

EDUCATION GRID – A DISTRIBUTED LEARNIN ENVIRONMENT AND MANAGEMENT FRAMEWORK ACROSS INSTITUTIONS

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ABSTRACT: A Web-based networked information and collaboration architecture is hereby presented as Information and Knowledge Grids. This architecture is made possible by a new generation of advanced web-servers called as Aggregation Grid Servers (AGS) based on a concept called Info-Space Operating System (iSOS). Using iSOS, a class of Education Servers have been developed that configure themselves as Education Grid. The Education Grid supports multiple independent course-specific collaborative information and knowledge networks across distributed servers over the Internet. These are in the process of getting deployed in the colleges of Kerala in India for improving the quality of higher education. The Education Grid provides affordable and pedagogically effective online assisted learning environment for the colleges in any subject. The paper describes in some details of the architecture of iSOS based AGS, the Education Grid and the processes of courses management over it.

I. INTRODUCTION

Key to enhancing education programs is to have high quality learning environment for the courses that are taken by students and learners. In recent times, several software products have helped providing Web-based interactive and collaborative learning resources support for courses. These have become very popular in the universities and for training in industry. In Dec. 2000, the bipartisan congressional Web-based Education Commission appointed by the President of United States strongly recommended enhancing use of web-based education [1]. Web supported instruction and pedagogy have become subjects of intense work and study, so much that IEEE has its LTSC [2], the IMS [3] or CISCO's re-usable learning objects model [4] are now taken as central to the format and process of content creation and learner centric education management. A good review of Re-usable Learning Objects may be found in the e-paper by Stephen Downes [5]. Several commercial web-server products as Learning Management System (LMS) are available that support Web-enhanced learning. Online courses for credit are available from several universities and educational organizations.

In parallel to these developments, industries are increasingly going for corporate web-enabled collaborative Intranets with Groupware, Document Management Systems, knowledge repositories, knowledge management functions, smart yellow pages, etc. However these have been developed in evolutionary ways in several leading industries, or they try to implement the same through commercial parties that offer custom solutions of Web-enabled groupware and parts of Knowledge Management facilitating platforms.

As stand-alone solutions, neither the LMS type platforms, nor the Enterprise Information Portal solutions appear to meet the diverse needs of real networked environment for education. This situation is particularly truer when it comes to using LMS effectively in a LAN environment in school and undergraduate education. Further, the available solutions and products address more of the need for delivery of content. The real need in Online Assisted Learning Environment (or, OAL environment as we shall refer to it) is that we need effective support for (i) the Content Creation and Maintenance Process Management, (ii) Learning Process Management and (iii) Learning Environment Management.

In many university systems, these three components of OAL environment management often need to be carried out across geographically dispersed participating institutions. A major effort was initiated at the Indian Institute of Information Technology and Management – Kerala in India to address the development of a low-cost education server platform that supports the above class of OAL environment related management functions across geographically distributed set of servers. This paper describes the requirements specifications and architecture for such servers. A concept called Education Grid across participating organizations and institutions is being established in the State of Kerala in India. We feel that this concept is worthwhile extending globally.

INFORMATION AND LEARNING ENVIRONMENT FOR EDUCATIONAL INSTITUTIONS

In the typical higher education scenario of a university in India, there are a few elite postgraduate level institutions, and a large number of colleges geographically spread out, offering graduate programs in Arts, Commerce, Sciences, Engineering and other professions. Most of these colleges are mainly of the teaching kind. Hence the advantage that a large integrated university or institution has, where the strong postgraduate programs enhance the quality of the undergraduate programs is not readily available. In such colleges, the maintenance of information and learning environment requires support from outside. The challenge is how does one go about this. The second challenge is to understand the many processes that support the learning environment across geographically spread out and loosely coupled colleges. These processes have to take into account several of the following constraints.

