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Grant Application Package

Opportunity Title:	Scientific Discovery Through Advanced Computing (SciDA(
Offering Agency:	Chicago Service Center
CFDA Number:	81.049
CFDA Description:	Office of Science Financial Assistance Program
Opportunity Number:	DE-FG02-06ER06-04
Competition ID:	
Opportunity Open Date:	12/23/2005
Opportunity Close Date:	03/06/2006
Agency Contact:	Lori Jernigan Grants and Contracts Analyst E-mail: lori.jernigan@science.doe.gov

This electronic grants application is intended to be used to apply for the specific Federal funding opportunity referenced here.

If the Federal funding opportunity listed is not the opportunity for which you want to apply, close this application package by clicking on the "Cancel" button at the top of this screen. You will then need to locate the correct Federal funding opportunity, download its application and then apply.

☐ **I will be submitting applications on my behalf, and not on behalf of a company, state, local or tribal government, academia, or other type of organization.**

*** Application Filing Name:** SciDAC LHC Measurement

Mandatory Documents

Move Form to Submission List =>

Move Form to Documents List <=

Mandatory Completed Documents for Submission

- SF424 (R&R)
- Research & Related Other Project Information
- Research & Related Budget

Open Form | Open Form

Optional Documents

- Disclosure of Lobbying Activities (SF-LLL)

Move Form to Submission List =>

Move Form to Documents List <=

Optional Completed Documents for Submission

- Research & Related Subaward Budget

Open Form | Open Form

Instructions

1 Enter a name for the application in the Application Filing Name field.

- This application can be completed in its entirety offline; however, you will need to login to the Grants.gov website during the submission process.
- You can save your application at any time by clicking the "Save" button at the top of your screen.
- The "Submit" button will not be functional until the application is complete and saved.

2 Open and complete all of the documents listed in the "Mandatory Documents" box. Complete the SF-424 form first.

-It is recommended that the SF-424 form be the first form completed for the application package. Data entered on the SF-424 will populate data fields in other mandatory and optional forms and the user cannot enter data in these fields.

-The forms listed in the "Mandatory Documents" box and "Optional Documents" may be predefined forms, such as SF-424, forms where a document needs to be attached, such as the Project Narrative or a combination of both. "Mandatory Documents" are required for this application. "Optional Documents" can be used to provide additional support for this application or may be required for specific types of grant activity. Reference the application package instructions for more information regarding "Optional Documents".

-To open an item, simply click on it to select the item and then click on the "Open" button. When you have completed a form or document, click the form/document name to select it, and then click the => button. This will move the form/document to the "Completed Documents" box. To remove a form/document from the "Completed Documents" box, click the form/document name to select it, and then click the <= button. This will return the form/document to the "Mandatory Documents" or "Optional Documents" box.

-When you open a required form, the fields which must be completed are highlighted in yellow. Optional fields and completed fields are displayed in white. If you enter invalid or incomplete information in a field, you will receive an error message.

3 Click the "Submit" button to submit your application to Grants.gov.

- Once you have properly completed all required documents and saved the application, the "Submit" button will become active.
- You will be taken to a confirmation page where you will be asked to verify that this is the funding opportunity and Agency to which you want to submit an application.

Application Submission Verification and Signature

Opportunity Title:	**Scientific Discovery Through Advanced Computing (SciDAC)**
Offering Agency:	**Chicago Service Center**
CFDA Number:	**81.049**
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Competition ID:	
Opportunity Open Date:	**12/23/2005**
Opportunity Close Date:	**03/06/2006**
Application Filing Name :	**SciDAC LHC Measurement**

Do you wish to sign and submit this Application?

Please review the summary provided to ensure that the information listed is correct and that you are submitting an application to the opportunity for which you want to apply.

If you want to submit the application package for the listed funding opportunity, click on the "Sign and Submit Application" button below to complete the process. You will then see a screen prompting you to enter your user ID and password.

If you do not want to submit the application at this time, click the "Exit Application" button. You will then be returned to the previous page where you can make changes to the required forms and documents or exit the process.

If this is not the application for the funding opportunity for which you wish to apply, you must exit this application package and then download and complete the correct application package.

Sign and Submit Application

Exit Application

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 Identifier

5. APPLICANT INFORMATION *** Organizational DUNS:** 0095842100000

* Legal Name: California Institute of Technology

Department: | Division:

* Street1: 1200 E. California Blvd., Mail Code 201-15 | Street2:

* City: Pasadena | County: | * State: CA | * ZIP Code: 91125

* Country: USA

Person to be contacted on matters involving this application

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Miss	Lucy		Molina	

* Phone Number: 626-395-2372 | Fax Number: 626-795-4571 | Email: Lucy.Molina@caltech.edu

6. * EMPLOYER IDENTIFICATION *(EIN) or (TIN):*

95-1643307

7. * TYPE OF APPLICANT:

L: Private 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:

Collaborative Technology for Distibuted Science: Fusion Science and High Energy Physics

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

USA

13. PROPOSED PROJECT:

* Start Date	* Ending Date
07/01/2006	06/30/2010

14. CONGRESSIONAL DISTRICTS OF:

a. * Applicant	b. * Project
CA-29	USA-all

15. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix:	* First Name:	Middle Name:	* Last Name:	Suffix:
Dr	Harvey		Newman	

Position/Title: Professor | * Organization Name: California Institute of Technology

Department: High Energy Physics | Division:

* Street1: 1200 E. California Blvd., Mail Code 201-15 | Street2:

* City: Pasadena | County: | * State: CA | * ZIP Code: 91125

* Country: USA

* Phone Number: 626-395-6694 | Fax Number: 626-584-9304 | * Email: hitlin@hep.caltech.edu

OMB Number: 4040-0001
Expiration Date: 04/30/2008

16. ESTIMATED PROJECT FUNDING

a. * Total Estimated Project Funding	1,559,528.00
b. * Total Federal & Non-Federal Funds	1,559,528.00
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:
Miss	Lucy		Molina	

* Position/Title:	Contract and Grant Analyst	* Organization:	California Institute of Technology
Department:	Office of Sponsored Research	Division:	
* Street1:	1200 E. California Blvd., Mail Code 201-15	Street2:	

* City:	Pasadena	County:		* State: CA	* ZIP Code: 91125
* Country:	USA				
* Phone Number:	626-395-2372	Fax Number:	626-795-4571	* Email:	Lucy.Molina@caltech.edu

*** Signature of Authorized Representative**

Completed on submission to Grants.gov

*** Date Signed**

Completed on submission to Grants.gov

20. Pre-application Add Attachment | Delete Attachment | View Attachment

OMB Number: 4040-0001

Expiration Date: 04/30/2008

RESEARCH & RELATED Other Project Information

1. * Are Human Subjects Involved? ☐ Yes ☑ No

1.a If YES to Human Subjects

Is the IRB review Pending? ☐ Yes ☐ No

IRB Approval Date:

Exemption Number: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6

Human Subject Assurance Number:

2. * Are Vertebrate Animals Used? ☐ Yes ☑ No

2.a. If YES to Vertebrate Animals

Is the IACUC review Pending? ☐ Yes ☐ No

IACUC Approval Date:

Animal Welfare Assurance Number

3. * Is proprietary/privileged information included in the application? ☐ Yes ☑ No

4.a. * Does this project have an actual or potential impact on the environment? ☐ Yes ☑ No

4.b. If yes, please explain:

4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed? ☐ Yes ☐ No

4.d. If yes, please explain:

5.a. * Does this project involve activities outside the U.S. or partnership with International Collaborators? ☐ Yes ☑ No

5.b. If yes, identify countries:

5.c. Optional Explanation:

6. * Project Summary/Abstract LHC-MI-Abstract.pdf | Add Attachment | Delete Attachment | View Attachment

7. * Project Narrative LHC - MINarrative_v5_9__2_.pdf | Add Attachment | Delete Attachment | View Attachment

8. Bibliography & References Cited PE_TMP_0001xrb00001do.pdf | Add Attachment | Delete Attachment | View Attachment

9. Facilities & Other Resources Leveraged_Facilities_Caltech.doc | Add Attachment | Delete Attachment | View Attachment

10. Equipment | Add Attachment | Delete Attachment | View Attachment

11. Other Attachments Add Attachments | Delete Attachments | View Attachments ☐

OMB Number: 4040-0001

Expiration Date: 04/30/2008

Applicant/Institution: California Institute of Technology

Project Title: LHC – Measurement Infrastructure

Principal Investigators:

Harvey Newman, California Institute of Technology
Les Cottrell, Stanford Linear Accelerator Center (SLAC)
Shawn McKee, University of Michigan

We address major challenges for existing and future data-intensive sciences such as HEP, by providing a standards-based infrastructure to monitor and forecast network performance among collaborating sites. This is required for predictable transmission, sharing and analysis of large-scale datasets. It requires an in-depth, cohesive, robust, persistent network monitoring infrastructure for setting expectations, planning, forecasting, problem identification and isolation, and providing input for problem mitigation and resolution services. As area leaders, we propose to integrate, deploy and support this monitoring infrastructure widely on behalf of HEP and other DOE programs, working in partnership with ESnet, Fermilab, BNL, LBNL, UltraScienceNet and LHCNet, with advanced network development projects such as UltraLight, and the Open Science Grid.
The proposed system will provide an easy-to-deploy, robust measurement, monitoring and forecasting infrastructure building upon the MonALISA architecture and incorporating techniques and tools developed in the IEPM-BW project. It will incorporate other measurement infrastructures and tools such as NLANR/AMP, Internet2/OWAMP and perfSONAR, adding new ways to analyze and present data. Support will be provided for monitoring QoS paths such as in the OSCARS and Terapaths projects. MonALISA is an agent-based distributed system (with no single failure point) providing end-to-end 24X7 monitoring of globally distributed components.

Applicant/Institution: California Institute of Technology

Address: 1200 E. California Blvd., Mail Code 201-15 Pasadena, CA 91125
Principal Investigator: Harvey Newman
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Telephone number: 626-395-6656
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DOE/Office of Science Program Officer: Mary Anne and Craig Tull
DOE/Office of Science Program Office Technical contact: Lori Jernigan

Collaborating institutions (All submitting applications):
Les Cottrell, *Stanford Linear Accelerator Center (SLAC)*,*
Shawn McKee, *University of Michigan*.*

LHC – Measurement Infrastructure

1 Background and Significance

Introduction/Overview

We propose to develop and deploy the Large Hadron Collider (LHC) Measurement Infrastructure (LHC-MI), a standards-based monitoring and measuring system for wide area networks on a global scale, to be used by CERN's LHC experiments. The LHC is due to begin operating in 2007, but there is already extensive computing and network infrastructure deployed, which is being scaled up and made production-ready through a series of "service challenges" in preparation for data-taking. Pre-standard components of the proposed LHC-MI are already part of this process, although further integration and extension to serve the full set of client communities, as well as standardization is required by the early stages of LHC operation. While the initial target community is High Energy Physics (HEP), driven by near-term mission needs, the developments proposed address general needs, and will be used to serve many fields of DOE-supported as well as NSF-supported science. These aspects will be implemented through partnership with major grid initiatives including the Open Science Grid and EGEE, as well as the Global Grid Forum (GGF), and by leveraging our existing leadership or active involvement in, or partnerships with the major research and education networks, network-infrastructures and network-research projects in the U.S., Europe and Asia. These include Internet2, ESnet, National Lambda Rail (NLR), UltraScience Net, UltraLight, CENIC, MiLR, Pacific Wave and TeraGrid in the U.S., and with US LHCNet, GEANT, the LHC Optical Private Network (OPN), GLORIAD, WHREN/LILA, JGN2, and TransPAC across the Atlantic and Pacific.

The LHC-MI project will directly make use of field-proven technologies developed and operated round the clock by the MonALISA[MONAL] and IEPM[IEPM] projects, and will closely collaborate Global Grid Forum's Network Measurement Working Group (GGF-NMWG)[NMWG] and the LHC-OPN (LHC Optical Private network). The goal of the project is to provide end-to-end tools for the measurement of network connections across multiple domains. While these projects

are already engaged in meeting the challenges of managing such diverse, distributed and complex networks, a new system is required which encompasses the existing capabilities and so allows us to optimize the use of them all to serve the entire communities of HEP, and in the later phases DOE-supported science and other major NSF-supported programs. Thus we propose to provide tools to monitor, account, diagnose, tune and manage the ensemble of networks used now and in the future by the LHC collaborations, and the broader science and engineering community, and to provide critical tools and services that will help manage the next generation of hybrid optical packet- and circuit-switched networks that represent the future direction of ESnet, as well as NLR, GEANT2 and many U.S. state and European national research and education networks.

The software architecture we have chosen to achieve these goals is a real-time services fabric. This architecture allows multiple independent services to easily and reliably interact, discovering one another, exchanging data and real-time status as required by the system.

We do not propose to develop a real-time services fabric from scratch. Instead, the MonALISA system, which is itself a global, dynamic managed publish/subscribe infrastructure specifically designed for easy integration of third-party software components, will be used for LHC-MI. By using MonALISA as the real-time services fabric, we will be able to add monitoring, measurement, control and analysis modules to the LHC-MI system straightforwardly. Moreover, the MonALISA system is already widely deployed and has proved to be highly robust, reliable and performant in heavy daily use by a diverse set of communities.

The first modules to be plugged in to the LHC-MI fabric will be the measurement tools developed by the Internet End-to-end Performance Monitoring (IEPM) PingER [PINGE] and Band Width (BW) [IEPMB] projects, namely:

- Lightweight ping based monitoring of over 700 sites in over 120 countries worldwide, especially focusing on the Digital Divide (PingER);
- More focused measurements of bandwidth, throughput, routes etc. on high performance paths between sites such as those involved in BaBar, CDF, D0 and the LHC (BW).

Measurements of Round Trip Time (RTT) and loss are made using ping; of routes using traceroute; of bandwidth using packet pair dispersion tools such as pathload [PATHL], pathchirp [PATHC], and ABwE [ABWE] ; and of achievable TCP throughput using iperf [IPERF] and thrulay [THRUL]. The measurements are archived and analyzed to provide web accessible visualization in terms of time-series, histograms, correlations, tables, and topologies. In addition forecasting and detection of significant, persistent changes in performance ("events") are provided.

Our milestones (Section) detail the individual tools and software components that are planned for integration into LHC-MI's real-time services fabric.

History of Measurement and Monitoring for HEP

Since networks were first used to move HEP data there has been a corresponding effort to measure and monitor those networks to understand their performance, account for their usage and find and diagnose their problems or misconfigurations.

Over the last decade several network measurement infrastructures have been developed (see [INFRA] for a partial list). In particular we are focused on IEPM-PingER, IEPM-BW, MonALISA, NLANR/AMP [AMP], the Internet2 E2E Performance Initiative [PIPES] and PerfSONAR [PERFS], though others may be added later. Each of these has different foci and strengths. It is important now to federate these infrastructures so they can interoperate and leverage one another. By this we mean to provide standard interfaces so for example the event detection

from IEPM-BW can be applied to measurements made by MonALISA, PerfSONAR or NLANR/AMP. These interfaces will require the application of standard measurement data formats such as the NMWG schema. Further since many "network" events are actually caused by end host effects, diagnosis of events requires access to measurement of host behaviors. Such measurements include those based on tools such as Nagios [NAGIO], Ganglia [GANGL] and Lisa [LISA].

The IEPM effort has its origins in the 1995 WAN monitoring group at SLAC. Initially IEPM-PingER was set up to make lightweight active end-to-end ping measurements to monitor performance (loss, RTT, jitter etc.) from SLAC to collaborator sites. Later, following the success of this project, the deployment was extended to over 30 monitoring sites and 700 remotely monitored sites (targets) to make measurements to understand the Digital Divide [ICFA]. In 2001, to meet the requirements of monitoring high performance end-to-end paths such as used by HEP and Grid sites, IEPM-BW was developed to provide an infrastructure more focused on a making active end-to-end performance measurements for a few high-performance paths. There are now IEPM-BW monitoring hosts at BNL, Caltech, CERN, FNAL, and SLAC. Between them these hosts monitor each other and about 40 other target sites. As part of the proposed project, the monitoring sites will be extended to the other LHC tier1 sites and some Tier-2 sties. Currently IEPM-BW can use the ping, traceroute, iperf (single and multiple parallel streams), thrulay, pathchirp, pathload and ABwE measurement tools. As other tools become available they will be evaluated and added as required.

