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WE B-BASED EDUCATIONAL *TECHNOLOGY*

CASA CARTII DE STIINTA

Web-based Educational Technology

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The objective of this paper is to present Web based e-educational environments and also the design decisions of the Virtual University (http://www.coned.utcluj.ro or http://wouc.utcluj.ro), e-educational component of Tempus Project IB_JEP 13467-98 CONED. It is architectured as a three tier distributed system implemented in Java technology for platform independence. We aim at a flexible educational framework to allow active learning, co-operation and knowledge building. The client tire uses Java Script to enhance client side presentations. The middle tier implements the Web server and the application logic. Client tire - middle tire interaction uses applets, forms and servlets. Back end tire represents the application data in the form of DBMS. Middle tier - Back end tire interaction uses SQL, JDBC and JDBC/ODBC bridge. All functionality of the Virtual University Web server is achieved by means of servlet technology.

1. Introduction

Educational Technology includes a set of methodologies for curricula and teaching material development, teaching, learning and assessment. The use of computers for educational technology enhancement created the domains of CAI (Computer Aided Instruction), CAA (Computer Aided Assessment), CMC (Computer Mediated Communication).

During the past years, the rapid growth of the Web and multimedia determined a shift of Computer based Educational Technology towards the Web. Virtual universities express the Web based educational resources. A Virtual University offers the same set of services to its clients as a real university does.
The educational technology components uses the services offered by the Virtual University. The services of Virtual Universities are implemented by different platforms, software tools and components. This paper presents the implementation of a Web based Virtual University using Java technology.

2. Web based education

Web based virtual universities are considered as the future environment of educational technology [1]. The educational potential of the Web covers all aspects of educational technology. Web offer to the educational technology include repository of teaching materials, course administration (lecture schedule, course attendees, assignments, reports), course delivery (explanations, interactive demonstrations, use of multimedia and virtual reality), on line student interactions in experiments and simulations, on line assessment, on line feedback, student - student and student - lecturer computer mediated communication.

Out of Web based education benefit the students, the lecturers and the organizations. Students benefits include direct access of a large amount of information, instant feedback, assessment and evaluation, working anonymous, direct interactions in simulations, more involvement and more responsible about the learning process. Lecturer benefits relates to time savings for research, for course design and teaching material improvements, for assignment design and evaluation. Institutional advantages of Web based education include: savings in teaching costs, increasing number of students, better educational quality, flexibility in use of time and space.

Viewed from the outside the main advantages of Web based education over the classic education can be stated as:

- No timetable constraints. The students can take the courses whenever they want.
- No classroom constraints. The students are not constrained to be all present at the same time into a classroom;
- A student can progress over the teaching materials at his / her own speed;
- The principle "develop once - use anywhere" can be use for course and teaching material development;
- No limitation for the number of students enrolled to take a certain course;
- No geographical limitation of taking courses;
- Web based education is an effective and low cost solution;

Figure 1 shows the place and role of a Virtual University in the context of Educational and IT Technologies. Open Distance Learning (ODL) is a special case of Educational Technology with particularities and constraints related to course delivery, communication, evaluation and assessment. A Virtual University implements the ODL paradigms and constraints using Web oriented technologies.

