

Evolutionary Design of Complex Systems

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

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Richard N. Taylor, David Redmiles
Department of Information and Computer Science
University of California
Irvine, California 92697-3425

{taylor, redmiles}@ics.uci.edu
<http://www.ics.uci.edu/pub/edcs/edcs.html>

Voice: 949-824-6429 FAX: 949-824-1715

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Technical Status Report

1. Ongoing Research and Development

1.1. Hyperware

This quarter we successfully integrated the Jargo C2 design tool as a Chimera client. This means that the independently designed and implemented Jargo architecture tool was integrated with Chimera, allowing for any other Chimera client application to be integrated with Jargo. This integration allowed the components of a C2 architecture modeled in Jargo to be linked to the actual C2 source code files for these entities. A demonstration of this integration was presented at the Third Annual EDCS Demo Days in Arlington, VA.

Further Chimera research was undertaken at the University of Colorado at Boulder. The focus of work at CU was on the refinement of the servers and data models for Chimera. This has resulted in an new Chimera version, Chimera 3.0 which should be publicly available next quarter.

The WebDAV project at UCI released the first WebDAV client DAVExplorer. DAVExplorer was released open source which has allowed for a wide pool of developers to study the WebDAV protocol and to improve the design of DAVExplorer. DAVExplorer has successfully been used as a test bed for WebDAV servers from Apache, Microsoft, and IBM.

Wide industry support for WebDAV has included client support of WebDAV on Microsoft's Office 2000 release, and server support on Microsoft's Windows 2000 operating system. IBM has likewise supported WebDAV through DAV4J, a freely available WebDAV server, and Java client API for WebDAV, available on IBM's AlphaWorks site.

Work continued in the Web Versioning and Configuration Management working group, a follow-on working group to WebDAV, to develop requirements and protocol documents. Within the WebDAV working group, work continued on the Advanced Collections protocol draft.

1.2. Software Architecture

During the last quarter, we build ArchStudio 2.0 (previously referred to as TIIDE), an extensible, integrated software architecture development environment. ArchStudio 2.0 incorporates a number of UCI's software architecture technologies, including: (a) ArchShell, an tool that enables runtime modification of software architectures; (b) Argo/C2, the graphical design environment that uses critics to continuously analyze software designs; (c) DRADEL's parser and topological constraint checker, a toolset that imports and statically analyzes C2 SADEL ADL descriptions; (d) Chimera integration, which allows hypertext linking between our design environment and other software artifacts such as source code and requirements documents; (e) a Web browser for downloading additional software components; and (f) off-the-shelf XML tools for viewing and manipulating the common architectural model. All of these tools use an extensible XML-based architectural model. This permits the addition of new attributes and properties as new tools are added to the environment.

This quarter the Argo/UML web site was updated with new documentation and new example design documents. We also explored the requirements for generating a web site to document a

design modeled in Argo/UML and the requirements for managing programmatic extensions to Argo/UML. Jason Robbins also investigated the relationship of usage-centered design to our group's UML and user interface prototyping efforts.

Arabica's goal is to enable composition of JavaBeans components in the C2 architectural style. The JavaBeans developer expects an interface that enables easy, visual composition of individual JavaBeans into applications that are usable. Arabica not only allows this kind of visual JavaBeans composition, but also enforces C2 stylistic rules and provides customization mechanisms that allow an architect to compose JavaBeans according to the requirements of his or her particular specification of a C2 architecture. This is achieved with a wrapping mechanism that wraps every bean and customizes it into a C2 component. The wrapper also takes care of queuing outgoing events from the component after converting them into C2 messages and queuing incoming messages and converting them into JavaBeans events. Standard C2 connectors are provided, and an additional mechanism is provided to allow an architect to specify his or her own filtering or monitoring mechanisms and embed them into a C2 connector. The visual composition environment allows the architect to then link the wrapped components and connectors into the C2 architecture. C2 style rules guide this composition task. These features were implemented by taking Sun's Bean Development Kit (BDK 1.0) and extending it to implement the features of our tool. All implementation was done using Java 1.1.