The MonALISA framework has been designed and implemented as a set of autonomous agent-based dynamic services that collect and analyze real-time information from a wide variety of sources (grid nodes, network routers and switches, optical switches, running jobs, etc.). MonALISA's multi-threaded, self-describing agents collaborate to process and analyze the information they gather in a distributed way, enabling them to perform a wide range of monitoring and/or control tasks.

The agility and real-time character of MonALISA, which has been proven in the field over the last three years, is a result of its ability to propagate "events" (state changes) among sites around the globe within 1 second. Higher level functions in the agents provide support for automated control decisions and global optimization of workflows in complex grid systems, and in other large-scale distributed applications. By investing the ensemble of agents with increasing degrees of intelligence, based on accumulated experience, the system is highly adaptable, and well-suited to respond to and troubleshoot difficult failure modes, such as network or storage resource failures affecting work in progress at multiple sites.

The MonALISA framework is capable of collecting a complete set of network measurements and of correlating these measurements from different sites to present a global picture. Currently the system allows gathering monitoring information from:

- SNMP agents to describe traffic on routers , switches and computer nodes
- Netflow [NETFL] to analyze and filter flows. It can provide dynamically user defined aggregations.
- Global WAN topology based on tracepath (traceroute) measurements from may end points.
- Correlated Available Bandwidth measurements. It is using a synchronization mechanism to drive active measurements like pathload.
- Connectivity maps and the optical power for optical switches (using TL1).
- PIPES system to measure available bandwidth, one way delay.
- ABping a simple bandwidth and RTT measurement tool.

- Interface to MRTG and any other monitoring systems using RRD.
- ABILENE traffic via a Web Service interface.
- Ganglia using the multicast protocol or gmetad.

MonALISA is currently running around the clock monitoring computing facilities, network traffic and running jobs in several Grids and distributed applications on more than 250 sites. It collects complete information for more than 12,000 computers, more than 100 Wide Area Network links and thousands of concurrent scientific jobs. It is collecting more than 250,000 parameters with an aggregate update rate of ~ 25,000 parameters per second.

The major scientific communities using the MonALISA system to monitor Grid facilities are:

- Open Science Grid
- The CMS experiment at CERN
- The ALICE experiment at CERN
- The STAR experiment at BNL
- The Tier2 US CMS sites (DISUN project)
- Grid sites in Russia, SE Europe, Mexico ….
  It is also used to monitor traffic, connectivity, topology and available bandwidth in several academic networks:
- Internet2
- Ultralight
- LHCNet
- Enlightened
- RoEduNet.

Importance for HEP

End to end monitoring (including the network) is important for HEP as the number of resources (cpu, storage, network) available for the physics collaborations will be limited (not enough hardware to be shared). As a result of these limited resources we need to make optimal use of these resources through minimizing downtime, and avoiding unnecessary delays (long queue lengths) for resource usage. In order to detect anomalies and optimize a global distributed system, a global distributed monitoring system is needed. Due to the complexity and size of the distributed system, human intervention (based on this monitoring data) is inefficient and creates a large *delay* between the event, its detection and actual action being taken. Such long delays could render the actions decided upon to mitigate a failure, inappropriate or irrelevant. Instead we propose to develop and deploy autonomous applications (agents) that detect and act on these anomalies and optimize (manage) resource usage, targeted at networks.

Optimizing (managing) network resource usage is *especially* important for the upcoming LHC experiments, which have adopted a globally-distributed hierarchical Tier-n center concept consisting of 1 Tier-0 where the data is first processed, 11 Tier-1 national centers which receive, curate and re-process the data periodically as needed, and 100+ Tier-2s and many Tier-3s which in addition to the Tier1s provide a major part of the cpu and storage capacity to support physics analysis, all interconnected over a global ensemble of local and wide area networks. According to current planning the Tier1 connections will reach 10-40 Gbps by 2008, and many of the Tier2s in the U.S. are already connected at 10 Gbps. The overall scale of networking among the LHC tiered-center sites will therefore rise from the 100+ Gbps level in 2006, to several hundred Gbps within

the next few years. Typical data "transactions" among the sites will involve data transport in the 1 to 10 Terabyte (TB) range at LHC startup, rising to the 100 TB range in some cases as the LHC approaches design luminosity in 2009-2010. A coherent monitoring infrastructure, with the ability to rapidly detect, evaluate and help troubleshoot and mitigate network failures, is thus essential to support the LHC science mission.

Figure 1 shows the planned LHC-OPN (Optical Private Network) connection the Tier-0 at CERN with the known Tier-1's around the world. The Tier1-Tier1 flows that will be time-critical right after a cycle of re-reconstruction or re-calibration will require comprehensive monitoring to insure proper operation and track progress. Also flows to and from more than 100 Tier2 centers, including ~15 in the US among the LHC experiments will require similar tracking.

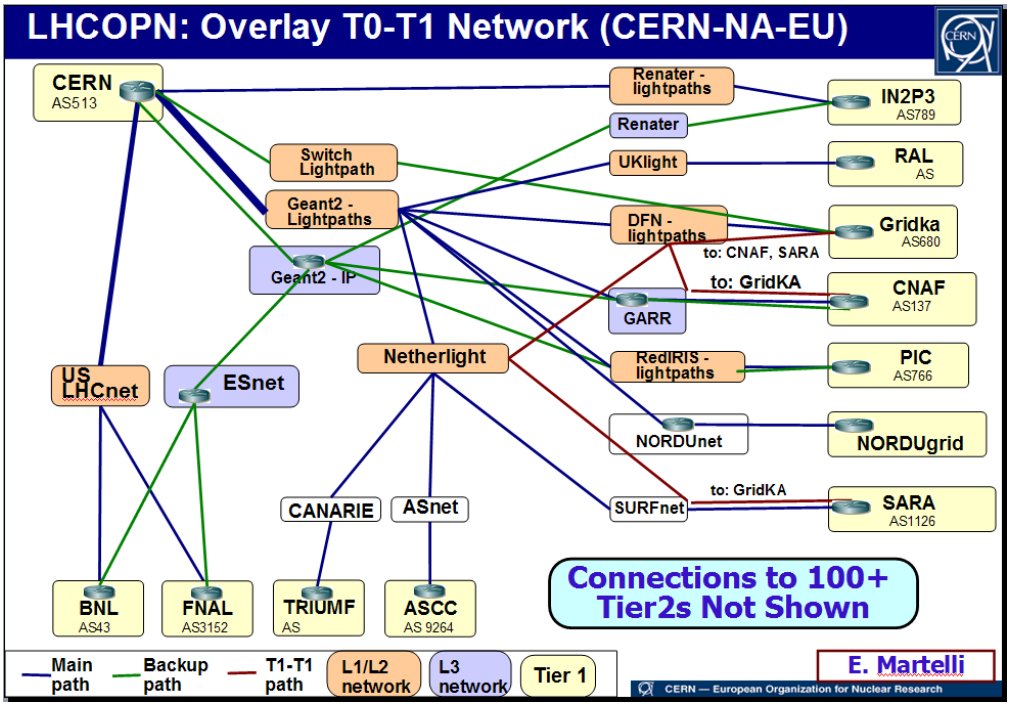

Figure 1 The LHC Optical Private Network showing multiple 10GE connections between the Tier-0 at CERN and Tier-1's around the world.

In this Tier-n model Tier-2s will play an important role due to their relative size (storage and cpu) as part of the complete system. Due to the (globally) distributed nature of the system it will be likely that in many cases cpu and storage resources will not always match (cpu resources are available at places where the datasets are not). Users wanting to analyze datasets currently will need to have access to local cpu resources (where the data resides). However these cpu resources might not be readily available due to long job queue wait times. Similarly no site has the storage (and process) capacity to host all data being generated in the LHC experiments. It is therefore important that systems (software and hardware) will be in place to facilitate multiple on demand and strategic data transfers to minimize the access time (the ability to analyze the dataset) of essential large scale (Petabytes) datasets.

Summarizing:

- Networks are fundamental to the HEP computing model (grids).
- Network performance (or lack thereof) will have a significant impact on the time to scientific discovery.

- Our system will enable monitoring and measurement of what is currently being achieved and where bottlenecks exist.
- Any form of managed network will require extensive measurements to understand current and future use and availability for allocation.

Actively managing networks will therefore increase the ability to analyze (and thus access) data by many (US based) users which is vital for scientific discoveries and the competitiveness of the US physics community.

2 Preliminary Studies

Modular Architecture

MonALISA is based on a scalable Dynamic Distributed Services Architecture, and is implemented in Java using JINI and WSDL technologies. The scalability of the system derives from the use of a multi threaded engine to host a variety of loosely coupled self-describing dynamic services or agents, the ability of each service to register itself and then to be discovered and used by any other services, or clients that require such information. The framework integrates many existing monitoring tools and procedures to collect parameters describing computational nodes, applications and network performance. Specialized mobile agents are used in the MonALISA framework to perform global optimization tasks or help and improve the operation of large distributed system by performing supervising tasks for different applications or real time parameters.

The MonALISA architecture, presented in Figure 1, is based on four layers of global services. The first layer is the network of JINI - Lookup Discovery Services (LUS) which provides dynamic registration and discovery for all other services and agents. The second layer of MonALISA services is used for information gathering and can execute many monitoring tasks through the use of a multithreaded execution engine and to host a variety of loosely coupled agents that analyze the collected information in real time. The collected information can be stored locally in databases. The code mobility paradigm (mobile agents or dynamic proxies) used in the system extends the approaches of remote procedure call and client-server. Both the code and the appropriate parameters are downloaded dynamically into the system. Several advantages of this paradigm are: optimized asynchronous communication and disconnected operation, remote interaction and adaptability, dynamic parallel execution and autonomous mobility.

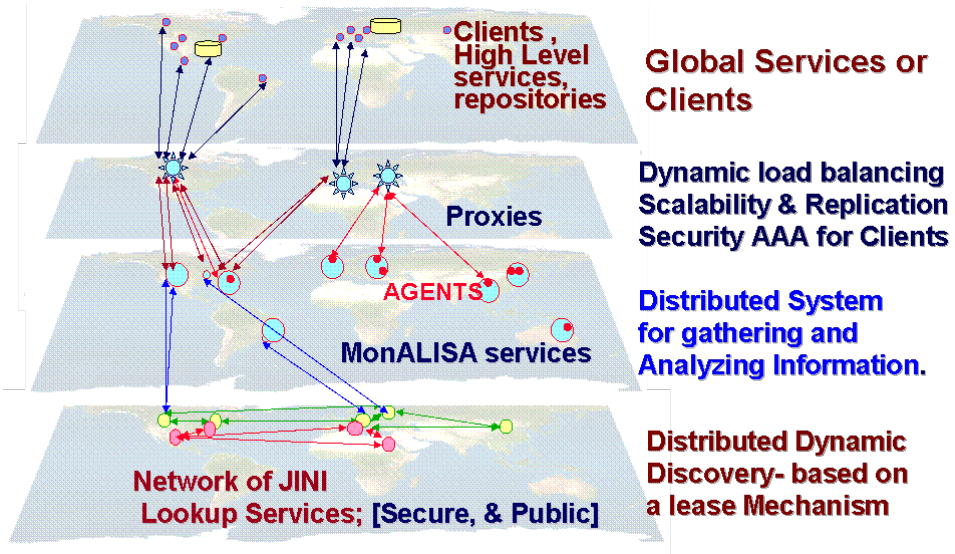

Figure 2 The MonALISA service architecture: a distributed system with no single point of failure.

The combination of the service architecture and code mobility makes it possible to build an extensible hierarchy of services that is capable of managing very large systems. The third layer of Proxy services, shown in the figure, provides a reliable communication layer for agents and an

intelligent multiplexing of the information requested by the clients or other services. It can also be used as an Access Control Enforcement layer. Clients and higher level services or global repositories can access any information in the system, deploy agents to provide customized aggregation or to act based on the information collected. The higher level services or the agents can implement alarm triggers, automatic action to resolve well known problems or to provide global optimization workflow for complex applications.

Core Measurement and Monitoring Infrastructure

The core measurement infrastructure for LHC-MI is intended to reliably provide a number of network and host performance parameters along end-to-end paths. This will extend and leverage existing and emerging measurement projects to meet the needs of the LHC-MI to provide both network-centric and cluster-centric performance data.

We expect to gather and use data from the following network sources to provide an end-to-end performance data resource:

1. The IEPM-BW toolkit, developed at SLAC, is currently deployed at monitoring hosts at about 40 sites around the world, including major measurement hosts at SLAC, CERN, FNAL, BNL and Caltech. These measurement hosts run active end-to-end light-weight measurement tools, such as ping, traceroute, pathchirp and pathload and heavy-weight measurement tools, such as thrulay, iperf and GridFTP [GRIDFTP] at regular intervals. The light-weight, more frequent measurements, can be used to assist in interpolating the less frequent, more heavy-weight measurements to reduce the strain on network resources. The type of data collected by these measurement tools includes RTT, hop-by-hop router response, capacity and available bandwidth, achievable throughput and file transfer rates.
2. Proxy access to Simple Network Monitoring Protocol (SNMP) Management Information Bases (MIBs) information from core routers and switches which form the backbone of Abilene and ESnet in the US and GEANT in Europe is becoming available via the Abilene Measurement Infrastructure (AMI) [AMI] and the perfSONAR projects. This will initially provide router interface utilization and capacity data using standardized schemas and web service facilities. Both projects allow data access using standardized web services interfaces. AMI is currently deployed across Internet2's Abilene network and passively measures 11 core routers. There is currently much momentum behind the perfSONAR project with support from Energy Science Network (ESnet) and the Pan-European GEANT network and Internet2 to provide uniform data access to all routers with many of ESnet's and GEANT's router interfaces being made available through perfSONAR.
3. Netflow passive measurement data that can be obtained from select routers, in particular, border routers at collaborating sites. The Netflow records from a given router will be collected by a host collocated in the Autonomous Systetm (AS) of the router. This host will suitably anonymize and select relevant records (e.g. long lived flows, selected ports/applications, etc.) and make them available.

A goal of these measurements is to obtain data on the start times, transfer sizes, end times and characterizations (e.g. top talkers, transfer rates, arrival rates and flow durations) of the traffic coming in and out of the AS. As a crude model, we propose using flow data to gather statistics on long-lived flows for file transfer applications and end site destinations to provide basic accounting facilities.

Modules for LHC-MI

The real-time services framework we are proposing for LHC-MI allows us to independently develop, test and deploy needed functionality in the form of modules. We intend to provide modules for LHC-MI in the following areas:

- Monitoring – We need to monitor many different parameters in the network using SNMP, Netflow and other tools and protocols.
- Alerting – Providing quick customized alerting capabilities once problems are discovered is an important part of LHC-MI. We intend to develop alerting agent modules designed to minimize "false postives" while maximizing sensitivity to critical problems.
- Persistency – We need modules which can store and manage our acquired data.
- Querying – Access using complex queries capabilities is required for LHC-MI, both for clients and other modules within our system.
- Analysis/Diagnostics – Understanding how problems can be located and accurately described and diagnosed is one of the most important modular capabilties we intend to develop and deploy.
- Finger Pointing (Problem Location – Depends on all the previous) – Having a system which can localize network problems is very difficult to achieve but its benefits are correspondingly important for maintaining an effective infrastructure. We intend to develop a module or set of modules, building upon our other work, which can localize the source of network related problems leading to quick problem resolution.