1. The Internet quality is not that good. The external link may be down unpredictably. Hence accessing a server outside for time-critical functions is not recommended.
2. The external link capacity is not likely to be anywhere near a reliable T1 for most institutions. It will be more likely of 64 or 128 Kbps. Hence the information flow over the pipe needs to be effectively cached for all interactions. More asynchronous interaction is desirable.
3. It is possible to have servers and LAN based access within the college premises. Since the college does not have the manpower or capacity to maintain the configurations and run these services, the servers/systems is best outsourced to external parties. However these parties have no ability or knowledge of academic support functions. Hence we need to segregate the information services and management from those of servers and systems.

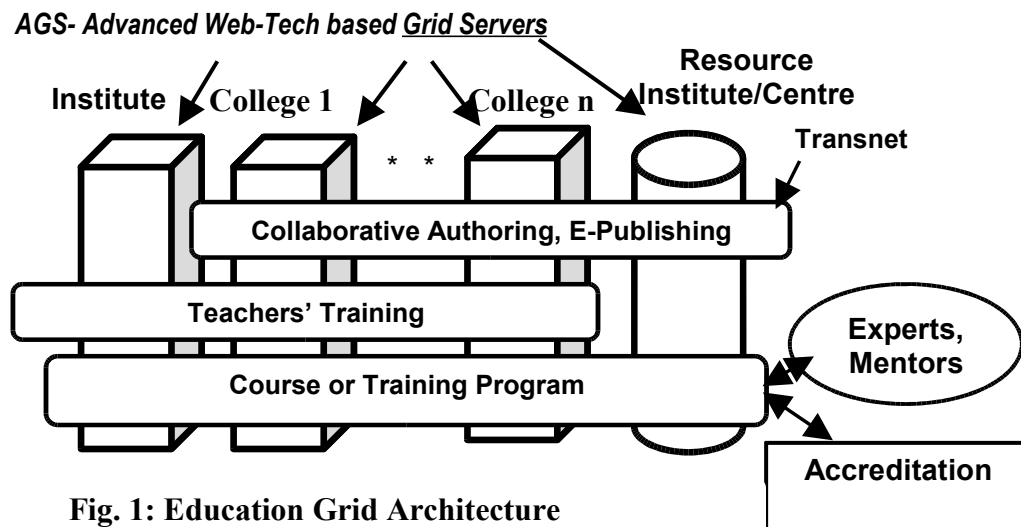


Fig. 1: Education Grid Architecture

4. Since many of the colleges have inexperienced teachers, they need to be networked in a collaborative group environment centred on the respective designated subject experts who are available in the better institutions.

Extrapolating the above requirements we may arrive at a distributed architecture of web-enabled OAL Environment over a network of Information servers. Such information and learning environment servers need to have the facility to support multiple independent course specific networked learning environments for each subject across a collection of them over the Internet. We refer to such collaborative information servers as Aggregation Grid Servers (AGS). The collection of AGSs over the Internet that support multiple independently managed intranets as Education Grid. They may also be referred to as Information and Knowledge Grids.

A typical Education Grid architecture is illustrated in Fig. 1. In terms of components and associated constraints, the Education Grid needs to be built on the following considerations.

- a) Each college has at least one AGS.
- b) The servers are on a college LAN. Proxy and Firewall insulate the LAN from the Internet. The Internet is accessed through a Router. Hence, the main access available and one that can be secured reasonably from direct systems level security attacks are the http ports.
- c) Every course-specific information and collaboration Intranet exists across the whole or a subset of the collection of parallel AGSs. We call each such Intranet as Transversal Network, or, Transnet for short. Such a collection of Transnets over geographically distributed network of AGSs is referred to as Education Grid.
- d) All Transnets support fully web-enabled services. The collection of such services include Course Management Systems, Digital (multimedia) Library, Transnet specific E-Groups, Email, Group and Personal Web spaces, Message Boards and Threaded Discussions, Chat, asynchronous and synchronous interaction tools, etc.

In the matter of developing such AGS, we have additionally imposed the following realistic restrictions that help configure and manage the large number of administrative functions of the Education Grid in ways that protects every user from the information glut.

