TOTAL TRAVEL				$27,500	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS (0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$40,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				$40,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$314,163	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 10.5% on Travel expense and 16.58% on all other M&S expense; 30.94% on SWF					
TOTAL INDIRECT COSTS				$85,837	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$400,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$400,000	

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TOTAL of 5 Year Funding Proposal

ORGANIZATION: FERMILAB Computing Division — **Budget Page No:** 6

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Matt Crawford — Requested Duration: 60 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Matt Crawford, Computer Professional	15.00			$162,751	
2. Wenji Wu, Computer Professional	30.00			$241,311	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)	45.00			$404,062	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES	0.00			$0	
2. (4) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	68.40			$520,640	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$924,702	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$326,420	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$1,251,122	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$120,000	
2. FOREIGN				$17,500	
TOTAL TRAVEL				$137,500	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$180,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				$180,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				$1,568,622	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 10.5% on Travel expense and 16.58% on all other M&S expense; 30.94% on SWF					
TOTAL INDIRECT COSTS				$431,378	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$2,000,000	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				$2,000,000	

BUDGET JUSTIFICATION
Fermi National Accelerator Laboratory

Fermilab will be providing approximately 2.0 FTE of effort towards CANTIS:Center for Application-Network Total-Integration for SciDAC. The compensation is consistent with similar work both within and outside of Fermilab. Personnel Cost amounts in Years 2-5 are estimated based upon a uniform escalation of 3.5%.

A. SENIOR PERSONNEL. Proposed compensation is consistent with that paid to other personnel engaged in similar work both within and outside Fermilab.

Matt Crawford and Wenji Wu are senior Computing Professionals at Fermilab. Their work here matches their skills and experience.

B. OTHER PERSONNEL
B2. Computing professionals – requested support for computer professionals is based on the anticipated starting date, escalated 3.5% annually in Years 2-5.

C. FRINGE BENEFITS
Benefits are requested at the rate of 35.3% of professional salaries.

D. PERMANENT EQUIPMENT.

E. TRAVEL AND SUBSISTENCE.

Our travel budget of $27,500 will support trips for meetings with our collaborators and partners in the CANTIS initiative and with other SciDAC researchers, and to present results at conferences. We estimate 10 short domestic trips at $1,300 each and 5 long (4-5 days) domestic trips at $2,200 each, and 1 foreign trip at $3,500.

G. OTHER DIRECT COSTS.
G1. Materials and supplies

The first year budget includes $35,000 for a system of servers and storage to build, distribute, and support system software for SciDAC user and application machines. The fourth and fifth year budgets include $20,000 for updating and replacing these servers as they age, expanding the capacity if needed. All years include hardware and software costs for kernel and API R&D, and maintenance costs the foregoing.

I. TOTAL INDIRECT COSTS. Fermilab's predetermined indirect cost rate is currently 30.94% (Salaries), 10.5% (Travel), and 16.58% (Other M&S) of MTDC, in accordance with Fermilab's contract with the University Research Association (URA), and the Department of Energy.

APPLICATION FOR FEDERAL ASSISTANCE

SF 424 (R&R)

2. DATE SUBMITTED	Applicant Identifier
3. DATE RECEIVED BY STATE	**State Application Identifier**
4. Federal Identifier	

1. * TYPE OF SUBMISSION

☐ Pre-application ☑ Application
☐ Changed/Corrected Application

5. APPLICANT INFORMATION * Organizational DUNS: 0973940840000

* Legal Name: Georgia Tech Research Corporation
Department: Office of Sponsored Programs Division:
* Street1: 505 Tenth Street, NW Street2:
* City: Atlanta County: Fulton * State: GA * ZIP Code: 30332-0420
* Country: USA

Person to be contacted on matters involving this application

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Ms.	Serelia	D.	Woods	

* Phone Number: 404-385-0866 Fax Number: 404-894-5945 Email: serelia.woods@osp.gatech.edu

6. * EMPLOYER IDENTIFICATION *(EIN) or (TIN):* 58-0603146

7. * TYPE OF APPLICANT: F: State-Controlled Institution of Higher Education

Other (Specify):

Small Business Organization Type

☐ Women Owned ☐ Socially and Economically Disadvantaged

8. * TYPE OF APPLICATION: ☑ New

☐ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

If Revision, mark appropriate box(es).

☐ A. Increase Award ☐ B. Decrease Award ☐ C. Increase Duration
☐ D. Decrease Duration ☐ E. Other *(specify)*

* Is this application being submitted to other agencies? Yes ☐ No ☑

What other Agencies?

9. * NAME OF FEDERAL AGENCY: Chicago Service Center

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: 81.049

TITLE: Office of Science Financial Assistance Program

11. * DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:

Cantis: Center for Applications-Network Total-Integration for SciDAC

12. * AREAS AFFECTED BY PROJECT *(cities, counties, states, etc.)*

Atlanta, GA USA

13. PROPOSED PROJECT:

* Start Date: 07/01/2006 * Ending Date: 06/30/2011

14. CONGRESSIONAL DISTRICTS OF:

a. * Applicant: 5th b. * Project: 5th

15. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Dr.	Karsten		Schwan	

Position/Title: Professor * Organization Name: Georgia Tech Research Corporation
Department: College of Computing Division:
* Street1: 801 Atlantic Dr. Street2: 505 Tenth Street
* City: Atlanta County: Fulton * State: GA * ZIP Code: 30332-0420
* Country: USA
* Phone Number: 404-894-2589 Fax Number: 404-894-0271 * Email: karsten.schwan@cc.gatech.edu

OMB Number: 4040-0001

Expiration Date: 04/30/2008

SF 424 (R&R) APPLICATION FOR FEDERAL ASSISTANCE

16. ESTIMATED PROJECT FUNDING

a. * Total Estimated Project Funding	1,485,390.00
b. * Total Federal & Non-Federal Funds	1,485,390.00
c. * Estimated Program Income	0.00

17. * IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES ☐ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE:

b. NO ☐ PROGRAM IS NOT COVERED BY E.O. 12372; OR

☑ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

18. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

☑ *** I agree**

**** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.***

19. Authorized Representative

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Ms.	Serelia	D.	Woods	

* Position/Title:	Contracting Officer	* Organization:	Georgia Tech Research Corporation
Department:	Office of Sponsored Programs	Division:	
* Street1:	505 Tenth Street, NW	Street2:	505 Tenth Street

* City: Atlanta County: Fulton * State: GA * ZIP Code: 30332-0420

* Country: USA

* Phone Number: 404-385-0866 Fax Number: * Email: serelia.wwoods@osp.gatech.edu

* Signature of Authorized Representative	* Date Signed
Completed on submission to Grants.gov	Completed on submission to Grants.gov

20. Pre-application Add Attachment Delete Attachment View Attachment

OMB Number: 4040-0001

Expiration Date: 04/30/2008

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(04-93)

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Budget Page

(See reverse for Instructions)

OMB Control No.

1910-1400

OMB Burden Disclosure

Statement on Reverse

ORGANIZATION Georgia Tech Research Corporation				Budget Page No: Year 1	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Karsten Schwan				Requested Duration: 60 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Karsten Schwan	2			35,542	
2. Greg Eisenhauer	6			43,092	
3. Ada Gavrilovska	3			15,606	
4. Matthew Wolf	3			20,715	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (4) TOTAL SENIOR PERSONNEL (1-6)	14	0	0	114,955	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (2) GRADUATE STUDENTS				33,415	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				148,377	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				27,014	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				175,384	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) See budget explanation page					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,000	
2. FOREIGN					
TOTAL TRAVEL				6,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				0	
2. TUITION & FEES				0	
3. TRAINEE TRAVEL				0	
4. OTHER (fully explain on justification page)				0	
TOTAL PARTICIPANTS (0) TOTAL COST				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				9,677	
5. SUBCONTRACTS					
6. OTHER				8,640	
TOTAL OTHER DIRECT COSTS				11,678	
H. TOTAL DIRECT COSTS (A THROUGH G)				201,701	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 49.40% of 159,646					
TOTAL INDIRECT COSTS				95,377	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				297,078	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				0	
L. TOTAL COST OF PROJECT (J+K)				297,078	

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Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Georgia Tech Research Corporation				**Budget Page No:** Year 2	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Karsten Schwan				Requested Duration: 60 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Karsten Schwan	2			35,542	
2. Greg Eisenhauer	6			43,092	
3. Ada Gavrilovska	3			15,606	
4. Matthew Wolf	3			20,715	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (4) TOTAL SENIOR PERSONNEL (1-6)	14	0	0	114,955	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (2) GRADUATE STUDENTS				33,415	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				148,377	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				27,014	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				175,384	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) See budget explanation page					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,000	
2. FOREIGN					
TOTAL TRAVEL				6,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				0	
2. TUITION & FEES				0	
3. TRAINEE TRAVEL				0	
4. OTHER (fully explain on justification page)				0	
TOTAL PARTICIPANTS (0) TOTAL COST				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				9,677	
5. SUBCONTRACTS					
6. OTHER				8,640	
TOTAL OTHER DIRECT COSTS				11,678	
H. TOTAL DIRECT COSTS (A THROUGH G)				201,701	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 49.40% of 159,646					
TOTAL INDIRECT COSTS				95,377	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				297,078	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				0	
L. TOTAL COST OF PROJECT (J+K)				297,078	

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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Georgia Tech Research Corporation				Budget Page No: Year 3	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Karsten Schwan				Requested Duration: 60 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted
	CAL	ACAD	SUMR	by Applpicant	by DOE
1. Karsten Schwan	2			35,542	
2. Greg Eisenhauer	6			43,092	
3. Ada Gavrilovska	3			15,606	
4. Matthew Wolf	3			20,715	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (4) TOTAL SENIOR PERSONNEL (1-6)	14	0	0	114,955	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (2) GRADUATE STUDENTS				33,415	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				148,377	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				27,014	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				175,384	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) See budget explanation page					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,000	
2. FOREIGN					
TOTAL TRAVEL				6,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				0	
2. TUITION & FEES				0	
3. TRAINEE TRAVEL				0	
4. OTHER (fully explain on justification page)				0	
TOTAL PARTICIPANTS (0) TOTAL COST				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				9,677	
5. SUBCONTRACTS					
6. OTHER				8,640	
TOTAL OTHER DIRECT COSTS				11,678	
H. TOTAL DIRECT COSTS (A THROUGH G)				201,701	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 49.40% of 159,646					
TOTAL INDIRECT COSTS				95,377	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				297,078	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				0	
L. TOTAL COST OF PROJECT (J+K)				297,078	

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All Other Editions Are Obsolete	(See reverse for Instructions)	OMB Burden Disclosure Statement on Reverse

ORGANIZATION Georgia Tech Research Corporation				Budget Page No: Year 4	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Karsten Schwan				Requested Duration: 60 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Karsten Schwan	2			35,542	
2. Greg Eisenhauer	6			43,092	
3. Ada Gavrilovska	3			15,606	
4. Matthew Wolf	3			20,715	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (4) TOTAL SENIOR PERSONNEL (1-6)	14	0	0	114,955	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (2) GRADUATE STUDENTS				33,415	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				148,377	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				27,014	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				175,384	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) See budget explanation page					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,000	
2. FOREIGN					
TOTAL TRAVEL				6,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				0	
2. TUITION & FEES				0	
3. TRAINEE TRAVEL				0	
4. OTHER (fully explain on justification page)				0	
TOTAL PARTICIPANTS (0) TOTAL COST				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				9,677	
5. SUBCONTRACTS					
6. OTHER				8,640	
TOTAL OTHER DIRECT COSTS				11,678	
H. TOTAL DIRECT COSTS (A THROUGH G)				201,701	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 49.40% of 159,646					
TOTAL INDIRECT COSTS				95,377	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				297,078	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				0	
L. TOTAL COST OF PROJECT (J+K)				297,078	

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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION: Georgia Tech Research Corporation				Budget Page No: Year 5	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Dr. Karsten Schwan				Requested Duration: 60 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Karsten Schwan	2			35,542	
2. Greg Eisenhauer	6			43,092	
3. Ada Gavrilovska	3			15,606	
4. Matthew Wolf	3			20,715	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (4) TOTAL SENIOR PERSONNEL (1-6)	14	0	0	114,955	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (2) GRADUATE STUDENTS				33,415	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				148,377	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				27,014	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				175,384	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) See budget explanation page					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,000	
2. FOREIGN					
TOTAL TRAVEL				6,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				0	
2. TUITION & FEES				0	
3. TRAINEE TRAVEL				0	
4. OTHER (fully explain on justification page)				0	
TOTAL PARTICIPANTS (0) TOTAL COST				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				9,677	
5. SUBCONTRACTS					
6. OTHER				8,640	
TOTAL OTHER DIRECT COSTS				11,678	
H. TOTAL DIRECT COSTS (A THROUGH G)				201,701	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 49.40% of 159,646					
TOTAL INDIRECT COSTS				95,377	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				297,078	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				0	
L. TOTAL COST OF PROJECT (J+K)				297,078	

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Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Georgia Tech Research Corporation				Budget Page No: Totals	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dr. Karsten Schwan				Requested Duration: 60 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Karsten Schwan				177,710	
2. Greg Eisenhauer				215,460	
3. Ada Gavrilovska				78,030	
4. Matthew Wolf				103,575	
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (4) TOTAL SENIOR PERSONNEL (1-6)				574,775	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (2) GRADUATE STUDENTS				167,075	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				741,850	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				135,072	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				876,922	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) See budget explanation page					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				30,000	
2. FOREIGN					
TOTAL TRAVEL				30,000	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				0	
2. TUITION & FEES				0	
3. TRAINEE TRAVEL				0	
4. OTHER (fully explain on justification page)				0	
TOTAL PARTICIPANTS (0) TOTAL COST				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				10,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				48,385	
5. SUBCONTRACTS					
6. OTHER				43,200	
TOTAL OTHER DIRECT COSTS				101,585	
H. TOTAL DIRECT COSTS (A THROUGH G)				1,008,507	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 49.40% of 798,232					
TOTAL INDIRECT COSTS				476,885	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				1,485,390	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				0	
L. TOTAL COST OF PROJECT (J+K)				1,485,390	

Budget Justification

A. – Personnel – (Please disclose salary/wage percentage increase per year if applicable)

A.1- Karsten Schwan is requesting 2 month's of summer salary, Matthew Wolf and Ada Gavrilovska is requesting 3 month's of summer salary and Greg Eisenhauer is requesting 6 month's of salary for each year of the five year project.

B.1-The remaining portion of the labor costs is to support 2 graduate student researchers. The project calls for salaries and tuition for two graduate students in each of the remaining years of support. These students are budgeted full time (20 hours per week) for the academic year and summer term. A 2% salary adjustment has been applied in calculating subsequent year's salary.

B.2

Explanation/Justification of Cost (For both A & B)

_X__ Salaries/Wages are based upon University established rates/salaries which are comparable to other research effort both within and outside the University.

___ Salaries/Wages are based upon ____.

C. - Fringe – 23.5% of A.1, B.1 and B.2. A fringe rate of 23.5% has been applied to Karsten Schwan, Matthew Wolf, Ada Gavrilovska and Greg Eisenhauer's salary for the five year period of the project. No fringe rate is required for graduate students salaries.

G.1 - Materials and Supplies - The budget includes $2,000 in each year for provisions of materials such as, research-related software, books, and conference proceedings.

D. – **Equipment** –

Year 1:
Year 2:
Year 3:

or N/A –There is no equipment costs associated with this project.

E. – Travel –The PI and Co-PI's and two graduate students will travel to the High Performance Distributed Computing Systems, International Conferences on Autonomic Computing, etc. There will be quite a few remote collaborators; therefore funds will be spent going to meetings with those collaborators at various sites.

G.6 - Other - Graduate Student Tuition Remission: $480 per month per student or $5,760 per year per student. There are two graduate student associated with this project, both will receive $480 per month over the five year period of the project

I - Indirect Costs - 49.4% of the Modified Total Direct Costs: Total direct cost excluding equipment and graduate student tuition remission and only on the first $25,000 of each Subcontract. Further details of the FY06 Negotiated Indirect Cost Rate Agreement can be retrieved at this website: http://www.osp.gatech.edu/fact/overhead.shtml .

RLF 5700.12
(01/06)

U. S. DEPARTMENT OF ENERGY
Pacific Northwest Site Office

OFFICE OF SCIENCE

1. Work Proposal Number	2. Revision No.	3. Date Prepared
51187		03-06-06

4. Work Proposal Title:
CANTIS: Center for Application-Network Total-Integration for SciDAC

5. Budget and Reporting Code	6. Work Proposal Term
KJ-01-00-00-0	Begin: 07-01-06 End: OPEN
7. Headquarters/Operations Office Program Manager (Name: Last, First, Middle Initial; Phone: area code-7 digit #)	8. Headquarters Organization
Johnson, Frederick C.; (301) 903-3601	SC
9. DOE Field Element Work Proposal Reviewer (Name: Last, First, Middle Initial; Phone: area code-7 digit #)	10. DOE Field Element
Day, Jeffrey, W.; (509) 372-4629	Pacific Northwest Site Office
11. PNNL Work Proposal Manager and Principal Investigator (Name: Last, First, Middle Initial; Phone: area code-7 digit #)	12. Contractor Name
Khaleel, Mohammad A.; (509) 375-2438 (PM) McKenna Jr., Thomas P.; (509) 372-6180 (PI)	Battelle Memorial Institute Pacific Northwest National Laboratory

13. Work Proposal Description (Approach, Anticipated Benefit, in 200 Words or Less)

Traditional network technologies are inherently limited in their ability to support real-time instrument control and storage of large real-time data streams. The network research areas PNNL will be addressing in CANTIS are remote microscope & instrument access and new ways of storing the large amount of data generated by these devices. This will include:

1) Microscope & Instrument Control Research: The main goal of this research is to develop and deploy networking technologies needed for remote instrument control and real-time streaming of large-scale data for genomics applications operating in the framework of SciDAC genomic applications. This goal will be accomplished through basic real-time control protocol research, application of other research efforts in visualization and data transport, and prototype implementation and testing using dedicated channel capabilities, for instance.

2) Network Storage Research: We propose to research and prototype a system for providing high performance network storage and retrieval of microscopy and other instrument data. This would include high performance file systems, parallel file systems, and the associated network infrastructure needed to enable the system.

Impact: This work will facilitate genomic discovery by enabling SciDAC scientists throughout the world to research, teach, and collaborate utilizing state of the art instruments.

14. PNNL Work Proposal Manager		15. DOE Operations Office Review Official	
M. Khaleel	2-27-06		
(Signature)	(Date)	(Signature)	(Date)

PNNL 4650.2
(1/06)

U.S. DEPARTMENT OF ENERGY
OFFICE OF SCIENCE (SC)

PROPOSAL

1. TITLE OF PROPOSED PROJECT: CANTIS: Center for Application-Network Total-Integration for SciDAC

1a. SC PROGRAM ANNOUCEMENT TITLE: Scientific Discovery through Advanced Computing

2. NUMBER OF SOLICITATION: LAB 06-04 3. NAME OF LABORATORY: Battelle, Pacific Northwest National Laboratory

4. NAME OF PRINCIPAL INVESTIGATOR (PI): Thomas P. McKenna, Jr.

5. POSITION/TITLE OF PI: Senior Scientist

6. MAILING ADDRESS OF PI: Battelle, Pacific Northwest National Laboratory, PO Box 999, Mail Stop K7-65, Richland, WA 99352-0999

7. TELEPHONE NUMBER OF PI: 509-372-6180 8. FAX NUMBER: 509-372-6904

9. ELECTRONIC MAIL ADDRESS OF PI: Thomas.mckenna@pnl.gov

10. NAME OF OFFICIAL SIGNING FOR LABORATORY: Mohammad A. Khaleel, Ph.D.

11. TITLE OF OFFICIAL: Division Director, Computational Sciences and Mathematics Division

12. TELEPHONE NUMBER OF OFFICIAL: (509) 375-2438 13. FAX NUMBER: (509) 375-4392

14. ELECTRONIC MAIL ADDRESS OF OFFICIAL: moe.khaleel@pnl.gov

15. PNNL REQUESTED FUNDING FOR EACH YEAR; TOTAL REQUEST:

YEAR 1: $400,000 YEAR 2: $400,000 YEAR 3: $400,000 YEAR 4: $400,000 YEAR 5: $400,000 TOTAL: $2,000,000
NOTE: See budget section for detailed information.

16. COLLABORATORS REQUESTED FUNDING FOR EACH YEAR; TOTAL REQUEST:

Total Collaborator Budget Requests: YEAR 1: YEAR 2: YEAR 3: YEAR 4 YEAR 5: TOTAL:
NOTE: See appendix for collaborator(s) detailed budget information.

17. TOTAL REQUESTED FUNDING FOR EACH YEAR; TOTAL REQUEST:

YEAR 1: $400,000 YEAR 2: $400,000 YEAR 3: $400,000 YEAR 4: $400,000 YEAR 5: $400,000 TOTAL: $2,000,000
NOTE: See budget pages for detailed information.

18. (a) USE OF HUMAN SUBJECTS IN PROPOSED PROJECT:

If activities involving human subjects are not planned at any time during the proposed project period, check "NO"; otherwise check "YES", provide the IRB Approval date and Assurance of Compliance Number and include all necessary information with the application.

( ) YES IRB APPROVAL DATE: ______________ (X) NO ASSURANCE OF COMPLIANCE NUMBER: ______________

(b) USE OF VERTEBRATE ANIMALS IN PROPOSED PROJECT:

If activities involving vertebrate animals are not planned at any time during this project, check "No"; otherwise check "YES" and provide the IACUC Approval date and Animal Welfare Assurance number and include all necessary information with the application.

( ) YES IACUC APPROVAL DATE: ______________ (X) NO ANIMAL WELFARE ASSURANCE NUMBER: ______________

19. SIGNATURE OF PI: DATE:

Thomas P. McKenna Jr. [signature] 2/27/06

20. SIGNATURE OF OFFICIAL: DATE:

Mohammad A. Khaleel [signature] 2-27-06

RLF 5700.12R
(01/05)

WORK PROPOSAL REQUIREMENTS FOR OPERATING/EQUIPMENT OBLIGATIONS AND COSTS

Contractor Name	Work Proposal No.	Rev. No.	Date Prepared
Battelle Memorial Institute Pacific Northwest National Laboratory	51187		03-06-06

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
16. Staffing (in Staff Years)								
A. Scientific	1.5	1.4	1.7	1.6	1.5			
B. Other Direct								
C. Total Direct	1.5	1.4	1.7	1.6	1.5			
17. Operating Expense (in Thousands)								
A. Total Obligations	400	400	400	400	400			
B. Total Costs	400	400	400	400	400			
18. Equipment (in Thousands)								
A. Obligations								
B. Costs								

19. Tasks or Milestones	Proposed Dollars Year 1	Year 2	Year 3
Staffing and funding proposed are for PNNL only and does not include partners.			
Per lead institution's instructions, period of performance for each year is as follows:			
Year 1 - July 1, 2006 to June 30, 2007			
Year 2 – July 1, 2007 to June 30, 2008			
Year 3 – July 1, 2008 to June 30, 2009			
Year 4 – July 1, 2009 to June 30, 2010			
Year 5 – July 1, 2010 to June 30, 2011			

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy

Budget Page

Year 1 (7/06-6/07)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Battelle, Pacific Northwest National Laboratory				Budget Page No: 1	
PRINCIPAL INVESTIGATOR (PI)/PROJECT DIRECTOR (PD) McKenna Jr., Thomas P.				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates	DOE Funded Person - mos			Funds Requested	Funds Granted
List each separately with title, A.8 show number in bracket(s)	CAL	ACAD	SUMR	by Applicant	by DOE
1. Nieplocha, Jarek - 65 - SCIENTIST/ENGINEER F	1.1			$ 19,339	
2. McKenna Jr., Thomas P - 72 - MANAGEMENT C	3.9			$ 58,416	
3. Lamarche, Brian L - 60 - SCIENTIST/ENGINEER A	4.9			$ 28,972	
4. Kempka, Anthony A - 64 - SCIENTIST/ENGINEER E	2.3			$ 31,582	
5. Hughes, Chad O - 61 - SCIENTIST/ENGINEER B	5.9			$ 43,405	
6. -	0.0			$ -	
7. -	0.0			$ -	
8. ( ) OTHERS					
9. (5) TOTAL SENIOR PERSONNEL (1-8)	18.1			$ 181,714	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES *	0.0			$ -	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)				$ -	
3. ( ) GRADUATE STUDENTS *				$ -	
4. ( ) UNDERGRADUATE STUDENTS *				$ -	
5. (1) SECRETARIAL - CLERICAL				$ 475	
6. ( ) OTHER				$ -	
TOTAL SALARIES AND WAGES (A+B)				$ 182,188	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)	Included in Above				
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 182,188	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM)					
TOTAL PERMANENT EQUIPMENT				$ -	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$ 2,707	
2. FOREIGN				$ -	
TOTAL TRAVEL				$ 2,707	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$ -	
2. TUITION & FEES				$ -	
3. TRAINEE TRAVEL				$ -	
4. OTHER (fully explain on justification page)				$ -	
TOTAL PARTICIPANTS ( ) TOTAL COST				$ -	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$ 47,573	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$ -	
3. CONSULTANT SERVICES				$ -	
4. COMPUTER (ADP) SERVICES				$ -	
5. SUBCONTRACTS				$ -	
6. OTHER				$ -	
TOTAL OTHER DIRECT COSTS				$ 47,573	
H. TOTAL DIRECT COSTS (ATHROUGH G)				$ 232,469	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) See attachment "Indirect Cost" for explanation.					
TOTAL INDIRECT COSTS				$ 167,531	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$ 400,000	
K. AMOUNT OF ANY REQUIRED COST-SHARING FROM NON-FEDERAL SOURCES				$ -	
L. TOTAL COST OF PROJECT (J+K)				$ 400,000	

* Section B, lines 1,3, and 4 are third party cost.