Monitoring at 10GE

Active end-to-end measurements and monitoring at 10 gigabits and beyond is a significant problem because:

- The timing to measure packet pair dispersion is approaching the resolution of the host's system clock;
- 10 GE Network Interface Cards (NICs) use functions like interrupt coalescence (e.g. TCP Segment Offload, Receive Offload) or TCP offloading which interferes with timing packets in the host;
- There are no standards for reading timing information out of the NICs;
- On long-distance paths (e.g. trans-Atlantic) slow start can take 6 seconds, so to make a measurement with TCP in its stable (non-slow-start) state for 90% of the time requires a 60 second measurement or potentially transmitting 75GBytes of data;
- Though not specifically a 10 gigabits and beyond problem, the increasing use of dedicated layer 1 or 2 paths or the use of Quality of Service (QoS) also gives rise to problems:
    - Traceroute will not work on layer 1 or 2 paths;
    - If the path to be measured requires QoS to be applied, or the path to be scheduled then this needs to be built into the measurement infrastructure.

We will need to study ways to by-pass the above problems, such as:

- Using packet trains instead of pairs so as to require less clock resolution;

- Working with the NIC vendors to disable offload functions and/or to extract timing measurements from the NICs;
- Modifying achievable throughput tools such as iperf or thrulay, to only report measurements after the initial slow-start has terminated (see for example [TIR-03]);
- Build wrappers for tools to enable path set-up and tear down before and after a measurement.

An alternative to active tools is to use passive measurements e.g. from Netflow or by accessing network device SNMP MIBs, or by capturing packets. The advantages are:

- No extra traffic is introduced onto the wide area network;
- The measurements reflect real traffic, collaborations and applications;
- No accounts/password/certificates/keys are needed to install servers at other sites;
- No paths need to be reserved.

On the other hand:

- Access to Netflow data has to be granted by the relevant network administrator,
- Netflow can create large (hundreds of Mbytes to GBytes) volumes of data,
- There are privacy issues with the data.
- Access to the MIBs is usually limited, however the perfSONAR project is attempting to overcome this problem for Abilene, ESnet and GEANT.
- Currently tools to capture at 10Gbits/s rates are very expensive (e.g. the Endace kit costs about $100k).

We plan to explore using Netflow not only for network characterization (e.g. top talkers and applications, flow lengths and size distributions) but also to see whether we can use the data to forecast performance. We will also work with the perfSONAR developers analyze utilization and capacity information to provide forecasts, detect significant changes in utilization/available bandwidth, and to help diagnose the cause of events.

Dynamism and Measurement Variables

A measurement infrastructure like LHC-MI has to provide a number of different parameters which have varying intervals of validity. Certain measured variables are fairly constant (memory in a host) and may need to be updated infrequently, while others, (utilized network bandwidth on a network segment) can vary significantly over short timescales. Part of the task of providing a measurement infrastructure is to determine upon what timescales certain data must be updated to meet the needs of the various clients and reconcile this with data acquisition constraints and the impact of the measurement infrastructure on the network.

We intend to attach “interval of validity” (IoV) metadata to each measured or monitored parameter in the LHC-MI system. The IoV is the range in time a value, or set of values, is valid for the conditions when the data was taken. Thus, the IoV values will determine how often parameters must be measured, captured or updated and will represent an explicit contract with clients guaranteeing the maximum age of a given parameter. Part of our research we be in optimizing the IoV’s to insure data timeliness while minimizing the intrusiveness of the system on the overall infrastructure.

End-to-End Considerations

Networks can no longer be considered in isolation from the end systems: the interactions between networks and the hosts driving the network are closely coupled. Not infrequently drops in end-to-

end performance are related to host effects such as host resource (e.g. cpu, bus, memory, disk, process slots) utilization/congestion or to mis-configuration (e.g. too small TCP windows, Ethernet duplex mismatch). Thus we also need to monitor host configuration and resource utilization. Open source host monitoring tools such as Ganglia, LISA and Nagios are commonly used in the LHC community to provide such measurements. To effectively diagnose the cause of events we need to develop tools to access on demand the current and recent host monitoring data and analyze it to detect anomalies that may result in degraded performance.

LISA is a lightweight monitoring agent that runs on any end-user's system (Linux, Windows, or MacIntosh) using Java Web Start technology. The LISA agent detects the architecture on which it is deployed and dynamically loads the binary applications necessary to perform monitoring and end-to-end network performance measurements. It uses MonALISA lookup services to discover and register with the services and applications it needs, based on a set of attributes. As it monitors the end-system and network state, it reports all the monitored values to the relevant MonALISA services. When using an external MonALISA service, the LISA agent reports the real IP address and domain name of the computer on which the agent is running, and whether a network address translation (NAT) is being used. This allows the external service to contact the end-system as needed.

The LISA Agent provides:

- Complete monitoring of the end-system (load, CPU usage, memory allocation, disk usage, disk IO, paging, running processes, network traffic and connectivity).
- Detection of hardware devices on the system and the drivers used by the kernel to control them.
- Measurements of end-to-end network performance using different applications (Ping like measurements, iperf, WEB100), which are reported to the user.
- A user friendly GUI to present all the measured values and the system parameters.
- Filters to trigger actions when predefined conditions are detected.

LISA agents can use the discovery mechanism from MonALISA and use this information to select dynamically services or applications registered in the system.

Based on information such as AS number or location, it determines a list with the best possible services from the user perspective. It continuously monitors the network connection with several selected services and provides the best one to be used from the client's perspective. It also provides dynamic load balancing for services based on attributes like load or the number of connected clients.

3 Proposed Research and Methods

Development of the Modular Framework

The central component of our infrastructure is the real-time service fabric supporting modules for monitoring, measurement, analysis, diagnostics, persistency and alerting. A schematic of our proposed framework, showing the components of LHC-MI, is shown in Figure 3. To develop our modular framework we a proposing to build upon a fully functional architecture already broadly deployed which meets many of our needs for LHC-MI: MonALISA.

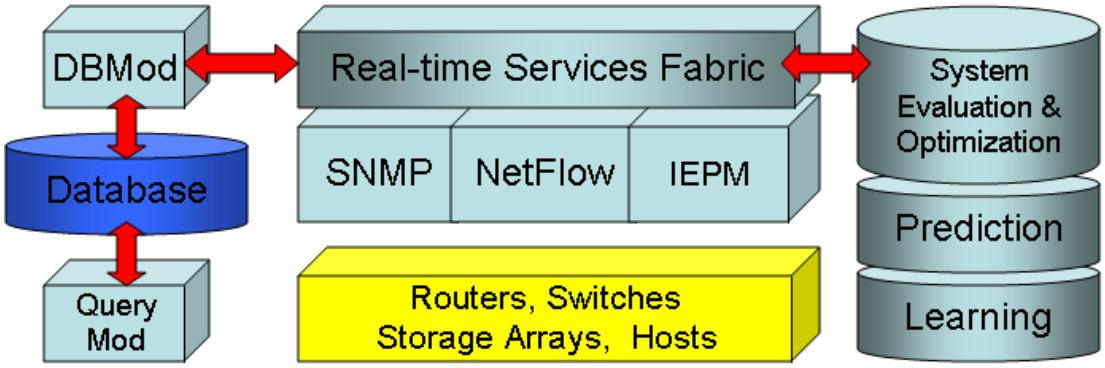

Figure 3 The LHC-MI architecture

MonALISA is designed to easily integrate existing monitoring tools and procedures and to provide this information in a dynamic, self describing way to any other services or clients. The modules used for collecting different sets of information, or interfacing with other monitoring tools, can be dynamically loaded by the MonALISA service. Both, push and pull models are supported. The core of the monitoring service is based on a multi-threaded engine used to perform many data collection modules in parallel, independently.

To improve the efficiency, a dynamic pool of threads is created, and the threads are then reused when a task assigned to a thread is completed. This allows one to run concurrently and independently a large number of monitoring modules, and to dynamically adapt to the load and the response time of the components in the system. If a monitoring task fails or hangs due to I/O errors, the other tasks are not delayed or disrupted, since they are executing in other, independent threads. A dedicated control thread is used to stop properly the threads in case of I/O errors, and to reschedule those tasks that have not been successfully completed. A priority queue is used for the tasks that need to be performed periodically. This approach makes it relatively easy to monitor a large number of heterogeneous systems or devices with different response times, and at the same time to handle monitored units which are down or not responding, without affecting the other measurements. Agents can change the scheduling of monitoring modules or trigger predefined measurements. As an example, if a simple time series of RTT measurements may indicate a possible deterioration in the available bandwidth, a more precise measurement is triggered by the agent before generating an alarm.

The MonALISA distribution contains a set of monitoring modules used to collect monitoring information from other monitoring tools: modules for standard Web Services with SOAP binding, generic modules for NMWG services, generic modules for network tools using RRD for local

storage, interfaces to the Ganglia multicast communication system and to common monitoring tools like tracepath, ping or pathload.

It also implements modules to support standard network protocols like SNMP, Netflow datagrams and TL1. All these modules are currently used in gathering monitoring information on Abilene, Ultralight, LHCnet, and Gloriad networks.

We will develop modules to collect the monitoring information provided by the IEPM toolset.

All the collected values are stored in a relational database, locally for each MonALISA service. The clients, other services or agents can get any real-time or historical data using a predicate mechanism for requesting or subscribing to selected values.

This can be done using the internal communication layer in the MonALISA system which is based on serialized (marshaled) objects or using the WSDL / SOAP binding.

For all the network measurements collected, we also provide a full NMWG binding.

Persistent Data Stores

One of the primary uses of the LHC-MI will be to maintain historical information about all the measured and monitored components. This is important for trend analysis, accounting, problem identification and new analysis development. We intend to utilize a standard schema like NMWG, augmented as required by the types of data we measure and monitor, to persistently store all the LHC-MI data. The actual database implementation will likely be based upon Postgres or MySQL as dictated by testing in during our development and deployment. This persistency capability will be developed as another module which "plugs-in" to the real-time services fabric. This will allow us to easily setup redundant repositories within the infrastructure.

Searchable access to the persistent data stores will be provided by web services interfaces into the database as well as web-enabled database GUI's (PHP based or alternatives) utilizing standard tools like Java, ODBC and Apache. Part of this work will involve creating customized domain specific interfaces allowing quick and easy access to specific types of information as needed by different clients.

Netflow and Other Passive Monitoring

Active measurements can be problematic, so we will also explore passive monitoring based on Netflow and SNMP MIBS as described in section . One of the primary motivations to use Netflow are the difficulty in accurately measuring current and future high-speed networks. We will explore how to effectively incorporate passive techniques to meet the needs of our clients for unobtrusively monitoring LHC-MI networks.

Accounting and Network Measurements

Accounting for network usage is becoming an important aspect of grid systems. Understanding how all grid resources are being used (and allocated) is important for both the effective operation of the system and to allow users and groups to understand and track their usage. One approach to gather information for accounting will be to analyze Netflow records to provide information on the numbers and lengths of flows and applications used between pairs of sites. However, Netflow does not provide information on the user account, so we will investigate other ways to provide this information.

Forecasting, Event Detection and Alerting

A network measurement and monitoring infrastructure can provide an overwhelming amount of information to manage and understand. Typically this is in the form of time series plots of multiple metrics between multiple hosts and can quickly require reviewing thousand or tens of thousands of graphs. To be effective this information needs to be automatically filtered and analyzed to locate anomalies which require corrective action. Anomalies include loss of connectivity, route changes (which may or may not have noticeable effects on end-to-end performance), and effects caused by congestion or mis-configuration. The anomalies may be characterized by their duration, the percentage change observed and the rate at which the change occurs. The anomalies may also be detected by one or more measurement metrics, and on one or more paths in either or both directions. We will base our work on the initial network anomaly detection work of the IEPM group [CO-06]. They evaluated the effectiveness of the Holt-Winters triple exponential weighted moving average technique [HW] to provide forecasts in the presence of seasonal changes and compare the Plateau algorithm and the Kolmogorov-Smirnov [KS] techniques effectiveness at detecting step changes. Future work will explore using ARMA and ARIMA statistical methods for forecasting and Principal Component Analysis (PCA) to detect anomalies using multiple metrics and paths. Other possible avenues that we expect to explore include the use of neural networks and wavelets.

Finger Pointing Capability

Having the ability to quickly isolate the cause of a problem within an end-to-end system is on every network manager's wish list. With a broadly distributed system like a set of networks it can be very time consuming just to localize a problem to one administrative domain. We intend to develop a rudimentary "Finger Pointing" system using our event detection capabilities along with our extensive set of network and host measurements.

Having detected a potential anomaly, it will need to be analyzed to see if it constitutes a noteworthy event. For example, did the anomaly persist long enough, did the magnitude of the change exceed some threshold, did the onset of the change occur quickly enough? Careful research is needed here to reduce the number of missed events while minimizing the false positives. Following this the event will need to be studied in more detail by gathering extra information (e.g. from other network measurements (metrics or paths), from the end hosts, and/or the intermediate routers) to try and diagnose the likely cause or at least eliminate obvious causes. Initially this will be done manually and a library of interesting events and their diagnosis will be created. As we gain experience the heuristics and expertise that we manually apply to diagnose event will be automated using scripts to gather the relevant measurements and isolate the causes.

Once the diagnosis is complete the relevant people will need to be alerted and provided with the appropriate information such as time, magnitude, affected paths, likely diagnosis and relevant data (e.g. pointers to time series, routes before and after). Typically this will be done by email.

The facility to be able to determine when there is a problem on the network using the event detection module will be extended to provide details of the location(s) that represent the cause of the problem(s) experienced. For example, should we identify (e.g. by looking at perfSONAR) that a routed link suddenly becomes very congested due to cross traffic, this Finger Pointing facility will show that it is this particular network path and link rather than some other factor.

Bottleneck detection will also become more important in the future as network resources become more competitive as end-host link speeds increase. Besides using perfSONAR to detect a bottleneck, we also intend to evaluate the use of Pathneck [PATHNECK] in this role.

Similarly, if a link goes down due to a cut fiber, this module will determine quickly (e.g. by looking at routes, one way active delay measurements (OWAMP), minimum RTTs, or where possible by monitoring the fiber loss) that the event occurred..

We intend to develop a rudimentary Finger Pointing module that will be used in conjunction with the event detection module to quickly identify the occurrence and isolate the cause of the problem.

The implementation of such a system will considerably reduce the time and effort required to localize and quickly determine the cause of the problem(s); the more precise the Finger Pointing can be, the more substantial the savings in time and effort.

The implementation of such a system requires detailed information from the numerous independent systems end-to-end. By utilizing the real-time services fabric and external modules to systematically collect historical data and possibly initiate new tests, a logical deduction of the cause of the event will be determined. This will need to then be cross correlated against comparable (or even non-comparable) tests such that confidence can be given to the deduction.

We expect to require detailed historical information in order to make such a system successful; topology information to provide the network path, performance data using multi-domain systems such as perfSONAR, historical changes in node configurations and also the end-to-end performance data such as that from IEPM-BW. We are currently exploring the application of specific network tools (such as PathNeck) and using federated services such as perfSONAR to develop mathematical and systematic isolation techniques to discover bottlenecks in the real Internet. We are also working with the Internet2 piPES [PIPES] program and wish to extend our involvement in the project by utilizing our expertise in network monitoring and event detection.

Such data will be provided into the LHC-MI system via the various modules which will collect such data to be stored into persistent data stores from which this Finger Pointing module will interoperate through.

We imagine that concise reports will be generated that will provide all relevant performance data and logical deductions to the root of the problem so that network engineers and managers can provide feedback in the capability of the system and enable us to evolve the system further.

4 Collaborative Organization, Deliverables and Milestone

Strengths of team

The team includes: the PI, chief architect and members of the MonALISA project; the PI, chief architect and members of the IEPM-PingER and IEPM-BW projects. The Michigan PI is the chairperson of the LHC Network monitoring group and former chair of the Internet2 End-to-End technical advisory group. The SLAC PI is a member of the Internet2 End-to-End Performance Initiative Technical Advisory Group. Caltech is an LHC/CMS tier 2 site; SLAC and Michigan are probable LHC/ATLAS tier 2 sites. The SLAC PI also has practical operational network experience as head of SLAC's production networking group. The Caltech PI is the UltraLight and US LHCNet PI, the co-PI of LambdaStation, and the chairperson of the ICFA/SCIC working group. The Caltech and Michigan PIs are the co-chairs of the HENP Internet Working Group. The SLAC PI is a Co-PI on the Terapaths project.

