

Evolutionary Design of Complex Systems

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

Quarterly Report Volume 2, Number 4

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Technical Status Report

1. Ongoing Research and Development

1.1. Hyperware

Research on the Chimera hyperware project focused in the areas of interoperability and back-end optimizations for this quarter. UCI released a beta version of the COM API which allows for Win32 Applications to access Chimera services. This release was then used by one graduate student project at the University of Colorado at Boulder in an effort to integrate Windows based applications as Chimera clients. UCI ported the Chimera servers onto Linux as well as the Xemacs and jimage clients.

Chimera research at the University of Colorado at Boulder identified efficient restructuring of the hyper-base through changes in the structure of the back-end database. During this investigation, other back-end databases (i.e. relational, object-relational, etc.) were examined for viability. Chimera will integrate these changes into future releases of Chimera 2 beta.

Chimera user support was followed through two ongoing developments this quarter. A utility program which configures the XML preference files for the servers was developed and will be released next quarter, and a Adobe Acrobat client integration was developed and will also be released next quarter.

The WebDAV working group, led by Jim Whitehead, continues to develop extensions to the base Distributed Authoring Protocol for advanced collections functionality, for versioning and configuration management operations, and for access control. Work also continues to increase awareness of DAV among a broader audience, and to foster adoption of the WebDAV protocol by a wide range of commercial and open source development efforts.

1.2. Software Architecture

Peyman Oreizy completed a survey that compares different approaches to Decentralized Software Evolution (DSE). DSE enables third-parties to evolve a software application independent of the organization that originally developed it. Application vendors employ DSE as a means of attracting additional users to their applications - and, consequentially, increasing their market share. This benefits everyone involved: the original application vendor sells more product since customization constitutes use; third-party developers deliver a product in less time and with lower cost by reusing software as opposed to building it from scratch; and customers receive a higher quality product, customized to suit their needs, in less time and with lower cost. While there are a variety of approaches to DSE, there were no clear characterizations of their differences or of their relative benefits and shortcomings. Our survey paper broadly surveys different approaches to DSE and helps answer the following questions: What is decentralized software evolution and why is it important? What are the characteristic approaches to DSE? What are the important issues to consider when evaluating different DSE approaches? How do different approaches compare and what are their benefits and shortcomings? Where do current approaches fall short? What are some open areas for further research and development? The results of this survey can be found in [Ore98-3].

Argo/UML version 0.5.2 was released this quarter. Argo/UML is an object-oriented design tool that has cognitive support features as found in the existing Argo/C2 tool supporting C2-style software architectures, but it is applied to the Unified Modeling Language, a standard notation for object-oriented design. Like the previous Argo/C2 tool, Argo/UML has design critics and a dynamic “to do” list that together help designers resolve identified problems in a design. New features in Argo/UML include customizable navigational perspectives that structure the design around specific design tasks, checklists which save time in later design reviews, novel diagram editing tools, and some support for attaching problem-fixing wizards to critics. Argo/UML v0.5.2 includes new support for UML activity diagrams, table views of the design, enhanced “clarifier” icons that visually highlight problems, and a cooperative design query mechanism.

This quarter two experiments were conducted with Argo/UML users. First, Argo/UML was used by undergraduate students as part of a software design project course. Second, we conducted a controlled user study that evaluated the usability and effectiveness of Argo/UML’s novel diagram editing capabilities. Specifically, we found that our “broom” alignment tool allowed users to organize design diagrams more easily than standard alignment commands. A CHI’99 submission describing this work is in progress.

Jaya Vaidyanathan and Jason Robbins conducted a trial of a new user interface prototyping method that uses off-the-shelf HTML editors to make early prototypes of complex user interfaces. This approach makes early prototypes available to more project stakeholders and is more convenient than previous paper-based approaches or the use of special-purpose prototyping languages. a CHI’99 submission describing this work is in progress.

1.3. Process

An initial implementation of the Endeavors User and System levels as C2 components was completed this quarter. Using the C2-style allows the System and User levels bi-directional communication through any of the C2 Connector objects. The C2-style enables various Endeavors architectures to be constructed. For example, a server side architecture is created with a standard C2 connector welded to the System level component and the other end of the connector accessible by a servlet. The servlet is part of a C2 connector which uses a web server and a combination of Java’s Socket, ServerSocket, and URL Connection classes to form the connector. This allows a User level component running as either an applet or as a stand alone application to connect to a remote System level component. Thus, multiple distributed User level clients can connect to the same System level component and receive updates when changes are made. Ninety-six of the messages have been implemented and we have validated the design. We are continuing to explore event based integration issues in Endeavors.

