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Opportunities and options for Web-enabled databases: comparing in choosing the right software for virtual courses and communities

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The landscape of Web-based instruction is changing due to the convergence of the Web and database servers. Web-based database (WBD) servers enhance Web-based instruction by providing benefits to both students and instructors. From a student viewpoint, a WBD server facilitates virtual communities for discussion, present linked resources in relational databases, deliver instant feedback, and customized instructional sequences. From an instructor standpoint, this system provides centralized management of course resources, online data collection, online statistical analysis, and collaborative research. This paper examines the features, functionality, and interoperability of WEDs.

Introduction

When the World Wide Web was introduced, web servers were no more than showrooms of static information. Today the advancement of Internet and database technologies enables web servers to present dynamic information. Users can upload information, submit a query, update a record, take a test, or produce a report through a Web interface running off a database server. The landscape of Web-based instruction is changing due to the convergence of the Web and database servers (Calvi & De Bra, 1997; De Bra, 1997; Houben & De Bra, 1997). This paper examines the functionality and benefits of currently available Web-based instructional delivery applications. Guidelines for educators constructing Web-based database systems to organize online instructional materials are presented. Examples of web-based courses employing database applications are examined and selection criteria for building various types of instructional systems are proposed.

Benefits of Web-enabled databases

Virtual community

There are many advantages of building instruction delivered via a Web-enabled database (WED) server. A WED server can be used to form a virtual community, where participants in remote locations can exchange ideas in electronic formats. Virtual communities such as newsgroups and Listserv discussion groups have been around even before the introduction of World Wide Web, but suffer from several shortcomings such

as a lack of organization and searching capabilities. It is not uncommon in newsgroups and Listserv environments for some of the same questions to recur over and over again. To alleviate this problem, a WED server could be configured so that ideas among students become searchable archives. For example, before a student posts a question, she could look up the group archives to check whether the issue has been addressed earlier. This query could alternately be initiated by the server, as part of the question-submission algorithm, providing the student with 'answers' to the question from the existing database. The student could then determine if the question needs to become a part of the database, or could refine the question to address an area not presently covered in the existing archive. This approach combines the functionality of a traditional, passive, FAQ (frequently asked questions listing) with an interactive query system, forming an intelligent and dynamic information acquisition and contribution resource.

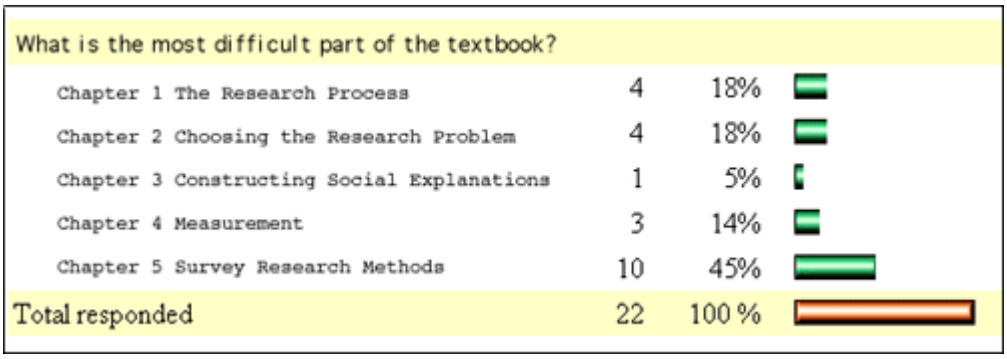
Relational database

Many modern databases are relational. Information presented in a single database can be linked to another, thereby enriching the learning experience. This approach is different than using traditional hypertext linking, where hotlinks are inserted manually. In a relational database, many records from two or more database files can be merged on the fly. For instance, an art professor can create separate databases for his course: one containing images of many paintings, another housing artists' biography, and a third storing critics of different paintings. It is beneficial for an art student to learn to appreciate paintings by gathering information on the artist's background, other works, and related critics. Using conventional hypertext linking, the Webmaster must insert the hotlinks to each artist's history, painting, and critics--one by one. In a relational database, all three databases could be linked so that users could retrieve all information at once.

