A WEB ARCHITECTURE FOR AN INFORMATION SYSTEM FOR MALAYSIAN MUSIC

Minni Ang[1]; A.K. Ramani[2] and Abu Talib Othman[2]
[1]Music Department
[2]Computer Science Department
Universiti Putra Malaysia
minni@music.upm.edu.my

ABSTRACT

The design and development of a comprehensive web resource on Malaysian music involves the archiving of information from published and unpublished sources, based on a previously developed classification scheme. The data to be presented includes text data, audio samples, music sequences, still images, video data, and animated graphics. The web site architecture comprises two layers - the visible layer, determined by the subject architecture; and the underlying layer, or the application architecture, which is dependant to a certain extent on the visible layer, but does not mirror its structure completely. The development procedure starts with the data preparation, including the organization of the information content to be published, and the selection of specific data formats to be used. Software design issues include: objectives, system components, the subject architecture, and the application architecture. Coding and testing are also carried out. Site performance and access results indicate that the proposed web architecture is suitable for the delivery of information on Malaysian music over the World Wide Web (WWW).

KEYWORDS: World Wide Web architecture, Information system, Music education, Web music resources, Malaysian music.

INTRODUCTION

Studies have shown that the computer is a very useful medium of instruction in the teaching of music (Lee, 1994; Chen & Dennis, 1993; Conant, 1988; Heath, 1982). Music, being one of the elements of a cultural identity, has been taught at primary school level for many years now (Johami, 1990), and has recently also been introduced at the secondary school level in Malaysia (Ang, 1995). However, there is a shortage of trained teachers and teaching materials. Since the schools have been provided with easy access to the Internet, an interactive on-line multimedia application for instruction on Malaysian music, if developed, can be of significant use in the Malaysian schools context (Ang *et al*, 1997). 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 about Malaysian music, in schools where a trained music teacher may not be available. This paper discusses the design and development details of the prototype application on Malaysian music (Ang,

1997). Information from published and un-published sources is archived, based on the comprehensive classification scheme (Ang, 1997) for Malaysian music. The development procedure starts with the data preparation. This includes preparation of text-based data, audio samples, music sequences, still images, video data, and animated graphics. The rationale in selecting, which information is to be published, and which specific data formats are to be used, is also presented. Software design issues discussed include: objectives, system components, the subject architecture, and the application architecture. A description of how the application's visible features as well as underlying functionalities are coded is presented. The web architecture developed is implemented on a web server and tested in terms of its validity and performance.

DATA PREPARATION

The data gathered on Malaysian music is in various formats, including text based data, photographs, video footage, audio cassette recordings, audio compact disc recordings, and musical scores. Data preparation for inclusion in the computer application thus requires the digitisation of the materials collected.

Text-Based Data

Text-based data is organized into an archi-tecture based on the classification hierar-chy for Malaysian music. The content included within the individual web pages consists of four main types: pages provi-ding information on the types of music in Malaysia, as classified in Figure 1, (Ang,

1997), pages providing information about music in the various states in Malaysia; pages providing information on the various musical instruments in Malaysia; and pages providing information on the background and context of music in Malaysia. (Figure 2).

The largest amount of text-based informa-tion is contained within the documents describing Malaysian music by type and the documents describing the various musical instruments in Malaysia. The documents describing Malaysian music by type include the following text-based information:

- classification of the music (Ang, 1997).
- type or genre: for example, Malay ga-melan, joget, keroncong, et cetera. (Matusky & Tan, 1997).
- with which Malaysian state or ethnic community the music is identified, if applicable.
- a brief description of the origin of the music, if available.
- a brief description of the context in which the music is performed.
- a list of musical instruments used in the specific type of music concerned.
- any other supporting information which may be available.
- bibliographic reference from which the information was obtained, if applicable.

There are two main branches of the clas-sification architecture, describing four main categories of music. Documents con-taining information on music included un-der the categories of "classical music" and "folk music", which form the bulk of the documents in the web tree, are organised as

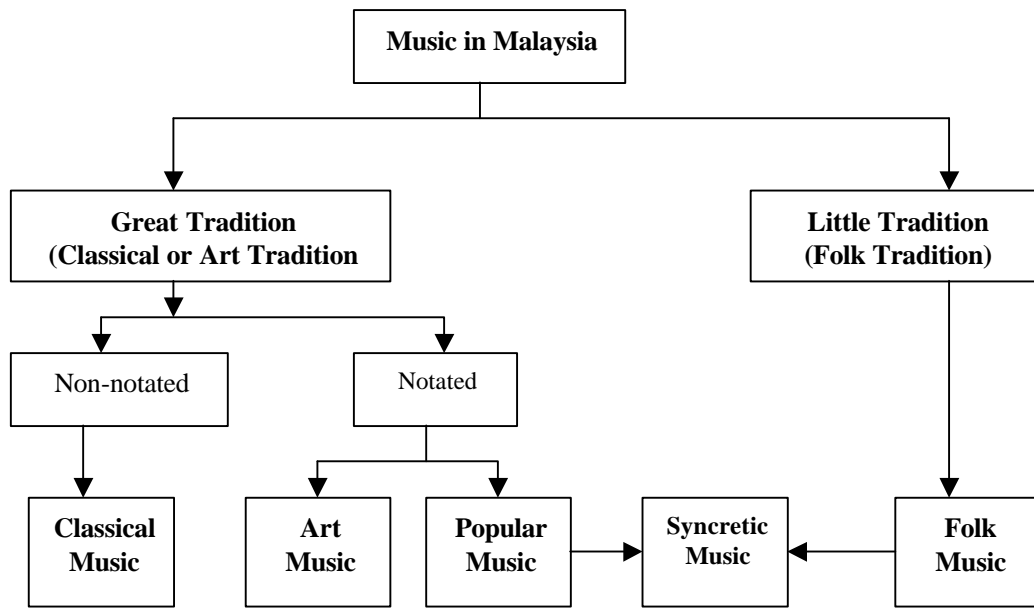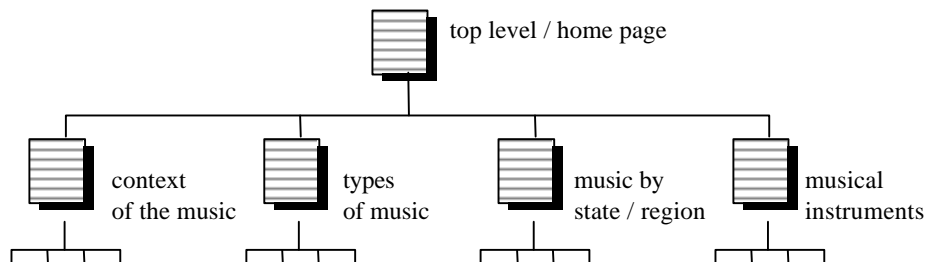**Figure 1: Diagrammatic Representation of Types of Music in Malaysia**

Figure 2: Hierarchical View of Web Documents by Included Content.

described in the previous paragraph. Most of the text information included in these documents is gleaned from various published sources. Some of the types of music included are, however, not covered by any publications. In these cases field research was carried out to obtain the information included in the web application. Specifically, this includes the information on the following types of music, primarily those associated with the Indian community in Malaysia: Carnatic music, Hindustani music, Bhajan, and Chinese drum ensembles. Additionally, field research was also carried out to obtain supplementary information on certain types of music, including: Malay gamelan, Chinese orchestra, and the music of the Temiar indigenious people. In these cases, besides obtaining text-based information, field trips also included video and audio recordings as well as the taking of photographs.

