

Evolutionary Design of Complex Systems

Open Technology for Software Evolution:
Hyperware, Architecture, and Process

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Technical Status Report

1. Ongoing Research and Development

1.1. Hyperware

Work on Chimera has been focused on producing the first beta candidate for Chimera 2.0. The beta release is scheduled for early February 1998. New features will include the ability to export and import hyperwebs in XML (Extensible Markup Language) format, integration with the Rivendell Tool Server (from Columbia University) and the ability to select among a choice of user-interface look-and-feels provided by the Java Foundation Classes. The first feature was included in anticipation of XML becoming the primary data format for structured information on the Web. The second feature allows Chimera to support delayed link traversals. The third feature allows end-users to select a look-and-feel for Chimera's hypermedia servers that matches the look-and-feel of the host platform. Features requested by Northrop such as a standardized plug-in architecture are still being developed and will be released later in the beta lifecycle.

Ken Anderson and Yuzo Kanomata both participated in the EDCS Cross Cluster meeting held at UC Irvine in October 1997. At this event, meetings were held between Chimera's developers and developers from Gail Kaiser's group at Columbia University in order to discuss ways to more tightly integrate Chimera, the Rivendell Tool Server, and the Pern Transaction manager. In addition, a meeting was held between Chimera's developers and Gary Brannum from Northrop Grumman to discuss ways in which Chimera can continue to support Northrop's EDCS-related efforts. This latter meeting resulted in the Chimera team developing a set of requirements and a "wish-list" of functionality from the Northrop group for inclusion in later versions of Chimera. Finally, a Chimera demo was given to Robert Stockton of the Gwydion team from CMU, who was interested in evaluating the use of Chimera to provide open hypermedia services to the Gwydion environment.

The WebDAV working group released the -05 version of its distributed authoring protocol specification draft [GW+97-2], and initial versions of its access control requirements document [Pal97], and access control protocol document [LG97]. The Internet Engineering Steering Group (IESG) approved the document "Requirements for a Distributed Authoring and Versioning Protocol for the World Wide Web" [SVW+98] for publication as an Informational RFC, completing this work item of the WebDAV working group.

Roy Fielding authored the revision of the Internet standard for Uniform Resource Identifiers [BFM97-2] and continues to guide it through the standards process with the expectation that it will be approved as an IETF Draft Standard in early 1998. He is also in the editorial group responsible for updating the HTTP/1.1 specification [FG+97-2] for its transition from Proposed to Draft Standard in mid-1998. Roy is currently working on a survey of software interconnection paradigms and their impact on application protocol performance, which will hopefully lead to a better understanding of how to design or dynamically choose the best protocol for different types of communication in a distributed hyperprogramming system.

1.2. Software Architecture

During this quarter, we conducted research in comparing various approaches to post-deployment software evolution. These approaches enable software systems to be updated to better suit the needs of customers after they have been deployed to customer sites.

We also continued our work in comparing various approaches to runtime software evolution. As a part of this effort, we organized and participated in a panel on dynamic software evolution at the EDCS Cluster Meeting in Austin, TX. Panel participants included Bob Balzer, David Garlan, Jim Veitch, John Peterson, Peyman Oreizy, Peter Feiler, and Rick Brenner. The participants outlined the role of their respective technology in supporting runtime software evolution and identified open research issues in the area.

In an effort that is a continuation of a paper presented at the SIGSOFT'96 (FSE4) conference [MT97], in which we motivated the need for a flexible subtyping and type checking mechanism for software architectures, we are developing an architectural type theory that will support architecture-based software evolution.

We have been revising the design and implementation of the Argo software architecture design environment to make it more efficient and flexible, and to ease integration with design tools implemented in Java. Specifically, we are preparing a Java version of the UML meta-model and associated visualizations in GEF and critics in Argo. In addition, a survey of design critiquing systems is still in progress.

1.3. Process

Integration of the mSQL relational database system with the Endeavors foundation is being pursued. This proof of concept project enables Endeavors to store system and user data in third party RDBMS or ORDBMS when configured accordingly by a system programmer. The system will connect to relational databases using the Java JDBC interface; therefore, any RDBMS that has a JDBC driver may be used to store Endeavors data. The integration uses a table scheme that provides indexed key fields for query performance, static scheme for system performance, and will allow for the use of ORDBMS when that technology is more readily available (oracle8, Informix, etc.). The integration shows that speed improvements are possible by the integration of a high-end database engine. The integration implementation uses an alternative caching mechanism which allows for efficient operation of Endeavors, even with very large projects. This implementation is enabling groundwork for user level (handler) integration of RDBMS software in which the Endeavors process engine is used in the management of legacy data stores.