Instant feedback and customized sequence

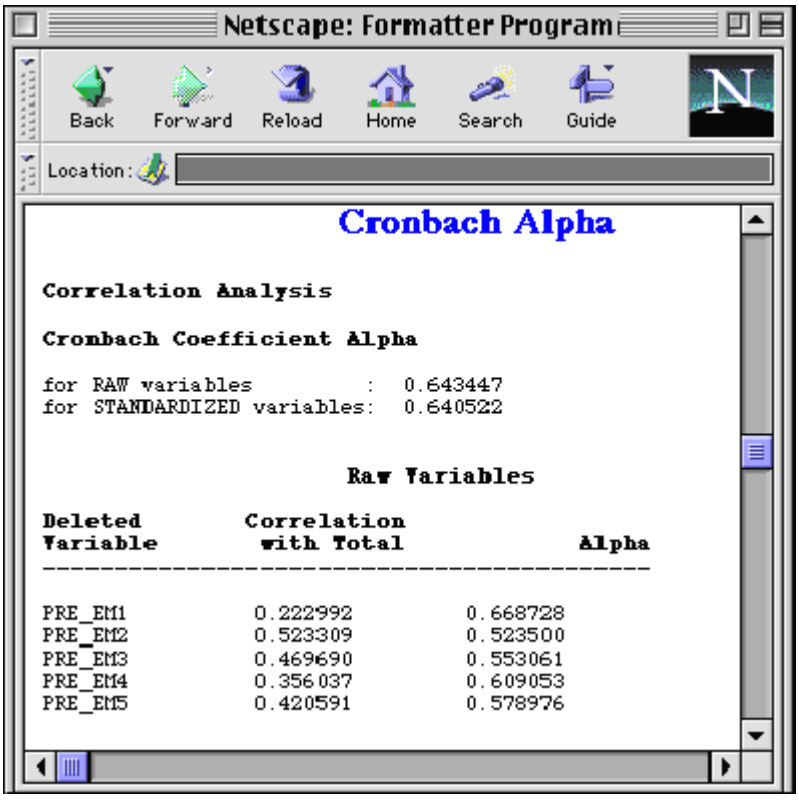
A WED server could be configured to perform online surveys and online tests with immediate feedback. Although an electronic survey or test located on a stand alone computer or a computer wired to a local area network (LAN) could also provide instant feedback to a respondent or a test-taker, a WED server includes more functions. For instance, Dragon (Wave in Motion, 1998), a plug-in for File Maker Pro, allows both respondents of a survey and the instructor to see the latest statistics produced by the poll (see Figure 1). In a standalone or LAN client, it is impossible to compute the data, which are input by users in various locations, and produce a report immediately. This feature has been used in a course at Arizona State University to build a positive feedback loop for enhancing the instruction.

Figure 1. Statistics of an online survey (D)



Instant reports with more sophisticated statistics are available in SAS/IntrNet (SAS Institute, 1998). Using this software, for example, the instructor can calculate Cronbach Alpha coefficients for checking the reliability of a survey or a test (see Figure 2). With the use of relational database, the instructor can retrieve students' demographic information from another database table. When the demographic data and the scores are merged, the instructor can conduct independent t-tests as well as other analyses to gain insight of the instruction, the test, and the learners. The data are well-organized and available online, therefore evaluation may be expanded as online collaborative research among several faculty members.

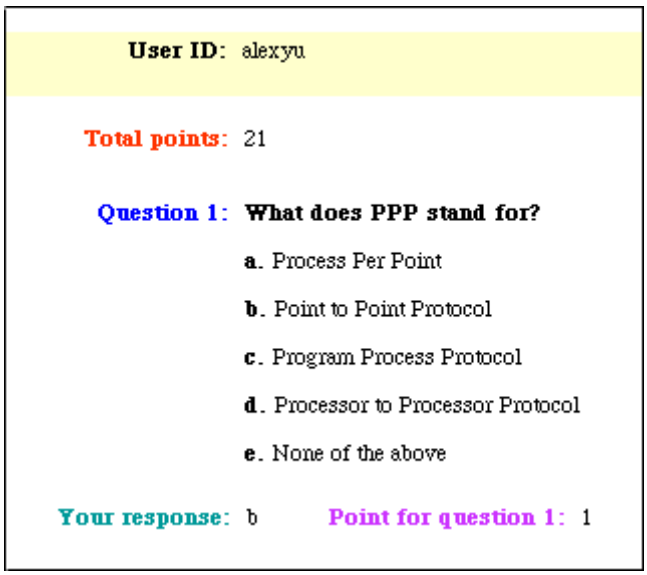
Figure 2. Statistical report from SAS/IntrNet (D)



An online test powered by a WED will return the grade to the test-taker (see Figure 3), and also determine which module the student should go next based upon his score. In this example, after a remedial session was presented to the learner, the questions which were answered incorrectly the first time would be re-posted in the second test. Although

a standalone or a LAN-based computer-assisted instruction could perform similar functions, it is more efficient for a WED to deploy any update to all clients. This feature has been effectively used by a Web-based course teaching basic statistical methods at Arizona State University.