Documents containing information on "art music" consist of three main types: original material about various Malaysian contemporary art music composers; pages providing background information on the state of art music in Malaysia; and links to various external web sites related to art music in Malaysia. The information on the various composers was also gathered through field research. The bulk of text-based information included within these pages is in the form of lists of compositions. Brief background information on the composer is also provided. For some composers, brief program notes are included for selected compositions.

The section on popular music in Malaysia is essentially a collection of links to external web sites featuring Malaysian popular musicians. One link, however, leads to a collection of documents on the local server. This is the P.Ramlee site (Ang, 1997), featuring Malaysia's all-time most well-known popular composer-musician. Information included here was collected through field research. This site was developed in parallel with the Malaysian music web site, but maintains its own design theme and layout. This is to maintain consistency with all the other documents to which the page listing Malaysian popular music is linked, every link leads to a separate external page.

The pages providing information on the various musical instruments in Malaysia are linked from the pages providing information on the types of music in Malaysia. The documents describing the musical instruments include the following text based information:
- name of the instrument.
- classification of the instrument, i.e. chordophone, aerophone, membranophone, idiophone.
- origin of the instrument.
- with which Malaysian state or ethnic community the instrument is identified, if applicable.
- a brief description of the context in which the instrument is played, if available.
- the type of music in which the instrument is used.
- any other supporting information which may be available.

- bibliographic reference from which the information was obtained, if applicable.

Most of the text information included in these documents is gleaned from various published sources. Some of the instruments included are, however, not specifically covered by any publications. In these cases field research was carried out to obtain the information included in the web application. Specifically, this includes the information on the following instruments: *awar, batak, dabo, di, ghatam, gu* and *palas*.

Pages providing information about music in the various states in Malaysia consist primarily of links to the documents about the various types of music, including specific composers, associated with each state.

Additionally, a link is provided from each state's page to an external link providing background information about the state.

Pages providing information on the background and context of music in Malaysia are also presented. Background information presented includes: geographical information; social and political background of the nation; and trends and developments in music in the country. Additionally, supporting pages are also provided including background information on the various categories of music, such as the history of and current developments in art music in Malaysia, definitions and an explanation of the classification method used. Figure 3 is an expanded version of Figure 2, taking into account the elaborations in the paragraphs above.

Figure 3: Expanded Hierarchical View of Web Documents by Included Content
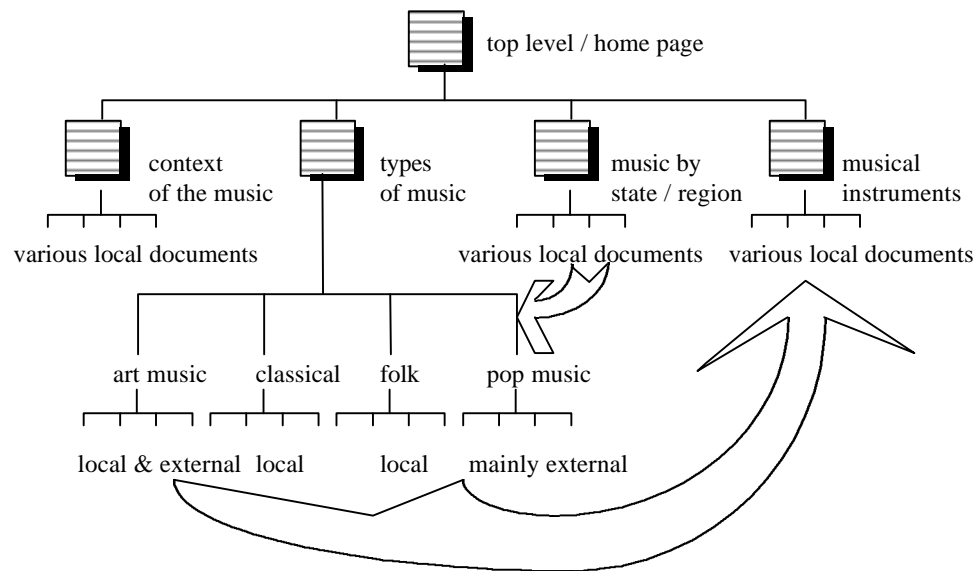
Each web page is constructed based on educational principles: each page has a specific objective or topic to be presented; the amount of information contained in each page is focused on the topic to be presented, if the amount of information is too large to be grasped by the reader at one glance, it is broken up into smaller sections which are easily understood; subtopics of the main topic within a particular page are assigned pages of their own, if the information to be included is sufficiently substantial - these are accessed as hyperlinks from the parent page. A vital feature of the educational design is the inclusion of an interactive feedback mechanism, which incorporates one or two questions asked of the reader about the topic at hand, to test the understanding of the subject matter presented. As the application developed is a prototype, this feature is presently inclu-ded in a limited number of pages.

The text-based data thus organized is then coded into HTML. Page layout features are kept strictly consistent to maintain a site wide characteristic look and feel. This consistency is especially important in a WWW-based application as certain links, which contain support information to the topic at hand may take the user away from the parent site. The user is made instantly aware of this transportation by the changed appearance of the new site. This enables the user to know when it is necessary to click the "back button" on the web browser to return to the original topic of interest.

Layout consistency also means that the user is not distracted by peripheral compo-nents of the application. Once the user has learned how to navigate through the site, where specific items such as audio clips are located on a page, which icons identify which types of data or navigation controls, the user can focus on the topics presented without having to be concerned with these peripherals again. This helps in optimizing the learning capacity of the user.

Audio Samples

Where available, the prototype includes digital audio samples of various music categories to illustrate and provide listening examples for the text-based information described above. Sample sources include recordings collected through field research, as well as commercially available cassette tapes and compact disc recordings. Audio samples included are only of sections of any particular piece, generally up to one minute long. This is partly due to the copyright laws, which prevent most recordings from being made publicly available on a web server in their entirety, and partly due to Internet bandwidth limitations.

Many Malaysian musical pieces, especially those under the categories of folk music, popular music and classical music, with art music generally being the exception, have two distinct sections which may be repeated in various combinations a varying number of times, depending on the genre of the music. The approximately one minute long audio clips thus generally include at least one complete AB section, to provide the listener with a general idea as to how the music sounds. The emphasis in these listening examples is thus placed on the nature of the sound, i.e. the orchestration,

melodic characteristics, timbre of the instruments, and so on, rather than on the musical form. Selection of the final digital audio output file format was based on the following criteria:

- Universality of format - the selected file format should be able to be played back on as many different types of computer hardware and operating systems as possible, with freely and easily available playback software.
- Relative file size of format - the selected file format should be as small as possible due to Internet bandwidth constraints.
- Playback quality of resultant file - the selected file format should retain a reasonably high quality of playback with minimal signal loss.

