Monitoring Grid Functionality and Performance with Inca

ABSTRACT

Determining whether a Grid is “up” in the face of complex Grid software deployments can be difficult and depends on the types of applications and users that utilize it. By detailing a set of software, services, and features that should be available on a Grid in a machine-readable format, a Grid can be tested periodically by an automated system to verify its health and usability to users. To this end, we’ve developed Inca as a flexible framework for the automated testing, benchmarking and monitoring of Grid systems. Inca includes mechanisms to schedule the execution of information gathering scripts, and to collect, archive, publish, and display data. While initially developed for the TeraGrid project, Inca has been successfully deployed to other Grids worldwide. This tutorial will cover the Inca 2.0 software and engage attendees in hands-on sessions to customize their own Inca installations.

TUTORIAL DESCRIPTION

Grids users execute their applications at a large scale by accessing a number of compute, data, and visualization resources. Running applications on a Grid, however, can be difficult due to the distributed, heterogeneous nature of Grid resources and their susceptibility to failures. From a user's perspective, a Grid is "up" if they can run their particular application on a set of resources, access their data and the software/services their application requires, and get reasonably good performance. A Grid may appear to be "down" to a user due to Grid software stack, hardware, and network failures. In order to provide a unified, usable system for running scientific applications, Grid architects and system administrators define a set of Grid functionality requirements and test that resource providers are meeting those requirements. Due to the dynamic nature of Grids, periodic, automated testing is necessary in order to have confidence that users are able to successfully run their applications.

This tutorial presents Inca, a unique tool for verifying the reliability, functionality, and performance of today's production Grids. Inca offers user-level, automated, continuous checking and benchmarking of a Grid's services, software and environment. Inca includes mechanisms to schedule the execution of information gathering scripts, and to collect, archive, publish, and display data. The Inca project began three years ago in order to validate and verify software stack and services for the TeraGrid, a scientific discovery infrastructure with resources from eight U.S. partner sites. Inca continues to be the only tool whose primary objective is to provide *user-level* Grid functionality testing and performance measurement. A production release of Inca 2.0 software is planned for the summer of 2006 and will be ready to extend to the wider Grid community at SCI06.

Grid managers, site system administrators, and others responsible for delivering a usable Grid are the target audience for this tutorial. Grid managers can use Inca to verify that their resource provider requirements are being met and system administrators can use it use to debug user-level problems detected by Inca. Attendees will learn about the architecture and features of the Inca 2.0 software and participate in hands-on sessions to write Grid tests and deploy them within an Inca installation. Self-guided sessions throughout the tutorial will be provided for participants to work at their own pace and interests. Attendees are expected to be familiar with Grid systems, software and services and to have programming or scripting experience.

Material is based on a successful 2-day workshop provided at SDSC in February 2006 and will be updated for SCI06 with new content based on upgrades to the Inca software in 2006.

Tutorial Content:

Inca 2.0 overview:
We will describe the challenges and requirements of Grid testing and performance monitoring, provide an overview of Inca and its approach to Grid testing and performance monitoring and discuss how Inca relates to other monitoring tools. We will then show examples of Inca in use today including the Inca deployment on TeraGrid. Finally, we will discuss the status of the Inca 2.0 software and roadmap.

Working with Inca Reporters:
A reporter is an executable program that tests or measures some aspect of a Grid system or installed software. Attendees will learn about the input/output requirements for an Inca reporter and the process for publishing them into a repository where an Inca deployment can discover them. This session will also cover the Perl API libraries that facilitate the writing of reporters and will review the standard set of reporters available to users.

Inca Control Infrastructure:
The control infrastructure stages, schedules, and executes reporters on Grid resources. Attendees will learn about the control infrastructure architecture, design goals and configuration for executing sets of reporters on Grid resources. We will also describe features designed to ease installation and maintenance of an Inca deployment.

Administering Inca with incat:
Incat (Inca Administration Tool) is the GUI interface to Inca's control infrastructure. This talk parallels much of the control infrastructure talk and will illustrate how a user would configure Inca to test and/or measure performance of their Grid resources using incat.

Inside the Inca Depot:
The depot is the component of Inca responsible for storing data produced by reporters and deployment configuration. Attendees will learn about the architecture and design goals of the depot and the types of queries (including historical queries) and triggers (e.g., email) that it supports.