INDIRECT COSTS

PROPOSAL # 51187

ORGANIZATIONAL OVERHEAD

ORGANIZATIONAL MANAGEMENT, SUPERVISION, AND ADMINISTRATIVE COSTS ARE INCLUDED HERE. ALSO INCLUDED ARE COSTS INCURRED BY TECHNICAL ORGANIZATIONS IN SUPPORT OF RESEARCH, AND EQUIPMENT WHICH WOULD BE IMPRACTICAL TO ALLOCATE TO INDIVIDUAL CONTRACTS. THIS COST CATEGORY INCLUDES: LABORATORY SUPPLIES, SMALL TOOLS, LAUNDRY, DECONTAMINATION/WASTE DISPOSAL, MAINTENANCE EXPENSES AND OTHER DEPARTMENTAL COSTS, AND EXPENSES ASSOCIATED WITH BATTELLE-OWNED EQUIPMENT WITH A FIRST COST OF LESS THAN $50,000, SUCH AS DEPRECIATION, MAINTENANCE, TAXES, AND INSURANCE. THESE COSTS ARE ACCUMULATED IN AN INTERMEDIATE COST POOL AND ARE ALLOCATED TO COST OBJECTIVES AT A PREDETERMINED RATE PER DIRECT LABOR HOUR.

PROGRAM DEVELOPMENT AND MANAGEMENT (PDM)

PROGRAM DEVELOPMENT AND PROGRAM MANAGEMENT COSTS INCLUDE COSTS FOR BUSINESS DEVELOPMENT, PLANNING, AND MONITORING FOR A GROUP OF PROJECTS. COSTS ARE POOLED AND THEN APPLIED TO VALUE ADDED COSTS, LESS PDM COSTS, PLUS MATERIALS AND NON-OPF SUBCONTRACTS.

GENERAL AND ADMINISTRATIVE EXPENSE (G&A)

THE ALLOCATION BASE FOR G&A EXPENSES IS VALUE ADDED TO FINAL COST OBJECTIVES. THE VALUE-ADDED BASE INCLUDES: LABOR, TRAVEL, SERVICE AND EQUIPMENT CENTERS, ORGANIZATIONAL OVERHEAD, BUILDING AND UTILITY COST, AND OTHER DIRECT COSTS. IT EXCLUDES THE BASE COST FOR PROCUREMENT, SUBCONTRACTS, AND OTHER HANFORD CONTRACTOR SERVICES.

INITIAL GRANT PERIOD, FROM 7/1/2006 THROUGH 6/30/2007

	FY2006	FY2006			FY2007			Task Total
	RATE	RATE	BASE	IND COST	RATE	BASE	IND COST	
PROGRAM DEV AND MGMT (PDM)	6.0%	6.0%	$107,069	**6,424**	6.0%	$180,574	**10,834**	**17,259**
ORGANIZATIONAL OVERHEAD:								
Lab Technical Mgmt Cost[1]	$ 0.15	$ 0.15	659 hrs	99	$ 0.15	1,986 hrs	298	
ORG OVERHEAD RATES								
D7D21 - Rich Interaction Environments								
D7D21-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 20.75	4.26 hrs	88	$ 21.27	13 hrs	277	
D7D36 - Computer Science								
D7D36-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 20.75	41 hrs	851	$ 21.27	123 hrs	2,616	
D7D01B - Major Program Integration								
D7D01B-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 20.75	141 hrs	2,926	$ 21.27	422 hrs	8,976	
D7M43 - Instrument Development Laboratory								
D7M43-EMDR - DOE ONLY-EMSL NON-LAB REIM [1]	$ 19.15	$ 19.15	173 hrs	3,313	$ 19.63	530 hrs	10,404	
D7D26 - Cyber Security Defense								
D7D26-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 20.75	85 hrs	1,764	$ 21.27	254 hrs	5,403	
D7D23 - Cyber Security								
D7D23-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 20.75	215 hrs	4,461	$ 21.27	644 hrs	13,698	
TOTAL ORGANIZATIONAL OVERHEAD				**13,502**			**41,671**	**55,173**
GENERAL AND ADMINISTRATIVE COST - 541[3]	33.0%	33.0%	$68,362	**22,560**	33.0%	$191,409	**63,165**	**85,724**
SERVICE ASSESSMENT	2.4%	2.4%	$136,052	**3,265**	2.4%	$254,573	**6,110**	**9,375**
TOTAL INDIRECT COST				**45,751**			**121,780**	**167,531**

NOTES:

[1] Unit-based Rate

[2] Percentage-based Rate

[3] Applies to Value-Added Base

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy

Budget Page

Year 2 (7/07-6/08)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Battelle, Pacific Northwest National Laboratory				Budget Page No: 2	
PRINCIPAL INVESTIGATOR (PI)/PROJECT DIRECTOR (PD) McKenna Jr., Thomas P.				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates	DOE Funded Person - mos			Funds Requested	Funds Granted
List each separately with title, A.8 show number in bracket(s)	CAL	ACAD	SUMR	by Applicant	by DOE
1. Nieplocha, Jarek - 65 - SCIENTIST/ENGINEER F	1.1			$ 19,217	
2. McKenna Jr., Thomas P - 72 - MANAGEMENT C	3.8			$ 59,133	
3. Lamarche, Brian L - 60 - SCIENTIST/ENGINEER A	4.0			$ 24,203	
4. Kempka, Anthony A - 64 - SCIENTIST/ENGINEER E	2.3			$ 31,704	
5. Hughes, Chad O - 61 - SCIENTIST/ENGINEER B	5.9			$ 44,128	
6. -	0.0			$ -	
7. -	0.0			$ -	
8. ( ) OTHERS					
9. (5) TOTAL SENIOR PERSONNEL (1-8)	17.1			$ 178,385	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES *	0.0			$ -	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)				$ -	
3. ( ) GRADUATE STUDENTS *				$ -	
4. ( ) UNDERGRADUATE STUDENTS *				$ -	
5. (1) SECRETARIAL - CLERICAL				$ 302	
6. ( ) OTHER				$ -	
TOTAL SALARIES AND WAGES (A+B)				$ 178,687	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)		Included in Above			
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 178,687	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM)					
TOTAL PERMANENT EQUIPMENT				$ -	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$ 2,720	
2. FOREIGN				$ -	
TOTAL TRAVEL				$ 2,720	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$ -	
2. TUITION & FEES				$ -	
3. TRAINEE TRAVEL				$ -	
4. OTHER (fully explain on justification page)				$ -	
TOTAL PARTICIPANTS ( ) TOTAL COST				$ -	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$ 48,648	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$ -	
3. CONSULTANT SERVICES				$ -	
4. COMPUTER (ADP) SERVICES				$ -	
5. SUBCONTRACTS				$ -	
6. OTHER				$ -	
TOTAL OTHER DIRECT COSTS				$ 48,648	
H. TOTAL DIRECT COSTS (ATHROUGH G)				$ 230,055	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) See attachment "Indirect Cost" for explanation.					
TOTAL INDIRECT COSTS				$ 169,945	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$ 400,000	
K. AMOUNT OF ANY REQUIRED COST-SHARING FROM NON-FEDERAL SOURCES				$ -	
L. TOTAL COST OF PROJECT (J+K)				$ 400,000	

* Section B, lines 1,3, and 4 are third party cost.

INDIRECT COSTS

PROPOSAL # 51187

ORGANIZATIONAL OVERHEAD

ORGANIZATIONAL MANAGEMENT, SUPERVISION, AND ADMINISTRATIVE COSTS ARE INCLUDED HERE. ALSO INCLUDED ARE COSTS INCURRED BY TECHNICAL ORGANIZATIONS IN SUPPORT OF RESEARCH, AND EQUIPMENT WHICH WOULD BE IMPRACTICAL TO ALLOCATE TO INDIVIDUAL CONTRACTS. THIS COST CATEGORY INCLUDES: LABORATORY SUPPLIES, SMALL TOOLS, LAUNDRY, DECONTAMINATION/WASTE DISPOSAL, MAINTENANCE EXPENSES AND OTHER DEPARTMENTAL COSTS, AND EXPENSES ASSOCIATED WITH BATTELLE-OWNED EQUIPMENT WITH A FIRST COST OF LESS THAN $50,000, SUCH AS DEPRECIATION, MAINTENANCE, TAXES, AND INSURANCE. THESE COSTS ARE ACCUMULATED IN AN INTERMEDIATE COST POOL AND ARE ALLOCATED TO COST OBJECTIVES AT A PREDETERMINED RATE PER DIRECT LABOR HOUR.

PROGRAM DEVELOPMENT AND MANAGEMENT (PDM)

PROGRAM DEVELOPMENT AND PROGRAM MANAGEMENT COSTS INCLUDE COSTS FOR BUSINESS DEVELOPMENT, PLANNING, AND MONITORING FOR A GROUP OF PROJECTS. COSTS ARE POOLED AND THEN APPLIED TO VALUE ADDED COSTS, LESS PDM COSTS, PLUS MATERIALS AND NON-OPF SUBCONTRACTS.

GENERAL AND ADMINISTRATIVE EXPENSE (G&A)

THE ALLOCATION BASE FOR G&A EXPENSES IS VALUE ADDED TO FINAL COST OBJECTIVES. THE VALUE-ADDED BASE INCLUDES: LABOR, TRAVEL, SERVICE AND EQUIPMENT CENTERS, ORGANIZATIONAL OVERHEAD, BUILDING AND UTILITY COST, AND OTHER DIRECT COSTS. IT EXCLUDES THE BASE COST FOR PROCUREMENT, SUBCONTRACTS, AND OTHER HANFORD CONTRACTOR SERVICES.

SECOND GRANT PERIOD, FROM 7/1/2007 THROUGH 6/30/2008

	FY2006	FY2007			FY2008			Task Total
	RATE	RATE	BASE	IND COST	RATE	BASE	IND COST	
PROGRAM DEV AND MGMT (PDM)	6.0%	6.0%	$106,936	**6,416**	6.0%	$176,328	**10,580**	**16,996**
ORGANIZATIONAL OVERHEAD:								
Lab Technical Mgmt Cost[1]	$ 0.15	$ 0.15	621 hrs	93	$ 0.15	1,862 hrs	279	
ORG OVERHEAD RATES								
D7D21 - Rich Interaction Environments								
D7D21-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.27	3 hrs	64	$ 21.80	7.71 hrs	168	
D7D36 - Computer Science								
D7D36-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.27	40 hrs	851	$ 21.80	119 hrs	2,594	
D7D01B - Major Program Integration								
D7D01B-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.27	139 hrs	2,957	$ 21.80	417 hrs	9,091	
D7M43 - Instrument Development Laboratory								
D7M43-EMDR - DOE ONLY-EMSL NON-LAB REIM [1]	$ 19.15	$ 19.63	143 hrs	2,807	$ 20.12	430 hrs	8,652	
D7D26 - Cyber Security Defense								
D7D26-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.27	83 hrs	1,765	$ 21.80	249 hrs	5,428	
D7D23 - Cyber Security								
D7D23-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.27	213 hrs	4,531	$ 21.80	639 hrs	13,930	
TOTAL ORGANIZATIONAL OVERHEAD				**13,067**			**40,142**	**53,209**
GENERAL AND ADMINISTRATIVE COST - 541[3]	33.0%	33.0%	$67,102	**22,144**	36.5%	$186,908	**68,221**	**90,365**
SERVICE ASSESSMENT	2.4%	2.4%	$135,495	**3,252**	2.4%	$255,129	**6,123**	**9,375**
TOTAL INDIRECT COST				**44,879**			**125,066**	**169,945**

NOTES:

[1] Unit-based Rate

[2] Percentage-based Rate

[3] Applies to Value-Added Base

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy

Budget Page

Year 3 (7/08-6/09)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION
Battelle, Pacific Northwest National Laboratory

Budget Page No: 3

PRINCIPAL INVESTIGATOR (PI)/PROJECT DIRECTOR (PD)
McKenna Jr., Thomas P.

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates List each separately with title, A.8 show number in bracket(s)	DOE Funded Person - mos CAL	ACAD	SUMR	Funds Requested by Applicant	Funds Granted by DOE
1. Nieplocha, Jarek - 65 - SCIENTIST/ENGINEER F	1.2			$ 21,680	
2. McKenna Jr., Thomas P - 72 - MANAGEMENT C	4.0			$ 62,572	
3. Lamarche, Brian L - 60 - SCIENTIST/ENGINEER A	6.3			$ 39,312	
4. Kempka, Anthony A - 64 - SCIENTIST/ENGINEER E	2.4			$ 34,063	
5. Hughes, Chad O - 61 - SCIENTIST/ENGINEER B	6.0			$ 46,080	
6. -	0.0			$ -	
7. -	0.0			$ -	
8. ( ) OTHERS					
9. (5) TOTAL SENIOR PERSONNEL (1-8)	19.9			$ 203,707	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES *	0.0			$ -	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)				$ -	
3. ( ) GRADUATE STUDENTS *				$ -	
4. ( ) UNDERGRADUATE STUDENTS *				$ -	
5. (1) SECRETARIAL - CLERICAL				$ 446	
6. ( ) OTHER				$ -	
TOTAL SALARIES AND WAGES (A+B)				$ 204,153	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)		Included in Above			
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 204,153	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM)					
TOTAL PERMANENT EQUIPMENT				$ -	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$ 2,788	
2. FOREIGN				$ -	
TOTAL TRAVEL				$ 2,788	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$ -	
2. TUITION & FEES				$ -	
3. TRAINEE TRAVEL				$ -	
4. OTHER (fully explain on justification page)				$ -	
TOTAL PARTICIPANTS ( ) TOTAL COST				$ -	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$ -	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$ -	
3. CONSULTANT SERVICES				$ -	
4. COMPUTER (ADP) SERVICES				$ -	
5. SUBCONTRACTS				$ -	
6. OTHER				$ -	
TOTAL OTHER DIRECT COSTS				$ -	
H. TOTAL DIRECT COSTS (ATHROUGH G)				$ 206,941	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) See attachment "Indirect Cost" for explanation.					
TOTAL INDIRECT COSTS				$ 193,059	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$ 400,000	
K. AMOUNT OF ANY REQUIRED COST-SHARING FROM NON-FEDERAL SOURCES				$ -	
L. TOTAL COST OF PROJECT (J+K)				$ 400,000	

* Section B, lines 1,3, and 4 are third party cost.

INDIRECT COSTS
PROPOSAL # 51187

ORGANIZATIONAL OVERHEAD
ORGANIZATIONAL MANAGEMENT, SUPERVISION, AND ADMINISTRATIVE COSTS ARE INCLUDED HERE. ALSO INCLUDED ARE COSTS INCURRED BY TECHNICAL ORGANIZATIONS IN SUPPORT OF RESEARCH, AND EQUIPMENT WHICH WOULD BE IMPRACTICAL TO ALLOCATE TO INDIVIDUAL CONTRACTS. THIS COST CATEGORY INCLUDES: LABORATORY SUPPLIES, SMALL TOOLS, LAUNDRY, DECONTAMINATION/WASTE DISPOSAL, MAINTENANCE EXPENSES AND OTHER DEPARTMENTAL COSTS, AND EXPENSES ASSOCIATED WITH BATTELLE-OWNED EQUIPMENT WITH A FIRST COST OF LESS THAN $50,000, SUCH AS DEPRECIATION, MAINTENANCE, TAXES, AND INSURANCE. THESE COSTS ARE ACCUMULATED IN AN INTERMEDIATE COST POOL AND ARE ALLOCATED TO COST OBJECTIVES AT A PREDETERMINED RATE PER DIRECT LABOR HOUR.

PROGRAM DEVELOPMENT AND MANAGEMENT (PDM)
PROGRAM DEVELOPMENT AND PROGRAM MANAGEMENT COSTS INCLUDE COSTS FOR BUSINESS DEVELOPMENT, PLANNING, AND MONITORING FOR A GROUP OF PROJECTS. COSTS ARE POOLED AND THEN APPLIED TO VALUE ADDED COSTS, LESS PDM COSTS, PLUS MATERIALS AND NON-OPF SUBCONTRACTS.

GENERAL AND ADMINISTRATIVE EXPENSE (G&A)
THE ALLOCATION BASE FOR G&A EXPENSES IS VALUE ADDED TO FINAL COST OBJECTIVES. THE VALUE-ADDED BASE INCLUDES: LABOR, TRAVEL, SERVICE AND EQUIPMENT CENTERS, ORGANIZATIONAL OVERHEAD, BUILDING AND UTILITY COST, AND OTHER DIRECT COSTS. IT EXCLUDES THE BASE COST FOR PROCUREMENT, SUBCONTRACTS, AND OTHER HANFORD CONTRACTOR SERVICES.

THIRD GRANT PERIOD, FROM 7/1/2008 THROUGH 6/30/2009

	FY2006	FY2008			FY2009			Task Total
	RATE	RATE	BASE	IND COST	RATE	BASE	IND COST	
PROGRAM DEV AND MGMT (PDM)	6.0%	6.0%	$67,053	**4,023**	6.0%	$202,921	**12,175**	**16,198**
ORGANIZATIONAL OVERHEAD:								
Lab Technical Mgmt Cost[1]	$ 0.15	$ 0.15	723 hrs	108	$ 0.15	2,165 hrs	325	
ORG OVERHEAD RATES								
D7D21 - Rich Interaction Environments								
D7D21-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.80	4 hrs	87	$ 22.35	11.44 hrs	256	
D7D36 - Computer Science								
D7D36-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.80	44 hrs	959	$ 22.35	131 hrs	2,928	
D7D01B - Major Program Integration								
D7D01B-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.80	144 hrs	3,139	$ 22.35	430 hrs	9,611	
D7M43 - Instrument Development Laboratory								
D7M43-EMDR - DOE ONLY-EMSL NON-LAB REIM [1]	$ 19.15	$ 20.12	227 hrs	4,567	$ 20.62	681 hrs	14,042	
D7D26 - Cyber Security Defense								
D7D26-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.80	87 hrs	1,897	$ 22.35	261 hrs	5,833	
D7D23 - Cyber Security								
D7D23-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 21.80	217 hrs	4,731	$ 22.35	651 hrs	14,550	
TOTAL ORGANIZATIONAL OVERHEAD				**15,488**			**47,544**	**63,033**
GENERAL AND ADMINISTRATIVE COST - 541[3]	33.0%	36.5%	$71,076	**25,943**	36.5%	$215,096	**78,510**	**104,453**
SERVICE ASSESSMENT	2.4%	2.4%	$97,018	**2,328**	2.4%	$293,606	**7,047**	**9,375**
TOTAL INDIRECT COST				**47,783**			**145,276**	**193,059**

NOTES:
[1] Unit-based Rate
[2] Percentage-based Rate
[3] Applies to Value-Added Base

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy

Budget Page

Year 4 (7/9-6/10)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Battelle, Pacific Northwest National Laboratory				Budget Page No: 5	
PRINCIPAL INVESTIGATOR (PI)/PROJECT DIRECTOR (PD) McKenna Jr., Thomas P.				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates	DOE Funded Person - mos			Funds Requested	Funds Granted
List each separately with title, A.8 show number in bracket(s)	CAL	ACAD	SUMR	by Applicant	by DOE
1. Nieplocha, Jarek - 65 - SCIENTIST/ENGINEER F	1.2			$ 22,222	
2. McKenna Jr., Thomas P - 72 - MANAGEMENT C	4.0			$ 64,026	
3. Lamarche, Brian L - 60 - SCIENTIST/ENGINEER A	5.6			$ 35,724	
4. Kempka, Anthony A - 64 - SCIENTIST/ENGINEER E	2.4			$ 34,914	
5. Hughes, Chad O - 61 - SCIENTIST/ENGINEER B	6.0			$ 47,233	
6. -	0.0			$ -	
7. -	0.0			$ -	
8. ( ) OTHERS					
9. (5) TOTAL SENIOR PERSONNEL (1-8)	19.2			$ 204,119	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES *	0.0			$ -	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)				$ -	
3. ( ) GRADUATE STUDENTS *				$ -	
4. ( ) UNDERGRADUATE STUDENTS *				$ -	
5. (1) SECRETARIAL - CLERICAL				$ 543	
6. ( ) OTHER				$ -	
TOTAL SALARIES AND WAGES (A+B)				$ 204,662	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)		Included in Above			
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 204,662	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM)					
TOTAL PERMANENT EQUIPMENT				$ -	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$ 2,858	
2. FOREIGN				$ -	
TOTAL TRAVEL				$ 2,858	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$ -	
2. TUITION & FEES				$ -	
3. TRAINEE TRAVEL				$ -	
4. OTHER (fully explain on justification page)				$ -	
TOTAL PARTICIPANTS ( ) TOTAL COST				$ -	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$ -	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$ -	
3. CONSULTANT SERVICES				$ -	
4. COMPUTER (ADP) SERVICES				$ -	
5. SUBCONTRACTS				$ -	
6. OTHER				$ -	
TOTAL OTHER DIRECT COSTS				$ -	
H. TOTAL DIRECT COSTS (ATHROUGH G)				$ 207,520	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) See attachment "Indirect Cost" for explanation.					
TOTAL INDIRECT COSTS				$ 192,480	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$ 400,000	
K. AMOUNT OF ANY REQUIRED COST-SHARING FROM NON-FEDERAL SOURCES				$ -	
L. TOTAL COST OF PROJECT (J+K)				$ 400,000	

* Section B, lines 1,3, and 4 are third party cost.

INDIRECT COSTS

PROPOSAL # 51187

ORGANIZATIONAL OVERHEAD

ORGANIZATIONAL MANAGEMENT, SUPERVISION, AND ADMINISTRATIVE COSTS ARE INCLUDED HERE. ALSO INCLUDED ARE COSTS INCURRED BY TECHNICAL ORGANIZATIONS IN SUPPORT OF RESEARCH, AND EQUIPMENT WHICH WOULD BE IMPRACTICAL TO ALLOCATE TO INDIVIDUAL CONTRACTS. THIS COST CATEGORY INCLUDES: LABORATORY SUPPLIES, SMALL TOOLS, LAUNDRY, DECONTAMINATION/WASTE DISPOSAL, MAINTENANCE EXPENSES AND OTHER DEPARTMENTAL COSTS, AND EXPENSES ASSOCIATED WITH BATTELLE-OWNED EQUIPMENT WITH A FIRST COST OF LESS THAN $50,000, SUCH AS DEPRECIATION, MAINTENANCE, TAXES, AND INSURANCE. THESE COSTS ARE ACCUMULATED IN AN INTERMEDIATE COST POOL AND ARE ALLOCATED TO COST OBJECTIVES AT A PREDETERMINED RATE PER DIRECT LABOR HOUR.

PROGRAM DEVELOPMENT AND MANAGEMENT (PDM)

PROGRAM DEVELOPMENT AND PROGRAM MANAGEMENT COSTS INCLUDE COSTS FOR BUSINESS DEVELOPMENT, PLANNING, AND MONITORING FOR A GROUP OF PROJECTS. COSTS ARE POOLED AND THEN APPLIED TO VALUE ADDED COSTS, LESS PDM COSTS, PLUS MATERIALS AND NON-OPF SUBCONTRACTS.

GENERAL AND ADMINISTRATIVE EXPENSE (G&A)

THE ALLOCATION BASE FOR G&A EXPENSES IS VALUE ADDED TO FINAL COST OBJECTIVES. THE VALUE-ADDED BASE INCLUDES: LABOR, TRAVEL, SERVICE AND EQUIPMENT CENTERS, ORGANIZATIONAL OVERHEAD, BUILDING AND UTILITY COST, AND OTHER DIRECT COSTS. IT EXCLUDES THE BASE COST FOR PROCUREMENT, SUBCONTRACTS, AND OTHER HANFORD CONTRACTOR SERVICES.