Work has progressed on the installation process for Endeavors processes. Installation executables were developed that can be invoked by an Endeavors process network. This installation system allows the overall installation process to be managed as an advanced workflow, and thus allows for more sophisticated flow, decision, and event handling.

We have also continued to investigate transaction models for distributed workflow systems. Transaction management systems provide significant benefits to any computer operation that has components which are a long duration processes or set of related steps. Most of the systems looked at thus far support two phase commits. They use the XA/open standard. There are similar simple

APIs to the functionality. The differences found lie in: platform dependence, footprint, cost, language, and completeness. A possible good fit system for the Endeavors project would be Java Enterprise Beans JTS. This is an architecture - not an implementation - and would require development of, or purchase of beans. Another good fit for Endeavors is Sybase Jaguar Component Transaction Server.

Arthur Hitomi gave a 40 minute talk on SWAP (Simple Workflow Access Protocol) at the IETF in Florida, Orlando. He and industry workflow vendors (Oracle, C4, ...) promoted the SWAP mechanism for supporting interoperability of workflows using HTTP and XML technologies. SWAP extends and leverages the HTTP protocol to allow different workflow applications to communicate over this ubiquitous service. SWAP also leverages XML to allow better interoperability and extensibility of workflow data.

There were three major activities related to research in Project Awareness and Knowledge Depot during this time period. First, we enhanced the Java Knowledge Depot's usability in response to initial user feedback. Second, we enhanced Bell Atlantic's Lotus Notes subscription feature to scale up to handling the thousands of people who use the Lotus Notes Knowledge Depots. This will help us gather usage data which will in turn enhance our understanding of the Java Knowledge Depot and how to improve it. Third, we processed survey and interview data from a prior study of the Lotus Notes subscription feature, and will be submitting a short paper to CHI'99 based on our results.

EDEM 2.0, a system for performing large-scale collection of application usage data and user feedback to inform software development, was released this quarter with updated support for JDK 1.2 and enhanced support for more flexible data abstraction, selection, reduction and context-capture.

This quarter Shilpa Shukla wrapped up her work relating to a summer research internship with Hewlett Packard Labs, Palo Alto, California (Summer 1998). This research involved: 1. Conducting an ethnographic study on Hewlett Packard's customer support process of knowledge authoring. This study provided input to requirements for knowledge authoring technology. 2. Applying Activity Theory to analyze the data collected from the study of Hewlett Packard's customer support process. The Activity Theory framework provided the means to deliver various models of the artifacts involved in a diagnostic authoring process. 3. And helping improve Hewlett Packard's Research and Development's understanding of the Customer Support documentation process. She and David Redmiles are preparing a paper on this data which will appear in a Special Issue of CSCW Journal (Co-edited by Bonnie Nardi and David Redmiles). They are also writing up data results from a similar study at Apple Computer which they plan to submit to the ITP (Information Technology and People) journal.

2. Participants

Faculty:

David Redmiles
David S. Rosenblum
Richard N. Taylor

Research Assistants:

Gregory Bolcer
Roy Fielding
David Hilbert
Arthur Hitomi
Peter Kammer
Michael Kantor
Rohit Khare
Neno Medvidovic
Rema Natarajan
Peyman Oreizy
Jason Robbins
Shilpa Shukla
Doris Tonne
Jaya Vaidyanathan
James Whitehead

Research Programmers:

Clay Cover
Yuzo Kanomata
Edwin Kraemer
Kari Nies

3. Notable Accomplishments and Technology Transition

3.1. Hyperware

A beta version of the COM API to Chimera was released. A port of the Xemacs client integration on Linux was completed.

Two papers by Ken Anderson were submitted and accepted for publication: one to the Hypertext 1999 Conference entitled “Data Scalability in Open Hypermedia Systems” [And99] and one to the 1999 International Conference on Software Engineering entitled “Supporting Industrial Hyperwebs: Lessons in Scalability” [And99-2] (both were missed in the previous quarterly report).

