Abstract: - E-learning aims to foster significant learning improvements through the use of advanced and proven educational techniques. It encompasses the vision of achieving the essential educational goal of lifelong learning. However, literature reviews on the current e-learning system identified some significant shortcomings. Among these shortcomings, we single out the lack of personalization, collaborations and the failure to adopt technological advancements to enhance learning as the key impediments to successful adoption of e-learning. Integrating our understanding across the surveyed literature, we proposed a concept-based knowledge environment that is based on modern technologies like Semantic Web, Grid Computing and Web Services.

Key-words: - e-learning, concept map, distance learning, instructional design, learning objects

1. Introduction

E-learning aims to foster significant learning improvements using the most advanced and proven educational techniques. The advancement of technology and the advent of the information highway coupled with e-learning have eliminated barriers of time, distance and socioeconomic status, creating a whole new dimension to learning. The dramatic opening of access to the ever burgeoning deposit of knowledge has increased the need for collaborative learning.

However, despite its ambitious vision, literature reviews unveiled major concerns regarding its effectiveness and appropriateness [1, 2]. Although there are many strands of research, no person or organization is solely responsible for its development or standardization. With no validating guidelines, organizations are jumping into the arena and proclaiming their products as ‘e-learning compliant’. However, what they are doing is just purely automating their services online. Except for the elimination of time and space barrier, this online content provides no enhancement to the learning experiences.

Existing research tends to emphasize on the standardization of metadata standards and the structure of learning resources. Although these are challenging intentions to enable widespread adoption, these challenges are not the only important aspect within the comprehensive vision.

This paper identified the lack of personalization, collaborations and adoption of technological advancements for learning as the key impediments to the successful adoption of e-learning. Therefore, to address these limitations, a concept-based knowledge environment for interactive e-learning was designed to exploit modern technologies to provide the personalization of learning experiences. This environment employs concept map educational advantages to build up knowledge in our collaborative e-learning system. Each concept will function as digital objects to serve as the most basic form of learning.

This paper is organized as follows: Section 2 presents the skeleton system architecture and key design issues. Section 3 discusses the high level system modules. Lastly, this paper will be concluded in section 4 and some future research work is suggested.
2. Architectural Considerations

This section presents the skeleton document that span the entire design process of the environment. Although this research addresses problems only in the domain of e-learning, the system must be modeled with an architecture that is flexible enough to be independent on any infrastructure. Considerations must be taken to avoid the pitfalls of CASE where a thousand different modeling languages are conjured, causing the problem to be escalated.

To cater for e-learning, the system must be open in its architecture and supports a large and extensible class of distributed digital information services. The basic entities to be stored, retrieved and managed will be information stored in the form of learning objects. In the system’s context, these learning objects will be seen technically as a form of digital objects to be stored, accessed and managed. Thus, the basic function is to provide a access protocol service for locating and disseminating these digital objects.

This basic function will constitute a minimal set of requirements for the system to be fully functional. While it is not the research’s intent to build a universal, wide-area digital information infrastructure, considerable design efforts are employed to ensure that the infrastructure, at its very least, must be interoperable, robust, and flexible enough to support other advanced services and elaborations that will come into existence as the system matures. Thus, the system will be built upon an interoperable layer that will not restrain the higher level user and service level choices such that it will become inappropriate to add in new features at any point of time.

With the primarily aim set at creating a platform for supporting social, intellectual, and technological innovation, the knowledge system will harness the capabilities of Grid Computing, Semantic Web and Web Services. These three technologies are seen as the future IT technologies that will spearhead the knowledge revolution. Applications will be developed to illustrate the environment’s generality and efficiency in the sharing of resources. A collaborative workspace for supporting diversified virtual, Grid computing and e-learning applications will also be provided.

2.1 Framework Design

The knowledge environment will be developed using the layered architecture as shown in Fig. 1. The layered architecture is chosen over other architectural patterns such as client/server, three-tier or peer-to-peer pattern as it aids in organizing the systems into layers of subsystem. This is extremely important as organizing the design model in layers aids reuse, one of the most important aspects of object oriented design (and e-learning). Besides reusability, portability is also enhanced as changes are isolated only to one layer.

Each layer in the layered architecture is a set of subsystems that share the same degree of generality and interface volatility.