A bug tracking system is being developed using Endeavors. The system allows for the input, storage, and retrieval of issues (bugs). The storage is into Endeavors Artifacts using the native file system or commercial database software at user discretion. Full user interface and data storage capabilities are in place. The user interface design uses pull-down selection boxes where possible to avoid free form text entry of issue submissions. This design feature will enable better tracking and quantifying of the issues and issue trends as submission vocabulary will be limited.

We have created alternate architectural configurations and implemented new ways of launching Endeavors from web pages and other applets.

New features have been added to the Endeavors user interface made possible by incorporating the new event model available in the JDK-1.1 release.

We are currently evaluating Rational Rose for Java as a tool for creating Endeavors Category hierarchies.

David Hilbert is continuing a survey of techniques for extracting usage information from automatically generated user interaction logs.

2. Participants

Faculty:

David Redmiles
David S. Rosenblum
Richard N. Taylor

Research Specialist:

Kenneth Anderson

Research Assistants:

Gregory Bolcer
Roy Fielding
David Hilbert
Peter Kammer
Michael Kantor
Rohit Khare
Neno Medvidovic
Peyman Oreizy
Jason Robbins
Shilpa Shukla
James Whitehead

Research Programmers:

Clay Cover
Arthur Hitomi
Yuzo Kanomata
Edwin Kraemer
Kari Nies

3. Notable Accomplishments and Technology Transition

3.1. Hyperware

Paul Gleichauf of the Gwydion team from CMU successfully downloaded and installed Chimera 2.0 alpha to begin an evaluation of Chimera's open hypermedia services. The results of this evaluation are pending.

Posters for both the Chimera open hypermedia system and WebDAV were presented at the California Software Symposium (CSS'97).

Capturing momentum generated by front-page InfoWorld coverage in October [Rad97] the UCI/

EDCS led WebDAV effort is now in the final stages of approval for its Web Distributed Authoring protocol document. Microsoft, Netscape, Xerox, Columbia University, and U.C. Irvine are currently developing WebDAV prototypes, indicating strong support for this emergent Internet standard. Once fielded, WebDAV technology will enhance and simplify collaborative authoring of documents.

The WebDAV Working Group held two meetings during this reporting period. A WebDAV Design Team meeting was held at Netscape, November 20-21, 1997, with attendees from Microsoft, Novell, Netscape, and U.C. Irvine. On December 8-9, 1997, WebDAV meetings were held at the Washington, DC IETF meeting, with 78 people in attendance.

Minutes from the Netscape Design Team meeting can be found at:

<http://lists.w3.org/Archives/Public/w3c-dist-auth/1997OctDec/0167.html>

Minutes from the Washington, DC IETF meeting can be found at:

<http://www.ics.uci.edu/pub/ietf/webdav/washington/minutes.html>

3.2. Software Architecture.

Nenad Medvidovic presented a paper titled “Domains of Concern in Software Architectures and Architecture Description Languages” (originally submitted and reported in the previous QR under the title “Architectural Domains: A Framework for Characterizing Architectural Description”) at the USENIX Conference on Domain-Specific Languages [MR97].

A paper entitled “Integrating ADLs with a Standard Design Method” was accepted to the 1998 International Conference on Software Engineering [RMRR97].

Jason Robbins attended CSS’97 (California Software Symposium) and presented the paper “Integrating C2 with the Unified Modeling Language” [RRR97]. Jason also demonstrated the Argo software architecture design environment at this symposium.

Peyman Oreizy presented a poster on UCI’s Dynamic Software Architecture technology at the California Software Symposium (CSS’97).

A paper entitled “Architecture-based Runtime Software Evolution” was accepted to the 1998 International Conference on Software Engineering [OMT97].

A paper entitled “Software Architecture and Component Technologies: Bridging the Gap” was submitted and accepted to the OMG-DARPA Workshop on Compositional Software Architectures [OMT97-2].

A paper entitled “On the Role of Connectors in Modeling and Implementing Software Architectures” was submitted to the Ninth IEEE International Workshop on Software Specification and Design (IWSSD-9) [ORT97].

A paper entitled “Architectural Implications of Common Operator Interfaces” was submitted and accepted to the 1998 Ground System Architectures Workshop (GSAW98) [TMO97].

Sugato Bagchi, a research staff member at IBM T. J. Watson Research Center, expressed interest in using GEF in a commercial product. Dinesh Katiyar of MayaSoft, Inc. expressed interest in

using GEF in a commercial product. Predrag Krstic, a physicist at Oak Ridge National Labs, expressed interest in using GEF. Robert A. Dennis, a researcher at UCLA's Crump Institute for Biological Imaging, expressed interest in using GEF and Argo in medical and biological courseware.

3.3. Process

The University of California, Irvine, Office of Financial Aid is considering using Endeavors for its internal and external processing of financial aid delivery.