1.3. Process

Several reusable process components were created to support rapid development and reuse of workflow processes. A library of components, called e-lib (Endeavors libraries), has been developed for the domain of document routing and approval, and web-based workflows. The web-based workflow components allow end users to easily assign web pages as work activities. By using these web-based workflow components and WebNavigator, an interface that lies between an HTTP server and Endeavors, end users can initiate, continue complete and change a workflow process from a URL or HTML form.

Two workflow analysis tools are being developed. The first tool converts control flow based workflows into a Petri-net. The conversion requires that the control flow and all of its artifacts are converted into a data-flow model. By feeding the data-flow model into the Petri-net tool we can analyze five important attributes for workflow: Soundness of workflow, syntax, time analysis, simulations, and axiomatic verification. Soundness of workflow checks for reachability and completion, deadlock and livelock. Deadlock detection algorithms assure that one or more processes will not reach starvation due to conflicting or unavailable resources. Reachability analysis will ensure that the workflow will always start and end properly. Time analysis can be used to calculate minimum, average and maximum time for completion of a workflow. Simulations can provide cognitive walkthroughs to users before a system is deployed. Axiomatic verification can verify properties pertaining to a workflow.

The second tool called RealityCheck, supports analysis and filtering of data generated from adaptive workflow management tools. RealityCheck compares the history of completed workflow processes against the initially prescribed workflow. After the comparative analysis, RealityCheck constructs a new generalized process using a smoothing algorithm. The process manager can then interactively customize the new process by manipulating different aspects of the process.

2. Participants

Faculty:

David Redmiles
David S. Rosenblum
Richard N. Taylor
Kenneth M. Anderson (*University of Colorado at Boulder*)

Research Assistants:

Joachim Feise
Roy Fielding
Michael Guntersdorfer
David Hilbert
Arthur Hitomi
Peter Kammer
Michael Kantor
Rohit Khare
Rema Natarajan
Peyman Oreizy
Jason Robbins
Shilpa Shukla
Doris Tonne
Jaya Vaidyanathan
James Whitehead

Research Programmers:

Clay Cover
Adam Gauthier
Yuzo Kanomata
Kari Nies

3. Notable Accomplishments and Technology Transition

3.1. Hyperware

In June, 1999, the IESG published our specification of the Hypertext Transfer Protocol (HTTP/1.1) as a Draft Standard (RFC 2616) [FG+99]. HTTP/1.1 is an application-level protocol for distributed, collaborative, hypermedia information systems and is the primary transfer protocol for the World Wide Web. It is a generic, stateless protocol that can be used for many tasks beyond its use in hypertext, such as name servers, distributed object management systems, and global software engineering environments, through extension of its request methods, error codes and header fields. A feature of HTTP is the typing and negotiation of data representation, allowing systems to be built independently of the data being transferred.

Chimera, the DAVExplorer client, the Apache ModDAV server, the Office 2000 client, and the Windows 2000 server were demonstrated at the Third Annual EDCS Demo Days in Arlington, VA, June 28-29th.

A presentation introducing WebDAV was given at the 1999 Software Technology Conference in Salt Lake City, UT, May 2-6.

Ken Anderson presented a paper entitled “Supporting Industrial Hyperwebs: Lessons in Scalability” at the International Conference on Software Engineering [And99-2].

3.2. Software Architecture

ArchStudio 2.0, Argo/UML, and Arabica were demonstrated at the 3rd EDCS Demo Days in Arlington, VA, June 28-29th.

Peyman Oreizy and Richard N. Taylor submitted a paper to the International Workshop on the Principles of Software Evolution (IWPSE-2) entitled “Coping with Application Inconsistency in Decentralized Software Evolution”. The paper was accepted.

A paper entitled, “An Architecture-Based Approach to Self-Adaptive Software” by Peyman Oreizy, Michael M. Gorlick, Richard N. Taylor, Dennis Heimbigner, Gregory Johnson, Nenad Medvidovic, Alex Quilici, David S. Rosenblum, and Alexander L. Wolf appeared in IEEE Intelligent Systems [OG+99].