FOURTH GRANT PERIOD, FROM 7/1/2009 THROUGH 6/30/2010

	FY2006	FY2009			FY2010			Task Total
	RATE	RATE	BASE	IND COST	RATE	BASE	IND COST	
PROGRAM DEV AND MGMT (PDM)	6.0%	6.0%	$66,940	**4,016**	6.0%	$203,034	**12,182**	**16,198**
ORGANIZATIONAL OVERHEAD:								
Lab Technical Mgmt Cost[1]	$ 0.15	$ 0.15	696 hrs	104	$ 0.15	2,091 hrs	314	
ORG OVERHEAD RATES								
D7D21 - Rich Interaction Environments								
D7D21-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.35	4.31 hrs	96	$ 22.90	14 hrs	321	
D7D36 - Computer Science								
D7D36-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.35	44 hrs	983	$ 22.90	131 hrs	3,000	
D7D01B - Major Program Integration								
D7D01B-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.35	143 hrs	3,196	$ 22.90	430 hrs	9,847	
D7M43 - Instrument Development Laboratory								
D7M43-EMDR - DOE ONLY-EMSL NON-LAB REIM [1]	$ 19.15	$ 20.62	201 hrs	4,145	$ 21.14	604 hrs	12,769	
D7D26 - Cyber Security Defense								
D7D26-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.35	87 hrs	1,944	$ 22.90	261 hrs	5,977	
D7D23 - Cyber Security								
D7D23-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.35	217 hrs	4,850	$ 22.90	651 hrs	14,908	
TOTAL ORGANIZATIONAL OVERHEAD				**15,319**			**47,135**	**62,454**
GENERAL AND ADMINISTRATIVE COST - 541[3]	33.0%	36.5%	$70,956	**25,899**	36.5%	$215,216	**78,554**	**104,453**
SERVICE ASSESSMENT	2.4%	2.4%	$96,855	**2,325**	2.4%	$293,770	**7,050**	**9,375**
TOTAL INDIRECT COST				**47,559**			**144,921**	**192,480**

NOTES:

[1] Unit-based Rate

[2] Percentage-based Rate

[3] Applies to Value-Added Base

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy

Budget Page

Year 5 (7/10-6/11)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Battelle, Pacific Northwest National Laboratory				Budget Page No: 5	
PRINCIPAL INVESTIGATOR (PI)/PROJECT DIRECTOR (PD) McKenna Jr., Thomas P.				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates	DOE Funded Person - mos			Funds Requested	Funds Granted
List each separately with title, A.8 show number in bracket(s)	CAL	ACAD	SUMR	by Applicant	by DOE
1. Nieplocha, Jarek - 65 - SCIENTIST/ENGINEER F	1.2			$ 22,778	
2. McKenna Jr., Thomas P - 72 - MANAGEMENT C	4.0			$ 65,627	
3. Lamarche, Brian L - 60 - SCIENTIST/ENGINEER A	4.9			$ 32,022	
4. Kempka, Anthony A - 64 - SCIENTIST/ENGINEER E	2.4			$ 35,787	
5. Hughes, Chad O - 61 - SCIENTIST/ENGINEER B	6.0			$ 48,413	
6. -	0.0			$ -	
7. -	0.0			$ -	
8. ( ) OTHERS					
9. (5) TOTAL SENIOR PERSONNEL (1-8)	18.5			$ 204,627	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES *	0.0			$ -	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)				$ -	
3. ( ) GRADUATE STUDENTS *				$ -	
4. ( ) UNDERGRADUATE STUDENTS *				$ -	
5. (1) SECRETARIAL - CLERICAL				$ 578	
6. ( ) OTHER				$ -	
TOTAL SALARIES AND WAGES (A+B)				$ 205,205	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)		Included in Above			
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 205,205	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM)					
TOTAL PERMANENT EQUIPMENT				$ -	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$ 2,929	
2. FOREIGN				$ -	
TOTAL TRAVEL				$ 2,929	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$ -	
2. TUITION & FEES				$ -	
3. TRAINEE TRAVEL				$ -	
4. OTHER (fully explain on justification page)				$ -	
TOTAL PARTICIPANTS ( ) TOTAL COST				$ -	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$ -	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$ -	
3. CONSULTANT SERVICES				$ -	
4. COMPUTER (ADP) SERVICES				$ -	
5. SUBCONTRACTS				$ -	
6. OTHER				$ -	
TOTAL OTHER DIRECT COSTS				$ -	
H. TOTAL DIRECT COSTS (ATHROUGH G)				$ 208,134	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) See attachment "Indirect Cost" for explanation.					
TOTAL INDIRECT COSTS				$ 191,866	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$ 400,000	
K. AMOUNT OF ANY REQUIRED COST-SHARING FROM NON-FEDERAL SOURCES				$ -	
L. TOTAL COST OF PROJECT (J+K)				$ 400,000	

* Section B, lines 1,3, and 4 are third party cost.

INDIRECT COSTS

PROPOSAL # 51187

ORGANIZATIONAL OVERHEAD

ORGANIZATIONAL MANAGEMENT, SUPERVISION, AND ADMINISTRATIVE COSTS ARE INCLUDED HERE. ALSO INCLUDED ARE COSTS INCURRED BY TECHNICAL ORGANIZATIONS IN SUPPORT OF RESEARCH, AND EQUIPMENT WHICH WOULD BE IMPRACTICAL TO ALLOCATE TO INDIVIDUAL CONTRACTS. THIS COST CATEGORY INCLUDES: LABORATORY SUPPLIES, SMALL TOOLS, LAUNDRY, DECONTAMINATION/WASTE DISPOSAL, MAINTENANCE EXPENSES AND OTHER DEPARTMENTAL COSTS, AND EXPENSES ASSOCIATED WITH BATTELLE-OWNED EQUIPMENT WITH A FIRST COST OF LESS THAN $50,000, SUCH AS DEPRECIATION, MAINTENANCE, TAXES, AND INSURANCE. THESE COSTS ARE ACCUMULATED IN AN INTERMEDIATE COST POOL AND ARE ALLOCATED TO COST OBJECTIVES AT A PREDETERMINED RATE PER DIRECT LABOR HOUR.

PROGRAM DEVELOPMENT AND MANAGEMENT (PDM)

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GENERAL AND ADMINISTRATIVE EXPENSE (G&A)

THE ALLOCATION BASE FOR G&A EXPENSES IS VALUE ADDED TO FINAL COST OBJECTIVES. THE VALUE-ADDED BASE INCLUDES: LABOR, TRAVEL, SERVICE AND EQUIPMENT CENTERS, ORGANIZATIONAL OVERHEAD, BUILDING AND UTILITY COST, AND OTHER DIRECT COSTS. IT EXCLUDES THE BASE COST FOR PROCUREMENT, SUBCONTRACTS, AND OTHER HANFORD CONTRACTOR SERVICES.

FIFTH GRANT PERIOD, FROM 7/1/2010 THROUGH 6/30/2011

	FY2006	FY2010			FY2011			Task Total
	RATE	RATE	BASE	IND COST	RATE	BASE	IND COST	
PROGRAM DEV AND MGMT (PDM)	6.0%	6.0%	$66,996	**4,020**	6.0%	$202,978	**12,179**	**16,198**
ORGANIZATIONAL OVERHEAD:								
Lab Technical Mgmt Cost[1]	$ 0.15	$ 0.15	672 hrs	101	$ 0.15	2,015 hrs	302	
ORG OVERHEAD RATES								
D7D21 - Rich Interaction Environments								
D7D21-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.90	5.03 hrs	115	$ 23.48	14 hrs	329	
D7D36 - Computer Science								
D7D36-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.90	44 hrs	1,008	$ 23.48	131 hrs	3,076	
D7D01B - Major Program Integration								
D7D01B-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.90	143 hrs	3,275	$ 23.48	430 hrs	10,096	
D7M43 - Instrument Development Laboratory								
D7M43-EMDR - DOE ONLY-EMSL NON-LAB REIM [1]	$ 19.15	$ 21.14	176 hrs	3,721	$ 21.67	528 hrs	11,442	
D7D26 - Cyber Security Defense								
D7D26-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.90	87 hrs	1,992	$ 23.48	261 hrs	6,128	
D7D23 - Cyber Security								
D7D23-ISD - DOE ONLY-CISD Department [1]	$ 20.75	$ 22.90	217 hrs	4,969	$ 23.48	651 hrs	15,285	
TOTAL ORGANIZATIONAL OVERHEAD				**15,181**			**46,659**	**61,839**
GENERAL AND ADMINISTRATIVE COST - 541[3]	33.0%	36.5%	$71,016	**25,921**	36.5%	$215,156	**78,532**	**104,453**
SERVICE ASSESSMENT	2.4%	2.4%	$96,937	**2,326**	2.4%	$293,689	**7,049**	**9,375**
TOTAL INDIRECT COST				**47,448**			**144,418**	**191,866**

NOTES:

[1] Unit-based Rate

[2] Percentage-based Rate

[3] Applies to Value-Added Base

DOE F 4620.1 (04-93) *All Other Editions Are Obsolete*	**U.S. Department of Energy** **Budget Page** Fiscal Years 2006-2011	OMB Control No. 1910-1400 OMB Burden Disclosure Statement on Reverse

ORGANIZATION Battelle, Pacific Northwest National Laboratory				Budget Page No: 6	
PRINCIPAL INVESTIGATOR (PI)/PROJECT DIRECTOR (PD) McKenna Jr., Thomas P.				Requested Duration: 60 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates	DOE Funded Person - mos			Funds Requested	Funds Granted
List each separately with title, A.8 show number in bracket(s)	CAL	ACAD	SUMR	by Applicant	by DOE
1. Nieplocha, Jarek - 65 - SCIENTIST/ENGINEER F	5.8			$ 105,236	
2. McKenna Jr., Thomas P - 72 - MANAGEMENT C	19.7			$ 309,774	
3. Lamarche, Brian L - 60 - SCIENTIST/ENGINEER A	25.7			$ 160,233	
4. Kempka, Anthony A - 64 - SCIENTIST/ENGINEER E	11.8			$ 168,050	
5. Hughes, Chad O - 61 - SCIENTIST/ENGINEER B	29.8			$ 229,259	
6. -	0.0			$ -	
7. -	0.0			$ -	
8. ( ) OTHERS					
9. (5) TOTAL SENIOR PERSONNEL (1-8)	92.8			$ 972,552	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES *	0.0			$ -	
2. ( ) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)				$ -	
3. ( ) GRADUATE STUDENTS *				$ -	
4. ( ) UNDERGRADUATE STUDENTS *				$ -	
5. (1) SECRETARIAL - CLERICAL				$ 2,344	
6. ( ) OTHER				$ -	
TOTAL SALARIES AND WAGES (A+B)				$ 974,896	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)	Included in Above				
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$ 974,896	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM)					
TOTAL PERMANENT EQUIPMENT				$ -	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$ 14,002	
2. FOREIGN				$ -	
TOTAL TRAVEL				$ 14,002	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$ -	
2. TUITION & FEES				$ -	
3. TRAINEE TRAVEL				$ -	
4. OTHER (fully explain on justification page)				$ -	
TOTAL PARTICIPANTS ( ) TOTAL COST				$ -	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$ 96,221	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$ -	
3. CONSULTANT SERVICES				$ -	
4. COMPUTER (ADP) SERVICES				$ -	
5. SUBCONTRACTS				$ -	
6. OTHER				$ -	
TOTAL OTHER DIRECT COSTS				$ 96,221	
H. TOTAL DIRECT COSTS (ATHROUGH G)				$ 1,085,119	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) See attachment "Indirect Cost" for explanation.					
TOTAL INDIRECT COSTS				$ 914,881	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				$ 2,000,000	
K. AMOUNT OF ANY REQUIRED COST-SHARING FROM NON-FEDERAL SOURCES				$ -	
L. TOTAL COST OF PROJECT (J+K)				$ 2,000,000	

* Section B, lines 1,3, and 4 are third party cost.

PNNL Budget Explanation

Funding Mechanism: PNNL is to receive funds only for those dollars identified on PNNL budget pages.

A./B. Senior Personnel/Other Personnel:

Senior Staff	**Total Months**	**Primary Role/Responsibility**
McKenna Jr., Thomas P	19.7	Principal Investigator, manages all aspects of project, including research agenda.
Kempka, Anthony A	11.8	Chief Architect for the project.
Nieplocha, Jarek	5.8	Research Lead, helps with the research agenda and coordination with other SciDAC.
Other Staff	**Total Months**	**Primary Role/Responsibility**
Hughes, Chad O	29.8	Programmer/Researcher, lead programmer for the project.
LaMarche, Brian L	25.7	Programmer/QA

C. **Fringe Benefits:** Not applicable – included in A and B above.
D. **Permanent Equipment:** Not applicable
E. **Travel:**
   1. **Domestic:** Travel funds are requested to participate in client PI meetings, coordinate research on project with partners, and participate in technical conferences/workshops to present results.
   2. **Foreign:** Not applicable
F. **Trainee/Participant Costs:** Not applicable
G. **Other Direct Costs:**
   1. **Materials and Supplies:** Computer hardware.
   2. **Publication Costs:** Not applicable
   3. **Consultant Services:** Not applicable
   4. **Computer (ADP Services):** Not applicable
   5. **Subcontracts:** Not applicable
   6. **Other:** Not applicable
H. **Direct Costs:** $ 1,085,119
I. **Indirect Costs:** $ 914,881
J. **Total Direct and Indirect:** $ 2,000,000
K. **Amount of any Required Cost-Sharing from Non-Federal Sources:** Not applicable.
L. **Total Cost of Project:** $ 2,000,000

Office of Science (SC)

Face Page

TITLE OF PROPOSED RESEARCH:
CANTIS: Center for Application - Network Total - Integration for SciDAC

1. CATALOG OF FEDERAL DOMESTIC ASSISTANCE #
81.049

2. CONGRESSIONAL DISTRICT:
Applicant Organization's District: 14th District
Project Site's District: 14th District

3A. I.R.S. ENTITY IDENTIFICATION OR SSN:
94-11-56365

3B. DUNS Number:
009214214

4. AREA OF RESEARCH OR ANNOUNCEMENT TITLE/#:
Scientific Discovery through Advanced Computing (SciDac)

5. HAS THIS RESEARCH PROPOSAL BEEN SUBMITTED TO ANY OTHER FEDERAL AGENCY?
☐ YES ☑ NO

PLEASE LIST

6. DOE/OER PROGRAM STAFF CONTACT (if known):

7. TYPE OF APPLICATION:
☑ New ☐ Renewal
☐ Continuation ☐ Revision
☐ Supplement

8. ORGANIZATION TYPE:
☐ Local Govt. ☐ State Govt.
☑ Non-Profit ☐ Hospital
☐ Indian Tribal Govt. ☐ Individual
☐ Other ☐ Inst. of Higher Educ.
☐ For-Profit
☐ Small Business ☐ Disadvan. Business
☐ Women-Owned ☐ 8(a)

9. CURRENT DOE AWARD # (IF APPLICABLE):
None

10. WILL THIS RESEARCH INVOLVE:
10A. Human Subjects ☑ No ☐ If yes
Exemption No. ______ or
IRB Approval Date ______
Assurance of Compliance No: ______
10B. Vertebrate Animals ☑ No ☐ If yes
IACUC Approval Date ______ or
Animal Welfare Assurance No: ______

11. AMOUNT REQUESTED FROM DOE FOR ENTIRE PROJECT PERIOD $ 1,996,147.00

12. DURATION OF ENTIRE PROJECT PERIOD:
07/01/06 to 06/30/11
MM/DD/YY MM/DD/YY

13. REQUESTED AWARD START DATE
07/01/06
MM/DD/YY

14. IS APPLICANT DELINQUENT ON ANY FEDERAL DEBT?
☐ Yes (attach an explanation) ☑ No

15. PRINCIPAL INVESTIGATOR/PROGRAM DIRECTOR
NAME Roger Cottrell
TITLE Assistant Director, SLAC Computing Services
ADDRESS 2575 Sand Hill Road
Menlo Park, CA 94025

PHONE NUMBER (650) 926-2523

SIGNATURE OF PRINCIPAL INVESTIGATOR/ PROGRAM DIRECTOR
(please type in full name if electronically submitted)
Date

PI/PD ASSURANCE: 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 submission. Willful provision of false information is a criminal offense. (U.S. Code, Title 18, Section 1001).

16. ORGANIZATION'S NAME Stanford Linear Accelerator Center
ADDRESS 2575 Sand Hill Road
Menlo Park, CA 94025

CERTIFYING REPRESENTATIVE'S
NAME Jerry Jobe
TITLE Associate Director
PHONE NUMBER (650) 926-4245

SIGNATURE OF ORGANIZATION'S CERTIFYING REPRESENTATIVE
(please type in full name if electronically submitted)
Date

CERTIFICATION and ACCEPTANCE: I certify that the statements herein are true and complete to the best of my knowledge, and accept the obligation to comply with DOE terms and conditions if an award is made as the result of this submission. A willfully false certification is a criminal offense. (U.S. Code, Title 18, Section 1001).

(04-93)

All Other Editions Are Obsolete

Budget Page

(See reverse for Instructions)

1910-1400

OMB Burden Disclosure Statement on Reverse

FY2007

ORGANIZATION Stanford Linear Accelerator Center				**Budget Page No:** 1	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR R. Les. Cottrell				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested by Applpicant	Funds Granted
	CAL	ACAD	SUMR		
1. R. Les Cottrell	1.00	0.00	0.00	$13,588	
2. Yee-Ting Li	6.00	0.00	0.00	$40,560	
3. C. Logg	4.00	0.00	0.00	$39,200	
4.					
5.					
(1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)	11.00	0.00	0.00	$74,360	
7. (1) TOTAL SENIOR PERSONNEL (1-6)	22.00	0.00	0.00	$167,708	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. (0) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	$0	
3. (2) GRADUATE STUDENTS	0.00	9.00	3.00	$48,504	
4. (0) UNDERGRADUATE STUDENTS	0.00	0.00	0.00	$0	
5. (0) SECRETARIAL - CLERICAL	0.00	0.00	0.00	$0	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$216,212	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$52,800	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$269,012	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$4,500	
2. FOREIGN				$3,000	
TOTAL TRAVEL				$7,500	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$0	
2. TUITION & FEES				$0	
3. TRAINEE TRAVEL				$0	
4. OTHER (fully explain on justification page)				$0	
TOTAL PARTICIPANTS (0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$0	
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES				$0	
5. SUBCONTRACTS				$0	
6. OTHER (Graduate-Student tuition)				$26,484	
TOTAL OTHER DIRECT COSTS				$26,484	
H. TOTAL DIRECT COSTS (A THROUGH G)				$302,996	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 36% on labor and travel 6.80% on M&S					
TOTAL INDIRECT COSTS				$99,544	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$402,540	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				$0	
L. TOTAL COST OF PROJECT (J+K)				$402,540	

(04-93)

All Other Editions Are Obsolete

Budget Page

(See reverse for Instructions)

FY2008

1910-1400

OMB Burden Disclosure

Statement on Reverse

ORGANIZATION: Stanford Linear Accelerator Center

Budget Page No: 2

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: R. Les Cottrell

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted
1. R. Les Cottrell	1.00	0.00	0.00	$14,131	
2. Yee-Ting Li	6.00	0.00	0.00	$42,182	
3. C. Logg	4.00	0.00	0.00	$40,768	
4.					
5.					
6. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)	10.00	0.00	0.00	$70,304	
7. (1) TOTAL SENIOR PERSONNEL (1-6)	21.00	0.00	0.00	$167,386	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. (0) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	$0	
3. (2) GRADUATE STUDENTS	0.00	9.00	3.00	$44,139	
4. (0) UNDERGRADUATE STUDENTS		0.00	0.00	$0	
5. (0) SECRETARIAL - CLERICAL	0.00			$0	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$211,524	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$52,553	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$264,077	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL — 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$4,680	
2. FOREIGN				$3,120	
TOTAL TRAVEL				$7,800	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$0	
2. TUITION & FEES				$0	
3. TRAINEE TRAVEL				$0	
4. OTHER (fully explain on justification page)				$0	
TOTAL PARTICIPANTS (0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$0	
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES				$0	
5. SUBCONTRACTS				$0	
6. OTHER (Graduate-Student tuition)				$27,543	
TOTAL OTHER DIRECT COSTS				$27,543	
H. TOTAL DIRECT COSTS (A THROUGH G)				$299,421	
I. INDIRECT COSTS (SPECIFY RATE AND BASE): 36% on labor and travel; 6.80% on M&S					
TOTAL INDIRECT COSTS				$100,595	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$400,015	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				$0	
L. TOTAL COST OF PROJECT (J+K)				$400,015	

(04-93)
All Other Editions Are Obsolete

Budget Page

(See reverse for Instructions)

FY2009

1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION: Stanford Linear Accelerator Center

Budget Page No: 3

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: R. Les Cottrell

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applicant	Funds Granted
1. R. Les Cottrell	1.00	0.00	0.00	$14,696	
2. Yee-Ting Li	5.00	0.00	0.00	$36,558	
3. C. Logg	4.00	0.00	0.00	$42,399	
4.		0.00	0.00	$0	
5.		0.00	0.00	$0	
6. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)	10.00	0.00	0.00	$73,116	
7. (1) TOTAL SENIOR PERSONNEL (1-6)	20.00	0.00	0.00	$166,769	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. (0) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	$0	
3. (2) GRADUATE STUDENTS	0.00	9.00	0.00	$40,527	
4. (0) UNDERGRADUATE STUDENTS		0.00	0.00	$0	
5. (0) SECRETARIAL - CLERICAL	0.00			$0	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$207,296	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$52,243	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$259,539	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$4,867	
2. FOREIGN				$3,245	
TOTAL TRAVEL				$8,112	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$0	
2. TUITION & FEES				$0	
3. TRAINEE TRAVEL				$0	
4. OTHER (fully explain on justification page)				$0	
TOTAL PARTICIPANTS 0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$0	
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES				$0	
5. SUBCONTRACTS				$0	
6. OTHER (Graduate-Student tuition)				$29,504	
TOTAL OTHER DIRECT COSTS				$29,504	
H. TOTAL DIRECT COSTS (A THROUGH G)				$297,155	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 36% on labor and travel 6.8% on M&S					
TOTAL INDIRECT COSTS				$99,031	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$396,186	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				$0	
L. TOTAL COST OF PROJECT (J+K)				$396,186	

(04-93)

All Other Editions Are Obsolete

Budget Page

(See reverse for Instructions)

1910-1400

OMB Burden Disclosure Statement on Reverse

FY2010

ORGANIZATION: Stanford Linear Accelerator Center

Budget Page No: 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: R. Les Cottrell

Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applicant	Funds Granted
1. R. Les Cottrell	1.00	0.00	0.00	$15,284	
2. Yee-Ting Li	5.00	0.00	0.00	$38,020	
3. C. Logg	4.00	0.00	0.00	$44,095	
4.		0.00	0.00	$0	
5.		0.00	0.00	$0	
6. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)	9.00	0.00	0.00	$68,437	
7. (1) TOTAL SENIOR PERSONNEL (1-6)	19.00	0.00	0.00	$165,836	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. (0) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	$0	
3. (2) GRADUATE STUDENTS	0.00	9.00	1.50	$45,660	
4. (0) UNDERGRADUATE STUDENTS		0.00	0.00	$0	
5. (0) SECRETARIAL - CLERICAL	0.00			$0	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$211,496	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$52,132	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$263,629	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$5,062	
2. FOREIGN				$3,375	
TOTAL TRAVEL				$8,436	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$0	
2. TUITION & FEES				$0	
3. TRAINEE TRAVEL				$0	
4. OTHER (fully explain on justification page)				$0	
TOTAL PARTICIPANTS 0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$0	
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES				$0	
5. SUBCONTRACTS				$0	
6. OTHER (Graduate-Student tuition)				$29,791	
TOTAL OTHER DIRECT COSTS				$29,791	
H. TOTAL DIRECT COSTS (A THROUGH G)				$301,856	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 36% on labor and travel; 6.80% on M&S					
TOTAL INDIRECT COSTS				$97,943	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$399,799	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				$0	
L. TOTAL COST OF PROJECT (J+K)				$399,799	

(04-93)

All Other Editions Are Obsolete

Budget Page

(See reverse for Instructions)

FY2011

1910-1400

OMB Burden Disclosure Statement on Reverse

ORGANIZATION: Stanford Linear Accelerator Center — **Budget Page No:** 5

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: R. Les Cottrell — Requested Duratioı 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted
1. R. Les Cottrell	1.00	0.00	0.00	$15,896	
2. Yee-Ting Li	6.00	0.00	0.00	$47,449	
3. C. Logg	4.00	0.00	0.00	$45,858	
4.		0.00	0.00	$0	
5.		0.00	0.00	$0	
6. (1) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)	9.00	0.00	0.00	$71,174	
7. (1) TOTAL SENIOR PERSONNEL (1-6)	20.00	0.00	0.00	$180,378	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	$0	
2. (0) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	$0	
3. (2) GRADUATE STUDENTS	0.00	6.00	1.50	$31,918	
4. (0) UNDERGRADUATE STUDENTS		0.00	0.00	$0	
5. (0) SECRETARIAL - CLERICAL	0.00			$0	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$212,296	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$56,100	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$268,396	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$5,264	
2. FOREIGN				$3,510	
TOTAL TRAVEL				$8,774	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$0	
2. TUITION & FEES				$0	
3. TRAINEE TRAVEL				$0	
4. OTHER (fully explain on justification page)				$0	
TOTAL PARTICIPANTS 0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$0	
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES				$0	
5. SUBCONTRACTS				$0	
6. OTHER (Graduate-Student tuition)				$20,655	
TOTAL OTHER DIRECT COSTS				$20,655	
H. TOTAL DIRECT COSTS (A THROUGH G)				$297,825	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 36% on labor and travel; 6.80% on M&S					
TOTAL INDIRECT COSTS				$99,781	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$397,606	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				$0	
L. TOTAL COST OF PROJECT (J+K)				$397,606	

(04-93)

All Other Editions Are Obsolete

Budget Page

(See reverse for Instructions)

1910-1400

OMB Burden Disclosure Statement on Reverse

FY2007-FY2011

ORGANIZATION: Stanford Linear Accelerator Center

Budget Page No: 6

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: R. Les Cottrell

Requested Duration: 60 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. R. Les Cottrell	5.00	0.00	0.00	$73,595	
2. Yee-Ting Li	28.00	0.00	0.00	$204,770	
3. C. Logg	20.00	0.00	0.00	$212,320	
4.	0.00	0.00	0.00	$0	
5.	0.00	0.00	0.00	$0	
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)	49.00	0.00	0.00		
7. (1) TOTAL SENIOR PERSONNEL (1-6)	#####	0.00	0.00	$490,685	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00			$0	
2. (0) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	0.00			$0	
3. (2) GRADUATE STUDENTS		42.00	6.00	$210,748	
4. (0) UNDERGRADUATE STUDENTS		0.00	0.00	$0	
5. (0) SECRETARIAL - CLERICAL	0.00			$0	
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				$1,058,824	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				$265,829	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				$1,324,652	
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				$0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				$24,373	
2. FOREIGN				$16,249	
TOTAL TRAVEL				$40,622	
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				$0	
2. TUITION & FEES				$0	
3. TRAINEE TRAVEL				$0	
4. OTHER (fully explain on justification page)				$0	
TOTAL PARTICIPANTS (0) TOTAL COST				$0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				$0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				$0	
3. CONSULTANT SERVICES				$0	
4. COMPUTER (ADPE) SERVICES				$0	
5. SUBCONTRACTS				$0	
6. OTHER (Graduate-Student tuition)				$133,978	
TOTAL OTHER DIRECT COSTS				$133,978	
H. TOTAL DIRECT COSTS (A THROUGH G)				$1,499,252	
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 37% on labor and travel 6.8% on M&S					
TOTAL INDIRECT COSTS				$496,894	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				$1,996,147	
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES				$0	
L. TOTAL COST OF PROJECT (J+K)				$1,996,147	

Budget Justification – SLAC

SLAC Personnel

R. Les Cottrell — (0.08 FTE) will supervise the work on this project, direct and participate in the research and data analysis, work with developers to evaluate the tools and software we develop, interface with the various communities to gather requirements and promote deployment.

Yee-Ting Li - (0.47 FTE) and Connie Logg (0.33 FTE) will be responsible for; research, detailed design and implementation of the 'network sensors' will that gather and represent network performance data in a federated manner; research, detailed design and implementation of the event detection, bottleneck detection and forecasting systems that will be deployed; and supervision of students.

Software Developer – (0.82 FTE) will be responsible for the detailed design and full implementation and deployment of the event detection, bottleneck detection and forecasting techniques; develop, maintain a web site for the CANTIS SLAC efforts, publish findings, and present results at various conferences and meetings.

SLAC Direct Costs

The salary costs presented in this proposal reflect the estimated annual salary based on current rates set by Stanford University with an escalation of 3% for each year of the proposal.

Senior Personnel – Item A.1-7
The salary figure listed for Senior Personnel is an estimate based on the current actual salary plus 4% per year for inflation.

Fringe Benefits – Item C
The Stanford University fringe benefit rate is 30.5% for regular staff and 3.4% for graduate research assistants.

Travel – Items E.1 and E.2
Three senior staff members will each attend one domestic meetings each year to present results, and meet face to face with partner. The domestic travel will include trips to Socrates collaborator sites, plus visits to ensure excellent cooperation with the perfSONAR, ESnet, Internet2 and other collaborators. One of the senior staff members will attend an International

Other Direct Costs- Item G.6
The estimated cost of tuition for two graduate students for 9 academic months throughout the project. They will also be two summer students for the first two years of the project and one for the last two years of the project.

Indirect Costs – Item I

SLAC indirect costs are applied at 36% to salaries (including fringe) and Travel, and 6.85% on materials and supplies. No indirect costs are applied to tuition.

APPLICATION FOR FEDERAL ASSISTANCE

SF 424 (R&R)

2. DATE SUBMITTED

Applicant Identifier

3. DATE RECEIVED BY STATE

State Application Identifier

1. * TYPE OF SUBMISSION

☐ Pre-application ☑ Application ☐ Changed/Corrected Application

4. Federal

5. APPLICANT INFORMATION

*** Organizational DUNS:** 0471200840000

* Legal Name: Regents of the University of California, Davis

Department: Sponsored Programs Division:

* Street1: One Shields Avenue Street2: 118 Everson Hall

* City: Davis County: Yolo * State: CA * ZIP Code: 95616

* Country: USA

Person to be contacted on matters involving this application

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Dr	Dipak		Ghosal	Ph.D.

* Phone Number: 530-754-9251 Fax Number: 530-752-4767 Email: ghosal@cs.ucdavis.edu

6. * EMPLOYER IDENTIFICATION *(EIN) or (TIN):* 94-6036494

7. * TYPE OF APPLICANT: Please select one of the following

Other (Specify):

Small Business Organization Type

☐ Women Owned ☐ Socially and Economically Disadvantaged

8. * TYPE OF APPLICATION: ☑ New

☐ Resubmission ☐ Renewal ☐ Continuation ☐ Revision

If Revision, mark appropriate box(es).

☐ A. Increase Award ☐ B. Decrease Award ☐ C. Increase Duration

☐ D. Decrease Duration ☐ E. Other *(specify)*:

* Is this application being submitted to other agencies? Yes ☐ No ☑

What other Agencies?

9. * NAME OF FEDERAL AGENCY: Chicago Service Center

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER: 81.049

TITLE: Office of Science Financial Assistance Program

11. * DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:

CANTIS: Center for Application-Network Total-Integration for SciDAC

12. * AREAS AFFECTED BY PROJECT *(cities, counties, states, etc.)*

Davis, Yolo County, CA

13. PROPOSED PROJECT:

* Start Date: 07/01/2006 * Ending Date: 06/30/2011

14. CONGRESSIONAL DISTRICTS OF:

a. * Applicant: CA-001 b. * Project: CA-001

15. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Dr.	Dipak		Ghosal	Ph.D.

Position/Title: Professor * Organization Name: Regents of the University of California, Davis

Department: Compute Science Division:

* Street1: One Shields Avenue Street2: 2063 Kemper Hall

* City: Davis County: Yolo * State: CA * ZIP Code: 95616

* Country: USA

* Phone Number: 530-754-9251 Fax Number: 530-752-4767 * Email: ma@cs.ucdavis.edu

OMB Number: 4040-0001

Expiration Date: 04/30/2008

16. ESTIMATED PROJECT FUNDING

a. * Total Estimated Project Funding	$1,500,00.00
b. * Total Federal & Non-Federal Funds	$1,500,000.00
c. * Estimated Program Income	0.00

17. * IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES ☐ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE:

b. NO ☐ PROGRAM IS NOT COVERED BY E.O. 12372; OR

☑ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

18. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

☑ *** I agree**

** The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.*

19. Authorized Representative

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
	Trisha		Dinh	

* Position/Title: Contract & Grants Analyst
* Organization: Regents of the University of California, Davis
Department: Sponsored Program
Division:
* Street1: On Shields Avenue
Street2: 118 Everson Hall
* City: Davis
County: Yolo
* State: CA
* ZIP Code: 95616
* Country: USA
* Phone Number: 530-754-7670
Fax Number: 530-752-8893
* Email: tndinh@ucdavis.edu

*** Signature of Authorized Representative**	*** Date Signed**
Completed on submission to Grants.gov	Completed on submission to Grants.gov

20. Pre-application Add Attachment Delete Attachment View Attachment

DOE F 4620.1 (04-93) All Other Editions Are Obsolete	**U.S. Department of Energy** **Budget Page** (See reverse for Instructions)	OMB Control No. 1910-1400 OMB Burden Disclosure Statement on Reverse

ORGANIZATION Department of Computer Science, University of California at Davis				Budget Page No: 1	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dipak Ghosal				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Ghosal, D. Summer Salary			1.50	14,933.00	
2. Mukherjee, B. Summer Salary			1.50	27,500.00	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				42,433.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (4) GRADUATE STUDENTS				94,290.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				136,723.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,321.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				144,044.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) Storage Device					
TOTAL PERMANENT EQUIPMENT				10,000.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,865.00	
2. FOREIGN				5,000.00	
TOTAL TRAVEL				9,865.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				500.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				1,080.00	
5. SUBCONTRACTS					
6. OTHER				54,434.00	
TOTAL OTHER DIRECT COSTS				56,014.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				219,923.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 7/1/06-6/30/07 51.50%					
TOTAL INDIRECT COSTS				80,077.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				300,000.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				300,000.00	0.00

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(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy
Budget Page
(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Department of Computer Science, University of California at Davis				Budget Page No: 2	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dipak Ghosal				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested	Funds Granted
	CAL	ACAD	SUMR	by Applpicant	by DOE
1. Ghosal, D. Summer Salary			1.50	15,531.00	
2. Mukherjee, B. Summer Salary			1.50	28,600.00	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				44,131.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (4) GRADUATE STUDENTS				90,362.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				134,493.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,401.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				141,894.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) Storage Device					
TOTAL PERMANENT EQUIPMENT				10,000.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,175.00	
2. FOREIGN				5,000.00	
TOTAL TRAVEL				9,175.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				1,080.00	
5. SUBCONTRACTS					
6. OTHER				57,214.00	
TOTAL OTHER DIRECT COSTS				59,294.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				220,363.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 7/1/07-6/30/08 52.0%					
TOTAL INDIRECT COSTS				79,637.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				300,000.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				300,000.00	0.00

DOE F 4620.1
(04-93)
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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
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OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Department of Computer Science, University of California at Davis				Budget Page No: 3	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dipak Ghosal				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested by Applpicant	Funds Granted by DOE
	CAL	ACAD	SUMR		
1. Ghosal, D. Summer Salary			1.50	16,152.00	
2. Mukherjee, B. Summer Salary			1.50	29,744.00	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				45,896.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (4) GRADUATE STUDENTS				87,086.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				132,982.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,508.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				140,490.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) Storage Device					
TOTAL PERMANENT EQUIPMENT				10,000.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,000.00	
2. FOREIGN				4,915.00	
TOTAL TRAVEL				8,915.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				1,080.00	
5. SUBCONTRACTS					
6. OTHER				59,742.00	
TOTAL OTHER DIRECT COSTS				61,822.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				221,227.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 7/1/08 to 6/30/09 52% of $151,486					
TOTAL INDIRECT COSTS				78,773.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				300,000.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				300,000.00	0.00

DOE F 4620.1
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U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION Department of Computer Science, University of California at Davis				Budget Page No: 4	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR Dipak Ghosal				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos.			Funds Requested by Applpicant	Funds Granted by DOE
	CAL	ACAD	SUMR		
1. Ghosal, D. Summer Salary			1.50	16,798.00	
2. Mukherjee, B. Summer Salary			1.50	30,934.00	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				47,732.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (4) GRADUATE STUDENTS				87,100.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				134,832.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,723.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				142,555.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				8,229.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,000.00	
2. FOREIGN				4,000.00	
TOTAL TRAVEL				8,000.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				1,080.00	
5. SUBCONTRACTS					
6. OTHER				59,766.00	
TOTAL OTHER DIRECT COSTS				61,846.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				220,630.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 7/1/09 - 6/30/10 @ 52% $ 152,635					
TOTAL INDIRECT COSTS				79,370.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				300,000.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				300,000.00	0.00

DOE F 4620.1	**U.S. Department of Energy**	OMB Control No.
(04-93)	**Budget Page**	1910-1400
All Other Editions Are Obsolete	(See reverse for Instructions)	OMB Burden Disclosure Statement on Reverse

ORGANIZATION: Department of Computer Science, University of California at Davis				Budget Page No: 5	
PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Dipak Ghosal				Requested Duration: 12 (Months)	
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Ghosal, D. Summer Salary			1.50	17,470.00	
2. Mukherjee, B. Summer Salary			1.50	32,171.00	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				49,641.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (4) GRADUATE STUDENTS				83,554.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				133,195.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,840.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				141,035.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT				9,019.00	
E. TRAVEL — 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,000.00	
2. FOREIGN				5,000.00	
TOTAL TRAVEL				9,000.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				1,080.00	
5. SUBCONTRACTS					
6. OTHER				59,766.00	
TOTAL OTHER DIRECT COSTS				61,846.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				220,900.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 7/1/10-6/30/11 @ 52% $152,115					
TOTAL INDIRECT COSTS				79,100.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				300,000.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				300,000.00	0.00

DOE F 4620.1
(04-93)
All Other Editions Are Obsolete

U.S. Department of Energy

Budget Page

(See reverse for Instructions)

OMB Control No.
1910-1400
OMB Burden Disclosure
Statement on Reverse

ORGANIZATION: Department of Computer Science, University of California at Davis — **Budget Page No:** 1

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Dipak Ghosal — Requested Duration: 12 (Months)

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title; A.6. show number in brackets)	DOE Funded Person-mos. CAL	ACAD	SUMR	Funds Requested by Applpicant	Funds Granted by DOE
1. Ghosal, D. Summer Salary			1.50	14,933.00	
2. Mukherjee, B. Summer Salary			1.50	27,500.00	
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				42,433.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. ( ) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (4) GRADUATE STUDENTS				94,290.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				136,723.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				7,321.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				144,044.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) Storage Device					
TOTAL PERMANENT EQUIPMENT				10,000.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				4,865.00	
2. FOREIGN				5,000.00	
TOTAL TRAVEL				9,865.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)					
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				0.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				500.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES				1,080.00	
5. SUBCONTRACTS					
6. OTHER				54,434.00	
TOTAL OTHER DIRECT COSTS				56,014.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				219,923.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) 7/1/06-6/30/07 51.50%					
TOTAL INDIRECT COSTS				80,077.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				300,000.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				300,000.00	0.00

UCDavis Budget Justification

Graduate Student Researchers (GSRs): Four GSR IV for 5 years. These graduate student researchers will assist PI in the project, and work toward their M.S. or PhD degrees. They will work 45% during the Academic Year (AY) and 100% during summer which in total is equal to 7.05 months per year.

Summer Salary: PI and Co-PI will contribute 1.50 month each year to the project for 5 years.

Benefits rates: GSR@1.3 AY & 3.0% summer. Summer Salary@12.7%,

Supplies: publications, documentation, books, software, memory upgrades, disk repairs, small hardware equipment such as hard-drives.

Travel: Domestic & foreign travel to conferences specific to research project and sponsor meetings. Additionally, there will be travel to project meetings held at ORNL and other locations.

Equipment: This project will have an experimental component. These experiments will be carried out both over controlled high-speed networks deployed in the lab as well as over wide area network connections between ORNL, UC Davis and Pittsburgh Supercomputer Center (PSC). The latter will be enabled via connections to CENIC, UltraScience Net, and the National LambdaRail. The equipment budget includes high-speed workstations, 10Gigabit Ethernet cards, and workstations for students.

OTHER: Based upon the University's current approved fee rates, a total of $47,726 ($23,863 each) for two students for each year is included in this budget for Non-Resident Tuition and Non-Resident Student Fees. Because fees are subject to gubernatorial, legislative, and Regental action, these fees may change without notice. All student fees are excluded from the indirect cost calculation.

Other: NRTF in the amount of $24,629 is being requested for one student for year one; $25,324 for year two; $25,962 each year for years three to five. Based upon the University's current approved fee rates, In-state Fees of $29,805 ($9,935 each) is being requested for 3 students for year 1; $31,890 ($10,630 each) for year 2; $33,780 (11,260 each for year 3; $33,804 ($11,268 each) each year for years 4 and 5. Because fees are subject to gubernatorial, legislative, and Regental action, these fees may change without notice. All student fees are excluded from the indirect cost calculation.

Technical Support is requested for specialized support directly related to the scientific research objectives here: specifically, we anticipate need for technical support to install and support open-source software, such as GNU Intoyer Programming software, and commercial Software CPLEX, with associated plug-ins, and associated services. This includes project-specific troubleshooting, configuring and installing the above mentioned, and other software systems, related hardware and/or network capabilities required to meet the scientific research objectives of this project. Technical support will be administered via the formalized College of Engineering Technical Staff Recharge System at an hourly rate of $54.00 per hour for approximately 10 hours each year.

Indirect Cost Rates: 7/1/06 to 6/30/07 @ 51.5%; 7/1/07 to 6/30/11 @ 52.0%

Other Support of Investigators

Institution	Name	Active or Pending	Funding Agency or Org.	Inclusive Dates of Project	Annual funding	Level of Effort
University of California, Davis	Dipak Ghosal	Active	National Science Foundation	9/1/03 – 8/31/06	$52.7K	1.0m
University of California, Davis	Dipak Ghosal	Active	National Science Foundation	03/01/06 – 02/28/09	$200K	1.0m
University of California, Davis	Biswanath Mukherjee	Active	National Science Foundation	09/15/05 – 09/30/09	$30K	0.0m
University of California, Davis	Biswanath Mukherjee	Active	National Science Foundation	09/15/04 – 09/30/08	$200K	1.0m
University of California, Davis	Biswanath Mukherjee	Active	National Science Foundation	09/15/05 – 09/30/09	$200K	1.0m
Oak Ridge National Laboratory	Nageswara S. Rao	Active	Department of Energy	01/08/04 - 09/30/06	$1,500K	3.0m
Oak Ridge National Laboratory	Nageswara S. Rao	Active	National Science Foundation	01/01/04 - 09/30/06	$300K	1.0m
Oak Ridge National Laboratory	Nageswara S. Rao	Active	Department of Energy	07/01/03 - 09/30/06	$200K	2.0m
Oak Ridge National Laboratory	Nageswara S. Rao	Active	ORNL LDRD	01/10/04 - 09/30/06	$180K	2.0m
Oak Ridge National Laboratory	William R. Wing	Active	National Science Foundation	01/01/04 - 09/30/06	$300K	1.0m
Oak Ridge National Laboratory	William R. Wing	Active	Department of Energy	01/08/04 - 09/30/06	$1,500K	3.0m
Oak Ridge National Laboratory	Steven Carter	Active	Department of Energy	01/08/04 - 09/30/06	$1,500K	2.0m
Oak Ridge National Laboratory	Steven Carter	Active	ORNL LDRD	01/10/04 - 09/30/06	$180K	4.0m
Oak Ridge National Laboratory	Qishi Wu	Active	National Science Foundation	01/01/04 - 09/30/06	$300K	6.0m

Institution	Name	Active or Pending	Funding Agency or Org.	Inclusive Dates of Project	Annual funding	Level of Effort
Fermi National Accelerator Laboratory	Matt Crawford	Active	Department of Energy	10/01/04 - 09/30/07	$400K	6.0m
Fermi National Accelerator Laboratory	Matt Crawford	Active	Department of Defense	03/01/06 - 09/30/06	$23K	1.0m
Fermi National Accelerator Laboratory	Wenji Wu	Active	Department of Energy	10/01/04 - 09/30/07	$400K	6.0m
Fermi National Accelerator Laboratory	Matt Crawford	Pending	National Science Foundation	10/01/06 - 09/30/07	$55K	2.0m
Stanford Linear Accelerator Center	Roger Cottrell	Active	Department of Energy	9/1/2005 – 9/31/2006	$400K	6.0m
Stanford Linear Accelerator Center	Yee-Ting Li	Active	Department of Energy	9/1/2005 – 9/31/2006	$400K	6.0m
Brookhaven National Laboratory	Dantong Yu	Active	Department of Energy	7/1/2004 – 6/30/2007	$300K	6.0m
Brookhaven National Laboratory	Dantong Yu	Pending	National Science Foundation	7/1/2006 – 6/30/2011	$200K	2.0m
Brookhaven National Laboratory	Bruce Gibbard	Active	Department of Energy	7/1/2004 – 6/30/2007	$300K	0.0m
Brookhaven National Laboratory	Bruce Gibbard	Pending	National Science Foundation	7/1/2006 – 6/30/2011	$200K	2.0m
Brookhaven National Laboratory	Dimitrios Katramatos	Active	Department of Energy	7/1/2004 – 6/30/2007	$300K	12.0m
Georgia Institute of Technology	Karsten Schwan	Active	National Science Foundation	8/1/2005- 7/30/2006	$100K	1.0m
Georgia Institute of Technology	Karsten Schwan	Active	Intel Corporation	8/1/2205- 8/30/2006	$100K	1.0m
Pacific Northwest National Laboratory	Tom Mckenna	Active	Department of Energy	7/1/2004 – 6/30/2007	$300K	2.0m
Pacific Northwest National Laboratory	Tom Mckenna	Active	NSA/CIA	7/1/2005 – 6/30/2006	$400K	6.0m

Biographical Sketches

Steven M. Carter, *Oak Ridge National Laboratory*
Roger Leslie Anderton Cottrell, *Stanford Linear Accelerator Center*
Matt Crawford, *Fermi National Accelerator Laboratory*
Dipak Ghosal, *University of California, Davis*
Bruce G. Gibbard, *Brookhaven National Laboratory*
Dimitrios Katramatos, *Brookhaven National Laboratory*
Anthony A. Kempka, *Pacific Northwest National Laboratory*
Yee-Ting Li*, Stanford Linear Accelerator Center*
Brian La Marche, *Pacific Northwest National Laboratory*
Tom McKenna, *Pacific Northwest National Laboratory*
Biswanath Mukherjee, *University of California, Davis*
Jarek Nieplocha, *Pacific Northwest National Laboratory*
Nageswara S. Rao, *Oak Ridge National Laboratory*
Karsten Schwan, *Georgia Institute of Technology*
William R. Wing, *Oak Ridge National Laboratory*
Qishi Wu, *Oak Ridge National Laboratory*
Wenji Wu*, Fermi National Accelerator Laboratory*
Dantong Yu, *Brookhaven National Laboratory*

STEVEN M CARTER

National Center for Computation Sciences
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, TN 37831-6008
scarter@ornl.gov

EDUCATION

- M.S. Computer Science, Mississippi State University, 2001.
- B.S. Computer Engineering, Mississippi State University, 1997.

PROFESSIONAL EXPERIENCE

2003-present: National Center for Computational Sciences, Oak Ridge National Laboratory
Senior Network Engineer
2001-2002: Extreme Networks
Embedded Software Engineer
1993-2000: Information Technology Services, Mississippi State University
Senior Network Engineer

SELECTED PUBLICATIONS

S. M. Carter, Networking the Leadership Computing Facility, CUG, 2005.

N. S. V. Rao, W. R. Wing, S. M. Carter, Q. Wu, UltraScience Net: Network testbed for large-scale science applications, IEEE Communications Magazine, 2005, in press.

N. S. Rao, S. M. Carter, Q. Wu, W. R. Wing, M. Zhu, A. Mezzacappa, M. Veeraraghavan, J. M. Blondin, Networking for large-scale science: Infrastructure, provisioning, transport and application mapping, SCiDAC Meeting, 2005.

N. S. V. Rao, Q. Wu, S. M. Carter, W. R. Wing, Experimental results on data transfers over dedicated channel, First International Workshop on Provisioning and Transport for Hybrid Networks: PATHNETS, 2004.

ROGER LESLIE ANDERTON COTTRELL

SLAC Computing and Computer Services
Stanford Linear Accelerator Center
2575 Sand Hill Road
Menlo Park, CA 94025
cottrell@slac.stanford.edu

EDUCATION

1962-1967 Manchester Unversity, UK
Ph.D: Thesis title – Interactions of Deuterons with Carbon Isotopes
1959-1962 University College London, UK
B.Sc.: Physics

PROFESSIONAL EXPERIENCE

1997-Present Stanford Linear Accelerator Center, USA
Assistant Director SLAC Computing Services: Management of computer networking services, telecommunications and networking research
1995-1997 Stanford Linear Accelerator Center, USA
Acting Director SLAC Computing Services: Management of all SLAC's computing services
1982-1995 Stanford Linear Accelerator Center, USA
Assistant Director, Computing Services: Management of networking and Computing services
1980-1982 Stanford Linear Accelerator Center, USA
Computer Network Manager: Management of SLAC's computer Network activities
1979-1980 IBM U.K. Laboratories, UK
Visiting Scientist: Graphics and intelligent distributed Workstations

SELECTED PUBLICATIONS

Evaluation Of Techniques To Detect Significant Network Performance Problems Using End-To_End Active Measurements, R. L. Cottrell, C. Logg, M. Chhaparia, M. Grigoriev, F. Hara, F. Nazir, M. Sandford. Contributed to 2006 IEEE/IFIP Network Operations & Management Symposium.

A Hierarchy Of Network Performance Characteristics For Grid Applications And Services, B. Lowekamp, B. Tierney, R. L. Cottrell,, R. Hughes-Jones, T. Kielmann, M. Swany, GGF document GFD-R-P.034, 24 May, 2004, also see SLAC-PUB-10537.

Pathchirp: Efficient Available Bandwidth Estimation For Network Paths, Vinay Ribeiro, Rudolf Reidi, Richard Baraniuk, Jiri Navratil, Les Cottrell, SLAC-PUB-9732, published at PAM 2003, April 2003.

Experiences And Results From A New High Performance Network And Application Monitoring Toolkit, Les Cottrell, Connie Logg, I-Heng Mei, SLAC-PUB-9641, published at PAM 2003, April 2003.

MATT CRAWFORD

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Fermi National Accelerator Laboratory
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matt.crawford@fnal.gov

EDUCATION

Doctor of Philosophy in Physics, University of Chicago, 1985
Bachelor of Science (Honors) in Applied Mathematics and Physics, Caltech, 1978

PROFESSIONAL EXPERIENCE

Fermi National Accelerator Laboratory: Group Leader, Wide Area Systems 2005-present; CPPM/Computer Security Coordinator (1998-2005); Network Analyst (1992-1997).

University of Chicago: Senior Research Associate, Department of Astronomy and Astrophysics, Physical Sciences Division, and Office of the Provost (1987-1992); Research Associate, Department of Astronomy and Astrophysics (1985-1987).

HONORS AND AWARDS

Fermilab Employee Performance Recognition Award, 2002, for leading the computer security technical program.

University of Chicago's Valentine Telegdi Prize, 1978, for doctoral candidacy exam in the Department of Physics.

CURRENT RESEARCH INTERESTS

Researching behavior of dynamically rerouted packet flows and receiver-side packet handling in Linux kernel. Project Manager of the Lambda Station project (`http://www.lambdastation.org/`).

SELECTED PUBLICATIONS

W. Wu and M. Crawford, The Performance Analysis of Linux Networking–Packet Receiving, *Proceedings of Computing in High Energy Physics (CHEP) 2006*, Mumbai, India, 2006.

A. Bobyshev, M. Crawford, et al., Lambda Station: Production Applications Exploiting Advanced Networks in Data Intensive High Energy Physics, *Proceedings of Computing in High Energy Physics (CHEP) 2006*, Mumbai, India, 2006.

A. Bobyshev, M. Crawford, V. Grigaliunas, M. Grigoriev, R. Rechenmacher, Investigating the Behavior of Network Aware Applications with Flow-Based Path Selection, *Proceedings of Computing in High Energy Physics (CHEP) 2006*, Mumbai, India, 2006.

M. Crawford, Building Global HEP Systems on Kerberos, *Proceedings of Computing in High Energy Physics (CHEP) 2004*, Interlaken, Switzerland, 2004.

Internet RFCs 2894, 2874 (with C. Huitema), 2673, 2672, 2470 (with T. Narten and S. Thomas), 2467, 2464, 2019, 1972.

DIPAK GHOSAL

Department of Computer Science
University of California
Davis, CA 95616
e-mail Ghosal@cs.ucdavis.edu

EDUCATION

Ph.D**.** Computer Science, University of Louisiana, 1988
M.S. Computer Science, Indian Institute of Science, Bangalore, India, 1985
B.Tech. Electrical Engineering, Indian Institute of Technology, Kanpur, India, 1983

PROFESSIONAL EXPERIENCE

December 1996 – Present: (Assistant/Associate) Professor, Department of Computer Science, University of California, Davis, CA 95616.
September 1990 – December 1995: Member of the Technical Staff, Bell Communications Research, Red Bank, New Jersey 07701, USA.

HONORS AND AWARDS

National Science Foundation CAREER Award, 1997 – 2002

PATENTS

Keith Kong and Dipak Ghosal, "A Self-Scaling Scheme for Avoiding Server-Side Congestion in the Internet," Approved October 2002, US Patent 6,473,401 B1

SELECTED PUBLICATIONS

A. Banerjee, W-Chun Feng, B. Mukherjee, D. Ghosal, RAPID: An End-System Aware Protocol for Intelligent Data Transfer over Lambda Grids, IPDPS 2006 Conference, Rhode Island, Greece.

S. Mueller and D. Ghosal, Analysis of a Distributed Algorithm to Determine Multiple Routes with Path Diversity in Ad Hoc Networks, 3rd Intl. Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks, WiOpt 2005, Riva del Garda, Trentino, Italy, April 3 - 7, 2005.

J. Anda, J. LeBrun, D. Ghosal, C.-N. Chuah and M. Zhang, VGrid: Vehicular AdHoc Networking and Computing Grid for Intelligent Traffic Control, IEEE 61st Vehicular Technology Conference VTC 2005 Spring, 29th May - 1st June, Stockholm, Sweden.

A. Banerjee, W.-C. Feng, B. Mukherjee, and D. Ghosal, Routing and Scheduling Large File Transfers over Lambda Grids, Third International Workshop on Protocols for Fast Long-Distance Networks PFLDNet 2005, February 3,4 2005,Lyon France.

A. Banerjee, N. Singhal, J. Zhang, D. Ghosal, C. -N Chuah, and B. Mukherjee, A Time–Path Scheduling Problem (TPSP) for Aggregating Large Data Files from Distributed Databases using an Optical Burst-Switched Network, in International Communication Conference (ICC), Paris, 2004.

BRUCE G. GIBBARD

Affiliations and Positions:

- Ph.D. in Physics from University of Michigan, 1970
- Research Associate, Princeton University, 1970
- Junior Visiting Scientist, CERN, 1970 – 1972
- Research Associate / Senior Research Associate, Cornell Univ. 1972 – 1978
- Associate Physicist / Physicist / Senior Physicist, Brookhaven National Lab. 1978 – present

Experimental Elementary Particle Physics Research:

- Hadron Scattering - (U of Michigan / Princeton / CERN) 1970 – 1974
- Electo-production & e^+e^- Collisions - (Cornell) 1973 – 1981
- Neutrino Scattering - (Brookhaven) 1979 – 1990
- High Energy pp*bar* and pp Collisions - (Brookhaven) 1983 – 2006

Computing Related Technical Accomplishments:

- Designed and implemented online and data acquisition systems for electro-production experiments at Cornell Laboratory of Nuclear Studies
- Designed and implemented data management system used for initial decade of CLEO running and for Japanese/American neutrino experiment at BNL
- Designed and implemented online system for Japanese/American neutrino experiment at BNL
- Designed and implemented D0 online system including detector configuration and run control for Fermilab Collider Run 1

Management Roles*:*

- Leader, computing, software and data acquisition, BNL Japanese/American neutrino experiment, 1979 – 1983
- Leader, ISABELLE Data Acquisition Group, 1980 – 1981
- Leader, computing, software and data acquisition, Fermilab D0 Experiment, 1984 – 1997
- Leader, BNL HENP Computing Group, 1988 – 1998
- Associate RHIC Project Director and RHIC Computing Facility Director, Feb. 1997 – 1999
- RHIC Computing Facility Director and US ATLAS Computing Facilities Manager, 1999 – Present

Numerous Scientific and Technical Publications

- Experimental Elementary Particle Physics
- Software, Computing & Data Acquisition

Professional Organizations:

- Member - American Association for the Advancement of Science
- Fellow - American Physical Society

DIMITRIOS KATRAMATOS

RHIC/ATLAS Computing Facility
Brookhaven National Laboratory
Upton, NY 11973
dkat@bnl.gov

Education

Ph.D. Computer Science, University of Virginia, Charlottesville, VA, Jan 2005.

M.S. Computer Science, Kent State University, Kent, OH, Dec 1996.

B.S. Mechanical Engineering, National Technical University of Athens, Athens, Greece, Feb 1988.

Professional Experience

Brookhaven National Laboratory, Physics Dept., Upton, NY (Sep 2005 – present). Advanced Technology Engineer, RHIC/ATLAS computing facility. Responsible for the DOE-funded TeraPaths project.

University of Virginia, Dept. of Computer Science, Charlottesville, VA (Jan 1997 – Dec 2004). Research assistant. Developed, as part of Ph.D. research, a mapping evaluation and selection service for scheduling parallel applications on heterogeneous clusters. Funded by Sandia National Laboratories, Albuquerque, NM. Contributed to the Legion project at UVa by designing, implementing, and testing key parts of the Resource Management Infrastructure of the Legion grid system.

Sandia National Laboratories, Albuquerque, NM (May – Aug 2000). Visiting researcher, Computer Science Research Institute. Examined performance and communication latency differences between cluster nodes and their effect on application mapping efficiency.

Kent State University, Dept. of Computer Science, Kent, OH (Jan – Dec 1996). Research assistant. Designed and implemented software and necessary kernel modifications to perform process migration between the Sandia/UNM developed Puma and the Linux operating systems running on a massively parallel processor. Funded by Sandia National Laboratories, Albuquerque, NM.

Domus Key Factory S/A, Athens, Greece (Apr 1992 – May 1993). Planning manager. Planned and controlled manufacturing resources with the aid of the company's custom software package, and supervised the operation and staff of the raw materials warehouse.

Softa S/A, Athens, Greece (May – Sep 1989). Research associate. Developed software modules for the analysis of large-scale natural gas networks.

National Technical University of Athens, Athens, Greece (Feb 1988 – May 1989). Research assistant, Laboratory of Thermal Turbomachines. Developed algorithms and software for analyzing viscous flow phenomena on axial compressor blades.

Selected Publications

S. Bradley, F. Burstein, L. Cottrell, B. Gibbard, D. Katramatos, Y. Li, S. McKee, R. Popescu, D. Stampf, D. Yu. ***TeraPaths: A QoS-Enabled Collaborative Data Sharing Infrastructure for Peta-scale Computing Research.*** CHEP 2006, Mumbai, India, Feb 13-17, 2006

D. Katramatos, S. Chapin. ***A Scalable Method for Predicting Network Performance in Heterogeneous Clusters.*** Proceedings of ISPAN 2005, pp. 288-295, Las Vegas, NV, Dec 7-9, 2005.

D. Katramatos, S. Chapin. ***A Cost/Benefit Estimating Service for Mapping Parallel Applications on Heterogeneous Clusters.*** Proceedings of Cluster 2005, Boston, MA, Sep 26-30, 2005.

D. Katramatos, M. Humphrey, A. Grimshaw, S. Chapin. ***JobQueue: A Computational Grid-Wide Queuing System.*** Proceedings of GRID 2001, pp. 99-110, Denver, CO, Nov 12, 2001.

D. Katramatos, M. Humphrey, C. Hwang, S. Chapin. ***Developing a Cost/Benefit Estimating Service for Dynamic Resource Sharing in Heterogeneous Clusters: Experience with SNL Clusters.*** Proceedings of CCGrid 2001, pp. 355-362, Brisbane, Australia, May 15-18, 2001.

D. Katramatos, D. Saxena, N. Mehta, S. Chapin. ***A Cost/Benefit Model for Dynamic Resource Sharing.*** Proceedings of HCW 2000, Cancun, Mexico, 1-5 May 2000.

S. Chapin, D. Katramatos, J. Karpovich, A. Grimshaw. ***Resource Management in Legion.*** Future Generation Computer Systems 15, pp.583-594, 1999.

ANTHONY A. KEMPKA

Sr. Cyber Security Staff Scientist
P.O. Box 999 MSIN: K7-30
Richland, WA 99352
Tel: 509-375-4421
email: anthony.kempka@pnl.gov

EDUCATION

Master of Science - Computer Science	Washington State University, 1992
Bachelor Computer Science	University of Minnesota - Morris, 1990
Bachelor Philosophy	University of Minnesota - Morris, 1990

PROFESSIONAL EXPERIENCE

Battelle/Pacific Northwest National Laboratory 2004 – Present ***Sr. Cyber Security Staff Scientist***
Cyber Security research and applied engineering solving critical problems of national security and infrastructure protection.

Device Drivers International, Inc. 8/96 – 2004 ***Consulting Software Engineer – Principal Co-Founder***
Founding member and corporate officer of company. Responsible for customer/client development, contract negotiations, software licensing, requirements gathering, project management and full lifecycle product development of several differing product lines.

3Com Corporation 2/97 – 2/98 ***Staff Software Engineer***

Integrity Instruments, Inc. (previously Integrity Designs, LLC) 11/95 - Current (Board of Directors) ***Co-Founder, Software/Firmware Engineer***

Cogito Software, Inc. 12/93 – 10/95 ***Consulting Software Engineer***

HACH Company 5/93 - 12/93 ***Consulting Software Engineer / Firmware Engineer***

EXABYTE Inc. 6/92 - 5/93 ***Firmware Engineer***

Hunt Technologies Inc. 1987 – 1989 ***Engineering Programmer - Firmware***

SYS-CON Inc. Backus, MN 1984 – 1987 ***Engineer***

PUBLICATIONS

“*Microcomputers and Multi-Tasking Machine Control*”, Winter 1991/1992 ACM SIG SMALL/PC Notes.
“*Fuzzy Logic in the real world*”, March 1991, Sensors Magazine
“*Activating Neural Networks: Part 1*”, June 1994, AI Expert
“*Activating Neural Networks: Part 2*”, August 1994, AI Expert
“*The Neural Net Connection - Revving Up*”, September/October 1994, PC AI
“*Using Neural Networks*”, Personal Engineering & Instrumentation News
“*AI: The Fundamental Fatal Assumption*”, Minnesota Philosophy Conference, May 1990, College of St. Catherine, St. Paul

YEE-TING LI

SLAC Computing and Computer Services
Stanford Linear Accelerator Center
2575 Sand Hill Road
Menlo Park, CA 94025
ytl@slac.stanford.edu

EDUCATION

2001-2005 University College London, UK
Ph.D: Thesis title - An Investigation into Transport Protocols and Data Transport Applications Over High Performance Networks
1997-2001 University College London, UK
M.Sci.: Physics

PROFESSIONAL EXPERIENCE

2005-Present Stanford Linear Accelerator Center, USA
Network Specialist: Research on High Performance Networking technologies and solutions
2005-2005 Hamilton Institute, Ireland
Researcher: Simulation and real-life studies of TCP congestion control algorithms
2004-2004 EGEE, JRA4, UK
Software Engineer: Design and implementation of network monitoring middleware

CURRENT RESEARCH INTERESTS

Distributed systems, network monitoring architectures and schemas, high performance networking, TCP congestion control algorithms, MPLS and Diffserv implementation.

SELECTED PUBLICATIONS

Experimental Evaluation Of Tcp Protocols For High-Speed Networks, Y. Li, D. Leith and R. Shorten, Contributed to IEEE/ACM Transactions on Networking, June 2005

Bringing High-Performance Networking To Hep Users, R. Hughes-Jones, S. Dallison, N. Pezzi and Y. Li, Computing in High Energy and Nuclear Physics 04, September 2004

Systematic Analysis Of High Throughput Tcp In Real Network Environments, Y. Li, S. Dallison, R. Hughes-Jones and P. Clarke, Second International Workshop on Protocols for Long Distance Networks, February 2004

BRIAN LA MARCHE

Environmental Molecular Sciences Laboratory
Pacific Northwest National Laboratory
P.O. Box 999
Richland, WA 37831
brian.lamarche@pnl.gov

EDUCATION

B.S. with Honors, Computer Science, Washington State University, Pullman 2004.

PROFESSIONAL EXPERIENCE

1999-Present Pacific Northwest National Laboratory
Research and development of real-time control and imaging applications for live cell imaging.

2002-2003 Student Computing Services, Washington State University
Developed web based applications to manage network account access for student managed computer labs at Washeington State University.

2000-2001 Surface Dynamics Laboratory, Washington State University
Studied charge transfer between a perfluoropolyether lubricant and aluminum stylus.

HONORS AND AWARDS

Outstanding Performance Award, Fundamental Science Directorate –
National Society of Collegiate Scholars
Phi Eta Sigma National Honors Society

CURRENT RESEARCH INTERESTS
Real-Time three dimensional image reconstruction.

SELECTED PUBLICATIONS

Perrine KA, DF Hopkins, BL Lamarche, and MB Sowa. 2005. "Pixel Perfect: a real-time image processing system for biology." Scientific Computing & Instrumentation 16-20.

Seifert CE, JL Orrell, DE Coomes, BL Lamarche, M Bliss, KA Jones, G Champi, and KG Lynn. 2005. "Performance of CdZnTe detectors grown by low-pressure Bridgman." Presented at IEEE Nuclear Science Symposium, Fajardo, Puerto Rico on October 27, 2005. PNNL-SA-47448.

J.V. Wasem, B.L. LaMarche, S.C. Langford, and J.T. Dickinson, 15 February 2003 "Triboelectric charging of a perfluoropolyether lubricant" Journal of Applied Physics, Vol. 93, No. 4

THOMAS P. MCKENNA, JR.

Product Line Manager
Computational & Information Sciences Directorate
Pacific Northwest National Laboratory
P.O. Box 999
Richland, WA 37831
thomas.mckenna@pnl.gov

EDUCATION B.S. Computer Science, Seattle Pacific University

PROFESSIONAL EXPERIENCE

October 2005 – Present CISD Product Line Manager Key contact for business development and marketing of CISD's products and services to external clients. Responsible for developing and deploying a structured proposal process for major program calls and supporting the proposal development and review process. Responsible for building and managing partnerships internally within Battelle and externally with government and commercial clients that leverage Battelle's capability and business base.

December 2002 October 2005 Project Manager Project Manager for DOE UltraScienceNet Application Testbed, Responsible for various Program Management activities relating to Cyber Security.

June 2001 – October 2002 digeo, Inc. Sr. Patent Portfolio Manager Responsible for digeo's patent portfolio, which includes managing more than 180 filed patent applications, and more than 500 patent ideas.

June 2000 – June 2001 digeo, Inc. Sr. Product Manager Responsible for developing and defining strategic business initiatives and recommending the policies, strategies and plans for new products relating to interactive televison..

June 1999 – June 2000 BSQUARE Corporation Sr. Product Manager Set, created, lead, and executed the market segment direction, business model and initiatives for BSQUARE to succeed in its target market (Consumer Information Appliances).

June 1993 – June 1999 InterGroup Technologies Chief Executive Officer Co-founder of InterGroup. Responsible for all technical sales, marketing, and business development for all products, including both OEM and shrink-wrap products.

HONORS AND AWARDS
Outstanding Performance Award (2)
Emmy Award for Technology
Product of the Year Award, Windows Tech Magazine

PATENT "System and method for managing television programs within an entertainment system" US. Patent No. 6,915,528, July 2005.

CURRENT RESEARCH INTERESTS
High Performance Networking, Network Security, Bioinformatics

BISWANATH MUKHERJEE

Department of Computer Science
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mukherje@cs.ucdavis.edu

EDUCATION

Ph.D.: Electrical Engineering, University of Washington, Seattle, 1987
M.S.: Electrical Engineering (1983); Computer Science (1984); Southern Illinois University
B.S.: Electronics & Elec. Commun. Eng., Indian Institute of Technology, Kharagpur, India, 1980

PROFESSIONAL EXPERIENCE

1987-present:	Department of Computer Science; Professor (95-present); Associate Professor (92-95); Assistant Professor (87-92); Department Chairman (97-00)
1984-87:	Graduate Student (TA and RA), University of Washington, Seattle
1981-84:	Graduate Student (TA, RA, Lecturer), Southern Illinois University
1980-81:	Technical Support Engineer, Operations Research Group Systems, India

HONORS AND AWARDS

2004	**Winner, Distinguished Graduate Mentoring Award, UC Davis**
2004	Supervisor, **Best Doctoral Dissertation Award** in Engineering (**K. Zhu**'s Dissertation)
2000	Supervisor, **Best Doctoral Dissertation Award** in Engg. (**L. Sahasrabuddhe**'s Dissertation)
1994	Co-winner, Paper Award, 17th National Computer Security Conference, for "Testing Intrusion Detection Systems: Design Methodologies and Results from an Early Prototype"
1991	Co-winner, Best Paper Award, 14th National Computer Security Conference, for "DIDS (Distributed Intrusion Detection System̃ Motivation, Architecture, and an Early Prototype"
1986-87	General Electric Foundation Fellowship, University of Washington
1984-85	GTE Teaching Fellowship, University of Washington

PATENTS

- B. Mukherjee, S. Yao, "Method and Apparatus for Hierarchical Optical Switching," *US Patent No. 6,792,208*, 9/14/04.
- B. Mukherjee, K. Zhu, and L. Sahasrabuddhe, "Method and Apparatus for Guaranteeing a Failure-Recovery Time in a Wavelength-Division Multiplexing Network," *US Patent No. 6,850,487*, 2/1/05.
- B. Mukherjee, J. Zhang, and K. Zhu, "Method and Apparatus for Providing a Service Level Guarantee in a Communication Network," *US Patent No. 6,963,539*, 11/8/05.

CURRENT RESEARCH INTERESTS

Lightwave Networks; Network Security; Wireless Networks

SELECTED PUBLICATIONS

Please visit Mukherjee's website (http://networks.cs.ucdavis.edu/˜mukherje/) for details on his publications.

1. B. Mukherjee, *Optical Communication Networks*, Springer, Jan. 2006. (Supercedes: B. Mukherjee, *Optical WDM Networks*, Mc-Graw-Hill, July 1997.)
2. A. Banerjee, W. Feng, B. Mukherjee, D. Ghosal, "Routing and Scheduling Large File Transfers over Lambda Grids," *Proc., Workshop on Protocols for Fast Long-Distance Networks (PFLDNet),* Feb'05.
3. A. Banerjee, W. Feng, B. Mukherjee, D. Ghosal, "RAPID: End-System Aware Protocol for Intelligent Data-Transfer over Lambda-Grids," *Proc., Int Parallel & Dist. Proc. Symp. (IPDPS),* Apr'06.
4. B. Mukherjee, D. Banerjee, S. Ramamurthy, and A. Mukherjee, "Some principles for designing a wide-area optical network," *IEEE/ACM Transactions on Networking*, vol. 4, pp. 684-696, Oct. 1996.
5. B. Mukherjee, "WDM Optical Communication Networks: Progress and Challenges" (Invited Paper), *IEEE Journal on Selected Areas in Communications*, vol. 18, no. 10, pp. 1810-1824, Oct. 2000.

JAREK NIEPLOCHA

Group Leader, Applied Computer Science Group
Computational Sciences and Mathematics Division
Pacific Northwest National Laboratory
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EDUCATION

- Ph.D. Department of Electrical and Computer Engineering, University of Alabama, 1993.
- M. S. Department of Electrical Engineering, Warsaw University of Technology, 1985.

PROFESSIONAL EXPERIENCE

Jarek Nieplocha is a Laboratory Fellow and the technical group leader of Applied Computer Science Group in Computational Sciences and Mathematics Division of the Computational and Information Science Directorate at Pacific Northwest National Laboratory (PNNL). He is also the Chief Scientist for High Performance Computing in Computational Sciences and Mathematics Division. He leads Advanced Computing Technology Laboratory at PNNL.

HONORS AND AWARDS

He received four best paper awards at leading conferences in high performance computing: IPDPS'03, Supercomputing'98, IEEE High Performance Distributed Computing HPDC-5, and IEEE Cluster'03 conference, and an R&D-100 award for Molecular Sciences Software Suite (MS3).

CURRENT RESEARCH INTERESTS

Interprocessor communication, high-performance networks, high-performance input/output, programming models for parallel computing , emerging computer architectures, fault tolerance

SELECTED PUBLICATIONS

- Tipparaju V, and J Nieplocha. 2005. "Optimizing All-to-All Collective Communication by Exploiting Concurrency in Modern Networks." In Proc. SuperComputing (SC'05), The International Conference for High Performance Computing and Communications. 2005.
- Felix EJ., K. Schmidt, K. Regimbal, J. Nieplocha, Active Storage Processing in a Parallel File System. Proc. 6th LCI International Conference on Linux Clusters: The HPC Revolution 2005, Chapel Hill, NC on April 26, 2005.
- Krishnan M, Y Alexeev, TL Windus, and J Nieplocha. 2005. "Multilevel Parallelism in Computational Chemistry using Common Component Architecture." In Proc. SuperComputing (SC'05), The International Conference for High Performance Computing and Communications. 2005.
- Nieplocha J, M Krishnan, BJ Palmer, V Tipparaju, and Y Zhang. 2005. "Exploiting Processor Groups to Extend Scalability of the GA Shared Memory Programming Model." In Proceedings of the ACM SIGMicro Computing Frontiers'2005. 2005.
- Nieplocha J, DJ Baxter, V Tipparaju, C Rasmussen, and RW Numrich. "Symmetric Data Objects and Remote Memory Access Communication for Fortran 95 Applications." In Proceedings of Euro-Par 2005. 2005.

NAGESWARA S. RAO

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EDUCATION

Ph.D. Computer Science, Louisiana State University, 1988
M.S. Computer Science, Indian Institute of Science, Bangalore, India, 1984
B.S. Electronics Engineering, Regional Engineering College, Warangal, India, 1982

PROFESSIONAL EXPERIENCE

1. Distinguished Research Staff (2001-present), Senior Research Staff Member (1997-2001), Research Staff Member (1993-1997), Intelligent and Emerging Computational Systems Section, Computer Science and Mathematics Division, Oak Ridge National Laboratory.
2. Assistant Professor, Department of Computer Science, Old Dominion University, Norfolk, VA 23529- 0162, 1988 – 1993; Adjunct Associate Professor, 1993 - present.
3. Research and Teaching Assistant, Department of Computer Science, Louisiana State University, Baton Rouge, LA, 1985 - 1988.

HONORS AND AWARDS

Special Commendation for Significant Contributions to Network Modeling and Simulation Program, Defense Advanced Research Projects Agency, 2005.
Research Initiation Award of National Science Foundation, 1991-1993.

SELECTED RECENT PUBLICATIONS

N. S. V. Rao, W. R. Wing, S. M. Carter, Q. Wu, High-speed dedicated channels and experimental results with hurricane protocol, *Annals of Telecommunications*, 2006, in press.

N. S. V. Rao, W. R. Wing, S. M. Carter, Q. Wu, UltraScience Net: Network testbed for large-scale science applications, *IEEE Communications Magazine*, November 2005, vol. 3, no. 4, pages, S12-17.

N. S. V. Rao, J. Gao, L. O. Chua, On dynamics of transport protocols in wide-area Internet connections, in *Complex Dynamics in Communication Networks*, L. Kocarev and G. Vattay (editors), 2005.

X. Zheng, M. Veeraraghavan, N. S. V. Rao, Q. Wu, and M. Zhu. CHEETAH: Circuit-switched high-speed end-to-end transport architecture testbed, *IEEE Communications Magazine*, 2005.

J. Gao, N. S. V. Rao, J. Hu, J. Ai, Quasi-periodic route to chaos in the dynamics of Internet transport protocols, *Physical Review Letters*, 2005.

J. Gao, N. S. V. Rao, TCP AIMD dynamics over Internet connections, *IEEE Communications Letters*, vo. 9, no. 1, 2005, pp. 4-6.

N. S. V. Rao, Q. Wu, S. S. Iyengar, On throughput stabilization of network transport, *IEEE Communications Letters*, vol. 8, no. 1, 2004, pp. 66-68.

N. S. V. Rao, Probabilistic quickest path algorithm, *Theoretical Computer Science*, vol. 312, no. 2-3, pp. 189-201, 2004.

KARSTEN SCHWAN

College of Computing, Georgia Institute of Technology, Atlanta, GA 30332-0280

PROFESSIONAL PREPARATION

Ph.D. (Computer Science, 1982), M.Sc. (Computer Science, 1977) Carnegie-Mellon University, Pittsburgh, PA.

APPOINTMENTS

Professor, Assoc. Professor (since 1995, 1988), College of Computing, Georgia Institute of Technology.
Assistant Professor (1981-1988), Computer and Information Science, The Ohio State University.

SELECTED, RECENT PUBLICATIONS

1. Ada Gavrilovska, Sanjay Kumar, Srikanth Sundaragopalan, Karsten Schwan, ``Advanced Networking Services for Distributed Multimedia Streaming Applications'', *Journal on Multimedia Tools and Applications*, Springer Publishing, to appear 2006.
2. Greg Eisenhauer, Fabian Bustamante, and Karsten Schwan, ``Publish-subscribe for High-performance Computing'', *IEEE Internet Computing*, Jan./Feb. 2006.
3. Richard West, Yuting Zhang, Karsten Schwan and Christian Poellabauer, ``Dynamic Window Constrained Scheduling of Real-Time Streams in Media Servers'', *IEEE Transactions on Computers*, June 2004.
4. Sanjay Kumar, Ada Gavrilovska, Karsten Schwan, and Srikanth Sundaragopalan,``CCoreB: Using Communication Cores for High Performance Network Services'', *4th IEEE International Symposium on Network Computing and Applications*, IEEE, June 2005.
5. Raj Krishnamurthy, Sudhakar Yalamanchili, Karsten Schwan and Richard West, ``Leveraging Block Decisions and Aggregation in the ShareStreams QoS Architecture'', *International Conference of Parallel and Distributed Systems* (IPDPS), IEEE, June 2003.
6. Matt Wolf, Zhongtang Cai, Weiyun Huang, Karsten Schwan, ``SmartPointers: Personalized Scientific Data Portals in Your Hand'', *Supercomputing 2002*, ACM/IEEE, Nov. 2002.
7. Qi He and Karsten Schwan, ``IQ-RUDP: Coordinating Application Adaptation with Network Transport'', *High Performance Distributed Computing* (HPDC-11), ACM/IEEE, July 2002.

