

# 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

Research on WebDAV continued this quarter with specific emphasis on extending the WebDAV protocol to existing tools. Efforts were focused on the redesign of the WebDAV client application, DAV Posties, a tool which used an early version of the protocol in order to manage annotations on artifacts which were accessible to distributed collaborators. The reimplementations of DAV Posties, done by two undergraduate project teams at UCI, allowed for new capabilities in the protocol to be fed back to the tool which in turn extended its ability to manage the artifacts it manipulates.

Support for further research developments was initiated this quarter with work on versioning aspects WebDAV. Current work by the Delta-V working group (which is tasked by the IETF to add versioning to WebDAV) is leading to versioning standards that will be amended to the WebDAV specification. Work done by UCI this quarter has included a layering of WebDAV on top of remote CVS, a widely used Open Source configuration management system. This effort is in support of a modification to Apache mod\_dav which will extend a WebDAV versioning prototype to the Apache web server.

Further refinement of Chimera 3.0 occurred this quarter at the University of Colorado, Boulder. This work focused on implementing first-class typing of anchors and links within the Chimera hypermedia model. The result of this effort should result in a release of Chimera 3.0 in the following quarter.

### 1.2. Software Architecture

Research in software architecture continued this quarter with work in extending the C2 Architectural Style in architecture development environments and to integrate the XML-based shared data repository (known as XADL) for the architecture to all tools. To support this work, a redesign of the architecture design tools supporting C2 was begun. This work will result in the tools themselves conforming to C2 architecture rules, which in turn allows these tools to benefit from future tools and components which can be plugged directly into the architectural design environment framework using C2 composition rules.

### 1.3. Process

Endeavors has designed and implemented a set of new and reusable process components for the field of scheduling and reservation systems. This process enables end users to add, modify, and remove their schedules from a database and uses the Endeavors process system to manage the user interactions and transactions as a high level processes. Typically, these systems interact with database systems which model these as transactions and enforce them through a database transaction manager to ensure their consistency. However, as the resource reaches capacity, the point at which exceptions occur, transaction systems are often too rigid to deal with these problems gracefully. By using the high level and interactive process components, dynamic flexibility and excep-

tion handling capabilities of Endeavors, Endeavors better resolves these complex scheduling issues, especially those that require coordination such as group calendaring systems.

## **2. Participants**

### *Faculty:*

David Redmiles  
David S. Rosenblum  
Richard N. Taylor

### *Research Assistants:*

Eric Dashofy  
Roy Fielding  
Arthur Hitomi  
Peter Kammer  
Michael Kantor  
Rohit Khare  
Peyman Oreizy  
James Whitehead

### *Research Programmers:*

Yuzo Kanomata  
Kari Nies

## **3. Notable Accomplishments and Technology Transition**

### **3.1. Hyperware**

WebDAV continues to experience wide scale adoption by a number of leading commercial software vendors and open source projects. The WebDAV Protocol (IETF RFC 2518 [GWF+98]), developed through research in hyperware at the University of California, Irvine, enables collaborative authoring of Web content through extensions to the HTTP/1.1 Protocol. WebDAV provides a network protocol for creating interoperable, collaborative applications which includes concurrency controls (e.g., locking). These capabilities will allow DoD and commercial applications to integrate distributed collaborating teams by leveraging common productivity tools and Web services which they have become accustomed to.

Adopters include Microsoft (Office 2000, IE5, IIS 5), IBM (DAV4J), and open source projects (Apache mod\_dav, DAV Explorer). This has resulted in 10 client applications, 2 publicly available client API libraries, 17 WebDAV servers (12 class-2, 5 class-1), and 2 WebDAV-enabled Web storage sites. These applications run on a range of platforms, with client support for Windows, Unix, and MacOS, and server support for Windows and Unix.

The paper "WebDAV: A network protocol for remote collaborative authoring on the Web" was presented at the 1999 European Conference on Computer Supported Cooperative Work (ECSCW'99), September 12-16 [WG99], and "Goals for a Configuration Management Network Protocol" was presented at the Ninth Int'l Symposium on System Configuration Management,

September 5-7 [Whi99-2]. Jim also presented an update on WebDAV at the Open Hypermedia Workshop 5.5, September 17-19, and a presentation on Web collaboration systems at 3rd Nordic Interactive Multimedia Research School, September 8-11.

Jim Whitehead and Rohit Khare attended the IETF meeting in Washington, DC.

Roy T. Fielding and Richard N. Taylor submitted a paper entitled “Principled Design of the Modern Web Architecture” to the International Conference on Software Engineering (ICSE 2000). [FT00].

### 3.2. Software Architecture

Siena is an advanced middleware infrastructure that implements content-based routing to support event-based applications on a wide-area network. The components of a loosely-coupled system are typically designed to operate by generating and responding to asynchronous events. An event notification service is an application-independent infrastructure that supports the construction of event-based systems. The two primary services that should be provided to components by the infrastructure are notification selection and notification delivery. Numerous event notification services have been developed for local-area networks, generally based on a centralized server to select and deliver event notifications. Therefore, they suffer from an inherent inability to scale to wide-area networks, such as the Internet, where the number and physical distribution of the service's clients can quickly overwhelm a centralized solution. The critical challenge in the setting of a wide-area network is to maximize the expressiveness in the selection mechanism without sacrificing scalability in the delivery mechanism.

