

A DISTRIBUTED COLLABORATIVE HYPERMEDIA WEB ARCHITECTURE FOR MUSIC EDUCATION: A MODEL FOR MALAYSIAN MUSIC ON THE WORLD WIDE WEB

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ABSTRACT

A web architecture for a distributed collaborative environment (DCE) for music education through the World Wide Web (WWW) is presented. The system development procedure is illustrated. Computer application issues are specified, including the types of information to be processed, the functions and performance desired from the application, the interface to be established, specific design constraints, and validation criteria. System specifications are presented for a collaborative learning environment for music education.

Keywords: *Music Education, Computer-Assisted Learning, Distributed Collaborative Learning, World Wide Web Architecture, Hypermedia,*

1.0 INTRODUCTION

Malaysia's information technology (IT) development policies [1, 2, 3], and the development of the Malaysian *Multimedia Super Corridor* (MSC), is aimed to move the country to the status of a developed nation by the year 2020. More and more primary and secondary schools are going online, with the government providing support for Internet access in the classroom. The above developments are likely to affect the national culture of any country, so there is an urgent need to disseminate information about the cultural background of the nation, to maintain the cultural integrity of the society. Music, being one of the elements of a cultural identity, has recently been introduced at the secondary school level in Malaysia [4]. However, there is a severe shortage of trained teachers and teaching materials. Studies have shown that the computer is a very useful medium of instruction

in the teaching of music across cultural boundaries [5]. Since the schools have been provided with easy access to the Internet, an interactive multimedia web application for instruction on Malaysian music, if developed, can be of significant use in the Malaysian schools context. This application can be used both as a teaching aid and as a resource material for the classroom music teacher, and also as the primary or even sole means of learning in schools where a trained music teacher may not be available.

1.1 The Distributed Collaborative Environment

The Internet is by its nature distributed, accessible from client machines anywhere in the world, with available information scattered at various geographical locations on thousands of independent web servers. This existing infrastructure makes it possible for a truly collaborative computer based learning application to be developed and implemented. Ideally, such an application would bring together independently provided text based data, as well as multimedia data made up of many different file formats, and present these in a suitable manner tailored to local needs. Presently, there is nothing to prevent anyone running a web site from downloading remote data and repackaging it for serving through their own local server. However, it is envisioned that in future information may not be so freely available, perhaps due to copyright law or other developments. Our web site seeks to resolve this anticipated obstacle by compiling on the fly the information available through cooperative efforts, creating a *distributed collaborative environment* (DCE) where data retrieved from remote sites is presented in a consistent and aesthetic layout on the local client. [6].

established, specific design constraints, and validation criteria used to determine whether or not the system developed is successful.

2.1 Information to be Processed

The information to be processed is in the form of written text or textual data, sound samples or audio data, music sequences or MIDI data, still images or graphic data and moving pictures or video data. The information to be processed is not available in digitized format. Digitization of the information available into formats suitable for delivery over the Internet must thus be carried out.

2.2 Function and Performance Desired

Several desirable functions and performance features are identified. From the viewpoint of the end user these encompass the following:

- Remote access, using standard TCP/IP protocols, especially http.
- Minimal fuss with foreign format types, i.e. the application will cause the browser to download or launch the correct program to playback available media files.
- Modularity, for example, any change of media file format remaining transparent to the end user.
- Meta information, for example help and assistance features.

Several additional features are also identified as desirable, but not necessarily vital to the present application. These include the following:

- Categorical access for the casual web browser and registered course users as well as for privileged users.
- Restricted or graded access to higher course levels, include bookmarking features.
- Course registration and course progression features, for example generating reminders for submission of assignments and payment of fees.

- Secure course evaluation.