![Fig. 1](image1)

2.2 Functional Layers

The knowledge framework will exploit the capabilities of open-standard Web technologies such as XML and Web Services to construct a Grid infrastructure that will harness the Semantic Web advantages. The Knowledge Framework encompasses three functional layers, namely, wire, description and discovery layer.

![Fig. 2](image2)

2.2.1 Wire Protocol Layer

This layer forms the platform and specifies the wire protocol for supporting the client and server running on different machines in the distributed
network. Among the numerous wire protocols, Simple Object Application Protocol (SOAP) is chosen as it is seen as the technology that will be deeply embedded in the future of distributed computing. Besides, SOAP offers ease of interoperability and scalability when used with Web Services, one of the future IT revolutions.

Thus, with the ease of coupling with other technologies such as the Universal Discovery, Description, and Integration (UDDI) and Web Services Description Language (WSDL), SOAP is chosen as the wire protocol to transform the knowledge applications and aids communication over the Web with the concept of Web Services. However, as SOAP is merely a wire protocol, it does not implement security. Thus, we are proposing the use of SOAP with Extensible Markup Language (XML) protocol to allow the employment of application-level security.

As SOAP is a text-based protocol that uses XML for data encoding, XML will be employed at the base of the framework. XML is a cross-platform, extensible, and text-based standard for representing data. It is also a key technology in the development of Web Services.

The following standards are employed: XML Version 1.3, and SOAP Version 1.2.

### 2.2.2 Description Layer

The Description Layer lies directly above the Wire Protocol Layer. With a sound and solid platform exemplified by XML and SOAP or XML Protocol, this layer serves as the general purpose description language layer for identifying the required information. With the proliferation of information, it is extremely difficult to find the exact information in the giant information dump. This problem is further amplified when dealing with different machines in the distributed networks. Besides the problem of locating and understanding the information, the proliferation of communication protocols and message formats posed another problem. Thus, this layer is included to address these problems.

To enable efficient retrieval, the environment needs to understand the information’s semantics. This is done through the use of metadata. Metadata has the potential of transforming information from ‘machine readable’ to ‘machine understandable’. Thus, we employed Resource Description Framework (RDF) and Resource Description Framework Schema (RDFS) to achieve “machine understandable” information.

Although RDF is used as the ‘descriptive language’ for resources, it is a further W3C initiative, building upon earlier developments such as Dublin Core and the Platform for Internet Content Selectivity (PICS) content rating initiative. Thus, while RDF is used to empower creation, exchange and the use of metadata, the framework will use the Dublin Core Element Set to capture a representation of essential aspects related to the description of resources.

This layer also includes XML Namespace (XML-NS), a construct which is adopted in RDF to provide a comprehensive system describing all resources’ aspects. XML-NS provides a simple method for qualifying elements and attribute names by associating them with namespaces identified by URI references. It harnesses the great power of XML and RDF to declare their own modes of expression for resources description and yet allows 'authorship' sharing. Thus, the framework will employ Dublin Core Element Set when possible and use XML/RDF to allow terms in a metadata vocabulary to be treated as reliably, unambiguous, describable objects.

Besides providing description, this layer also looks into describing the communication of protocols and message formats. To provide a standardized way to structure communication, WSDL is used. WSDL defines an XML grammar for describing network services as a collection of communication endpoints capable of exchanging messages. It is extensible and allows description of endpoints and their messages regardless of the message formats or network. In short, for Web Services, although SOAP offers the basic communication, it does not state how messages must be exchanged to successfully interact with a service. Thus, WSDL is used as the specification to describe all available services through a set of endpoints operating on the message.

Aiming to incorporate the dynamic service nature of Grid, the Open Grid Services Architecture (OGSA) is included to bring about a convergence of the Grid and Web Services communities. As OGSA adopts the general Web Services approach and protocols to build its own Grid infrastructure, we will use Grid Service
Description Language (GSDL) on top of WSDL. Grid services described in terms of GSDL will serve as an additional building block to function as an enhanced Web Service that extends the conventional Web Service functionalities into the Grid domain. These Grid services will be published and registered in the Discovery Layer through specialized Grid registry and can be invoked by using Internet protocol such as SOAP.

The following standards will be employed: RDF Version 1.0, RDF Schema Specification 1.0, DCMES 1.1 and WSDL Version 2.0.

