AWI Project Final Report

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SUBJECT: Final Report on the 2008 AWI project
   Arizona Hydrological Information Portal – A collaborative web environment for the AHIS

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Overview

In a statewide survey of researchers, water management decision-makers, industry representatives and others, the most frequent request from stakeholders was better access to water-related data. In response, the Arizona Water Institute (AWI) designated the Arizona Hydrologic Information System (AHIS) as one of its priority projects. AHIS will provide a one-stop resource for water-related data across the state of Arizona, linking users with widespread and diverse information sources. The system will connect government agencies, the three state universities, and databases developed and maintained in the private sector. Its user-friendly format and services will not only enable simple access, but will also allow manipulation of data to aid in responses to complex questions.

The first year of the AHIS project (2007) concentrated on creating web services that provide an interface to important stakeholders’ data. The emphasis of this second round of AHIS funding is on creating a data portal that can integrate the first year’s services and more generally any future services we will provide.

Project objectives and priorities

The immediate objective of this project is to create an AHIS portal web site. The original intent was to “concentrate on integrating existing components of the AHIS, including a metadata catalogue manager, an intelligent data search engine, a metadata editor for data providers to include data in AHIS, and a data download tool.” Please see the project proposal for additional background.

However, due to a number of difficulties resulting from previous development for AHIS, integrating the different existing AHIS components required additional development and refinement. This has significantly affected the pace of establishing access to ADEQ and ADWR data sources. Accessing SRP data has become possible only lately. Our current assessment of AHIS development places us at a point where prior dialogue with data providers is starting to bear fruit.

On the other hand, by carefully researching different CMS (Content Management System) platforms and choosing a highly efficient portal architecture the technical implementation of the portal website turned out to be less involved than anticipated to develop. As a result we were able to reallocate our resources to higher priority areas.

Moreover, with the help of our newly hired project manager for the AHIS, Matthew Garcia, we have developed essentially new products, such as the AHIS map interface and the Daily Arizona Water News service.
Stakeholder engagement

Since the beginning of 2008 engagement with AHIS stakeholders has focused on the development of web services allowing AHIS to access data from three primary sources: the Salt River Project (SRP), the Arizona Department of Environmental Quality (ADEQ), and the Arizona Department of Water Resources (ADWR). AHIS developers have been coordinating with SAHRA programmers at the University of Arizona to access water quality data from ADEQ for AHIS concurrently with the SAHRA-based ArizonaWells project. Discussions with ADEQ data managers on the most efficient and strategic access to ADEQ data for both AHIS and ArizonaWells are ongoing. Although significant progress has been made to date, there is still much potential in continuing this dialogue, especially once ADEQ overcame staffing shortages in its IT department late in the project year.

James McGill at the UA-AWI-SAHRA worked closely together with programmers at SRP. This collaboration resulted not only in a set of stable web services to the SRP Flood Warning System databases, but also provides a solid foundation for future expansion into a wide array of web services for time series-based data sources.

Data from ADWR for AHIS is acquired indirectly through web services to the SRP Flood Warning System. The interaction with ADWR regarding direct web services to data on the agency’s servers had been limited prior to the very end of this project year. As web services for SRP and ADEQ data are implemented, we are hopeful that more ADWR data can be incorporated into AHIS via web-based access to the agency’s servers and public products.

In the second half of the project year, the AHIS team welcomed a new AHIS project manager whose role is primarily to coordinate overall AHIS stakeholder engagement. Matthew Garcia accepted the informatics position at the University of Arizona and started his work in August 2008. In Matt Garcia we found a truly competent leader with vision and exceptional project management skills.

In December 2008 we began to make available to select partners and reviewers our prototype AHIS portal website, and in January 2009 the portal was introduced to a wider selection of AHIS stakeholders and the broader public; see http://www.AZh2o.org or http://chubasco.hwr.arizona.edu/ahis-drupal/. The portal is intended to both inform the public about latest developments in the AHIS, as well as to provide access to our products. This public portal or “production site” is supplemented by a non-public site, hosted at NAU, that allows for “beta-testing” of developmental components for later release to the public.