Project Organization and Management

The proposers already have a close working relationship and leadership or co-leadership roles in UltraLight, LambdaStation, Terapaths and LHCNet. The PI, Co-PIs and senior personnel will have bi-weekly phone or video-conference meetings to plan and direct the project. Annual collaboration meetings will provide opportunities to summarize and deliver the previous year's efforts and target the next year's activities and focus.
We will also coordinate with our partner projects to ensure we meet the application needs of HEP and other target science communities, as well as the operational needs of the major US research and education networks supporting DOE programs.

Milestones

4.1.1 Year 1

The first year will focus on development, federation, deployment and integration of the various network-monitoring solutions available to facilitate network monitoring of the LHC project. This will involve:

1. Understanding and developing distribution packages for end-to-end monitoring systems such as IEPM-BW and IEPM-Pinger utilizing tools such as PacMan.
2. Deploy and monitor the LHC-MI software Tier-0 and Tier-1 sites, ensuring proper configuration (ports opened, accounts setup, pre-required libraries, host specification etc. are in place), leverage contacts at sites.
3. Identification of useful monitoring solutions and performance metrics (e.g. OWAMP, GridFTP, lightweight user applications such as bbcp) for each site (requirements capture). Customize measurement solutions to match, with optimized throughput
4. Evaluation and implementation of a MonALISA-based coordination service that schedules measurements and or systems between multiple hosts to prevent interference of measurement. (A first implementation of the coordination service has just been deployed in MonALISA)
5. Evaluation and prototyping of passive monitoring solutions using Netflow and SNMP.
6. Evaluation and development of multi-AS network monitoring solutions such as perfSONAR.
7. Definition of software interfaces for system-service fabric communication for measurement needs.
8. Identifying, prototyping and refining visualization of performance data.
9. Develop prototype LHC-MI schema based upon NMWG, DMTF-CIM, GLUE and others.
10. Create, test and deploy prototype data persistency module.
11. Research back-end database technologies and select initial database system.

12. Develop and optimize interval of validity (IoV) metadata for the LHC-MI schema.
13. Deploy initial database system for data persistency.
14. Develop query modules including initial GUI and API.
15. Develop MonALISA modules and services as needed, and integrate them with the framework as needed, for items 5. – 9. after the initial prototyping and interface definitions.
16. Develop and test MonALISA service-interfaces for the schema in item 9.
17. Development of the real time services fabrics, including the modular architecture, integrating the MonALISA distributed system.
18. Development of system analysis, control, configuration, diagnostic, forecasting and other dynamic modules to support LHC-MI.
19. Development of APIs to support user applications, so allowing them to make use of the monitoring information and predictive capabilities of the system.
20. Integration of end hosts systems in the monitoring foot print, providing end to end monitoring and detection of anomalies of not only networks but also the end systems (e.g. storage systems)

4.1.2 Year 2

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

1. Survey and evaluation of existing finger pointing algorithms for computer networks.
2. Development, testing and deployment of prototype advanced finger pointing algorithms and visualization techniques.
3. Survey and evaluation of existing anomalous event detection techniques for various network performance metrics such as achievable throughput, available bandwidth, latency and jitter.
4. Development, testing and deployment of prototypes for anomalous event detection-representation and visualization techniques. We expect to work with and compare/contrast PCA (both for multiple metrics and for multiple paths), neural networks, wavelets among others.
5. Initial design of interfaces encompassing network monitoring, event detection and bottleneck detection.
6. Deploy IEPM-BW to LHC major Tier-2 sites. Deployment of passive monitoring solutions to various Tier-0 and Tier-1 sites based on interest and availability.
7. Determine system compatibility with PerfSONAR, Open Science Grid and the LHC experiments computing infrastructure and evolve as required to interoperate.
8. Evolve and update LHC-MI schema, including new requirements for IoV
9. Test and evolve database system for interoperability with PerfSONAR and other efforts.
10. Extend and evolve LHC-MI query interfaces
11. Monitoring in near real-time the network topology and developing algorithms for analyzing network anomalies (failure, bottle necks, intrusion,..)
12. Agents for alarm triggers, and automatic notification based on network analysis.
13. Testing and refinement of the LHC-MI infrastructure using UltraLight network testbed and WAN in Lab including the Caltech Tier2 .
14. Development of learning and prediction algorithms using traffic patterns on all network segments, and by using inter-site correlations.
15. Continue development and integration of the MonALISA services and interfaces with standardized schemas and interfaces (as in the Year 1 milestones 15-20).
16. Reach at-scale deployment and test the end-to-end functionality of the LHC-MI during the first LHC physics runs, and during daily operations of LHCNet, Internet2, GEANT2 and other participating R&E networks.

4.1.3 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. Design and implementation of interfaces for finger pointing, event detection and forecasting.
2. Development, evaluation, comparison of performance forecasting techniques for time-series data, particular taking into account seasonal effects.
3. Widespread adoption of finger pointing module to numerous Tier-0, Tier-1 and Tier-2 sites. Evaluation and tuning to improve accuracy and scalability of solution(s).
4. Widespread adoption of anomalous event detection services to numerous Tier-0, Tier-1 and Tier-2 sites. Evaluation and tuning to improve accuracy and scalability of solutions(s).
5. Finalization of software interfaces for network monitoring, event detection, bottleneck detection and network performance forecasting.
6. Produce "hardened" database system incorporating current schema and techniques for robust operation and maintenance.
7. Develop "custom" LHC-MI data query modules for specific targeted users and applications
8. Prototype network accounting module and interfaces and deploy and test. Development and improvement of network monitoring modules.
9. Evaluate and develop lightweight tools capable to provide good estimate for available bandwidth
10. Provision and support of dedicated global repositories for the collected monitoring information.
11. Integration of network monitoring data with other monitoring data (cpu, storage, jobs) and development of algorithms (heuristics) to optimize the integrated resource usage by groups and individuals.
12. Continue development and integration of the MonALISA services and interfaces with standardized schemas and interfaces (as in the Year 1 milestones 15-20), with a focus on production-readiness and operations at-scale.
13. Test production-readiness of the end-to-end of the LHC-MI, including during LHC running with increasing luminosity, data volumes, aggregate network volumes, and thus with increasing levels of network use.
14. First field-tests of the LHC-MI as an input to a prototype service aimed at automatic system-level network throughput optimization. (While this service is outside the scope of this proposal, the monitoring aspects are within its scope.)

4.1.4 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 through event detection algorithms. Manual analysis of performance data to identify the cause, or at least eliminate non-causes of events.
2. Build a library of events, their likely cause(s) and classify events.
3. Investigate, design and implement systematic additions to finger pointing modules that will gather further data from relevant sources to help diagnose event causes. 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.
4. 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.
5. Develop alerting tools that provide event and diagnostic information, with the alerts being sent by email, pagers etc.

6. "Productize" the tools developed, providing documentation and integration. Work with ESnet and others to deploy and integrate the tools into network operations centers.
7. Complete "release" versions of schema, database and query modules including documentation
8. Test and insure compatibility of network accounting module for LHC and other grid systems.
9. Release network accounting module and final document interfaces
10. Continue improving reliability and robustness of data persistency system.
11. Continue evolving schema as required by client needs
12. Distributed intrusion detection system based on optimized algorithms and heuristics developed in previous years. As soon as an intrusion pattern is identified in the flows or individual systems at one site the attacker IP is distributed to all sites, who may then block it
13. Fair and balanced usage of network resources by individuals and groups through integration of policy agreements and enforcement of these policies through analysis of network resources.
14. Continue development and integration of the MonALISA services and interfaces with standardized schemas and interfaces (as in the Year 1 milestones 15-20), with a focus on full production-readiness and operations at-scale, in time for operation at LHC design luminosity.
15. Verify production-readiness of the end-to-end of the LHC-MI, including during LHC running with increasing luminosity, data volumes, aggregate network volumes, and thus with increasing levels of network use.
16. Complete field-tests and deploy LHC-MI as an input to a MonALISA subsystem that provides system-level network throughput optimization. (While this service is outside the scope of this proposal, the monitoring aspects are within its scope.)

Deliverables

4.1.5 California Institute of Technology

Caltech will focus on deliverables in the following areas:

- Development of the real time services fabric, including the modular architecture, integrating the MonALISA distributed system
- Development of system analysis, control, configuration, diagnostic, forecasting and other dynamic modules to support LHC-MI
- Testing and refinement of the LHC-MI infrastructure using the Caltech Tier2 as a testbed.

4.1.6 SLAC

SLAC will focus on deliverables in the following areas:

- Forecasting of network performance
- Detection of anomalous network events
- Diagnosis and reporting of anomalous network events, also incorporating end-host information
- Mining Netflow type information to characterize the use of networks and provide estimates of performance of various bulk throughput applications on frequently used LHC network paths
- Integration of the above with MonALISA and perfSONAR.
- Extension of IEPM-BW to LHC Tier-1 and Tier-2 sites

4.1.7 University of Michigan

The University of Michigan will focus on deliverables in three primary areas:

- Monitoring and Measuring Data standardization
    - Schema development
    - Data Interval of Validity
- Data persistency
    - Storage technologies
    - Query mechanisms and interfaces
- Network Accounting

In addition we will be active participants in overall architecture development for LHC-MI, testing and deployment, including on the LHC-OPN and ATLAS grid infrastructures.

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Education

B.S.	Massachusetts Institute of Technology	1968 Physics
Sc.D.	Massachusetts Institute of Technology	1974 Physics

Research and Academic Positions in Physics

Board Chair	US CMS Collaboration	1998-present
Professor of Physics	California Institute of Technology	1990-present
Associate Professor	California Institute of Technology	1982-1990
Physicist; MARK J Spokesperson	Deutsches Elektronen Synchrotron (DESY) Hamburg	1978-1982
Consultant	MIT Laboratory for Nuclear Science	1975-1982
Research Fellow	Harvard University	1975-1977
Scientific Associate	CERN - NP Division, Geneva	1974-1975

Positions in Information Technology

Principal Investigator	LHCNET (US-CERN Network)	1985-present
Principal Investigator	Particle Physics Data Grid Project	1999-present
Chair	Internet2 HENP Working Group	2001-present
Chair	ICFA Standing Committee on Inter-regional Connectivity	2002-present
Principal Investigator	UltraLight Project	2004-present
Co-Principal Investigator	iVDGL (GriPhyN) Project	2001-present
Chair	CMS Software and Computing Board	1996-2001
Chairman, Vice Chair, Founder	VRVS Global Corporation	2001-2004
Chairman, Co-Founder	EVOGH, Inc. (Enabling Virtual Organizations)	2006-present
Principal Investigator	Globally Interconnected Object Databases (GIOD) Project	1996-2000
Systems Analyst	Operations Research Division, Chase Manhattan Bank, New York NY	1968, 1969
Systems Analyst	STC, New York, NY	1967
Systems Engineer	IBM, New York, NY	1965

Awards

CENIC "Biggest and Fastest in the West" Award; Partnership Awards	2003; 2004, 2005
Guinness Book of Records, Internet Division	July 2003
Internet2 Land Speed Records (Team Lead; 11 Awards)	2003-5
Internet2 Land Speed Record	November 2002
European Physical Society Special Award for the Discovery of Gluons at PETRA	1995
General Electric Award for Advances in Time Sharing Technology	1968

Selected National and International Committees

NSFnet Technical Advisory Group	1986
Internet Engineering Task Force on Scientific Computing	1986-1989
National Academy of Sciences Panel on Information Technologies and the Conduct of Research	1986-1987
ESNet International	1996-present
ICFA Network Task Force	1997-1998

ICFA Standing Committee on International Connectivity (SCIC)	1999-present
International Committee on Future Accelerators (ICFA)	2001-present
Transatlantic Network Working Group (Chair)	2001
Internet2 Applications Strategy Council	2001-present
Internet2 End-to-end Initiative, HENP Contact	2001-present
Internet2 HENP Working Group (Chair)	2001-present

5 Selected Related Publications

1. FAST TCP: From Theory to Experiments, S. H. Low, H. Newman, J. Bunn, S. Ravot et al., IEEE Network, January 2005
2. Networking for High Energy and Nuclear Physics as Global e-Science, H. Newman, Proceedings of the International Conference on Computing for HEP, Interlaken, October 2004
3. Data-intensive E-Science Frontier Research, H. Newman, M. Ellisman, J. Orcutt, CACM 46 (2003) 68-77
4. Data Intensive Grids for High Energy Physics, in *Grid Computing, Making the Global Infrastructure a Reality,*Berman, Fox and Hey (Ed.), Wiley, UK, 2003, ISBN 0-470-85319-0
5. H. Newman, S. Ravot, Y. Xia, D. Nae, X. Su, O. Martin. Practical Approach To TCP High Speed WAN Data Transfers. In Proc. *Broadnets 2004 conference*, *PATHNets Workshop,* October 2004.

5 Other Significant Recent Publications

1. L3 Collaboration, P. Achard et al., Physics Letters B, Volume 580 (2004) pp. 37-49.
Search for Scalar Leptons and Scalar Quarks at LEP.
2. L3 Collab., P. Achard et al., Physics Letters B, Volume 587 (2004), pp. 16-32.
Single- and Multi-Photon events with Missing Energy in e+e- Collisions at LEP
3. L3 Collab., P. Achard et al., Physics Letters B 589 (2004) 89-102
Search for Anomalous Couplings in the Higgs Sector at LEP
4. L3 Collab., P. Achard et al., Physics Letters B 597 (2004) 119-130
Study of the e+e- to Z+gamma Process at LEP and Limits on Triple Neutral-Gauge-Boson Couplings
5. L3 Collab., P. Achard et al., Physics Letters B 609 (2005) 35-48
Search for an Invisibly-Decaying Higgs Boson at LEP

Collaborators

P. Avery (U Florida), L. Bauerdick (FNAL), J. Bunn (Caltech), R. Cavanaugh (Florida), R. Cottrell (SLAC), D.Foster (CERN), I. Fisk (FNAL), I. Foster (U. Chicago), I. Gaines (FNAL), R. Gardner (U. Indiana), J. Huth (Harvard), S. Kent (FNAL), C. Kesselman (USC/ISI), A. Lazzarini (Caltech), M. Livny (U. Wisc), S. Low (Caltech), O. Martin (CERN), R. Mount (SLAC), V. O'Dell (FNAL), D. Petravick (FNAL), R. Pordes (FNAL), D. Riley (Maryland), L. Robertson (CERN), J. Schopf (Northwestern), A. Szalay (Johns Hopkins), T. West (NLR), J. Dolgonas (CENIC), V. White (FNAL)

Samuel C. C. Ting (MIT) and the members of the L3 Collaboration at CERN.
Michel Della-Negra (CERN) and the members of the CMS Collaboration.
R. Mount (SLAC) and the members of the Particle Physics Data Grid Collaboration.
Members of the GriPhyN, iVDGL, UltraLight, LambdaStation and CHEPREO projects.