Functions and performance features identified from the viewpoint of course administration include:

- Support for submission or inclusion of new material on Malaysian music, course topics and related mixed media files.
- Maintenance of course administrators, for example particulars of and access for lecturers and / or examiners.
- Quality assurance and verification, even remotely for external auditors / moderators.
- Maintenance ease of course evaluation questions.
- Information on course modules and relation of course modules.
- Course registration and course progression maintenance for users.
- Management information, for example on enrollment and access.
- Possible technical support for registered users, for example via e.mail, requiring support information database.
- Possible integration with existing administrative / management systems, for example data or file transfer of registered course user particulars.
- Data replication of slow links (*collaborative proxy*) to reduce download time. The collaborative proxy server stores reformatted web pages and possible query results as opposed to the statistical proxy server which pre-fetches frequently accessed and sanctioned web pages. Data is not replicated on the system as the collaborative environment provides for resource ownership (access may be chargeable in future as an avenue to sustain web site operations), and also reformatting is supposedly performed on a per-request basis.

- *Resource submission functions*, including data capture of submission particulars, automatic link status verification, submitted file status verification, that may include checks for virus and validity, i.e. to ensure file is useable; and notifying application administrators via e.mail when automated checks are concluded. Resources that are submitted reside in their own server and are verified using standard http calls to fetch files for verification and other processes.
- *Automated link maintenance (ALM)* performs periodic checks on URL addresses stored in the meta data library and on links published on the web through hypertext markup language (HTML) pages. This function may be performed using an automated virtual robot to search and update the status of web links. Links that are too slow or not responding may be served with an appropriate message by the local server. The troublesome links meanwhile will be checked frequently and the actual status logged for further action. Links that are not valid, for example web pages which have been removed; will be excluded automatically or flagged for human intervention.
- Auto detection of browser and machine types, where possible, to deliver the appropriate file type. This is to prevent downloading large or complex files when the client's system is unable to process the files, such as on older machines and browsers which are unable to interpret or process the *Java* language, or a system which is not set to process *Java* programs or scripts.
- Tools and utilities warehouse, for example, conversion facilities for audio-visual files to industry standard file formats. This function caters for remote access to execute a tool, utility or process (on a separate *process server*), to download stand alone programs or to invoke standard Internet applications, for example telnet or file transfer. Analysis tools and file conversion utilities among other software that are useful for work on the subject of interest, of the application such as on music, could aid field researchers and others by way of Internet access. A

process that may be applied to a file may be invoked from the web browser or through e.mail using structured script commands. The files to be processed may reside on a remote server and are fetched using standard http calls. Script instructions should be generic and user definable. A stand alone program may be executed as a background process to enable sharing and also cost savings in a formal collaborative environment. Such a program's interface may be handled through virtual calls [7]. Running remote processes using the Internet to process data, both process and data which are lodged on different servers over different geographical locations, is a topic in itself and is currently being studied [7, 9].

- Reservation for privileged access during peak usage periods. A user may send an instruction to reserve a channel or to access a particular port at a certain time, whereby a fixed time window, in minutes, will be allocated to wait for the priority access by setting a *cookie*¹ on the user's browser for identification. However, this approach will not resolve network congestion but may eliminate some congestion at the server by denying access to casual users. A possible solution is to use reserved access port / line or to redirect the access request to a less congested proxy server at a different geographical location.

Server performance may be considered from the type of Internet system to be developed, a real-time critical application environment, for example video conferencing (streaming data), will need a higher performance machine compared to an Internet system serving only textual data. Other factors that are considered include the machine architecture, operating system and http server software employed.

2.3 Interfaces to be Established

The standard graphical Web Browser interface is chosen due to its universal availability. A standard HTML document template is designed

¹ Set and used by a http server application as a self-addressed record or note.

incorporating principles of good interface design. (Figure 2).

2.4 Design Constraints

Among the constraints that are considered include bandwidth, copyright and the suitability of collaborative partners.



