The Application of Zachman Framework in Architecting a Collaborative Digital Library

Article · January 2008

CITATION
1

READS
394

2 authors:

A. Abrizah
University of Malaya
112 PUBLICATIONS **675** CITATIONS
SEE PROFILE

A.N. Zainab
University of Malaya
81 PUBLICATIONS **588** CITATIONS
SEE PROFILE

The Application of Zachman Framework in Architecting a Collaborative Digital Library

Abrizah Abdullah and **A.N. Zainab**

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

Abstract: *This paper illustrates the possibility of using an Enterprise Architecture as an instrument for requirements analysis and evaluation in digital library development. The collaborative digital library has been conceived to support secondary school students information needs in conducting school-based projects. The researchers examine the needs of digital library stakeholders and how a collaborative digital library might be designed to meet these needs. Zachman Framework for Enterprise Architecture was used as the approach to investigate the user requirements and define the digital library organisation, resources, processes, technology and information flows. In applying Zachman Framework and to holistically control the study, the case study approach and multiple data collection techniques were adopted. Information obtained from these data gathering techniques helps to populate the requirements of the top three layers (18 cells) in Zachman Framework to ascertain the design details of the digital library's scope, business and system model. The framework abstracts the characteristics and features of the digital library based on six dimensons, Motivation, Data, People, Process, Place and Time, and explains their structures and processes from the perspectives of the planner, owner and designer of the digital library. This paper provides the detailed mapping between the first three layers of the Zachman cells and the dimensions utilized in formulating the requirements and design of the collaborative digital library. It consists of the various elements that a digital library should provide for as delineated in several frameworks being conceptualized and described in digital library research since 1995 for the design, development, and evaluation of digital libraries. Instead of listing the elements as requirements, the researchers embed the requirement process and development in an architectural framework, thus presenting it more systematically taking into account the six digital library dimensions mentioned earlier*

Keywords: Collaborative digital libraries: Digital library for education; Zachman Framework for Enterprise Architecture; User requirement elicitation

1. Introduction and Context of Enquiry

In the information systems development practices, the absence of common frameworks undermines the ability to develop and design systems efficiently, to create large-scale collaborative activities, and to communicate the value of the systems to other communities. Formal frameworks are crucial to specify and understand clearly and unambiguously the characteristics, structure, and behavior of complex information systems such as digital libraries. It was in this context, and in recognition of efforts already underway to align library services with emerging information environments, that the Digital Library Federation (DLF) in 2005 sponsored the formation of the Service Framework Group (SFG) to consider a more systematic, community-based approach to align the functions of digital libraries in fulfilling the needs of information environments (Lavoie, Henry and Dempsey, 2006). The SFG seeks to understand and model the digital library services by developing a framework within which the services offered by libraries, represented both as business logic and computer processes, can be understood in relation to other parts of the institutional and external information landscape.

Gladney et al. (1994) wrote that the broad and deep requirements of digital libraries demand frameworks and theories in order to understand better the complex interactions among their components. There are several frameworks being conceptualized and described in digital library

research since 1995 for the design, development and evaluation of digital libraries. In one of the key early research papers, Kahn and Wilensky (1995) described a framework for digital libraries, which resulted in some basic definitions and terminology used to describe digital library services. Levy and Marshall's (1995) framework highlights three crucial characteristics of digital libraries: document, technology, and work process (which involves research and service). Moen and McClure (1997) identified a framework of five interacting dimensions in Government Information Locator Service (GILS): policy, users, technology, contents, and standards. The evaluation framework includes three perspectives, representing the "views" of the stakeholders in the GILS: users, agencies, and the government. Marchionini and Fox (1999) identified four dimensions of digital library development: community, technology, service and content. Saracevic and Covi (2000) presented a framework, consisting seven levels, for examining digital libraries: social, institutional, individual, interface, engineering, processing and content. Fuhr et al's (2001) framework consists of four major dimensions, namely data/collection, system/technology, users and usage. Sandusky (2002) developed a list of six attributes in framing digital library usability research: audience, institution, access, content, services, and design and development. Soergel (2002) offered a digital library research framework consisting of three guiding principles and eleven specific themes for research and development. Conclaves (2004) introduced 5S and formalisms for streams, structures, spaces, scenarios, and societies — as a framework for providing theoretical and practical unification of digital libraries. All these frameworks emphasize the importance of a holistic approach to examine digital libraries as examining a single view of such as services are likely to be limited in their utility.