A paper entitled "Supporting Distributed Workflow Using HTTP" was submitted for consideration to WWW7 [KB+97-2]. The paper describes the use of HTTP to provide support for distribution in Endeavors.

The Endeavors group gave Bonnie Nardi, an Apple Researcher, a demonstration of Endeavors and discussed potential for integration with Apple's bug tracking system.

This quarter we delivered the presentation portion of JavaTrain to Sun Microsystems. JavaTrain is a training system built on top of Endeavors for use in content creation and delivery of web-based training.

Both the Endeavors process support system and the EDEM Expectation-Driven Event Monitoring systems were demonstrated at the California Software Symposium (CSS'97).

An EDEM paper entitled "An Approach to Large-Scale Collection of Application Usage Data Over the Internet" was accepted for presentation at the 1998 International Conference on Software Engineering (ICSE'98) [HR97].

An EDEM paper entitled "Agents for Collecting Application Usage Data Over the Internet" was accepted for presentation at the 1998 Conference on Autonomous Agents (Agents'98) [HR97-2].

4. Progress on Inter/Intra Cluster Collaborations

4.1. Hyperware

As a result of the October Cross Cluster meeting at UC Irvine, the Rivendell Tool Server and the Pern Transaction manager were installed at UCI. Integration of Rivendell into Chimera is proceeding and is scheduled for release in the first beta of Chimera 2.0. Integration with Pern has been put on hold and will not be included in the first beta of Chimera 2.0 since it required substantial changes to the infrastructure of Chimera 2.0. This integration will appear later in the Chimera 2.0 beta lifecycle.

A group of students under the direction of Steve Dossick and Gail Kaiser at Columbia University developed a prototype WebDAV server which implemented the -05 version of the protocol. This effort is an important validation of the WebDAV protocol, showing that the protocol is implementable, and in a relatively short time period.

4.2. Software Architecture

Peyman Oreizy organized a panel on dynamic software evolution at the Architecture and Genera-

tion EDCS Cluster Meeting in Austin, Texas at MCC. Participants included Bob Balzer, David Garlan, Jim Veitch, John Peterson, Peyman Oreizy, Peter Feiler, and Rick Brenner. Participants outlined the role of their respective technology in supporting runtime software evolution and identified open research issues in the area.

Also at this meeting, Nenad Medvidovic hosted a birds-of-a-feather session on the Unified Modeling Language and its relationship to software architectures.

Also at this meeting, Jason Robbins presented a summary of the UML (Unified Modeling Language) object-oriented design notation and the content of the UCI Tech report “Integrating ADLs with a Standard Design Method” [RM+97-2].

Nenad Medvidovic also gave a talk on the UCI software architecture research project to the research group led by Don Batory at UT Austin. While there, he also participated in a two-day discussion centered on the relationship between UCI’s C2 and UTA’s GenVoca architectural styles.

UCI’s Dynamic Architecture research has been evaluated and adopted by Northrop Grumman’s B-2 avionics simulation environment project (directed by Greg Johnson). The B-2 simulation environment consists of a large collection of complex tools, comprising approximately 1.7 million SLOC. Northrop Grumman is using UCI’s C2 architectural style to model the complex relationships between tools and UCI’s dynamic architecture technology (e.g., ArchStudio, ArchShell, Argo) to reconfigure the B-2 avionics simulation environment during runtime.

4.3. Process

The Endeavors group participated in the October Cross Cluster EDCS meeting at UC Irvine where they held discussions with Columbia University about using Rivendell and Amber in Endeavors.

5. Publications

Kenneth M. Anderson, Richard N. Taylor, and E. James Whitehead, Jr. *A Critique of the Open Hypermedia Protocol*. Journal of Digital Information, special issue on open hypermedia systems, Vol.1 Issue.2. [ATW97]

Jason E. Robbins, David M. Hilbert, David F. Redmiles. *Extending design environments to software architecture design*. To appear in the International Journal of Automated Software Engineering. [RHR96-5]

Jason E. Robbins, David M. Hilbert, David F. Redmiles. *Software Architecture Critics in Argo*. To appear in the Proceedings of the 1998 Conference on Intelligent User Interfaces. [RHR97-2]

Jason E. Robbins, Nenad Medvidovic, David F. Redmiles, David S. Rosenblum. *Integrating Architecture Description Languages with a Standard Design Method*. To appear in the Proceedings of the 1998 International Conference on Software Engineering. [RMRR97]

Jason E. Robbins, Nenad Medvidovic, David F. Redmiles, and David S.