Inca data display:
Attendees will learn how to use JSP, tag libraries, stylesheets, and Jetty to display views of the testing and performance data collected by Inca in web pages. Specifically, we will describe an example to display the status of a common Grid software stack and environment.

DESCRIPTION OF HANDS-ON EXERCISES

1. **Reporters:** attendees will write sample reporters that exercise the Perl APIs described in Session II.
2. **Sample Inca Deployment:** attendees will learn how to specify resources, select and configure reporters, and set scheduling options. Users will install incat on their laptop and use it to connect to an Inca deployment on a machine located at SDSC in a self-guiding 2-part hands-on session. Attendees will then use incat to change the default configuration (add/delete/change reporters and add an additional resource located at SDSC).
3. **Data Display:** attendees will make small changes to the display of the Grid software stack web page from the default installation created in the hands-on exercise #2 above.

Requirements

Attendees will need laptops with SSH capability and JDK 1.4.2_09 or later. We will make the sample exercises available remotely.

TUTORIAL OUTLINE

Course Outline (morning):

I. **Inca 2.0 overview (45 mins)**
   a. Grid testing and performance monitoring challenges and requirements
   b. Inca goals and objectives
   c. Inca in use
      i. Software stack validation and verification
      ii. Network bandwidth measurements
      iii. Grid benchmarking
   d. Inca 2 Architecture/Components
   e. Inca Software Status

II. **Working with Inca Reporters (40 mins)**
   a. Goals and objectives
   b. Input/Output requirements
   c. Perl Reporter APIs and examples

III. ***Hands-on:*** **Reporter API and Repository (35 mins)**

IV. **Inca Control Infrastructure (30 mins)**
   a. Goals and objectives
   b. Description of control components
   c. Configuration options
   d. Installation and maintenance

V. **Administering Inca with incat (30 mins)**
   a. Installation and execution
   b. Specifying reporter repositories
   c. Specifying resources
   d. Managing suites and report series

Course Outline (afternoon):

VI. ***Hands-on:*** **Inca deployment - part 1 (30 mins)**

VII. **Inside the Inca Depot (30 mins)**
   a. Goals and objectives
   b. Architecture
   c. Storage capabilities
   d. Queries and triggers

VIII. **Inca data display (25 mins)**
   a. Overview
   b. Querying the depot
   c. Rendering depot query results in a web page

IX. ***Hands-on:*** **Inca data display (25 mins)**

X. ***Hands-on:*** **Inca deployment - part 2 (60 mins)**

SHAVA SMALLEN

San Diego Supercomputer Center
9500 Gilman Drive, Mail Code 0505
La Jolla, CA 92093-0505
(858)822-0962
ssmallen@sdsc.edu

EDUCATION:

M.S., Computer Science, University of California, San Diego, June 2001

B.S., Computer Science, *magna cum laude*, University of California, San Diego, June 1998

WORK EXPERIENCE:

Programmer/Analyst, San Diego Supercomputer Center, La Jolla, CA, October 2002 - present
Leading development of the Inca Test Harness and Reporting Framework, software for automated testing, verification, and monitoring of a Grid hosting environment.

Research Associate, Indiana University, Bloomington, IN, July 2001 - October 2002
Worked on science portal effort in the Extreme! Computing Lab under the supervision of Professor Dennis Gannon. Developed and maintained portal for ATLAS physicists to submit Athena jobs to the Grid using XCAT Science Portal framework software. This work was in collaboration with the IU Physics department, the US-ATLAS collaboration, and the Grid Physics Network (GriPhyN) project. Lead development of lab's next generation science portal software based on Apache's Jetspeed. Also, contributed to system administration of lab machines.

Graduate Student Researcher, University of California, San Diego, June 1998 - June 2001
Worked in the AppLeS (Application-Level Scheduling) group under the supervision of Professor Francine Berman to develop a dynamic scheduler for an on-line parallel tomography Grid application used by the National Center for Microscopy and Imaging Research. This work was part of a collaborative NPACI Alpha project, *Telescience for Advanced Tomography Applications*.

Applications Programmer, IBM Global Services, Santa Clara, CA, Summer 1997
Assisted in maintenance of an internal billing report, client-server application for Lucent Technologies. Developed project plan and interacted with customer for design and testing of an additional feature to application. Created server-side korn shell scripts, SQL queries, and SQR reports. Designed and implemented client-side user interface in Visual Basic.