1. Each college subscribes to the membership of a subset of the collection of Transnets and controls the policies of memberships of individuals (students, teachers, etc.).
2. Each Transnet is administered by the domain members as per their own governing rules.
3. Any individual is member of a small sub set of Transnets where he/she has a role to perform.
4. Several of the Transnets may maintain their own open public portal.

The purpose of these restrictions is to architect a configuration paradigm over the open Web-space that helps building collaborative group-specific and personalized areas as 'Knowledge Estates'. Our next restriction is that the AGS software runs entirely over Web servers such as Apache, IIS and similar ones. This helps run these server packages over any underlying operating system – be they Windows-NT, Linux, Solaris or others. This allows AGS to run over many different server systems suppliers, making the system robust. Since our target is to make all the information, knowledge and collaboration services fully web-enabled, the client systems need nothing more than a Web-browser – be it Netscape, Internet Explorer, Mozilla and the like. For processing of information that require specific applications, necessary application packages will be needed in the client systems.

III. SOFTWARE ARCHITECTURE OF AGGREGATION GRID SERVERS

Based on the configuration and management paradigms and the associated restrictions stated above, a server architecture for AGS was developed and fully implemented. We call this architecture as the Infor-Space Operating System (iSOS). The following abstractions are made to explain the functionalities of iSOS.

1. The collection of information space available over the web-servers of all the participating AGSs is referred to as global web-space.
2. All Transnets are set over different subspaces of the global web-space according to administrative policies of the different organizations. Every user is a member of one or more of the Transnet space.
3. The subspace of the global web-space covered by each Transnet is called the Transnet space. Each Transnet space may exist across multiple web-servers. The members of each Transnet space govern different administration functions as per its management needs.
4. Within each Transnet space, there may be many groups that manage the different component functions. Such groups share a subspace of the Transnet space that we call as the group-spaces. The setting up, dismantling, interaction and collaboration functions within the group-spaces are given a great deal of flexibility and governed by the group members themselves.

The iSOS architecture consists of an iSOS core and a number of APIs built over the core. The core code is fairly extensive and has the architecture shown in Fig. 2. Typically this iSOS core runs on top of a Web-server such as Apache. To ensure modularity and platform independence, iSOS essentially makes calls to and serves calls from the Apache or similar web-servers. All system-dependent functions are accessed in this manner. Very minor tuning of iSOS is needed to get it working across different web-servers.

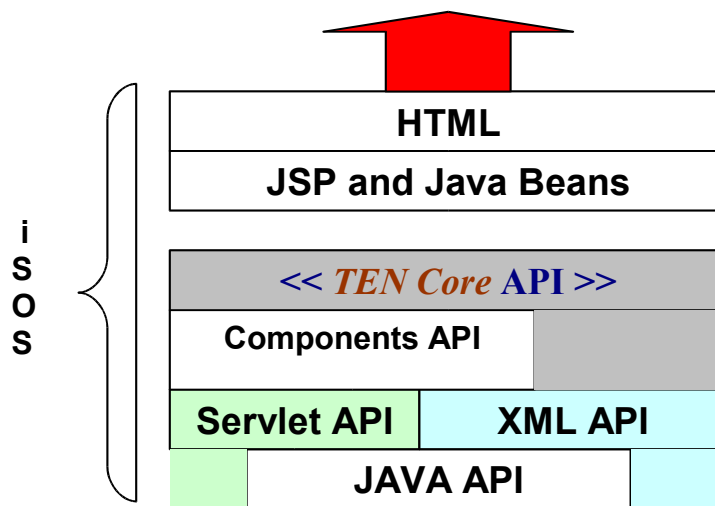


Fig.2: Layered architecture of iSOS

As may be seen, the architecture follows current trends in developing web-enabled applications. Our current distribution of iSOS implementation runs on top of Apache and uses Tomcat servlets for the web-browser based GUI and interactions. The XML APIs augmented by the Java APIs handle much of the system related calls over standard web-server hooks. The TEN Core API gives rich set of key primitives like functions over which different useful applications have been configured and run. The

principal difference is that iSOS by itself is not an application, but one that provides a large core of information processing and presentation APIs over which we have built many of our Education Applications. Typical applications are listed later.