Three software architecture papers were presented at the 1999 International Conference on Software Engineering: “Exploiting ADLs to Specify Architectural Styles Induced by Middleware Infrastructures” by Elisabetta Di Nitto and David Rosenblum [DR99]; “A Language and Environment for Architecture-Based Software Development and Evolution” by Nenad Medvidovic, David S. Rosenblum, and Richard N. Taylor [MRT99]; and “Using Off-The-Shelf Middleware to Implement Connectors in Distributed Software Architectures” by Eric M. Dashofy, Nenad Medvidovic, and Richard N. Taylor [DMT99].

Two papers on Argo/UML were presented at conferences this quarter. The paper entitled “Sweeping Away Disorder with the Broom Alignment Tool” by Jason Robbins, Michael Kantor, and David Redmiles was presented at the 1999 Conference on Human Factors in Computing Systems (CHI’99) [RKR99]. Also, the paper “Cognitive support, UML Adherence, and XMI Interchange in Argo/UML” by Jason Robbins and David Redmiles was presented at the 1999 Symposium on the Construction of Software Engineering Tools (CoSET’99) [RR99]. This paper was selected to appear in the Journal of Information and Software Technology in a special issue on the Best of CoSET’99 [RR99-2].

The paper “Using HTML to Create Early Prototypes” by Jaya Vaidyanathan, Jason Robbins, and David Redmiles was presented at the 1999 Conference on Human Factors in Computing Systems (CHI’99) [VRR99].

3.3. Process

The University of California, Irvine licensed the Endeavors technology to Endeavors Technology Incorporated (ETI). ETI is a small, highly responsive technology company that will provide Web-based workflow, wireless workflow, Web-based information systems, and E-Business solutions. ETI will use Endeavors to build several products: a lightweight, HTTP-based workflow server that easily integrates with existing tools and technologies at use in a business; a full featured graphical environment for non-technical users to visualize, describe, and share executable descriptions of

their work; a lightweight, HTTP-based document management repository; and a scaled down, small footprint version of the Endeavors desktop for use on PDAs, palmtops, and handheld computing devices.

The University also licensed the JavaBrain technology to Sun Microsystems, Inc. Sun is using the JavaBrain technology for the development and deployment of Computer Based Training (CBT) materials. JavaBrain is build on top of the Endeavors technology.

The Course Syllabus Process (CSP) has been deployed at UCI. The CSP lets end users systematically design a course syllabus by following a prescribed process using the Endeavors process engine. If necessary, any task of the CSP can be assigned and routed to different people. Professors and lectures at the Irvine campus now use the CSP for their courses.

David Hilbert and David Redmiles submitted a paper entitled “Collecting User Feedback and Usage Data on a Large Scale to Inform Software Development” to ACM Transactions on Computer-Human Interaction [HR99].

David Hilbert completed the degree requirements for Ph.D. in Information and Computer Science based on his work on large-scale collection of application usage data and user feedback to inform application development [Hil99].

The Endeavors process execution environment and EDEM 2.0, a system for performing large-scale collection of application usage data and user feedback, were demonstrated at the 3rd Annual EDCS Demo Days in Arlington, VA, June 28-29th.

4. Publications

Papers that have been published or accepted for publication this quarter.

Kenneth M. Anderson. *Supporting Industrial Hyperwebs: Lessons in Scalability*. In Proceedings of the 1999 International Conference on Software Engineering. [And99-2]

Eric M. Dashofy, Nenad Medvidovic, and Richard N. Taylor. *Using Off-The-Shelf Middleware to Implement Connectors in Distributed Software Architectures*. In Proceedings of the 1999 International Conference on Software Engineering, Los Angeles, CA, May 16-22, 1999. [DMT99]

David M. Hilbert. *Large-Scale Collection of Application Usage Data and User Feedback to inform Interactive Software Development*. Ph.D. Dissertation, Department of Information and Computer Science, University of California, Irvine, June 8, 1999. [Hil99]

Elisabetta Di Nitto and David Rosenblum. *Exploiting ADLs to Specify Architectural Styles Induced by Middleware Infrastructures*. In Proceedings of the 1999 International Conference on Software Engineering. [DR99]

Nenad Medvidovic, David S. Rosenblum, and Richard N. Taylor. *A Language and Environment for Architecture-Based Software Development and Evolution*. In Proceedings of the 1999 International Conference on Software Engineering. [MRT99]