Special Technical Associate in Network Systems, Lucent Technologies, Santa Clara, CA, Summer 1996
Assisted in maintenance of internal billing report, client-server application. Modified and created server-side korn shell scripts, Sybase SQL queries, and SQR reports. Designed client-side user interface for enhancements to application in Visual Basic. Also upgraded software on Windows NT systems.

TEACHING EXPERIENCE:

Tutorials

Kate Ericson, Jim Hayes, Shava Smallen, "Inca 2.0 Workshop", SDSC, February 23-24, 2006.

Sandeep Chandra, Sriram Krishnan, Shava Smallen, "Grid Services tutorial at ESRI", 1-day, Redlands, CA, Nov 2004.

Sandeep Chandra, Shava Smallen, "GT3 Tutorial", SDSC Summer Institute, August 24, 2004.

Courses

Guest Lecturer, *Web Programming*, University City High School, January-June 2000
Co-taught class with two other guest lecturers. Created assignments, designed curriculum, lectured, and assisted students in lab. Assisted with system administration of Linux machines.

Teaching Assistant, *Introduction to Parallel Computation*, University of California, San Diego, Spring 1999

Lead sections, created and graded programming projects, and helped students in lab. (Conjoined undergraduate and graduate course.)

PUBLICATIONS:

S. Smallen, C. Olschanowsky, K. Ericson, P. Beckman, and J. Schopf. "The Inca Test Harness and Reporting Framework", *Proceedings of Supercomputing 2004*, November 2004, Pittsburg, Pennsylvania.

D. Gannon, R. Bramley, G. Fox, S. Smallen, A. Rossi, R. Ananthakrishnan, F. Bertrand, K. Chiu, M. Farrellee, M. Govindaraju, S. Krishnan, L. Ramakrishnan, Y. Simmhan, A. Slominski, Y. Ma, C. Olariu, N. Rey-Cenevaz. "Programming the Grid: Distributed Software Components, P2P and Grid Web Services for Scientific Applications", *Journal of Cluster Computing*, 2002.

F. Berman, R. Wolski, H. Casanova, W. Cirne, H. Dail, M. Faerman, S. Figueira, J. Hayes, G. Obertelli, J. Schopf, G. Shao, S. Smallen, N. Spring, A. Su, D. Zagorodnov. "Adaptive Computing on the Grid Using AppLeS", *IEEE Transactions on Parallel and Distributed Systems*, Volume 14, Number 4, 2003.

Shava Smallen, Henri Casanova, and Francine Berman. "Applying Scheduling and Tuning to On-line Parallel Tomography", *Proceedings of Supercomputing 01*, November 2001, Denver, Colorado (Best student paper award). Extended version published in *Scientific Programming*, Volume 10, Number 4, 2002.

Shava Smallen, Walfredo Cirne, Jaime Frey, Francine Berman, Rich Wolski, Mei-Hui Su, Carl Kesselman, Steve Young, and Mark Ellisman. "Combining Workstations and Supercomputers to Support Grid Applications: The Parallel Tomography Experience," *Proceedings of the 9th Heterogenous Computing Workshop*, May 2000, Cancun, Mexico.

SELECTED PRESENTATIONS:

"The Inca Test Harness and Reporting Framework", Grid Performance Workshop, UK National eScience Centre, Edinburgh, June 2005.

"The Inca Test Harness and Reporting Framework", Supercomputing 2004, Pittsburgh, PA, November 2004.

"Grappa: Grid Access Portal for Physics Applications", ATLAS Software Week, CERN, Geneva, Switzerland, March 7, 2002 (also given at University of Versailles, Versailles, France, March 11, 2002).

"Telescience for Advanced Tomography Applications", HPC Games, SC99, Portland, OR, November 1999.

"Parallel Tomography", Globus Retreat, Redondo Beach, CA, July 1999.

PROFESSIONAL ACTIVITIES:

Supercomputing 2002 Technical Program Committee member.

AWARDS:

Best Student Paper Award, Supercomputing 01, November 2001.

VOLUNTEER WORK:

Barrio Logan College Institute, San Diego, CA, February 2000 - present

Web page design and maintenance.

Active Students for Kids, San Diego, CA, January 1997 - December 1998

Tutored 4th/5th grade students at Bay Park Elementary School one day a week.