Figure 2: Sample Screen Layout

2.4.1 Bandwidth Constraints

The majority of clients are expected to access the site via dialup access, with a significant proportion accessing the site via dedicated leased line clients. The system design is thus constrained by the minimum expected access speed and bandwidth. A survey conducted in 1996 showed that the majority of Malaysian WWW users accessed the Internet via telephone lines using 14.4 kbps modems [12]. It is expected that in 1997 many users are also accessing the Internet using 28.8 kbps modems. Client machines are primarily IBM desktop compatible computers. The bandwidth constraint means that multimedia files served

need to be as small as possible without significant deterioration in quality. As the site's focus is primarily on music, this means that the audio file format selected is a major concern, with selection based on file size, audio quality and universality of playback.

2.4.2 Copyright Laws

These are also a constraint faced - most songs or musical pieces cannot be served in their entirety even if bandwidth considerations permit. In practical terms, this means that audio clips included can only be of a portion of any particular piece. Ideal sample durations can be up to a minute long. In this way, rather than

posing a threat to released recordings, samples may be viewed as “advertisements” for these music pieces. In any case, sample quality is inferior to commercially available audio compact discs due to bandwidth considerations and cannot be viewed as a serious alternative to actually purchasing the original music. Future technological developments may enable CD quality music to be served through the Internet and in view of that system extensibility needs to be planned for, but with considerations as to copyright law, billing and other related factors. For the purposes of the present application however, audio sample duration and quality are considered as design constraints.

2.4.3 Collaborative Partners

Another constraint faced is the lack of actual potential collaborative partner sites. Currently available on-line information on Malaysian music is limited to commercial popular music sites (for example, *EMI Malaysia*), radio stations (*Rediffusion* and *Time Highway Radio*) and other non-authoritative personal sites. Information available is scattered and validity of information provided cannot be vouchsafed. As such, to develop the ideal DCE application, is beyond the scope of the present work. However, the application framework is set up with a view of future extension.

2.5 Validation Criteria

One of the aims of the present work is to create an authoritative resource on Malaysian music, which would be widely and easily accessible to the general public. As such, one way of determining the success of the system designed, is to monitor access to the site. This can be in terms of who accesses the site (i.e. from where do the accesses originate) and how often do accesses occur. For the system to claim to be a successful one, it would have to be shown that a significant number of users were accessing the site and looking through its various pages from a reasonably wide spread of locations.

Distributed transparency is an especially significant target in a DCE system. This assures users of an unhindered passage through the application regardless of where (i.e. on

which server) specific components of a particular HTML page may reside. This can be seen very specifically in data loading time of the various page components. Distributed transparency can be considered as achieved if there is no significant difference between a file served entirely from one location, and another utilizing the HTML section filter technique (described in the next chapter) to reconstruct a page drawn from various DCE sources.

WWW pages are served primarily through the use of HTML. Various other functions may be embedded within HTML pages, including JAVA applets, JAVA scripts, CGI program calls and output which may be in standard HTML format and virtual reality modeling language (VRML). Language transparency, ensuring a seamlessness in pages served is thus an important desired feature.

As the present application’s target operating environment is the WWW, the primary communication protocol used is the hypertext transfer protocol (http). Besides http, electronic mail and file transfer protocol (ftp) are other communications protocol used. Again, in a successful system there must be a seamless integration between the component parts.

Application consistency in terms of layout, functionality and performance is another criterion which should be met. The end user should be able to intuitively grasp the functions of each and every on-screen component, based on his or her prior experience with the application, if the application is consistent in these respects.

The DCE system is required to run smoothly on heterogeneous hardware. The openness of the Internet based system allows for files to be served from any type of server computer system, using any type of hardware. Again, a seamless integration of the various components is a requirement of a successful system.

In brief, a seamless integration of all components of the system is required for a successful system, and the design should allow for system extensibility.