The WebDAV Working Group, led by Jim Whitehead, achieved a major milestone during the reporting period with the approval by the Internet Engineering Task Force (IETF) of the WebDAV Distributed Authoring Protocol as a Proposed Standard. This indicates the WebDAV standard is stable and of high technical quality, has undergone significant community review, and is generally believed to have resolved known design choices. Approval by the IETF also acts as a signal for corporations and other organizations to begin adopting the protocol in their products. The Microsoft Corporation announced that they will be providing broad WebDAV support in their Internet Information Services (IIS) web server product, in their Internet Explorer web browser, and in Office 2000 applications. Novell also announced that WebDAV will be a significant part of their future product plans. Two independent software developers working on open source projects also announced WebDAV support: Greg Stein began work on a WebDAV module (`mod_dav`) for the popular Apache web server, and Joe Orton developed a tool called `sitecopy` which synchro-

nizes a local directory with a remote WebDAV server. Together, these developments show the benefits of EDCS involvement in network protocol standardization, since once the standard has been approved, significant development coalesces around the standard, leveraging DARPA investments.

The WebDAV working group held three meetings during the reporting period. A full working group meeting was held on December 10, 1998, at the Orlando, Florida IETF meeting, including breakout sessions on the topics of advanced collections functionality, and access control. Two meetings of the Versioning and Variant Authoring Design Team were held on October 1-2, 1998, at the offices of FileNet, in Costa Mesa, California, and on December 1-2, 1998, in Portland, Oregon, sponsored by Intersolv. These design team meetings focused on the development of a protocol for versioning and configuration management of Web content.

Additionally, Jim Whitehead visited Sun Computer to discuss WebDAV with their Web server development team on October 15, 1998.

Jim Whitehead and Rohit Khare presented two tutorials. The first, “Web Collaboration and Automation: XML, WebDAV, and ISEN”, was given on October 23 at the 1998 California Software Symposium in Irvine, CA. The second, “XML and WebDAV: Emerging Web standards and their impact on Software Engineering” was presented on November 5, at the Sixth International Symposium on the Foundations of Software Engineering (FSE-6), Lake Buena Vista, Florida. Jim Whitehead had his paper, “Control Choices and Network Effects in Hypertext Systems”, accepted for inclusion in the proceedings of the Hypertext’99 conference [Whi99], and was one of three papers nominated for the Engelbart best paper award.

Roy Fielding attended APACHECON’98 in San Francisco, October 14-16, as a speaker and founding member of the Apache Group where he gave a presentation on collaborative development of open source software. He also gave an invited, expanded version of this talk regarding “The Apache HTTP Server Project: Lessons Learned from Collaborative Software Development” at AT&T Labs Research in Florham Park, New Jersey, on October 26.

Rohit Khare has continued writing *Seventh Heaven*, a bimonthly column on application-layer protocol design in IEEE Internet Computing [Kha98-2, Kha98-3]. Topics covered this quarter include the contributions of Jon Postel to protocol specification, and histories of Network News Transfer Protocol (NNTP), Gopher, and Hypertext Transfer Protocol (HTTP). His research into evolvable data interchange formats is reflected in the creation of a tutorial curriculum on Extensible Markup Language (XML) and Resource Description Format (RDF), presented in various forms at CSCW’98 [KR98-2], FSE’98, and graduate seminars at UCI. In addition, he spoke on the “Evolution of the World Wide Web Consortium” at Georgetown’s Media & Cultural Studies program and the “Web of Trust” for a Bay Area Roundtable on Internet-scale security.

3.2. Software Architecture

A paper entitled “On the Role of Software Architectures in Runtime System Reconfiguration” by Peyman Oreizy and Richard N. Taylor was published in the IEE Software Engineering journal [OT98-2]. The paper describes how architectural style, architectural connectors, and architecture-based analyses combine to provide a reliable and systematic approach to runtime reconfiguration of mission-critical software systems.

A paper entitled “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 was accepted for publication in IEEE Intelligent Systems [OGT+99].

A paper entitled “A Language and Environment for Architecture-Based Software Development and Evolution” by Nenad Medvidovic, David S. Rosenblum, and Richard N. Taylor was accepted to the 1999 International Conference on Software Engineering [MRT99].

Nenad Medvidovic presented a paper entitled “Employing Off-the-Shelf Connector Technologies in C2-Style Architectures” at the California Software Symposium (CSS’98) [MDT98].

A paper entitled “A Classification and Comparison Framework for Software Architecture Description Languages” by Nenad Medvidovic and Richard N. Taylor was accepted for publication by IEEE Transactions on Software Engineering [MT98-2].