The Real Audio 3.0 (.ra) 28.8 mono full response file format is selected as the final output format of choice. Compared with previous releases of the same format, version 3.0 retains a high quality audio output. Its encoder and player are freely available from the Progressive Networks (1997) web site, and are easy to install and use. An approximately 95 percent savings on file size is achieved compared with the Windows Pulse Code Modulation (PCM) (.wav) format at almost no loss in signal quality (Table 1).

The samples are first captured in the Windows PCM format and not directly in the Real Audio 3.0 format. Although the Real Audio 3.0 Encoder software does allow for direct signal recording, it only includes primitive editing controls and does not include noise reduction or normalization features, which are available in other Windows audio editing software. Normalization[1] is necessary to optimize the dynamic range of the digitized samples, while noise reduction is necessary to remove tape hiss, system hum, and other constant extraneous noise, which may be present in either the original recording or created during the process of digitizing the sample. Using the *Cool Edit 96* (1996) digital audio editing software, each recorded sample is first normalized and filtered for noise[2], and all extraneous sample portions trimmed[3] off. Where appropriate, samples are also faded[4] in and out to provide a smoother quality final sound.

Music Sequences (MIDI Data)

In cases where recorded audio samples were unavailable but example music scores are obtainable, it was decided that the best way to present the music data in an audible format is through the use of MIDI sequences. The use of MIDI sequences has the added advantage of allowing the user to download the data and see, or even print out, the music notation of the piece at hand. In certain cases, primarily in serving of original compositions by contemporary

---

[1] This is carried out by the software, which first calculates the exact amount of gain needed to increase the signal with the highest amplitude within the sample to the system's maximum value, and then increases the amplitude of the entire sample by this gain ratio.

[2] The software analyzes a brief, isolated noise passage from within the audio sample and uses this to create a noise template which is digitally subtracted from the original audio sample.

[3] Digital audio sample trimming is carried out by selecting the exact length of the waveform required and deleting the remaining [unwanted] sections.

[4] The software calculates the sample's relative amplitude over the selected duration, and proportionally increases the selection's gain from zero to full gain [fading in], or the reverse [fading out].

Malaysian art music composers, data was obtainable pre-prepared in MIDI format. In the majority of cases however, data preparation is carried out as part of the present work. General MIDI format 1 is selected as the generic format of choice, as track and patch information are retained in this format. Table 2 indicates examples of MIDI patches chosen to represent folk instruments.

Still Images

Still images, mainly scanned photographs, are included in the various pages within the web application, with the primary objective being to provide the user with pictures of the musi-cal instruments and musicians mentioned in the text. Still images are obtained from two main sources: through field research, where photographs were taken of musicians and musical instruments at various locations in Malaysia; and from published photographs, which were digitised for use in the application. Where published photographs are used, bibliographic reference is always included as a caption beneath the image. Lack of a caption thus means that the photograph was taken during the course of this research. Two Internet standard inline image file formats are selected as the final output format types: the JPEG (.jpg) format used primarily for scanned photographic images, and the GIF89A (.gif) interleaved graphic format for all other still image types.

Table 1: Examples of reductions in file sizes after encoding with Real Audio

.wav file size	.ra file size	% of reduction
2890 KB	131 KB	95.5
2061 KB	94 KB	95.4
1500 KB	69 KB	95.4

Table 2: Examples of MIDI patches chosen to represent Folk Instruments

Folk Instrument	MIDI patch
angklung	xylophone
gendang, high note	D5 or Db5 from the percussion patch map on channel 10
gendang, low note	E5 or Eb5 from the percussion patch map on channel 10
harmonium	reed organ
kesi / canang	Eb4, F4 or B4 from the percussion patch map on channel 10
rebab	violin
rebana	G3, A3, D5, Eb5 and E5 from the percussion patch map on channel 10
seruling	pan flute / recorder
serunai	oboe
tabla, high note	C5, Db5, D5 from the percussion patch map on channel 10
tabla, low note	G3, A3 from the percussion patch map on channel 10
various sized large gongs	vibraphone, notes lower than one octave below middle C

Moving Images

Moving images utilized include both video or moving picture images, and animated graphics. Video is used to provide illustration to the text information contained in the web application, as described in the section on text based data preparation. Animated graphics are used primarily for animated banners and icons.

Video Data

Video footage is obtained from two sources. One source of video footage is non-commercial videotapes obtained from individuals. Video footage obtained in this way includes the footage on the Chinese Orchestra and the Chinese drum ensemble. All other video footage is the result of field recordings, taken using a portable hand-held video camera, the Panasonic VHS-C movie camera model NV-A3. Footage obtained in this way includes the footage on the Malay Gamelan, the Temiar Orang Asli music, and all other footage included in the application. In the prototype, video is used mainly within the musical instruments section to provide moving picture cum audio examples of performers in action.

The preparation of video data included two main steps: the digitization or data capture of the analog video tape information; and the conversion of that information from the audio-visual interleaved (.avi) Windows format, into the compressed .viv streaming video format. Video picture quality is quite low due to the low frame rate (10 frames per second) and low picture resolution (160 by 120 pixels) selected. This situation is unavoidable due to Internet bandwidth constraints.

Animated Graphics

Animated graphics are used to liven up certain pages, with the specific intention of drawing attention to the items with which they are associated. For example, an animated loud speaker icon is used to draw the user's attention to the section of the page where sound samples are available for playback at the click of the mouse.

Many animated graphics are borrowed from various animated gif repositories on the WWW, but some are created originally. In the case of animated gifs created from multiple photographic images, the steps in preparing the multiple images are those outlined in the section on still image data processing described earlier in this paper. An example of this type of animated image is found on the P. Ramlee page, which includes a filmstrip[5] created in this manner. In the case of animated graphics prepared using multiple bitmap drawings, the multiple drawings are created using either Windows Paintbrush or Aldus Photostyler's graphic editing tools, and then processed in the same manner. An example of this type of animated graphic is found on the home page[6] of the prototype application: the site welcome banner.

The animation process itself was created using the *Gif Construction Set* software. The multiple images were selected in the desired sequence within the software and various parameters were set, such as the transition time between succeeding images, transparent or background colour and

---

[5] http://www.music.upm.edu.my/P.Ramlee/film.gif, accessible from the web application page at http://www. music.upm.edu.my/P.Ramlee/index.html
[6] http://www.music.upm.edu.my/malaysia/

number of repetitions of the animation. The final step in the preparation of a gif animation was the compacting of the file, that is the optimizing of the file size in relation to the data contained.

SOFTWARE DESIGN

The web architecture consists of two layers: the visible or apparent layer, which is determined by the subject architecture; and the file storage structure or underlying layer, i.e. the application architecture. The visible layer consists of the hierarchy of web documents, determined by the relationship between the contents of the different documents. The underlying structure is dependant to a certain extent on the visible layer, but does not mirror its structure completely. The underlying layer may contain files stored locally, or references to URL addresses of files stored on remote servers.

The complete application runs on a client-server architecture, with the distributed clients accessing the web server through the visible layer, to obtain files from the underlying layer, requested using standard http calls. The client-server request procedure may also be conceptualized as in Figure 4. The distributed clients initially only "see" the link documents, which are present in the visible or apparent layer of the web architecture. An http request is then sent to the web server, which returns the requested file, which may be one of several types of files: an informative document containing text-based material, as described in the section on text-based data preparation; a multimedia data file, such as a MIDI file, a digital audio file, or a video

file; another link document, further elaborating on the subject architecture; or, if the original link references is a remote URL, a document is fetched from a remote site. Requests sent in this manner may or may not invoke CGI scripts en route, depending on whether the particular link is set up to retrieve data directly or through a gateway script. An example of a document requested through a CGI script is a document containing the results of a keyword search. Such a document is constructed on the fly, in response to the request. Another point to note is that the original http request for an informative document may also return simultaneously embedded multimedia data files including embedded graphic files, and embedded audio, MIDI or video files, if these are included in the requested page.

Objectives

The broad objective in designing the application is to make available the content on Malaysian music to the general public, through the medium of the WWW. The user should have several options as to how the information is viewed: to browse casually through the material; to systematically study the material in a logical manner; or to rapidly search the material for specific information required. Further specific objectives of the software design are itemized as follows:

- hardware independence: the web application is designed so it can run on any server system. It is not dependant on the server hardware. It is, however, dependent on the client hardware, to display all the multimedia data types included in the application. The application can still run on inadequate hard-

Figure 4: Conceptual View of Client-Server Request Procedure
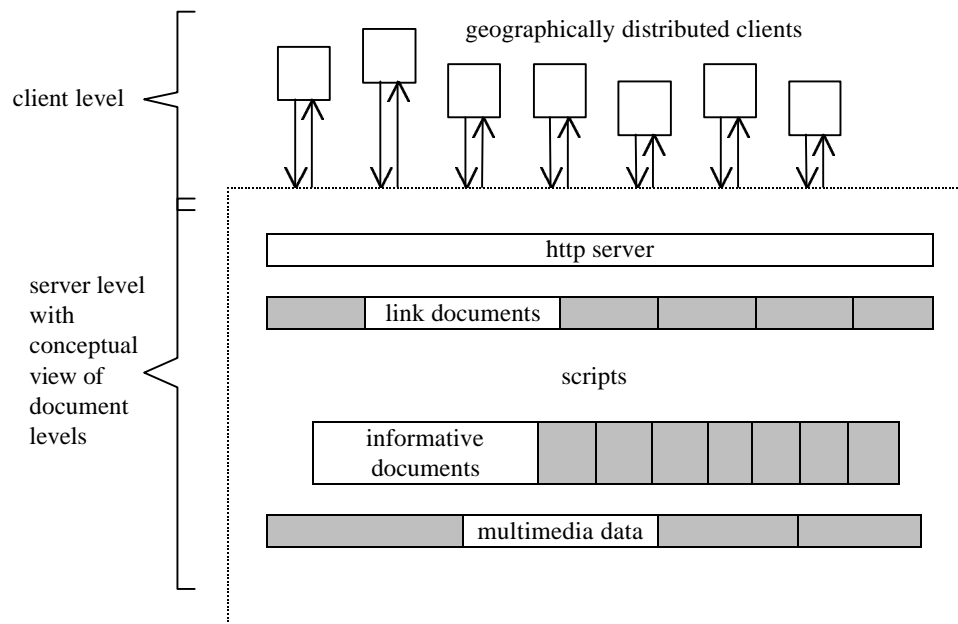
ware, for example, a client machine without a sound card. In this case, multimedia files will not be played back, but text and graphic information will still be viewable.

- distributed architecture: the application may reference documents stored on the local server, or documents stored on various remote servers, which may also be geographically distributed.

- open system: the application is served from distributed servers and viewed by distributed clients, all of which run on heterogeneous platforms.

- modularity: the application architecture, or underlying file storage structure, is organized into several directories, each containing different types of

files. For example, MIDI files are stored in one separate directory, digital audio files in another, and so on. Text-based information is stored within the HTML documents, which are organized into several directories based on the subject architecture, as explained in the section on text-based data preparation. This modular approach to the file storage structure allows for ease of extensibility, as new components are easily added on to the existing structure. It also helps in providing for ease of enhancement and ease of maintenance.

- portability: the web application is designed to be portable, or movable, for example to another server, or onto

a CD-ROM which can be mounted under a web server for local browser access. This design objective is implemented through the use of relative URL references [versus absolute ones] to files from the application contained within the local server hard disk. An example of this is seen in Figure 5, which shows a sample file storage structure.

- efficiency of HTML coding: certain information occurs repeatedly within all the web documents, for example, the page footer which contains contact information, date of latest modification to the document, and so on. To avoid data redundancy, such information is only coded once and recalled when required through the use of an automated script.
- maintainability: the HTML document source files are properly formatted for readability, including remark lines where necessary.
- extensibility: the web architecture allows for the addition of new components to the application, as well as new information to the content on Malaysian music, including additional branches in the text-based data structure tree, for example, a new branch providing information on music education and institutes for the study of music in Malaysia.

System Components

The system components are illustrated in Figure 6. The complete application runs on a client-server architecture. The application is viewed on the client machine through any web browser software available on the client, with multimedia file playback being achieved through various player software installed on the client machine. If a new data type is encountered, the browser may obtain the relevant player software from the Internet. The exact response of the browser depends on which browser is used - the two most commonly encountered browsers, Netscape Navigator and Microsoft Internet Explorer (MSIE), both handle new data types slightly differently. Netscape launches a dialog box which asks the user if the required plug-in should be installed. If the user replies in the affirmative, the browser automatically calls up a "plug-in finder" page. The user then needs to manually install the appropriate player software, as identified by the browser. Internet Explorer, on the other hand, automatically retrieves from the Internet and installs the appropriate player software without any choices being made on the part of the user. The procedure is almost transparent to the user, who is only aware of a slight delay while the new software is installed.

The TCP/IP communications protocol is used for all communications between the client and the server. The physical network connection is thus another component of the system. On the server side, components of the system include the web server hardware and software, and also the three main types of data types to be served: text data, multimedia data, and scripts.

The Subject Architecture

The subject architecture is shown in the hierarchy of HTML documents (Ang, 1997) accessible through the standard web
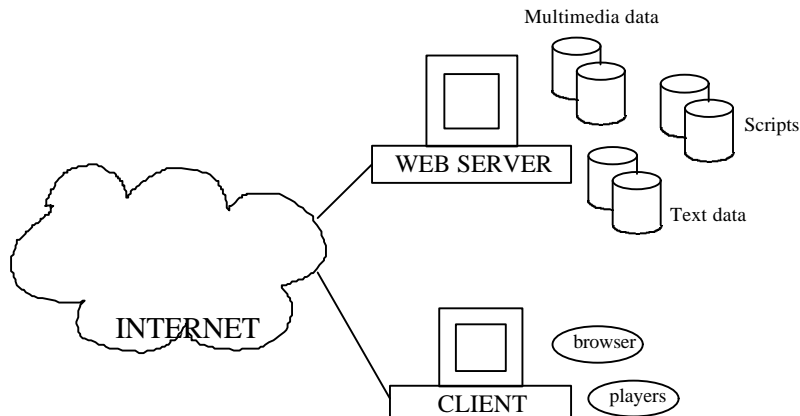
Figure 5: Sample File Storage Structure

Figure 6: System Components.
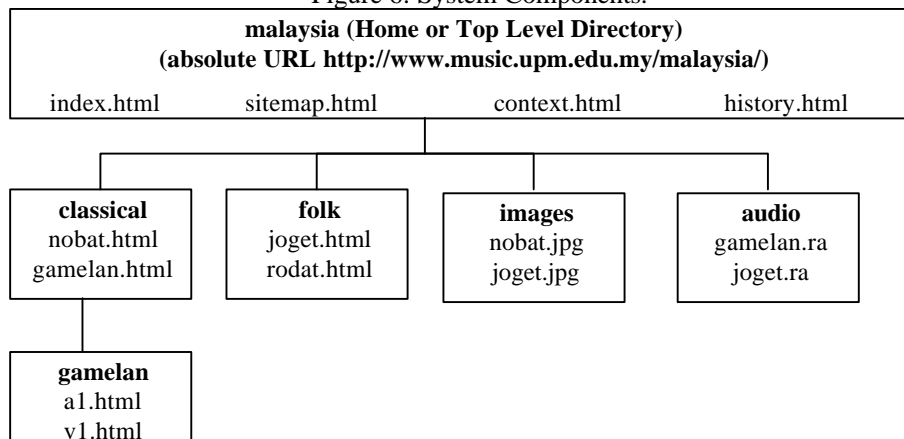
browser user interface. This consists of a multiple level document tree, up to a maximum of 5 levels (Figure 7), as shown in the site map (Ang, 1997). However, all pages within the site may be accessed using a maximum of 3 mouse clicks from the site home page. This principle is adopted to ensure easy accessibility of all documents within the site, during the course of normal browsing. For fast access, users may locate

any page within the site using only 2 mouse clicks, via the site map page: the first click to view the site map, and the second to view the page desired. Further, to assist users in locating specific information desired, a CGI search script is also implemented. It locates documents containing keywords specified by the user, via an online form.

The Application Architecture

The application architecture supports the subject architecture, which reflects the details of the proposed systematic classification method for Malaysian music (Ang, 1997). This is organized into several hierarchical directories and subdirectories, as illustrated in Figure 8.

CODING

The web application consists of a structured collection of hypertext markup language documents, and several CGI scripts. Javascript is also used. The HTML documents are built from scratch, while the Java scripts and CGI scripts used are adapted from public domain scripts available through the WWW. Visible pages of the application are coded using HTML, while underlying functions such as the site search script, on-line quizzes and musical instrument index, are coded using either Java script, PERL or the C programming language. A limited form of collaboration is also implemented in the use of configurable external linked applications such as the site guest book[7] and statistical access monitor[8]

that are seamlessly integrated into the present application. Further, external sites providing additional information on specific subjects are also linked from within the relevant pages. A heterogeneous open system is thus achieved.

HTML Coding Conventions

To maintain a consistent look and feel throughout the application, an HTML document template is designed.

Document Type Declaration
All HTML pages begin with the Document Type Declaration code, used to maintain clarity of documentation.
<!DOCTYPE HTML PUBLIC
"-//W3C//DTD HTML 4.0//EN">
This code indicates that the documents are consistent with the HTML version 4.0 document type definition proposed recommendation to the World Wide Web Consortium of companies (Ragget *et al*, 1997). In addition to the text, multimedia and hypertext features of the previous versions of HTML, version 4.0 supports more multimedia options, scripting languages, style sheets, et cetera.

Header Information
After the <HTML> tag, come the header tags <HEAD></HEAD>. Information coded between these two latter tags is termed header information. Besides the usual <TITLE></TITLE> tags, meta name tags were also used in all pages to provide additional information. For example,
<META NAME="Author"
 CONTENT="Minni Ang">

---

[7] http://www.Lpage.com/wgb/wgbsign.dbm?owner=MusicalMalaysia

[8] http://w23.hitbox.com/a.cgi?I32820300

Figure 7: Five-Level Directory Tree Structure

Little Tradition (Culture Identifier)
    9 Folk Music
        9.1 Music for Theater
           9.1.1 Dance Drama
                9.1.1.1 Boria
                9.1.1.2 Mak Yong
                9.1.1.3 Mekmulung
                9.1.1.4 Menora
                9.1.1.5 Hamdolok

} 5 levels (including the home page)
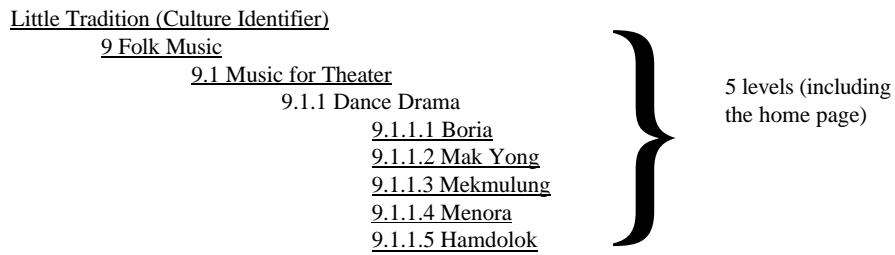
Figure 8: The Application Architecture in the Form of a Hierarchical Directory Tree

Server Home Directory

/malaysia   /cgi-bin

html documents   multimedia data   graphic

/folk /classical /popular /syncretic /composers /instruments   /audio /midi /video   /images /banners /buttons   /quizzes   /accesswatch

/gamelan /chinese   /P.Ramlee   /chan /minni /razak /su-lian /valerie
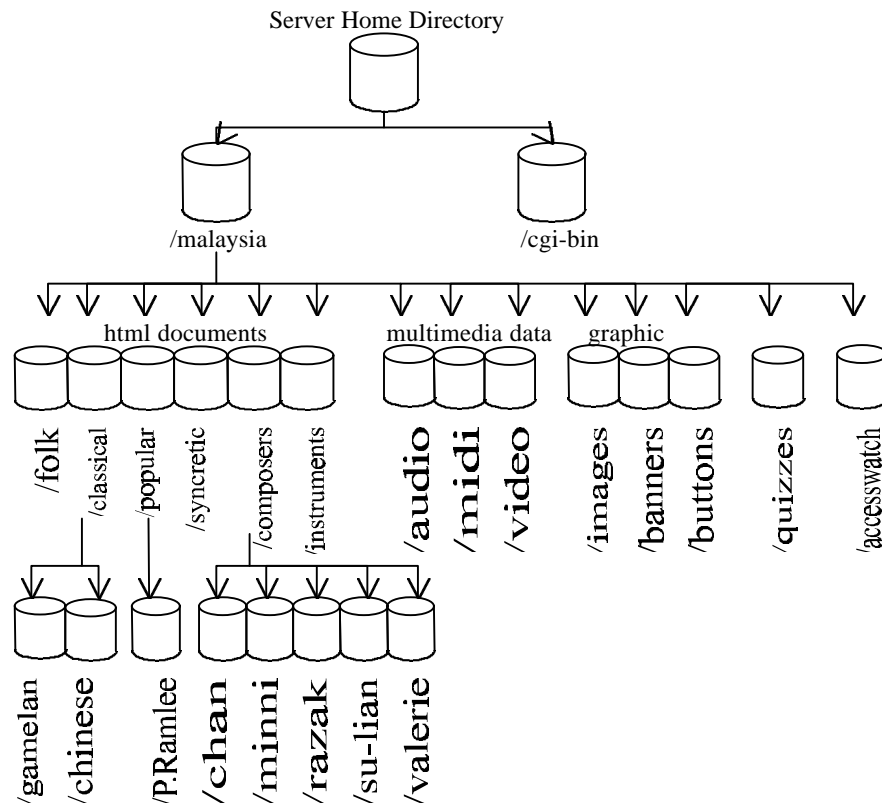
was used throughout to identify the author of the documents,
<META NAME="Description"
 CONTENT="Comprehensive site
 on Malaysian Music">
was used to facilitate location of site by various search engines,

- <META NAME = "Classification" CONTENT = "music, Malaysia, South-East Asia, culture, folk music, ethnomusicology, musical instruments, traditional music, composers, Asia, Asian music, ASEAN music">
- <META NAME = "KeyWords" CONTENT = "music, Malaysia, South-East Asia, culture, folk music, ethnomusicology, musical instruments, traditional music, composers, Asia, Asian music, ASEAN music">

Body Information
The main body of the HTML document is contained within the <BODY></BODY> tags. Formatting conventions such as text colour and document-wide fonts are specified.

<BODY TEXT="#000000"
BGCOLOR="#F0F0F0"
LINK="#FF00FF" VLINK="#800080"
ALINK="#0000FF"
BACKGROUND="images/background.gif">
is used throughout the site to create a consistent formatting convention. A background image consisting of an approximately one inch wide purple vertical stripe on the left side of each page is used. Black text on a white background is used for the main body of text. Links to other web pages are indicated by purple text, matching the background stripe. Visited links are

indicated by dark purple text while active links temporarily turn blue, in keeping with the overall site colour scheme.

Banner headlines, which use a consistent colour, font and size are used throughout the site. The banner headline colour is identical to the purple background stripe. For example,
<CENTER><IMG
SRC="banners/musical.gif" HEIGHT=55
WIDTH=298 ALT="Musical Malaysia
Banner"></CENTER>

Spatial layout of text and images within individual pages are fixed using TABLE tags. Primary pages (the majority of pages) are divided into three columns: the left column containing the document title or specific subject heading; the middle column containing the main body of text and any images; and the right column containing menus to subsequent related pages. A navigation bar is included on each page, providing easy access to top level documents. This bar is located at the bottom of every page's main body text. A copyright notice is also included on every page, immediately beneath the navigation bar.

A slightly different page layout conven-tion is used in the documents describing music by region to accommodate for the wider graphic images used. Pages on the various states adopt a two-column format, while the top level document, an image map of the whole of Malaysia from which users can access pages with information on music from any particular Malaysian state, does not use columns.

Footer Information

A site wide custom footer is implemented through the use of the Netscape server "add custom signature" feature. This feature allows a custom footer to be auto-matically added to every HTML document served from within a specified directory. Footer information needs only to be coded once. This information is stored in the obj.conf web server configuration file[9], and need not appear at all in the HTML docu-ments stored in the local web site databank.

Local Site Search Script

A local site search script is implemented, which allows users to search the specified directories within the site, based on key-words input via an online form. This PERL script is configured from freeware code available online. This feature is implemented to provide users with an easy way to locate specific information desired.

Musical Instruments Index

The musical instruments index consists of 5 pull down menus within one HTML page, providing access to HTML docu-ments about all types of folk instruments found in Malaysia. The pull-down menus are coded using Java script. The Musical Instruments Index is constructed using 5 separate scripts, one for each pull down menu. The original scripts were obtained from the various freeware archives on the WWW and modified for the present purpose. The web page mentioned in the above paragraph also uses Java script to identify client browser software. The web

application is targeted primarily towards the large majority of WWW users, who use either of the two major browsers, Netscape Navigator and MSIE. MSIE does not interpret Java script, while Netscape does. If the script mentioned in this paragraph detects that the client browser is not Netscape, it automatically redirects the client to an alternative non-Java script version of the information on the page, i.e. a list of connecting links.

Online Quizzes

As the application developed is a proto-type, online assessment tests are only implemented within one section of the application: pages appearing under the general heading "Classical Music"[10]. The user is able to select from multiple choice answers and receive an immediate response on how well the test was performed.

The online quiz prototype layout adheres to a simple three-question format, with four multiple choice answers each. Answers obtained via input of user selection from the drop down answer menu boxes are sent to the CGI script for calculation of results, which are returned to the user via a HTML page. Script responses are customised for all possible quiz results. For simplicity, presently only one of three responses are output: a perfect score results in a congratulatory message, one or two mistakes results in a message of encouragement to the user to try again, while three mistakes (all wrong answers) also results in a simi-lar message, worded slightly differently.

---

[9] This configuration file specifies information such as http access control parameters (password information is stored elsewhere) and other user definable features.

[10] http://www.music.upm.edu.my/malaysia/ classical.html

The CGI script used is one obtainable free from the WWW (Kendrick, 1997). Quiz contents are coded in HTML, while customised responses are coded in a file named responses.dat which is stored in the same directory as the CGI script. Header and footer information is added from two separate customised HTML files called top.html and bottom.html respectively which are also stored in the same directory as the CGI script.