Siena is an event notification service that we have designed to maximize both expressiveness and scalability. It has a formally defined application interface, which is an extension of the familiar publish/subscribe protocol. Its selection and delivery mechanisms are designed for networks of peer-to-peer event servers and adopt strategies for optimizing the performance of the notification matching process as well as the network resources used to propagate and store subscriptions and notifications.

The first version of Siena has been publicly released. The package includes a peer-to-peer server (implemented in C++), a hierarchical server (implemented in Java), and a client-side API for both the C++ and the Java language. Both servers implement the subscription-forwarding algorithm. This quarter, two papers on Siena [CRW00,CRW00-2] were prepared for publication.

The Argo/UML design tool has seen wide scale use in the Open Source community. This design tool includes over 19,000 registered users and more than 150 developers in leading software development companies such as IBM and Collab.Net.

Two software architecture papers were submitted to the International Conference on Software Engineering (ICSE 2000): “Decentralized Software Evolution” by Peyman Oreizy and Richard N. Taylor [MOT+00] and “An Architecture-Centered Approach to Software Environment Integration” by Nenad Medvidovic, Peyman Oreizy, Richard N. Taylor, Rohit Khare, Michael Guntersdorfer [OT00].

### 3.3. Process

An internet start-up company, ETI, has continued to developed Endeavors for commercial applications. ETI has been licensing the Endeavors process technology developed at UC Irvine.

## 4. Travel

**Table 1: Project Meetings/Conferences and Attendance**

| <b>Meeting</b>                                    | <b>Location</b>                          | <b>Dates</b> | <b>Attendees</b> |
|---|--|--------------|------------------|
| DARPA Meeting                                     | Washington, D.C.                         | Oct 1-2      | RT               |
| Bay Area Roundtable                               | Palo Alto, CA                            | Oct 8        | RT               |
| Internet Engineering Task Force (IETF-46) Meeting | Washington, D.C.                         | Nov 7-12     | RK, JW           |
| Interplanetary Internet Research Seminar          | University of Maryland, College Park, MD | Nov 12       | RK               |

*\*Initials for attendees are based on the list of participants given on page 4.*

## 5. Near Term Plans

### 5.1. Hyperware

Work on WebDAV will continue on versioning hypermedia systems next quarter. This will include work on creating network versioning of web artifacts on Web Proxies such as SQUID and making Web browsers version aware. This work extends the concepts presented in work done at UCI on a network versioning protocol which was presented last quarter at SCM-9 [Whi99-2] and ECSCW '99 [WG99].

Examining versioning of the Web itself presents a unique way of examining versioned artifacts in a hypermedia environment. No existing hypermedia system has attempted to allow for read-only versioning of their content on the scale of the Web. A prototype Web "way back" browser will be examined to determine the efficacy of such versioning systems. This effort will include an evaluation of NUCM as a version store for complex hypermedia artifacts.

## References

- [CRW00] Antonio Carzaniga, David S. Rosenblum, Alexander L. Wolf. *Achieving Scalability and Expressiveness in an Internet-Scale Event Notification Service*. Submitting to the Nineteenth ACM Symposium on Principles of Distributed Computing (PODC 2000), Portland, Oregon, July 16-19 2000.
- [CRW00-2] David Rosenblum. *Content-Based Addressing and Routing: A General Model and its Application*. Submitting to SIGCOMM 2000, August 28- September 1, 2000, Stockholm, Sweden.
- [FT00] Roy T. Fielding and Richard N. Taylor. *Principled Design of the Modern Web Architecture*. Submitted to the International Conference on Software Engineering (ICSE 2000), Limerick, Ireland, June 4-11, 2000.
- [GW+99] Y. Goland, E. Whitehead, A. Faizi, S. Carter, and D. Jensen. *HTTP Extensions for Distributed Authoring -- WEBDAV*. Internet Proposed Standard Request for Comments 2518. February, 1999.
- [MOT+00] Nenad Medvidovic, Peyman Oreizy, Richard N. Taylor, Rohit Khare, and Michael Guntersdorfer. *An Architecture-Centered Approach to Software Environment Integration*. Submitted to the International Conference on Software Engineering (ICSE 2000), Limerick, Ireland, June 4-11, 2000.
- [OT00] Peyman Oreizy and Richard N. Taylor. *Decentralized Software Engineering*. Submitted to the International Conference on Software Engineering (ICSE 2000), Limerick, Ireland, June 4-11, 2000.
- [WG99] E James Whitehead, Jr., Yaron Y. Goland. *WebDAV: A network protocol for remote collaborative authoring on the Web*. In Proceedings of the Sixth European Conference on Computer Supported Cooperative Work (ECSCW'99), Copenhagen, Denmark, September 12-16, 1999, pp. 291-310.
- [Whi99-2] E. James Whitehead, Jr. *Goals for a Configuration Management Network Protocol*. In Proceedings of the Ninth International Symposium on System Configuration Management (SCM-9), LNCS 1675, Toulouse, France on September 5-7, 1999, pp. 186-204.