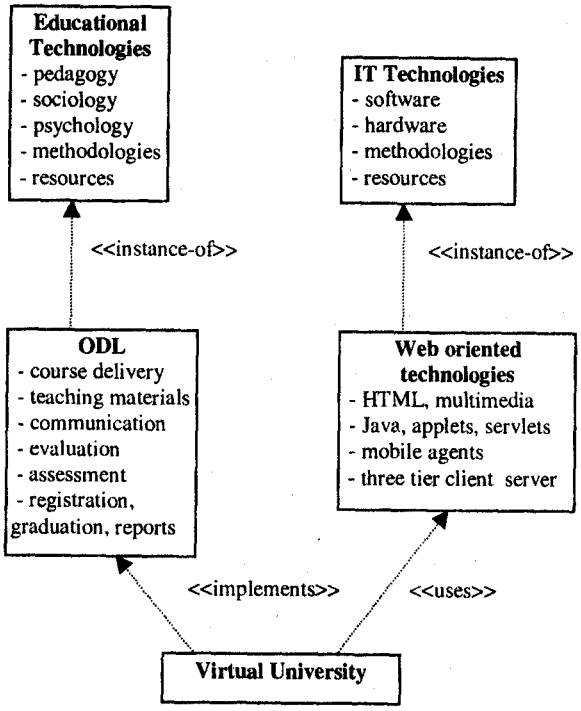

Fig. 1 Virtual University development context

3. Three tier architectures

Three tier architectures are best suited for implementing Web based virtual universities. A three-tier architecture consists of three independent architectural layers: presentation level (also known as client level or first-tier), functional level (middle-tier) and data level (back-end). A service requested at the presentation level is passed for processing to the functional level. The necessary data are supplied to the functional level by the back end level. After the processing is done, the functional level passes the results to the presentation level, which will display the result in a friendly way to the user. The middle-tier server is multithreading and it can process several requests at the same time. The first-tier consists of the client desktop on which a Web browser is running. The second tier (layer) is the Web server that contains the semantics of the application. The third tier contains the data servers for the application, including database servers linked to the Web server through bridges

(ODBC or JDBC). The three-tier model implies a high level of scalability, allowing the use of several Web servers and the automatic client switching from one server to another in a transparent way for the client.

The main advantages of three tier architecture:

- the presentation level (first-tier) may not know the SQL language, so the data structure at the database level (back-end) may be changed without affecting the first tier. At the same time, for the data level, different data models can be used (relational, hierarchical, Object-Oriented, etc.).
- the existence of separate software entities at each level allows the development in parallel of each level
- the resource allocation is more flexible because the middle-tier can be changed dynamically according to the needs
- the middle-tier can be also used by other applications.

A three-tier architecture disadvantage is the increase of the traffic inside the network.

4. Virtual Educational Services

The UML use case diagram for the Virtual University, presented in figure 2, shows the main actors and use cases involved.
Manage Site use case interacts with the Virtual University "Administrator" actor. "Manage Site" includes functionality for reporting, backup and update services.
Classroom use case interacts with the "Student" and "Academic" actors. "Classroom" functionality is the heavy part of the Virtual University. "Classroom" uses "Authentication", "Course delivery", "Communication" and "Evaluation" use cases. (figure 3).

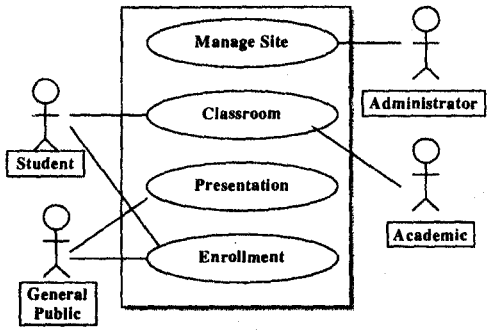

Fig. 2. Virtual University use case diagram

Authentication is implemented by means of a User ID and Password. Each enrolled student is assigned a unique Used ID and a Password which are stored in the administration part of the database. This prevents unauthorized access to the virtual university services.

Course delivery ensures the presentation of educational materials to the students using interactive, adaptive and multimedia facilities. The educational material and resources (useful references, multimedia and VRML players, etc.) reside on the Web, on the University Web server or back-end tier (local or Web wide). All course delivery process and associated resources are managed by the Virtual University implementation of this service.

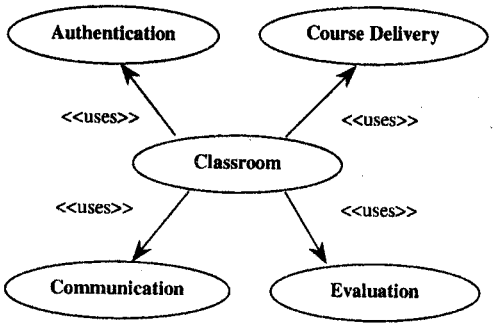

Fig. 3. Classroom use case

Communication service uses Computer Mediated Communication to provide one to one (individual interaction), and many to many (class interaction) communication:

- Individual interaction uses e-mail for student to student or student to tutor asynchronous communication.
- Class interaction is achieved by audio/video conference provisions and a chat space for synchronous communication.

