# E-LEARNING IN MEDICAL ENVIRONMENTS USING INTELLIGENT TUTORING AGENTS

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**Abstract – e-Learning in the health care sector is soaring. Indeed, e-Learning tools are becoming so popular, that the organizations, like university ones, are keen to their subscription. Increase of productivity, efficiency and quality of service are the main challenges. On the other hand, education and training are strategic objectives. Simulation also plays a fundamental role in e-learning, information technology exchange and management. Therefore, this work it is presented in the context of an electronic system that enables the integration of highly heterogeneous information into a coherent knowledge base, oriented for the health care arena.**

***Keywords:*** ***Multiagent Systems, e-learning, educational aid, web, tutoring agents.***

## I. INTRODUCTION

Technologies as broadband networks, hypermedia, virtual reality and artificial intelligence constitute the founding base of the so called e-learning world, a quaint reality. Information and knowledge systems developed under the form of front-ends supported by WEB technology have proliferated like mushrooms. In fact, small farms of e-learning sites in the Internet exist that integrate and distribute information worldwide, namely to physicians, patients or students, just to name a few. They have developed themselves in a way so ubiquitous that they are becoming victims of their own popularity.

Technological problems associated to the problems related to maintenance of a high number of specific sites directing the stream of information, knowledge and services and serving several users have been well described in the literature [1]. To eliminate these drawbacks working is being done on the consolidation and integration methodologies of multiple small WEB sites in an only entity: the so called e-learning holding portal (**portal** is a new internet word that started to catch up very strongly in the last few years. It refers usually to a main guide that includes a search engine, plus additional content, such as current news or entertainment info, designed to keep someone at the portal for as long as possible). Operational efficiency and cost reduction can be achieved using holding portals thru information centralization, directing business or educational processes, and linking users for eventual collaboration, going from the e-business, e-procurement, e-health up to e-learning.

The vitality of a holding portal lies in its integration potential, in support of communities of virtual entities and in the gathering, organization and diffusion of information. Any good strategy for the creation of such an engine should capitalize in this point. The departments, schools, or entities have generally different architectures, different people in charge, and duplicated information. Thus it would be desirable to join these different states into one (i.e., in terms of a holding).

## II. MEDICAL TEACHING

Today more than ever, learning medicine is a huge challenge. It requires developing a vast range of manual, intellectual, visual and tactile skills as well as taking into account large amounts of factual information. As the result of medical research we assist to a constant impact upon clinical practice. Continued medical education is essential. Traditionally, medical teaching is based on texts, lectures and bedside teaching, with self-guided individual learning from books being the mainstay. It is believed that traditional medical teaching and individual learning in particular, can be complemented with electronic systems delivered on the Internet/Intranet. If implemented, these systems can present a variety of advantages:

- Interactivity (the learner has control over the learning process);

- Timeliness (fast and continuous update of content);
- Simultaneous access to textual, visual and audible information (multimedia);
- Non-linearity (information can be presented/ retrieved in flexible sequence through hyper linking (intranet as well as Internet);
- Self-assessment (the system can provide immediate feedback on the learner's advances, which enhances motivation);
- Tutorial assessment (instructors can review the learner's progress objectively and continuously);
- Quality control (results from the various levels of assessment can be used to improve the system); and
- Can support individual and small-group learning.

The most important advantage of electronic systems in teaching is that it opens the road to increased involvement of the learner. The learner can set the pace, choose the content and select the mode of presentation according to the requirement of his/her individual preference and situation. Awareness of the knowledge constructing process is increased, as well as the satisfaction gained from learning. As an overall result, medical teaching can be more effective and efficient.

In order to achieve these benefits, electronic systems in medical teaching must meet certain requirements. On the infrastructural side, client/server network architecture is required, where a *data center* holds the data warehouse, medical data (e.g., medical imaging) and most of the specific software agents that deliver medical content. This approach facilitates continuous content updates and assessment. The network should allow fast transfers with low latencies to avoid waiting times. Finally, the client computers where the learners work on should be easy to set up and economical. Fortunately, the new academic and Hospital networks currently being built will meet these requirements. Thanks to the availability of commodity standards that the internet is founded upon, we will be able to implement the system on widely available, scalable network hardware. On the client side, internet technology will ensure platform independence. This is important as it keeps down costs of ownership and allows adapting to the rapidly developing marketplace for computer hardware and system software.