SELECTED RECENT FUNDING

PI, with Ada Gavrilovska, ``Dynamic Data Appliances: Enabling Remote Device Virtualization with Heterogeneous Multi-core Machines'', Intel Corporation, $25,000, Dec. 2005.

PI, with Richard Fujimoto and Greg Eisenhauer, ``Effective Virtualization of Multi-core Systems'', Intel Corporation, $100,000, Aug. 2005.

PI, with Santosh Pande, Greg Eisenhauer, and Ada Gavrilovska, ``Service Paths -- Optimizing end-to-end Behaviors in Distributed Service Architectures'', National Science Foundation, $100,000, Aug. 2005 - July 2006.

PI, with Greg Eisenhauer, Santosh Pande, Rajiv Gupta, Hsien-Hsin Lee, ``Morphable Software Services'', NSF ITR, $1,033,775, Sept. 2003.

PI, jointly with Greg Eisenhauer, and Matt Wolf, ``Adaptive-XML: Tools for Collaborative Network Computing'', National Science Foundation, approx. $507,000, Jan. 2003 - Dec. 2005.

PI, jointly with Constantinos Dovrolis, Greg Eisenhauer, Calton Pu, Matt Wolf, Nagi Rao (ORNL), ``NetReact Services: Middleware Technologies to Enable Real-time Collaboration Across the Internet'', National Science Foundation, $950,000, Sept. 2002 - Aug. 2005.

PI, with Greg Eisenhauer, Mustaq Ahamad, Sudha Yalamanchili, ``IQ-ECho - Interoperability and Quality of Service Across Heterogeneous Hardware/Software Platforms'', Department of Energy, approx. $160,000/yr, July 2001 - June 2004.

WILLIAM R. WING

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EDUCATION

Ph.D. 1972 Physics, University of Iowa, Iowa City, IA
M.S. 1968 Physics, University of Iowa, Iowa City, IA
B.S. 1965 Physics, University of Iowa, Iowa City, IA

PROFESSIONAL EXPERIENCE

1999 - Present; Senior Research Staff Member - Networking Research Group
Oak Ridge National Laboratory
1991-1999 Senior Research Staff Member - Computing, Information, and Networking Division,
Oak Ridge National Laboratory
1972-1991 Senior Research Staff - Fusion Energy Division, Oak Ridge National Laboratory

HONORS AND AWARDS

ORNL Honors Night Team Award 1990

CURRENT RESEARCH INTERESTS
Network Monitoring and instrumentation

SELECTED PUBLICATIONS

1. UltraScience Net: Network testbed for large-scale science applications, with N. S. Rao, et. al. IEEE Communications Magazine, November 2005, in press.
2. Experimental results on data transfers over dedicated channel, with N. S. Rao, et. al., First International Workshop on Provisioning and Transport for Hybrid Networks: PATHNETS, 2004.
3. Internet Monitoring in the Energy Research Community, with Cottrell et. al. IEEE Network Transactions, special issue on the Internet 1997.
4. Data Acquisition in Support of Physics, Chapter in "Basic and Advanced Diagnostic Techniques for Fusion Plasmas" Published by Commission of the European Communities Directorate General XII – Fusion Programme, 1049 Brussels, Belgium - 1986
5. Soft X-ray Techniques, Chapter in "Course on Plasma Diagnostics and Data Acquisition" Eubank and Sindoni Editors, Published by C. N. R. – Euratom – 1975
6. Configuration Control Experiments Using Long-Pulse ECH Discharges in the ATF Torsatron, 18th Conf. On Controlled Fusion and Plasma Physics, Berlin, 19

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EDUCATION

Ph.D.	2000-2003	Computer Science	Louisiana State University, Baton Rouge, LA, USA
M.S.	1999-2000	Geomatics	Purdue University, Lafayette, IN, USA
B.S.	1991-1995	Remote Sensing	Zhejiang University, Hangzhou, P.R. China

PROFESSIONAL EXPERIENCE

2003-present	Research Fellow, Computer Science & Math Division, Oak Ridge National Laboratory.
2002-2003	Doctoral Student Research Associate, Computer Science and Math Division, Oak Ridge National Laboratory.
2000-2002	Instructor, Research/Teaching Assistant, Dept of Computer Science, Louisiana State University.
1999-2000	Research Assistant, Dept of Geomatics, School of Civil Engineering, Purdue University.
1998-1999	Research Assistant, Dept of Electrical and Computer Engineering, University of Florida.
1996-1998	Research/Teaching Assistant, Dept of Electrical Engineering, Zhejiang University, China.

HONORS AND AWARDS

Certificate of Exemplary Achievement: nominee for the 2003 LSU Distinguished Dissertation Award in Science, Engineering, and Technology.

CURRENT RESEARCH INTERESTS

Computer networking, large-scale computational science, scientific visualization, distributed high-performance computing, distributed sensor networks, algorithms, artificial intelligences.

SELECTED PUBLICATIONS

1. Q. Wu, M. Zhu, and N.S.V. Rao. System design for on-line distributed computational visualization and steering. In *Proceedings of International Conference on E-learning and Games*, Hangzhou, P.R. China, April 16-18, 2006 (Edutainment06).
2. Q. Wu and N.S.V. Rao, A class of reliable UDP-based transport protocols based on stochastic approximation, the 24th IEEE INFOCOM, Miami, FL, March 13-17, 2005.
3. Q. Wu, N.S.V. Rao, and S.S. Iyengar, On transport daemons for small collaborative applications over wide-area networks, the 24th IEEE International Performance Computing and Communications Conference, Phoenix, Arizona, April 7-9, 2005 (IPCCC05).
4. N.S.V. Rao, Q. Wu, S.M. Carter, and W.R. Wing. High-speed dedicated channels and experimental results with hurricane protocol. *Annals of Telecommunications, Special Issue on Transport Protocols for the Next Generation Networks*, October 2005.
5. N.S.V. Rao, Q. Wu, and S.S. Iyengar, On throughput stabilization of network transport, IEEE Communications Letters, vol. 8, no. 1, ICLEF 6, pp. 66-68, January 2004.

WENJI WU

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EDUCATION

Ph.D., Computer Engineering, University of Arizona, Tucson, USA, 2003
M.S., Industrial Engineering, University of Arizona, Tucson, USA, 2001
M.S., System Engineering, Zhejiang University, Hang Zhou, China, 1997
B.S., Electrical Engineering, Zhejiang University, Hang Zhou, China, 1994

PROFESSIONAL EXPERIENCE

2005 – Present, Wide Area Network Researcher, Wide Area Systems, Fermi National Accelerator Laboratory;
2003 – 2005, Research Assistant Professor, Dept. of Electrical & Computer Engineering, University of Arizona;
2001 – 2003, Research Assistant, Dept. of Electrical & Computer Engineering, University of Arizona;
1999 – 2001, Research Assistant, Dept. of System & Industrial Engineering, University of Arizona;

HONORS AND AWARDS

Distinguished Paper Award, Simulation-Based GMPLS Photonic Router using the OPNET MPLS Module, *OPNETWORKS, 2002*, Aug. 2002, Washington.

PATENTS

Wenji Wu, Mingkuan Liu, Kevin M. McNeill, "Method and System for Improving the Quality of Voice Information Transmitted over a Packet Switched Network", pending, April 2004.

CURRENT RESEARCH INTERESTS

Performance Analysis of Network End Systems, working on the Linux-based network end systems to analyze the network end systems' networking performance bottlenecks.

SELECTED RECENT PUBLICATIONS

W. Wu and M. Crawford, The Performance Analysis of Linux Networking–Packet Receiving, *Proceedings of Computing in High Energy Physics (CHEP) 2006*, Mumbai, India, 2006.

Wenji Wu, Natalia Gaviria, Kevin M. McNeill, Mingkuan Liu, "Two-layer Hierarchical Wavelength Routing for Islands of Transparency Optical Networks", submitted to *Journal of computer communications*, September 2004. In Review.

Ralph Martinez, Wenji Wu, Peng Choop, "A Modeling Process and Analysis of GMPLS-based Optical Switching Routers", *Photonic Network Communications Magazine,* Volume 8, Issue 1, Jun 2004.

Wenji Wu, Ralph Martinez, and Peng Yin Choop, "Simulation-based GMPLS Photonic Router", Proc. of SPIE, Optical Networking II, vol. 4910, Sep. 2002, pp. 353-364.

Dantong Yu

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Education

State University of New York at Buffalo Computer Science Ph.D,	2001
State University of New York at Buffalo Computer Science M.S.,	1998
Beijing University Computer Science B.S.,	1995

Appointments

2001-now	Physics Department Brookhaven National Laboratory, Group Leader, Information Technology Architect
1995-1996	Department of Computer Science and Technology Beijing University, Teaching Assistant

Publications Most Relevant to Proposed Research Program

1. YU, D., AND ZHANG, A. "ClusterTree: Integration of Cluster Representation and Nearest Neighbor Search for Large Datasets with High Dimensionality". *IEEE Transactions on Knowledge and Data Engineering 15*, Number 5 (Sept. 2003).
2. YU, D., AND ROBERTAZZI, T. "Divisible Load Scheduling for Grid Computing". In *IASTED International Conference on Parallel and Distributed Computing and Systems (PDCS 2003)* (Marina del Rey, CA, Nov. 2003).
3. WONG, H., YU, D., VEERAVALLI, B., AND ROBERTAZZI, T. "Data Intensive Grid Scheduling: Multiple Sources with Capacity Constraints". In *IASTED International Conference on Parallel and Distributed Computing and Systems (PDCS 2003)* (Marina del Rey, CA, Nov. 2003).
4. CARCASSI, G. AND YU, D, ETC. "A Scalable Grid User Management System for Large Virtual Organization". In *Conference for Computing in High Energy and Nuclear Physics* (Interlaken, Switzerland, Sep. 2004).
5. YU, D. *Multidimensional Indexing and Management for Large-Scale Databases*. PhD thesis, University at Buffalo, Feb. 2001.

Synergistic Activities

- Review Panel for DOE Early Career and Small Business Innovative Research (SBIR/STTR) Principle Investigator for network research.
- PI of the DOE MICS proposal *TeraPaths: A QoS Enabled Collaborative Data Sharing Infrastructure for Peta-scale Computing Research*.
- Lead and coordinate the Grid software deployment effort at BNL, deployment of the Globus
- software for the experiments: USATLAS, STAR, PHENIX.
- Design and improve high-speed network protocol to transfer files, coordinate the data transfer between BNL and other ATLAS and RHIC collaboration institutes.
- Reviewer for several journals and conferences: International Journal of Computers and their applications, Journal of ACM Multimedia Systems, International Conference on Data Engineering, and International Conference on Knowledge Discovery and Data Mining.

Description of Facilities

A. **Brookhaven National Laboratory**
B. **Fermi National Accelerator Laboratory**
C. **Georgia Institute of Technology**
D. **Oak Ridge National Laboratory**
E. **Stanford Linear Accelerator Center**
F. **University of California at Davis**

Description of Facilities and Resources
Brookhaven National Laboratory

ATLAS Tier 1 and RHIC Tier 0 Computing Facility (RCF)

Both ATLAS Computing Facility (ACF) [34] and RHIC Computing Facility (RCF) [35] are co-located in the same operating center. The ATLAS Computing Facility (ACF) was established as LHC Tier 1 center to support the USATLAS collaboration. The RCF was established to support the computing needs of the experiments at the Relativistic Heavy Ion Collider (RHIC) [18]. Both facilities are managed by the same computing administration group and leverage each other's resources and computing services. The center is currently a fully participating component of various grid projects that include GriPhyN [36], iVDGL [37], and PPDG [38]. BNL is one of the leading institutional participants in the Open Science Grid (OSG) [39]. The facility consists of an OSG enabled computing cluster, a grid-enabled disk storage system, an HPSS tape-based mass storage system [40], and a high-speed network.

A detailed list of BNL's equipment and facilities is as follows:

OSG Production ATLAS/RHIC Cluster

- 2025 1U/2U dual-Xeon hosts with 4050 Intel Processors in total provide 14 TeraFlops computing capacity.
- Multiple production clusters are provisioned via the local batch queues (LSF [43] and Condor [44]).
- OSG head node: 4 1U dual Xeon, each has 3.0Ghz processor , 2GB RAM, 450 GB SCSI disk space. RHEL4, OSG-0.4.0
- Network: CISCO 6509 switches with 10/100/1000 Mbps Ports.
- Software: RHEL3 (SL3), dCache [27], ATLAS applications (Athena, Panda, DDM) [11], Pool [41].

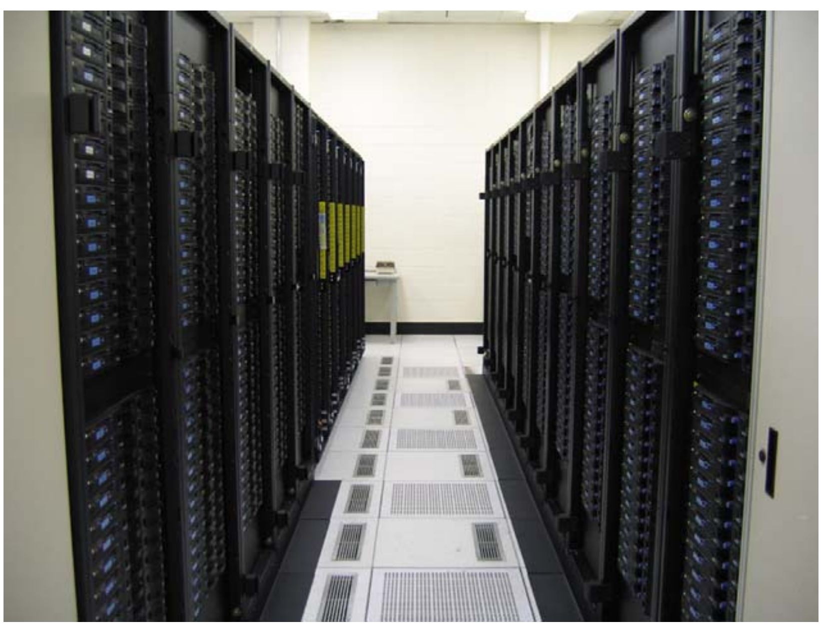


Figure 1: BNL ATLAS/RHIC Computing Cluster

Grid Enabled Disk Storage System

- Distributed disk storage system with 200 terabytes is provided via dCache/SRM using the local disks of 500 RHIC/USATLAS computing cluster nodes.
- Centralized 350 terabytes are provided by fiber-channel SAN and Panasas [42] storage systems, and exported by OSG GridFTP [28] servers.

Mass Storage System

- Based on HPSS technology to provide 7x24 archiving and retrieving services.
- 6 tape silos with a combined capacity of up to 29,000 tapes and 124 tape drives.
- 7 Peta-Byte of tape storage capacity and 12-terabyte front-end disk cache.
- Capable to handle 1 gigabyte/sec data transfer rates.
- 8 front-end hosts, each of which has dual 1-gigabit network interface.
- dCache/SRM provides the front-end Grid interface for BNL HPSS. The shared name space between dCache and HPSS seamlessly integrates HPSS into OSG, and provides uniform data service regardless of the underlying storage media.

Figure 2: BNL HPSS Mass Storage System

High Speed Network Testbed:

For software development and testing purposes, we put together a fully featured test bed using the same Cisco hardware (two CISCO Catalyst 6509 and one CISCO Catalyst 2948 switches) as in the BNL production network (see Figure 3). This test bed allows for all kinds of experiments without the risk of adversely affecting the production network.

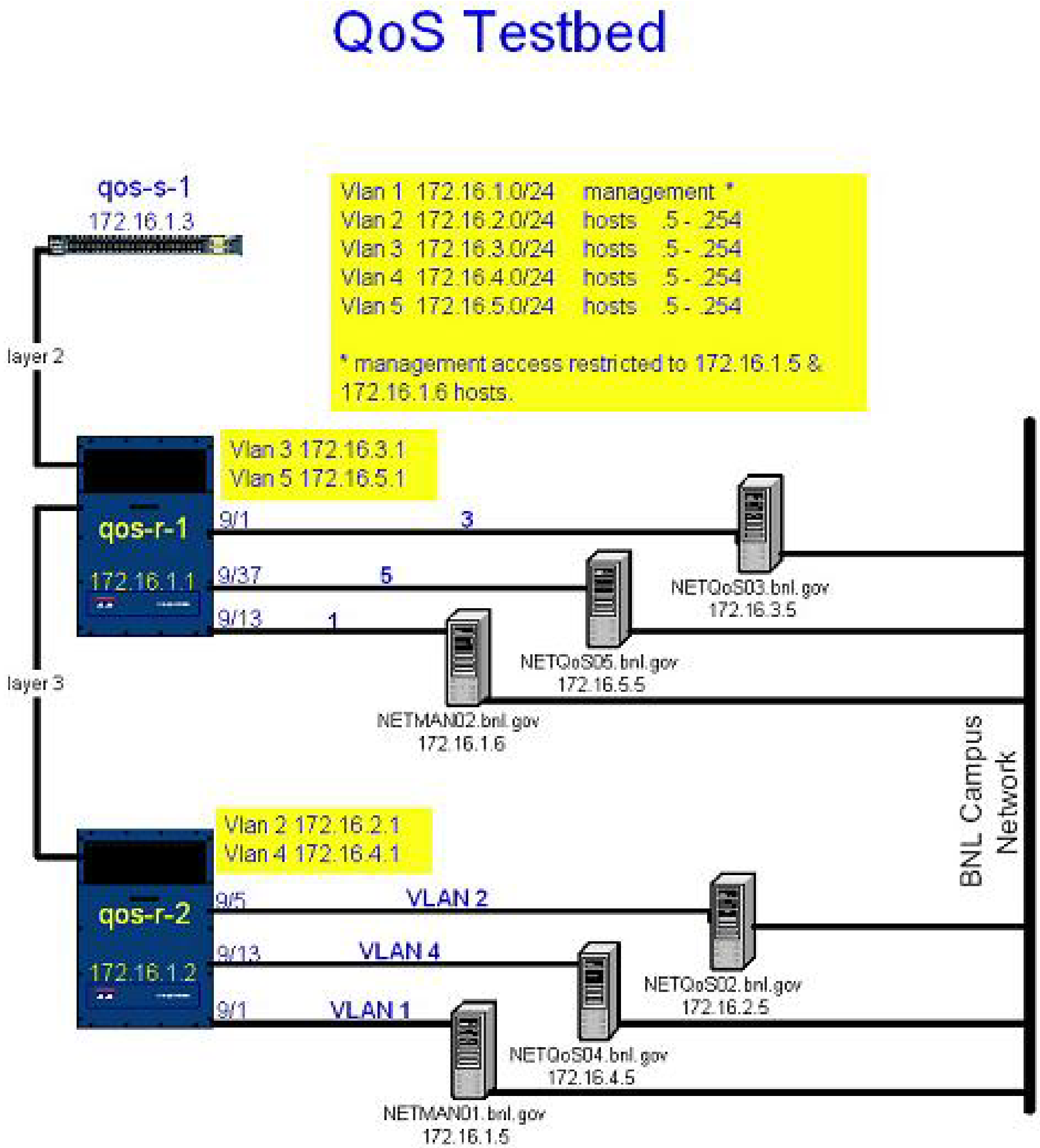


Figure 3: BNL Quality of service Testbed

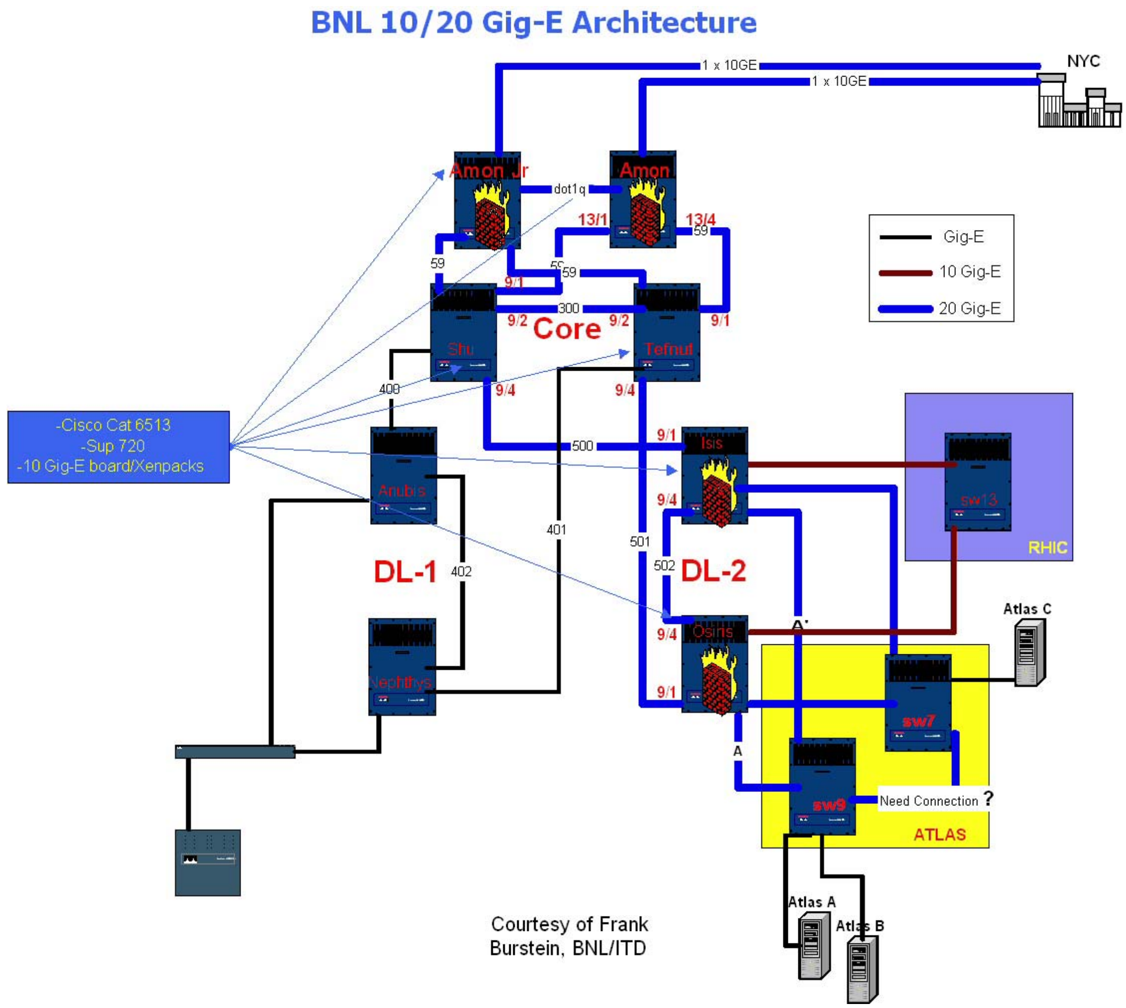


Figure 4: BNL Network Upgrade Plan for LAN and WAN Connection.

High Speed Network

The BNL production network includes:

- A series of Cisco 6509/6513 interconnected by multiple 10 Gbps connections provide high availability and reliability.
- BNL Campus Network: 10 Gbps LAN with full redundancy operates 7x24.
- OC-48 (2.5Gbps) WAN connection from BNL to ESnet, which will be decommissioned after February.
- Two wavelengths with 20Gpbs bandwidth were put into production in February 2006 connecting BNL to 32 AoA in New York City.
- One dedicated 10 Gbps layer-2 LHC network link connecting BNL's PoP in NYC to CERN.

Description of Facilities and Resources
Fermi National Accelerator Laboratory

Existing FNAL facilities to be leveraged at FNAL include our infrastructure and experience in build and support secure operating system configurations, appropriate for deployment with or without external firewall protection. We also have developed and released Lambda Station, a service mediating between applications and any advanced networks available for their use. FNAL also has a small number of high-performance host systems, and cluster of lower-rated machines, available for network and application R & D. Complementing this, multiple 10Gbps wavelengths are available from FNAl to the international exchange point, Starlight.

Description of Facilities and Resources
Georgia Institute of Technology

The Center for Experimental Research in Computer Systems (CERCS) has established a laboratory for university research in high performance computing. This Interactive High-Performance Computing Lab (IHPCL) is a University-wide project funded by grants from Intel, HP, and the National Science Foundation (NSF). These serve as a focus for interdisciplinary research and instruction involving high-performance computer systems at Georgia Tech. The two co-directors of IHPCL (Schwan and Wolf) can commit these resources for use in this project. These facilities are linked by a dedicated, non-blocking backbone utilizing multiple Gigabit Ethernet links, and includes:

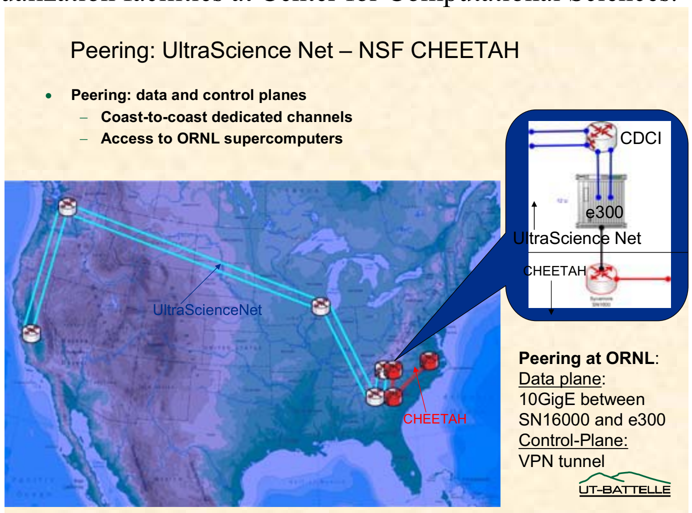
Warp Cluster: a 100-node Linux cluster with dual Xeon processors and Gigabit Ethernet.