Peyman Oreizy, Michael M. Gorlick, Richard N. Taylor, Dennis Heimbigner, Gregory Johnson, Nenad Medvidovic, Alex Quilici, David S. Rosenblum, and Alexander L. Wolf. *An Architecture-Based Approach to Self-Adaptive Software*. IEEE Intelligent Systems. [OG+99]

Peyman Oreizy and Richard N. Taylor. *Coping with Application Inconsistency in Decentralized Software Evolution*. To appear in Proceedings of the International Workshop on the Principles of Software Evolution (IWPSE-2). [OT99]

Jason Robbins, Michael Kantor, and David Redmiles. *Sweeping Away Disorder with the Broom Alignment Tool*. In Proceedings of the 1999 Conference on Human Factors in Computing Systems (CHI'99). [RKR99]

Jason Robbins and David Redmiles. *Cognitive support, UML Adherence, and XMI Interchange in Argo/UML*. In Proceedings of the 1999 Symposium on the Construction of Software Engineering Tools (CoSET'99). [RR99]

Jason Robbins and David Redmiles. *Cognitive support, UML Adherence, and XMI Interchange in Argo/UML*. To appear in the Journal of Information and Software Technology special issue on the best of CoSET'99. [RR99-2]

Jaya Vaidyanathan, Jason Robbins, and David Redmiles. *Using HTML to Create Early Prototypes*. In Proceedings of the 1999 Conference on Human Factors in Computing Systems(CHI'99). [VRR99]

5. Travel

Table 1: Project Meetings/Conferences and Attendance

Meeting	Location	Dates	Attendees
EDCS PI Meeting	Santa Rosa, CA	April 26-28	DR, DSR, RT, DH, PO
Software Technology Conference, STC'99	Salt Lake City, UT	May 2-6	JW
University of Alberta Talk (Speaker)	Alberta, Canada	May 12	RT
ACM SIGCHI Conference on Human Factors in Computing Systems, CHI'99	Pittsburgh, PA	May 15-20	MK, JR, SS, JV
International Conference on Software Engineering, ICSE'99	Los Angeles, CA	May 19-21	DR, DSR, RT, JF, RF, MG, DH, AH, PK, MK, RK, RM, PO, JR, DT, JW, AG, KN

Table 1: Project Meetings/Conferences and Attendance

Meeting	Location	Dates	Attendees
University of Washington Colloquim (Speaker)	Seattle, WA	June 1	RT
EDCS Demo Days	Arlington, VA	June 27-July 1	DR, DSR, RT, DH, AH, MK, RK, RN, PO, JR, JW, YK

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

6. Near Term Plans

6.1. Hyperware

Chimera research will begin to focus on versioning issues related to Chimera-managed collections.

WebDAV research will focus on architecture of an WebDAV API layer. This API will allow for various WebDAV clients to utilize functions for WebDAV much in the same way that one would use a TCP/IP stack. Research will focus on multi-threaded and transaction issues, and also the possibility of plugging in existing tools to support further functionality in the API layer.

WebDAV researchers at UC Irvine will be working to release a redesigned DAVExplorer and a new client, DAVPosties.

6.2. Software Architecture

Near-term efforts on the Argo/UML tool will focus on evaluating and documenting the tool's cognitive support features. In the next quarter, Jason Robbins will complete and defend his dissertation.

We plan to implement additional features in Arabica that allow the specification of a C2 architecture to be imported into the tool, so that it can be used to validate the composition of JavaBeans according to that architecture specification.

6.3. Process

Future work in process will focus on: rapid formation and coordination of virtual workgroups across geographic boundaries; mechanisms to produce, manage, and consume information more easily using the WWW rather than just sharing it; identification of automatable and reusable work flow processes such as artifact approval, update, routing, versioning, notification, and creation to coordinate common work practices.

David Hilbert will revise and resubmit two journal papers documenting UCI's work on large-scale usage data collection.

EDEM will be used to conduct a remote usage study of Argo/UML, another system developed at UCI under the EDCS contract.

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- [VRR99] Jaya Vaidyanathan, Jason Robbins, and David Redmiles. *Using HTML to Create Early Prototypes*. In Proceedings of the 1999 Conference on Human Factors in Computing Systems(CHI'99), Pittsburgh, PA, May 19-23, 1999.