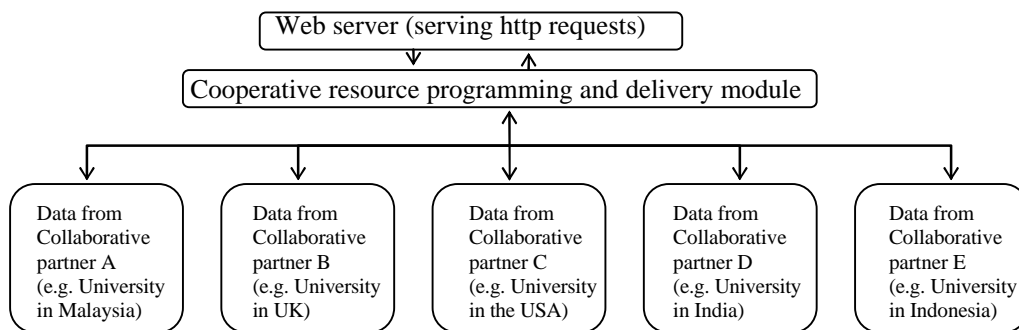


Figure 3: Diagrammatic view of the Cooperative resource/course programming and delivery module

3.0 SYSTEM SPECIFICATIONS

To cater for collaborative learning or the sharing of the course with other course content providers, the application should cater for distributed databases through loosely coupled access (for example using http and CGI), to extend course modules, contents and referrals. A means to filter hypertext tags and to reorganize content and media files is necessary, as discussed previously. The management of this design calls for a localized resource or course delivery module, which can be tailored to meet local needs.

Cooperative course programming and delivery is in the form of a top level module that draws data from participating Internet sources, providing a comprehensive delivery mechanism while maintaining the independent setup of the participating data sources. (Figure 3). The module maintains the meta description of the course and logs shared user access to data sources .

The system model, which consists of database clusters, is shown in Figure 4 [13], and is briefly discussed here. The general components such as the administration database, the web site users database etc., and their organisation that construct the Malaysian music resources web site are also indicated in Figure 4.

- administration database, maintains data pertaining to the operation of the web site which include data on materials submitted for publication on the Internet.
- web site users database, maintains registered and guest users.
- database for logs, for example for access counters, errors, utilization statistics.
- web site databank, which includes HTML pages, multimedia files and other data pertaining to Malaysian music.
- CGI scripts databank, which include scripts for data search and to invoke *server-side include* (SSI) functions.
- general help text, or meta information database.
- browser loadable programs databank, for example include compiled Java applets, platform specific media player programs.
- meta data database, which describes component contents of the system and resources for creating/formatting HTML pages.
- courses databank, which includes course structure information such as various curriculums which may be compiled from the data resources within the Malaysian music web site.
- examinations databank, which includes questions for assessment of students.