## III. E-LEARNING

The electronic learning, which it will de referred from now as e-Learning, can be defined basically as the electronic systems in teaching/learning that are produced through web technology. Among its components we can include distributed contents in multiple formats, learning experience administration, network community of apprentices, content developers and experts. Thus, the term e-Learning refers to the use of Internet technologies to provide an extensive spectrum of solutions that improve knowledge and performance in teaching/learning, based on three fundamental criteria [2] :

- It is produced in network, a fact that makes it capable of an instant updating, enabling the recovery, distribution and use of shared information and knowledge;
- It is provided to the final user's through a computer using standard Internet technology;
- Centres itself in the most extensive vision of learning (solutions of learning that go beyond the traditional paradigms of teaching, with a growing emphasis in an informal type of learning in function of the demand [3]).

One of the main impacts of e-Learning in University education resides in the fact that it provides opportunities to create resources that turn the learning process flexible. This implies a different relation between teachers and students and even between institutions, in the sense that the students participate on their own formation and the vertical hierarchy tends to become increasingly more horizontal. With relation to this theme, some of the main changes enabled by the use of Internet technology in the e-Learning process are:

- Access to contents in digital format that can be accessed, stored, distributed, shared and updated instantaneously. In this manner the student's access to more structured educational resources and better oriented to its needs is enabled;
- Support for associative and group work using the connections provided by the computer's network. Consequently a more intense communication among students will be possible through the support of the new communicative tools (e.g., videoconference, chats);
- Articulated communication using e-mail that permits students to contact with experts and colleagues through the Intranet. Likewise, writing an e-mail forces rationalise in a concise and articulated way. In this way a greater interaction among students and teachers will be possible; and
- Virtual experimentation environments using new types of practices in the learning process, like simulators. Development by the students of new competencies and practical abilities in virtual investigation laboratories.

## IV. Multiagent Systems

Multiagent Systems (MS) set a new paradigm in problem-solving via theorem proving; i.e., agent-based computing has been hailed as a significant break-through in problem solving and/or a new revolution in software development and analysis. Indeed, agents are the focus of intense interest on many sub-fields of Computer Science, being used in a wide variety of applications, ranging from small systems to large, open, complex and critical ones [4][5]; i.e., agents are not only a very promising technology, but are emerging as a new way of thinking, a conceptual paradigm for analyzing problems and for designing systems, for dealing with complexity, distribution and interactivity; may be a new form of computing and intelligence.

Although there is no universally accepted definition of agent, in this work such an entity is to be understood as a computing artefact, being it in hardware or software, that exhibit properties such as:

- autonomy; i.e., whereby such entities have the ability to act without the direct intervention of their peers, namely humans;
- reactivity; i.e., whereby such entities are situated in an environment that they can perceive through sensors and act in reaction to stimuli (e.g., revising their beliefs according to or in reaction to new inputs);
- proactivity; i.e., whereby such entities exhibit intelligent problem solving capabilities (e.g., planning their activities in order to achieve short or long term goals); and
- social behaviour; i.e., whereby such entities are aware of one another, can interact with one another and may modify their behaviour in response to others; can communicate via a set of low or high level constructs and protocols as well as means of addressing and direct communication; can cooperate in order to achieve joint as well as individual goals, what this means is that they must have the ability to negotiate with other agents either to accomplish their own goals or to joint plans to achieve common goals; to perform belief revision in the context of additional sources of information provided by their peers.

To develop such systems, a standard specification method is required, and it is believed that one of the keywords for its wide acceptance is simplicity [6]. Indeed, the use of intelligent agents to understand students and their knowledge, and to infer the most appropriate strategy of teaching from the interaction with the students offers the potential to set an appropriate software development and analysis practice and design methodology that do not distinguish between agent and human until implementation. Being pushed in this way the design process, the construction of such systems, in which humans and agents can be interchanged, is simplified; i.e., the modification and development in a constructive way, of multiagent based e-learning systems with a human-in-the-loop potential aptitude is becoming central in the process of agent-oriented software development and analysis [7][1](Figure 1).

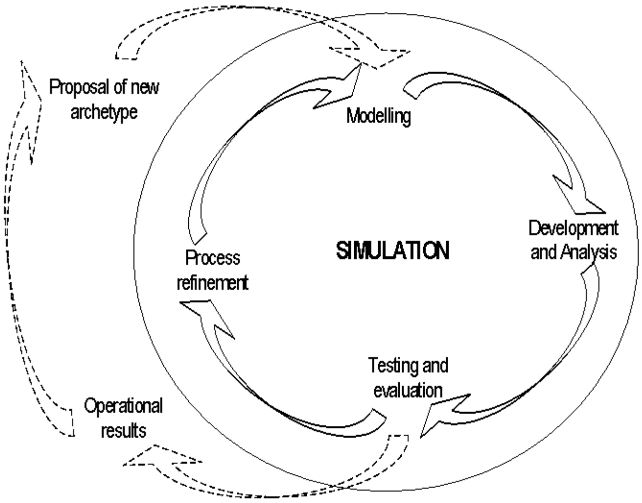


**Figure 1** - The process surrounding the development of agent-oriented software in teaching environments.

These systems have provided a clear means of monitoring the agent's behaviour with significant impact in their process of knowledge acquisition and validation [8]. This type of model will be now applied in the development of intelligent agents that will support the e-learning system.