A second important feature of iSOS is the provision of inter-web-server communication paths entirely through http ports. This method gives us tremendous flexibility in setting up the Education Grid across web-servers situated behind firewalls and proxies. The aggregation of several application specific services (such as legacy Database Systems, custom application packages, etc.) that are run in specialized systems scattered across the different institutions, or by special service providers is done through CGI or similar functions linked through the iSOS APIs. Fig. 3 gives a graphic picture of these inter-server connectivities.

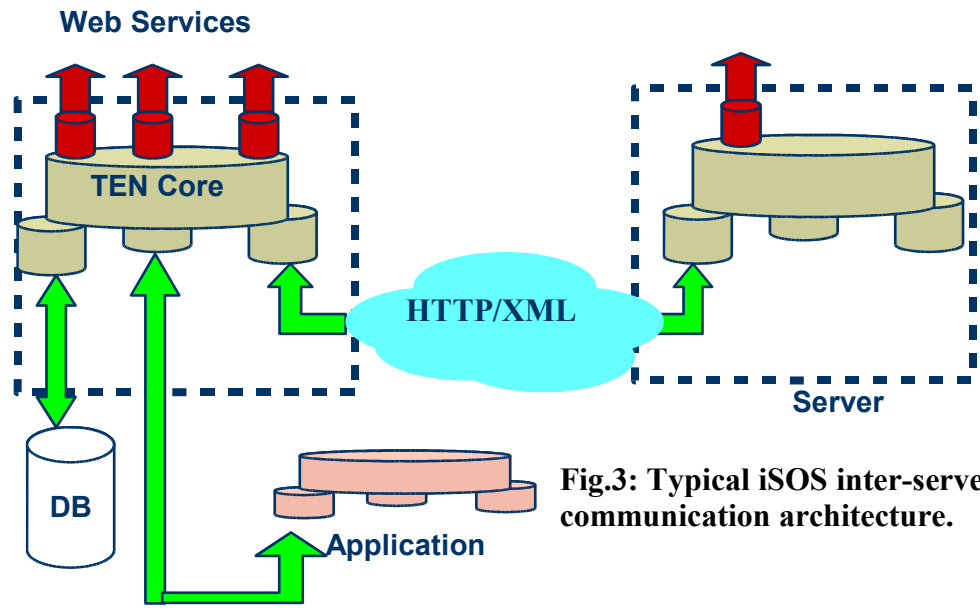


Fig.3: Typical iSOS inter-server communication architecture.

Combining the internal and the network architectures shown in Fig. 2 and Fig.3, the iSOS provides powerful logical and network paradigms that support concepts such as Education Grid, or, Information and Knowledge Grids. In many ways, iSOS provides for efficient configuration and development of a large number of information and knowledge related functions and unifies typically both the Learning Management Systems type web-server developments and the Enterprise Information Portals customised and marketed for industries and business.

The entire iSOS approach was developed and several useful applications over it implemented by the group called Transversal E Networks (TEN) working at the technology incubation facility of the Indian Institute of Information Technology and Management – Kerala. Typical AGS with applications that have been programmed over iSOS using its APIs and supported by an underlying Database System such as MySQL are stated below.

- (i) Personalized Desktop over Web browsers that gives each user essential information, alerts and single click-away access to one’s important information and interaction functions.
- (ii) Digital Library, with capacity for documents submission, refereeing process and advanced search facilities.
- (iii) Course Management System with full complement of tools to manage a class, students registration, tracking and other facilities.

- (iv) E-Groups management that allows a member to set up, manage and participate in group activities in each Transnet space.
- (v) Group and personal web-spaces wherein one can place files/folders that can be accessed and worked upon from anywhere over the Web after usual authentication and security checks.
- (vi) Content Authoring Wizard that provides flow and template assistance to authors to compose media documents through linking different component documents.

Work is also progressing on creating workf that low and project management utilities over iSOS. We have also provided for backend integration with popular/legacy applications, including those of existing LMS made by other vendors. An advanced concept Digital Library is now being defined and likely to be implemented in the next several months. Different variants of these AGS are currently being made and marketed by the TEN Group that is now funded as a startup company (see www.transversalnet.com). This ensures the growth and availability of the series of AGS. AGS servers made by TEN are now being used some institutions and companies already.

IV. PROGRAMS MANAGEMENT OVER EDUCATION GRID

Currently readily available LMS are mostly used over standalone web-servers to support an instruction team and the registered students in a class for conducting the class. When we manage courses over the Education Grid (see Fig. 1) the management takes on different wider perspectives with multiple independent task managers. We have categorized these into two groups – locally managed functions and Grid managed functions over respective course-specific Transnets. These are stated below.

Locally Managed Functions

There are four of these in any given course.

1. Approved and Structured Course Content: Here a university curriculum group designs and places pedagogically (such as problem based learning or other methods) structured and learning objectives oriented course content is placed. The material is Read-Only for all the concerned teachers and students of the course in the different institutions.
2. Administration and Work Materials distribution: Office automation related space for admitting and registering students for the course(s) is done over this space. In addition various exercises, and reading materials in printed form are distributed as pdf documents. Our goal is to minimize the students' time required to be spent over the net to one of more essential interactions such as taking self-tests, computer based problem solving, etc. This is essential for two reasons – not many students can afford computers; in many cases pedagogically paper medium is just as good and the time available to students for sitting at terminals is rather restricted.
3. Course Schedule and Calendar Management: Different colleges are not necessarily synchronized. They can personalize their course events scheduling in this area.
4. Students Monitoring and Counseling: This is an important aspect of Education Grid. Well-designed self-test are placed against each course module. As the students answer these, their track record of answering is analyzed and necessary corrective actions, such as – delivering supplementary materials for identifiable knowledge gaps, or, special tutorials when many students struggle on a given problem – are held.

Grid level Education Support Functions

Besides the above four class management functions, we also have four other major Grid level functions that are given below.

5. Teachers Assistance and Mentoring Support: This is a Transnet function exclusively for teachers to be assisted by content of use for them, new case-studies that they can use in the class, support from experts or experienced teachers from other well equipped institutions and even certification programs for the teachers for competence in the subject as teachers.
6. Question Bank, Examination and Evaluation Area: All computer assisted/evaluated examination functions are delivered through this area. This will also be useful to share the problem sets across multiple institutions and build larger question banks in the subject.
7. Open Course Portal and Authoring Assistance: The public portal will give access to relevant Digital Library area in the subject (through restricted subscription where necessary) that helps motivate would be scholars in the area, gives historical perspectives, FAQs, non-formal content, invites interested persons to add to content for refereeing, industries that use the ideas in the subject, related other courses, pre-work materials, even placement opportunities, etc. Besides, it will support authoring portal services to invite competent faculty from anywhere to feed new content for further course development.
8. Interaction and Collaboration Space: The popular tools such as threaded message board, bulletin board, whiteboard, chat, synchronous classrooms (if bandwidths permit), etc. are accessed through this window.

While not all of the tools will work in the restrictive and less reliable Internet context, the vast and pedagogically effective part of the Education Grid supported functions can effectively be run of existing type of access solutions with some physical management.

SUMMARY

A practical way of deriving most of the advantages of Web-assisted or Online Assisted Learning for the vast number of colleges under typical Indian conditions that does not require very heavy investments in terms of Internet infrastructure is being implemented as Education Grid. Such a Grid is being planned for deployment in the State of Kerala in India. This is made possible by advanced technology web-servers based on a new architecture built over iSOS – the Info-Space Operating System. The availability of such a grid has the scope to improve quality of education and learning substantially.

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