- Rohan Cluster: a 53-node Dell PowerEdge 1850 Linux cluster with dual Xeon EMT64 processers using non-blocking Infiniband interconnects, Gigabit Ethernet, and multi-terabyte infiniband-attached storage.
- Sith Cluster: a 36-node Linux cluster with dual Itanium2 processors, Gigabit Ethernet, and terabyte distributed storage.
- Jedi Cluster: a cluster of 17, 8-processor Pentium III systems utilizing Gigabit Ethernet running Linux,
- Conference Room with Access Grid node connectivity providing collaborative visualization and interaction with researchers worldwide over Internet2.

The combination of distributed and localized storage coupled with compute resources provides a development platform. The advanced teleconferencing capabilities will enhance the joint team abilities. Through the recent joint Georgia Tech-Oak Ridge facilities agreement, additional access between the two institutions will also be leveraged.

Description of Facilities and Resources
Oak Ridge National Laboratory

In this project we will extensively utilize the DOE UltraScience Net and NSF CHEETAH networks and supercomputers and visualization facilities at Center for Computational Sciences.



ORNL Research Networks

ORNL is currently funded by two projects, DOE UltraScienceNet (USN) and NSF CHEETAH, for developing the technologies needed for such networks. USN spans ORNL, Chicago, Seattle and Sunnyvale with two parallel 10 Gbps connections. It provides two types of dedicated channels on-demand to applications: (i) SONET channels of various resolutions from OC1 (50Mbps) to OC192 (10Gbps); and (ii) Ethernet channels with resolutions ranging from 50Mbps to 10Gbps. CHEETAH provides a network infrastructure for provisioning dedicated bandwidth channels and the associated transport, middleware and application technologies to support large data transfers and interactive visualizations needed for eScience applications, particularly TSI. The footprint of CHEETAH spans ORNL, NCSU, UVA, and CUNY with the latter two sites added in 2006 depending on the pricing at that time. CHEETAH provisions dedicated channels between these nodes at various SONET resolutions.

Under a recently funded DOE project, UltraScienceNet and CHEETAH network infrastructures peer at ORNL to provide dedicated channels that span the US, and to develop next generation components for end-to-end visualization of supernova applications. We emphasize that both these networks are fundamentally different from the Internet. The latter provides shared connections whose available bandwidth depends on other traffic but the hosts are always connected to it albeit often at unpredictable connection performances. On the other hand, both these networks provide dedicated channels at the specified bandwidths with no other traffic on them but only during the allocated periods.

ORNL Production Network Connectivity

ORNL is connected to every major research network at rates of 10 gigabits per second or greater. Connectivity to these networks is provided via optical networking equipment owned and operated by ORNL that runs over leased fiber optic cable. This equipment has the capability of simultaneously carrying either 192 10-gigabit per second circuits or 96 40-gigabit per second circuits and connects the CCS computing facility to major networking hubs in Atlanta and Chicago. Currently, only 16 of the 10-gigabit circuits are committed to various purposes, allowing for virtually unlimited expansion of the networking capability. As part of this proposal, we will expand the current TeraGrid connection from 10 to 30 gigabits per second. Currently, the connections into ORNL include: TeraGrid, Internet2, ESnet, and

Cheetah at 10 gigabits per second as well as UltraScienceNet and National Lambda Rail at 20 gigabits per second.

Center for Computational Sciences

The Center for Computational Sciences (CCS) was established in 1992 and is a designated User Facility. The CCS has the following goals:

- Focus on grand challenge science and engineering applications
- Procure the largest scale systems (beyond vendors design point) and develop software to manage and make them useful
- Deliver leadership-class computing for science and engineering
  - By 2005: ***50x*** performance on major scientific simulations
  - By 2008: ***1000x*** performance
- Educate and train next generation computational scientists

The CCS houses the computing platforms and has a long history of taking delivery of emerging, yet promising architectures to drive computational sciences at the leading edge.

CCS Network Connectivity

The CCS local-area network is a common physical infrastructure that supports separate logical networks, each with varying levels of security and performance. Each of these networks is protected from the outside world and from each other with access control lists and network intrusion detection. Line rate connectivity is provided between the networks and to the outside world via redundant paths and switching fabrics. A tiered security structure is designed into the network to mitigate many attacks and to contain others. The new Cray system will be connected in the TeraGrid enclave to the TeraGrid Force10 E600 router via a 10 Gbps link.

Visualization and Collaboration. ORNL has state-of-the-art visualization facilities that can be used on site or accessed remotely. ORNL's Exploratory Visualization Environment for REsearch in Science and Technology (EVEREST) is an immersive 30' wide by 8' high PowerWall for data exploration and analysis. Twenty-seven projections are virtually seamlessly edge-matched for an aggregate resolution of more than 11,000 by 3,000 pixels. This projection environment is driven by a 64-node rendering and analysis cluster comprised of dual-processor Opteron workstations. This cluster is networked to the resources in the National Center for Computational Sciences (NCCS) and performs additional visualization-related functions including computation, pre-analysis, and pre-rendering. The rendering cluster has been demonstrated with a variety of COTS and open-source visualization tools including CEI Ensight, OpenDX, AVS-Express, VMD, and VTK. Our rendering environment currently utilizes 64-bit Suse Linux, Chromium, Distributed Multi-Head X (DMX), and state-of-the-art graphics cards with pixel shader support. The facility itself has a 600 square-foot projection area, and a 1000 square-foot viewing area. The viewing area can accommodate a wide range of groups...from a couple researchers to a 25-member collaboration. The ORNL-developed PowerWall Toolkit is a GUI environment which enables groups to use the EVEREST PowerWall as a large desktop pixel space with static imagery, movies, and interactive 3D visualizations. Other visualization capabilities include LCD arrays and a reconfigurable CAVE.

Archives and Access. A high-performance, scalable filesystem is vital to data-intensive applications. Archival storage is provided by the High Performance Storage System (HPSS) operated by ORNL. ORNL has an HPSS installation with a capacity of up to 5 petabytes of data and regularly supports data transfers of more than 10 TB per day. Both the bandwidth and capacity of HPSS can be increased as needed. The CCS will deliver a shared secondary file storage system to enable sharing of data among the computer systems, data analysis systems, visualization systems, and archival storage. A project is currently underway with Cray and other strategic partners to implement a single high-speed shared file system linking all of the computing systems within the CCS. The underlying technology of this file system will be based on the LUSTRE file system developed by Cluster File Systems Inc.

Physical and Cyber Security. ORNL has a comprehensive physical security strategy including fenced perimeters, patrolled facilities, and authorization checks for physical access. An integrated cyber security plan encompasses all aspects of computing. Cyber security plans are risk-based and separate systems of differing security requirements into enclaves of similar requirements allowing the appropriate level of protection for each system, while not hindering the science needs of the projects.

Systems Engineering, Administration, and Operations. ORNL has a professional, experienced operational and engineering staff comprised of groups in HPC Operations, Technology Integration, User Services, and Scientific Computing. The ORNL computer facility is staffed 24 hours a day, 365 days a year to provide for continuous operation of the center and for immediate problem resolution. On evenings and weekends, the operators provide first-line problem resolution for users with additional user support and system administrators on-call for more difficult problems. Primary CCS systems include the following:

- **Jaguar**: a 5,296 processor Cray XT3 system providing a peak performance of over 25 teraflops and over 10 TB of memory. Planned upgrades of Jaguar are to 100 TF in 2006 and to 400 TF in 2007.
- **Phoenix:** a Cray X1E, with 1,024 multistreaming vector processors (MSPs) and 2 TB of globally addressable memory. Each MSP has 2 MB of cache, and four MSPs form a node with 8 GB of shared memory. Memory bandwidth is very high, up to half the cache bandwidth. The interconnect functions as an extension of the memory system, offering each node direct access to memory on other nodes at high bandwidth and low latency. The peak performance of Phoenix is 18.5 teraflops.
- **OIC:** ORNL Institutional Cluster is a collection of eight SGI Xeon clusters providing 640 dual-processor nodes and almost 10 TF of peak performance.
- **Cheetah**: a 27-node IBM Power-4 system. Each Power-4 node of Cheetah has thirty-two 1.3-GHz Power4 processors. Twenty of the nodes have 32 GB of memory, five nodes have 64 GB of memory and two nodes have 128 GB of memory. The peak performance of Cheetah is 4.5 teraflops.
- **Ram:** a 256-processor SGI Altix with 2 TB of shared memory. Each processor is the Intel Itanium2 1.5 GHz processor. The full system runs a single Linux image and the large shared memory facilitates analysis of very large data sets. The peak performance of Ram is 1.5 teraflops.

The **Joint Institute for Computational Sciences (JICS)** facility represents a $10M investment by the State of Tennessee and features a state-of-the-art distance learning center with 66 interactive seating; conference rooms, informal / open meeting space, executive offices for distinguished scientists and directors, and incubator suites for students and visiting staff. Users of the NCASE will have ready access to this facility.

Description of Facilities and Resources
Stanford Linear Accelerator Center

SLAC has an OC12 (622Mbit/s) Internet connection to ESnet, and a 1 Gigabit Ethernet connection to Stanford University and thus to CalREN/Internet2. In addition we will soon (currently planned for Summer 2006) have a 10 Gbits/s production plus a 10Gbits/s test network connections to the ESnet Bay Area Metropolitan Area Network (MAN). We also have two high performance hosts at the Sunnyvale PoP that are connected at 10Gbit/s onto Ultra Science Net for testing and tuning purposes. SLAC is connected to the IPv6 direct connection onto ESnet with 3 hosts making measurements for IPv6.

We recently demonstrated utilization of 35Gbit/s (in both direction) using only two 10Gbit/s connections as part of our record breaking Bandwidth Challenge at the SuperComputing 2005 conference. Contributing with Caltech and Fermilab, we managed to transfer real physics data at a rate of 150Gbit/s peak during a two hour window.

SLAC has hosts dedicated to network measurement from the following projects: AMP, NIMI, PingER, RIPE, Monalisa, OWAMP and IEPM-BW. SLAC has two GPS aerials and connections to provide accurate time synchronization. In addition the SLAC IEPM group has a small cluster of five high performance Linux hosts with dual 2.4 or 3GHz processors, 2/4GB of memory and with 133MHz PCI-X buses. Two of these hosts have 10GE Intel interfaces and the other have 1 GE interfaces. We have also recently acquired two Sun V20z (Dual Opteron) with 10Gbit/s Neterion cards. These hosts are used for high performance testing including the all the previous successful bandwidth challenges (winning the bandwidth challenge year on year since 2003) and the Internet 2 Land Speed Records.

The SLAC data center contains two Sun E6800 20 and 24 symmetric multiprocessor and an SGI Altix. In addition there is a Linux cluster of over 3,700 CPUs, an 800 CPU Solaris cluster. For data storage there are 550TByte of online disk, and automated access tape storage with a capacity of 10 PetaBytes and utilization of over a PetaByte.

SLAC is the home site of the BaBar High Energy Physics (HEP) experiment that has large data transfer needs with collaborators in the US and Europe. It is the home site of the Stanford Synchrotron Radiation Laboratory that includes the SPEAR-3 photon source and will be the future home of the Linear Coherent Light Source. Both of these have or will have challenging data network needs that we hope to partially address in the current proposal.

Description of Facilities and Resources
University of California Davis

The University of California has established a Networks Research Laboratory at UC Davis, equipping it with a large number of Pentium III and Pentium IV-based desktops and notebooks, all of which are connected by a 100 Mbps Ethernet backbone. There are workstations with 10GE interfaces for experimental research in end-system and transport adaptation. In addition we have software licenses of many commercial tools such as CPLEX for solving Mixed Integer Programming bases optimization problems, OPNET for network simulations and many others. These tools will be used for evaluating network scheduling algorithms as well as simulation analysis of the end-system models.

The Networks Research Laboratory at UC Davis is housed in an approximately 100 square-feet facility. These facilities will be available to this project, but additional high-performance, state-of-the-art workstations (Intel dual-processor based) will also need to be purchased for the experimentation and the development and analysis of various network models associated with the proposed effort.

Appendix 1: Institutional Tasks and Milestones and Deliverables

1. Brookhaven National Laboratory
2. Fermi National Accelerator Laboratory
3. Georgia Institute of Technology
4. Oak Ridge National Laboratory
5. Pacific Northwest National Laboratory
6. Sanford Linear Accelerator Center
7. University of California, Davis

Brookhaven National Laboratory: Tasks and Milestones

BNL will participate in various liaison and research activities; directly maintain the project website, software repository, and archive; and participate in monthly teleconferences and annual meetings. BNL acts as liaison for the following SciDAC physics programs:

- High Energy Physics (primarily for the LHC USATLAS project [31]),
- Nuclear Physics (mainly for STAR [32] and PHENIX [33], the two largest RHIC experiments),
- Lattice QCD [30].

BNL will develop technologies for guaranteeing end-to-end QoS to the data transfers and data management activities needed by the above programs and for optimizing the performance of the major components involved: network, data transfer middleware, and application-level data management software.

Liaison Activities:

The following are the liaison assignments of BNL PIs. For each area, the requirements will focus on terabyte or petabyte data transfer rates:

SciDAC Application Area	Assigned BNL PI	Science Area contact(s)	Status
LHC USATLAS	Bruce Gibbard	Torre Wenaus, BNL	Dr. Gibbard (facility) and Dr. Wenaus (data management) are the primary managers at BNL for the USATLAS computing project. Two groups, under their leadership, jointly provide data services to the whole USATLAS program.
RHIC STAR	Dantong Yu	Jerome Lauret	This is an ongoing collaboration. Dr. Yu's group already provides grid services to the STAR collaboration.
RHIC PHENIX	Dantong Yu	David Morrison	Dr. Yu's group already provides data transfer services to the PHENIX collaboration.
Lattice QCD	Dimitrios Katramatos	Eric Blum	Initial contacts are being made; primary area is remote data transfer support with tools and middleware provided by Dr. Katramatos.

PI Bruce Gibbard is the director of RHIC and USATLAS computing facilities. One of the primary responsibilities of these computing facilities is to provide 20% of the total data services needed by the global ATLAS collaboration. The two facilities have already demonstrated the capability of achieving data transfer rates as required by the collaborators. There is an ongoing effort to ensure the stability and predictability of high-level data services, from the point of view of physicists doing production and analysis tasks. The increasing computing requirements of RHIC experiments are beyond the capacity of the in-house computing facilities, which makes necessary to transfer data to remote computing resources. The success of the RHIC 2005 data transfers to Japan demonstrates the feasibility of integrating remote resources into the data handling and processing chain of large experiments, and stimulates much larger scale data transfers and more remote recipients, as viewed by the RHIC 2006 run.

Technical Area Activities:

The main focus of BNL activities is to develop network-aware data transfer tools and to integrate them with application software through multiple software engineering lifecycles. More specifically, BNL focuses on the following areas:

1) Development of tools for integrating an array of DOE-funded network projects,

2) Optimization of high-performance data transfer methods over quantitatively provisioned channels/circuits,
3) Vertical integration of fine-grained network services with data storage middleware and application data management layers, and
4) Building of technology transfer and support center.

Task #1 is a joint activity of SLAC (network monitoring), FNAL (LambdaStation), ORNL (UltraScience Net), and BNL (TeraPaths), while tasks #2 and #4 are joint activities of ORNL and BNL.

Year 1:

1. Deploy the TeraPaths bandwidth provisioning system at SLAC. Collaborate with UltraScience Net, LambdaStation, and OSCARS projects to prototype constraint-based intra-domain and inter-domain network path discovery.
2. Set up a software repository and document center for the development of the entire CANTIS project.
3. Develop end-to-end Network Reservation Services (NetReServ), which integrate reservation scheduling, network path selection, and network service negotiation.
4. Add grid-based authentication/authorization modules to NetReServ.
5. Integrate NetReServ into general-purpose data transfer tools such as GridFTP, bbftp, bbcp, and LCG/OSG Storage Elements (e.g. dCache/SRM).

Year 2:

1. Set up a data transfer support center and provide data transfer technology and services for end users of selected SciDAC applications.
2. Integrate NetReServ with the data distribution software of the following two RHIC experiments:
   STAR: enhance XROOTD/SRM to be network-aware and deliver data for analysis jobs in terms of seconds instead of hours.
   PHENIX: enhance capabilities with support for high-speed data transfers and help migrate the raw on-line RHIC data acquisition system to national and international collaborators, such as PHENIX at Oak Ridge National Lab and the PHENIX Computing Center in Japan (CCJ) respectively.
3. Integrate NetReServ with ATLAS/CMS Data Placement and Transfer Services (collaboration with FNAL) into a QoS-guaranteeing data distribution framework based on web services.
4. Enhance Distributed Data Management Systems, including Dataset Bookkeeping and Location Services (ATLAS DDM, US CMS PhEDEx), to be network-aware (collaboration with FNAL).

Year 3:

1. Enable network-aware dCache-based Lattice QCD data transfers between BNL, Columbia University, FNAL, and the University of Edinburgh**.**
2. Enhance NetReServ with support for enforcing policy-based network access and allocation.
3. Collect user feedback for supported application areas and refine data transfer requirements as needed.

Year 4:

1. Revise the design of the modular network bandwidth provisioning API and the grid-enabled web services for data transfer applications. Suitably augment/modify implementation to address user-raised and other encountered issues and improve performance.
2. Incorporate framework into overall CANTIS project and perform stress testing at all USLHC Tier-2 sites and selected Tier-3 sites.
3. Issue second release of the QoS-guaranteeing data distribution framework for the USLHC (ATLAS and CMS), RHIC experiment (nuclear physics), and Lattice QCD collaborations.
4. Expand the scope of the data transfer support center to nation-wide and more SciDAC applications in the areas of materials science and climate modeling.

Year 5:

1. Expand requirements to support worldwide LHC collaboration and design the communication interface and message exchange mechanisms.
2. Issue third release of the QoS-guaranteeing data distribution framework.
3. Expand the existing data transfer support center to assist troubleshooting at all LHC collaborator sites that use the data distribution framework.

Fermi National Accelerator Laboratory: Tasks and Milestones

Fermilab tasks comprise the following areas:

- Distributing and supporting Scientific Linux, with customized configurations and rapid security updates for the SciDAC community.
- Discovering and fixing kernel implementation or design flaws that unnecessarily reduce performance of SciDAC applications. Our starting points will be the already-discovered the antagonism between network and computational tasks described in [FNAL-1] and the known problem of sudden ARP cache flushing.
- Assisting in the eventual porting of SciDAC toolkits and applications to an IPv4/IPv6 mixed environment.
- Act as CANTIS project liaison to the HEP, HENP/Petabyte, and LQCD areas.

Tuning of network operating parameters such as buffer sizes is generally well-understood and is not considered a significant part of our work.

Year 1

1. Acquire and deploy SciDAC Scientific Linux distribution servers.
2. Begin outreach to SciDAC Linux users, inaugurate system installation and update service.
3. Reengineer Linux ARP cache maintenance to remove abrupt flushing; incorporate changes into Scientific Linux.
4. Investigate and evaluate approaches to solving locked receiver socket TCP problems.

Year 2

1. Continue outreach to SciDAC Linux users.
2. Implement and test one or more solutions to the locked-socket TCP problem; incorporate the best into Scientific Linux.
3. Establish relationships with the Linux kernel maintainers.
4. Continue research into other receiver-side bottlenecks.
5. Publish results in appropriate journals and conferences.
6. Begin survey of IPv4 dependencies in SciDAC applications and toolkits.

Year 3

1. Work to have our kernel improvements merged back into the standard Linux kernel.
2. Establish a small "first-mover" SciDAC deployment IPv6 community (work through ESnet and Abilene forums).
3. Select at least two SciDAC applications and/or tool kits and begin IPv6 porting and demonstration deployment.
4. Widen kernel performance research into other areas of buffer, queue and memory management and thread scheduling.
5. Publish results in appropriate journals and conferences.
6. Support SciDAC Linux installations; expand SciDAC user base.

Year 4

1. SciDAC operating system support and IPv4/IPv6 porting efforts continue.
2. Performance research is speculative, likely to include:
   - Continuing research and performance improvements in buffer, queue and memory management and scheduling.
   - Exploration of memory-mapped files as network data buffers for data transfers with reduced context switching.
   - Collaboration with Smart-NIC ("offload engine") developers.
3. Publish results in appropriate journals and conferences.

4. Support SciDAC Linux installations; expand SciDAC user base.

Year 5

1. Plan and prepare the operating system installation and update service for a transition to a self- or community-supported mode.
2. Complete all performance work in progress, leave in stable, robust state.
3. Publish results, including areas where further work seems fruitful.
4. Prepare and submit final report.

Georgia Institute of Technology: Tasks and Milestones

The Georgia Tech team participating in the CANTIS project will focus its efforts on middldeware research. In addition, building on other ongong joint work, our team will be a liason for the SciDAC science areas of Fusion Science and Computational Biology at ORNL and also collaborate with ORNL in supporting computational monitoring and steering on supercomputers.

Liaison Activities:

The following are the liaison assignments of GT PIs.

SciDAC Application Area	Assigned GT Investigators	Science Area contact(s)	Status
Fusion Science	Karsten Schwan, Greg Eisenhauer	S. Klasky, ORNL	Initiating collaboration on low latency computational monitoring on supercomputers
Computational Biology	Matt Wolf	N. Samatova, ORNL	Initiating collaboration on the timely exchange of raw and analyzed experimental data

In addition, there has been extensive joint work between N. Rao at ORNL and our group at GT. We expect to use the results of said joint work to also address some of the additional applications targeted by ORNL team members, including ORNL's collaboration with Climate Modeling and Simulation and Combustion Science (J. Chan) researchers.

Technical Area Activities:

There are three major themes of activities for GT technical task.:

1. How to effectively `share' a lambda reservation between the different communication needs in a single complex distributed application,
2. How to manage the interaction between the constant high-rate data stream of a lambda network and the variable capacity of the IP networks that extend lambda connections to the machines used by end users, and
3. Making the system-level mechanisms outlined in (1) and (2) accessible to end users via network-aware middleware that spans the heterogeneous networks used by applications and helps manage the application-level data streams traversing those networks.

Also, in joint work with ORNL, we will include into high performance middleware and thereby make accessible to applications tools for generation of application-to-application profiles for wide area connections.

Year 1:

1. Kick-off meeting.
2. Requirement analysis for GT liaison areas to be updated and discussed at the annual meetings;
3. Coordination with ESnet, UltraScienceNet, CHEETAH networks for IP/lambda interaction;
4. Development of lambda sharing and IP/lambda transition testbeds;
5. Design of application-level interaction with network-level interfaces; and
6. Study implications of wide-area supercomputers network behavior for data transfer applications.

Year 2:

1. Refinement of requirements, and development of technical tasks for GT liaison science areas;
2. Development of lambda sharing and IP/lambda interface middleware for data transfers;

3. Release and field testing of application-to-application channel profiling tools;
4. Development of visualization pipeline decomposition and optimal wide-area mapping systems;
5. Analysis and testing of wide-area connectivity of supercomputers for remote visualizations; and
6. Organization of year 2 meeting.

Year 3:
1. Analysis of data transfer performance of GT liaison science areas;
2. Focus on balancing compute/monitoring data flows within a lambda and across IP/lambda boundaries;
3. Integration of channel signaling modules into remote visualization systems;
4. Release and field testing of in-situ tuning and selection tools;
5. Analysis and testing of wide-area connectivity of supercomputers for computational monitoring; and
6. Organization of year 3 meeting.

Year 4:
1. Analysis of remote visualization performance in GT liaison science areas;
2. Development of integrated visualization, monitoring and steering system;
3. Integration of channel signaling modules into computational monitoring and steering system;
4. Release and field testing of in-situ tuning of computational monitoring tools;
5. Analysis and testing of wide-area connectivity of supercomputers for computational steering; and
6. Organization of year 4 meeting.

Year 5:
1. Analysis of computational monitoring and steering performance in GT liaison science areas;
2. Focus on lambda/IP interaction for end-to-end latency and predictability;
3. Focus on application-deployable filters and network customization to benefit monitoring;
4. Development of application-specific deployable steering filters (autonomic controls); and
5. Year 5 meeting.

Oak Ridge National Laboratory: Tasks and Milestones

As an overall lead for this project, ORNL will (i) coordinate various liaison and research activities, (ii) closely work with BNL in maintaining the project website, software repository and project archive, and (iii) organize monthly teleconferences, and annual and other meetings. ORNL is a liaison for the SciDAC areas of Astrophysics, Climate Modeling and Simulation, Fusion Science, and Combustion Science and Simulation. ORNL is the lead for technology areas of dedicated-channel reservation and provisioning, and optimized transport methods. ORNL will collaborate with UCDavis in supporting remote visualizations. In addition, ORNL will develop technologies for computational monitoring and steering, and address the aspects specific to optimizing various components for execution on supercomputers.

Liaison Activities:

The following are the liaison assignments of ORNL PIs. For each of the areas, the requirements will be identified in terms of data transfers rates, support for remote visualization, need for computational monitoring and steering, and other wide-area capabilities.

SciDAC Application Area	Assigned ORNL PI	Science Area contact(s)	Status
Astrophysics	N. S. Rao	A. Mezzacappa, ORNL	Ongoing collaboration with PSI projects; primary area
Climate Modeling and Simulation	W. R. Wing	D. N. Williams, LLNL	Initial contact made; primary area is data transfers
Combustion Science and Simulation	Q. Wu	J. Chan, SNL	Initial contact made; primary area is visualization
Fusion Science	W. R. Wing	S. Klatsky, ORNL	Initial contacts being made; primary area is remote workflow support

In addition, co-PI, S. M. Cater, is a member of ORNL National Center for Computational Sciences and will act as a liaison in matters relating to supercomputers of NLCF. There have been three on-going collaboration projects (all ending FY06) between ORNL PIs and TSI project, which resulted in the requirements analysis and development of first versions of component technologies including provisioning of dedicated channels over NSF CHEETAH network between ORNL and NCSU, protocol development and customization for data transfers between ORNL Cray X1 and NCSU cluster, and implementation of computational monitoring and steering modules for specific TSI VH1 code. Next version of TSI project, called Petascale Supernova Initiative (PSI), raises the requirements by an order of magnitude due to the increased scale of computations and participation of a larger team. Our plans are to work closely with PSI PIs to further strengthen the collaborations, and also make initial contacts with other SciDAC projects in Astrophysics area. Initial contacts have been made in the other three ORNL liaison areas, which will be further fostered in this project.

Technical Area Activities:

There are two major themes of activities for ORNL technical tasks. First theme corresponds to the development of various component technologies that culminate in an integrated system for data transfer, remote visualization, and computational monitoring and steering computations. This system can be configured with a suitable subset of tasks to suit the application at hand and will be capable of in-situ optimization to obtain various parameters, decompositions and mappings needed for the connections at hand. Various components of this integrated system will be gradually designed, tested and integrated over the span this project; the individual pieces, however, will be provided to applications at various stages. The second theme of ORNL tasks focus on analyzing and profiling the supercomputer architectures for various components of the integrated system to optimize performance on high-performance computers, including clusters and customized architecture. In addition to customizing the software modules, this task involves developing cross-connects and provisioning the needed network connections. The following are the technical areas of ORNL: (a) tools for generation of application-to-application profiles for wide area connections; (b) optimization and testing of high performance data transfer methods for dedicated channels and implementing them as a set of in-situ optimization tools, (c) design and development of effective support methods for visualization streams over wide-area connections, (d) design and development of computational monitoring and steering methods over network connections; (e) analysis and development of wide-area connectivity methods for leadership-class computers and applications for cluster-based and customized architectures. The task (a) is a joint activity with SLAC and GaTech,; task (b) is a joint activity with BNL; and task (c) is a joint activity with UCDavis .

Year 1:
1. Requirement analysis for liaison areas to be updated and discussed at the annual meetings;
2. Coordination with ESnet, UltraScienceNet, CHEETAH networks to provision needed channels;
3. Development and testing of application-to-application channel profiling tools;
4. Testing and optimization of date transfer methods;
5. Analysis and testing of wide-area connectivity of supercomputers for data transfer applications; and
6. Organization of kick-off meeting.

Year 2:
1. Refinement of requirements, and development of technical tasks for ORNL liaison science areas;
2. Development of in-situ tuning and selection tools for data transfers;
3. Integration of channel signaling modules into data transfer systems;
4. Release and field testing of application-to-application channel profiling tools;
5. Development of visualization pipeline decomposition and optimal wide-area mapping systems;
6. Analysis and testing of wide-area connectivity of supercomputers for remote visualizations; and
7. Organization of year 2 meeting.

Year 3:
1. Summary analysis of data transfer performance of all liaison science areas;
2. Development of computational monitoring and steering systems;
3. Integration of channel signaling modules into remote visualization systems;
4. Release and field testing of in-situ tuning and selection tools;
5. Analysis and testing of wide-area connectivity of supercomputers for computational monitoring; and
6. Organization of year 3 meeting.

Year 4:
1. Summary analysis of remote visualization performance in all liaison science areas;
2. Development of integrated visualization, monitoring and steering system;
3. Integration of channel signaling modules into computational monitoring and steering system;
4. Release and field testing of in-situ tuning of computational monitoring tools;
5. Analysis and testing of wide-area connectivity of supercomputers for computational steering; and
6. Organization of year 4 meeting.

Year 5:
6. Summary analysis of computational monitoring and steering performance in all liaison science areas;
7. Integration of signaling, transport, remote visualization, computational monitoring and steering methods into unified end-user toolkit that can be customized to application at hand;
8. Release and field testing of in-situ tuning of computational steering tools;
9. Summary analysis and testing of the integrated visualization, computational monitoring and steering system for supercomputers; and
10. Organization of year 5 meeting.

Pacific Northwest National Laboratory: Tasks and Milestones

The primary goal of this proposal is to enable multiple scientists working in different locations to efficiently team up using a distributed system of remote equipment while sharing immense data sets typical in genomics research. The resulting system will address issues of distributing huge data sets and provide remote instrument control all in near real-time manner. Traditional microscopes analyze samples using a single imaging modality, usually with a single wavelength of light. We are building advanced algorithms that combine the capabilities of multiple instruments, allowing different dimensions of information to be gathered simultaneously. We are also developing advanced algorithms to extract quantitative data from multi-spectral images. Advances in microscopy require not only the development of more sensitive and specific instruments, but also the creation of software to operate the instruments and manage the large amounts of data they can generate.

In general, many performance and usability issues relevant to remote instrumentation appear at the host endpoint. This phenomenon extends beyond the networking communication path into the very interfaces used by applications and system services. Therefore, systems will be implemented to profile host endpoints and acquire performance data while the systems are in use (in-situ) under a variety of operating conditions. The goal is to support accurate data collection which ultimately leads research and evaluation of new methods of network communication service that provide the capability required of remote and distributed scientific instrumentation.

New technology is needed to enable scientific discovery through efficient collaboration and distributed science by maximizing the utilization of one-of-a-kind scientific instruments. By maximizing usage of these unique instruments, science can progress at an increased rate. Furthermore, time and costs can be saved by giving scientists across the country access to unique instruments housed in different locations without regardless to physical location, reducing travel costs. The same capability also provides the foundations to enable massively parallel scientific experimentation which greatly reduces the time to perform complex research. Traditional collaborative scientific research infrastructures and technologies are inherently limited in their ability to support real-time instrument control and transport of large data streams in a real time manner. By enabling distributed access to the instruments, data, and analytical results in real-time, a multiplicity of benefits can be obtained.

First, we can significantly reduce the experimentation cycle time. Currently, after an experiment has been performed, the data sets are often transferred to a DVD-ROM and mailed out for examination. Experiments are therefore limited in scope to the availability of the personnel and the transport time of conventional shipping and delivery systems. Solving the data transport problem can reduce the turnaround time from days to minutes. This increases the number of experiments that can be performed over a given period of time and also increases the scope of experiments that can be performed. In turn, this results in a drastic reduction in time to scientific discovery. Second, we can create a distributed lab environment that marries up non-collocated equipment and personnel that may be impractical otherwise. This is an important factor for both research and training. There is a great deal of unique equipment that has limited availability due entirely to its geographic location. For example, PNNL has a Confocal Microscope that is one out of only five in the world.

The primary network research areas PNNL will be addressing in this project are supporting distributed laboratory equipment such as the Confocal Microscope. The main goal of this research is to develop and deploy networking technologies needed for real-time remote and distributed instrument control and real-time streaming of large-scale data for genomics applications operating in the framework of SciDAC genomic applications. This goal will be accomplished through basic real-time control protocol research, application of other research efforts in visualization and data transport, and prototype implementation and testing using dedicated channel capabilities. An essential element is building a common high-performance interface framework to front-end user interface software that can accommodate even typically low performance instrumentation and control applications. For example, it should work with applications written in Visual Basic and LabView as well as those that are written in fully compiled languages. Furthermore, a robust safety interlock system is needed to protect personnel and equipment for inadvertent damage. This safety system will be built upon continuous A/V streams to provide a real-time picture of the distributed laboratory environment. Performance and reliability experimentation is necessary to handle diverse network infrastructures, including shared IP connections, such as ESNet, and dedicated paths such asUSN. The following are PNNL tasks and milestones.

Year 1:
1. Requirement analysis for liaison;
2. Coordination with ORNL to develop a timeline for a test cycle using ESnet, UltraScienceNet, CHEETAH networks to provision needed channels;
3. Research existing remote and distributed Network Storage systems;
4. Define test cases on existing high speed networks for showcasing the prototype. Including data sets, networks, and end user applications;
5. Develop the requirements for a real-time control interlock system that provides the context of the distributed lab environment; and
6. Testing and optimization of date transfer methods for the three principal data channels;

Year 2:
1. Refinement of requirements, and development of technical tasks for PNNL liaison science areas;
2. Design a real-time control interlock for providing the context of the distributed lab environment;
3. Development of in-situ tuning and selection tools testing the three principal data channels;
4. Generalize the transport layer research beyond high-speed circuit switch networks to include high-speed packet switched networks;
5. Integration of transport layer into the existing framework;
6. Begin field testing of application-to-application profiling of the data transport service; and

Year 3:
1. Integration of the automatic provisioning system being designed by ORNL;
2. Integration of channel signaling modules into remote visualization systems;
3. Implement the real-time control interlock for providing the context of the distributed lab environment
4. Integrate into visual system and data processing of ORNL;
5. Release and field testing of in-situ tuning tools pertaining to the three principal data channels;
6. Generalize the current system to be adaptable to other microscopes; and

Year 4:
1. Summary analysis of remote visualization, data transfer, and control performance;
2. Integrate into the CANTIS tool kit designed by ORNL;
3. Development of integrated visualization, monitoring and steering system;
4. Integration of channel signaling modules into computational monitoring and steering system;
5. Integrate the real-time control interlock for providing the context of the distributed lab environment with the control visualization, the real-time steering, and the data transfer channels
6. Release and field testing of in-situ tuning and monitoring tools;
7. Generalize the current system to be adaptable to other lab equipment.
8. Generalize the use of the system beyond UltraScienceNet so that it is customizable to networks like ESnet, and CHEETAH networks;
9. Analysis and testing using wide-area connectivity; and

Year 5:
1. Summary analysis of performance when used in wide-are networks;
2. Integration of signaling, transport, remote visualization, computational monitoring and steering methods into unified end-user toolkit that can be customized to application at hand;
3. Release and field testing of in-situ tuning of computational steering tools;
4. Summary analysis and testing of the integrated visualization, computational monitoring and steering system for supercomputers;

Stanford Linear Accelerator Center: Tasks and Milestones

SLAC will focus on the areas of network performance measurement and monitoring and also the roles of network transport applications at both application and protocols levels. Our first task will be to provide the facilities to enable federated mechanisms for performance data retrieval. These 'network sensors' will provide a rich and extensive framework for the mining of network performance data from which more advance services will be developed and deployed.

We currently already have simple algorithms to provide event detection in our IEPM-BW suite that provides notifications of anomalous events. It has vastly improved the ability to determine the occurrence of network problems from days to hours. However, much more research needs to be conducted in order to determine the best algorithms for different types of event.

We will also develop automatic methods to reduce the labor intensive manual diagnosis and cross correlation of network monitoring information to identify the 'bottleneck(s)' of the system. Bottleneck detection will become important in the future as network resources become more competitive as end-host link speeds increase. It will also help to narrow down the search to specific network components.

We also wish to develop innovative mechanisms to forecast network performance using techniques such as Holt-Winters triple Exponential Weighted Moving Averages (EWMA), Principal Component Analysis, wavelets, and/or the use of neural networks. By using data from various network sensors located in real production networks, short and long-term (hours to days) forecasting techniques for predicting bottleneck magnitude and location will be developed taking into account short term variations, long term trends and seasonal changes. These forecasts, including confidence levels, will form the foundation of higher level services such as application network provisioning.

Liaison Activities:

The evaluation, implementation and evolution of numerous disparate monitoring systems to provide a uniform method of data access for network monitoring data will require close ties with the following: GGF's NMWG, perfSONAR, AMP, ESnet, Internet2 (OWAMP, bwtcl), Geant, MonALISA. We will also work closely with the relevant groups to determine specific network monitoring requirements from various SciDAC groups such as High energy particle physics (Babar and LHC), Fusion Energy and Genomics research to provide qualitatively useful view of network performance.

Year 1:

The first year will focus on the federation, deployment and integration of the various network-monitoring solutions available to facilitate network monitoring of the various application leads that CANTIS will focus upon. This will involve:

1. Identification of useful monitoring solutions and performance metrics for each application area (requirements capture).
2. Evaluation and prototyping of passive monitoring solutions using netflow and SNMP.
3. Addition of web service/NMWG front ends to network monitoring solutions if necessary
4. Development and prototyping of visualization tools of useful performance metrics to be shown on web front-ends. Using web service backends to communicate with the various network monitoring solutions.
5. Potential significant contribution to GGF NMWG and perfSONAR projects based on experience.

Year 2:

The second year will refine the technological tracks of Year 1 with extra focus on liaison and implementation of application requirements. We will also begin the prototyping and implementation of advanced network monitoring solutions involving bottleneck detection and anomalous event detection.

1. Close liaising with application areas to refine visualization of network monitoring solutions.
2. Survey and evaluation of existing bottleneck detection algorithms for computer networks.
3. Development, testing and deployment of prototype advanced bottleneck detection algorithms and visualization techniques using service orientated architectures.

4. Survey and evaluation of existing anomalous event detection techniques for various network performance metrics such as achievable throughput, available bandwidth, experienced latency and jitter.
5. Development, testing and deployment of prototypes for anomalous event detection representation and visualization techniques using service orientated architectures. We expect to work with and compare/contrast PCA (both for multiple metrics and for multiple paths), neural networks, wavelets among others.
6. Initial design of APIs encompassing network monitoring, event detection and bottleneck detection.

Year 3:
Year 3 will put into production the work from Year 2 and implement a forecasting prototype to help facilitate advanced network-application steering.
1. Development, evaluation, comparison of performance forecasting techniques for time-series data, particular taking into account seasonal effects.
2. Widespread adoption of bottleneck detection services to numerous application areas. Evaluation and tuning to improve accuracy and scalability of solution(s).
3. Widespread adoption of anomalous event detection services to numerous application areas. Evaluation and tuning to improve accuracy and scalability of solutions(s).
4. Finalization of APIs, working closely with application area to gather requirements and implementation details, with initial prototype with network monitoring, event detection, bottleneck detection and network performance forecasting.

Year 4:
Year 4 will develop techniques for diagnosing the cause of events including sources such as route and other network configuration changes, multi-path anomalies, multi-metric anomalies, network path congestion, host related problems, etc.
1. Build canonical data sets of events.
2. Manual analysis of performance data to identify the cause, or at least eliminate non-causes of events.
3. Build a library of events, their likely cause(s) and classify events.
4. Develop, test and deploy tools to discover and gather data from relevant sources to help diagnose event causes using service orientated architectures. These will include host measurements (e.g. from Ganglia, Nagios, LISA, etc.), network path router utilization from perfSONAR, traceroute, active E2E measurements where available, Netflow data etc.
5. Provide tools to analyze the gathered data to help identify the most likely cause(s) of events. This will include applying anomaly detection techniques developed earlier to time series data.
6. Develop alerting tools that provide event and diagnostic information, with the alerts being sent by email, pagers etc.

Year 5:
Year 5 will “productize” the tools developed, providing documentation, download, installation support, and integration. This will involve integration into the CANTIS toolkit as they mature. It will also provide training on their use and publicize by means of presentations and publications. We will work with ESnet and others to deploy and integrate the tools into network operations in order to consolidate all measurement tools and associated processing methods into the CANTIS measurement toolkit.

University of California, Davis: Tasks and Milestones

As a participant in this project, UCDavis will, in collaboration with ORNL, (i) provide liaison support for SciDAC area Combustion Science and Simulation, (ii) develop various network scheduling algorithms for large data transfers, (iii) develop end-system performance-aware transport adaptation for networked pipelined visualization, and (iv) develop systems tools required to implement the technologies developed in (ii) and (iii).

Liaison Activities:

The following is the liaison assignment of UCDavis PIs. The requirements will be identified in terms of data transfers rates, support for remote visualization, need for computational monitoring and steering, and other wide-area capabilities.

SciDAC Application Area	Assigned UCDavis PIs	Science Area contact(s)	Status
Combustion Science and Simulation	D. Ghosal B. Mukherjee	J. Chan, SNL	Initial contact made by ORNL; primary area is visualization

The co-PI, Professor Biswanath Mukherjee, has been collaborating with Dr. Nagi Rao, Dr. Bill Wing, and others over the past three years towards defining the research challenges for bandwidth-provisioning problems for DOE large-science applications. Professor Mukherjee was invited by Dr. Nagi Rao and Dr. Bill Wing to serve as a working-group chair at the "DOE Workshop on Ultra-High Speed Transport Protocols and Provisioning for Large Scale Science Applications" held at Argonne National Laboratory in April 2003 [D03]. Professor Mukherjee co-led the discussions on dynamic provisioning. Our additional collaborators in the DOE community include Professor Ghosal's research collaboration with Exploratory Science Division of Sandia National Laboratory. This relationship will also be utilized, if necessary, for the proposed project. It should also be worth mentioning that Professors Mukherjee and Ghosal had a collaborative research project with Dr. Wu-Chun Feng of Los Alamos National Laboratory via a UC-LANL seed-grant project entitled "Wide-Area Transport and Signaling Protocols for Genome-to-Life (GTL) Applications"; 9/1/03 - 8/31/04.

Technical Area Activities:

There are two major themes of the key technical area activities of the UCDavis team. First is the development of underlying algorithms for system tools including CPT, IOT and PMT described in Section 3.1. The second theme relates to the application of these tools in the design and implementation of optimized remote networked visualization. The development of the tools will involve characterizing different end-system workloads as well as network architecture and provisioning, and would entail queuing network based models of the end-systems and detailed investigation of operating system specific internal process scheduling. This will be performed in a progressive manner and will be gradually designed, tested, and integrated over the span of this project; preliminary implementations, however, will be provided to applications at various stages. The second theme of the UCDavis technical area activity will be the application of the tools to optimize networked remote visualization. This will entail investigating the application of the tools for transport adaptation. Another aspect of the work will deal with the development of on-line and off-line network scheduling algorithms.

The following are the technical areas of the UCDavis team: (a) develop end-system performance modeling tools to determine the location and the intensity of end-system bottleneck; (b) develop methods to detect changes in end-system workloads and their attributes; (c) design and support methods for transport adaptation for visualization streams over wide-area connections; (d) design and develop network scheduling algorithms for large data transfers over wide-area networks; and (e) analyze and develop wide-area connectivity methods for leadership-class computers and applications for cluster-based and customized architectures. The tasks (a), (d), and (e) will be conducted in collaboration with ORNL.

Year 1:
1. Define requirements for SciDAC application area Combustion Science and Simulation;
2. Quantify end-system workload for remote visualization of applications involving Combustion Science and Simulation;
3. Develop queuing network models of end-systems running visualization engines;
4. Develop detailed understanding of different operating systems with regards to internal scheduling algorithms of various types of processes;
5. Determine typical network configuration for science users in Combustion Science and Simulation;
6. Prepare report outlining the requirements analysis and queuing network models.

Year 2:
1. Refine requirements and develop technical tasks for Combustion Science and Simulation;
2. Refine queuing network model to improve accuracy of results;
3. Design and develop prediction algorithms to predict changes in end-system workload and changes in attributes of component processes;
4. Measure accuracy of prediction algorithms for different types of end-systems including symmetric multiprocessors;
5. Design network scheduling algorithms for aggregating data from multiple data repositories;
6. Prepare report outlining analysis of the algorithms and the application requirements.

Year 3:
1. Refine requirements and technical tasks for Combustion Science and Simulation;
2. Implement the end-system performance monitoring tool (PMT);
3. Design network scheduling algorithms for aggregating data from multiple data repositories for group sharing, i.e., for multipoint-to-multipoint applications besides the prior multipoint-to-point system;
4. Deploy various network scheduling algorithms on wide-area network testbeds;
5. Prepare report describing the scheduling algorithms and provide libraries for using the performance monitoring tool for different science activities.

Year 4:
1. Provide summary analysis of the developed tools in remote visualization performance in all liaison science areas;
2. Refine network scheduling algorithms for aggregating data from multiple data repositories for group sharing;
3. Measure performance of various network scheduling algorithms on wide-area testbeds, and refine them as necessary;
4. Analyze experimentally different network scheduling algorithms for different network architecture;
5. Integrate system tools with OS-specific tools and methods;
6. Prepare report outlining the key algorithms and tools.

Year 5:
1. Integrate the performance modeling tool with other system tools including the channel profiling and in-situ optimization tools;
2. Refine system tools and network scheduling algorithms for different science applications;
3. Integrate system tools and network scheduling algorithms with the end-user tools;
4. Prepare final reports and software libraries for various tools and algorithms.

Appendix 2: Letters of Collaboration

1. Jackie Chan, Sandia National Labortory
2. Karten Schwan, Georgia Institute of Technology
3. Don Holmgren, Fermi National Accelerator Laboratory
4. Michael Creutz, Brookhaven National Laboratory

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February 23, 2006

To Whom It May Concern:

This letter is to support the SciDAC proposal titled "CANTIS: Center for Application-Network Total-Integration for SciDAC" led by Oak Ridge National Laboratory (ORNL).

We propose to establish a computational combustion science end-station, under the same SciDAC Institute part of the call, to enable scientific discovery performed on leadership class machines and to generate high-fidelity numerical benchmarks used to develop and validate predictive models for the design and optimization of practical combustion devices. The end station team will provide the lead responsibility for maintaining, evolving, and supporting the suite of capability computational codes and analysis tools needed to advance highly visible scientific milestones. The combustion end station will be a focal point in the combustion community for using advanced simulation technologies and fundamental benchmarks to understand detailed turbulent combustion physics and evaluate next generation models. The core effort will focus on the key phenomena that control performance and emissions, such as (i) flame extinction and re-ignition, (ii) flame stabilization, (iii) autoignition, (iv) flame propagation and (v) soot formation.

Most of our computations will be performed on the supercomputers at ORNL. These computations will generate terabyte simulation datasets on a regular basis, which must be transferred promptly to remote locations, including Sandia National Laboratory (SNL), for collaborative visualization and data analysis. Currently, each component of the remote simulation-based combustion research is performed manually, and we had to invest a significant amount of time and funds to resolve the networking issues. This not only constrains our productivity but also prevents us from fully utilizing the computing facilities.

With the assistance of the state-of-the-art networking and visualization support tools and technologies proposed by CANTIS team, we will be able to automate the entire work flow of simulation, filtering, transport, visualization, and computational monitoring and steering over wide-area networks. In later years, CANTIS will provide us with a critical capability of steering simulations on the fly on remote supercomputers and clusters. Such capability will significantly improve our productivity by cutting down the simulation-visualization cycle time.

More importantly, I am very pleased that Dr. Qishi Wu is our application liaison from CANTIS team exclusively assigned to work with us to develop effective solutions, and deploy and optimize CANTIS tools. I have interacted with him in the past, and our team will be very happy to work with him to optimize our workflows. This collaboration will untangle us from constantly searching for and installing the evolving tools so that we can concentrate on our original scientific goals.

Sincerely,

Jacqueline Chen
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February 26, 2006

Dr. Nagi Rao
Oak Ridge National Laboratories
P.O. Box 2008
Oak Ridge, TN 37831-6355

Dear Dr. Rao:

I will be quite pleased to collaborate with your proposed "CANTIS: Center for Application-Network Total Integration" for SciDAC.

The proposed "SciDIT: Scientific Data in Transit" focuses on the data sharing needs of petascale end user applications. The distributed data workspaces to be created by SciDIT would strongly benefit from CANTIS' network-level support. Specifically, we have strong interests in working with CANTIS on the effective use of optical network infrastructures; we would like to leverage the online network monitoring methods developed in CANTIS; and the network-aware middleware to be created in SciDIT would show improved performance and reduced implementation costs if it were met by CANTIS' middleware-aware network solutions.

Sincerely,

Karsten Schwan
Professor

Don Holmgren
Project Manager, SC Lattice QCD Computing
Computing Division
Fermilab
M/S 120, PO Box 500, Batavia, IL 60510

February 27, 2006

To whom it may concern:

I am writing in support of the proposal for the Center for Application-Network Total-Integration for SciDAC (CANTIS). This letter explains the importance of CANTIS for the lattice QCD computing facilities at Fermilab (FNAL), Jefferson Lab (JLab), and Brookhaven (BNL).

Currently, FNAL, JLab, and BNL operate dedicated facilities delivering an aggregate 5.85 TFlops (sustained) computing capacity to the US lattice QCD computing community. As of October 1, 2005, these facilities are operated as part of the DOE Office of Science Lattice QCD Computing Project. During FY06-FY09, this project will add an additional 12 TFlops (sustained) capacity through expansions at FNAL and JLab.

Lattice QCD calculations are very compute intensive, with many TFlops-years required for completion of typical calculations. They also are data intensive. As an example, the next major analysis campaign on weak decays will use 750 vacuum gauge configurations each of size 4.6 GBytes, and will generate over 480 GBytes of heavy and light quark propagators for each configuration, for a total of 365 TBytes. The gauge configurations are generated at the large QCDOC supercomputers at BNL and at UKQCD, and the propagators are generated and analyzed on the clusters at FNAL. Because prompt access to the configurations and propagators is critical for efficient utilization of the computing resources, this analysis campaign will be localized at FNAL. However, if transparent high performance data access were available, this analysis campaign could be performed using a combination of FNAL and JLab computing resources, taking advantage of available systems on a given day at either or both sites. Indeed, one of the long term goals of the Lattice QCD Computing Project includes the implementation of a computational grid allowing submitted lattice QCD jobs to automatically utilize available resources at any of the BNL, FNAL, or JLab locations. For this to succeed, on-demand high-performance access to data stored in mass storage facilities at any of the sites must be realized at the application level in order to properly schedule the computing resources.

As described in their proposal, CANTIS will provide the tools and expertise needed to realize the data access performance required by a projects like lattice QCD, as we attempt to fully automate the complex, data intensive workflows typical of our analysis campaigns.

Sincerely,

Don Holmgren

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23 February 2006

To whom it may concern,

I would like to strongly endorse the SciDAC II proposal led by Nageswara Rao to create the Center for Applications-Network Total- Integration for SciDAC (CANTIS). This project will establish common data transfer technology and tools which used to facilitate the data transfer in large scientific computing projects.

This is particularly relevant in connection with our own SciDAC II proposal to develop a "National Computational Infrastructure for Lattice Gauge Theory" (lead PI Robert Sugar, UC Santa Barbara). Our project will generate large data sets in the form of gauge field configurations for QCD. These will be generated at BNL, FNAL, and JLAB. They will be ultimately stored at NERSC, and then accessed by collaborators from around the country. Having the CANTIS project to support the incumbent data transfer will not only enhance our ability to do research but should help in cross disciplinary interaction with the other SciDAC projects.

Sincerely yours,

Michael Creutz