Rema Natarajan, Nenad Medvidovic, David Rosenblum, Richard Taylor, Elisabetta Di Nitto, and Roy Fielding participated in the Third International Software Architecture Workshop (ISAW-3) [NR98, MT98]. Rema’s paper entitled “Merging Component Models and Architectural Styles” was one of only 8 out of 40-odd position papers to be selected for a presentation in a plenary session of the workshop.

A paper entitled “Exploiting ADLs to Specify Architectural Styles Induced by Middleware” by Elisabetta Di Nitto and David Rosenblum was accepted to the 1999 International Conference on Software Engineering [NR99].

The paper “Software Architecture Critics in the Argo Design Environment” [RR98] by Jason Robbins and David Redmiles appeared in Knowledge-Based Systems, an international journal. Also, the paper entitled, “Extending Design Environments to Software Architecture Design” by Jason E. Robbins, David M. Hilbert, and David F. Redmiles appeared in Automated Software Engineering [RHR98] (note this publication was missed in last quarter’s report).

Jason Robbins completed a survey of design critiquing systems [Rob98].

We supported Mark J. Schnitzius of ISX Corporation (a defense contractor) in using our Java Graph Editing Framework (GEF) to build a user interface system. Jean-Michel Roque of Versant France is currently using GEF to build a user interface for a manufacturing application. Geoff Hay, a Teaching Fellow at the University of Otago, Dunedin, New Zealand, used GEF in a student project to develop an Issue Based Information System for collaborative engineering. We supported George Sugar of Mitel Corp. in using GEF to develop a network management tool.

Our Argo/UML web site had over 6000 visitors in the last quarter of 1998. Our Argo/UML mailing list currently has approximately 650 registered users, including employees of Aonix (a CASE tool vendor), ISX (a defense contractor), IBM, Oracle, Motorola, and many universities.

3.3. Process

Greg Bolcer filed his Ph.D. dissertation titled “Flexible and Customizable Workflow Execution on the WWW” [BoI98]. In addition, the paper “Advanced Workflow Management Technologies” by Greg Bolcer and Richard Taylor was approved for publication in the Journal of Software Process

Improvement and Practice [BT98].

Peter Kammer participated in the Workshop on Internet-based Groupware for User Participation in Product Development held in conjunction with CSCW'98 [KBB98].

Peter Kammer, Greg Bolcer, Richard N. Taylor, and Mark Bergman submitted a paper entitled "Techniques for Supporting Dynamic and Adaptive Workflow" to the Journal of Computer Supported Cooperative Work [KBTB98].

The University of California, Irvine is currently negotiating the commercial license for use of the Endeavors technology to a small startup company, Endeavors Technology, Inc.

Bolcer in conjunction with Gail Kaiser of Columbia University submitted to Internet Computer, an overview of the Simple Workflow Access Protocol (SWAP) that will be published in the first quarter, 1999 [BK99].

David Hilbert and David Redmiles presented a paper entitled "Separating the Wheat from the Chaff in Internet-Mediated User Feedback" at the Workshop on Internet-based Groupware for User Participation in Product Development held in conjunction with CSCW'98 [HR98-2].

David Hilbert and David Redmiles submitted a revised version of [Hil98] entitled "Extracting Usability Information from User Interface Events" to ACM Computing Surveys [HR98-4].

Shilpa Shukla attended an Activity Theory Tutorial at CSCW '99 in November where she gave an invited presentation on how she applied ethnography and Activity Theory to study collaborative problem resolution contexts within companies such as Apple and Hewlett Packard.

4. Publications

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

Kenneth M. Anderson. *Data Scalability in Open Hypermedia Systems*. To appear in Proceedings of the ACM Hypertext '99 Conference. [And99]

Kenneth M. Anderson. *Supporting Industrial Hyperwebs: Lessons in Scalability*. To appear in Proceedings of the 1999 International Conference on Software Engineering, Los Angeles, CA, May 16-22, 1999. [And99-2]

Gregory Alan Bolcer. *Flexible and Customizable Workflow Execution on the WWW*. Ph.D. Dissertation, Department of Information and Computer Science, University of California, Irvine. [Bol98]

Gregory Alan Bolcer and Gail Kaiser. *SWAP: Leveraging the Web to Manage Workflow*. To appear in IEEE Internet Computing. [BK99]

Gregory Alan Bolcer and Richard N. Taylor. *Advanced Workflow Management Technologies*. To appear in the Journal of Software Process Improvement and Practice. [BT98]