2.2.3 Discovery Layer

The first two layers discussed so far are required for interoperable Grid and Web Services. They serve as the basic infrastructure to enable specific services and applications to leverage the current Grid and Web Services over the Internet. The next layer, the Discovery Layer will deal primarily with the provision, publication and discovery of those existing services for knowledge discovery. These services can be classified into 2 domains, namely, Grid and e-learning domain, and used the Web and Semantic Services for publication and discovery. This layer will cover the interaction between machines that agree on the protocols and services described by the lower layers to aggregate the supporting and more specific services or applications.

The Universal Description, Discovery and Integration (UDDI) and the Web Services Inspection Language (WSIL) will be used as the mechanism to discover the service. Service Discovery is defined as any action that enables a service requester to find and access the WSDL documents. This process can be as simple as accessing a file or URL containing the WSDL or as complex as querying a UDDI registry and using the WSDL file(s) to select potential services.

UDDI is a specification for a registry that can be used by a service provider to publish WSDL documents. Clients search the registry looking for services and then fetch the WSDL documents. Building upon the basic platform of XML, XML-S and SOAP, UDDI provides a foundational infrastructure for a Web Services based environment for the Grid and e-learning domain.

Alternatively, the service descriptions can be published locally within the service hosting environment and discovered using distributed protocol such as WSIL. WSIL is also an XML-based document format that allows the inspection, discovery and aggregation of Web Services description in a simple and extensible fashion. While similar in scope to UDDI, WSIL is a complementary but different model to service discovery. Unlike UDDI, WSIL approaches service discovery in a more decentralized fashion with the assumptions that the service requester is already familiar with the service provider.

This layer also integrates the Semantic Web vision of machine interpretability of content by incorporating semantic meanings. Web Ontology Language (OWL) is intended to be used explicitly to represent the meaning of terms in vocabularies and their relationships. It is built on top and beyond the basic semantics of RDF-S and will be used to formally describe the terminology. Thus, OWL goes beyond XML, RDF, and RDF-S in its ability to represent machine interpretable content.

The following standards will be employed: WS-Inspection 1.0, UDDI, OWL, DAML + OIL.

3. System Components

The full system component is depicted in Fig. 3. However, limited by the scope of this paper, only the e-learning modules will be discussed. In the following section, we will discuss the key e-learning services, namely the Ontology Services, Inference Services, Collaborative Authoring Services, Augment Services and Agent Services.
3.1 Ontology Services

To serve as an interoperating medium for communication, explicit specification of learning resources must be established. A common understanding is vital for different machines to use and share knowledge. This is established in the form of ontology. Ontology is an explicit specification of some topic. It is a formal and declarative representation which includes the vocabulary for referring to the terms used in a particular subject area and the logical statements that describe what the terms are, how they can or cannot be related. In our context, ontology is defined as a formal explicit description and representation of the learning resources and their relationships in a domain of discourse. It will contain vocabulary that stores machine-interpretable definitions of the concepts and its relations among them. Employing ontology for communicating knowledge will put the system in line with the Semantic Web Vision whereby information is given explicit meaning, making it easier for machines to automatically process and integrate information available on the future Web.

With OWL employed as the ontology language, the system will use the open source Protégé-2000 tool as the system’s ontology and knowledge-base editor. Protégé is an open-source, Java tool that provides an extensible architecture for the creation of customized knowledge-based applications. Although it is currently only being used in clinical medicine and biomedical sciences, it can be used in any field where concepts can be modeled as a class hierarchy. As an ontology editing tool, the system uses the Protégé's OWL Plug-in to describe the ontology declaratively, state explicitly what the class hierarchy is and to which class it belong.

Employing a concept-based approach, concept will be described by class. Class will be the main focus of the ontology. Thus, ontology together with individual instances of classes constitutes a knowledge base. However, as ontology development and design is not the main research focus, this research will not focus on its development and instead adopt standardized libraries of Web ontologies. We will import ontologies from Ontolingua ontology library, DAML ontology library and/or OpenCyc Selected Vocabulary and Upper Ontology.

Although there exists a number of publicly available commercial ontologies (e.g. UNSPSC, RosettaNet) and educational ontologies (e.g. DMOZ, KSL), the system also acknowledges that sometimes, no relevant ontologies for a particular subject exist. Thus, the SMEs can also develop a new ontology from scratch using Protégé. Although, there is no single correct ontology-design methodology, a rather comprehensive guide exists in Ontology Development 101 [3].