Thesis advisor: Prof. Louis S. Osborne (MIT), ***Postdoctoral Advisor:*** Prof. S. C. C. Ting (MIT)
Postdocs and Graduate Students advised: R. Clare (UC Riverside), G. Gratta (Stanford), M. Gruenewald (UC Dublin), D. Kirkby (UCSC), W. Lu (JPL), H. Ma (BNL), H. Stone (Princeton, deceased), C. Tully (Princeton), L. Xia (ANL)

JULIAN JAMES BUNN

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Professional Preparation

Ph.D.	Particle Physics	University of Sheffield (England)	1983
B.Sc.(Hons)	Physics	University of Manchester (England)	1980
FInstP	Fellow of the Institute of Physics		
CPhys	Chartered Physicist		
AES	Member of the Audio Engineering Society		
IEEE	Member of the Institute of Electrical and Electronic Engineers		

Appointments

Member of the Professional Staff	Caltech, Pasadena	2002-	
Senior Scientist	Caltech, Pasadena	1999-	2002
Visiting Faculty Associate (Physics)	Caltech, Pasadena	1997-	
Project Leader (GIOD)	CERN, Geneva	1997-	2000
Computing Coordinator	CERN, Geneva	1996-	1997
Project Leader (DEC)	CERN, Geneva	1991-	1996
Section Leader	CERN, Geneva	1986-	1991
Physicist/Programmer	CERN, Geneva	1985-	1986
Research Associate	Rutherford Appleton Laboratory, Oxford	1984-	1985
Research Associate	Max Planck Institute, Munich	1983-	1984

Research Positions

Co Principal Investigator	TeraGrid GIG Portals for HEP/NVO	2005-	
Co Investigator	Contamination Transport (NASA/JPL)	2004-	
Co Investigator	CAIGEE (Grid Analysis) Project	2002-	2004
Co Investigator	iVDGL Project	2001-	
Co Investigator	Grid Physics Network (GriPhyN)	2000-	
Co Investigator	Virtual Sky Project	2000-	2004
Co Investigator	Immersed Boundary Model of the Cochlea	1999-	
Co Principal Investigator	ALDAP (NSF/KDI) Project	1999-	2001
Co Investigator	Particle Physics Data Grid Project	1999-	
Co Investigator	MONARC Project	1998-	2000
Co Principal Investigator	Globally Interconnected Object Databases	1996-	2000

Related Publications

[1] F. van Lingen, **J. Bunn**, I. Legrand, H. Newman, C. Steenberg, M. Thomas, A. Anjum, T. Azim, *The Clarens Web Service Framework for Distributed Scientific Analysis in Grid Projects*, In Proceedings of the International Conference on Parallel Processing Workshops, Oslo, Norway, June 2005, IEEE Computer Society Order Number P2381, ISBN 0-7695-2381-1, pp45-52

[2] Low S.H., Newman H., **Bunn J**., Ravot S. et al.; *FAST TCP: From Theory to Experiments* IEEE Network, January 2005

[3] **Bunn J** and Newman H; *Data Intensive Grids for High Energy Physics*, in *Grid Computing, Making the Global Infrastructure a Reality*, Berman, Fox and Hey (Ed.), Wiley, UK, 2003, ISBN 0-470-85319-0

[4] Allcock W, Bresnahan J, **Bunn J**, Hegde S, Insley J, Kettimuthu R, Newman H, Ravot S, Rimovsky T, Steenberg C, Winkler L; *Grid-enabled particle physics event analysis: experiences using a 10 Gb, high-latency network for a high-energy physics application*, FUTURE GENERATION COMPUTER SYSTEMS 19 (6): 983-997 AUG 2003
[5] **Bunn J**, Holtman K, Newman H, Wilkinson R; *The GIOD Project – Globally Interconnected Object Databases* – Comp. Phys. Comm. 140 (2001) 162-171
[6] **Bunn J.J.**, Cotrell L., Luitz S.,Mount R., Newman H.B., Patton J., Salomoni D.; *Evaluation of WAN and LAN links in the GigaBit/sec range for Large Scale Data Transfers* – 2001. Proc. of the International Conference on Computing in High Energy and Nuclear Physics: CHEP 2001, Beijing, China; 3-7 Sep 2001.
[7] **Bunn, J**; Holtman, K; *Scalability to Hundreds of Clients in HEP Object Databases* - 1998. Proc. of the International Conference on Computing in High-Energy Physics : CHEP'98 Chicago, USA; Sep 1998.
[8] **Bunn, J**; *Collaborative Computing Environments for HEP* – Comp. Phys. Comm. 110 (1998) 51-58.
[9] **Bunn, J**; *A step towards light life cycle global hypertext* - Proceedings / Ed. by R Cailliau, F L Navarria and P G Pelfer Int. J. Mod. Phys., C : 5 (1994) 765-766
[10] Ghiselli A., et al.*Distributed Applications Monitoring at System and Network Level* -(By the MONARC Collaboration) Computer.Phyics Communications 140:219-225,2001

Awards and Activities

SC2005 Bandwidth Challenge Award	Seattle		2005
CENIC “On the Road to a GigaBit” First Place Award			2005
Internet 2 Land Speed Records		2001-	2005
SC2004 Sustained Bandwidth Challenge Award	Pittsburgh		2004
SC2003 Sustained Bandwidth Challenge Award	Baltimore		2003
CENIC “Biggest and Fastest in the West” Award			2003
Guinness Book of World Records, Internet Division			2003
Session Chair, Computing in High Energy Physics Conference	San Diego		2003
Team member, Internet2 Land Speed Record	Baltimore		2002
NSF “MAGIC” Workshop	Chicago		2002
Session Chair, Computing in High Energy Physics Conference	Beijing		2001
Invited lecturer on Distributed Databases	Islamabad		2001
Joint EU-US Workshop on Large Scientific Databases	Annapolis		1999
Member of the SLAC Computing Advisory Committee	Stanford		1999
Presenter at the Internet-2 DSI workshop	Chapel Hill		1999
Interfaces to Scientific Data Archives committee member	Pasadena		1998
Plenary speaker at Computing in High Energy Physics Conference	Berlin		1997
Secretary of report "Computing at CERN in the 1990s"	CERN		1991

Collaborators and other Affiliations

Selected Collaborators J.Butler(FNAL), I.Foster(ANL), F.Gagliardi(CERN), I.Gaines(FNAL), B.Gibbard(BNL), A.Hanushevsky(SLAC), I.Hinchcliffe(LBNL), M.Livny(Wisconsin), S.Loken(LBNL), D.Malon(ANL), E.May(ANL), D.Millsom(SLAC), R.Moore(SDSC), Y.Morita(KEK), R.Mount(SLAC), H.Nordberg(LBNL), V.O'Dell(FNAL), D.Petravick(FNAL), J.Pinfold(Alberta), J.Pool(Caltech), R.Pordes(FNAL), L.Price(ANL), L.Robertson(CERN), T. Schalk(Stanford), A.Shoshani(LBNL), K. Sliwa(Tufts), A.Szalay(JHU), S.Tuecke(ANL), C.Watson(JNAF), T.Wenaus(BNL), V.White(FNAL), R.Wilkinson(Caltech), R.Williams(Caltech)

Thesis advisor Professor William Galbraith (Sheffield, England)

Postdocs and Graduate Students advised Pascal Cheung-Mon-Chien(Telmat, Paris), Francois Dardare(Telmat, Paris), Thomas Gilbert(Brussels), Pamela Hardaker(UWE, England), Nicola Pellow(Leicester Polytechnic, England), Rick Wilkinson(Caltech).

SYLVAIN RAVOT

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European Organization for Nuclear Research
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CH-1211 Geneva 23, Switzerland
Telephone: (+41) 22 767 4415
Email: ravot@caltech.edu

Professional Preparation

Engineering Degree in Communication Systems:	
Swiss Federal Institute of Technology (EPFL)	2000-

Appointments

Senior Network Engineer	Caltech, Pasadena	2001-
IT Consultant	AWK Engineering, Lausanne (CH)	2000-2001

Research Positions

Network administrator of the CERN-US transatlantic network.	2001-
Leader of the Internet2 HENP Working Group goal # 3	2001-

Related Publications

[1] FAST Kernel: Background Theory and Experimental Results. C.Jin, D. Wei, S. H. Low, G. Buhrmaster, J. Bunn, D. H. Choe, R. L. A. Cottrell, J. C. Doyle, H. Newman, F. Paganini, S. Ravot, S. Singh, submitted to IEEE Communications Magazine, April 1, 2003.
[2] GridDT: How to improve TCP performance? S. Ravot, Presented at the First International Workshop on Protocols for Fast Long-Distance Networks, February 3-4, 2003, CERN, Geneva, Switzerland.
[3] ICFA SCIC Advanced Technologies Interim Report. R. Hughes-Jones, O. Martin, S. Ravot, H. Newman. ICFA SCIC report February 8, 2003.
[4] TCP Congestion Control in Fast Long-Distance Networks. Technical Report CALT-68-2398, J.P. Martin-Flatin and S. Ravot. California Institute of Technology, July 2002.
[5] DataTAG proposal: Research and Technological Development for a Trans-Atlantic GRID - August 2001.

Awards

CENIC “Biggest and Fastest in the West” Award	2003
Internet2 Land Speed Record IPv4 class	2003
Internet2 Land Speed Record IPv6 class	2003
Internet2 Land Speed Record IPv4 class	2002

Collaborators and other Affiliations

Selected Collaborators O. Martin (CERN), J.P. Martin Flattin (CERN), P. Galvez(Caltech), H. Newman (Caltech), Steven Low (Caltech), I. Legrand(Caltech), J.C. Doyle(Caltech), L. Cottrell(SLAC), Shawn McKee (UMich), R. Hughes-Jones (PPARC), Peter Clarke (UCL), Robin Tasker (Daresbury Laboratory), Guy Almes (Internet2), Wu-chun Feng (Los Alamos National Laboratory)

Graduate Students advised Adrian Sarbu (University Polytechnic of Bucharest)

Iosif Charles Legrand
Senior Scientist

Division of Physics, Mathematics and Astronomy
California Institute of Technology
1200 East California Boulevard
Pasadena, CA 91125, USA

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Fax: +41 22 7678530
Iosif.Legrand@cern.ch

Education

MS in Nuclear Engineering,	University of Bucharest, Romania	1984
PhD in Theoretical Physics,	Institute of Atomic Physics, Bucharest	1991

Appointments or Positions:

Engineer	Institute of Nuclear Power Reactors, Romania	1984-1986
Researcher	Institute of Atomic Physics, Bucharest	1986-1988
Senior Researcher	Institute of Atomic Physics, Bucharest	1988-1992
Associate Professor	University of Bucharest	1989-1992
Scientific Associate	European Center for Nuclear Research	1992-1994
Scientific Associate	Deutsches Elekronen Synchrotron, Germany	1994-1998
Senior Scientist	California Institute of Technology	1998-present

Award

The Romanian Academy of Science Award for Physics ("Dragomir Hurmuzescu") received in 1992.

Selected Publications

MonALISA: An Agent based, Dynamic Service System to Monitor, Control and Optimize Grid based Applications, I.C.Legrand, H.B.Newman, R.Voicu, CHEP 2004, Interlaken, Switzerland, September 2004

MonALISA: A Distributed Monitoring Service Architecture *I.C. Legrand, , H.B. Newman, R. Voicu,* CHEP 2003, La Jola, California, March 2003

A Distributed Agent-based Architecture for Dynamic Services, I.C. Legrand, H.B. Newman, J. J. Bunn, CHEP – 2001, Beijing, Sept 2001

The MONARC Toolset for Simulating Large Network-Distributed Processing Systems, I.C. Legrand , H.B. Newman, Proceeding of the 2000 Winter Simulation Conference, Orlando, 2000

A Dynamic Self-Organizing Job Scheduling System, , I.C. Legrand, H.B. Newman, ACAT2000, Chicago

Simulation of Real-Time, Distributed data Processing Architectures for High Energy Physics Experiments. System Analysis Modelling Simulation, I.C. Legrand , Vol 18-19 (1998) 845

A Real-Time Application for CS-2, I.C. Legrand , Lecture Notes in Computer Science 919, High-Performance Computing and Networking, Springer Verlang,, 1996, p684

Coupled Channel Treatment of the L- Shell Ionization in Ion-Atom Collisions, I.C. Legrand
Journal of Physics B: Atomic Molecular and Optical Physics, B25 (1992) 189

Coupled Subshell Calculation of the L-shell Cross-Section for Heavy Ion – Collisions, I.C. Legrand et. all, Nuclear Instruments and Methods in Physics Research B56/57 (1991) 21

Recent Projects (Technical coordinator)

- MONitoring Agents using a Large Integrated Services Architecture (MonALISA) http://monalisa.caltech.edu
- The MONARC Simulation Framework: http://monarc.cacr.caltech.edu
- Virtual Intelligent Networks for Computing Infrastructures (VINCI), http://monalisa.caltech.edu /vinci/

Updated:January 2006

CONRAD DAVID STEENBERG

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1200 E. California Blvd., Pasadena, CA, 91125
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E-mail: conrad@hep.caltech.edu

Professional Preparation

Ph.D.	Cosmic Ray Physics	University of Potchefstroom (South Africa)	1998
M.Sc.	Physics	University of Potchefstroom (South Africa)	1995

AGU	American Geophysical Union member
COSPAR	IUPAP Commission on Space Research Associate

Appointments

Software Engineer/Associate Scientist	Caltech, Pasadena	2000-
Postdoctoral Research Fellow	Caltech, Pasadena	1998-2000

Co-chair of the Monitoring and Information Systems group of the Open Science Grid consortium.

Related Publications

1. H. Newman, J. Bunn, I. Legrand, S. Low, D. Nae, S. Ravot, C. Steenberg, X. Su, M. Thomas, F. van Lingen, Y. Xia, R. Cavanaugh, S. McKee, *The Ultralight project: The Network as an Integrated and Managed Resource for Data Intensive Science*, in Computing In Science and Engineering, Issue on grid computing, 2005
2. Conrad Steenberg, Julian Bunn, Iosif Legrand, Harvey Newman, Michael Thomas, Frank van Lingen, Ashiq Anjum, Tahir Azim, *The Clarens Grid-Enabled Web Services Framework: Services And Implementation,* Proceedings of CHEP 2004, paper 184, 2004
3. Conrad D. Steenberg, Eric Aslakson, Julian J. Bunn, Harvey B. Newman, Michael Thomas, Ashiq Anjum, Asif J. Muhammad, *Web Services and Peer to Peer Networking in a Grid Environment,* 8th International Conference on Advanced Technology and Particle Physics, 2003

Other Significant Publications

1. A.C. Cummings, E.C. Stone, C.D. Steenberg, *Composition of anomalous cosmic rays and other heliospheric ions*, Asgtrophysical Journal, 578 (1), p. 194, 2002
2. B. Klecker et al., *Anomalous Cosmic Rays*, Space Science Reviews, Vol. 83, p. 259, 1998
3. L.A. Fisk et al., *Global Processes That Determine Cosmic Ray Modulation*, Space Science Reviews, Vol. 83, p. 179, 1998
4. C.D. Steenberg, H. Moraal, *An Acceleration/Modulation Model for Anomalous Cosmic Ray Hydrogen in the Heliosphere*, Astrophysical Journal, 463, p. 776, 1996

Collaborators and other Affiliations

J.J. Bunn (Caltech), H. Newman (Caltech), E.C. Stone (Caltech/JPL), A.C. Cummings (Caltech), F.B. McDonald (U. Maryland/NASA-GSFC), R. Wilkinson (Caltech), I. Legrand (Caltech), M. Thomas (Caltech), F. van Lingen (Caltech),

ROGER LESLIE ANDERTON COTTRELL

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Stanford Linear Accelerator Center
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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.

CONNIE LOGG

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EDUCATION:
1970 – MS in EECS, College of Engineering, U.C. Berkeley
1965-1969 – BA in Computer Science, U.C. Berkeley

PROFESSIONAL EXPERIENCE:
1991-present: SLAC Computing and Computer Services, Network Analyst; LAN and WAN monitoring development
1988-1991: SLAC Controls Department, Systems Analyst; Analysis, specification, and design of maintenance database (DEPOT) for the SLAC LINAC control equipment
1978-1987: SLAC Electronics Department, Systems Analyst; Developed a software engineering group for the SLAC Electronics Department. Job activities included the analysis, specification, design, and implementation of monitoring, control, and test systems for CAMAC and FASTBUS equipment. Member of FASTBUS standard's committee
1971-1978: SLAC Experimental Group A, Mathematician; Online & offline line interactive data analysis; development of data acquisition, monitoring and control systems for SLAC HEP experiments

NARRATIVE:
Connie Logg joined SLAC in July 1971. In 1991 she joined the SLAC Computing Services department, and started working on network monitoring. In 1992-93, she was responsible for the development of the first network monitoring presentation system based on the World Wide Web. The components of this system included SNMP monitoring of all of SLAC's network support equipment as well as the network connectivity monitoring of SLAC's world wide collaborators via Ping. In addition, she is responsible for SLAC's daily Netflow analysis. Over the past 4 years, she has been the primary architect and implementer for the IEPM-BW bandwidth measurement and monitoring system which is deployed at several sites around the world.