This paper shows how an Enterprise Architecture (EA) 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. EA emerges to help organizations to understand and express their business, structure and processes. More commonly, EA refers to the models, documents and reusable items (such as components, framework and objects) that reflect the actual architecture (McGovern et al., 2003). The EACommunity (http://www.sharedinsights.com/networks/ea, 2006) decribes an EA framework as a blueprint for how the organisation achieves the current and future business objectives. It examines business processes, information technology, software and hardware, local and wide area networks, people, operations and projects with an organisation's overall strategy. Further justification on using the framework and specific approach on how it is incorporated in the research instruments are described in the following sub-section

2. Zachman Framework for Enterprise Architecture

Zachman introduced a well-defined framework, which is considered to be one of the major origins of EA. This is the most referenced framework that is also a basis for evaluating, establishing and customizing other enterprise architecture frameworks, methods and tools (Jalalinia and Fatolahi, 2004) The Zachman Framework is a logical structure for classifying and organising the descriptive representations of the enterprise that are significant to the management of the enterprise, as well as to the development of the enterprise' systems (Zachman, 2002). The framework uses a grid model to provide a logical structure for classifying and organising the descriptive representation of an enterprise, in six different dimensions, and each dimension can be perceived in five different perspectives. In this framework, the architecture is described across two independent aspects, the rows represent the views of five different types of stakeholders (planner, owner, designer, builder and sub-contractor) and the columns represent six different aspects of the architecture (data, function, network, people, time and motivation). Each column is supposed to answer a single question regarding the enterprise. *What are important things for the enterprise*? is answered by Data column. *How does it run*? is answered using Function column. *Where is it located*? is answered in Network column. *Who are acting within the enterprise*? is answered by People column. *When does it perform its businesses*? is answered using Time column and *Why the enterprise does the businesses*? is answered in Motivation column. The points of intersection between the rows and the columns (between the views and the aspects) form cells. Each of these cells holds important information of the enterprise (also known as artifacts) that needs to be understood and explicitly declared.

This research has chosen the Zachman Framework for Enterprise Architecture 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 digital library design and development (Marchionini, Plaisant and Komlodi, 2002; Giersch et al., 2004)
c) The framework is robust enough and requires the designer to consider all aspects of the digital library design (Pereira and Sousa, 2004).
d) The framework is generic in nature and can be applied to any domain.

This framework is used to formulate the architecture for the collaborative digital library that positions and ensures that the standards for creating the information environment exist and they are appropriately integrated. The paper specifically focuses on the contextual (scope), the conceptual (business model) and the logical (system model) layer in the framework to determine the six dimensions of the collaborative digital library from the perspectives of the planner, owner and designer of the digital library.

3. Methodology

The methodology involves extensive literature reviews and deductive reasoning was used to carry out this research. Drawing from Zachman Framework, the study conducted a needs assessment by understanding the existing stake holder's needs, conditions and environment that would ensure the reception of a collaborative digital library for school projects; and develop a framework to design a prototype for the collaborative digital library for school projects. The aim is to design a useable digital library prototype that can handle multiple-source datasets. The domain of the digital library 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. 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 is used with the following data-gathering techniques:

a) survey of 397 Secondary 2 and 3 students an urban secondary school in Malaysia
b) focus group interviews involving 30 students
c) interviews with 6 History subject teachers
d) on-site observations of the school to observe specific environment of the collaborative digital library implementation;
e) 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;
f) user testing and evaluation of the digital library prototype; CoreDev (http://coredev.fsktm.um.edu.my)

Findings were then used to populate the Zachman Framework at the top three layers, namely the scope, business model and the system model. Scope describes the system's vision, mission, context, boundaries, architecture and constraints. For the digital library 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. Business model defines goals, strategies, structure and processes that are used to support the mission of the digital library enterprise. The owner of the business model in Row 2 is the educational community who owns the digital library. System model contains system requirements, objects, activities and functions that implement the business model. The system model states how the system is to perform its functions. The owner of the system models in Row 3 is the researcher who designs the requirements of the digital library.

The columns divide the focus of attention into six areas: Motivation, Data, People, Process, Place and Time. These perspectives help ensure that everything relevant to the digital library enterprise is covered. In this work, the columns are arranged so that the most important column or the focus of attention is on the left. The formulation of a viable requirement matrix for the collaborative digital library model using Zachman Approach is presented in Figure 1. The next section illustrates how the 18 out of 36 cells (in Row 1, 2 and 3) are developed for the digital library framework

	Why MOTIVATION	What DATA	Who PEOPLE	How FUNCTION	Where LOCATION	When TIME
	VISION (GUIDELINES)					
Scope (Planner) The researcher	1. Motivation to use, major goals and objectives, curricular and programmes significant to the digital library	2. Digital library resources to fulfill students information needs in conducting research projects	3. Identification and description of people and organisations to which the digital library assigns responsibility for work.	4. The activities students perform in conducting research projects; The activities teachers perform in supervising research projects	5. Identification and description of organisation and individual location of access where stakeholders use the digital library.	6. Events to which the Digital Library responds relative to time
	DESIGN (STANDARDS)					
Business model (Owner) The educational community (stakeholders)	7. Business plans to use the digital library	8. Semantic description of domain focus and topics of resources in the digital library	9. Users and related roles (Person & Role Diagram)	10. Conceptual model of services in the digital library	11. The organisation's (owner) digital library network diagram	12. Chronology of events and duration of research project
System model (Designer) The researcher)	13. Digital library functional requirements	14. Data definition for digital library resources	15. Users and Functional Roles in the Digital Library Architecture	16. Digital library programme modules	17. Digital library notional distributed systems architecture	18. Event phases and process components
	IMPLEMENTATION (STANDARDS)					
Physical design	19. System operational requirements	20. Physical data model for digital library resources	21. Digital library system human-system interface description	22. System design, language specification and structure chart	23. Digital library information network detailed architecture	24. Digital library system control structure
Modules and Subsystems	25. Technical requirements	26. Digital library resources' metadata and DBMS scripts	27. System security architecture and operations	28. Code statements, control blocks, DBMS stored procedures	29. Physical data network components, addresses and communication protocols	30. Digital library component timing description
	OPERATION STANDARDS					
Functioning digital library system	Users feedback on systems overall operation	Users feedback on the ease of handling data	Digital library participant description	User s feedback on procedural and system documentation	Users feedback on the robustness of the network	Users feedback on system operation related to time

Figure 1: The Collaborative Digital Library Framework Using Zachman Approach

4. Findings

4.1. Motivation Column: Why the digital library is needed

Why (Motivation) describes the motivation of the people and the digital library that support the plan for realization. This reveals the reasons for creating the digital library, as well as the establishment of goals, objectives and business plan of the digital library. The stakeholders' concern is the primary focus of the Why cell in each row. Findings from the survey and focus group interviews help ascertain that the educational community in this case study is ready to collaboratively build the digital library as reflected by the following motivating indicators

- students digital library readiness score of >60%;
- high acceptability to use digital libraries;
- strategic readiness or governance support to integrate ICT in teaching and learning; and
- technical readiness related to infrastructure requirements for ICT-mediated learning.

Therefore, in Row 1, the planner identified the Planner's Goals and Objectives in the form of vision statement needed to define the strategic direction for the collaborative digital library project. The collaborative digital library has been conceived to 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 report findings (Blumenfeld 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 [Bos, 1998; Sidman-Taveau, and Milner-Bolotin, 2004). Based on this premise and fact finding analysis, as well as building from various illustrations of digital library initiatives' vision statement, the planner establishes the vision of the collaborative digital library to populate Row 1 of the Motivation column (Abdullah & Zainab, 2006)

With the vision in mind, the broad thrust and goals for developing and implementing the collaborative digital library include: (a) 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 digital library 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; (b) constructed to enable dynamic use of a broad array of materials for learning, primarily in digital format; and (c) managed actively to promote reliable anytime - anywhere access to quality collections and services, available both within and without the network.

Row 2 of Motivation identifies the owners' business plan that is the approach to use the collaborative digital library. The digital library is modeled to focus on serving students information needs in conducting research projects. As such, in the implementation of this digital library project, the use of the online resources would be an integral part of history projects-based learning activities. The implementation of the business plan (Abdullah & Zainab, 2006) to populate Row 2 of the Motivation Column is consistent with the Malaysian Ministry of Education's implementation and evaluation of History project, by which will make the accomplishment of the goals and objectives feasible.

Using data from the survey, interviews and review of existing digital library initiatives, the researcher develops the mandatory functional requirement of the digital library expressed as behavioural objectives to populate the Motivation (Why) component of Row 3. The formulation of the eleven behavioural objectives (Abdullah & Zainab, 2006) assists the researcher in the development of the user requirement and successively detailed definitions of the digital library services in order to populate the Function (How) column (Row 3 Column 4).

4.2 Data Column: What constitutes the digital library

This column refers to the collaborative digital library's data. It describes the digital library 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 digital library, and at the micro level, concerned the collections, quality, accuracy, usability, description and organisation of the resources in the digital library.

Row 1 Column 2 begins with the identification and description of the resources that concern the digital library and affect its direction and purpose to fulfill students' information needs in conducting research projects. The survey indicates that high proportions of students 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. Therefore, to cater for their information needs, the content available through the digital library, the Planner's Data column describes three main categories of resources. 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 digital library. The digital library 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 Column 2 is a contiguous model of the resources expressed in terms of domain focus and topics seen by the owners of the digital library. History has been chosen as the domain of the digital library test-bed based on the survey findings that indicated the students surveyed (n=397) mainly use Internet resources to get information for their History project (75.5%, 299).). The content is typically made available in the form of collections, which refers to groups of resources organised around a theme or topic. Figure 2 presents the semantic description of the domain focus, contents, content criteria and scope of the collaborative digital library, which populates the Data (What - Row 2 Column 2) component of the Zachman Framework. The students and teachers interviewed emphasized the needs for contents to be "clear, accurate, adequate, organised, valid, reliable, informative and resourceful". These needs are therefore used as a set of general guidelines or selection criteria of resources accepted for submission (Abdullah, 2007).

Row 3 Column 2 concerns with the description and organisation of the resources and provides a more information-based perspective of the digital library, which shows that the collaborative digital library contains repositories of knowledge, information, data, metadata, relationships, annotations, user profiles, and documents. This cell describes the table definition for the digital library 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 digital library 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.

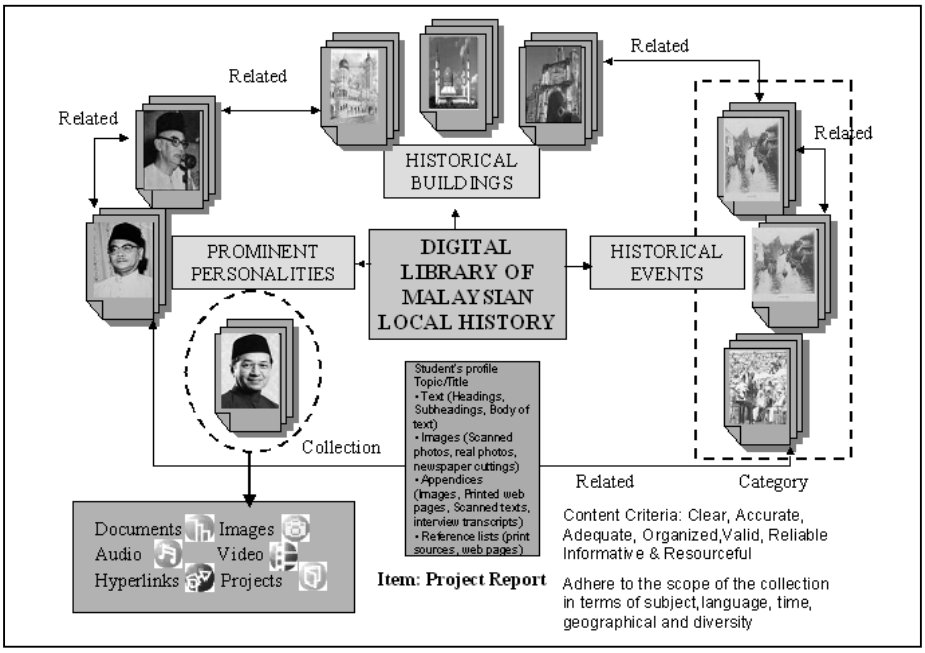

Figure 2: Domain Focus, Contents, Content Criteria and Scope of the Collaborative Digital Library of Students Project (Owner's View of Data Column)

4.3 People Column: Who Interacts With / Within the Digital Library

People represents the stakeholders or the human actors within the digital library enterprise to which the digital library assigns responsibility for work. Thus, this component concerns the identification of the digital library 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.

The planner identifies the audience and the digital library organization. There are three types of audiences within the digital library enterprise, categorized as partners, guests and affiliate members. The digital library organisational structure (Row 1 Column 3) identified these groups of people. Row 2 Column 3 provides the model, which illustrates the four main classes of people or actors and their respective roles in the collaborative digital library. 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 Column 3, the interaction between actors and technology is fleshed out into a rich picture linked to the functional requirements (Figure 3). Here, the digital library 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 digital library services.

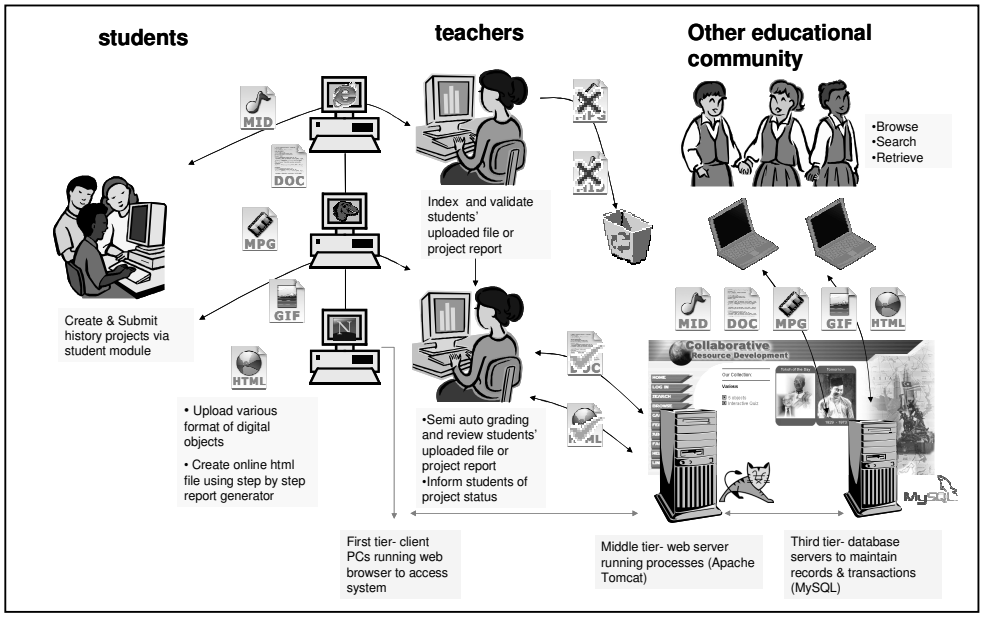

Figure 3: Actors and Their Roles Depicted in the Digital Library's Three-Tier Client-Server Architecture (Designer's View of People Column)

4.4 Function Column: What Happens in the Digital Library?

How (functions) defines the functions, or activities, the enterprise is concerned about relative to each perspective. 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. Using data from analysis of the activities culled from the research, analysis of digital library functional requirements, as well as from the formulation of behavioural objectives of the digital library (Row 3 of Motivation), the researchers develop 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 digital library services. This structured chart populates Row 2 of the Function Column and describes the process of translating the objectives of the digital library enterprise into successively more detailed definitions of its services. Feedback from students survey on the potential features of a service and digital library design implication derived from observations as well as document analysis of project reports have helped to ascertain the main features required by the collaborative digital library.

Row 3 Column 4 portrays the 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 (Abdullah & Zainab, 2006)

4.5 Network Column: Where Can One Access the Digital Library

Network shows the sites or geographical locations and the interconnections between activities within the digital library enterprise. It illustrates the network-related aspect of the digital library in terms of the physical locations of members in the digital library which spread over a geographical area. Row 1 Column 5 (Figure 4) presents the big picture of the digital library 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 digital library system. 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 conceptual model of "Where" (Row 2 Column 5) as perceived by the owner (School A) includes the location of access and place where the primary stakeholders, namely the students and teachers use the digital library. It illustrates the collaborative digital library's deployment expressed in term of location of access, computing facilities and network, which facilitate the implementation of the collaborative digital library initiative. The school community may access the collaborative digital library system from any 10 locations in the school, as all computers there are connected to the network.

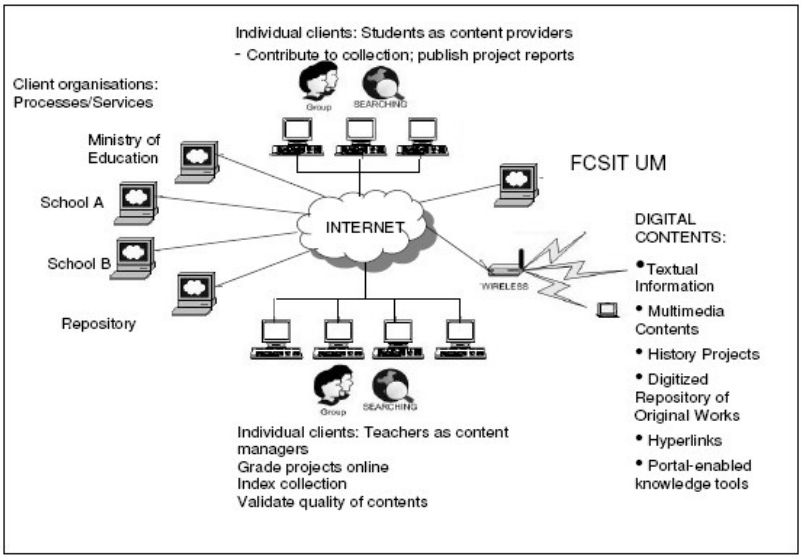

Figure 4: The Physical Network of the Collaborative Digital Library (Planner's View of Location Column)

From the designer's perspective, Row 3 Column 5 presents the logical model of the network component of the collaborative digital library 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 digital library 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.

4.6 Time Column : When Can One Use the Digital Library (When Do Things Happen)

The last column, "When" represents time, or the events to which the digital library responds in relation to time. A model of time mainly contains events and time cycles to design 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 (Row 1), this is a description of the business cycle and overall business events. As has been delineated in the Goals and Objectives, the digital library provides round-the-clock access. As the Internet is a 24/7 medium, the digital library is available 24 hours a day, 7 days a week (Row 1 of Time Column)

In the detailed model of the business model (Row 2), 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 digital library, the chronology of events indicating the processes that take place in the digital library environment populates Row 2 of the Time Column. Row 3 defines the business events or the processes in the digital library, which cause specific data transformations and entity state changes to take place (Table 1). The business events populate Row 3 of the Time Column of the Zachman Framework used.

Table 1: Business Events in the Digital Library (Designer's View of Time Column)

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

5. Discussion and Conclusion

In alignment with the vision already expressed by the DLF (2005), it is felt that digital library community should "get out of the box" and give more attention to the development of conceptual frameworks giving preference to scopes, goals requirements and processes, in the sense as those concepts are already common in the classic EA processes and Zachman Framework for Enterprise Architecture can be a very simple comprehensive reference for this. Borbinha (2007) opined that the digital library practitioners should be motivated to give more emphasis to the need to better integrate its efforts and body of knowledge with the more generic area of enterprise systems, where important concepts, regulations and good practices have been emerging, defined by the industry and the stakeholders. Perhaps is time for the digital library researchers and practitioners to recognize that the focus of the digital library should move from the perspective of the engineer, who are responsible for systems design, to the perspective of the architect who prepares, plans and develops specifications, that bridge the gap between the systems (that the engineers design] and what the community needs.

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 digital library; and illustrated the possibility of using Zachman approach as an instrument for requirements analysis and evaluation in digital library development. This framework contributes to another dimension of a framework for digital library research and development and "a structured vision for the development of new ideas" (Soergel, 2002). The digital library named CoreDev adheres to Soergel's guiding principles and ten themes for digital library research and development, as well as incorporates the dimensions of others' framework (Moen and McClure, 1997; Marchionini and Fox, 1999; Marcos, 2004; Sandusky, 2004), but instead of listing them as requirements or ticking against a checklist, this researchers embedded the requirements in a system's architectural framework and present them more systematically taking into account:

a) The vision, goals, objectives, business plans and the functional requirements of the digital library;
b) The types of resources, domain focus, collection and data definition of the digital library;
c) The stakeholders and users, their roles and functional roles in the digital library;
d) The activities users perform, service conceptual model and the digital library programme modules'
e) The location of access, the network diagram and the notional distributed system architecture;
f) The availability, business cycle and overall business events

These are interlaced processes and events that overlap and a change in one element would trigger accountability to other related processes and events. An effective EA is more than just populating Zachman cells or independently defining Information, Technology or Applications Models. Without an integrated perspective, all architectures and strategies will be misaligned, inflexible and will remain unused. This framework portrays the "real life" situation and therefore considered more robust.

The study has also interpreted the "the functioning system" level in Zachman Framework, and added to the digital library framework as user testing and evaluation of the system to make the design and development process wholesome. Table 2 compares the dimensions in Zachman and selected digital library research framework reviewed in Section 1 and position them against the taxonomy derived

from a significant corpus of digital library literature by Conclaves (2004). However, building a collaborative digital library goes beyond these user issues, as Zachman Framework for Enterprise Architecture also looks at other aspects such as processes, technology and information flows. It aims to encompass all possible areas of design, development and deployment issues when building complex, enterprise systems.

Table 2: Dimensions in Digital Library Research Framework

Digital Library Taxonomy	Moen and McClure, 1997	Marchionini and Fox, 1999	Sandusky, 2002	5S – Marcos, 2004	Zachman
Actors	Users	Community	Audience Institution	Societies	People (Stakeholder)
Activities	Technology	Technology Service	Services Design & development	Scenario	Process (Functions)
Components	Contents	Contents	Contents	Structures, Streams	Data (Domain focus, types)
Socio-economic, legal aspects	Policy Standards	---	---	---	Motivation (to participate)
Environment	---	---	Access	Space	Location and Time (of process)

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. The application of Zachman framework in the design and implementation of the collaborative digital library is an original contribution which may improve and expand the conceptual framework of the research in this field.

References

Abdullah, A and Zainab A.N. (2006). "Ascertaining Factors Motivating Use of Digital Libraries and Formulating User Requirements Using Zachman Framework". *Malaysian Journal of Library Information Science* Vol.11 No 2: 21-40

Abdullah, A. 2007. (2007). "Applying the Zachman Framework Data Dimension to Determine Content of a Digital Library". In Abdullah et al. (eds) Building an Information Society for All. *Proceedings of the International Conference of Libraries, Information & Society for All,* Petaling Jaya Malaysia, 26-27 June 2007: 233-247

Blumenfeld, C., Soloway, E., Marx, R. W., Krajcik, J. S., Guzdial, M., and Palincsar, A. (1991). "Motivating project-based learning: Sustaining the doing, supporting the learning". *Educational Psychologist.* 26 (3&4). 369-398

Borbinha, Jose. 2007. It is the time for the digital library to meet the Enterprise Architecture. International Conference on Asian digital Libraries ICADL 2007, Vietnam, In *Lecture Notes in Computer Science LNCS 4822.* Springer-Verlag. 176-185.