MIDI File Rotater

A different MIDI file (selected from the local MIDI archive) is played in the background each time the main top level or home page is reloaded. The PERL script is adapted by the developer from a script which rotates graphic files. The script is called using the embedded audio tags, which are placed at the bottom of the web page so that all other text and graphics will be displayed before the MIDI file is loaded. This is to avoid delay in visible response to the client mouse click. <EMBED> </EMBED> tags are used for recognition by Netscape browsers, while the <BGSOUND SRC> tag is used for recognition by Internet Explorer browsers: <EMBED SRC="../cgi-bin/midi.pl" autostart=true hidden=true></EMBED> <BGSOUND SRC="../cgi-bin/midi.pl">

Accesswatch

A freely available customised PERL script is used to monitor site usage (Maher, 1997). Access log data is organised and displayed graphically. Statistics are displayed on daily basis and refreshed at a customised rate. Information displayed includes overall access statistics for the day, hourly statistics, specific pages accessed and client IP addresses or names. Irrelevant accesses may be filtered out, such as accesses by the local host, graphic file accesses or other specified accesses.

Other Features

Guest book

Visitors to the site are invited to sign the site guest book, which is accessible from all pages within the local web site through the use of the site-wide custom footer, described earlier in this paper. The guest book itself resides on a foreign server[11], is customised, and is provided free of charge by *GuestWorld* (GuestWorld, 1997). The guest book HTML add-on page may also, if so desired, be saved on the local web server, with the CGI script (which is used to process entries) being called from the foreign site. Guest book administration is via the HTML document interface, with all administrative components residing on the foreign server. The seamless integration of the guest book into the local web site is an example of a model of a collaborative open system.

Access Monitor

A site access monitor is implemented which also resides on a foreign server[12]. This access monitor is known as *Hitbox* and is provided free of charge by *WebSide Story, Incorporated* (1997). An icon on the *Musical Malaysia* home page provides a link to this site. Each time this icon is loaded from the foreign server, a CGI script sends information to the account

---

[11] http://www.Lpage.com/wgb/wgbsign.dbm?owner= MusicalMalaysia

[12] http://w23.hitbox.com/a.cgi?I32820300

Access database stored on the foreign server. Graphical and text-based access information can be obtained through input of the appropriate username and password. Additionally, the site's position within the world's top 1000 most frequently accessed sites (i.e. only those sites registered with this site) is updated every four hours. The Hitbox is another example of an open collaborative system.

TESTING

Testing of the prototype application is undertaken to ensure that it works correctly. Web application testing involves HTML validation, script validation, and server performance. Testing is carried out using various web site validation tools available on the Internet. These are listed, where utilized, below.

Besides testing for functionality, it is also necessary to test the ease of use of the graphical user interface, from the point of view of the user. This includes testing the items listed below:

- Clarity of instructions. This means that on screen instructions and functions are clear and easy to comprehend.
- Ease of navigation. This means that the user faces no difficulty in figuring out how to navigate through the web site.
- Simplicity of mixed media file playback. This means that the user need not manually reconfigure the client system to view various types of media files available from the site.

The above items are tested using volunteers who are invited to browse through the

prototype. Comments on the above points, or any other relevant constructive comments, are taken into consideration and enhancements or modifications to the application are made. Comments received via e-mail and from guestbook entries are also considered in this manner.

HTML Validation

HTML validation essentially involves checking all HTML documents for correct usage of HTML tags, and verifying all hypertext links contained within the document. Different on-line and off-line tools may include checking for different additional features. The HTML validation standard is selected by the user, for example, documents may be tested for compliancy with the HTML version 3.2 standard, or for support by current versions of MSIE or Netscape.

Syntax Check

Testing is carried out using the *Doctor HTML* $^{(TM)}$ (Tongue, 1997) online web analysis utility. This utility performs the following tests: spelling check, image analysis, document structure test, image syntax check, table structure check, form structure check and hyperlink validity. All tests, except the spelling check and the hyperlink validity tests, are performed using this utility. The spelling check is not carried out because many of the terms included in the text content of the documents are Asian names and so on, which return false spelling errors as the utility only checks for standard English words. The hyperlink validity test is performed using a different software utility, primarily due to the slowness of using this particular

on-line utility. Tests performed and results returned are very thorough, however, only single URL analysis is provided free of charge[13]. This means that to check the entire web site requires manual input of all the individual URL's within the site. The procedure is carried out as a foreground procedure, which means that the URL to be checked is submitted via an on-line form and results are returned to the browser. The whole process takes about two minutes per page under validation. Thus identified, deficiencies in coding are corrected and the document concerned is re-tested. This procedure continues until all HTML documents are free of all errors.

Link Validation

Link validation software utilities locate any broken or invalid links referenced from the HTML pages being tested, by searching the web site, testing, verifying and validating each link. The trial version of the *InfoLink Link Checker* (BiggByte Software, 1997) is used for speedy[14] validation of all links within the prototype. Broken links are manually updated. It is found that certain external links are slow to load, causing the utility to return error messages, or to report broken links. However, when the problem URL's are checked manually, it is found that the links are actually functional, but slow to respond once the host is accessed. The slowness of these links is outside the control of the prototype. These links are still included in the web application as they provide support information to the main body of information, and do not slow down access to pages within the local server.

Script Validation

Testing on the validity of the specific-function scripts used within the web site is done manually, as described below.

Local Site Search Script

The site search script supposedly returns all public web documents within the site containing keywords input by the user. Various keywords are, therefore, input into the search page online form and search results are compared against known information. It is found that it is necessary, within the PERL script used, to specify each directory, which is to be searched. Providing a wildcard instruction to search everything below a particular top level directory causes the script to search only the documents within that directory and not to search its subdirectories. Specific subdirectories to be included in the search domain must also be named within the script to cause these directories to be searched. This provides protection for information contained within private subdirectories, for example, within the access watch subdirectory where not all the files available are made visible to the public.

Musical Instruments Index

Testing of this feature involves selecting different pull down menu items to see if the desired page is loaded. The use of several different scripts within one web page requires careful checking of the assignment of variable names to ensure that no conflicts occur. The scripts are found to function as expected.

---

[13] Complete site analysis is available, at a fee.

[14] Testing of the entire web site takes approximately 15 minutes.

MIDI File Rotater

The home page which calls the MIDI file rotater script is loaded many times to test whether or not different MIDI files are embedded and automatically played back each time. The script works as expected.

Output of Online Quiz

The online quizzes implemented for a limited section of the prototype application are tested as to the accuracy of their output. Each quiz consists of three questions with four multiple choice answers per questions. Specific output is defined for three types of quiz results: all correct, all wrong, and any other combination of results, i.e. one or two mistakes. Various combinations of input answers are tested to see if the desired output is achieved. The script works as expected.

Server Performance

Server performance is tested using the online tool, *NetMechanic* (Monte Sano Software, 1997), which rates server response time. Each time the service is requested, an automated robot monitors and tests the server by sending http document requests, at 15 minutes intervals for a period of 8 hours, measuring the amount of time required for each step of the retrieval process. The steps in the retrieval process are: the time taken to look-up the server address; the time taken to establish a network connection; the ping response time, which provides an independent assessment of the network performance time; and the time to retrieve and transmit the requested file over the Internet.

Location of Web Site by Various Search Engines

One of the aims of the prototype application is to provide information on Malaysian music to the general public. As such, users should be able to locate the site using the various search engines on the WWW. As discussed earlier in this chapter, <META NAME> tags are used in the header section to facilitate location by the various search engines.