RELEVANT RECENT PRESENTATIONS SELECTED PUBLICATION:
IEPM-BW DEPLOYMENT EXPERIENCES, Connie Logg, February 2005, Joint Techs, Albuquerque. New Mexico. http://www.slac.stanford.edu/~cal/jt02-2005-IEPM-BW-deployment.ppt
IEPM-BW: BANDWIDTH CHANGE DETECTION AND TRACEROUTE ANALYSIS AND VISUALIZATION, Connie Logg, February 2005, Joint Techs, Albuquerque. New Mexico. http://www.slac.stanford.edu/~cal/jt02-2005-bwchange.ppt
EVALUATION OF TECHNIQUES TO DETECT SIGNIFICANT NETWORK PERFORMANCE PROBLEMS USING END-TO-END ACTIVE NETWORK MEASUREMENTS. By R.Les Cottrell, Connie Logg, et al. Contributed to 10th IEEE / IFIP Network Operations and Management Symposium (NOMS 2006), Vancouver, Canada, 3-7 Apr 2006
EXPERIENCES IN TRACEROUTE AND AVAILABLE BANDWIDTH CHANGE ANALYSIS. By Connie Logg, Les Cottrell, Jiri Navratil (SLAC),. SLAC-PUB-10518, Jun 2004. 6pp. Presented at SIGCOMM 2004 Workshops, Portland, Oregon, 30 Aug - 3 Sep 2004.
CORRELATING INTERNET PERFORMANCE CHANGES AND ROUTE CHANGES TO ASSIST IN TOUBLE-SHOOTING FROM AND END-USER PROSPECTIVE. By Connie Logg, Jiri Navratil, and Les Cottrell, February 2004. Contributed to PAM 2004: Passive and Active Measurement Workshop
EXPERIENCES AND RESULTS FROM A NEW HIGH PERFORMANCE NETWORK AND APPLICATION MONITORING TOOLKIT. By R. Les Cottrell, Connie Logg, I-Heng Mei (SLAC), Presented at Passive and Active Monitoring Workshop (PAM 2003)
PASSIVE PERFORMANCE MONITORING AND TRAFFIC CHARACTERISTICS ON THE SLAC INTERNET BORDER. By Connie Logg, Les Cottrell (SLAC), Presented at CHEP-2001.
WHAT IS THE INTERNET DOING? PERFORMANCE AND RELIABILITY MONITORING FOR THE HEP COMMUNITY. By R.L.A. Cottrell, Connie A. Logg (SLAC), David E. Martin (Fermilab),. Published in **Comput.Phys.Commun.110:142-148,1998**

YEE-TING LI

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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

Shawn P. McKee

Randall Laboratory

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FAX: (734) 936-6529
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EDUCATION

1991	Ph.D., Physics, University of Michigan, Ann Arbor, Michigan
1986	B.Sc., Physics, Michigan State University, Lansing, Michigan
1986	B.Sc., Astrophysics, Michigan State University, Lansing, Michigan

EMPLOYMENT

2004-	Joint appointment with MGRID and Physics, Assoc. Research Scientist
2003-2004	Joint appointment with MGRID and Physics, Asst. Research Scientist
1999-2003	Asst. Research Scientist, Physics Department, University of Michigan
1993-1999	Research Fellow, Physics Department, University of Michigan
1992-1993	SSC Fellow, Physics Department, University of Michigan
1991-1992	Research Fellow, Physics Department, University of Michigan
1986-1991	Rackham Fellow, GRA, Physics Department, University of Michigan
1983-1986	Undergrad RA, National Superconducting Cyclotron Facility, Michigan State Univ.

POSITIONS

2001-	Network Project Manager, US ATLAS
2001-	Co-Chair, HENP Internet2 Working Group
2002 - 2005	Technical Lead, UM NMI Testbed
2003 - 2004	Internet2 End-to-End Technical Advisory Group Chair
2005-	Organizer of LHC Tier0-Tier1 Network Monitoring
2005-	Co-Chair of new Open Science Grid technical group on networking

RECENT RESEARCH ACTIVITIES

ATLAS (A Toroidal LHC AparatuS) One of three primary experiments planned for the Large Hadron Collider (LHC) at CERN which will search for the Higgs particle and explore a new energy regime. I am coordinating the online software and database activities for the MDT (Monitored Drift Tube) production at Michigan, as well as working on the detector simulation and analysis software. My current focus is the USATLAS grid testbed and network efforts, where I am the Network Project Manager.

MGRID (Michigan Grid Research and Infrastructure Development) An initiative focused on developing, deploying and testing a grid infrastructure for the University of Michigan. We are prototyping a grid environment for researchers at Michigan which provides valuable knowledge about how to build grids at the national and international levels. I am on the technical leadership team for this effort (http://www.mgrid.umich.edu)

NMI (NSF Middleware Initiative) Testbed Member - I am the technical coordinator for the Michigan testbed site. We are exploring how to best deploy and utilize middleware for grid computing environments like that of MGRID and large collaborations like ATLAS. (http://www.nsf-middleware.org)

SNAP (SuperNova Acceleration Probe) A billion pixel space-based telescope being designed to measure type 1a supernova with redshifts from 0.1 to 1.7 to determine the expansion history of our Universe. I am working on the simulation, software environment and computing efforts.

RECENT TALKS

1. "The Grid: The Future of HEP Computing?", University of Michigan Physics Department Seminar, January 7, 2002 (http://wlap.org/umich/phys/seminars/hep-astro/2002/mckee/)
2. "Grids, Networks and the Future of High-Energy Physics Computing", Institute of High-Energy Physics (IHEP), Beijing, China, September 9, 2003.
3. "SNAP Development Paradigm…Some Thoughts and Questions", SNAP Collaboration Meeting Parallel Session, Berkeley, CA, June 7th, 2005.
4. "The LHC-OPN Monitoring Working Group Report", LHC T0-T1 Optical Private Network meeting at Super Computing 2005, Seattle, WA, November 14th, 2005.
5. "UltraLight Overview", US ATLAS Tier-1 and Tier-2 Network Planning Meeting, invited talk, Brookhaven National Lab, NY, December 14, 2005.

SELECTED PUBLICATIONS

1. Indirect Detection of WIMPs Using Cosmic-Ray Positrons and Antiprotons: Current Status and Future Prospects, Shawn McKee, *Nuclear Physics B (Proc. Suppl.),* **51B**, 204-208, November (1996).

2. Measurements of the Cosmic-Ray Positron Fraction from 1 to 50 GeV (S. Barwick, J. Beatty, A. Bhattacharyya, C. Bower, C. Chaput, S. Coutu, G. de Nolfo, J. Knapp, D. Lowder, S. McKee, D. Müller, J. Musser, S. Nutter, E. Schneider, S. Swordy, G. Tarlé, A. Tomasch, and E. Torbet), *Ap. J. Lett.* **482**, L191-L194 (1997).

3. Interpreting the Atmospheric Neutrino Anomaly, (Shawn McKee and Rudolph P. Thun), *Physics Letters B,* **439**, 123-139 (1998).

4. "Opportunities for Use and Development of Collaborative Tools in ATLAS" *Goldfarb et al.* (*CERN ATL-GEN-2003-002)*

5. "The UltraLight Project: The Network as an Integrated and Managed Resource in Grid Systems for High Energy Physics and Data Intensive Science*",* (Harvey Newman, et al.)*, Computing in Science & Engineering, CiSESI-0020-045, Special Issue - Grid Computing Part II, November/December 2005.*

RECENT COLLABORATORS

William Adamson – University of Michigan
Homer Neal – University of Michigan
Peter Honeyman – University of Michigan
Charles Severance – University of Michigan
Gregory Tarle – Thesis Advisor
Alan Chodos – American Physical Society
Paul Avery – University of Florida
Harvey Newman - Caltech

Current and Pending Support

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

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

Investigator: **Harvey B. Newman**	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **CMS: Part of RESEARCH ACCOMPLISHMENTS AND FUTURE GOALS, HIGH ENERGY PHYSICS**

Source of Support: DoE – Grant DE-FG03-92-ER40701
Total Award Amount: $ 1,320,000 Total Award Period Covered: 11/1/04 – 10/31/06
Location of Project: California Institute of Technology/ CERN Geneva, Switzerland
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **LHCNET: US CERN Part of RESEARCH ACCOMPLISHMENTS AND FUTURE GOALS, HIGH ENERGY PHYSICS**

Source of Support: DOE Grant DE-FG02-05-ER41359
Total Award Amount: $ 4,400,000 Total Award Period Covered: 11/1/04 – 10/31/06
Location of Project: : California Institute of Technology/ CERN Geneva, Switzerland
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **ITR/AP: In International Virtual-Data Grid Laboratory for Data Intensive Science**

Source of Support: University of Florida – UF01087
Total Award Amount: $894,000 Total Award Period Covered: 09/01/01 – 08/31/06
Location of Project: : California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **The GriPhyn Project: Towards Petascale Data Grids**

Source of Support: University of Florida UF00113
Total Award Amount: $ 762,000 Total Award Period Covered: 09/01/00 – 08/31/06
Location of Project: : California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **STI: A Next Generated Integrated Environment for Collaborative Work Across Advanced Networks**

Source of Support: NSF - NSF GRANT#ANI-0230937
Total Award Amount: $ 750,000 Total Award Period Covered:10/01/02 – 09/30/06
Location of Project: : California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **US CMS Software and Computing Project at Fermilab**.

Source of Support: Fermilab under DOE prime contract DE-AC02-76CH03000
Total Award Amount: $ 235,000 Total Award Period Covered:11/1/2001 – 10/31/2006
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **An Inter-Regional Grid-Enabled Center for Research & Educational Outreach at FIU**

Source of Support: NSF - Subcontract under Florida International
Total Award Amount: $ 641,677 Total Award Period Covered: 11/01/02 – 10/31/06
Location of Project: Florida International University
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: ITR: **UltraLight: An Ultrascale Information System for Data Intensive Research**

Source of Support: NSF (PHY-0427110)
Total Award Amount: $ 1,008,000 Total Award Period Covered: 7/1/2004- 6/30/2008
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Wide-Area Network in Laboratory**

Source of Support: NSF # EIA-0303620
Total Award Amount: $ 110,000 Total Award Period Covered:9/01/2003 - 8/31/2008
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **The Particle Physics Data Grid Project: From Fabric to Physics, Empowering International Virtual Organizations for Frontier Science.**

Source of Support: DoE # DE-FC02-01ER25459
Total Award Amount: $364,000 Total Award Period Covered: 7/1/04 – 6/30/06
Location of Project: : California Institute of Technology/ CERN Geneva, Switzerland
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **LAMBDA Station: Exploiting Advanced Networks in Data Intensive High Energy Physics Applications**

Source of Support: DOE DE-FG02-04ER25613
Total Award Amount: $280,000 Total Award Period Covered: 9/15/2004 – 9/14/2006
Location of Project: : California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Interactive Grid Analysis Environment (IGAE)**

Source of Support: U.S. Department of State # S-LMAQM-04-GR-170
Total Award Amount: $100,000 Total Award Period Covered: 9/20/2004 – 9/20/2006
Location of Project: : California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Data Intensive Science University Network**

Source of Support: NSF PHY-0533280
Total Award Amount: $2,950,000 Total Award Period Covered: 5/1/2005- 4/30/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **PLaNetS: Physics Lambda Network System**

Source of Support: NSF
Total Award Amount: $4,308,000 Total Award Period Covered: 4/1/2006 – 3/31/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: Collaborative Technology for Distributed Science: Fusion Science and High Energy Physics**
Source of Support: DOE
Total Award Amount: $750,000 Total Award Period Covered: 7/1/2006 – 6/30/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒ Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: Center for Experimental and Simulation Portal Technologies**

Source of Support: DOE
Total Award Amount: $750,000 Total Award Period Covered: 7/1/2006 – 6/30/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: Sustaining and Extending Open Science Grid (SciDAC OSG)**

Source of Support: DOE
Total Award Amount: $750,000 Total Award Period Covered: 7/1/2006 – 6/30/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: The Data Gateways Institute – A SciDAC Enabling Technologies Institute**

Source of Support: DOE (Collaboration with Indiana University)
Total Award Amount: $1,072,495 Total Award Period Covered: 7/1/2006 – 6/30/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: LHC – Measurement Infrastructure**
Source of Support: DOE
Total Award Amount: $842,990 Total Award Period Covered: 7/1/2006 – 6/30/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:
Support: ☐Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title:
Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support

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

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

Investigator: **Julian Bunn**	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **ITR/AP: In International Virtual-Data Grid Laboratory for Data Intensive Science**

Source of Support: NSF PHY-0122557 (University of Florida – UF01087)
Total Award Amount: $1,055,000 Total Award Period Covered: 09/01/01 – 08/31/06
Location of Project: : California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **The GriPhyn Project: Towards Petascale Data Grids**

Source of Support: NSF ACI-0086044 (University of Florida UF00113)
Total Award Amount: $ 762,000 Total Award Period Covered: 09/01/00 – 08/31/06
Location of Project: : California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Data Intensive Science University Network**

Source of Support: NSF PHY-0533280 (UCLA 1000 G GB150)
Total Award Amount: $2,500,000 Total Award Period Covered: 6/01/2005- 5/31/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Interactive Physics Data Analysis using Streaming Grid Technology**

Source of Support: DOE (Deep West Technologies)
Total Award Amount: $15,000 Total Award Period Covered: 7/1/2006- 3/31/2007
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SCI: ETF Grid Infrastructure Group: Providing System Management and Integration for the Teragrid**

Source of Support: University of Chicago
Total Award Amount: $828,000 Total Award Period Covered: 8/1/2006-7/31/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **Contamination Transport**
Source of Support: NASA
Total Award Amount: $109,967 Total Award Period Covered: 8/1/2004-7/31/2006
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:
Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **PLaNetS: Physics Lambda Network System**
Source of Support: NSF
Total Award Amount: $2,359,500 Total Award Period Covered: 9/1/2006 – 8/31/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:
Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: Sustaining and Extending Open Science Grid (SciDAC OSG)**
Source of Support: DOE
Total Award Amount: $750,000 Total Award Period Covered: 7/1/2006 – 6/30/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:
Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: The Data Gateways Institute – A SciDAC Enabling Technologies Institute**
Source of Support: DOE (Collaboration with Indiana University)
Total Award Amount: $1,072,495 Total Award Period Covered: 7/1/2006 – 6/30/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:
Support: ☐Current ☒Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title: **SciDAC: LHC – Measurement Infrastructure**
Source of Support: DOE
Total Award Amount: $842,990 Total Award Period Covered: 7/1/2006 – 6/30/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:
Support: ☐Current ☐Pending Submission ☐Planned in Near Future ☐*Transfer of Support
Project/Proposal Title:
Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support

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

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

Investigator: **Sylvain Ravot**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **ITR: UltraLight: An Ultrascale Information System for Data Intensive Research**

Source of Support: NSF (PHY-0427110)
Total Award Amount: $1,008,000 Total Award Period Covered: 9/15/2004- 8/31/2007
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **SciDAC: LHC – Measurement Infrastructure**

Source of Support: DOE
Total Award Amount: $842,990 Total Award Period Covered: 7/1/2006 – 6/30/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Current and Pending Support

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

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

Investigator:
Iosif Legrand

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **ITR: UltraLight: An Ultrascale Information System for Data Intensive Research**

Source of Support: NSF (PHY-0427110)
Total Award Amount: $1,008,000 Total Award Period Covered: 9/15/2004- 8/31/2007
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **PLaNetS: Physics Lambda Network System**

Source of Support: NSF
Total Award Amount: $2,359,500 Total Award Period Covered: 9/1/2006 – 8/31/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **SciDAC: LHC – Measurement Infrastructure**

Source of Support: DOE
Total Award Amount: $842,990 Total Award Period Covered: 7/1/2006 – 6/30/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support: NSF
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending Submission ☐ Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:

Current and Pending Support

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

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

Investigator: **Conrad Steenberg**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: [X] Current [ ] Pending Submission [ ] Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **ITR: UltraLight: An Ultrascale Information System for Data Intensive Research**

Source of Support: NSF (PHY-0427110)
Total Award Amount: $1,008,000 Total Award Period Covered: 9/15/2004- 8/31/2007
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: [ ] Current [X] Pending Submission [ ] Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **PLaNetS: Physics Lambda Network System**

Source of Support: NSF
Total Award Amount: $2,359,500 Total Award Period Covered: 9/1/2006 – 8/31/2011
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: [ ] Current [ ] Pending Submission [ ] Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title: **SciDAC: LHC – Measurement Infrastructure**

Source of Support: DOE
Total Award Amount: $842,990 Total Award Period Covered: 7/1/2006 – 6/30/2010
Location of Project: California Institute of Technology
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: [ ] Current [ ] Pending Submission [ ] Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title:

Source of Support: NSF
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: [ ] Current [ ] Pending Submission [ ] Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: [ ] Current [ ] Pending Submission [ ] Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: [ ] Current [ ] Pending Submission [ ] Planned in Near Future [ ] *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:

Current and Pending Support

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

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

Investigator: Roger Cottrell	Other agencies (including NSF) to which this proposal has been/will be submitted.