Figure 3. Feedback of an online test (D)



Selection variables

There are several critical variables to consider when selecting a WED server. Magnitude of the data to be stored, nature of the data analysis to take place, as well as comprehensiveness and interoperability across various platforms and database systems are important areas of consideration.

Magnitude of data

To assess the potential magnitude of data, two sub-dimensions may be studied: the number of records and the length of fields. When the number of records are in the millions, 'data warehouse' applications are typically employed. Data warehouse systems are often used by large institutions such as universities, banks, and utilities companies for administrative purposes. There are specific commercial data warehouse solutions available from Oracle (Oracle, Inc., 1998), Sybase (Sybase, Inc., 1998), Informix (Informix, Inc., 1998), and SAS (SAS Institute, 1998). However, for Web-based instruction, traditional data warehouse applications often prove unwieldy in terms of required system and administrative resources. In most cases, commonly available consumer databases products such as File Maker Pro (FileMaker, Inc. 1998), and Microsoft Access (Microsoft Corp., 1998a) are sufficient.

Microsoft SQL Server and Microsoft Access are good examples for illustrating the difference between data warehouse and database in terms of capacity. Microsoft Access can support up to 1 GB of data while SQL can go up to several terabytes. MS Access can allow 255 concurrent users while SQL permits thousands of simultaneous connections.

Nevertheless, it is advisable to have both database level and data warehouse level solutions to suit projects of different scales. Currently, Microsoft employs a parallel strategy, in which Microsoft Access is designed for small-scale database whereas Microsoft SQL server (Microsoft Corp., 1998b) is made for data warehousing. Access has an 'upsize' option for the developer to convert a small database into the format of SQL Server. At the present time, the Instruction and Research Support group at Arizona State University adopts this parallel strategy. File Maker Pro is used for small projects as well as for beta testing of new projects. When the number of users of the Web-based course increases or the development is mature, all course content migrates to Oracle Server.

Instructional designers should focus particular attention to the field length limit when purchasing a database system. For example, in some database systems the maximum length per field is 200-255 characters, while other database systems have no field length limit. Although some databases allow unlimited entries in a memo field, the data inside a memo field are not searchable and therefore offer limited utility. In Web-based instructional environments, student responses to essay-type questions can easily exceed the 200-255 character limit imposed by database products. The ability to construct searchable archives of these response fields provides the instructional designer with a potentially valuable resource. These requirements disqualify most database systems as candidates for Web-based instruction tools. Currently there are several database systems which are suitable to store essays: Lotus Notes/Domino, File Maker Pro, and Oracle. For a small-scale application, File Maker Pro is recommend for its user-friendliness, flexibility, and low cost. For a campus-wide solution, Oracle is preferable for its high performance and robustness.

Nature of data analysis

Web-based instructional environments must provide the instructor with the ability to conduct both qualitative and quantitative data analysis. A typical Web-based instruction database carries both text and numeric data. The former are usually essay-type input while the latter are test scores from online tests and frequency counts from the user access log. Data warehouse systems typically include 'data mining' and 'decision support' tools. Data mining is a descriptive statistical analysis tool for discovering the pattern of the data while decision support is an inferential tool for supporting decisions based upon the data pattern. For example, A SAS system can provide both these advanced services.

Consumer level database systems do not traditionally include sophisticated statistical analysis tools, often providing only basic statistics such as sum, mean, and counts. Instructional assessment needs exceed the computation of sum and mean, therefore a statistics-rich system should be used along with a text-based database system. SAS is a recommended choice for a 'statistic analysis' server because of its rich statistical features.

Comprehensiveness and interoperability

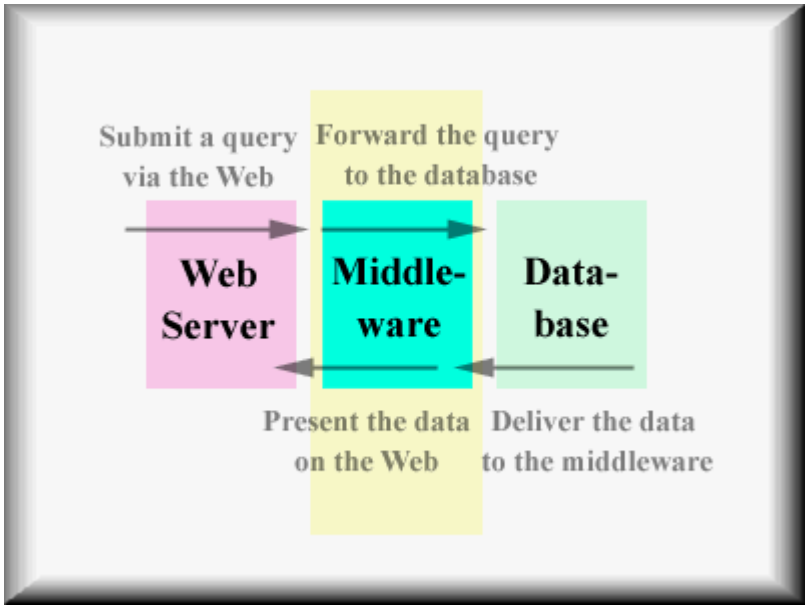
In most cases, comprehensiveness and interoperability of a Web-based database is in a negative relationship. The more comprehensive a WED system is, the less compatible with other systems it tends to be. The actual role of Web-based database software can be