James J. Hayes
4672 Desmond Circle, Oceanside, CA 92056
dulcimer@nethere.com

Education

M.S., Computer Science, UC San Diego, September, 1998. Focus: Software Engineering
B.S., Information and Computer Science, UC Irvine, June, 1982.

Programming Experience

Programmer/Analyst, San Diego Supercomputer Center, 2003 to present.
Member of a team that develops Inca, a system for monitoring the state of Grid resources.

Software Support Programmer, UCSD Grid Computing Laboratory, 1998 to 2003.
Provide software infrastructure for lab research projects in distributed computing. Produce software development tools and reusable modules useful in Grid program development. Restructure research software into releasable products. Provide documentation for lab software and procedures. Mentor graduate students working on research programming projects. Redesign and reimplement the Network Weather Service, an availability forecasting service for distributed computing resources, AMWAT, a distributed computing template for computational science, and APST, a tool for automating distributed application execution.

Research Assistant, UC San Diego Software Engineering Laboratory, 1997 to 1998.
Assist in the re-architecture of a medium-sized (100K lines of C++ and Tcl/Tk) graphical program restructuring tool. Adapt tool to new underlying AST architectures and source languages.

Senior Programmer/Analyst, TeleSoft Corporation, 1997 to 1990.
Member of a team that enhanced and maintained a symbolic Ada debugger on multiple systems. Primary responsibility for command parsing, error reporting, and window management functions of the debugger. Worked on adaptation of the debugger to the Sun Unix system.

Senior Programmer/Analyst, NCR Corporation, 1982 to 1986.
Member of project teams which produced compilers for NCR computers. Adapted Ada compilers to NCR 68000-based Unix systems. Designed, implemented and optimized code generator for a mainframe COBOL compiler. Produced software development tools and run-time resource management procedures.

Programmer, Public Policy Research Organization, 1980 to 1982.
Designed, implemented, and tested programs for statistical research. Worked extensively with faculty members of the UC Irvine School of Social Ecology.

Teaching Experience

Workshop, San Diego Supercomputer Center, 2006.
Taught several seminars and tutorials during a two-day workshop that introduced version 2 of the Inca grid monitoring system.

Software Seminars, UC San Diego Computer Science Department, 1999 to 2001.
Taught seminars on programming tools such as Perl, make, and CVS as part of the CS Department's Graduate Enrichment Seminar series.

Teacher's Assistant, UC San Diego Computer Science Department, 1996 to 1997.
Assist in the presentation of material on data structures, compiler code generation, and operating system architecture to undergraduates. Organize and lead discussion sections. Assist students with developing and debugger projects. Research and present material on Unix programming tools. TA Excellence Award from the UCSD Computer Science Department, 1996.

Publications

A. Birnbaum, J. Hayes, W. Li, M. Miller, P. Bourne, H. Casanova. "Grid workflow software for High-Throughput Proteome Annotation Pipeline", Proceedings of the *First International Workshop on Life Science Grid*, Ishikawa, Japan, June 2004.

W. Li, R. Byrnes, J. Hayes, V. Reyes, A. Birnbaum, A. Shabab, C. Mosley, D. Pekurowsky, G. Quinn, I. Shindyalov, H. Casanova, L. Ang, F. Berman, M. Miller, P. Bourne. "The Encyclopedia of Life Project: Grid Software and Deployment", *Journal of New Generation Computing on Grid Systems for Life Sciences*, 2004.

G. Cooperman, H. Casanova, J. Hayes, T. Witzel. "Using TOP-C and AMPIC to Port Large Parallel Applications to the Computational Grid", *Special Issue of Journal on Future Generation Computer Systems*, 2003.

H. Casanova, J. Hayes, Y. Yang. "Algorithms and Software to Schedule and Deploy Independent Tasks in Grid Environments", *Workshop on Distributed Computing, Metacomputing, and Resource Globalization*, Aussois, France, 2002.

R. Wolski, N. Spring, J. Hayes. "The Network Weather Service: A Distributed Resource Performance Forecasting Service for Metacomputing", *Journal of Future Generation Computing Systems,*October, 1999.

R. Wolski, N. Spring, J. Hayes. "Predicting the CPU Availability of Time-shared Unix Systems", *Proceedings of 8th IEEE High Performance Distributed Computing Conference*, August, 1999.

