PIAVEE – A Pedagogy-Independent Education Environment

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Abstract

A Platform Independent Agent-based Virtual Educational Environment (PIAVEE) is described. PIAVEE is conceptualized as a lightweight, flexible environment that links educational resources through a virtual data base and that is supported by an intelligent delivery system. PIAVEE is implemented through an evolutionary process, whose initial focus is the development of, and access to, the virtual data base. The paper describes the initial implementations, which focus on proof of concept and basic level functionality.

1. Introduction

There has been an increasing focus on the development of repositories for learning objects [10]. However, for such repositories to be of significant use, they need to employ technologies that streamline the process of adding learning objects to the repository, and that also support a variety of learning and teaching activities. Typically, the uptake and usage of these repositories has been hindered by the need for the developer of courseware to provide extensive meta-data/descriptors of learning objects as they are being added to the repository. This need imposes an additional workload for courseware developers. Flexibility in the deployment of repositories is further constrained by inflexible templates available to describe learning objects for the repository. Furthermore, there is sometimes little thought given to the pedagogical context in which such repositories might be used, with the emphasis placed predominately on the technical aspects of the repository.

The Web based search engine has changed the view of information complexity, information veracity and information accessibility. This fact, together with the limitations of current repositories of learning objects, has motivated the development of the *Platform Independent Agent-based Virtual Educational Environment* (PIAVEE). PIAVEE is based on two primary principles: *pedagogical soundness* and *technological innovation*. PIAVEE transcends the simple storage of educational materials into an environment that can use a variety of curricula structures to provide frameworks for intelligent information retrieval. PIAVEE operates in the areas of distributed information systems and best teaching and learning practice.

Learning object repositories are used typically in three contexts: the developer of learning objects adds the objects to the repository and includes some meta data or descriptors about the objects to aid in their retrieval; the course developer searches the repository to retrieve objects suitable for the course under development; and the consumer of the course (the student) accesses and learns from the objects, as retrieved, grouped and ordered by the course developer. Alternatively, the second context may be absent, with the student implementing a personal retrieval strategy. With this scenario in mind, PIAVEE has a number of functional requirements.

1. Alleviate the need for manual entry of meta-data/content descriptors as objects are added to the repository by incorporating automated and sophisticated strategies for indexing courseware on both low-level features (e.g. keywords) and higher-level educational constructs independent of physical data formats (e.g. lecture notes, reading material, references and WWW links).

2. Facilitate support for all teaching and learning models, by enabling the grouping and ordering of

objects in a personalized, cohesive and holistic manner by using sophisticated automated retrieval techniques.

3. Enable easy reuse of repository objects in a variety of ways based on search strategies used for retrieval.

4. Provide a dynamic environment for both learning and curriculum development, whereby, for example, a set of information parameters utilised for extracting information will be responding to the current state of the repository rather than any previous state, current at the time when the learning objects were being added to the repository.

feature reduces the management and maintenance onus of PIAVEE and fosters an autonomic self-managing educational environment.

This paper presents three views of PIAVEE: an architectural view, a pedagogical view and a view of the software system.

2. An Architectural View

PIAVEE provides a set of interacting components based upon mobile agents. The core system (Figure 1) is a virtual data-base that links to learning objects. *A*

