

# **A LAYERED ARCHITECTURAL MODEL FOR MUSIC EDUCATION: MALAYSIAN MUSIC ON THE WORLD WIDE WEB**

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## ***Abstract***

The design and development of the layered web architecture for Malaysian music can be applied as a model of web architecture for music education, specifically for the introduction of the music of a particular country or region. The model is designed and developed in two phases: the building of the subject architecture, and the design and development of the application architecture. The complete web architecture is analyzed and tested to determine its suitability for delivery of music related content. Research findings indicate that the web architecture is reliable, efficient and suitable for its purpose. The classification scheme proposed is found to provide a firm foundation for the building of the web architecture. In conclusion, the prototype model provides a suitable extensible platform for the delivery of music content, which may be packaged for the purpose of education.

## **1.0 Introduction**

The results of the research on Malaysian music (Ang, 1997a) are used as the primary source of content to be presented through the web application. An effective interactive multimedia computer-assisted instruction system should be developed based on the content to be communicated to the learners (Tu & Pai, 1996). The design and development of the web architecture for Malaysian music is therefore dependent on a well

structured and logical subject architecture, reinforcing the need for a comprehensive classification system for Malaysian music. The classification system proposed (Ang, 1997a), provides a systematic basis for the categorization and organization of information on Malaysian music [the subject architecture]. The subject architecture thus designed is used as to develop the application architecture.

The web architecture designed is a two-layer architecture, comprising 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 work thus consists of two primary sections: research on Malaysian music and the building of the subject design architecture, which in turn provides a framework for the application architecture; and the prototype application architecture development.

Many World Wide Web (WWW) sites exhibit poor implementation, being merely hypertext markup language (HTML) versions of printed information. Many on-line companies have sprung up specifically to address the need for structured web architectures, providing [chargeable] site design and restructuring services. The MUSE CD-ROM (1997), which contains the RILM abstracts of music literature and the Library of Congress music catalog, reveals that as yet no research has been published on the subject of web architectures for music. The design and development of the two-layered web architecture for Malaysian music can therefore be applied as a model of web architecture for music education, specifically for the introduction of the music of a particular country or region.

The subject architecture is reflected in the hierarchy of the web pages contained in the application. The application architecture reflects the subject architecture, but does not mirror it exactly. Design principles adopted include hardware independence, portability,

modularity, maintainability, extensibility, distributed architecture, open system, and efficiency of coding.

## **2.0 System Development Procedure**

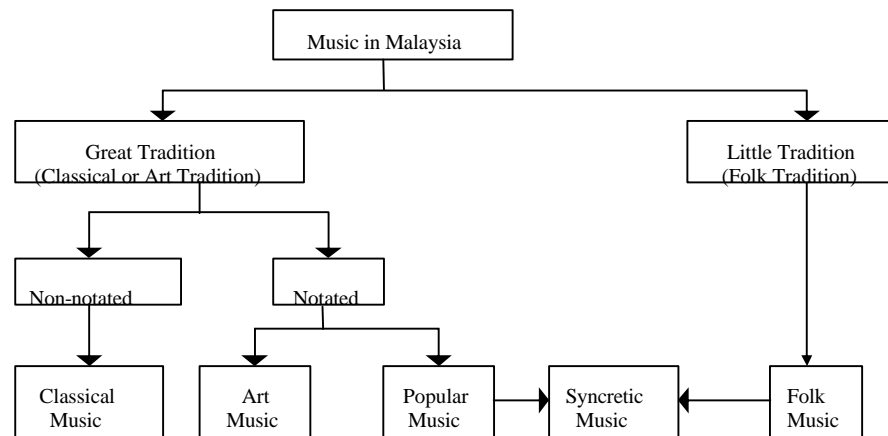
The system development procedure (Ang et al, 1998a) comprises two main sections: the general procedure in developing a multimedia system for education, and the procedure for developing the content to be presented. The right side of Figure 1 focuses on providing the content and building the subject design architecture for the computer-aided learning web application on Malaysian music. The review of literature on Malaysian music provides a foundation from where a systematic classification method for Malaysian music is proposed. This classification method provides a framework for the subject design architecture, which in turn provides a framework for the application architecture. The interface design is then developed, based on the application architecture, and the media to be communicated is decided. Data is then collected and archived. The data collection methodology is discussed later in this chapter. The need to amend the subject design architecture, application architecture, interface design or media used may arise as a consequence of data gathered, changing interface requirements or new technologies, as illustrated by the iterative loop at the right side of the flowchart. This allows for continual updating of data included.



this continual upgradation and enhancement of the application. The classification method for Malaysian music is considered further.

## 2.1 The Classification Method for Malaysian Music

It may be convenient to start by describing the musics unique to the various ethnic communities, as most material published at present is available in this format. However, to do so would be to further emphasise the artificial division of Malaysian society created by former colonialist policies. A better way of classifying and categorising Malaysian music may be seen as proposed in Figure 2. (Ang, 1997a).

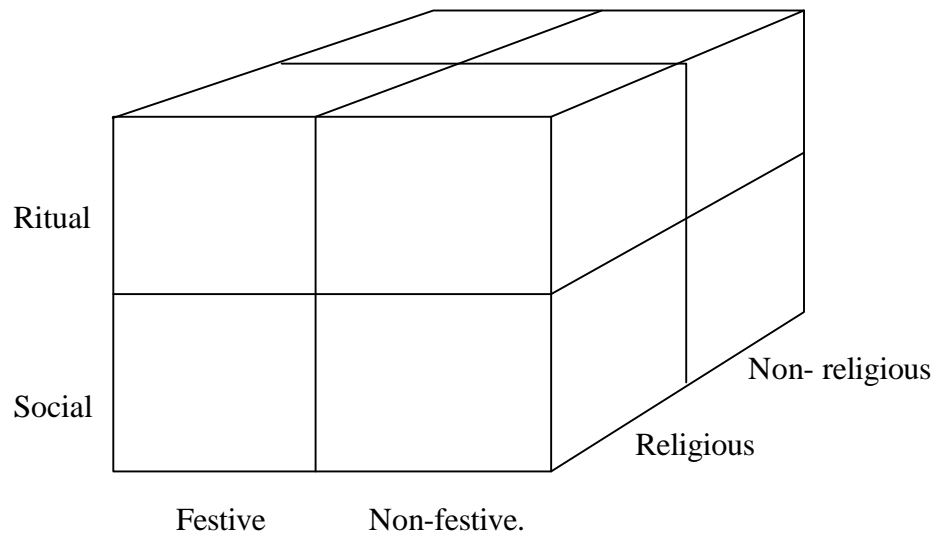


**Figure 2. Diagrammatic Representation of Types of Music in Malaysia.**

Robert Redfield (1973) in his work on culture theory defined the “great tradition” of the reflective few as one which is consciously cultivated, refined and handed down in a formal learning situation. The “little tradition” of the largely unreflective many is defined as one which keeps itself going, is taken for granted and is not put under much scrutiny or deliberate refinement and improvement. The initial step in designing a well structured web

architecture involves defining a first level of data categorisation. For this purpose, while it should be understood that Redfield's definition is by no means clear cut and that many grey areas exist, music commonly known as "traditional" or belonging to the little tradition as described by Redfield will be termed *folk music*, while music which is or has been consciously developed and cultivated deliberately will be classified as belonging to the great tradition. These definitions are adopted for our purposes from Redfield's culture theory. Great tradition music is further subdivided into three main categories: *contemporary art music*, which encompasses notationally transmitted music composed by specific individuals as an expression of their artistic creativity; *classical music*, which is defined here as traditional classical music developed as palace traditions such as gamelan Melayu and Nobat, consciously cultivated as a high art form but not primarily notationally transmitted; and *popular music*. This broad classification method is used by Matusky and Tan (1997), but is not defined rigorously or in greater detail.

The categories are proposed as a guide to organising the database of musical information for systematic data classification, ease of retrieval, and to help the layman to gain a broad overview of the types of music in the country. In addition to these categories, folk music may be further subdivided into various overlapping subcategories, represented by a flat table in First Normal Form<sup>1</sup> (Date, 1990). (Figure 3). "Religious" and "ritual" music are distinguished under the main headings "spiritual" and "individual" respectively. "Religious" music is defined as music which is used in conjunction with religious worship or religious services, while "ritual" music is defined as that which is used in conjunction with secular or social rituals such as Malay weddings. Music listed under the category "Non-religious" and "social" includes music which is used in a social context, though not in a ritualistic sense. Examples of this sort of music include children's songs. "Festive" music is defined as music which is associated with, and usually only performed during, specific



**Figure 3. Conceptual View of Overlapping Folk Music Sub-Categories**

festivals which occur at specific times of year, such as Hari Maulud Nabi, Chinese New Year and Deepavali. Independent songs as opposed to “dance” and “theatre” music is defined as any music, including vocal song, which is sung or performed independently of dance or drama. Any specific song or piece of folk music may be described as belonging to any or all of the subcategories listed, (i.e. the subcategories are not mutually exclusive): *spiritual, individual, community* or *function*. For example, a religious song which is sung only in a social context, though not part of any set ritual, during a specific festival each year might be categorised as “religious”, “social”, “festive” and “independent song”. Figure 3 shows a conceptual view of the first three of these overlapping subcategories (Table 2), all of which include the functional subcategories of music for dance or theatre or independent songs. (Ang, 1997a). The reason for the levels of subcategorization is to provide for alternative search criteria. These search terms are included in the HTML meta name tags. Documents containing these terms may be located using a keyword search.

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<sup>1</sup> A table in first normal form satisfies the property that at every row and column position within the table there is always exactly one data value, never a set of multiple values.

Further discussion on Malaysian music is approached from the point of view of the above representation, with data gathering being carried out systematically according to the schema described. The data collected is organised for the web application into a suitable architecture, based on the proposed classification method.

## **2.2 Data Collection Methodology**

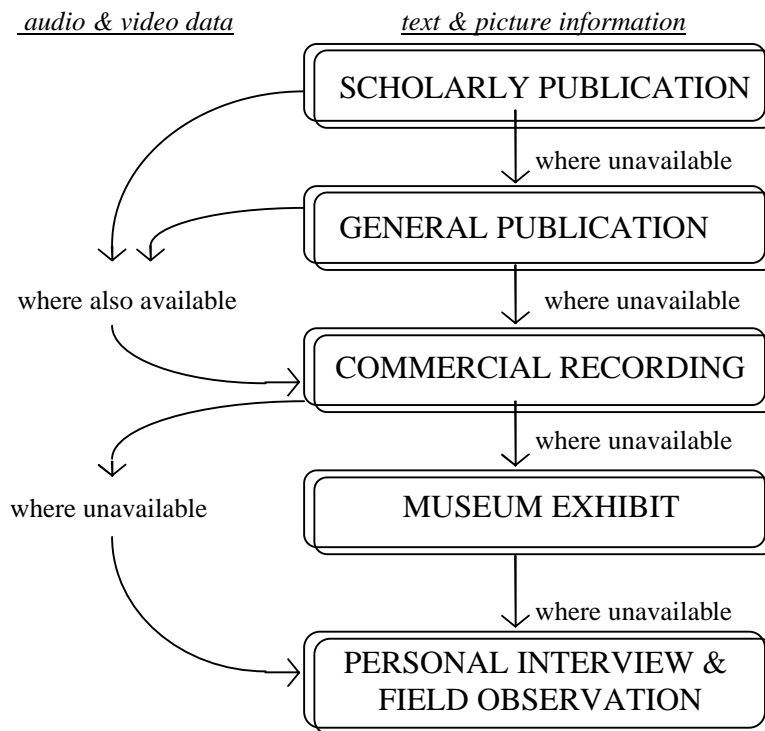
Data<sup>2</sup> on Malaysian music is compiled from several sources. The data collection methodology described in the following paragraphs is illustrated in Figure 4 (Ang et al, 1998b).

Where scholarly publications on the topic are available, information from these sources is used. General publications are referenced on topics which are not covered by scholarly publications. In addition to this, general references are also cited to indicate the type of information available to the general public on music in Malaysia, in view of the fact that one of the aims of the current work is to develop a source of general reference.

It is found that many types of music practised by various groups in Malaysia are not yet referenced by any publications at all, either scholarly or general, and that many more types are mentioned only in passing. Where commercial recordings of such music were available, clips of these have been included in the multimedia application. Such clips are also included to illustrate those topics which were covered by the existing other publications.

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<sup>2</sup> *data* as used here includes text-based information, pictures and photographs, music scores, audio recordings and video recordings.



**Figure 4. Data Collection Methodology.**

Information on certain types of music not covered in currently available publications is available from museum exhibits in various museums around the country. Several of these museums are visited to obtain such material.

Types of musics not covered by any of the other means above but nonetheless commonly known among various Malaysian communities is researched and documented through personal interviews and field observations. Field observations include audio as well as video recordings (where permitted), photographs, collection of music scores, and other related information including non-commercial audio and video recordings. A field study questionnaire is designed to aid data gathering. The web development methodology is discussed further.

### **3.0 Web Development Methodology**

The web development methodology is adopted from December's (1996, 1997) methodology for developing WWW-based hypermedia works. These principles are applied to the design of the Malaysian music web site, as discussed below.

#### **3.1 The Six Key Elements**

##### **3.1.1 Audience Information**

The target audience for the web application on Malaysian music is anyone who wants a general introduction to the topic of Malaysian music. The ultimate target audiences are Malaysian secondary school music teachers, secondary school children and tertiary music students who need a general introduction to Malaysian music. The audience is expected to possess fundamental knowledge on how to use the computer and the WWW. The audience may [in the case of music students and teachers], or may not [in the case of secondary school children in general and members of the public], have knowledge of music fundamentals, including the ability to read notation. Most of the target audience is expected to have only limited knowledge of Malaysian music, or even a misconception as to what constitutes Malaysian music, due to the lack of currently available general introductory information on Malaysian music. For most of the ultimate target audience, English is a second language. To reach a wider [international] audience, English is the chosen medium of communication for the web application. The fact that many of the target audience are not native English speakers is taken into consideration when writing the text to be contained within the HTML pages, to be read by the users.

### **3.1.2 Purpose Statement**

The web site aims to provide a comprehensive general introduction to all the types of music found and practised in Malaysia.

### **3.1.3 Objectives List**

To achieve the goals of the purpose statement above, the specific objectives that the web application on Malaysian music should accomplish are listed here:

1. As far as possible, all the types [genres] of music found in Malaysia should be represented.
2. The music of all the different ethnic groups in Malaysia should be represented.
3. Users should be able to answer the question, “What is Malaysian music and what does it comprise of ?” after going through this web site.
4. An on-line archive of information and multimedia files on Malaysian music is easily available to the public.

### **3.1.4 Domain Information**

The domain information is the content on Malaysian music. This includes all the data collected on Malaysian music, as described in the sections on data collection and organisation earlier in this paper. This information is what is used to build the subject architecture, or the visible layer of the two-layered web architecture.

### **3.1.5 Web Specification**

The specification statement details what pieces of domain information are to be presented as well as any technical or policy limitations on that presentation. The technical specifications, such as the exact content of the information to be presented and which data formats are to be used, are discussed in detail in (Ang et al, 1998b). Other design constraints, including legal and ethical aspects of the information to be presented, are discussed in (Ang et al, 1998c).

### **3.1.6 Web Presentation**

The presentation is the result of design and implementation processes that work within the web's specification, essentially the sum total of all the HTML files plus associated multimedia files or other software (CGI, Java, or other) to support the web. It also includes provision for backups and protection of the physical media, hardware, and electric resources that make the web site accessible to its users; and planning and provision for appropriate network, software, and hardware security measures to protect the web's infrastructure. (December, 1996). The presentation essentially consists of the underlying layer of the two-layer architecture [the application architecture]. This is discussed further later on in this paper.

## **3.2 The Six Ongoing Processes**

### **3.2.1 Planning**

The planning process begins with the identification of the six key elements, which has been carried out in the preceding section. It also includes identifying the skills and resources needed for developing, constructing, deploying, and operating the web.

#### **3.2.1.1 Required Skills of Application Developer**

To develop this web site on Malaysian music, the application developer needs to possess or acquire the following skills: advanced HTML, digital audio data processing and editing, digital video editing, MIDI sequencing and music arrangement, graphic processing and editing, JavaScript basic programming, basic PERL programming for CGI scripting, and layout and design of web based documents. Additional skills which are required for the effective implementation of the application are web server administration, for example for the purpose of logging accesses and restricting access to certain pages; and basic UNIX, for example for the purpose of scheduling jobs on the server.

#### **3.2.1.2 Hardware Resources**

1. Host Systems: Computers and Peripherals used for Development
  - IBM Pentium-Pro with 32 MB RAM, 3.2 GB hard disk and Soundblaster AWE-64 soundcard, quad-speed CD-ROM drive, Videoblaster video capture card, ethernet network card, and SCSI card for scanner.
  - Sun Sparc5 workstation with 64 MB RAM, 5.1 GB hard disk, uninterrupted power supply box.

2. Target Machine: computer on which the application will be eventually executed
  - primarily IBM or IBM-compatible personal desktop computers, 486 SX, 486 DX, Pentium, Pentium Pro and Pentium MMX.
  
3. Other Hardware Elements, used as resources for application development
  - Hewlett-Packard Scanner, for image capture.
  - Yamaha CSX-1 MIDI keyboard and MIDI y-cable, for MIDI sequencing.
  - Sony stereo headphones and multimedia PC speakers, for audio output.
  - Sony Walkman cassette player and audio stereo input cable, for cassette tape input.
  - Panasonic videocam, Panasonic video player and RCA and video input jacks, for video input.

### **3.2.1.3 Software Resources**

Software used as resources for development:

- Cakewalk Pro Audio, MIDI sequencer.
- Cool Edit, digital audio editor.
- RealAudio Encoder, to produce streaming audio format.
- Digital Video Producer, video capture software.
- VivoActive Now, to produce streaming video format.
- Aldus Photostyler, graphic editor.
- LView Pro, graphic editor to produce web optimised .gif and .jpg files.
- Gif Construction Set, to produce animated graphics.
- Windows Notebook, basic text editor for HTML programming.

- Netscape Navigator Gold, HTML WYSIWYG editor for fancy layout and web browser for viewing finished pages.
- Microsoft Internet Explorer, alternative web browser for viewing finished pages to ensure consistency of appearance in different major browsers.
- WSFTP file transfer protocol software, for uploading completed web pages and other digitized data from computer used for development to web server.

### **3.2.2 Analysis**

The objectives of the analysis is to weigh alternatives and gather information to help with the other processes of web development, including planning, design, implementation, promotion, and innovation. The analysis process involves three elements as described below. The details and results of the analysis are discussed later in this paper.

#### **3.2.2.1. The Technical Analysis**

This is a check of the technical implementation of the web with validation tools. It tests whether or not the web's presentation is functionally operational and consistent with its specifications and design, as well current HTML practices and syntax.

#### **3.2.2.2. The Usability Analysis**

This checks how the site is being accessed, both in terms of its own files and in terms of outside links into it; whether or not the web's user interface is usable and effective; and whether or not the web is accomplishing its stated purpose and meeting its objectives.

### **3.2.2.3. The Content Analysis**

This evaluates the consistency and verifies the correctness of the information content of the domain information. It checks that the domain information content is correct, relevant, and complete, and is accomplishing objectives that meet the needs of the users. This process is carried out continuously, from the moment of data gathering [the methodology of which was described in section 2.2], through the process of organising the data collected and proposing the classification method for Malaysian music, during the organisation of the subject architecture and after the implementation of the web site [through user feedback from experts in the field of Malaysian music].

### **3.2.3 Design**

The design process involves creating a consistent look and feel for the web, separating information into manageable page-sized chunks, providing cues for the user about the web's information structure and contents, context, and navigation, and using links to connect pages along the routes of use and user thinking. The details of this process are contained in section 4.1 below, with further details available in (Ang et al, 1998b).

### **3.2.4 Implementation**

The implementation is the process of building the web according to its design. This process involves the creation of an extendible directory and file structure to manage the web's files and / or software components (CGI or Java programs), in other words it is the building

of the application architecture, or underlying layer of the two-layer web architecture. This process is described in section 4.2 below, with further details available in (Ang et al, 1998b).

### **3.2.5 Promotion**

Promotion is the process of handling all the public relations issues of a web, including making the existence of a web known to on-line communities through publicity. Details on how this is carried out for the web site on Malaysian music, and results of this process, are discussed in section 5.2 below.