Kate Ericson
San Diego Supercomputer Center
9500 Gilman Drive, La Jolla, CA 92093-0505
kericson@sdsc.edu

EDUCATION:

B.A., Economics, Grinnell College, May 1996

PROFESSIONAL EXPERIENCE:

PROGRAMMER ANALYST III, SAN DIEGO SUPERCOMPUTER CENTER (SDSC)
SAN DIEGO, CA, 7/1/2004 - present

- Software deployment manager and programmer for the San Diego Supercomputer Center (SDSC).
- Contribute to the design, installation and management of a testing framework for large, multi-site Grids as part of the Inca project.
- Analyze, specify, design, and assist in implementation of the Inca system to address a variety of problems and tasks in scientific areas related to advanced computing and networking.
- Perform systems administration and analysis tasks, testing and benchmarking.
- Work with very complex systems and networks in a research and performance evaluation environment.
- Assume independent responsibility for Inca deployed on a variety of machines such as the TeraGrid cluster at SDSC.
- Resolve system engineering issues related to releasing Inca as production software.
- Collaborate with groups at nine TeraGrid partner sites, including the National Center for Supercomputing Applications (NCSA), Argonne National Laboratory (ANL), California Institute of Technology (Caltech) and Pittsburgh Supercomputing Center (PSC), for system integration.
- Work closely with SDSC's Grid Development Group, TeraGrid systems staff, and end users. Initiate collaboration with other Grids.
- Participate in SDSC and partner research projects.
- Create and maintain Inca software documentation and Web site.
- Develop Web and command line user interfaces to display Inca data.
- Supervise and mentor student interns.

SENIOR TECHNICAL WRITER
SAN DIEGO SUPERCOMPUTER CENTER (SDSC)
SAN DIEGO, CA, 5/1/01 - 6/30/04

- Technical writer and programmer for the San Diego Supercomputer Center (SDSC).
- Created documentation, GUIs, and applications (using object-oriented Perl, PHP, SQL, Javascript, Python, Shell Scripting, JSP, XSL, XML, UML, HTML, etc.) to support users of Grid and High-Performance Compute resources. Wrote HTML, including original page and graphic design.

- Worked closely with SDSC, TeraGrid, and PACI staff and users to develop highly functional and effective GUIs and documentation.
- Resolved GUI and documentation user issues.
- Designed, implemented, and maintained print and online documentation for the Scientific Computing Department (SciComp) and affiliated projects (e.g. TeraGrid and NPACI).
- Conceptualized, wrote, edited, proofread, and disseminated complex technical information in support of SciComp activities.
- Developed consistent writing standards for department Web presence.
- Created and maintained SciComp Web pages and associated graphics.
- Supervised and mentored student interns

PROGRAMMER ANALYST II, UNIVERSITY OF CALIFORNIA, SAN DIEGO (UCSD)
SAN DIEGO, CA, 2/1/01 - 4/30/01

- Programmer Analyst II for the California Space Institute (CalSpace) at UCSD.
- Space satellite operator and programmer for NASA's Triana satellite mission.
- Trained in Java programming, Unix/Linux systems, and Web design.

INTERN, UNIVERSITY OF CALIFORNIA, SAN DIEGO (UCSD)
SAN DIEGO, CA, 8/1/99 - 1/31/00

- Intern for Structural Engineering Department's Systems Analyst.
- Worked with NT/Win95/Win98 and Unix systems and servers in a networked heterogeneous environment of PCs, Macs, and Unix platforms for administration and research groups.
- System hardware/software configuration and maintenance, system and application program installation, troubleshooting, and repair for PC platforms.

PUBLICATIONS:

S. Smallen, C. Olschanowsky, K. Ericson, P. Beckman, and J. Schopf. "The Inca Test Harness and Reporting Framework", *Proceedings of Supercomputing 2004*, November 2004, Pittsburg, Pennsylvania.

TEACHING EXPERIENCE:

- San Diego Supercomputer Center, February 2006.
  Taught tutorials during a two-day workshop that introduced version 2 of the Inca grid monitoring system.
- San Diego Supercomputer Center, May 2004.
  Gave two-day tutorial on documentation for scientific computing.

PRESENTATIONS:

- Inca Overview, Supercomputing 2005, November 2005, Seattle, WA
- Inca Data Display, DEISA Grid Meeting, July 2005, Bologna, Italy
- Inca Project Plan, TeraGrid All Hands Meeting, April 2005, Austin, TX