3.2 Inference Services

The conceptual logics of the system will be implemented using the fundamental theory behind Language Engineering (LE). LE is the discipline or act of engineering software systems that perform tasks involving the processing of human language. Both the construction process and its outputs are measurable and predictable [4]. It is the application of Natural Language Processing (NLP) to the construction of computer systems that process language for some task usually other than the modeling language itself. LE will be used to create knowledge on the language (partially through the use of ontology) to enhance the query and retrieval capabilities of the system. It will enable the system to access the learning resources efficiently and focus precisely on the exact information that the learner needs, thereby, saving time and avoiding information overload. This will also undoubtedly enhance the learning experience.

The inference services will enhance and aid the query and search capabilities. For efficient retrieval, understanding the query is obviously the most fundamental step. However, perfect understanding of the whole query is not always necessary as the process is time consuming and complicated. Instead, our system employs a basic search function that first requires the learner to limit the scope of query. With the scope limited, the system then performs a shallow or partial analysis of the query through keywords extraction. This partial understanding is often a useful preliminary step because it makes it possible to be intelligently selective before taking the depth of understanding to further levels which is usually time consuming. Thus, with an initial keywords list, the system will try to match each keyword with the metadata repository (using ontology). With the semantic nature and structure of the
learning resources coupled with the domain identification, this initial analysis should be able to generate results of high precision.

However, should the initial analysis fails, the system could also perform a deeper semantic analysis using the Advanced Search. The Advanced Search uses the inference engine to refine and provide the semantics reasoning. Thus, the learner needs not process any prior knowledge on the query topic nor its domain and is free to enter a string of unconstrained texts that he feels best describes his problems. This raw query will be parsed using NLP techniques and the main keywords and rules will be passed into the inference engine for reasoning.

The inference engine will then be responsible for creating a conceptual domain of the query and provide possible reasoning over the conceptual representation. It then performs dynamic semantic analysis on the search criteria and matches them against the predefined semantics of the learning resources, thereby, giving a far better result than simple keyword searches.

The knowledge representation and reasoning services will be carried out using Description Logic (DL). DL has been used in a range of applications and reasoning with database schemas and queries [5]. They are also used widely as a formal basis for ontology language and to provide reasoning support for ontology design and deployment. To exploit the semantics of ontology based relations, the DL-based inference engine must be able to reason with the ontology language, OWL, which is proposed in the earlier section. Therefore, the inference engine will perform reasoning with OWL through the use of OWL DL.

Some key inference properties identified are Consistency Check, Subsumption, Equivalence Check, Instantiation Check and Retrieval.

Besides DL, Latent Semantic Indexing (LSI) will also be used to aid reasoning. LSI [6] is a well-defined mathematical method, which uses pure mathematics to create the semantic cohesion between documents and collections of documents. Besides pure keyword matching, LSI also employs indexing to find semantically close concepts that are associated with keyword. For example, when a learner wishes to learn “Quantum Mechanics”, instead of searching solely for the keyword of “Quantum”, “Mechanics” and “Quantum Mechanics”, the system will also be able to associate semantically close concepts such as “Wavelength-Momentum Relation”, “Schrodinger’s Equation” or “Wave Functions” to Quantum Mechanics although these concepts might not contain the keyword at all.

### 3.3 Collaborative Authoring Services

This service is designed with the basic concepts of the ADDIE Model and modified to cater to the learner-centric environment in the e-learning context. ADDIE is an acronym referring to the major processes that comprise the generic Instructional Systems Design (ISD) process: Analysis, Design, Development, Implementation, and Evaluation. It is one of the most popular instructional design models and has been considered by many e-learning professionals as the standard instructional model [7]. This model is a common model used for developing training programs and has been documented, examined extensively and used successfully by many instructional teams over the years.

This service makes use of a content development model that is developed in an earlier work. This methodology which is based on the modified ADDIE Model, presents a systematic approach to develop the concept’s contents using the developed content development template.

