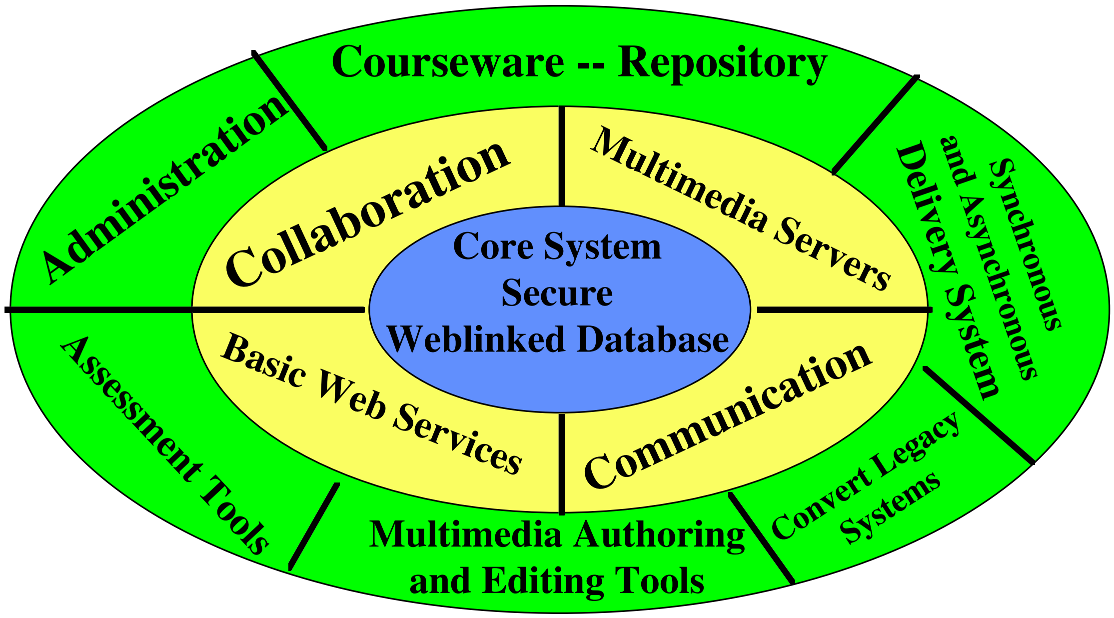
Architecture of Web-Based Training and Education System

Geoffrey Fox, NPAC Syracuse University, gcf@npac.syr.edu

See abstract at http://www.npac.syr.edu/users/gcf/wisewords/webwisdom1.html



WebWisdom Education and Training System

1: Introduction

Many organizations have used the Web very successfully as a tool to enhance education and training. Indeed although computers have been promoted in this area for many years, their impact (especially in the critical K-12 arena) has currently been modest. We believe that there is good reason to believe that the Web will change this and its pervasive use in education can lead to significantly improved learning environments with lower cost. In this article, we will not pursue the important social and business issues implied by this hypothesis and indeed will not try to quantify or justify the increasing use of the web in education. Rather we will try to design a web infrastructure for education that we term WebWisdom. The proposed design is shown above in figure 1, and in this paper we will describe how we arrived at this architecture based on the study of a set of experiments by NPAC and others on web-based education and training. These motivating projects are described in section 3, while we summarize issues in section 4. In the following section 2, we describe the general structure of WebWisdom.

2: Overview of WebWisdom

Our proposed layered design of WebWisdom includes a secure database at its core on top of which are built a set of services including audio and video servers; basic Web servers and a collaboration subsystem which is heart of both asynchronous and synchronous delivery. This has a set of basic collaboration capabilities including chat, audio-videoconferencing, whiteboard and shared applications. The communication system supports the worldwide delivery and includes support for distributed databases to get high performance with for instance core courseware replicated on delivery machines with CD-ROM's or other such mechanisms. The top layer of WebWisdom consists of education and training specific capabilities that customize and extend the generic middle-layer services. As well as standard curricula material, one must support 3D worlds and Virtual laboratories for programming and experimental science. Note assessment relies on database at heart of WebWisdom, which logs synchronous delivery of curricula and records interaction of students with courseware and tools. Authoring and Editing includes audio, video, and Java applet based animations as well as basic text (HTML) material. Conversion of Legacy systems includes putting Persuasion Framemaker PowerPoint etc. on the Web. The delivery system is based on customized shared browser windows for curricula together with more generic collaboration capabilities e.g. audio-videoconferencing is used by students and teachers for traditional voice interactions. The collaboration subsystem must support multiple rooms and many groups of users. WebWisdom is to be used by virtual Universities offering ab initio or continuing education or by not for profit or commercial organizations with K-12 curricula augmenting home or traditional education. We do not believe that there is any compelling consensus as to the "best" or "better" modes of learning in the emerging electronic virtual classroom. Rather WebWisdom must support a broad range of learning styles and in particular both asynchronous and synchronous interactions between teachers and students. In fact most historically successful education systems mix (albeit to different degrees) both face to face (synchronous) and offline (asynchronous) interactions. We do assume that a major reason for the attractiveness of the Web is its interactivity and that exploratory learning and its support will be very important.

The productivity of web technology is partly due to its high level application interface and partly to the immense amount of available interoperable software that is compatible with universal web interfaces which are reusable between fields. WebWisdom must be designed to use wherever possible capabilities developed outside the education arena. For example, web-linked database capability is being developed for the large enterprise Intranet market; multimedia servers for the electronic information and entertainment industry; and authoring tools for the general desktop (or what I call WebTop) publishing and productivity market. Most intriguing to us is the area of collaboration where we must support electronically the student, teacher and teacher assistant interactions. Millions of people are forming electronic societies with such sites as www.talkcity.com, www.mirabilis.com, www.worldkids.net, www.geocities.com, www.parentsoup.com building on the success of chat rooms (where America Online alone has 14,000) and Usenet news groups for both synchronous (e.g. chat) and asynchronous (e.g. mail) interactions. There is a popular description of this phenomenon in the recent May 5,1997 issue of Business Week. These sites are experimenting with different interaction mechanisms and being used for a variety of purposes and we believe that it is reasonable to expect to use these pervasive approaches as the basis of electronic collaboration for education. An interesting start-up (www.centra.com) came out of Lotus Notes and has a similar vision to WebWisdom with a mix of collaboration and Intranet technologies for corporate training. As always education will require enhancement and customization but for instance, the use of a broad based technology core will allow the K-12 area to build electronic curricula which can naturally involve parents and allow children to continue their involvement at home as well as at school.

The above discussion emphasizes that this paper inevitably strays from a pure HPCC focus. However HPCC is relevant and incorporated into our discussion in several ways. These include application of WebWisdom to electronic HPCC curricula such as computational science; use of high speed networking for digital video resources; incorporation of results of HPCC simulations into science curricula; and the relevance of WebWisdom to distributed HPCC consulting and training—especially in today's era of the distributed NSF centers.

The WebWisdom design tries to take advantage of the "best of the web" and in particular we are currently surveying an emerging crop of technologies for the support of databases and collaboration. However as the web is still evolving very fast, it is essential to design a modular system with as loose a coupling as possible between components. In this way, we can be best positioned to take advantage of new developments. In general this paper will not survey needed Web technologies but rather focus on their application to education.

3:Some Web based Education and Training Activities

3.1 K-12 Arena

Here my experience comes from the Living SchoolBook project (http://lsb.syr.edu) that was funded by New York State to explore new curricula opportunities opened by high-speed networking. This involved ATM linkage of three Central New York schools to NPAC and other sites via NYNET. Here NPAC developed advanced curricula resources, the University's School of Education provided key linkage with teachers and students, while NYNEX donated ATM link. This project was technically very successful, as we were able to develop and deploy (in a limited fashion) three important applications:

- Web-linked database search engine for educational material supplied traditionally in CD-ROM format. This was not surprisingly attractive to teachers and we are working with them to improve the interface.

- Text indexed video on demand server. This was one of few applications that demanded the high performance link and was used for both commercial videos and amateur material from students and teachers. The latter were made to record local landmarks and interviews with visitors. Here we found it hard to freely use material due to copyright restrictions. We found it particularly easy to use close captioned tapes as we can simultaneously read time stamped captions into a database as we digitized tape. However the interesting local material needed database indexing to be added in a less automatic fashion!

- Web-based Geographical Information System (GIS) using effectively VRML to display the terrain and allowing one an attractive intuitive interface to spatial data from either public sources or at teacher/student prepared sites. This shows that one can use and WebWisdom must support more general user interfaces than traditional text. The raw data for this project are stored in an object (not relational) database and these more general data types must be supported in the core WebWisdom database. Both Oracle and Informix (linked to Illustra) are possible commercial sources of combined object and relational storage. Our award winning VRML2 interface to the Visible Human data (http://www.npac.syr.edu/projects/3Dvisiblehuman/) needs similar support. Other interfaces one might need to support include sophisticated visualization front-ends such as the CAVE.

Most of the deployed applications were correctly curricula and not technology based and a good examples of this is our original Kidsweb resource (http://www.npac.syr.edu/textbook/kidsweb) which for last two years has been NPAC's most popular site. This is a selection of web sites in several areas while the schools have made interesting focussed group projects such as the Cyberzoo resource.

We have found it hard to capitalize on this success because so few schools have the necessary network infrastructure to use such high bandwidth. We found an interesting technology transfer statistic. Namely we started with a pretty representative (random) group of 20 teachers and of these, about half really took off and now provide a source of Internet/Web expertise in their schools. This illustrates that such projects can help retrain our educators.

3.2 Undergraduate Teaching

Here we have successfully worked with the Syracuse Physics department (http://www.phy.syr.edu/courses/modsim.html) on first integrating basic Web resources, then Java applets and now Tango collaboration technology into their introductory course PHY105/106 "Science for the 21st. Century". This course for non-science majors sustains great student interest (over 250 enrolled each semester) as it is organized into interesting modules (such as Mind and Machines or the Search for Extraterrestrial Intelligence) and the Web allows material to be very topical. Further using the web in the class teaches them skills of general value. This and several other such physics education projects (for instance TIPTOP) are described in the February 1997 special issue of IJMPC (International Journal of Modern Physics C http://www.wspc.com.sg/journals/ijmpc/81/ijmpc81.html). Here one needs both Java applets executing simplified simulations and visualizations of more sophisticated server side programs that could run on HPCC resources. The latter need to be shared (perhaps with collaboration technology) if scalable delivery of realistic simulations is to be supported. We have also learnt how to collaboratize simulation applets with a teacher manipulating a master system and interacting with students responding to questions. This requires quite complex session control to allow control of simulation to be safely shared between several users.

3.3 Graduate and Continuing Education

This area has much in common with training offered in corporations and to that supplied to users of HPCC supercomputer centers. This area has the characteristics of relatively focussed advanced curricula and typically highly motivated students. It is likely that asynchronous training such as that very successfully used by Cornell in their Virtual Workshop is particularly suitable. (http://www.tc.cornell.edu/Edu/VW/modules.html) However synchronous delivery of all part of the material is also important. Here we see the need for curricula to exist in several forms -- highlights (bullets in presentations) as typically used in lectures; exploratory detailed material as needed by asynchronous learners; background pedagogical resource for student reference. Very little material today has this multi-level structure although the Virtual Workshop does offer a partial hierarchical structure. Correspondingly synchronous systems such as our prototype WebWisdom (http://www.npac.syr.edu/users/gcf/wisdom/help/) offer "notes" capability (as available in Presentation software) or the availability of "voice or video-over" (typically in Real Audio Web format as pioneered at http://renoir.csc.ncsu.edu/RTCPP/index.html) to add detail to the highlights. I believe more experimentation is needed to find the optimal ways of supporting the different delivery mechanisms with both visually clear highlights and detailed asynchronous resources.

In teaching computer science, one needs to incorporate programming laboratories both into the actual delivery of the course and homework. This was emphasized to us when teaching Java, JavaScript and VRML where this is essentially automatic due to the natural Web integration of the languages. We found the ability to go through exemplar codes and illustrate their execution in real-time, an invaluable aid to teaching. Again students obviously prefer to learn such languages where success is not measured by dull text output -- printf("Hello World") -- but rather by the production of an interactive Web pages that can be shared with their peers. This motivated us to develop virtual programming laboratories (VPL) for both HPF and MPI (http://www.npac.syr.edu/projects/VPL/) and PERL (http://www.npac.syr.edu/users/gcf/perlvpl/). These are successful but still need more experimentation and our latest VPL is now available with integrated Java visualization of data and performance visualization. Such capability should be included in the design of WebWisdom and is incorporated through the notes feature of our current prototype.

We have linked the current WebWisdom to the collaborative system Tango and shown how a complex JavaScript teacher interface can be linked to a simpler student interface which has just the selected material and not the full capability of easily selecting material to teach. This ability to support multiple views of the same basic application is an important feature of collaborative systems. This set-up (teacher and student both with their own independent computer) is particularly helpful in teaching programming as it avoids visibility problems that occur if you try to go through programs which cannot easily fit on an overhead with font sizes that display in a classroom with a single display. Further we note that our educational applications have needed a link of Tango to C++ (3D GIS), Java (Physics Simulations) and HTML and JavaScript (web delivery). Such a multilingual interface appears to be a critical feature of collaboration systems.

In delivering lectures and courses, I found that when using transparencies and overhead projectors, I made up talks dynamically by selecting material from different foilsets that were produced on multiple computers in different fashions. It is not clear if the volume vendors will support the necessary authoring but currently I find it necessary to mix Persuasion, PowerPoint, Framemaker, Latex, Computer Screendumps and HTML pages in a given presentation. This integration of (legacy) systems is fully supported in current WebWisdom and in the future we will improve the user interface with a Java Applet to allow the user to define graphically the "play-list" of selected material. We also noted this type of capability is useful for storage and selection of other image collections such as those of family photos(http://www.npac.syr.edu/users/gcf/familyphotos/).

We have successfully used our HPCC and Web course material to teach across the globe (http://www.npac.syr.edu/projects/icpse_spring96) to students in China. This was inevitably asynchronous with a mirror site supplying material locally and email/ftp interactions between NPAC and Harbin Institute of Technology. This succeeded due to student commitment and the use of faculty at both NPAC and Harbin. We also learnt that although English is universally learnt in China, it would have been very useful to have the base material in Chinese. Thus Harbin has translated key material (such as HPF and MPI definitions) and some of my curricula material into Chinese HTML. (http://www.npac.syr.edu/projects/pcrc/cpswt/index.htm) This will be distributed freely on 1200 CD-ROM's. This is an example of using the Internet and Web technology to link technology knowledge rich organizations (such as most of those in HPCC) with technology knowledge poor institutions. We expect to try such an experiment this fall to teach faculty and students at selected Historically Black Universities and Colleges.

As a final example in this area, we turn to the novel Language Connect University (http://www.syrlang.com/) which has recently been started by Syracuse Language Systems (SLS), which is a leading PC vendor of language instruction. This work uses a core database technology (Web-linked Oracle plus PL/SQL) and features rich administrative functions built on top of this. An NPAC spin-off Translet designed and built this subsystem whose general structure, we intend to follow in WebWisdom. We can learn from SLS some interesting business pointers for future virtual universities. SLS will be able offer training (is this different from education?) at substantially lower cost than traditional Universities. However their strategy is to pursue corporate training opportunities where is a large market and the necessary accreditation is an easier process without government hurdles.

3.4 Special Education

A very innovative project led by medical doctor David Warner and biophysics Professor Ed Lipson is developing Web interfaces and customized material for physically and mentally disabled individuals. (http://www.pulsar.org) We can view this as bringing the special education requirements to the design of WebWisdom. Note that the Web offers tremendous opportunity to produce cheaper and higher capabilities for the disabled. Thus it provides a universal set of high functionality user interfaces to which we can link a wide variety of human input devices. A quadriplegic Eyal Sherman is able to browse the web using either optical detection of his facial muscle movements or the output of electrical sensors detecting muscle movement. We feed these general sensors through filters and use them to control Java and JavaScript event handlers. As long as the authoring system can produce relatively uniform interface, we can give Eyal and similarly severely handicapped individuals comparable learning opportunities to those without their disabilities. Note that currently WebWisdom uses Perl scripts to customize the same base material for a variety of uses. We see that this "indirection" between raw curricula and presented pages should be continued and will be invaluable in producing output customized to the needs of the particular viewer. Whereas this is currently done as a batch step, we expect to switch (or offer as an alternative) interactive real time generation of customized front ends from raw curricula stored in the web-linked database that we propose as the core of our next generation WebWisdom.

A WebWisdom feature pioneered in this project is the use of a database backend for assessment where this is natural from both an educational and medical point of view. This illustrates that the WebWisdom architecture can be extended to support areas such as Home Healthcare or more general medical database applications.

4: Conclusions

In the previous section 3, we described several educational initiatives with an emphasis on extracting lessons that can be used in the design of the next generation delivery, authoring and storage system WebWisdom shown in fig. 1. The lessons are not conclusive and in particular, we intend to further refine the requirements by studying the needs of both the new NSF Alliances and the DoD Modernization centers. However we do believe that there is enough education experience and further that Web technologies are well enough understood that one can start the major effort involved in implementing the system shown in figure 1. We are currently refining the design and exploring both federal state and commercial funding opportunities. We expect that a good and relatively complete prototype will be available by the end of this calendar year.