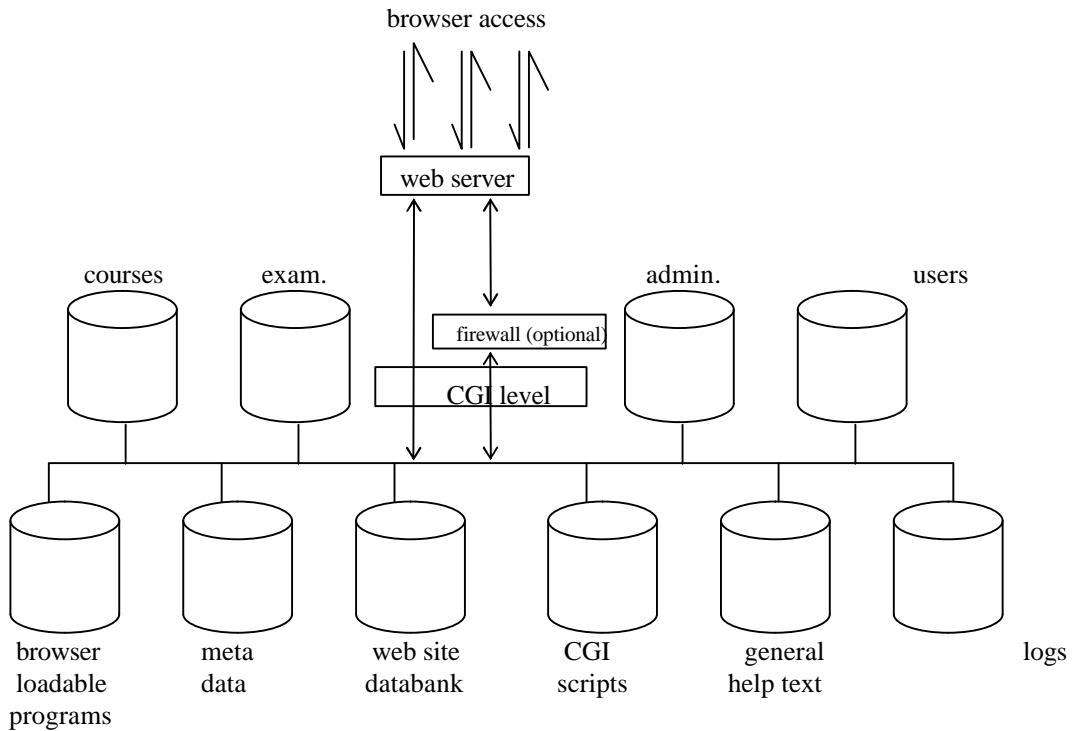


Figure 4: System model of the Malaysian music resources web site.

System security can be implemented at the application level or through secured server access, i.e. using a *firewall*. The web site databank (Figure 5) for example, is a repository that consists of files and databases which include the following:

- image files
- digital audio files
- MIDI files
- quiz database, contains quizzes called by CGIs linked from HTML pages
- external references database, i.e. a database describing external URLs which are updated periodically by a remote web site monitor robot

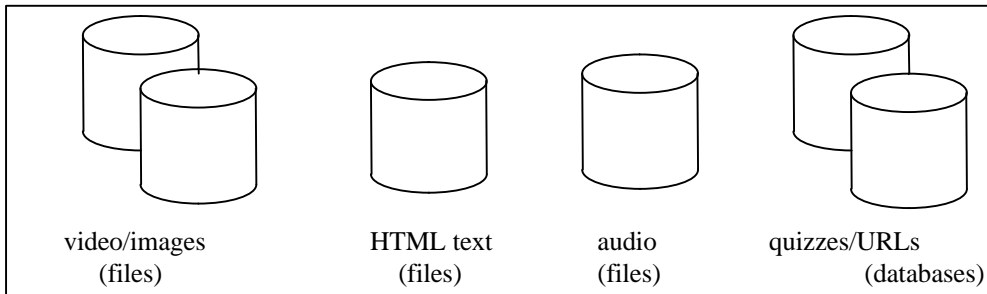


Figure 5. Web site databank components.

Table 1: A meta data file sample table describing *Asian musical instruments*.

Instrument	Site alive check date	General URL	Image	Sound	Text	Chargeable Access	Cost per full page load
gong	6.9.97	www.music.upm.edu.my/malaysia/	images/gong.jpg	audio/gong.viv	instruments/gong.html	13 sen	13 sen
kompan g	1.9.97	www.usm.my/music/	pics/kompang.jpg	-	kompang.html	13 sen	13 sen
pipa	31.8.97	www.nus.edu.sg	images/pipa.gif	sound/pipa.au	strings/pipa.html	13 sen	26 sen
saron	31.8.97	www.usu.ac.id/gamelan/	saron.gif	saron.ra	saron.html	13 sen	26 sen

The various file format types within the web site databank are described in the relevant meta data database. For example, the subject “Asian musical instruments” may pull together HTML text, images and audio files found in the web site databank or from other cooperative web sites. The meta data description of the files include file owner, author, file expiry date, access type, access chargeable code and subject code (Table 1). A meta data file as exemplified may be accessed by external participating web sites, and may be used to compile a suitable HTML page using CGI scripts when requested by a browser.