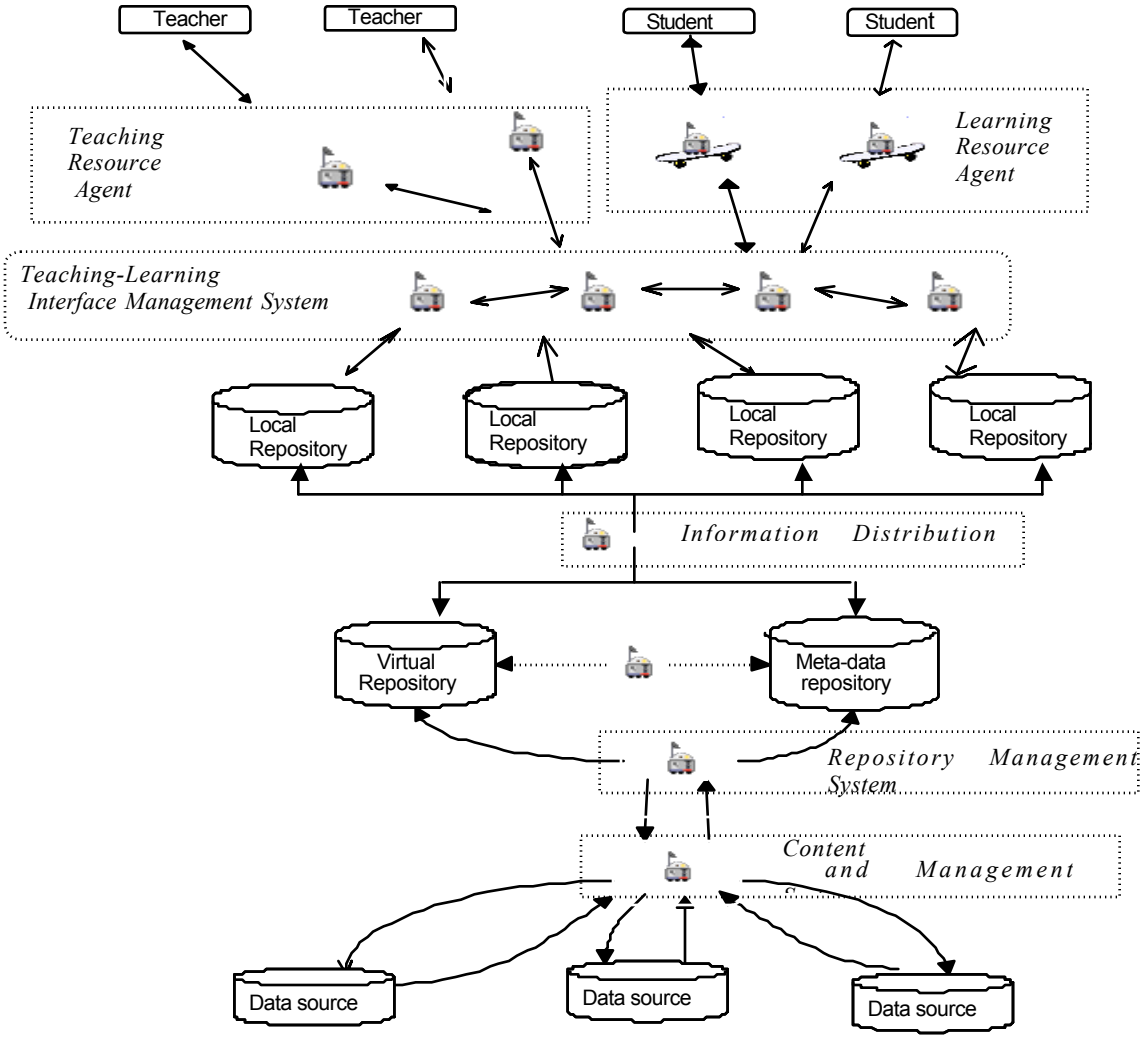

Figure 1 Overall View of PIVEE

5. Avoid the high maintenance challenges of maintaining a virtual database, which contains links to actual objects, stored around the world. When any such links become broken, PIAVEE must be aware of this fact and adjust the virtual database accordingly. This

Repository Management System, based on a group of mobile agents, controls the development, access and update of the data base. Importantly, below the *Repository Manager* is the *Content Search & Management System* that maintains dynamic

supervision of links to items, reducing the likelihood of broken links.

The second major system is the *Teaching-Learning Interface Management System*. It is through this that objects are grouped and ordered into any required curriculum structure, and where students this curriculum structure. It is planned that PIAVEE will be able to build links to existing delivery systems through this interface.