very confusing. Some comprehensive products can perform both web server and database functions while other products specialize in specific areas.

Some Web-based database packages provide the internet-database connection (IDC) only. This type of software is also called 'middleware' or 'application server.' A separate web server and a separate database are required to support these systems. Middleware does not perform Web serving or store data. Instead, it plays the role of a "middle man" between a web server, and a database (see Figure 4). The advantage of this approach is a high degree of flexibility. The network administrator can select any web server (e.g. Netscape Fast Track Server or Microsoft Internet Information Server), the database programmer can select any database software as far as it is Open Database Connectivity (ODBC) and Structural Query Language (SQL) compliant, (e.g. Oracle, Sybase, or MS Access) and the middleware can connect them both. Cold Fusion (Allaire, Inc., 1998), WebObjects (Apple Inc., 1998) and Netscape Application Server (Netscape Corp., 1998) are examples of middleware.

In this case, if a website has been built upon an existing web server and data have been stored in one or several existing database systems, there is no need to plan and implement a new structure. Instead, a middleware solution can easily tie all existing resources together. However, if a new system is installed, the cost for this approach is higher because three separate software packages are needed. Equipment requirements as well as staffing resources must be increased to support the system. Staff with expertise to install, configure, and maintain all three software applications will be necessary. Multiple system experts (network administrator, Webmaster, database programmer) need to continuously collaborate to maintain the system.

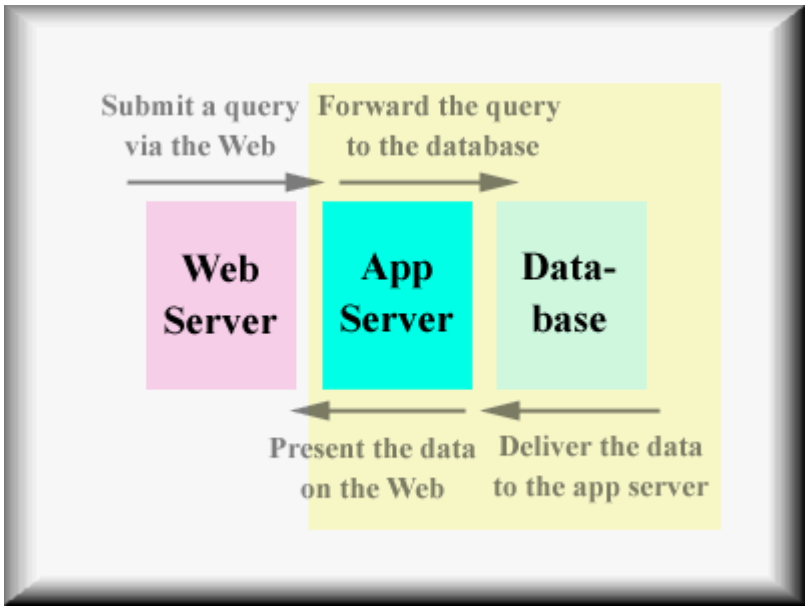
Figure 4. Workflow of a middleware (D)



Some products include an application server and a database, but have no web server. For instance, SAS can store data in SAS/DB and present them on the Web via SAS/IntrNet, but SAS runs on top of existing web server software (see Figure 5). The advantage of this approach is that the application server runs as a Web service, and thus it could