4.0 RESULTS AND DISCUSSION

The main web server utilised is the *Netscape Communications* server, set up on a *SUN Sparc5* workstation using UNIX and the *Solaris* operating system. Server hardware configurations include 64MB RAM, 5.54GB hard disk, 32-bit system, and a dedicated leased line Internet connection. Client machines are primarily IBM-compatible multimedia desktop computers, *Intel 486* microprocessor or better, with 8 to 16MB RAM, a 16-bit sound card, and a dial-up Internet connection. The prototype application on Malaysian music is available on the World Wide Web at <http://www.music.upm.edu.my/>. Current access statistics average 300 external accesses per day, not including image files. Pages linked to the site but served from other web servers showed insignificant differences in download time compared with pages served from the main server, when accessed via a 28.8 kbps dial-up

connection. The use of the new *.viv* streaming audio and video format, which prompts the user to automatically install the browser plug-in in the event of the playback software not being available on the client machine, provides support for a seamless integration of different mixed media file formats.

5.0 CONCLUSION

The web architecture proposed in this paper provides an ideal environment for collaborative music education over the WWW. Currently, implementation faces various constraints, as identified above. However, the ideal architecture proposed, provides many benefits and its implementation would be a significant contribution in the use of IT for education, in the context of the Malaysian MSC.

REFERENCES

- [1] Mohd. Awanglah. (1995). “Publishing Information on the Internet: Technical, Management and Policy Issues”, in *Using IT to Build a Better Future Conference*, Kuala Lumpur, 3 October 1995.
- [2] Kramer, K. (1995). “Competing in Computers: Business and Government Strategies in East Asia”, in *Persidangan Infotech Malaysia '95*, Kuala Lumpur, 1 November 1995.
- [3] Ohme, K. (1995). “Formulating Multimedia Policy for Malaysia”, in

- Persidangan Infotech Malaysia '95*, Kuala Lumpur, 1 November 1995.
- [4] Ang, M. (1995). *Cadangan Program Bacelor Muzik*. Serdang: Fakulti Ekologi Manusia, Universiti Pertanian Malaysia.
- [5] Chen, S.S. & Dennis, J.R. (1993). "Linking Different Cultures by Computers: A Study of Computer-Assisted Music Notation Instruction". *Journal of Educational Technology Systems*. 21(3): 207-224.
- [6] Ang M., Abu Talib Othman & Abdul Azim Abdul Ghani. (1997). "An Interactive Multimedia Courseware Repository Over The Internet". *INTEC '97: UPM Serdang*, 20 May 1997. Proceedings pp. D51-54.
- [7] Saran, A., Agrawal, D., El Abbadi, Smith, T.R. & Su, J. (1995). "Scientific Modeling Using Distributed Resources". *Jour. of Information Systems*, Special Edition on Scientific Databases, Vol. 2(20) May 1995.
- [8] Bodendorf, F. & Langer, K. (1996). "A System Architecture for Flexible, Knowledge-Based, Multimedia CBT-Applications." *International Journal of Engineering Education*. 1996. 12(4): 264-271.
- [9] Namgoong, H. & Yoo, I.. (1996). "HANURI: A Framework for Distributed Multimedia Applications". *Int. Conf. on Multimedia Technology and Management*. Hong Kong Baptist University. 11-14 December 1996, Proceedings (Springer) pp. 75-84.
- [10] Wong, J.S. & Parthasarathy, D.S. (1996). "Remote Access to Multimedia Databases: An Object Oriented Approach." *Software - Practice and Experience*. June 1996. 26(6): 677-704.
- [11] Tu, J. & Pai, W. (1996). "Interactive Multimedia Computer-Assisted Instruction System - For Information Management System". *Int. Conf. on Multimedia Technology and Management*. Hong Kong Baptist University. 11-14 December 1996, Proceedings (Springer) pp. 286-303.
- [12] Ang, M., Abu Talib Othman, & Tee, E.R. (1996). "World Wide Web Audio: Ensuring Adequate Hardware and Software Configurations." *Malaysian Journal of Computer Science*. 9(1): 1996.
- [13] Ang, M., Tee, E.R., Abu Talib O, A.T. & Abd Azim A.G. (1997). "An Interactive Multimedia Music Repository over the Internet." *Malaysian Journal of Library & Information Science*. 2:1 July 1997.

BIOGRAPHY

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