A project demonstration symposium was held on 14 January 2009 at the offices of the Arizona Department of Water Resources in Phoenix, AZ. All major parts of the data portal were presented to a broad audience of stakeholders including academics, agency representatives, utility providers, and private consultants. At the end of the meeting the
participants were handed out a questionnaire that asked for feedback on specific topics of interest. The list of symposium participants and a summary of their feedback is contained in the Appendix to this report.

**Project development environment**

That our programming team is distributed over all three universities added challenges to the development of AHIS. We have streamlined the development process by creating a number of project management resources, which proved to be very efficient. We suggest that similar tools should be used in other AWI projects that are working under similar conditions.

We have been holding regular teleconferences using a free voice-over-internet protocol (VOIP) teleconference system called Ventrilo (http://www.ventrilo.com/). This server- and client-based system provides a high quality environment for the team to discuss the various issues affecting AHIS development. There are servers and clients available for all mainstream operating systems. The installation of both the client and the server are easy to do.

We also created a public “wiki” website that allows the team to communicate agendas and progress reports, set up discussion forums, etc. We are using the free and open-source DokuWiki software (http://wiki.splitbrain.org/wiki:dokuwiki). The wiki is hosted on our development site at NAU: http://flagstaff.cse.nau.edu:9090/AHIS/.

Finally, we use the free and open-source SubVersion (SVN) software versioning system for our shared code repository. The SVN system allows for checking in and out source code files created by our developers so that changes and updates can be tracked more easily, especially when more than one developer is working on a particular aspect of the AHIS service.

**Development of the AHIS portal**

*Portal architecture*

In the methodology that we followed, it was important to create a sustainable software architecture early in the development process. The software architecture concerns the fundamental structure of a software system that is comprised of software components, the externally visible properties of those components, and the relationships between them.

In early stages of the process we looked at a number of portlet platforms. Portlets are small windows that can be rearranged and resized easily within a webpage and where each window represents a single application. The most promising portlet platforms are Google gadgets and Java portlets. However, after some investigation it became clear that these technologies work at a very low abstraction level. That is, they do not provide for
functionality such as user management or user interaction, as more typical content management systems (CMSs) can provide.

At the CMS level we looked into Java and PHP-based systems. On the Java side Jetspeed, Lenya (both are projects under the Apache foundation umbrella) and OpenCMS were promising candidates. However, all three architectures suffer from the same deficiencies that portlet architectures have, that is, they provided too little support for functionality at the higher abstraction level. Additionally, Jetspeed and Lenya don’t seem to be under active development. On the PHP side, we explored Drupal, Joomla, Xarya and Mambo. Here Joomla, Xarya and Mambo seemed to be poorly maintained, as their code bases relied on older versions of PHP. We eventually decided to develop the public AHIS portal using Drupal. Of all the CMSs evaluated, Drupal is the most consistently maintained, up-to-date, and stable system with the richest application programming interface (API) and the largest user base.

**The AHIS web portal development and production sites**

At the end of September, we brought our Drupal-based production AHIS portal online. It is hosted at UA and can be found on the web at [http://www.AZh2o.org](http://www.AZh2o.org) or [http://chubasco.hwr.arizona.edu/ahis-drupal/](http://chubasco.hwr.arizona.edu/ahis-drupal/). It not only contains links to the AHIS components and products that we have integrated thus far, but is also a general hub that serves an abundance of water-related information (see Figure 1).

![AHIS Production Portal](http://www.AZh2o.org)

**Figure 1 – AHIS production portal at [http://www.AZh2o.org](http://www.AZh2o.org).**
Apart from the main production site, we maintain a development site hosted at NAU that allows us to beta-test all products that are not yet considered stable and that we feel need further refinement before public release. The development portal was also constructed using the Drupal CMS and is found on the web at http://flagstaff.cse.nau.edu:9090/AHIS/.