Testing is carried out by searching the various engines using various related keywords. Examples of search results are shown in Table 3. The results indicate that the application is relatively easy to locate on the World Wide Web.

RESULTS AND DISCUSSION

The web architecture developed consists of 170 HTML documents, with an average page size of 4.4 Kb, including 625 image files, with an average image size of 4.6 Kb. Page download times comprise 76.4% rated fast (less than 1.7 seconds to download), 18.8% rated average (1.7 to 3.5 seconds), and only 4.7% rated slow (more than 3.5 seconds to download). The rates are calculated based on the total size of the files to be downloaded (that is the HTML file and all its embedded graphic files) over a 14.4 Kb connection. The *NetMechanic* (Monte Sano Software, 1997) server check utility returned an overall rating of "fair" for the site. Most tests returned results within the 32nd percentile of all servers tested. DNS look-up times average 0.12 seconds, while connect time averaged at

Table 3: Example Results for Search by Keywords

Keywords searched	Engine Searched	Highest placement (below 100)
Malaysian music	Alta Vista	5
	CARI	6
	Infoseek	1
	WebCrawler	2
Malaysian composers	Alta Vista	1 - 4
	CARI	search term not found
	Infoseek	1
	WebCrawler	1
Malaysian musicians	Alta Vista	6
	CARI	search term not found
	Infoseek	1
	WebCrawler	not listed

Search date: 13 December 1997, 5.00 pm**.**

0.81 seconds, while download time for a 10 Kb file averaged 3.29 seconds. This difference between real download times and predictions based on calculation is caused not by any shortcoming in the web archi-tecture, rather by the nature of TCP/IP connections, and network congestion. *NetMechanic* returned no server timeouts over a period of 2 days, which means that the site is reliable.

User feedback also indicates that the site is well received and that the visible web architecture and subject architecture are easily comprehended by the majority of users. The site guest book is one way in which user feedback is obtained. Other ways of obtaining feedback include elec-tronic mail correspondence with the webmaster and personal comments.

CONCLUSION

The web architecture for the prototype application on Malaysian music is reliable and structurally sound, and may form the basis for a complete application for use in the context of music education in Malaysia.

BIBLIOGRAPHY

Ang, M. 1995. *Cadangan program Bacelor Muzik.* Serdang: Fakulti Eko-logi Manusia, Universiti Pertanian Malaysia.

Ang, M. 1997. *Malaysian music - a comprehensive discussion on the different types of music found in the country: contemporary art music, classical music, syncretic music and folk music.* (Communicated).

Ang, M. 1997. *Musical Malaysia.* [Online]. Universiti Putra Malaysia. At: http://www.music.upm.edu.my/malaysia/ [Dec 12]

Ang, M. 1997. *P.Ramlee home page.* [Online]. Universiti Putra Malaysia. At: http : // www. music. upm.edu.my/ P.Ramlee/ [Dec 12]

Ang M.; Abu Talib Othman and Abdul Azim Abdul Ghani. 1997. An interactive multimedia courseware repository over the internet. *INTEC '97*: Universiti Pertanian Malaysia, Serdang, 20 May 1997: D51-54.

Ang M.; Ramani, A.K., Tee, E.R. and Abu Talib Othman. 1997. A web architecture for music education. *International Conference on Technical Education in 21st Century (ICTE -21)*: Bhopal, India, 8-10 January 1998: 494-501.

Ang, M.; Ramani, A.K., Tee, E.R. and Abu Talib Othman. 1998. A distributed collaborative hypermedia web architecture for music education: a model for Malaysian music on the world wide web, *Journal of Information Technology.* Jil. 10. bil. 1.(Accepted for publication).

Ang M.; Tee, E.R.; Abu Talib Othman and Abdul Azim Abdul Ghani. 1997. An interactive multimedia courseware repository over the internet. *Malaysian Journal of Library & Information Science*, Vol.2, no.1: 63-70.

BiggByte Software. 1997. *InfoLink link checker 1.9.* (Trial version). [Online]. At: http://www. biggbyte.com/download.html [Dec 13].

Chen, S.S. and Dennis, J.R. 1993. Linking different cultures by computers: a study of computer-assisted music notation instruction. *Journal of Educational Technology Systems*, Vol.21 no.3: 207-224.

Conant, B. 1988. *A study of cognitive processes of children creating music in a computer learning environment.* Ed.D Dissertation, University of Massachussetts.

GuestWorld. 1997. [Online]. At: http://www.Lpage.com/ [Nov 25].

Heath, B.J. 1982. *The effectiveness of CAI as a means of individualized instruction in music education.* MA Thesis, University of Victoria, Canada.

Johami Abdullah. 1993. P*endidikan muzik semasa.* Kuala Lumpur: Dewan Bahasa dan Pustaka.

Kendrick, B. 1997. *Form-Totaller.* [Online]. New Breed Software. At: http://zippy.sonoma.edu/kendrick/nbs/unix/www/form-totaller/ [Nov 25].

Lee, Y. 1994. *Teaching young children music fundamentals in a computer learning environment.* Ed.D Dissertation, Columbia University.

Maher, D.G. 1997. *AccessWatch.* (version 1.32). [Online]. At: http://access.watch. com/ [Nov 25].

Matusky, P. and Tan, S.B. 1997. *Muzik Malaysia: tradisi klasik, rakyat dan sinkretik.* Pulau Pinang: Asian Center Penang & Akademi Seni Kebangsaan.

Monte Sano Software. 1997. *NetMechanic - server monitoring and performance testing.* [Online]. At: http://www.etme-chanic.com/server_check.htm [Dec 13].

Newman, L. 1997. *Music education online.* [Online]. Los Angeles: Children's Music Workshop. At: http:// www.geocities.com/Athens/2405/ [Dec 10].

Progressive Networks. 1997. *Real audio home page*. [Online]. At:http:// www. realaudio.com/index.html [Nov 5].

Ragget, D., Le Hors, A. and Jacobs, I. 1997. *HTML 4.0 specification. W3C proposed recommendation.* [Online]. World Wide Web Consortium (W3C). At: http://www.w3.org/TR/PR-html40/ [Dec 11].

Tongue,T..1997..*DoctorHTML.* [Online]. Imageware, Inc. At: http://www2 .imageware.com/ RxHTML/ [Dec 12].

Vivo Software Incorporated. 1997. *Vivo software home page*. [Online]. At: http://www.vivo.com/ [Dec 1].

Wall, K. 1997. *Technology in music education database.* [Online]. Auburn University, Alabama. At: http://www. auburn.edu/ time/ [Dec 2].

WebSide story. 1997. *World 1000.* [Online]. WebSideStory, Incorporated. At: http:// www.hitbox.com/wc/world. html [Nov 25].

Wright, M. 1997. *Simple search.* [Online]. Matt's Script Archive, Incorporated. Available: http:// www.worldwidemart. com/scripts/ search.html [Dec 11].