A. Carzaniga, E. Di Nitto, D.S. Rosenblum, and A.L. Wolf, *Issues in Supporting Event-based Architectural Styles*. In Proceedings of the Third International

Software Architecture Workshop. [CDRW98]

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

Roy Fielding, E. James Whitehead, Jr., Kenneth Anderson, Peyman Oreizy, Gregory Bolcer, and Richard Taylor. *Web-based Development of Complex Information Products*. Communications of the ACM, vol. 41, no. 8, pp. 84-92. August 1998. [FWA+98]

David Hilbert, David Redmiles. *Separating the Wheat from the Chaff in Internet-Mediated User Feedback*. In Proceedings of the Workshop on Internet-based Groupware for User Participation in Product Development. [HR98-2]

Peter Kammer, Greg Bolcer, and Mark Bergman. *Supporting Dynamic and Adaptive Workflow on the WWW*. In Proceedings of the Workshop on Internet-based Groupware for User Participation in Product Development. [KBB98]

Peter Kammer, Greg Bolcer, Richard N. Taylor, and Mark Bergman. *Techniques for Supporting Dynamic and Adaptive Workflow*. Submitted to the Journal of Computer Supported Cooperative Work. [KBTB98]

Rohit Khare. *The News about Jon: Reflections on the Wizard of TPs; and other Network News*. IEEE Internet Computing. [Kha98-2]

Rohit Khare. *Who Killed Gopher? An Extensible Murder Mystery*. IEEE Internet Computing. [Kha98-3].

Rohit Khare with Adam Rifkin. *Modeling Data and Metadata: XML and RDF*. Tutorial In Proceedings of CSCW '98. [KR98-2]

Nenad Medvidovic, Eric M. Dashofy, and Richard N. Taylor. *Employing Off-the-Shelf Connector Technologies in C2-Style Architectures*. In Proceedings of the California Software Symposium (CSS'98). [MDT98]

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

Nenad Medvidovic and Richard N. Taylor. *Separating Fact from Fiction in Software Architecture*. In Proceedings of the Third International Software Architecture Workshop (ISAW-3). [MT98]

Nenad Medvidovic and Richard N. Taylor. *A Classification and Comparison Framework for Software Architecture Description Languages*. To appear in IEEE Transactions on Software Engineering. [MT98-2]

Rema Natarajan and David S. Rosenblum. *Merging Component Models and Architectural Styles*. In Proceedings of the Third International Software Architecture Workshop (ISAW-3). [NR98]

Peyman Oreizy. *Decentralized Software Evolution*. UCI-ICS Technical Report 98-42, Department of Information and Computer Science, University of California, Irvine. [Ore98-3]

Peyman Oreizy, Michael M. Gorlick, Richard N. Taylor, Dennis Heimbigner, Gregory Johnson, Nenad Medvidovic, Alex Quilici, David S. Rosenblum, and Alexander L. Wolf. *Self-Adaptive Software*. To appear in IEEE Intelligent Systems. [OGT+99]

Peyman Oreizy, Richard N. Taylor. *On the Role of Software Architectures in Runtime System Reconfiguration*. IEE Software Engineering Journal. [OT98-2]

Jason Robbins. *Design Critiquing Systems*. UCI-ICS Technical Report 98-41, Department of Information and Computer Science, University of California, Irvine. [Rob98]

Jason E. Robbins, David M. Hilbert, and David F. Redmiles. *Extending Design Environments to Software Architecture Design*. Automated Software Engineering. [RHR98]

Jason Robbins and David Redmiles. *Software Architecture Critics in the Argo Design Environment*. Journal of Knowledge-Based Systems. [RR98]

E. James Whitehead, Jr. *Control Choices and Network Effects in Hypertext Systems*. To appear in Proceedings of the ACM Hypertext '99 Conference. [Whi99]

5. Travel

Table 1: Project Meetings/Conferences and Attendance

Meeting	Location	Dates	Attendees
WebDAV Versioning and Variant Authoring Design Team Meeting	Costa Mesa, CA Filenet Corp.	Oct 1-2	JW
Fall EDCS PI Meeting	Del Mar, CA	Oct 4-6	DR, RT, NM
13th IEEE Int'l Conf. on Automated Software Engineering (ASE'98)	Honolulu, HI	Oct 13-16	DR
APACHECON '98 Conference	San Francisco, CA	Oct 14-16	RF
WebDAV Meeting with Web server development team	Sun Microsystems Palo Alto, CA	Oct 15	JW
ACM SIGSOFT'98 Foundations in Software Engineering	Lake Buena Vista, Florida	Nov 2-5	RT, DSR, RF, RK, NM, RN, JW