Within the overall operation of PIAVEE there are two phases of use: the first, directly supported by agent technology, provides facilities for the insertion and indexing of educational resources (learning objects); while the second is based upon the integration of standard web technology and agent technology to provide search and retrieval facilities. The top level of the Figure 1 shows teacher and student users accessing the *Teaching or Learning Resource Agents*. The teacher will develop a curriculum structure through the *Teaching Resource Agent*, creating a local repository. This local repository can be a mixture of data represented as meta-data structures and data stored only as links or pointers (a virtual data base).

The definitions in the Local Repositories are used by the *Information Distribution System* to update the main Meta-data Repository or to allocate links and pointers based on the Virtual Repository. The contents of the central data bases are managed by the *Repository Management System,* which works in real time to maintain the integrity of the contents, including the checking that live links and pointers are valid, thus eliminating the ubiquitous Error 404! This system also sends information to the *Content Search and Management System* that does the 'leg work' of collecting data and establishing the links and pointers. The student will use a *Learning Resource Agent* to tap into the curriculum that has been defined by the teacher and will be able to access the information that is stored or pointed to within the Local Repository.

An important point in understanding the pedagogical significance of this diagram is that the Data Sources shown at the bottom of the diagram can be any type of learning object: a standard library catalogue entry, a reading list, an actual sets of notes stored on a teacher's computer, a piece of simulation software that the student can run, a set of links to information on the Web, for example. *The Learning Resource Agent* can be instructed to provide access to educational materials in any way the teacher wishes to define using the teacher's preferred pedagogy.

2.1. User Relevance

Perhaps the greatest advantage of this system is the way in which it is independent of educational delivery issues. The teacher is not constrained by the underlying pedagogy of the developer; the teacher can build any type of curriculum system, from a traditional sequential term-based curriculum through to one that is based upon an educational resource structure through which the student can be guided. A clear advantage of an agent-based system is the artificial intelligence that can be built into to it to provide real-time help to a user.

2.2. The Ethical Issues

Agent technologies, by definition, operate in the background. They are hidden from the user. For example, virus scanning software involves a type of background agent scanning those files that it has been told to scan. The agent's level of real time reporting depends upon the settings chosen by the computer user.

It is important to recognise that the intelligence of an agent is limited to the ability to 'learn' based upon the sophistication of the software and, consequently, the capacity of the computer system to handle the software running in the background. The invasiveness of a piece of software is dependent upon the attitude of the software developer. The ethical programming of agents is an important issue requiring attention in agent based systems.

2.3. System Maintenance

Most attempts to develop complex educational environments are faced with the continuing costs associated with maintenance. From our previous experiences of developing a low-maintenance data base of educational best practice during the second phase of the AUTC funded ICT project [13], we recognised that the functionality of this data base was dependent upon those who deposited materials being willing to continue to maintain their entries. While a virtual or meta-level data base is generated under the PIAVEE system, a key feature is the use of an automatic dynamic indexing system, which indexes data through content searches for key word components. Coupled with this automated process is a facility for the learning object owner to manually modify the automated indexing, as appropriate.

It should also be noted that the agent-based management of the system means that there can be real-time maintenance of broken Web-links. This approach will be able, in real time, to establish all links as live links.

3. PIAVEE and Pedagogical Issues

3.1. The teacher as content authority

An important feature of the pedagogical philosophy behind PIAVEE is the primacy of the teacher's right to

define which learning objects will constitute all or part of a course or unit. These objects of themselves have no 'meta' status; they do not represent any transformation into some curriculum object. The object gains learning significance through the teacher's designation. Likewise, no prior structuring is attached to objects. The curriculum developer uses indexing words and phrases that best define the learning objects. This eliminates the need for the developer to allocate time for the interpretation of the material into the conceptual frame of the data base developer. Other approaches to educational resource databases have generated complex methodologies that require expert help (eg [10] [11]). Anecdotal evidence suggests that this inhibits the utilisation of such a resource.

A key to the practicability of the system lies in the fact that the central database simply provides pointers to the educational items. It does not contain the actual materials. They will be held physically where they were placed by the learning object developer. A task allocated to the *Content Search & Management System* is the management of these links, including the continuous testing of the validity of such links.

3.2. Pedagogical Agnosticism

Published research into the development of educational delivery and support systems appear to either utilise the constructivist pedagogical [8] position or offer no pedagogical support. Bahvan and Kinshuk [3] directly use the constructivist position. Westoff and Unger [16] say nothing about pedagogical issues in outlining their agent-based platform called "campus". Similarly, Liu et al [14] use the I-MINDS system as their framework for a virtual classroom without pedagogical reference.

PIAVEE has been developed deliberately as a pedagogically agnostic system. A given pedagogy, constructivism for example, might relate to PIAVEE in certain ways, but PIAVEE itself is not intrinsically linked to any existing pedagogical position. PIAVEE is being informed by a range of teaching, learning and behavioral issues that are outside the constructivist area, but which take seriously the substantial criticisms that are being levelled at constructivism [9]. PIAVEE takes a very broad pedagogical approach based upon open systems theory [7]. Associated with this are the behavioural issues of the self-managed learner [2] in virtual, global systems. Again, an open systems framework has more potential to provide a functional starting point.

4. PIAVEE as a Software System

PIAVEE is implemented using a combination of software technologies. The primary development language is Java ™. The mobile agent toolkit being used in the implementation is Grasshopper™ (http://www.grasshopper.de). The backend indexing server currently runs on SunOS™ 5.8, with a MySQL™ database. The teacher interface at the client-end for submission of learning materials is platform independent. The interface system for adding and indexing learning objects, and retrieving objects for grouping and ordering, is driven by Grasshopper. The learner interface is provided through web based access or alternatively through a Grasshopper agent-driven personalized access.

5. Related Research

There have been other attempts to develop intelligent education delivery systems, most notably the Technology Integrated Learning Environment (TILE) project [6][12] from Massey University. As it developed it moved to mobile agents as its core operational software. Unfortunately, TILE appears to have become bogged down and Jessup has, on his web site at the University of Hull (www2.dcs.hull.ac.uk/people/csscrj/research.html), said that an open-source group is being looked for to take over the work. Most other projects looking at virtual delivery systems have more constrained aims than TILE or PIAVEE, usually looking to provide some aspect of delivery or management[16][14][1].

PIAVEE is associated with other projects being conducted at Monash University in mobile education and pedagogical agents. It is linked to a project developing agents for intelligent evaluation of computer based educational tools [15], it is using work done on intelligent lecture theatres [5] and it is influenced by the thinking in the Walkabout Learning project [4]. PIAVEE is seen as a potential integrating project for part of this suite of activities.

6. Summary and Future Developments

PIAVEE is a prototype of a virtual education environment using agent technology as the management system. In its conceptualisation PIAVEE is setting new directions in virtual educational systems. PIAVEE is dynamic in its support for collating learning materials in a virtual learning environment and has minimal overhead for the teacher and also provides support for collation of materials for the student. It also enables reuse in the context of curriculum development activities. It reduces maintenance and management of the system due to its distributed, virtual organisational structure and the inclusion of autonomic capabilities in the underlying agent system. From this, PIAVEE is providing a structure that can be used to explore a wide range of

teacher/learner models within a dynamic educational framework.

PIAVEE is evolving and will realise its full potential, not when it has a realistic virtual data base of educational items, but when both teachers and students can access that database through curriculum structures that reflect user interests. We are currently focusing on completion of the first-phase of the prototype implementation. This will be followed by a formal pedagogical evaluation of the system and further system-level enhancements.