Evaluation and Assessment. Virtual University provides the necessary environment for Computer Aided Assessment (CAA) including computer adaptive testing (CAT). The Virtual University implements the necessary provisions for both push and pull testing techniques. In the push technique, the lecturer at the central site decides when and how to test the students, while in the pull technique, the individual student decides when and how to be tested. The Virtual University implementation also allows the use of mobile agents for testing and evaluation [2]. Experiments were carried out using aglets, Java mobile agents.

Presentation use case includes the services available for the general public like the virtual tour of the university, facilities, services and other university related issues.

Enrollment defines "how to enroll" as a Virtual University student and register to a certain course. The enrollment form (figure 4) is locally checked (at client level) by a Java Script function, then passed to the middle tier servlets for validation and saved for long term persistency in the database. Some of the enrollment data is further used by the Virtual University security system.

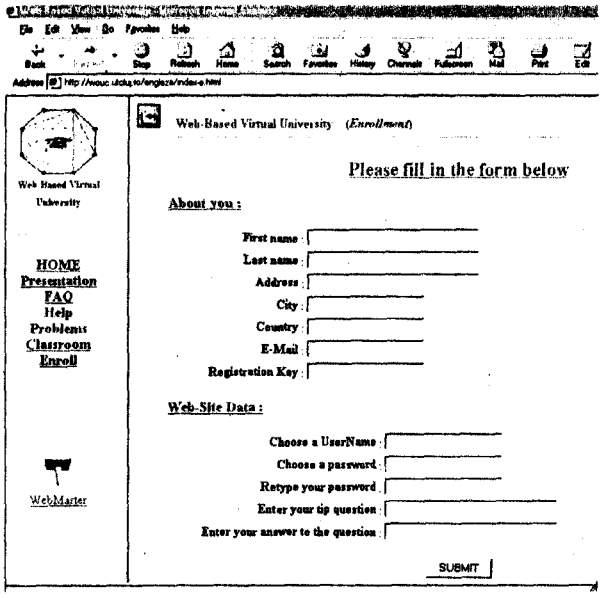

Fig. 4. Enrollment form

The Enrollment process is described in the figure 5 by an UML activity diagram.

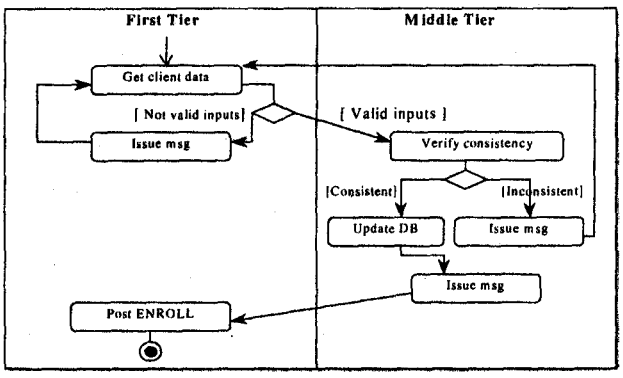

Fig. 5. Activity diagram of enrollment process

5. First-Tier (Client Level)

First tier structure and resources are presented in figure 6. The browser is the essenti resource at the client level. The Browser must be JVM enhanced and JavaScript co compliant.

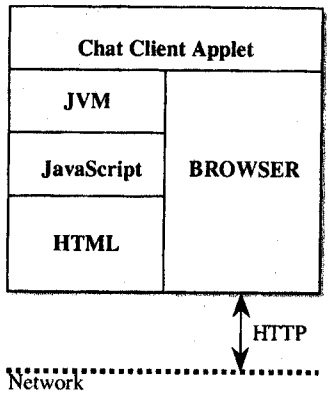

Fig. 6. Client side resources

The entire first tier resources are based on HTML (Hyper Text Markup Language). Java Script offers a wide set of objects for local processing of the information in the Web pages. By locally preprocessing of the client data, JavaScript increases the bandwidth effectiveness by reducing the first-tier middle-tier traffic. Chat client is implemented as an Applet which is downloaded from the middle tier and executed at the client side. The applet is targeting the one to one, one to many and many to many synchronous communication among the virtual university actors (students, professors, tutors).

6. Middle-Tier

Usually, the middle-tier level contains the application logic. All Virtual University services and GUI resources are implemented at the middle tier level (figure 7).

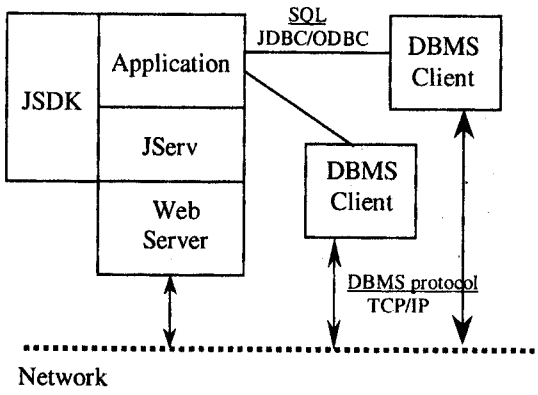

Fig.7 Middle tier resources

Web Server is the client's input gate to the Virtual University resources and services. Middle tier services implementations are based on servlets. In order to allow servlet running at middle tier level the Web server must be servlet enhanced. For example, the popular Apache Web server can be used with the JServ module to become servlets compliant.

Servlets are server-side agents meant to enhance the Web server functionality. For example, a servlet can be used for taking data from an HTML entry form (filled in at the client side), followed by processing the data according to the application logic (at the middle-tier server side). Servlets are to servers what applets are to browsers. The basic servlet structure and behavior is described in the JSDK API framework.

Middle tier also hosts the DBMS client for communication to the data store located at back-end tier. The Application – DBMS client uses SQL- 2 compliant statements through the native JDBC or through a bridge (for example JDBC/ODBC).

7. Back-end Tier

Back end tier is the data tier. It is usually supported by one or more database engines from different vendors and the associated data stores (figure 8).

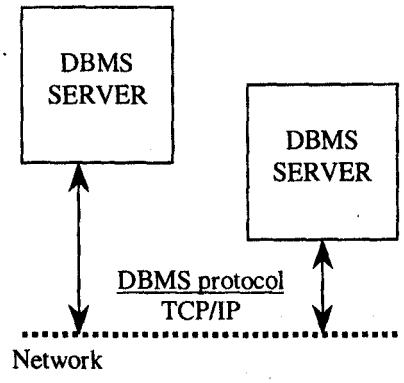

Fig. 8. Back end resources

The UML deployment diagram of Virtual University aetive processes is shown in the figure 9.

8. Middle tier service implementation

The application logic at the middle tier level is implemented by Java servlets. Servlet technology has several advantages over classic middle tier CGI technology:

- ease of development
- automatic garbage collection
- faster throughput and response
- inter-servlet communication
- only one servlet instance in memory - the first time a servlet is requested, it is loaded into the web server's memory space; subsequent client requests for the servlet result in calls to the servlet instance in memory
- threading facilities - servlets can use threading to process multiple requests efficiently if the JVM embedded in the web server offers thread support

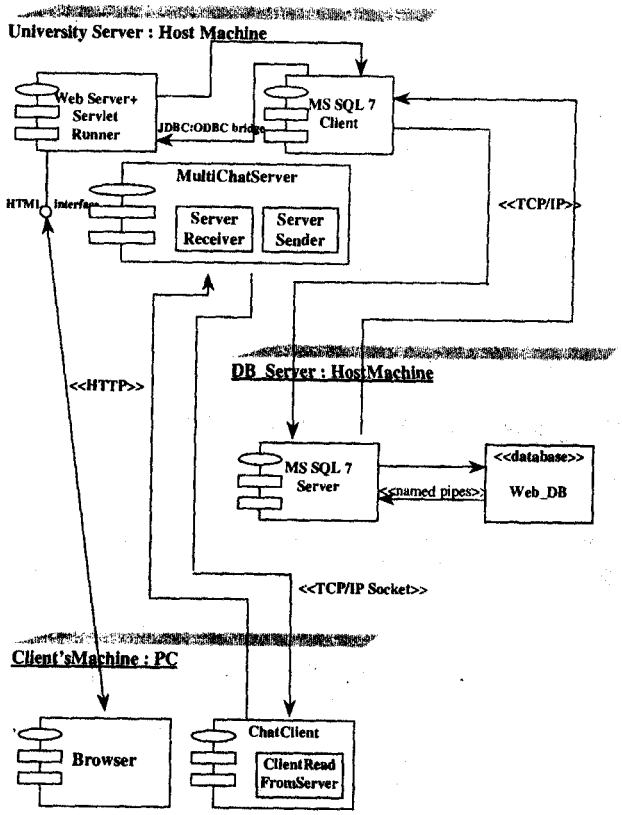

Fig. 9 . UML deployment diagram of Virtual University active processes

9. Client, Middle-tier, Data tier interaction

Servlets are effective substitutes for CGI scripts - they provide a way to generate dynamic HTML documents that are both easier to write and faster to run. Servlet technology is already supported by many popular web servers.