Table 1: Project Meetings/Conferences and Attendance

Meeting	Location	Dates	Attendees
1998 ACM Conference on Computer Supported Cooperative Work (CSCW98)	Seattle, WA	Nov 14-18	DR, DH MK, PK, RK, SS
WebDAV Versioning and Variant Authoring Design Team Meeting	Portland, OR	Dec 1-3	JW
IETF-43	Orlando, FL	Dec 6-11	AH, RK, JW
EDCS Meeting	Menlo Park, CA	Dec 8	RT, NM
UCI Meeting with David Notkin	UCI (travel from Seattle, WA)	Dec 14	David Notkin
EDCS Research Projects Meeting with Alex Wolf and Dennis Heimbigner	Boulder, CO	Dec 16	RT
DARPA visit	Washington, D.C.	Dec 19-21	RT

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

6. Near Term Plans

6.1. Hyperware

Next quarter the Chimera project is planning to release a utility program which formats the XML preferences files for Chimera, an Adobe Acrobat plug-in to Chimera, and a new beta version of the COM API.

The WebDAV working group will continue to work on increasing adoption of the Distributed Authoring Protocol. Work will also continue on the advanced collections functionality, and versioning and variant authoring. A design team meeting on the topic of Web versioning will be held February 10-11, 1999, at the offices of Novell in Orem, Utah. Jim Whitehead and Rohit Khare will attend the Minneapolis IETF meeting, March 15-19, 1999. Jim Whitehead will attend the Hypertext'99 conference, where he will give a paper presentation, and a tutorial on WebDAV.

Work will continue on the study of the Internet standards development process, focusing on the prospects for Internet-scale event-notification.

6.2. Software Architecture

In the area of dynamic architectures, plans for the next quarter include writing a conference paper on decentralized software evolution based on our recent survey and improving the implementation of our ArchStudio architecture tool suite. The planned improvements include interactive event

monitoring of executing applications at the architectural level. We will also be improving an existing cargo routing logistics system demonstration to support multiple destinations, on-the-fly cargo rerouting, and dynamic addition and removal of transportation vehicles and shipping centers.

Jason Robbins and Adam Gauthier will continue development of Argo/UML and support users of Argo/UML and GEF. Near term plans for Argo/UML include support for more UML diagram types, novel design visualizations, and the use of the XML Model Interchange (XMI) standard file format for UML design exchange and the Precision Graphics Markup Language (PGML) standard file format for diagram exchange.

Two CHI'99 submissions entitled "Sweeping Away Disorder With the Broom Alignment Tool" and "Using HTML to Create Early Prototypes" will be completed next quarter.

6.3. Process

We will be working on customizing Endeavors in such a way that it is easy to implement cross organizational, cooperating workflow processes using Internet protocols such as SWAP and intermediate data formats such as XML. We plan to build a component that can be embedded in arbitrary software systems that allows remote automated workflow participation.

There are three major goals for our work in Project Awareness and Knowledge Depot this quarter. The most important goal is to have a final release of the scaled up Bell Atlantic subscription feature. This will allow us to start gathering data and understanding the impact of this type of system. Data gathered by this system includes: Number of users to increase their use of the system, number of users to decrease their use of the system and number of users stop using the system entirely. This combined with surveys and interviews should give us a good idea of the overall perceived benefit of or resistance to the system. The second goal is to release the Java Knowledge Depot to more internal users/testers. The third goal is to begin a broad survey of existing subscription services listed under such definitions as "Push Technologies", "Digests", and related technologies.

Shilpa Shukla will be preparing two journal papers on how she applied ethnography and Activity Theory to study collaborative problem resolution contexts within Apple Computer and Hewlett Packard.

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- [And99] Kenneth M. Anderson. *Data Scalability in Open Hypermedia Systems*. To appear in Proceedings of the ACM Hypertext '99 Conference
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- [HR98-3] David Hilbert, David Redmiles. *Separating the Wheat from the Chaff in Internet-Mediated User Feedback*. In Proceedings of the Workshop on Internet-based Groupware for User Participation in Product Development, 1998 ACM Conference on Computer Supported Cooperative Work (CSCW'98), Seattle, WA, USA, November 14-18, 1998.
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