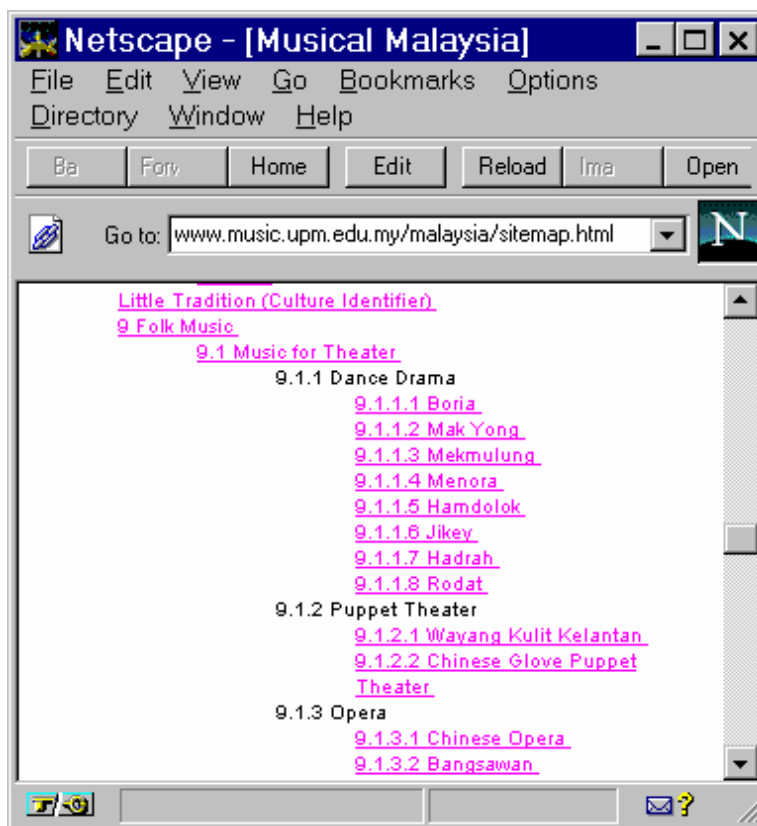
### **3.2.6 Innovation**

The final process in the web design methodology adopted (December, 1996-1997), is innovation, which is the process of continuously improving the usability and quality of the web to meet and exceed user expectations. This involves finding creative or unique ways to improve the elements of the web or engage the web's audience. Suggestions as to how this may be done for the web on Malaysian music are discussed in section 6.0.

## **4.0 Design and Implementation**

### **4.1 Design: The Subject Architecture**

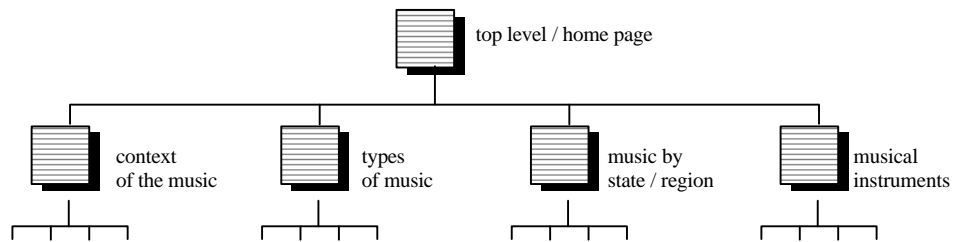
The subject architecture is shown in the hierarchy of HTML documents accessible through the standard web browser user interface. This consists of a multiple level document tree, up to a maximum of five levels as shown in Figure 5.



} Five levels including the home page

**Figure 5. Site Map illustrating Five-Level Document Tree Structure.**

Content to be presented is organised into an architecture based on the classification hierarchy for Malaysian music, described earlier. The content included within the individual web pages consists of four main types: pages providing information on the types of music in Malaysia, as classified in Figure 2; 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 6).



**Figure 6. Hierarchical View of Web Documents by Included Content.**

The biggest amount of text based information 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 information:

- classification of the music.
- type or genre: for example, Malay gamelan, joget, keroncong, et cetera.
- which Malaysian state or ethnic community the music is identified with, 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.
- photograph[s] of musicians, where available.
- example sound clip[s] of the music, in digital audio or MIDI format, where obtainable.
- bibliographic reference from which the information was obtained, if applicable.

As discussed in section 2.1 above, there are two main branches of the classification architecture, describing four main categories of music. Documents containing information on music included under the categories of “classical music”, “folk music” and “syncretic music”

form the bulk of the documents in the web tree, and are organised as described in the previous paragraph. The information included in these documents is gleaned from various sources, as described in section 2.2.

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. Brief background information on the composer and lists of compositions by the composer are provided, including MIDI files of original compositions where available. 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, 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 - i.e. every link leads to an individualistic 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 information:

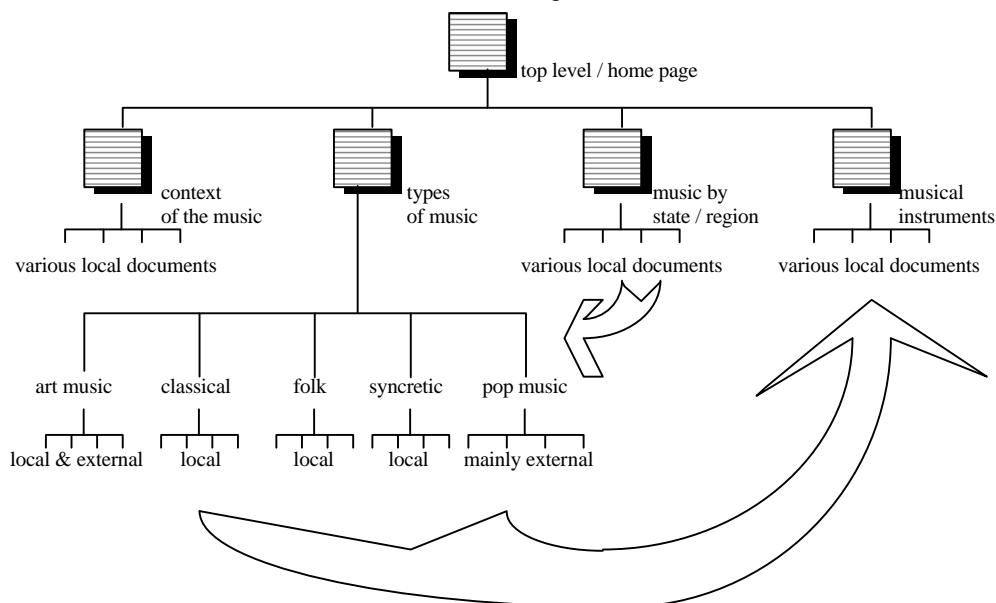
- name of the instrument.
- classification of the instrument, i.e. chordophone, aerophone, membranophone, idiophone.
- origin of the instrument.
- which Malaysian state or ethnic community the instrument is identified with, if applicable.
- a brief description of the context in which the instrument is played, if available.
- the type of music in which the instrument is used.
- any other supporting information which may be available.
- photograph[s] of the instrument.
- photograph[s] of musicians, if available.
- sample of the instrument sound in digital audio format, where obtainable.
- streaming video clip showing close-up view of musician performing on the instrument, where obtainable.
- bibliographic reference from which the information was obtained, if applicable.

Most of the text and photographic information included in these documents is gleaned from various published sources, as described in section 2.2. 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. Video and audio data were all obtained through field research.

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 summarised from the discussions in (Ang, 1997a). 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 7, an expanded version of Figure 6 taking into account the elaborations in the paragraphs above, concisely illustrates the subject architecture for Malaysian music, constructed based on the classification method (Figure 2).



**Figure 7. The Subject Architecture.**

Figure 7 provides the overview of the five-level document tree structure illustrated in Figure 5. The complete hierarchy of web pages is contained in (Ang, 1997b), which shows the site map. Although the document tree structure consists of five-levels, all pages within

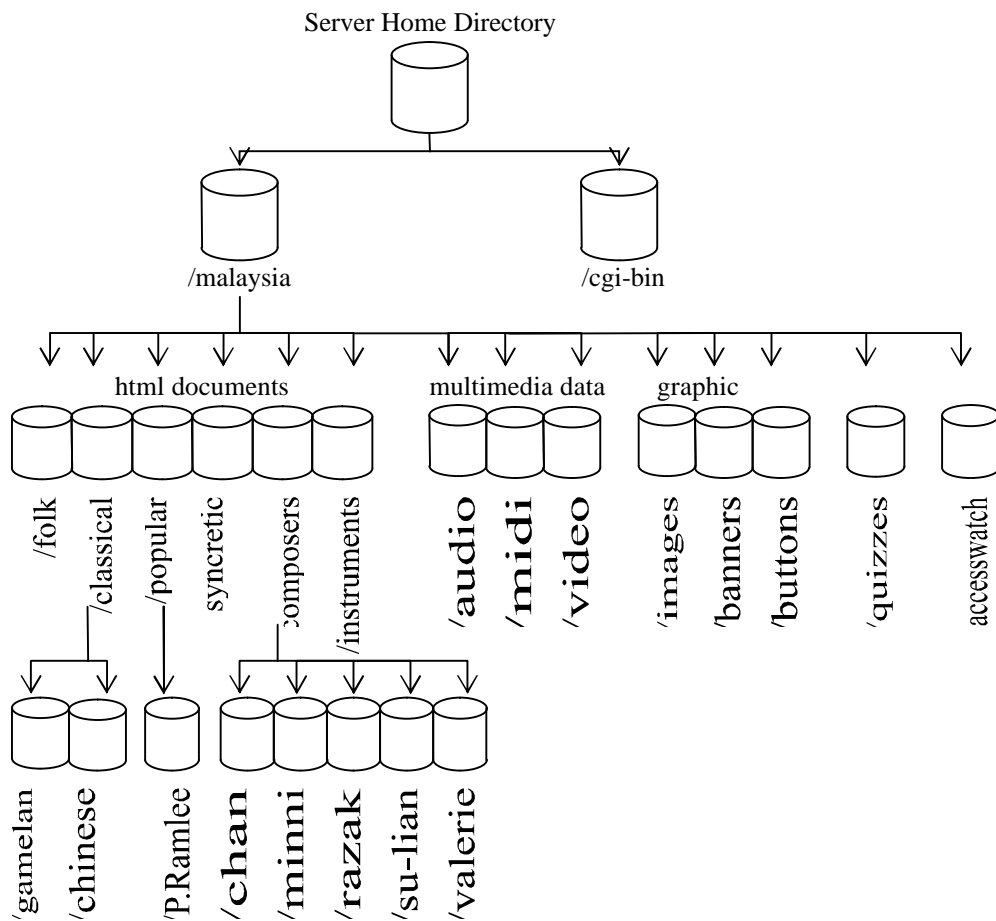
the site may be accessed using a maximum of 3 mouse clicks from the site home page. This principle is adopted to ensure easy accessibility of all documents within the site, during the course of normal browsing. For fast access, users may locate any page within the site using only 2 mouse clicks, via 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 on-line form.

#### **4.2 Implementation: The Application Architecture**

The application architecture supports the subject architecture, and forms the underlying layer of the two-layer web architecture, consisting essentially of the file storage structure. The application architecture reflects the subject architecture, but does not mirror it exactly. It is organised into several hierarchical directories and subdirectories, the details of which are illustrated in Figure 8.

**Figure 8. The Application Architecture in the form of a Hierarchical Directory Tree.**

The application architecture exhibits the modular design principle which is adopted in the web architecture design, with different file types separated into different directories. Figure 8 is essentially a detailed expansion of Figure 9. Four main types of files are stored: HTML or text files; multimedia files, comprising digital audio files [.ra format], streaming audio and video files [.viv format] and MIDI files [.mid format]; image files [.gif and .jpg formats]; and utility files, consisting of various scripts.



The HTML files are stored in a directory structure which closely resembles the subject architecture (Figure 7). This design provides for ease of extensibility. For example, the addition of the information about a new composer merely involves adding on another subdirectory for that composer under the relevant branch of the directory tree. The web page template is easily modified from existing composer pages.

The storage of all multimedia files in separate modular directories, by file format, provides for ease of enhancement. For example, a new improved version of the digital audio file format is easily implemented through the replacement of all existing files in the directory with those encoded in the new format. Links to the specific files from the parent HTML pages need not be updated if the new file format extension and mime-type remain identical, for example the old `.ra` format may be replaced by a newer version format which still uses the `.ra` extension without having to update anything other than the `.ra` files themselves. Replacement of the existing files with those using a different file extension can be handled through placing the new files into a new sub-directory. The server resource map file can then be updated to include the `Redirect` directive which redirects requests for specified files to the new location.

Image files are stored in three separate directories: `images`, `banners` and `buttons`. The `banners` directory contains all site banner headlines, the `buttons` directory contains icons and similar-function image files, with all other inline images being stored in the `images` directory. Utility files are similarly stored in a separate directory, providing for ease of enhancement and extensibility.

The modular application architecture is easily extensible to include additional directories containing new types of files, for example education modules [consisting of

HTML files] which may be built for the purpose of packaging the domain information for the delivery of educational courses.

## **5.0 Results and Discussions**

The results of the technical analysis, generated using an analytical application, are presented and discussed. The analysis of the prototype web architecture is carried out in terms of the number of web pages included within the site, the number and type of links within the HTML pages, the proportion of HTTP links versus links to inline images, the size of web pages to be downloaded, and the relative download times per page. The results of the server performance testing which was carried out, in terms of time required for the various steps in web page retrieval, are discussed as an indication of the reliability of the prototype. The prototype web architecture is also tested in terms of the validity of the links contained in the application<sup>3</sup>. Link validation results are discussed as an indication of the structural robustness of the architecture. The results of the usability analysis, in terms of site promotion, site access statistics and user feedback, are also discussed, as an indication of whether or not the site is successful achieving its objectives. Site promotion is the process of handling all the public relations issues of a web, including making the existence of a web known to on-line communities through publicity. Results of the promotion of the site are discussed. Site access statistics are considered as an indication of whether or not the site is successful in reaching a wide audience, as one of the objectives of the present work is to create a public resource on Malaysian music. Random user feedback is obtained through electronic mail correspondence, guestbook entries and personal interaction with volunteer testers. This is used to qualitatively evaluate the ease of use of the graphical user interface in terms of clarity of instructions [i.e.

with regards to on-screen instructions and functionalities], ease of navigation, and simplicity of mixed media file playback. Random user feedback is also used to qualitatively evaluate the clarity of presentation of the content on Malaysian music, i.e. the subject architecture.

## **5.1 The Technical Analysis**

The web architecture consists of a total 170 HTML pages, organised into an underlying structure comprising 23 different directories and sub-directories. The average page size is 4374 bytes. Theoretically, this should take approximately 2.6 seconds to download over a 14.4 Kbps Internet connection. However, this figure does not take into account the inline images which are usually downloaded together with the HTML page, unless the client browser has the “auto load images” option turned off. The total size of all pages, including all inline images is 3380 KB, averaging 19.9 KB per page. Theoretically, this should take approximately 11.3 seconds to download over a 14.4 kbps connection<sup>4</sup>. Browsers generally load the HTML content of the requested web page first, followed by the inline images. This causes the download process to appear faster to the end user. Download ratings generated by the testing utility rate 73.5 % [125 out of 170 pages] of the web pages included in the application as fast, 21.2 % [36 pages] as medium, and 5.3 % [9 pages] as slow. “Fast” pages average 10.7 KB per page, including inline images and take 6.1 seconds on average to load. “Medium” pages average 32.4 KB per page and take an average of 18.4 seconds to load, while “slow” pages average 96.8 KB in size and take an average of 55.1 seconds to load. “Fast” pages consist of an average of 3.3 KB [30.9%] of HTML data and 7.4

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<sup>3</sup> A procedure akin to “white box testing”, which tests that all statements in the program have been executed at least once and all logical conditions exercised (Pressman, 1992: 627).

KB [69.1%] of inline image data, while “medium” pages have an average of 4.8 KB [14.8%] of HTML data and 27.6 KB of inline image data [85.2%]. “Slow” pages average 7.8 KB [8.0%] of HTML data and 89.0 KB [92.0%] of inline image data. This indicates that the biggest contributing factor in obtaining a “slow” rating is the added graphic content. The implication here is that any inline images to be included need to be carefully optimised in terms of the file size. The summary of the findings discussed here is tabulated in Table 3 below. Theoretical download times are calculated for the 14.4 Kbps connection.

PLEASE INSERT TABLE 3 HERE.

The acceptable download time targeted for the application, set arbitrarily, is 3 seconds for a visible response to the user’s mouse click, and 15 seconds for the total page to be loaded. The results in Table 3 indicate that the first of these targets is met by 94.7% of the pages included in the application, while the second target is achieved for 73.5% of the pages. This is for connections at 14.4 Kbps. For connections at 28.8 Kbps and more, the first target is met for 100% of the pages, and the second target for 94.7%.

The theoretical download times obtained here are compared with actual download times obtained using an on-line testing utility. Tests were carried out over a period of three days, with each test consisting of a series of requests sent by the testing utility, at 15 minute intervals over a period of eight hours, from the remote site to the server under testing. The average download time for a 10 KB file, as obtained by this utility, is approximately 2.8 seconds, with no time-outs occurring for any of the pages requested. To compare this result

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$$\begin{aligned}
 {}^4 \text{ Download Time in seconds} &= \frac{\text{Size of Page in bits}}{\text{Connection Speed in bits per second}} \\
 &= \frac{(19.9\text{KB}) \times (1024\text{B per KB}) \times (8\text{b per B})}{(14.4\text{Kbp/s}) \times (1000 \text{ b per Kb})} \\
 &= 11.3 \text{ s}
 \end{aligned}$$

with the results obtained as summarised in Table 3, the average theoretical download time for a 10 KB file needs to be extrapolated from the previous results. The download time calculated in this manner results in an average download time of 5.7 seconds per 10 KB file. This duration is approximately twice as long as the actual download time recorded by the on-line testing utility, indicating that the connection speed between the two machines is approximately 28 Kbps, i.e. almost twice the connection speed on which the theoretical estimate was based. The 14.4 Kbps connection speed is used as the basis of calculation as this is expected to be the lowest connection speed commonly available to dial-up home users. In practise, many connections may be made at rates higher than this.

The significance of this result is that the actual download times are consistent with theoretical estimates. This implies that both the web architecture and the server hardware are efficient. Slow download times are generally caused by two classes of shortcomings: server related and application architecture related. Server shortcomings arise from insufficient RAM, slow hard disk access rates, CPU overload, and non-caching of frequently requested pages in memory. Architecture related shortcomings include web pages generated by CGI scripts or those with Server Side Includes, both of which take additional loading time. The consistency between the theoretical estimate for download time and the actual value obtained through testing indicate that, for the present application, these problems appear not to be an issue.

Download times for digital audio and MIDI files are calculated manually. Streaming audio [.viv format] and streaming video files play back while being downloaded, so download times for these types of files do not need to be considered. A summary of the multimedia data available from the prototype application is given in Table 4.

PLEASE INSERT TABLE 4 HERE.

The average playback time for digital audio files included in the application is 1 minute and 57 seconds. This takes 2 minutes and 6 seconds to download over a 14.4 Kbps connection, which means that the user has to wait this length of time before hearing any audible output, which lasts for 1 minute and 57 seconds on average. The average playback time for MIDI files included in the application is 1 minute and 36 seconds, but here the average download time is merely 4.3 seconds over a 14.4 Kbps connection. The advantage of using MIDI files instead of digital audio is thus immediately apparent. [It is noted here however that there are other drawbacks in using MIDI, as discussed earlier]. Streaming audio is used for longer playback samples, so that the user does not have to wait for the download process to be complete before hearing any audible output, but instead hears the playback as the downloading is carried out.

### **5.1.1 Link Validation Results**

The number of links available from the total number of pages within the prototype web architecture is 3017, of which 79.1% are http links and 20.1% are image links. The testing indicates that 99.1% of the links are valid while 0.9% are invalid. When tested manually, the 28 links, connecting to 18 unique URLs [all external to the local web site], listed as “invalid” were all found to be working. It was found that most of these external sites [comprising 14 unique URLs in total] were simply slow [more than 30 seconds] to load, causing a time-out error by the testing utility. The remaining four “invalid” links were caused by the unique functions of the links in question. The two links at the `w23.hitbox.com` site are actually part of the access monitor which returns information to

that server via a CGI script, while the two links at `ad-x.com` are remotely generated banner advertisements, included within the prototype as part of the banner exchange program undertaken to promote the Malaysian music web site.

The link validation results indicate that the web architecture is structurally sound. The few slow links caused by external URLs, which are outside the control of the local application, are retained within the prototype web application due to the relevance of the content of these URLs, as supplementary material, to the content on Malaysian music. As evident from the file storage architecture as illustrated in Figure 8, and the subject architecture as seen in Figure 7, these slow links do not generally disturb the workings of the application, as they are not central to the web architecture, but peripheral components of the application.

### **5.1.2 Server Performance Results**

Server performance testing results are summarised in Table 5 below.

PLEASE INSERT TABLE 5 HERE.

The server rating over this period, as awarded by the testing utility, was consistently “fair”. While this is quite low [i.e. only better than between 20% to 40% of all servers tested by the utility], it should be taken into consideration that the testing utility resides on a server in the USA, while the `music.upm.edu.my` server is in Malaysia, compared with the majority of servers tested, which probably reside in the USA. The actual figures as seen in

Table 5 indicate that the server, and consequently the web application, is reliable in terms of clients being able to gain rapid access to the server, without having to face server time-outs.

## **5.2 The Usability Analysis**

### **5.2.1 Site Promotion Results**

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. <META NAME> tags are used in the header section to facilitate location by the various search engines. The web site is registered with all the major search sites.

Testing is carried out by searching the various engines using various related keywords. Examples of search results are shown in Table 6.

PLEASE INSERT TABLE 6 HERE.

The results indicate that the application is relatively easy to locate on the WWW.

### **5.2.2 Site Statistics for the Prototype Application**

The site access statistics provide an indication of whether or not the on-line web resource for Malaysian music is reaching the general public, which was one of the objectives of this work - i.e. to provide an easily available resource on Malaysian music for the public in

general, and for the schools in particular. An analysis of the web server access log for last quarter of 1997 was carried out using a server log analysis application. The web server receives an average of 828 hits per day, with an average of 206 user sessions, each spending an average of 9 minutes and 13 seconds at the site. It is interesting to note that 54.21% of these users access the site from the USA, with the remaining 45.79% being spread among the various geographical regions. The Musical Malaysia home page is currently the most requested single page on the server, ranking higher than the more established [i.e. launched about one year earlier] UPM Music Department home page.

The domain from which the site is most frequently accessed is the home user dial-up service provider `tm.net.my`, with Internet service provided by Telekom Malaysia. These accesses accounted for 65.2% of all accesses to the site over a three month duration [October to December 1997]. The implication here is that the majority of those accessing the web application are home users, i.e. the general public.

The list of most active countries is interesting in that of the top 15 countries [accounting for 67.38% of total user sessions] accessing the site, 100% of these accesses come from abroad, spanning four different continents. Of these, 80.46% are from the USA, while none are from within Malaysia itself. These results may indicate that users in the USA and other countries abroad generally account for more WWW traffic [i.e. bigger number of users] than Malaysian users, or it may indicate that the web site on Malaysian music is more popular among people abroad than it is among Malaysians within the country. The former reason is found to be true when WWW demographic results are considered (Network Wizards, 1997) - of the 19,540,325 hosts on the WWW, only 40,533 are from Malaysia, a meagre 0.21%, so it is hardly surprising that user sessions originating from within the `.my` domain account for so few of the web site accesses in terms of relative numbers. This does

not however imply that the site is primarily accessed by non-Malaysians. The only conclusion that may be inferred from these results is that the site is primarily accessed from outside Malaysia. Guestbook entries indicate that the primary users of the web application at present are actually Malaysians, as implied by user names provided by guests. One inference that may be drawn from this state of events is that the web application is currently most frequently accessed by Malaysians residing abroad, perhaps primarily by Malaysian students abroad, as it is common knowledge that Malaysian students abroad number in the tens of thousands. This last inference is supported by the activity level results, which indicate peak access during mid-week and minimum usage on weekends: university and college students generally access the WWW from their respective schools, which they attend on weekdays.

The activity level by hour of day results show that the site is most frequently accessed at approximately 1 p.m. local time, with a smaller peak occurring at approximately 11 p.m. The period of least activity is at approximately 7 a.m. each day. The interpretation of these results is based on the previous results mentioned in the preceding paragraphs. It is known that the majority of users access the web site from the USA, while the majority of Malaysian users access the web site via tm.net.my dial-up accounts. Time zones in the USA are between 13 to 16 hours behind the Malaysian time zone. The activity level graph indicates that the number of user sessions generally start to increase from approximately 8 a.m. Malaysian time, or between 4 p.m. to 7 p.m. American time. Peak level activity occurs at 1 p.m. local time, or between 9 p.m. and midnight in the USA. These results are consistent with the assumption that users are mainly students in the USA who are probably accessing the WWW through on-campus client machines via leased lines, which explains why activity starts to rise after formal class hours. Malaysian users, on the other hand, gain their primary access via dial-up [presumably personal account] connections. Peak usage thus occurs for these users around lunch time [about 1 p.m.] and after dinner time.

These discussions merely reflect the current state of usage of the application. It is noted here that the original primary target audience for the web application is the Malaysian schools. This audience is however new to the WWW and new to the study of music (Ang et al, 1998a). Consequently, some promotion or advertisement of the web application needs to be done to this target group, before the application gains wide usage. As this is a prototype study, with the main focus being on the design and development of the web architecture for the delivery of the Malaysian music content over the WWW, the effort to promote the use of the application is not undertaken at this stage. It is however mentioned here as a point to note for future action.

Further results obtained from the web site log analysis show that for the three month period analysed, 100% of all server hits were successful hits, with no failed hits. This further affirms the server reliability, as indicated in previous paragraphs by the results of the testing by the on-line testing utility.

The results for the most downloaded file types and sizes show that, in terms of numbers of files requested, 68.9% of all requests are for HTML files, 19.6% for MIDI files, 10.2% for digital audio files (.ra format), and 1.3% for streaming audio or video files (.viv format). The web architecture contains 170 HTML files [55.2%], 36 digital audio files [11.7%], 79 MIDI files [25.6%], and 23 streaming audio and video files [7.5%]. Image files are not mentioned here as they are downloaded as inline images within the HTML files, and not requested for separately by the user. A comparison of the two percentages is presented in Figure 10.

PLEASE INSERT FIGURE 10 HERE.

Figure 10 shows that the overall profile for different types of files available from the site is similar to the overall profile for the different types of files downloaded by users, with slightly lower download figures being obtained for the multimedia files. While this implies a slight hesitation on the part of the users in downloading additional multimedia information, in general most users do make the conscious choice of downloading the multimedia files linked to a particular web page. Attention is drawn here to the relatively lower percentage of requests for streaming audio and video [.viv] files. This implies that users are not downloading all of the available content [actually 780 downloads were made during the survey period, but this figure is very low when compared with the total of 59228 downloads made during the same period]. This may be due to the fact that the .viv format was only recently introduced on the WWW and is consequently not so widely known as yet. The seamless integration of new file types is possible through the automatic installation of browser plug-ins. This process is, however, not 100% automated for the most popular browser on the WWW, Netscape Navigator, which requires the user to make certain choices in installation, causing perhaps many users not to install the required plug-in due to various reasons.

The final set of results obtained is the list of most accessed directories. The Musical Malaysia home directory emerged as the most accessed directory within the server for the period surveyed, accounting for 39% of all accesses, in spite of the fact that the Musical Malaysia web site was only launched approximately three months previously, as opposed to the top level directory housing the UPM Music Department home pages, which was launched about 18 months previously. This trend indicates that the Musical Malaysia web site should continue to grow in popularity as it becomes more well known on the WWW, with further enhancements made to the prototype.

### **5.3 The Content Analysis**

So far, the general response to the web site is positive and enthusiastic, as indicated by random site guestbook entries. Some positive comments were received from the few noted personalities [in the field of Malaysian music] who visited the site and signed the guestbook. Minor modifications to certain specific content on Malaysian music suggested by these visitors were taken on board and implemented accordingly. The fact that these modifications could be done without difficulty is an indication of the strength of the web architecture designed. Ease of enhancement through the use of a modular directory tree structure was thus achieved.

User feedback through private electronic mail correspondence to the web master was also obtained. It is noted here that several users expressed dissatisfaction at the use of MIDI to represent various folk music pieces. Primary reasons cited were lack of authenticity, and poor quality of playback [this is actually dependant on the client machine hardware]. These users were responded to by return electronic mail, with the justification for the inclusion of MIDI within the site: lack of availability of live recordings, availability of musical scores, and the advantage of being able to print out the representative notation using the appropriate software. [No mention was made of the probably inadequate MIDI playback hardware available to these users, in view of the complexity of the explanation]. It is interesting to note here that research findings by Bridger (1993) indicate that many listeners do actually find computer generated music disturbing and alienating, a finding confirmed here by these users responses. Volunteers tested the application for logic of approach [with regards to the content on Malaysian music] and ease of use of the interface. The subject architecture was well

received by all volunteers. Minor enhancements to the graphical user interface, i.e. the web page design, were made on the basis of suggestions by the volunteers, for example, explanatory text was added to certain imagemaps, and the site colour scheme was modified slightly. Again, the well designed architecture provided for ease of enhancement, and the alterations were made without difficulty.

## **6.0 Conclusion and Innovation**

The results of the analysis on the prototype web architecture showed the web architecture to be reliable and efficient, having been tested and validated. The web application also met the general objective of providing a publicly-accessible general resource on Malaysian music, as well as specific design objectives, listed below:

- portability: the HTML documents all use relative URLs for internal linking within the local web site. The application can be easily transferred *en bloc* to another location without upsetting the link information. This was demonstrated when the entire web site was shifted to another [back-up] server without disrupting the links within the site. This portability means that the domain information [the content material on Malaysian music] is not tied to any specific storage device. This allows for easy set-up of mirror sites or the transference of the site to a different storage medium [for example CD-ROM], and provides for the continued availability of the information content.
- hardware independence: the web architecture was implemented on a SunSparc5 server running the Solaris UNIX operating system, but, as explained in the paragraph above, may be easily moved to any platform server.

- distributed architecture: the web architecture may be conceptualised as consisting of a central core, implemented on the primary local server, but surrounded by essential links to various other URLs containing support information and peripheral components such as the site guestbook. The peripheral components are located at different geographical locations, thus achieving a distributed architecture.
- open system: the client-server architecture required for the complete retrieval and display of the content data is implemented on the WWW, thus achieving the open system.
- modular design: the application architecture is of a modular design. The file storage structure or directory tree was designed so that different types of information and different types of files are stored in different directories.
- efficiency of coding: the high percentage of small HTML file sizes indicate that this design objective was met.
- maintainability: the ease of modifying specific features or contents of the application, such as in response to user feedback, indicate that this design objective was met.
- extensibility: this design objective was also met. This was demonstrated when data gathered in the last stages of the development of the application was easily added on to the existing content.

The results of the prototype performance study are also significant in terms of inferences which can be made: the web architecture designed is efficient and suitable for the delivery of music-related information content; the application architecture is dependant on the subject architecture; initial accesses, and the listing of the web site in the various WWW search sites, indicate that the web application fulfils its purpose in reaching the general public; user feedback received indicates that the web application fulfils its purpose in providing the public with a broad and understandable introduction to Malaysian music;

access statistics indicate that users do generally download multimedia files although the download time is slower compared with pure text data, if they feel the information provided is worth the effort.

Web based music education in Malaysia is currently limited to that which is carried out at tertiary level, for example the considerable use of the WWW in the teaching of various music courses conducted by the UPM Music Department. The Malaysian schools are however still in the early stages of discovering how the computer and the Internet can be applied within the context of classroom education. However, the Malaysian government has stated its commitment to ensuring that, within the next two years, all its schools will be provided with Internet access. In this context, the web resource on Malaysian music can be of significant use in the teaching of music in Malaysian schools, in line with the objectives of the Malaysian MSC Smart School initiative (MSC, 1997).

The prototype application is currently packaged more as an informational resource than as an educational one, though certain educational components have been included such as the on-line self assessment quizzes. To extend the prototype for use in the classroom is relatively simple - it involves creating a sort of shell set of HTML pages which organise the material available from the prototype into various level educational packages. The modular design of the directory structure tree enables the easy addition of another directory, for example `modules/`. Within this directory are included various HTML documents, such as `course1.html`, `course2.html`, and so on, which contain descriptions and objectives of these courses, and the relevant progressive-level links, which primarily point to files on the local server, but may also include external supporting URLs. The quiz database also requires expansion to include quizzes for all the topics covered, as well as more questions per quiz.

The two-layer architectural model can be easily applied for the development of other web sites for music education, specifically for the introduction of the music of a particular country or region. The subject architecture and the application architecture models as depicted by Figures 7 and 8 can be adapted for the delivery of content on the music of other countries or regions.

The distributed collaborative environment (DCE) consisting of four component layers: the meta data level, the application level, the data level, and the network connection level (Ang et al, 1998c); is an extension to the two-layer architecture. The meta data level component supports the integration of extensible lower level components (application, data and network) through description of functionality, services and data that are provided by the respective lower levels. The main objective of the DCE is to provide a platform for the sharing of resources using existing infrastructures and systems. Incorporation of the various features mentioned under the DCE is relevant in the context of web based music education, as collaboration adds to the content to be delivered and allows different modules to be administered by different collaborative partners. The lack of information available on many specific areas of Malaysian music means that to develop such a DCE would be a desirable objective.

The meta level databases may include the following:

- Administrative database, maintaining data pertaining to the operation of the entire web site: examples include collaborative systems development blueprint and collaborative systems directory.
- Web site users database, maintaining registered users.
- Database for system logs, for example logs for access counters, errors, and utilisation statistics.

- Website databank description.
- CGI scripts databank for shared access, not restricted to the local web site.
- General help text or meta information database.
- Browser loadable programs databank, for example platform-specific media player programs.
- Components database describing system components.

The application level may be a suite of http compliant, or a purpose built Internet server application. Ideally, a specific system, such as the Musical Malaysia web site, can be developed either from an assortment of small programs or using a purpose built application. The http compliant programs may be loosely coupled with part of the processing handled by the browser itself. The system should support interoperability of data. Audio data format independence may be achieved through the use of a specially designed audio file format conversion routine or algorithm when audio data received from collaborating partner sites does not conform to main site formats. An example of this may occur when digital audio data received from an individual field researcher via remote login cannot be converted to the format of choice at the web site prior to transmission. The researcher may upload his or her sample via remote login. The system automatically detects the foreign data type and invokes a script to convert the data to the required format. Meta data may be used to store information as to the location of the original sample, if available on-line, or other relevant information.

A DCE web site may include non-standard peripheral hardware components. The actual implementation of the DCE may not account for these physical connections as most of the installations types are already handled by network server applications. The meta data level defines only the minimum of the physical level.

In conclusion, the two-layered web architecture [for the delivery of information on Malaysian music], which consists of the visible layer [the subject architecture] and the underlying layer [the application architecture], was found to be a suitable extensible modular architecture which can be applied as a model of web architecture for music education, specifically for the introduction of the music of a particular country or region. Suggestions for further development are itemised below.

1. The extension of the prototype to include educational modules which utilise the information available from the prototype, only packaged differently with the addition of peripheral components such as a larger number of on-line quizzes.
2. The adaptation of the architectural model for the development of other web sites for music education, specifically for the introduction of the music of a particular country or region.
3. The development of collaborative partner sites for the implementation of the distributed collaborative environment. The lack of currently available potential collaborative partner sites indicates that this is a viable area for future research and development. The extension to the present web architecture is theoretically not difficult, due to the existing modular, open system, distributed architectural design adopted.

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