Bos, N.D. (1998). *Affordances of the World Wide Web as a publishing medium in project based learning environment*. PhD thesis, University of Michigan

Giersch, S., Klotz, E.A., McMartin, F., Muramatsu, B., Renninger, K.A., Shumar, W. and Weimar, S.A. (2004). "If you build it, will they come? Participant involvement in digital libraries". *D-Lib Magazine*. July/August, 10 (7/8). Available at http://www.dlib.org/dlib/july04/giersch/07giersch.html

Gonçalves, M. A., Fox, E. A., Watson, L. T., and Kipp, N. A. 2004. "Streams, structures, spaces, scenarios, societies (5s): A formal model for digital libraries". *ACM Trans. Inf. Syst.* 22, 2 (Apr. 2004), 270-312

Digital Library Federation. 2005. DLF service framework for digital libraries: A progress report for the DLF steering committee. Available at: http://www.diglib.org/architectures/serviceframe/dlfserviceframe1.htm

Fuhr, N., Hansen, P., Mabe, M.., Micsik, A., and Solvberg, T. (2001*). "*Digital libraries: A generic classification and evaluation scheme". In *Proceedings of the 5th European Conference on Research and Advanced Technology for Digital Libraries*, *ECDL 2001*. LNCS 2163 Springer-Verlag. (p. 187-199).

Gladney, H., Fox, E. A., Ahmed, A., Ashany, R., Belkin, N. J.. and Zemankova, M. (1994). "Digital library: Gross Structure and Requirements: Report from a March 1994 Workshop." In *Proc. 1st Annual Conf. on the Theory and Practice of Digital Libraries*. Texas. (p. 101–107)

Kahn, Robert and Wilensky, Robert. *A framework for distributed digital object services*. Available at: http://www.cnri.reston.va.us/home/cstr/arch/k-w.html

Lavoie, B, Henry G. and Dempsey. L. 2006. "A service framework for libraries". *D-Lib Magazine*,. Vol 12, no 7/8. Available at: http://www.dlib.org/dlib/july06/lavoie/07lavoie.html

Levy, D. and Marshal, C. (1995). Going digital: A look at assumptions underlying digital libraries. *Communications of the ACM*. 38 (4). 77-84

Marchionini, G., and Fox, E. A. (1999). Progress toward digital libraries: Augmentation through integration. *Information Processing & Management.* 35(3). 219-225.

Marchionini, G., Plaisant, C., and Komlodi, A. (2002). "The people in digital libraries: Multifaceted approaches to assessing needs and impact". In: Bishop, A., Buttenfield, B. and VanHouse, N. (eds.) *Digital library use: social practice in design and evaluation*. MIT Press

McGovern, J., Ambler, S.W., Stevens, M., Linn, J., Sharan, V. and Jo, E. (2003). *The practical guide to Enterprise Architecture.* Prentice-Hall

Moen, W.E. and McClure, C.R. (1997). *An evaluation of the U.S. Government's implementation of the Government Information Locator Service (GILS).* Available at: http://www.unt.edu/slis/research/gilseval/gilsdocs.htm

Pereira, C.M. and Sousa, P. (2004). "A method to define an Enterprise Architecture using the Zachman Framework". *ACM Symposium on Applied Computing 2004*, Nicosia, Cyprus, March 14-17.

Saracevic, T., and Covi, L. (2000). Challenges for digital library evaluation. In Kraft, D. H. (ed.), ASIS 2000: *Proceedings of the 63rd ASIS Annual Meeting.Vol. 37* (p. 341-350). Medford, NJ: Information Today

Sandusky, R. J. (2002) Digital library attributes: Framing usability research. In Blandford, A. and Buchanan, G. (eds.) *Proceeding Workshop on Usability of Digital Libraries at JCDL'02.* (p. 35-38)

Sidman-Taveau, R. and Milner-Bolotin. (2004). *Constructivist inspiration: A project-based model for L2 learning in virtual worlds*. Available at http://studentorgs.utexas.edu/flesa/tpfle/ contents4.doc.

Soergel, D. (2002). A framework for digital library research: Broadening the vision. *Dlib Magazine*. 8 (12). Available at: http://www.dlib.org/dlib/december02/soergel/ 12soergel.html

Zachman, J. A. (2002). *Zachman International Enterprise Architecture*. Available at: http://www.zachmaninternational.com/Default.htm