7. References

[1] Betbeder, Marie-Laure & Tchounikine, Pierre "Symba: a Framework to Support Collective Activities in an Educational Context" in Kar Tin Lee & Koren Mitchell (eds*) Proceedings of the International Conference on Computers in Education 2003*, Hong Kong, 2003

[2] Betts, George T. (1992) *Autonomous learner model for the gifted and talented* Cheltenham, Vic.: Hawker Brownlow Education.

[3] Bhavan Sridharan, & Kinshuk "Integrating Constructivist Learning Paradigm and Knowledge Management Principles" in Kar Tin Lee & Koren Mitchell (eds) *Proceedings of the International Conference on Computers in Education 2003*, Hong Kong, 2003

[4] Casey, D. Building Internet Learning Communities, *Twelfth International Workshop on Database and Expert Systems Applications (DEXA 2001),* Munich, 3-7 September 2001 pp491-495

[5] Chhetri, Mohan, Krishnaswamy, Shonali and Loke, Seng "Mobile Agents as Smart Virtual Counterparts" *in The 18th International Conference on Advanced Information Networking and Applications (AINA 2004)*, Fukuoka, Japan. March 2004.

[6] Gehne, R., Jesshope, C.R. and Zhang, J. "Technology Integrated Learning Environment - A Web-based Distance Learning System", *Proceedings of IASTED International Conference 2001, Internet and Multimedia Systems and Applications*. Hawaii, USA. ISBN 0-88986-299-0. pp1-6.

[7] Emery, Merrelyn "The Current version of Emery's Open Systems Theory" *Systemic Practice and Action Research* 15, 5 , 2000, 623-644.

[8] Fosnot, C.T (ed) *Constructivism : theory, perspectives, and practice* New York : Teachers College Press (1996)

[9] Fox, Richard, Constructivism Examined *Oxford Review of Education,* 2001, 27, 1 , 23-35.

[10] Heinrich, E. & Chen, J.A framework for the multi-modal description of learning objects. International Conference on Dublin Core and Metadata Applications 2001 (DC-2001).

[11] Heinrich, E. and Kemp, R.H. A flexible scheme for representing and retrieving multimedia contents in computer-based educational systems. Proceedings of International Workshop on Advanced Learning Technologies (IWALT2000) (Palmerston North, New Zealand). Kinshuk, Chris Jesshope, Toshio Okamoto (Eds). IEEE Computer Society Press, Los Alamitos, California. ISBN 0-7695-0653-4. Pp 213-214.

[12] Hong H., Kinshuk, He X., Patel A. & Jesshope C. Application of Mobile agents in Web-based Learning environment. Proceedings of Ed-Media 2001, Tampere, Finland. Montgomerie, C. and Viteli, J. (Eds). AACE, Vancouver, USA. ISBN 1-880094-42-8.

[13] Hurst, J., and Lynch, J.. *Teaching ICT*: Higher Education Division, Department of Education, Training and Youth Affairs, 2001

[14] Liu, Xuli, Xuesong Zhang, Leen-Kiat Soh, Jameela Al-Jaroodi & Hong Jiang "A Distributed, Multiagent Infrastructure for Real-Time, Virtual Classrooms" in Kar Tin Lee & Koren Mitchell (eds) *Proceedings of the International Conference on Computers in Education 2003*, Hong Kong, 2003

[15] Markham, S., Ceddia, J., Sheard, J., Burvill, C., Weir, J., Field, B., Sterling, L. & Stern, Linda (2003) Applying Agent Technology to Evaluation Tasks in E-Learning Environments *Proceedings of the Exploring Educational Technologies Conference* Monash University, Melbourne, Australia July 16 – 17, 31-3

[16] Westoff, Dirk & Claus Unger "Campus – an agent-based platform for distance education" ED-MEDIA/ED-TELECOM 98 World Conference on Educational Multimedia and Hypermedia & World Conference on Educational Telecommunications Frieburg 1998.