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

Project/Proposal Title: Terapaths: DataGrid Wide Area Network Monitoring Infrastructure

Source of Support: DoE

Total Award Amount: $400,000 Total Award Period Covered: 9/1/2005 – 9/31/2006

Location of Project: SLAC

Person-Months Per Year Committed to the Project. 24 Cal: Acad: Sumr:

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

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

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

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

Investigator: Yee-Ting Li	Other agencies (including NSF) to which this proposal has been/will be submitted.

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

Project/Proposal Title: Terapaths: DataGrid Wide Area Network Monitoring Infrastructure

Source of Support: DoE

Total Award Amount: $400,000 Total Award Period Covered: 9/1/2005 – 9/31/2006

Location of Project: SLAC

Person-Months Per Year Committed to the Project. 24 Cal: Acad: Sumr:

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

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

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

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

Investigator: Connie Logg	Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

B

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

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

Investigator: **Shawn P. McKee**

Other agencies (including NSF) to which this proposal has been/will be submitted.

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

Project/Proposal Title: **UltraLight: An Ultra-scale Optical Network Laboratory for Next Generation Science**

Source of Support: **NSF**

Total Award Amount: **$ 2,000,000** Total Award Period Covered: **07/01/04 - 06/31/08**

Location of Project: **California Institute of Technology**

Person-Months Per Year Committed to the Project. 0.5 Cal: 0.5 Acad: 0.0 Sumr: 0.0

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

Project/Proposal Title: **PLaNetS: Physics Lambda Network System**

Source of Support**: NSF/California Institute of Technology**

Total Award Amount: **$4,308,500** Total Award Period Covered: **7/1/06 – 6/30/11**

Location of Project: **California Institute of Technology**

Person-Months Per Year Committed to the Project. 0.5 Cal: 0.5 Acad: 0.0 Sumr: 0.0

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

Project/Proposal Title: **TeraPaths: A QoS Enabled Collaborative Data Sharing Infrastructure for Peta-scale Computing Research**

Program notice: DE-FG01-04ER04-03/LAB 04-03

Source of Support: **DOE**

Total Award Amount: **$ 800,000** Total Award Period Covered: **07/01/04 - 06/31/07**

Location of Project: **University of Michigan**

Person-Months Per Year Committed to the Project. 0.5 Cal: 0.5 Acad: 0.0 Sumr: 0.0

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

Project/Proposal Title: **SCI: NMI Development GridNFS**

Source of Support: **NFS**

Total Award Amount: **$1,254,981** Total Award Period Covered: **09/14/04-09/13/07**

Location of Project: **University of Michigan**

Person-Months Per Year Committed to the Project. 1 Cal: 1.0 Acad: 0.0 Sumr: 0.0

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

Project/Proposal Title: **LHC – Measurement Infrastructure**

Source of Support: **DOE**

Total Award Amount: $ **358,269** Total Award Period Covered**: 07/01/06-06/30/10**

Location of Project: **University of Michigan**

Person-Months Per Year Committed to the Project. Cal: 2.0 Acad: 0.0 Sumr: 0.0

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

RESEARCH & RELATED BUDGET - SECTION A & B, BUDGET PERIOD 1

*** ORGANIZATIONAL DUNS:** 0095842100000

*** Budget Type:** ☐ Project ☑ Subaward/Consortium

Enter name of Organization: California Institute of Technology

Reset Entries *** Start Date:** 07/01/2006 *** End Date:** 06/30/2007 **Budget Period: 1**

(If the Reset Entries button is pressed, please navigate to previous year to enable the submission of the form.)

A. Senior/Key Person

	Prefix	* First Name	Middle Name	* Last Name	Suffix	* Project Role	Base Salary ($)	Cal. Months	Acad. Months	Sum. Months	* Requested Salary ($)	* Fringe Benefits ($)	* Funds Requested ($)
1.	Dr	Harvey		Newman		PD/PI					0.00	0.00	0.00
2.	Dr.	Julian		Bunn		Senior Personnel					0.00	0.00	0.00
3.	Mr	Sylvain		Ravot		Senior Personnel					0.00	0.00	0.00
4.	Dr	Iosif		Legrand		Senior Personnel					0.00	0.00	0.00
5.	Dr	Conrad		Steenberg		Senior Personnel					0.00	0.00	0.00
6.													
7.													
8.													
9.	**Total Funds requested for all Senior Key Persons in the attached file**												

Total Senior/Key Person **0.00**

Additional Senior Key Persons: Add Attachment Delete Attachment View Attachment

B. Other Personnel

* Number of Personnel	* Project Role	Cal. Months	Acad. Months	Sum. Months	* Requested Salary ($)	* Fringe Benefits ($)	* Funds Requested ($)
	Post Doctoral Associates						
	Graduate Students						
	Undergraduate Students						
	Secretarial/Clerical						
1	Other Professional (Technician, Programmer, etc.)	12.00			79,468.00	20,264.00	99,732.00
1	**Total Number Other Personnel**					**Total Other Personnel**	99,732.00

Total Salary, Wages and Fringe Benefits (A+B) **99,732.00**

OMB Number: 4040-0001

Expiration Date: 04/30/2008

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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: California Institute of Technology - - SciDAC: LHC - Measurement Infrastructure Year 1

Budget Page No: 1 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Harvey Newman

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. Harvey Newman					
2. Julian Bunn					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				0.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	12.00			79,468.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				79,468.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				20,264.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				99,732.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) An end-to-end network and grid monitoring system, integrated with our network and grid management tools running on LHCNet, ESnet and the LHC Tier1 and Tier2 facilities in the US and Europe					
TOTAL PERMANENT EQUIPMENT				17,600.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				5,500.00	
2. FOREIGN				4,500.00	
TOTAL TRAVEL				10,000.00	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				10,000.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS				284,199.67	
6. OTHER					
TOTAL OTHER DIRECT COSTS				294,199.67	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				421,531.67	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52.34% x $119,733 & 52.34% x $50,000					
TOTAL INDIRECT COSTS				88,838.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				510,369.67	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				510,369.67	0.00

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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: California Institute of Technology - SciDAC: LHC - Measurement Infrastructure Year 2

Budget Page No: 2 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Harvey Newman

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. Harvey Newman					
2. Julian Bunn					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				0.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	12.00			82,250.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				82,250.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				20,974.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				103,224.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) "An end-to-end network and grid monitoring system, integrated with our network and grid management tools running on LHCNet, ESnet and the LHC Tier1 and Tier2 facilities in the US and Europe"					
TOTAL PERMANENT EQUIPMENT				18,216.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				5,692.00	
2. FOREIGN				4,658.00	
TOTAL TRAVEL				10,350.00	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				10,350.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS				286,113.18	
6. OTHER					
TOTAL OTHER DIRECT COSTS				296,463.18	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				428,253.18	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52.34% x $123,923					
TOTAL INDIRECT COSTS				64,860.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				493,113.18	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				493,113.18	0.00

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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: California Institute of Technology - SciDAC: LHC - Measurement Infrastructure Year 3

Budget Page No: 3 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Harvey Newman

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. Harvey Newman					
2. Julian Bunn					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				0.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	12.00			85,128.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				85,128.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				21,708.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				106,836.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) "An end-to-end network and grid monitoring system, integrated with our network and grid management tools running on LHCNet, ESnet and the LHC Tier1 and Tier2 facilities in the US and Europe"					
TOTAL PERMANENT EQUIPMENT				18,853.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				5,892.00	
2. FOREIGN				4,820.00	
TOTAL TRAVEL				10,712.00	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				10,712.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS				295,060.63	
6. OTHER					
TOTAL OTHER DIRECT COSTS				305,772.63	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				442,173.63	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52.34% x $128,261					
TOTAL INDIRECT COSTS				67,132.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				509,305.63	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				509,305.63	0.00

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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: California Institute of Technology - SciDAC: LHC - Measurement Infrastructure Year 4

Budget Page No: 4 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR: Harvey Newman

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. Harvey Newman					
2. Julian Bunn					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				0.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	12.00			88,108.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				88,108.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				22,467.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				110,575.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) "An end-to-end network and grid monitoring system, integrated with our network and grid management tools running on LHCNet, ESnet and the LHC Tier1 and Tier2 facilities in the US and Europe"					
TOTAL PERMANENT EQUIPMENT				19,513.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				6,098.00	
2. FOREIGN				4,990.00	
TOTAL TRAVEL				11,088.00	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				11,087.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS				292,397.34	
6. OTHER					
TOTAL OTHER DIRECT COSTS				303,484.34	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				444,660.34	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52.34% x $132,750					
TOTAL INDIRECT COSTS				69,481.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				514,141.34	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				514,141.34	0.00

Budget Justification for "SciDAC - Monitoring"
Caltech
Year 1

Proposed budget includes:

Salaries $79,468:
Funding for .85 FTE's for **Management/Administration and Operations**
(.15 FTE's for **"An end-to-end network and grid monitoring system, integrated with our network and grid management tools running on LHCNet, ESnet and the LHC Tier1 and Tier2 facilities in the US and Europe" included under Equipment)**.
Total 1 FTE

Salaries and wages are based upon University established salaries which are comparable to others doing similar research effort both within and outside the University Industry.

Fringe Benefits $20,264:

The staff benefit rate at Caltech is 25.5% on salaries.

Fringe benefit rate is based upon an approved rate of 25.5%.

Equipment $17,600:

The Equipment budget is intended to support .15 FTE's for **"An end-to-end network and grid monitoring system, integrated with our network and grid management tools running on LHCNet, ESnet and the LHC Tier1 and Tier2 facilities in the US and Europe"**
Salaries: $14,024
Staff Benefits: $3,576

Cost estimates are based upon past experience of purchase of similar or like items.

Travel $10,000:

The Travel budget is intended to support travel by the staff to work in the US and foreign countries on the experiment and to support travel to collaboration meetings and conferences in the US and foreign countries.

Domestic travel:

4 Domestic trips for 5 days each

Airfare roundtrip	350
Car Rental	175

Hotel	450
Per diem & other costs	400
Domestic total per trip:	*$1,375*
Domestic travel:	*$5,500*

Foreign travel:

2 Foreign trips for 7 days

Airfare roundtrip	900
Hotel	650
Per diem & Other costs	700
Estimated cost per trip	*$2,250*
Total Foreign travel:	*$4,500*

Travel cost estimates are based upon past experience of similar number of trips to similar travel destinations.

Materials & Supplies $10,000:

The amount requested under **M&S** is intended to purchase workstations, disks and other computing supplies necessary to enable the staff working on the project.

Cost estimates are based upon past experience of purchase of similar or like items.

Materials & Supplies $10,000:

The amount requested under **M&S** is intended to purchase workstations, disks and other computing supplies necessary to enable the staff working on the project.

Cost estimates are based upon past experience of purchase of similar or like items.

Indirect Costs $88,838:

The Indirect Cost Rate of 52.34% is assessed on the direct costs related to **Management/Administration and Operations** and on the first $25,000 of each subcontract.

Year 2 - 4

Caltech's budget is incremented by 3.5% inflation per year.

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(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

ORGANIZATION
SLAC - SciDAC: LHC - Measurement Infrastructure Year 1

Budget Page No: 1 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Roger Leslie Cottrell	1.00			13,587.00	
2. Yee Ting Li	1.00			6,760.00	
3. Connie Logg	6.00			58,800.00	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				79,147.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)				18,189.00	
3. (1) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				97,336.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				24,758.45	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				122,094.45	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) File Server					
TOTAL PERMANENT EQUIPMENT				11,000.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,000.00	
2. FOREIGN				3,000.00	
TOTAL TRAVEL				6,000.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				13,243.00	
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				13,243.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				0.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				152,337.45	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 36% x $128,095 & 6.8% of $11,000					
TOTAL INDIRECT COSTS				46,862.22	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				199,199.67	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				199,199.67	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
SLAC - SciDAC: LHC - Measurement Infrastructure Year 2

Budget Page No: 2 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Roger Leslie Cottrell	1.00			14,131.00	
2. Yee Ting Li	1.00			14,061.00	
3. Connie Logg	6.00			61,152.00	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				89,344.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				12,611.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				101,955.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				27,678.68	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				129,633.68	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.) Powerful computers for high throughput testing					
TOTAL PERMANENT EQUIPMENT				12,500.00	
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,120.00	
2. FOREIGN				3,120.00	
TOTAL TRAVEL				6,240.00	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					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				0.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				148,373.68	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 36% x $135,874 & 6.8% of $12,500					
TOTAL INDIRECT COSTS				49,764.50	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				198,138.18	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				198,138.18	0.00

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ORGANIZATION
SLAC - SciDAC: LHC - Measurement Infrastructure Year 3

Budget Page No: 3 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Roger Leslie Cottrell	1.00			14,696.00	
2. Yee Ting Li	1.00			7,312.00	
3. Connie Logg	6.00			63,598.00	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				85,606.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				20,263.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				105,869.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				26,798.80	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				132,667.80	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,245.00	
2. FOREIGN				3,245.00	
TOTAL TRAVEL				6,490.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				14,752.00	
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				14,752.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				0.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				153,909.80	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 36% x $139,158					
TOTAL INDIRECT COSTS				50,096.83	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				204,006.63	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				204,006.63	0.00

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ORGANIZATION
SLAC - SciDAC: LHC - Measurement Infrastructure Year 4

Budget Page No: 4 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Roger Leslie Cottrell	1.00			7,642.00	
2. Yee Ting Li	1.00			7,604.00	
3. Connie Logg	6.00			66,142.00	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. ( ) TOTAL SENIOR PERSONNEL (1-6)				81,388.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)					
3. (1) GRADUATE STUDENTS				21,074.00	
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				102,462.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				25,539.90	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				128,001.90	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,375.00	
2. FOREIGN				3,375.00	
TOTAL TRAVEL				6,750.00	0.00
F. TRAINEE/PARTICIPANT COSTS					
1. STIPENDS (Itemize levels, types + totals on budget justification page)				14,895.00	
2. TUITION & FEES					
3. TRAINEE TRAVEL					
4. OTHER (fully explain on justification page)					
TOTAL PARTICIPANTS ( ) TOTAL COST				14,895.00	0.00
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES					
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				0.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				149,646.90	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 36% x $134,751					
TOTAL INDIRECT COSTS				48,510.44	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				198,157.34	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				198,157.34	0.00

Budget Justification – SLAC

SLAC Personnel

R. Les Cottrell — (0.073 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 - (0.082 FTE) and Connie Logg (0.5 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.