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David M. Hilbert, David F. Redmiles. *An Approach to Large-Scale Collection of Application Usage Data Over the Internet*. To appear in the Proceedings of the 1998 International Conference on Software Engineering. [HR97]

David M. Hilbert, David F. Redmiles. *Agents for Collecting Application Usage Data Over the Internet*. To appear in the Proceedings of the 1998 Autonomous Agents Conference (Agents'98). [HR97-2]

David M. Hilbert, Jason E. Robbins, David F. Redmiles. *EDEM: Intelligent Agents for Collecting Usage Data and Increasing User Involvement in Development*. Proceedings of the 1998 Conference on Intelligent User Interfaces. [HRR97-2]

Nenad Medvidovic and David S. Rosenblum. *Domains of Concern in Software Architectures and Architecture Description Languages*. Proceedings of the USENIX Conference on Domain-Specific Languages. (submission entitled *Architectural Domains: A Framework for Characterizing Architectural Description*) [MR97].

Peyman Oreizy, Nenad Medvidovic, Richard N. Taylor. *Architecture-based Runtime Software Evolution*. To appear in the proceedings of the International Conference on Software Engineering. [OMT97]

Peyman Oreizy, Nenad Medvidovic, Richard N. Taylor and David R. Rosenblum. *Software Architecture and Component Technologies: Bridging the Gap*. To appear in the Proceedings of the OMG-DARPA-MCC Workshop on Compositional Software Architectures, Monterey, CA, January 1998. [OMT97-2]

Richard N. Taylor, Nenad Medvidovic, Peyman Oreizy. *Architectural Implications of Common Operator Interfaces*. To appear in the Proceedings of the 1998 Ground System Architectures Workshop (GSAW'98). [TMO97]

6. Travel

Table 1: Project Meetings/Conferences and Attendance

Meeting	Location	Dates	Attendees
USENIX Conference on Domain-Specific Languages	Santa Barbara, CA	Oct 15-17	NM
DARPA/ITO EDCS Cross Cluster Workshop	Irvine, CA	Oct 27-31	Local EDCS participants
12th IEEE Int'l Conf. on Automated Software Engineering (ASE '97)	Incline Village, NV	Nov 3-5	DR

Table 1: Project Meetings/Conferences and Attendance

Meeting	Location	Dates	Attendees
DARPA/ITO EDCS Architecture and Generation Cluster Workshop	MCC, Austin, TX	Nov 10-12	RT, NM, PO, JR
WebDAV Working Group	Netscape, Mountain View, CA	Nov 20-21	JW
Invited Speaker, Bonnie Nardi, Apple Computers	UC Irvine, CA	Nov 24	Local EDCS participants
WebDAV Working Group	Washington, DC IETF Meeting	Dec 8-9	JW, RK

**Initials for attendees are based on the list of participants given on page 5.*

7. Near Term Plans

7.1. Hyperware

Work proceeds on the first beta release on Chimera 2.0. The plug-in architecture, interweb hyperlinks, and increased support for Java applets described in the last report is still pending and scheduled for inclusion in the second beta release of Chimera 2.0. In addition, support for XML will increase in future versions of Chimera possibly including the ability to store attribute information in XML and changing Chimera's network protocol to pass messages formatted in XML. This support will enable these formats to be more easily extended and evolved in future versions of Chimera.

7.2. Software Architecture

During the next quarter, we will be continuing work on techniques for runtime software evolution. Specifically, we will be incorporating a rule-based constraint system into ArchShell that enables software architects to specify rules that help preserve system integrity during runtime software change.

We are currently investigating the support provided by architectures for software evolution (both before and at runtime). Over the next three months, one part of this investigation will center on using a flexible subtyping and type checking mechanism in an ADL to evolve software components and incorporating off-the-shelf software bus (connector) technologies to evolve architectures.

Work on software architecture environments will focus on applying the Argo infrastructure to the domain of object-oriented software architecture using the UML notation. Jason Robbins will continue a survey of design critiquing systems. Critiquing systems are knowledge-based software tools that support designers by giving advice about potential errors, incomplete parts of the design, the implications of design decisions, and possible design alternatives. The Argo design

environment has a critiquing system as one of its major features.

7.3. Process

We plan to use Chimera in Endeavors to give users the ability to specify hypermedia links to outside resources.

We also plan to integrate with other UCI EDCS technologies including using the C2 design style for communication between the Endeavors User, System, and Foundation levels. This will improve inter artist communication and allow state changes originating in the Foundation and System levels to be propagated to the User level.

A meeting is scheduled for late January with Dan Matheson, Rich Wildman, and Anthony Earl, research engineers from CoCreate's workflow team, to discuss use of Endeavors in CoCreate's workflow module.

We plan to create a toolbox of Endeavors handlers to cover common activities while improving the FormDemo process.

Phase two of the Bug Tracking System (BTS) project will be undertaken by a new ICS125 project team. This phase of the project will add process control and execution to the existing database aspect of the BTS by creating an Endeavors process network.

In the following quarter, David Hilbert plans to complete his survey of techniques for extracting usage information from automatically generated user interaction logs.

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