The role of a servlet in middle tier interaction with the client and the data tier, as the most general servlet task, is presented in the form of a UML sequence diagram in the figure 10.
The "http servlet call" from the client, invokes a specific servlet at the middle tier level that will accomplish the client request. The servlet will connect to the database engine (according to its access rights) for data read/write.
After the local processing of the query result, the servlet will embed the data into a dynamic generated HTML document.

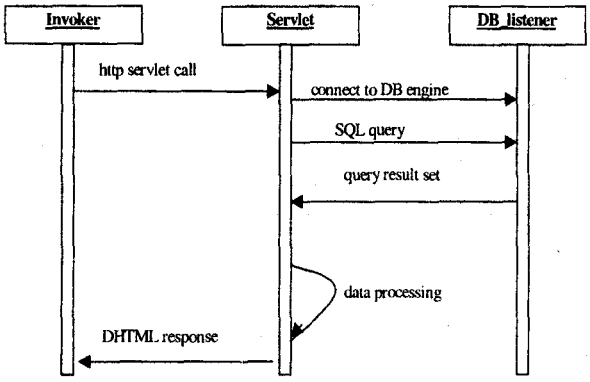

Fig.10. Middle tier interactions

10. Computer Mediated SYNCHRONOUS Communication

The synchronous communication for the Virtual University is implemented by a chat application. The chat application consists of a chat server, handling all the clients on the chat line and a Java applet as chat client.

The chat server is a multithreaded server application that listens on a certain port for TCP/IP connections from clients. It can handle a large number of clients, depending only on the resources of the host machine. The communication with the client is standardized using special designed frames. Each frame has the same fields for parametric behavior and depending on the field information certain actions are performed.

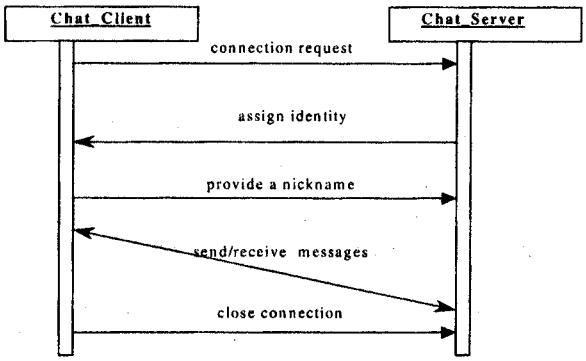

Fig.11. Chat communication

The chat client connects to the chat server by means of TCP/IP sockets. The only things that a client needs to know in order to connect to the server are the host name of the machine on which the server runs, and the port on which the server listens for connection requests. The connection-communication process (figure 11) is similar to a handshake protocol. The client requests for a connection, the server assigns the client an identity number and asks for the client nickname. After the clients provides the nickname he can start exchange messages. When finished, the client will close the connection.

11. Conclusions and future development

The virtual university offers the necessary environment for easy implementing different educational technologies using Web oriented technologies.

The Virtual University (http://www.coned.utcluj.ro or http://wouc.utcluj.ro) was developed in the framework of a Phare Tempus project IB_JEP 13467-98 and successfully experimented for short courses on European Matters to geographically distributed target groups. It is a flexible educational framework that allows active learning, co-operation and knowledge building.

The Virtual University was implemented using the following software resources: Windows NT OS, Java Development Kit (JDK) 1.2, Java Servlet Development Kit (JSDK) 2.0, Apache Web server, Apache JServ Servlet Engine, MS-SQL 7.0

For future development we plan to extend the evaluation and assessment virtual university service by using mobile agents, to ensure a better teaching material copyright protection and to consider the integration of CORBA based Object Web technologies.

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