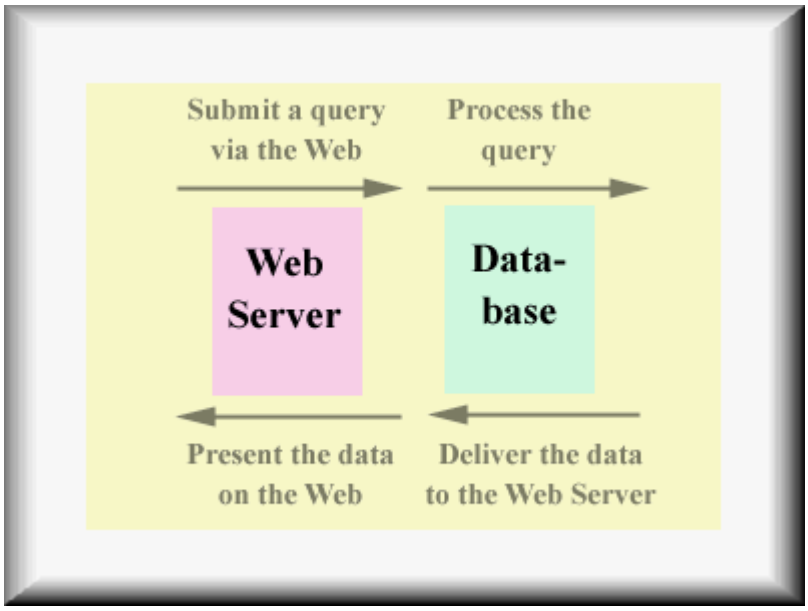
coexist with other application servers and services. In addition, it has its own database system and therefore there is no need to install another database software.

Figure 5. Workflow of an application server (D)



Some products offer integrated web server and database functionality. For example, Lotus Notes/Domino (Lotus Corp., 1998) and File Maker Pro can deliver data on the web without a separate web server software and a middleware (see Figure 6). After the software is installed, the website is ready instantly. However, this type of self-contained system may have difficulties when sharing data with other database systems. In addition, the functions of this type of built-in web server may be limited and cannot be easily extended. For example, many Server Side Includes (SSI) and Metatags are not supported by File Maker Pro. Webpages created by Lotus Notes/Domino are written in its proprietary language rather than standard HTML. Moreover, Lotus is a groupware rather than a true database server and therefore its database functions are limited. Nevertheless, File Maker Pro has designed their system to allow the inclusion of third-party web server solutions such as WebStar (StarNine, 1998), Tango (Everyware Development, 1998), and Lasso (Blue World Communications, 1998) for expanding their capabilities.

Figure 6. Workflow of an integrated Web-database server (D)



Trends

Three trends continue to shape the relationship between online instruction and WEDs. The first trend is the increasing user-friendliness of WEDs and the shortening time of its development. For instance, scripting for WEDs was moved from complex environments such as Common Gateway Interface (CGI) to less complicated environments such as Active Server Page (ASP) (Homer et al., 1997). Now wizard-oriented software such as DrumBeat (Elemental Software, 1999) could even generate ASP without manual scripting. However, handing over the control to the wizard will inevitably lead to a major drawback: Inefficient source codes. A wizard-based source code generator use a standard template for every scenario, but some of the source codes may not be applicable to particular projects. Instructional designers should still learn the syntax of scripting in order to troubleshoot or to customize the system.

The second trend is the increasing efforts in introducing open standards and in converging existing standards. Not only ODBC and SQL become the common protocols for data exchange among various systems, but also Light Weight Directory Access Protocol (LDAP) and X.500 are incorporated by many software vendors for centralizing data access in a hierarchical structure. Therefore, even if an educator develops a single system, he should think about how the system can fit into the overall structure in the future.

Third, more and more software vendors customize their databases for online instruction. For instance, IBM/Lotus builds LearningSpace as an extension to its Domino/Notes (Lotus, Corp., 1999). Oracle delivers Oracle Learning Architecture (OLA) based upon its Oracle database (Oracle, 1998) . Although adopting a customized system could reduce the technical burden and save considerable time, it is questionable whether the design of those systems is driven by educational research.

Summary

Considering each of these areas, the Instruction and Research Support group in Arizona

State University has chosen File Maker Pro as small scale database server, Oracle as our data warehouse server solution, Web Objects and Netscape Application Server as middleware, and SAS/IntrNet as our statistical server to support our Web-based instruction development (http://is.asu.edu).

The combination of the above database servers enhance Web-based instruction by providing benefits to both students and instructors. From students, a Web-based database server facilitates virtual communities for discussion, present linked resources in relational databases, deliver instant feedback, and customized instructional sequences. From an instructor standpoint, this system provides centralized management of course resources, online data collection, online statistical analysis, and collaborative research. Other merits of Web-enabled databases will be further explored as our Web-based courses expand.

Further information

* File Maker Pro write-ups

* Using SAS/IntrNet for evaluating web-based instruction

* Using SAS/IntrNet for analyzing user access log

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