![Fig. 4](image)

### 3.4 Augment Services

Knowledge augmentation will be fulfilled through the use of resource annotation. Initially, the system will employ Amaya as the Web editor to create rich annotation content for each concept.
3.5 Agent Services

Agent technologies have been used extensively for planning and designing interactive and collaborative communication [8, 9]. In this paper, we designed an agent service to provide the means to create a personalized learning experience. Personalization is catered for in two stages. The first stage generates the exact learning paths that the learner has to take to master a particular concept. These paths will be generated dynamically based on the learner’s expertise (through mapping with his cognitive structure) and the requested concept’s expertise. Initially, each new learner will be given an empty academic record categorized by the subjects domain that is offered by the system. Each domain is an externalization of the learner’s cognitive structure. The map initially empty will be filled with each successful acquisition of knowledge (through the completion of post-assessment). Thus, an exact learning path can be mapped easily by comparing the domain concept map with the learner’s cognitive concept map. The next stage is to select the type of learning approach to present the content. As a learning objective is realized with different content approaches and assessment styles based on the Index of Learning Styles (ILS), the system will dynamically match the learner’s preferences to the ILS and select the type of learning experience that best suit the learner.

The following illustrates two learning scenarios that show how the personalized learning paths can be generated dynamically. The first scenario describes a learner who has enrolled in a course and wishes to retrieve either the course materials or some additional reading materials to supplement the course material. In this scenario, the lecturer has to specify a course map as well as a supplement course map. The course map will cover all the key concepts that are prerequisite to the completion of the course, while the supplement course map will provide some additional reading materials. The system will allow the learners to access all these materials without checking for any pre-requisite requirements as it is the lecturer’s duty to ensure that these learners possess the prior knowledge.

i. Once the learner logs in, his preset preferences, and constraints will be retrieved.

ii. He can browse the course materials and select any concept that he wish to concentrate.

iii. He can also view all the related course concepts or retrieve the additional course supplement map to get a broad understanding.

iv. Upon selection of a particular concept, he can choose the required level of abstraction.

The second scenario describes a learner who wishes to enhance his knowledge on a particular domain in which he has not enrolled in.

i. Once the learner logs in, his preset preferences and constraints will be retrieved.

ii. He will use the domain specific ontology to search for the concept that he wishes to master.

iii. That concept will be assigned as the end point of his personalized learning path (EP).

iv. Limited to the specified domain, the system will first search and retrieve the entire domain concept map that the requested concept resides.

v. Next, the learner’s expertise in the specified domain will be retrieved. His prior knowledge and expertise in this particular domain which is stored in his cognitive structure will be externalized and presented in a concept map form. This cognitive map will then be used as a comparison with the basic domain concept map to find the next most immediate pre-requisite concept that is present in both maps.

vi. The identified concept will be assigned as the starting point of the learning path (SP).

vii. The system will route dynamically and provide all possible routes from SP to EP.

viii. With the routes generated, the system will then retrieved the learner’s preferences and pick the content presentation approach (based on ILS) that best suit the learner’s learning preferences.

ix. Lastly, depending on the system’s restrictions (such as course fees or the lecturer’s recommendation) and the recommended scope, the allowed routes are presented to the learner.

The routes will be displayed in the form of a meta-concept map. That is, upon selecting any one of the nodes in the meta-concept map, the selected node will act as a hyperlink and brings the learner to the beginning of either a course or a module. When the node is hyperlinked to a course, the course concept map will be presented. At this stage, the learner can then begin his learning
process by selecting the course nodes which will bring the learner to his personalized module. On the other hand, if the node of the meta-concept map corresponds to a module, the learner can immediately begin his personalized learning by clicking on that node.

4. Conclusion and Further Work

In this paper, we described an approach to use a concept-based knowledge environment to address the lack of personalization, collaborations and the failure to adopt technological advancements to enhance learning. We have shown how we can incorporate Grid Computing, Semantic Web and Web Services into our knowledge framework. Embedding these technologies into the e-learning pedagogy, we discuss how the system is able to provide for the personalization of learning experiences as well as the exploitation of the semantics for efficient searches and retrieval of learning resources.

Research efforts will be ongoing to revise the system design to include new research methods to improve the system. One key area will be pedagogy research. As the driving motivator for creating a successful enhancement in learning experience should be based on pedagogy rather than technology [10], pedagogy research effort will be centered on analyzing new methods to enhance the learning experiences of the learners.

References: