The Digital Library as an Enterprise: the Zachman Approach

Abrizah Abdullah and A.N. Zainab

Library & Information Science Unit,
Faculty of Computer Science & Information Technology,
University of Malaya, 50603 Kuala Lumpur, Malaysia
(abrizah, zainab) @um.edu.my

Abstract

Purpose: Examines the needs of digital library stakeholders and how a collaborative digital library might be designed to meet these needs. The collaborative digital library has been conceived to support secondary school students’ information needs in conducting school-based projects.

Design/methodology/approach: Uses the Zachman Framework for Enterprise Architecture as the approach to investigate the user requirements and define the digital library organisation, resources, processes, technology and information flows. In applying the Zachman Framework and to holistically control the study, the case study approach and multiple data collection techniques were adopted.

Findings: Information obtained from these data gathering techniques helps to populate the requirements of the top three layers (18 cells) in the Zachman Framework to ascertain the design details of the digital library’s scope, business and system model. The framework requires the abstraction of the characteristics and features of the digital library based on six dimensions, Motivation, Data, People, Process, Place and Time, as well as explains their structures and processes from the perspectives of the planner, owner and designer of the digital library.

Originality/Value: Would be of significance in the field of collaborative digital libraries since stakeholders’ needs and the contexts of use are not usually captured comprehensively, and the ongoing challenge is to model complex human and social behaviours in the form of collaboration and communication in such digital libraries.

Keywords: Collaborative digital libraries; Digital library research framework; Zachman Framework for Enterprise Architecture; Digital libraries in education; User needs; Malaysia

Paper type: Case study

Framework for Digital Libraries

Formal frameworks are often used to specify unambiguously the characteristics, structure, and behavior of complex information systems such as digital libraries. Gladney et al. (1994) wrote that the broad and deep requirements of digital libraries demand new frameworks and theories in order to understand better the complex interactions among their components. The summary report of the Joint NSF-European Union (EU) Working Groups on Future Directions of Digital 1 Libraries Research also supported this need and recommended that “new frameworks and theories be developed in order to understand the complex interactions between the various components in a globally distributed digital library” (Schauble and Smeaton, 1998).

Previous digital library (DL) research and initiatives have conceptualized and proposed several frameworks for the design, development, evaluation and interaction of digital libraries (Levy, and Marshal, 1995; Moen, and McClure, 1997; Marchionini and Fox, 1999; Saracevic, and Covi, 2000; Fuhr, 2001). Levy and Marshall (1995) described a work-oriented approach that is based on the work people do, and how digital libraries assist in the completion of work related tasks. Their framework highlights that digital libraries are characterized by documents, technology, and work processes (which involves research and service). Moen and McClure (1997) provided a framework of five interacting dimensions in Government Information
Locator Service (GILS), comprising policy, users, technology, contents, and standards. The framework also includes three perspectives, representing the "views" of the stakeholders in the GILS comprising users, agencies, and the government. Marchionini and Fox (1999) identified four dimensions of DL development constituting community, technology, service and content. Saracevic and Covi (2000) presented a seven-level framework for examining digital libraries: social, institutional, individual, interface, engineering, processing and content. Puhr et al’s (2001) framework consisted of four major dimensions, namely data/collection, system/technology, users and usage. Sandusky (2002) listed six attributes in framing DL usability research comprising audience, institution, access, content, services, and design and development. Soergel (2002) offered a DL research framework consisting of three guiding principles and eleven specific themes for research and development. Gonçalves et al (2004) introduced the 5S and formalisms for streams, structures, spaces, scenarios, and societies to frame the theoretical and practical unification of digital libraries. All these frameworks emphasize the importance of a holistic approach rather than examine digital libraries as a single view, which would be limited in their utility.

This paper attempts to show how Zachman Framework for Enterprise Architecture can be adopted as a formal framework for the design of digital libraries, providing a precise specification of requirements against which the implementation can be compared for correctness. In this research, the DL represents a special workspace for the Malaysian educational community, not only for search and access but also for the process or workflow management, information creation, sharing and exchange, and distributed workgroup communication

**Methodology**

In this paper a DL is regarded as an enterprise that requires architecting. The enterprise architecture often involves examining business processes, people, operations, technology, software and hardware, local and wide area networks all aligned with the organisation’s objectives. The blueprint or framework of the enterprise would reveal detailed statements and processes that characterized architectural drawings. The detail drawings would be in any form, such as rich pictures, structured charts, data flow diagrams, UML activity diagrams, database tables and entity-relationship model. An enterprise architecture for the DL is a framework or blueprint which shows how the DL organisation carries out an intended task currently and how the DL will or can improve the processes. In this context, the Zachman Framework for Enterprise Architecture (Figure 1) is found suitable to ground the design of a collaborative DL of school projects. The framework helps to explicitly show the many perspectives that need to be addressed by the DL. It requires the planner, owner and designer of the DL to involve the stakeholders to ensure that the DL meets their needs and will be used. This research has chosen the Zachman Framework for the approach to investigate the initial requirements and define the digital library organisation, processes, technology and information flows for the following reasons:

a) It holistically controls the study to investigate the user requirements and guides the data gathering techniques.

b) The framework requires the involvement of stakeholders and it aligns with the research problem on the need to involve stakeholders in DL design and development (Marchionini, Plaisant and Komlodi, 2002; Giersch et al., 2004). The framework is robust enough and requires the designer to consider all aspects of the DL design. The framework is generic in nature and can be applied to any domain or types of organization. (Pereira and Sousa, 2004).
The framework abstracts the characteristics and features of the DL based on the following six dimensions:

- **Motivation factor**, requiring the planner and owner to solicit answers to the “why” question, why there is need for the DL? Why does the current business process need special handling such as those provided by the DL?
- **Data factor** abstracts the “what” aspects of the DL. What data that is currently handled by the stakeholders? What format would the data take in the DL environment? What are the characteristics of the data used, processed, stored and presented or disseminated in terms of quality, accuracy, usability, description and organization?
- **People factor** looks at the “who” questions or the roles of people in the school project report environment. Who will be instructing? Who will be handling the data? Who will be reporting the collated or processed data? Are the players in the DL environment “ready” to participate and contribute to the DL initiative? Are they able to do so?
- **Function or Process factor** defines the “how” of the activities in the DL environment. How will users search for data, how will they store the data? How will students write, present and submit their report? How will the teachers ensure that the students know what is required? How do they grade the reports? How will they keep the reports submitted for the specified time required by the Malaysian Ministry of Education? How can the school’s history resource room accommodate these reports?
- **Place or Networks** looks at the “where” factor. Where will the DL be located? Where will it be accessed by the stakeholders?
• Time looks at the “when” aspects of the DL. When will submission of reports take place? This is useful for designing schedules, the processing and control architecture and timing systems.

To illustrate the use of Zachman’s framework in preliminary design of the collaborative DL, this paper focuses on all six columns of the framework comprising six dimensions described above: Motivation, Data, People, Process, Place and Time (Zachman, 2002). The study considers the three upper rows (Rows 1, 2 and 3) of the Framework comprising the “scope” from the “planner” or researcher’s perspective; the “business model” from the “owner’s” perspective (the educational community as stakeholders) and “system model” from the “designer’s” point of view. These perspectives help ensure that everything relevant to the DL enterprise is covered. In this work, the columns, comprising the six dimensions, are arranged so that the most important column or the focus of attention is presented first. Each of these dimensions is investigated from the perspective of the planner, owner and designer of the DL. At the end, the outcome would be in the form of listings and diagrams depicting the scope, business and system model of the DL. Rows 4, 5 and 6 are beyond the scope of this paper.

The domain of the DL is collections of history project reports submitted by Secondary 2 and 3 students. The community chosen comprises students aged between 14 and 15 who are required to produce the project reports as part of their school-based assessment. The aim is to design a useable prototype that can handle multiple-source datasets. In the process of collecting data for the study and in order to answer the questions triggered by the intersecting factors (cells) from the top three rows and columns of the Framework, multi-method research approach used are as follows.

• The case study approach of an urban secondary school in Malaysia, which was chosen because the school is willing to be a partner in the DL initiative; the school provides Internet access to both teachers and students. It is situated near cyber cafes placing stakeholders in an ICT rich environment and the school encourages community involvement in ICT projects among teachers and students.

• A survey was administered to 397 Secondary 2 and 3 students. The main use of the survey is to provide the following information: types of information needed and used by students and teachers, their information seeking behaviour, use and problems faced; their motivation and willingness to collaborate and share their report and resources; their roles in the DL environment; their readiness to collaborate as content providers and developers; their ICT skills, readiness and usage; knowledge and use of the Internet; their awareness and use of digital libraries (answering the framework’s component of Why, What, Who, How, Where, When). The questionnaire was developed and field tested on 30 students.

• Focus group interviews, involving 30 students, were carried out to understand student’s impressions, understanding, expectations and frustrations when searching for, organizing and presenting the information in their project report. Responses were sought on their use of the Internet and technology in conducting research, their information needs and seeking behaviour, their awareness of digital libraries and their motivation to be involved in the collaborative DL. The 30 students belonged to the group who expressed willingness to participate in the interview in their survey responses. On average each interview session lasted about 60 minutes.

• Interviews with six History subject teachers to ascertain their readiness to participate in building the DL as content manager and their attitude towards the DL initiative for educational use. In order to determine their readiness and willingness to collaborate it becomes necessary to determine their Internet use and degree of technology integration in their instructions. The six teachers’ names were submitted by the head teacher as those who have volunteered to be interviewed. Interviews lasted between 40 and 90 minutes.
On-site observations of the school to ascertain physical and infrastructure environment that would support the collaborative DL implementation. This would indicate the school’s ICT environment, Internet penetration, computer and networking facilities, ICT integration in the curriculum, ICT usage by teachers and students in the school, ICT policy and school library facilities. The school’s history resource room where all previous students project reports are kept, the usage and access to the reports was also observed.

Document analysis of students’ projects and official documents related to the goals and objectives, as well as processes and procedures of implementing school-based projects were examined. In doing this, information on the what, when and how component of the Zachman framework was collected. A total of 30 samples of student’s report were examined. This part of the study would revealed the presentation style used to write the reports as required by the Ministry of Education Malaysia, the objects included with the report (either embedded within the text or in the appendices) and kinds of tables, figures and citation style used to present information. Besides the reports, official documents generated by the school as well as the Ministry were also analysed for the assessment requirements of the report, especially the components and apportionment of marks. This information would affect the design and management of the collaborative DL.

Documents analyses of literature and collaborative DL projects were also perused and analysed to ensure that the prototype adopts all possible best practices.

User testing and evaluation of the functioning DL prototype was conducted; CoreDev (http://coredev.fsktm.um.edu.my) was evaluated by 44 users in terms of motivation (is it supporting set objectives), the functioning of the data, people and their roles, the network, and time.

Findings were then used to populate the Zachman Framework with contextual, conceptual, logical and module diagrams at every intersection between the columns (why, what, who, how, where, when) and the rows (scope, business model, system model). Scope describes the system’s vision, mission, context, boundaries, architecture and constraints. For the DL in this research, the owner of (or the person most interested in) the scope model in Row 1 is the researcher, who plans what the system is to do. The planner is concerned with positioning the DL in the context of its environment. This is when the planner enquires about the demographics of the stakeholders, ICT individual differences, their readiness to participate and collaborate, their awareness of the concept of digital libraries and their perception of the DL initiative. Business model defines goals, strategies, structure and processes that are used to support the mission of the DL enterprise. The owner of the business model in Row 2 is the educational community who owns the DL. The owner is interested in the DL’s deliverables and how it will be used. System model contains system requirements, objects, activities and functions that implement the business model. The owner of the system models in Row 3 is the researcher who designs the requirements of the DL. The designer is concerned with how the DL is to perform its functions. This involves investigating the resources that are used, the user behaviour of seeking for resources, the experience of searching, the relevance perceived and the problems encountered. It also involves review of current DL features through published literature, analysis of contents of reports produced and official documents, as well as site visits and observation.

Results
(a) Motivation: Why the DL is needed
Why (Motivation) column of Zachman extracts the motivation of the people that support the realization of the DL. This reveals the reasons for creating the DL, as well as the establishment of goals, objectives and business plan of the DL. The stakeholders’ motivation
is the primary focus of the Why question posed by the framework. Findings from the survey and focus group interviews revealed that the educational community in this case study is ready to collaboratively build the DL as reflected by the following results:

- Students are “Internet ready” as indicated by the following details (a) computer ownership at home is high (89.2%, 354) and as such they are ready to utilize the DL; (b) having access to the Internet is high either at home, school, cyber cafes or friend’s houses (95.0%, 377) and 75.3% (299) have Internet home accounts; (c) a high number of students either 3-4 years (116, 29.2%) or more than 5 years (178, 44.8%) experience in computer usage; (d) over 50% regularly goes online between once a week (24.9%, 99), every alternate days (8.8%, 35) or everyday (30.2%, 120). The results also show a significant difference between self-rated Internet skills and gender with more males rating themselves as intermediate and advance level than females (χ²=20.024, df=2, p<0.05)

- Students are “digital ready” as indicated by their awareness, experience in using and preferring digital sources. The survey indicates that all students know how to word process; over 80% know how to prepare slide presentations or draw using the computer; over 65% know how to use spread sheets; edit images (30%), create multimedia (28%) and a few (between 5-27%) know how to scan images, create web development, database or undertake simple programming. This results show that they are aware and competent in handling digital resources, which is necessary when using DLs.

- Students are also moderately “Web ready” as they know how to use the web. Although most had no formal training, they learn how to use the Web by self-teaching (29.0%, 182), from books and people (19.4%, 77). Only 19.6% (78) learn to use from computer or subject classes. The students also learn how to find sources on their own (26.2%, 104), from their parents (25.9%, 103) or from their classmates, friends, siblings and relatives (19%).

- Students are ready to collaborate as they indicated sharing the resources they create or found with their friends either my e-mailing the URLs of websites (09), inform others through chat room (95), create links to websites.

- Some students are “ready web publishers”, as 14.9% (59) maintain a group web page, 6.3% (25) have their own personal web page and 1.8% (7) have been creating page pages for others. The results show that the students have experience in creating digital resource over the Internet using webpage creator tools or HTML to develop their sites.

- Students do use the Internet for school related assignments (85.1%, 338) or as a major source for their school project (84.9%, 337). Students sampled used the Internet resources to get information for the following subjects, history (75.3%, 299), Science (56.7%, 225) and Geography (39.8%, 158). The results indicate that students believe that the Internet helps them with their school work.

- All students feel that there is a need for DLs of local information and feel that this would definitely benefit them. The results indicated very significant correlation between positive perception of the DL with high Internet use, length of Internet experience, accessibility of Internet from home high self ratings of Internet skills (p<0.01).

- The six teachers interviewed revealed that teacher’s level of readiness to use the Internet is limited and they lack experience in integrating ICT in their subject instructions. All six teachers however, felt that access to the Internet and digital resources where it can be usefully utilized to the curriculum. Teachers did see the value of digital resources and online publishing for their students. They expressed the willingness to play the role as a facilitator in the DL project. They were keen on the DL because students could contribute original works to the DL to be shared with other students, especially where some local contents are not available in textbooks; students would be more careful in their report if they make it available to wider audience, students could make corrections to their report
continuously until final submission; and students could teach each other when using, retrieving and submitting their reports.

• Observation of the History resource room indicated that teachers keep all reports for a period of five years. Students are seldom brought to the room to refer to the reports. Teachers would bring exemplary report to class to show their students. The reports in the History room cannot be retrieved by subject or topics or report by specific student’s name. Reports taken out of the room are also not recorded. The results revealed that a DL would solve problem of storage and retrieval of reports submitted.

• The visit to the school indicated that the school’s infrastructural facilities fare ready to support a DL as students can gain access to computers at self-accessed learning centres, especially for students and teachers who do not have computers or Internet access at their homes.

The findings from the survey and interviews indicated that the readiness factors serve as motivating indicators, goals and objectives that support the plan for developing the DL. Figure 2 presents the motivating factors that support the plan of the collaborative DL.

<table>
<thead>
<tr>
<th>School’s technical readiness</th>
<th>Students’ ICT readiness</th>
<th>Students’ digital readiness</th>
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</thead>
<tbody>
<tr>
<td>ICT infrastructure is in place</td>
<td>High computer ownership</td>
<td>Could use digital resources</td>
</tr>
<tr>
<td>New infrastructure is planned</td>
<td>Ease of Internet access</td>
<td>Strong preference for digital resources</td>
</tr>
<tr>
<td>Awareness of ICT support system</td>
<td>Home access to Internet</td>
<td>Adequate searching skills</td>
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<tr>
<td>Implementation of ICT mediated learning</td>
<td>Frequent users</td>
<td>Familiar with search agents</td>
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<th>Teachers’ ready to collaborate</th>
<th>Motivating Factors</th>
<th>Acceptance of the DL</th>
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<tbody>
<tr>
<td>Value of integrating with subject learning</td>
<td>Master plan for ICT integration</td>
<td>Perceive DL as useful</td>
</tr>
<tr>
<td>See the value of digital resources</td>
<td>Budget borne by government and IPTA</td>
<td>Willingness to contribute contents</td>
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<td>See the value of online publishing</td>
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Figure 2: Motivating Factors that Support the Plan for Realization of the DL

In Row 1, the Planner’s goals and objectives are defined in the form of vision statement that provides the strategic direction for the collaborative DL project. The collaborative DL will support secondary students’ information needs in conducting research projects. In project-based learning (PBL), students interpret, analyze, synthesize, generate, and evaluate information about a topic, collaborate with others, and produce a report (Blumfeld et al, 1991). To support students in these types of activities, a full compliment of tools is needed to meet the unique needs of learners, and Internet technologies such as digital libraries have the affordances to support students in these activities (Sidman-Taveau and Milner-Bolotin, 2004; Bos, 1998). Based on this premise and fact finding analysis, as well as building from various illustrations of DL initiatives’ vision statement, the planner establishes the vision of the collaborative DL to populate Row 1 of the Motivation column. The Planner’s vision of the DL is as follows:
“The collaborative digital library should enable secondary students conducting history school projects to access the information they need any time and any where, in a friendly, efficient and effective way, by overcoming the barriers of distance and language. The digital library should enable students to collaboratively contribute resources as the digital library is seen as a growing repository on Malaysian local history for education”.

With the vision in mind, the planner establishes the following goals for developing and implementing the collaborative DL: (a) the development of local historical resources; (b) provision of resources for lifelong learning; (c) provision of round-the-clock access; and (d) development of community of users. In this capacity, it establishes “a digital library service environment” – that is, a networked, online information space in which students can discover, locate, acquire access to and, increasingly, use information. The objective of the DL is therefore to provide a learning environment and resources network for history education which is: (a) designed to meet the information needs of learners, in both individual and collaborative settings (enable the creation, organisation and maintaining of local history resources); (b) constructed to enable use of a broad array of materials for local history learning, primarily in digital format submitted by the educational community themselves (they themselves become resource providers); and (c) managed actively to promote reliable access anytime - anywhere to quality collections and services (provided over the Internet), available both within and outside the network.

Row 2 of the Motivation column identifies the owners’ business plan that is the approach to use the collaborative DL. The DL is modeled to focus on serving students information needs in conducting research projects. As such, in the implementation of this DL project, the use of the online resources would be an integral part of history projects-based learning activities. Currently, project reports are written and submitted in print form and the DL may move the student community towards an emerging digital resources and the submission of reports in the electronic form is therefore feasible. The implementation of the business plan (Figure 3) is consistent with the Ministry of Education’s implementation and evaluation of History project, which will make the accomplishment of the goals and objectives feasible. The teachers on the other hand will be given the opportunity to validate the quality of submissions to maintain the quality of the DL, grade the report online and add links to resources found on the Internet. The business plan of the DL is given in Figure 2. The school perceived the benefit of the DL as:

- It pushes students and teachers to be active players in the development of the DL and indirectly inculcates ICT literacy through this push.
- It enables students to be independent learners, searching for information and publishing their report on their own. Allowing students to publish their report online would make them more careful in their writing and presentation and allow them to constantly improve before finally submitting their report for grading purposes and giving access for all users.
- The DL will open the access to students report to a wider community of users thus giving opportunities for others to view unique contributions to the DL, which can use for reference.

From the designer’s perspectives, the motivation of the DL is expressed as behavioural objectives. The objectives of the collaborative DL from the designer’s perspectives are to:

- Enable students to search and browse the DL resources through various access points regarding the topics they are exploring
- Allow the students to sequence and organize their project reports in various styles, construct references and append digital objects or pictures to their report.
- Provide the students with the experience of publishing their project report, allow teachers grade and their friends to view the repot. The motivation for this is to satisfy their innate
need to share their work, so that their peers can give comments for improvements before the report is finally submitted.

- Allow teachers to check the suitability of submissions, maintain quality of contents of the DL and grade the submissions.
- Allow teachers and students to provide metadata for resources submitted to the DL. A metadata schema (Dublin core) will be applied for this purpose.
- Enable students and user groups to register as members to login and submit and describe resources.
- Allow users to submit feedback or submit useful links to other resources in the Internet.
- Guide and assist users in using the DL’s functions and services.
- Allow authorized users to add, modify or delete submitted resources to the DL.

These behavioural objectives of the DL would assist the designer in developing the required DL. The motivation and objective statements subsequently assist in the development of the user requirement and detailed definitions of the DL services required in the Function (How) column of the Framework.

![Figure 3: The Business Plan: An Approach to Use the Collaborative DL](image)

**(b) Data: What Resources Constitute the DL.**

What (Data) column of the Zachman Framework describes the DL resources students used to fulfill their research needs. The data component, at the macro level identifies the information resources included or covered in the collaborative DL, and at the micro level, concerned the collections, quality, accuracy, usability, description and organisation of the resources in the DL. Findings from the study revealed the followings:

- A high proportion of students in the survey feel comfortable with digital resources, use them substantially, and are relatively well equipped to find these resources. Document analysis of students’ projects confirmed the various web resources students used for their projects.
• Students surveyed (n=397) mainly use Internet resources to get information for their History project (75.5%, 299).
• The students and teachers interviewed emphasized the needs for contents to be “clear, accurate, adequate, organised, valid, reliable, informative and resourceful”

Therefore, to cater for students’ information needs, in Row 1, the planner describes the three main categories of resources, without policy-controlled access (Abdullah, 2007). The types of resources are (a) resources that are born digital; (b) digitised resources or digital proxies for physical items; and (c) Links to other resources relevant to the domain focus of the DL. The DL collections incorporates not only digital resources in different media types such as text, images, web documents, audio and video, but also in different formats with different levels of content quality and metadata.

Row 2 of the Data column is a contiguous model of the resources expressed in terms of domain focus and topics seen by the owners of the DL. History has been chosen as the domain of the DL test-bed based on the survey findings that indicated the students surveyed mainly use Internet resources to get information for their History project. Observations of the History Room revealed that the project reports are typically made available in the form of collections, which refers to groups of resources organised around a theme or topic. Figure 4 presents the semantic description of the domain focus, contents, content criteria and scope of the collaborative DL, which populates the Data component of the Zachman Framework. The stakeholders’ needs for contents to be “clear, accurate, adequate, organised, valid, reliable, informative and resourceful” are therefore used as a set of general guidelines or selection criteria of resources accepted for submission.

Figure 4: Domain Focus, Contents, Content Criteria and Scope of the Collaborative DL of Students Project (Row 2 of Data)
From the designer’s perspective, the data of the DL is expressed as table definition for the DL data, which covers the digital objects data and metadata, user information, annotation and static information pages. Administrative, technical and descriptive metadata are used. Administrative metadata is created by the author, technical metadata is automatically-generated and descriptive metadata is assigned by the content access provider (human indexer). The descriptive metadata schema used for the object data description is the Dublin Core (DC) Metadata. The DL has altogether 16 metadata elements and incorporates DC’s 14 out of 15 elements, namely title, creator, subject, description, publisher, contributor, date, type, format, identifier, language, relation, coverage and rights. The DC source metadata element is not used. Two other elements incorporated are Collection and Ranking metadata.

(c) People: Who Interacts With / Within the DL
Who (People) represents the stakeholders or the people within the DL enterprise to which the DL assigns responsibility for work. Thus, this component concerns the identification of the DL users, their information needs, their usage of the Internet and online digital resources and their roles in the enterprise. The design of the enterprise has to do with the allocation of work and the structure of authority and responsibility. This column also deals with human-machine interfaces and relationships between the people and the work they perform.

In Row 1, the planner identifies the audience and the DL organization. There are three types of audiences within the DL enterprise, categorized as partners, guests and affiliate members. The planner identified these groups of people in the form of DL organisational structure.

From the owner’s perspective, Row 2 of the People Column illustrates the four main classes of people or actors and their respective roles in the collaborative DL. In this Consumer – Content Provider – Content Manager – Administrator model, each class of actors represents a particular generic role. The digital community follows certain rules and their members play different roles, as consumers, content developers or providers, content access providers and content manager.

In Row 3, the designer fleshed out the interaction between actors and technology into a rich picture linked to the functional requirements (Figure 5). Here, the DL community includes people as well as computers, agents, network connections, files and operating systems, user interfaces, communication links, and protocols, which either use or support the DL services.

(d) Function: What Happens in the DL?
How (functions) defines the functions or activities the enterprise is concerned about relative to each perspective. In Row 1, the planner describes the students’ research activities that take place, which encompass the entire information seeking process (from recognizing the need for information to finding, using and presenting it) and the submission and evaluation of the information in the form of project report. This is presented in the form of rich pictures. Basically, the students in this research do solitary information seeking, have spontaneous interactions with other people such as parents, siblings and friends and ask for help, and work with information in a group. However, a naive way of students’ information seeking process emerged through the focus group interviews. Instead of being a holistic process, it manifests itself in the form of information gathering only. Their problems are most of the time associated with finding and gathering information. Since the learning activities are focused on information gathering, such important phases as refining the question, evaluating, and synthesizing information, are often neglected. Document analysis of students’ projects shows that most reports are mere recitation of information. Contents, especially pictures and
illustrations, are either not cited, or cited inaccurately. Some reports bore inaccurate information. This was also supported by the teachers in this sample who indicated that difficulties in getting information from various resources leads to the presentation of reports that are “stereotype” and that very few students can really produce reports that fulfill the objective of the History PBL. Document analysis of students’ reports as well as teachers’ feedback provide the design implication of the report generation tool, display format of the reports and citation generator in the digital library. The description of the activities when conducting history projects are then transformed into the online activities the students and teachers would be able to perform in the collaborative DL. Figure 6 presents the workflows and processes the collaborative DL enterprise should conduct. These processes are also in line with the owner’s plan to use the DL for school project (Owner’s Motivation Column). The function component refers to the activities students perform in their research, such as choosing topic, searching for information, organising resources, writing, presenting, submitting and teachers grading of project work.

![Figure 5: Actors and Their Roles Depicted in the DL’s Three-Tier Client-Server Architecture](image)

Using data from analysis of the activities culled from the research (Planner’s Function Column), formulation of behavioural objectives of the DL (Owner’s Motivation Column) as well as from the analysis of DL functional requirements (Designer’s Motivation Column), the planner develops the user requirement expressed in terms of functions and present it as services in a contiguous structured chart, The structured chart is comprehensible to the owner as the conceptual model of the DL services. This structured chart populates Row 2 of the Function Column and describes the process of translating the objectives of the DL enterprise into successively more detailed definitions of its services. Feedback from students’ survey on the potential features of a service and DL design implication derived from observations as well as document analysis of project reports have helped to ascertain the main features required by the collaborative DL.

In Row 3, the designer portrays the DL services in terms of data transforming processes, described exclusively in terms of definition of programme modules and how they interact with each other. The three system modules, namely administrators (including teachers), students and guests, provide different access types for different level of users. Along with this are
specific definitions of security requirements, in terms of who (which role) is permitted access to what function, in the form of structured charts and detailed description of the modules menu.

(e) Network: Where Can One Access the DL
Network (Where) shows the sites or geographical locations and the interconnections between activities within the DL enterprise. It illustrates the network-related aspect of the DL in terms of the physical locations of members in the DL which spread over a geographical area. The planner provides the big picture of the DL as a centralized system with the control for the whole structure at the Faculty of Computer Science and Information Technology University of Malaya (FCSIT UM) as the developer of the DL system (Figure 7). FCSIT UM group manages the centralized database server. School A, in Shah Alam, Selangor, Malaysia, is the content collaborator and joint owner of the system and other potential future collaborators such as School B, Education Departments, Ministry of Education, as well as other repositories, would be able to utilise the application server running locally to fetch the required data from the database server.

The owner is interested in the conceptual model of “Where” which includes the location of access and place where the primary stakeholders, namely the students and teachers use the DL. It illustrates the collaborative DL’s deployment expressed in term of location of access, computing facilities and network, which facilitate the implementation of the collaborative DL initiative. The school community may access the collaborative DL system from any 10 locations in the school, as all computers there are connected to the network.

From the designer’s perspective, the Network Column presents the logical model of the network component of the collaborative DL which depicts the types of systems facilities and controlling software at the nodes and lines such as processors/operating systems, database and lines/line operation systems. The notional distributed systems architecture shows servers supporting the DL services served from the regional (FCSIT) and local data center.
environment to the school’s three primary locations of access. It is referred to as a notional architecture since the extent of the ability to remotely serve specific applications in both the baseline state and the target state remains to be established.

Figure 7: Planner’s Perspective: The Physical Network of the Collaborative DL

(f) Time: When Can One Use the DL (When Do Things Happen)
The last column, “When” represents time, or the events to which the DL responds in relation to time. This is useful for designing schedules, the processing architecture, the control architecture and timing systems. It is difficult to describe or address this column in isolation from the others, especially Column 2 (Process). At the strategic level, the planner describes Time as the business cycle and overall business events. As has been delineated in the DL goals and objectives (Motivation Column), the DL provides round-the-clock access. As the Internet is a 24/7 medium, the DL is available 24 hours a day, 7 days a week.

In the detailed model of owner’s perspective, the Time Column defines when activities or processes are to happen. Based on the interviews and observation of the school’s approach in using the DL, the chronology of events indicating the processes that take place in the DL environment populates owner’s view of the Time Column. The designer defines the business events or the processes in the DL, which cause specific data transformations and entity state changes to take place (Table 1). The business events populate the designer’s view of the Time Column of the Zachman Framework used.

Conclusion
This paper has provided a detailed mapping between the first three layers of Zachman cells and the concepts utilized in formulating the requirements and design of the collaborative DL. It has also illustrated the possibility of using the Zachman Framework as an instrument for requirements analysis and evaluation in DL development. The framework highlights the need to involve all possible stakeholders in the development of the architecture, not just the enterprise architects and developers, to ensure that it meets their needs and uses.
Table 1: Business Events in the DL

<table>
<thead>
<tr>
<th>The Process</th>
<th>Data transformations and entity state changes to take place.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students register</td>
<td>Students receive automatically generated e-mail notifying membership of the digital library.</td>
</tr>
<tr>
<td>Students create and submit report</td>
<td>Teachers and Administrators receive automatically generated e-mail notification indicating a new report has been submitted and ready to be viewed, graded or indexed.</td>
</tr>
<tr>
<td>Administrator registers teachers</td>
<td>Teachers receive automatically generated e-mail notification which indicates their User ID and Password.</td>
</tr>
<tr>
<td>Teacher evaluate and grade report</td>
<td>Students receive automatically generated e-mail notification indicating their projects have been evaluated.</td>
</tr>
</tbody>
</table>

The perspectives and artifacts established from the framework in this study help ensure that everything relevant to the DL enterprise is covered. Based on fact-finding surveys and interviews with stakeholders throughout the duration of this work, the utilization of the Zachman approach confirms the existence of the concepts that the researcher has designated as a dimension in a cell. In summary, the depiction of the Zachman’s cells in the view of the planner, the owner and the designer of Rows 1, 2 and 3 of the Collaborative DL Framework in this research is presented in Table 2. The planner’s perspective reflects the context that establishes the list of relevant constituents that must be accounted for in the descriptive representation for the other perspectives (owner and designer). The descriptive representation of owner’s perspective reflects the usage characteristics of the DL, what the owner is going to do with it and how they will use it once they get it in their possession. The descriptive representation of designer’s perspective forms the basis for the design of the DL system, as well as the features for manipulating the tangible aspects of the DL.

Table 2: Summary of the Artifacts in the Planner, Owner and Designer View of the Collaborative DL Framework

<table>
<thead>
<tr>
<th>ARTIFACTS</th>
<th>ZACHMAN FRAMEWORK</th>
<th>THIS STUDY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEVEL 1: Objectives /Scope – Planner’s View</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation (Why)</td>
<td>Identify and list goals and objectives - requirements analysis based on identified objectives</td>
<td>Motivating factors diagramme Vision statement List of DL goal List of DL objectives</td>
</tr>
<tr>
<td>Data (What)</td>
<td>Identify &amp; list features/data important to the repositories using needs survey from stack holders</td>
<td>DL resources in various media types and format</td>
</tr>
<tr>
<td>People (Who)</td>
<td>Identify &amp; list all stack holders and their roles in handing &amp; processing data - Roles analysis</td>
<td>DL organisational structure</td>
</tr>
<tr>
<td>Function (How)</td>
<td>Identify &amp; list processes the data performs - stack holder’s information use survey</td>
<td>Activities students perform when conducting history project in the DL</td>
</tr>
<tr>
<td>Location (Where)</td>
<td>Identify &amp; list locations where the enterprise operates - information flow survey</td>
<td>The physical network of the DL</td>
</tr>
<tr>
<td>Time (When)</td>
<td>Identify &amp; list business events cycles - events use analysis</td>
<td>Access to the DL (24/7)</td>
</tr>
<tr>
<td><strong>LEVEL 2: Business Conceptual Model – Owner’s View</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation (Why)</td>
<td>Business Plan Business plan - flow diagram / rich picture</td>
<td>Rich picture showing owners’ approach to use the DL List of perceived benefits to use the DL</td>
</tr>
<tr>
<td>Data (What)</td>
<td>Entity relationships diagrams - rich picture</td>
<td>DL Subject scope, collection and resource criteria</td>
</tr>
<tr>
<td>People (Who)</td>
<td>Organisation charts, roles, set of skills &amp; security issues - box charts / rich picture</td>
<td>DL actor-roles diagram</td>
</tr>
</tbody>
</table>
The DL adheres to Soergel’s (2002) guiding principles and ten themes for DL research and development, as well as incorporates the dimensions of others’ framework (Moen and McClure, 1997; Marchionini and Fox, 1999; Gonçalves et al, 2004; Sandusky, 2004), but instead of listing them as requirements or ticking against a checklist, this research has embedded the requirements in a system’s architectural framework and present them more systematically. This research has significance in the field of collaborative digital libraries since stakeholders’ needs and the contexts of use are not usually captured comprehensively, and the ongoing challenge is to model complex human and social behaviours in the form of collaboration and communication in such digital libraries.

References