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
Two senior staff members will each attend one domestic meetings each year to present results, and meet face to face with partners. The domestic travel will include trips to LHC-MI 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 meeting to present results, collaborate with Geant developers and meet with LHC people.

Other Direct Costs-
Item G.1: Materials and supplies – The first year budget includes $11,000 for a file server to provide archive support for the IEPM active end-to-end and passive Netflow and perfSONAR measurements. The second year includes $12,500 for two high performance computers with10GE NICs. These will replace aging computers which we have on loan at the moment.

Item G.6: The estimated cost of tuition for one graduate student for 9 academic months throughout the project. They will also be one summer student for the first year 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.

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ORGANIZATION
University of Michigan - SciDAC: LHC - Measurement Infrastructure Year 1

Budget Page No: 1 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Shawn McKee	2.00			9,738.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				9,738.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	6.00			27,700.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				37,438.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				10,483.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				47,921.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,000.00	
2. FOREIGN				2,000.00	
TOTAL TRAVEL				5,000.00	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				3,000.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				3,000.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				55,921.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52% x $55,921					
TOTAL INDIRECT COSTS				29,079.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				85,000.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				85,000.00	0.00

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U.S. Department of Energy

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ORGANIZATION
University of Michigan - SciDAC: LHC - Measurement Infrastructure Year 2

Budget Page No: 2 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Shawn McKee	2.00			10,000.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				10,000.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	6.00			29,300.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				39,300.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				11,004.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				50,304.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,000.00	
2. FOREIGN				2,000.00	
TOTAL TRAVEL				5,000.00	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				2,574.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				2,574.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				57,878.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52% x $57,878					
TOTAL INDIRECT COSTS				30,097.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				87,975.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				87,975.00	0.00

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Budget Page

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ORGANIZATION
University of Michigan - SciDAC: LHC - Measurement Infrastructure Year 3

Budget Page No: 3 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Shawn McKee	2.00			10,300.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				10,300.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	6.00			30,300.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				40,600.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				11,368.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				51,968.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,000.00	
2. FOREIGN				2,000.00	
TOTAL TRAVEL				5,000.00	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				2,936.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				2,936.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				59,904.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52% x $59,904					
TOTAL INDIRECT COSTS				31,150.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				91,054.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				91,054.00	0.00

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ORGANIZATION
University of Michigan - SciDAC: LHC - Measurement Infrastructure Year 4

Budget Page No: 4 of 4

PRINCIPAL INVESTIGATOR/PROJECT DIRECTOR
Harvey Newman

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. Shawn McKee	2.00			10,600.00	
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET EXPLANATION PAGE)					
7. (2) TOTAL SENIOR PERSONNEL (1-6)				10,600.00	0.00
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. ( ) POST DOCTORAL ASSOCIATES					
2. (1) OTHER PROFESSIONAL (TECHNICIAN, PROGRAMMER, ETC.)	6.00			31,703.00	
3. ( ) GRADUATE STUDENTS					
4. ( ) UNDERGRADUATE STUDENTS					
5. ( ) SECRETARIAL - CLERICAL					
6. ( ) OTHER					
TOTAL SALARIES AND WAGES (A+B)				42,303.00	0.00
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				11,844.00	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A+B+C)				54,147.00	0.00
D. PERMANENT EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM.)					
TOTAL PERMANENT EQUIPMENT					
E. TRAVEL 1. DOMESTIC (INCL. CANADA AND U.S. POSSESSIONS)				3,000.00	
2. FOREIGN				2,000.00	
TOTAL TRAVEL				5,000.00	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				2,853.00	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION					
3. CONSULTANT SERVICES					
4. COMPUTER (ADPE) SERVICES					
5. SUBCONTRACTS					
6. OTHER					
TOTAL OTHER DIRECT COSTS				2,853.00	0.00
H. TOTAL DIRECT COSTS (A THROUGH G)				62,000.00	0.00
I. INDIRECT COSTS (SPECIFY RATE AND BASE) (Excludes D. and G. 4-6) 52% x $62,000					
TOTAL INDIRECT COSTS				32,240.00	
J. TOTAL DIRECT AND INDIRECT COSTS (H+I)				94,240.00	0.00
K. AMOUNT OF ANY REQUIRED COST SHARING FROM NON-FEDERAL SOURCES					
L. TOTAL COST OF PROJECT (J+K)				94,240.00	0.00

BUDGET EXPLANATION PAGE
FOR COMPLETING DOE F 4620.2 (BUDGET PAGE)

7/1/06 – 6/30/10

Section	**Project Dollars**
A. Senior Personnel	**$40,638**

(List personnel, salary funds, and the number of person months as on the Budget Pages(s). Also include a written narrative that fully justifies the need for requested personnel.)

Name	Position	Hours/Time	Salary
Shawn Mckee	PI, Associate Researcher	2 cal months/year	$40,638
			$

B. Other Personnel	**$119,003**

(List personnel, salary funds, and the number of person months as on the Budget Pages(s). Also include a written narrative that fully justifies the need for requested personnel.)

Name	Position	Hours/Time	Salary
TBA	Technician/Programmer	6 calendar months/year	$119,003
			$

Explanation/Justification of Cost (for both A & B above)
Salaries/Wages are based upon University established rates/salaries which are comparable to others doing similar research effort both within and outside the University.

Shawn McKee — (0.16 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.

New Hire - (0.5 FTE) will be responsible for; research, detailed data definition and persistency design and implementation as LHC-MI modules and implementation of accounting interfaces.

Both Shawn McKee and the Technician/Programmer will be producing the Michigan deliverables for the LHC-MI project.

C. Fringe Benefits (Must include the current fringe benefit rate established for your organization as well as the total cost or a list of cost and type for each individual employed on the project.	**$44,699**

Explanation/Justification of cost
The University of Michigan does not have a negotiated fringe benefit rate. Rather, estimates of probable benefits expenses are used in proposal budgets; grants and contracts are then charged for actual benefits expenses incurred, in direct proportion to the applicable salaries and wages charged. Individual units are encouraged to examine their benefits patterns to determine an appropriate estimator. Currently, campus-wide benefits average 30%. Given the mix of personnel involved in this project, the unit determined that a lower rate of 28% was appropriate.

A table displaying the various benefits expenses follows:

Staff Benefits for 2006 (as of 1/1/2006)
Last Reviewed: 1/17/06 By DRDA

Maximum Chargeable to Federally Sponsored Accounts

Salary Level	Social Security & Medicare	TIAA/ CREF	Major Medical (family)	Dental (family)	Pre-scription Drugs	Disability & Group Life Insurance	Other Expenses	Total	Percent of Salary
$20,000	1,530	2,000	9,446	706	0	229	582	14,493	72.5%
$30,000	2,295	3,000	9,446	706	0	323	812	16,582	55.3%
$40,000	3,060	4,000	9,446	706	0	323	1,042	18,577	46.4%
$50,000	3,825	5,000	9,446	706	0	323	1,272	20,572	41.1%
$60,000	4,590	6,000	9,446	706	0	323	1,502	22,567	37.6%
$70,000	5,355	7,000	9,446	706	0	323	1,732	24,562	35.1%
$80,000	6,120	8,000	9,446	706	0	323	1,962	26,557	33.2%
$90,000	6,885	9,000	9,446	706	0	323	2,192	28,552	31.7%
$100,000	7,290	10,000	9,446	706	0	323	2,422	30,187	30.2%
$110,000	7,435	11,000	9,446	706	0	323	2,652	31,562	28.7%
$120,000	7,580	12,000	9,446	706	0	323	2,882	32,937	27.4%
$130,000	7,725	13,000	9,446	706	0	323	3,112	34,312	26.4%
$140,000	7,870	14,000	9,446	706	0	323	3,342	35,687	25.5%
$150,000	8,015	15,000	9,446	706	0	323	3,572	37,062	24.7%
$160,000	8,160	16,000	9,446	706	0	323	3,802	38,437	24.0%
$170,000	8,305	17,000	9,446	706	0	323	4,032	39,812	23.4%
$180,000	8,450	18,000	9,446	706	0	323	4,262	41,187	22.9%
$190,000	8,595	19,000	9,446	706	0	323	4,492	42,562	22.4%
$200,000	8,740	20,000	9,446	706	0	323	4,722	43,937	22.0%
$210,000	8,885	21,000	9,446	706	0	323	4,952	45,312	21.6%
$220,000	9,030	22,000	9,446	706	0	323	5,182	46,687	21.2%
$230,000	9,175	23,000	9,446	706	0	323	5,412	48,062	20.9%
$240,000	9,320	24,000	9,446	706	0	323	5,642	49,437	20.6%

D. Equipment (List each item, cost and reason it is needed for the project) **$0**

Item _____ Cost $

Explanation/Justification of Cost

Cost estimates are based upon past experience of purchase of similar or like items.

E. Travel (List each trip's destination, dates, estimated costs including transportation and subsistence, number of staff traveling, purpose of the travel and how it relates to the project) **$20,000**

Domestic $

Destination/Number of Individuals | Lodging/Subsistence | Cost Estimate | Dates (From – To)

Collaboration Mtgs, Conferences, 16 trips		$12,000 ($750/trip)	Jul 1, 2006-June 30, 2010

Foreign $

Destination/Number of Individuals	Lodging/Subsistence	Cost Estimate	Dates (From – To)
GGF, CERN, 4 trips		$8,000 ($2,000/trip)	Jul 1, 2006-June 30, 2010

Explanation/Justification of Cost

Travel cost estimates are based upon past experience of similar trips to similar destinations. We include the cost of semi-annual collaboration meetings and domestic conferences (Joint-techs, Internet2, SciDAC). International travel to CERN (LHC-OPN meetings, LHC meetings) and Global Grid Forum (GGF) meetings are budgeted.

F. Trainee/Participant Costs **$0**

Explanation/Justification of Cost

G. Other Direct Costs (Total Amount) **$11,363**

1. **Materials and Supplies** (Indicate types required and estimate of cost) $11,363

Type	Cost
Postage, overnight express, freight	$0
Telephone, long distance toll charges, ISDN, Video conferencing	$
Copying, duplication	$0
General office consumables	$2,000
General laboratory consumables	$2,000
General computing consumables, software	$7,363
Books, manuals	$0

Cost estimates are based upon past experience of purchases of similar or like items. This includes purchase of a database server and workstation to support the LHC-MI project deliverables.

2. **Publication Costs/Documentation/Dissemination** $0

Cost estimates are based upon past experience of purchases of similar or like items.

3. **Consultant Services** $0

Cost estimates are based upon past experience of services.

4. **Computer (ADP) Services** (Include justification based upon established computer service) $0

Cost estimates are based upon past experience of services and purchases of like items.

5. **Subcontracts** (Include separate budget and justification) $0

6. **Other Direct Costs** (Itemize and justify – place tuition expense here) $0

Type	Cost
Student tuition expense	$

Graduate student tuition expenses are based on current tuition rates, other estimates are based on quotes, vendor price lists and past purchases of similar nature.

H. Total Direct Costs	**$235,703**

I. Indirect Costs	**$122,566**

Explanation/Justification of Cost

Indirect Cost rate(s) is/are based upon an approved rate from DHHS (Approved by Federal Agency rate, i.e. DCAA, DHHS, ONR, etc. Attach a copy of the approved Federal Agency Rate Agreement). The rate of 26% was negotiated January 19, 1999.

Federal

Fiscal 2004, 2005 & 2006
(7/1/2003 -- 6/30/2006)

Type	Rate
Research: Federal	on campus: **53.0%** off campus: **26.0%**
Instruction	on campus: **54.0%** off campus: **26.0%**
Other Sponsored Activity	on campus: **30.0%** off campus: **26.0%**

Fiscal 2007 & 2008
(7/1/2006 -- 6/30/2008)

Type	Rate
Research: Federal	on campus: **52.0%** off campus: **26.0%**
Instruction	on campus: **54.0%** off campus: **26.0%**
Other Sponsored Activity	on campus: **30.0%** off campus: **26.0%**

The above rates are provisional after June 30, 2008 until new a new rate is negotiated

J. Total Direct and Indirect Costs	**$358,269**

K. Amount of Cost Sharing (List the amount of proposed Cost Sharing and also provide the basis of the cost sharing. This will include the estimate of cost and copies of documentation you based the estimate on.)	**$0**

L. Total Cost of Project	**$358,269**

DISCLOSURE OF LOBBYING ACTIVITIES

Approved by OMB
0348-0046

Complete this form to disclose lobbying activities pursuant to 31 U.S.C.1352

Review Public Burden Disclosure Statement

1. * Type of Federal Action:

- ☐ a. contract
- ☑ b. grant
- ☐ c. cooperative agreement
- ☐ d. loan
- ☐ e. loan guarantee
- ☐ f. loan insurance

2. * Status of Federal Action:

- ☐ a. bid/offer/application
- ☑ b. initial award
- ☐ c. post-award

3. * Report Type:

- ☑ a. initial filing
- ☐ b. material change

4. Name and Address of Reporting Entity:

☑ Prime ☐ SubAwardee

** Name*

** Street 1* *Street 2*

** City* *State* *Zip*

Congressional District, if known:

5. If Reporting Entity in No.4 is Subawardee, Enter Name and Address of Prime:

6. * Federal Department/Agency:

7. * Federal Program

Office of Science Financial Assistance Program

CFDA Number, *if applicable:* 81.049

8. Federal Action Number, *if known:*

9. Award Amount, *if known:*

$

10. a. Name and Address of Lobbying Registrant:

Prefix ** First Name* *Middle Name*

** Last Name* *Suffix*

Street 1 *Street 2*

City *State* *Zip*

b. Individual Performing Services (including address if different from No. 10a)

Prefix ** First Name* *Middle Name*

** Last Name* *Suffix*

Street 1 *Street 2*

City *State* *Zip*

11.

Information requested through this form is authorized by title 31 U.S.C. section 1352. This disclosure of lobbying activities is a material representation of fact upon which reliance was placed by the tier above when the transaction was made or entered into. This disclosure is required pursuant to 31 U.S.C. 1352. This information will be reported to the Congress semi-annually and will be available for public inspection. Any person who fails to file the required disclosure shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

Signature: Completed on submission to Grants.gov

***Name:** *Prefix* ** First Name* *Middle Name*

** Last Name* *Suffix*

Title:

Telephone No.:

Date: Completed on submission to Grants.gov

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R&R SUBAWARD BUDGET ATTACHMENT(S) FORM

Instructions: On this form, you will attach the R&R Subaward Budget files for your grant application. Complete the subawardee budget(s) in accordance with the R&R budget instructions. Please remember that any files you attach must be a Pure Edge document.

Click here to extract the R&R Subaward Budget Attachment

Important: Please attach your subawardee budget file(s) with the file name of the subawardee organization. Each file name must be unique.

1) Please attach Attachment 1	UMICHIGANSubawardRR_Budget-V1 0-U	Add Attachment	Delete Attachment	View Attachment
2) Please attach Attachment 2	SLACSubawardRR_Budget-V1 0-slac1.xfd	Add Attachment	Delete Attachment	View Attachment
3) Please attach Attachment 3		Add Attachment	Delete Attachment	View Attachment
4) Please attach Attachment 4		Add Attachment	Delete Attachment	View Attachment
5) Please attach Attachment 5		Add Attachment	Delete Attachment	View Attachment
6) Please attach Attachment 6		Add Attachment	Delete Attachment	View Attachment
7) Please attach Attachment 7		Add Attachment	Delete Attachment	View Attachment
8) Please attach Attachment 8		Add Attachment	Delete Attachment	View Attachment
9) Please attach Attachment 9		Add Attachment	Delete Attachment	View Attachment
10) Please attach Attachment 10		Add Attachment	Delete Attachment	View Attachment

OMB Number: 4040-0001
Expiration Date: 04/30/2008