**Metadata catalogue manager**

The metadata catalogue manager consists of a desktop design tool called the SchemaWalker that is used to generate code for the actual online editor, a native XML database, and an online user-access management application. The design tool is a Java Swing application that reads an XML schema and provides the developer with options to combine input fields into online forms and provide user-friendly tags for sometimes obscure field names. Based on these design decisions, the tool then generates web-capable code for the online metadata editor.

The generated code is an implementation of the XForms standard using the Orbeon framework. This design tool fulfills two requirements: first, data entry forms based on one metadata schema may be customized at design time, and second, data entry applications can be generated for any valid XML schema without concern for custom information in the schema. Any customized information generated at design time is saved in a configuration file which may then be re-used in the design tool should further changes be called for.

This system employs state-of-the-art XML technologies. A modular and distributed design was chosen for scalability, flexibility, available customizations, and the capability for additional functionality at a later stage (known as extensibility).

The following paragraphs describe the different components in detail.

**SchemaWalker**

Currently the SchemaWalker is set up in AHIS to read and parse the Ecological Markup Language (EML) schema v2.0.1 to enable a designer to organize EML data nodes within groups of Orbeon XForms web pages. In the process of parsing the EML schema, the SchemaWalker produces artifacts coined "parse fragments" used to handle parent and child schema references. The main dialog interface has a left panel allowing selection of EML data nodes for inclusion into a web page, an upper-right panel to display and edit attributes of a selected data node, and a lower right panel to add a web page with a title, file name, and navigation menu group. The SchemaWalker tool is coded in Java Swing using the IntelliJ integrated development environment (IDE) and is executed online as a Java application.
**Metadata Editor**

The Metadata Editor is a browser-friendly web application to enable the display, editing, addition, reduction, and removal of EML data nodes. Two XForms template patterns allow these actions, one for handling multiple nodes and another for single nodes. For each page, an upper left panel provides options to display the menu groups as an ordered list of individual forms defined in the SchemaWalker. A lower left panel allows navigation within the selected menu group to the individual forms. All Metadata Editor web pages are generated using Orbeon XForms by the SchemaWalker and are executed through a Tomcat web service. A browser call to the Java application starts the Metadata Editor, and the referenced EML metadata file is loaded from an eXist repository within the provided collection path. A user of the Filemanager module is able to open a managed EML metadata file with this same URL reference.

**Filemanager**

The Filemanager is a web application that performs basic management of EML metadata files in an eXist repository. It has a registration page with a secure MD5 password encryption login. The user is able to share authorship and maintenance of an EML metadata file within a specified group and organization. An administrator menu options allow a user to be activated within an organization as well as the creation of groups and organizations. The main Filemanager page lists all EML metadata files for a given collection path and allows the user to create a new EML metadata file in the collection path, search within the file titles for a given EML metadata file, and access the EML metadata file using a simple URL link. All user- and file-management operations are oriented on a MySQL database. The Filemanager is coded in the Java Server Faces (JSF) Netbeans IDE.

**Metadata search and data download tool**

The purpose of this tool is to find and provide access to datasets based on searches within the related metadata file. At this point in the project, we have concentrated only on keyword-based searches. One of the challenges of keyword-based searches is the ontological and semantic discrepancy between what a user “thinks” they are looking for and what the system is told the user is looking for. The system can return information only related to the explicit search terms, which may remain but a small subset of the larger and related concepts that the user has in mind.

To address this issue, different approaches were investigated. In the early stages of these investigations, the integration of text mining techniques for search terms was considered based on the work of Hung V. Nguyen [formerly at NAU, currently at ASU]. The idea is to calculate the “physical proximity of search terms” in order to develop “adjacency lists” of terms and then to orient keyword-based searches on the collection of adjacent terms. While the idea seems to be straightforward and especially well-suited for automatic keyword processing, the reality of the required process was discouraging. It turns out that the “physical proximity” of terms in training datasets (consisting of abstracts from the ecological literature) is not necessarily equivalent to the “semantic proximity” in a more
complete ontology of those terms. Whereas the search term adjacency lists generated by this process certainly provide useful data on the ecological literature, noise in this data currently outweighs the utility of this approach as a search methodology.

Figure 2 – Metadata keyword search interface.

For this reason, we took a different route: we simply offer the user what we have. This means that the user, upon entering a search term, is provided a list of keywords that are actually contained in any of the searched metadata files. Technically, what we currently provide is a proactive auto-complete method that dynamically fills a drop-down list with terms that contain the string of characters that the user has already entered in the text field (see Figures 2 and 3). This way, a user is far less likely to encounter the well-known situation where the desired search term returns an empty set of results.

Figure 3 – The keyword search, including a dynamic drop-down list of available terms.

When a valid keyword is entered, the search system returns a list of clickable metadata files. When a particular metadata file is chosen, its metadata contents are returned in a human-readable format. Among the information displayed is a link to download the referenced dataset.

At this time, this search tool is applicable only to repositories of metadata in EML.
format. For our proof-of-concept implementation, metadata and data from the CAP-LTER database was provided courtesy of ASU GIOS.

**Serving time-series-based data through CUAHSI ODM**

The AHIS portal site is capable of serving time-series-based datasets from a variety of sources. The fundamental challenge in serving datasets from different sources with potentially infinite variations on data representation is to obtain, and then explain or codify, a unified view on all of those dataset variations. The approach we have taken centers around a most important strategic design decision: we have adopted the CUAHSI Observations Data Model (ODM: http://his.cuahsi.org/odmdatabases.html) as an intermediate format for all time-series-based datasets.

This approach has some immediate benefits. Once a dataset has been transferred into conformance with this model, tools that access the ODM database can rely on a unified data format that is independent of the original data representation. This level of data abstraction allows us to separate the development of analytical tools that add value to the data from the development of tools that integrate new and different data sources.

During this project we applied two different methodologies for the import of datasets into the ODM: semi-online, and offline. For example, the SRP dataset to which we provide access is served semi-online. A web service hosted by the Salt River Project (SRP) makes its dataset accessible to a corresponding web service client on the AHIS server. The client reads the data and transfers it into a local ODM database. At the output side of the ODM, an AHIS web service provides “public” access to the SRP dataset by reading it from the ODM database. The most important aspect of this method is that the AHIS web service that obtains and loads a dataset into the ODM, and the AHIS web service that reads a dataset from the ODM for transfer to the end user, work independently and asynchronously (see Figure 4).

One value-added service that we currently provide is a map interface that allows for accessing elements of the SRP dataset by the specification of a geographic bounding box. This SRP-oriented map interface is designed for upcoming integration with a more widely-oriented Google Map interface in the AHIS web portal, discussed below. It is also important to note that the AHIS web service that allows access to ODM-based datasets is not only open to AHIS web clients. Conceptually, this AHIS web service serves also as an API that can be used by another properly-designed product or value-added service outside of the AHIS portal.
Providing access to ADEQ data through AHIS is an example of the offline mode of ODM database operation. In this case, a dataset is provided in XML files (or any other arbitrary format) via data transfer or on a CD/DVD and using specified client software. Our AHIS developers then created specific adapter tools that parse the provided dataset and transfer it into the ODM database. Unfortunately, the dialogue with our ADEQ contact was less than optimal in the second half of this project year due to staffing shortages in their IT department. On the other hand, the adapter tools that were created for AHIS are currently being refined for use by SAHRA to help update their ArizonaWells project. It can be expected that future AHIS efforts will benefit significantly from this work, as adoption of the ODM standard allows interaction with a wide array of data and information services currently in development by CUAHSI researchers.

**Google Map Interface**

The vast majority of information and datasets provided to users through AHIS have a spatial component in their collection and application. In order to make easier the discovery of datasets and information resources, we have developed a map-based interface using the free Google Maps applications programming interface (API). This method was selected as a viable alternative to the development of a licensed, and expensive, web map service based on GIS software such as ESRI’s ArcGIS Server. Programming for the service of information through Google Maps is based in JavaScript (JS), which is easy to learn and has many example-oriented resources available on the web. This ease of programming also allows us to maintain our goal for AHIS to remain an open-source information portal, by providing direct access to the code behind the
mapping interface to interested users.

At the time of the AHIS portal demonstration in January 2009, more than twenty location-based information collections had been included in our Google Map interface. Each point in a collection is associated with a geographic location, for placement on the map, and with related information including station or place name, operating agency or organization, and a web link to more information or datasets related to that location. For example, all of the surface water stream gauges in Arizona that are maintained by the US Geological Survey are available for display in the AHIS Map Interface. When one of the three stream gauge collections (real-time, daily summary, or water quality) is displayed, the user can find an individual stream gauge location by either textual or map-based search-and-zoom capabilities, of which seven different methods are programmed in the interface. When a desired stream gauge is identified, the user can click on that location to open within the map area a small information window that displays relevant information on the selected gauge: the unique USGS gauge identification (ID) number and common name, in the case of USGS collections. The ID number itself serves as a link to the USGS National Water Information System (NWIS) page for that particular gauge, where the user can find information on all aspects of the operation of that stream gauge from the most recent collected data to historical records extending, in some cases, almost 100 years into the past.

In addition to USGS surface gauges, ground water well measurements, and water quality information available through direct links to NWIS for more than 10,000 sites across Arizona, we have also incorporated location collections and information links from a variety of federal, state, and local sources. Several of these collections are provided by the Yavapai, Maricopa, and Pima county flood control district ALERT precipitation and stream gauge systems (almost 750 sites). We have also incorporated NOAA National Weather Service official and cooperative weather and precipitation measurement locations throughout Arizona (more than 450 sites), as well as the Arizona Meteorological Network supported by the University of Arizona’s Cooperative Extension efforts (34 sites). Although we have incorporated only point-based information collections up to this time, upcoming efforts will focus on the incorporation of line- and polygon-based information collections that are often shown easily in GIS-based systems but through which the dataset itself is often obscured from user access. We are currently formulating workflows necessary for the extraction of relevant information from such GIS data collections for ease of display in a Google Maps interface, which we expect will be one of the pioneering efforts at such information and data fusion for Earth sciences and, especially, the capability for information correlation in the hydrologic sciences.
Figure 5 – AHIS Map Interface showing weather stations in the vicinity of Flagstaff, AZ. Markers vary by the source of information: National Weather Service stations are marked with blue droplets, and UA Cooperative Extension AZMET sites are marked with white triangles. The individual markers are clickable and provide links to the dataset resources for the selected site.

**Daily Arizona Water News (DAWN) service**

The Daily Arizona Water News (DAWN) service was initiated for AHIS as an attempt at the collection of all official news media on the topic of, or related to, the status of water resources and their use in Arizona. There are only two other known existing resources for such news media collections: the Arizona Department of Water Quality (ADEQ) produces a daily “Early Bird” collection of water-related news stories from throughout the state and country, but this collection is reserved for dissemination and use within the agency itself, and it was only by special request (and our connection through AWI Associate Director Chuck Graf to ADEQ internal operations) that we have been able to obtain this collection on a daily basis. The other resource of potential use is a weekly “Arizona Water News” electronic newsletter produced by the private engineering firm Brown & Caldwell (B&C).

For our intended purpose, which is a daily collection of publicly-available news on water-related issues throughout Arizona, we rely primarily on automatic searches at the Google News site (http://news.google.com/) using specific keywords, the results of which are e-mailed directly to the AHIS project manager each evening. These results are then filtered by hand in order to exclude unwanted or unrelated content, and the remaining collection of news articles from all of these sources is listed on the AHIS DAWN page. The page is indexed by date of publication, with listings in reverse chronological order, and only the
stories published in the past 2-3 weeks are included on the main DAWN page. News listings older than that 2-3 week period are moved on a semi-weekly basis to the DAWN Archive page, where listings are also indexed by date of publication. At the time of this report, nearly two complete months of Arizona water-related news coverage is available on the main and archive DAWN pages at the AHIS portal.

In a cursory analysis it was found that the Google News searches catch approximately 40-50% of the relevant news items suitable for listing on the DAWN pages, that the ADEQ daily collections provide an additional 35-45% of the relevant news not obtained by the Google searches, and that the B&C weekly newsletter helps fill in the remaining 5-15% of otherwise undiscovered news items within the previous week. This DAWN service provides a potentially vital resource for those interested specifically in Arizona’s water issues but who cannot or would not be able to access all of these resources individually. Work to streamline and upgrade the AHIS DAWN listing and content dissemination process is ongoing.

Summary

This project has been a successful endeavor in many ways. Not only did we meet all of the project’s original stated goals for the year, most notably with the establishment of the AHIS portal web site, but we were also able to refine the operation of several existing components (the metadata catalogue manager, web services to SRP data, and the metadata search & download tool) as well as create new products (the Daily Arizona Water News service and the Google-based Map Interface).

Apart from these tangible results, the project work of this past year was a valuable experience in collaborative product development. We became a highly efficient team, working seamlessly across both physical and conceptual gaps within the development team and between different locations, including academic institutions and state agencies.

We continued our active dialogue with state agencies and other stakeholders at various levels, especially after our newly-hired project manager took his position. For our project, this dialogue culminated in a portal demonstration symposium that was held on 14 January 2009 at the offices of the Arizona Department of Water Resources (ADWR) in Phoenix, Arizona. Approximately 50 people were in attendance representing all three universities in the state, the Arizona DEQ and DWR, the Central Arizona Project, the Cities of Phoenix and Tucson, several private engineering and consulting firms, the National Weather Service, and SAHRA, CLIMAS, and the WRRC at the University of Arizona. The attendees provided valuable feedback throughout the demonstration, and we obtained additional feedback through questionnaires that were provided during the session. All of this feedback provides valuable guidance for the direction of our ongoing and future work. Please see the Appendix for a categorized summary of this stakeholder feedback and for a list of symposium participants.
From our perspective, ongoing and future work on AHIS will need to concentrate both on the breadth and depth of information service. More individual and comprehensive datasets need to be integrated and made available to the public. At the same time, a broad array of value-added services that help process, visualize, correlate and integrate the available dataset will need to be created for more effective service to decision-makers and the public.
Appendix

Stakeholder meeting 14 January 2009 - Summary of feedback

Web content:
- Be the hub for all water related data
- Promote other portals rather than duplicate efforts
- Provide regular project updates
- ‘Daily water news’ seem similar to existing news services
- Consider slow internet connections (i.e. dial ups)
- Have functionality to group data across agencies (e.g. all data for 1980)
- Include project descriptions and conclusions
- Make it easy to provide and retrieve data
- Standardize data, sites etc.
- Graphing capabilities to explore data
- Develop online ‘walk through’ instructions
- Have an acronym dictionary on site
- Open source document management system
- Implement web service access to data
- In the search application ‘Path to collection’ is not clear what that means

Organization:
- Set up a steering committee to include stakeholders
- Engage stakeholders
- Get a better management team

Share data:
- ADEQ
- CAP
- Montgomery Associates
- UA Water Resource Research Center (NEMO)
- Clear Creek Associates
- City of Phoenix
- Weston Solutions (maybe)

Concerns:
- Data security
- Sensitive data
- Liability

Other
- Provide training
## Stakeholder meeting 14 January 2009 - List of participants

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