## V. Intelligent Tutoring Agents

One of the present approaches in the fields linked to electronic systems in medical teaching and Artificial Intelligence (AI), as agent's software and multiagent systems, is the design of tutoring agents that supervise the user's actions in a data processing environment to provide aid. Specifically, tutoring agents are interface agents that cooperate with the users (e.g., students, health professionals) to reach an objective [9][10].

The idea is that computers could be employed to understand students and their knowledge, and to infer the most appropriate strategy of tutoring from the interaction with the students. Nevertheless, several factors delayed the development of the intelligent tutoring agents as for example the scarce knowledge they had then on cognition and human learning. These systems progressed following the progresses of knowledge in these areas. The transition of intelligent tutoring agents in laboratories where they where investigated in real applications has shown to be a fact for the majority of investigators. Still, some of the original challenges presented in this field are not fully resolved, as for example the problem of adapting the environment to the needs of the students [11].

The complexity problem of intelligent tutoring agents design is due in part to the monolithic architecture in which it is based. An approach to the design of these systems, and others inside the AI field, tries to resolve this problem applying a strategy of the type "divide and conquer", which give rise to the so called multiagent systems or agencies [12]. These types of systems are formed by a series of agents that work like computational entities with complete autonomy and that communicate among themselves to carry out a concrete task.

To incorporate in this architecture a certain degree of user adaptability, enabling personalized learning, intelligent agents should be developed in such a way that each agent adapts itself in function of the system's necessities [13][14][15][16] (Figures 2,3,4). By **intelligent** we mean that the agent pursues its objectives and executes its tasks so that it optimizes some measure related to its good performance [17][8][18].

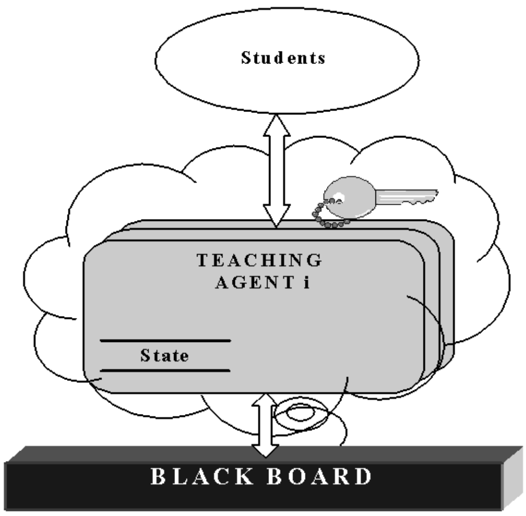


**Figure 2**- Tutoring Agents


**Figure 3**- The Tutoring Agent – A Study request for Diagnostic Purposes

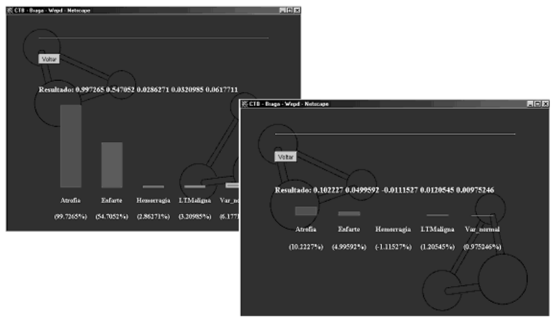

**Figure 4**- The Tutoring Agent – Presentation of diagnosis generated by the System

## VI. OVERALL SOFTWARE STRUCTURE

Designing software for the medical arena represents a great challenge. At the core of the system lies the data warehouse and a large amount of data (e.g., medical images, video, or text). This information is complemented with the knowledge base that defines its structure and classifies and defines the relationships between its parts. The next level consists of the multiagent system that accesses the information and presents it according to the meta-information and the specific task they are designed to do, which could be anything from pure textual referencing to a guided tour through a defined subject matter, to a three-dimensional annotated image reconstruction of an organ system (e.g., the students and health professional's interfaces). Another class of agents will allow updating and adding to the content database: authoring tools and medical data, and in doing so, will have to assure consistency within the meta-information (e.g., the medical equipment and the necessary teaching resources) (Figure 5).

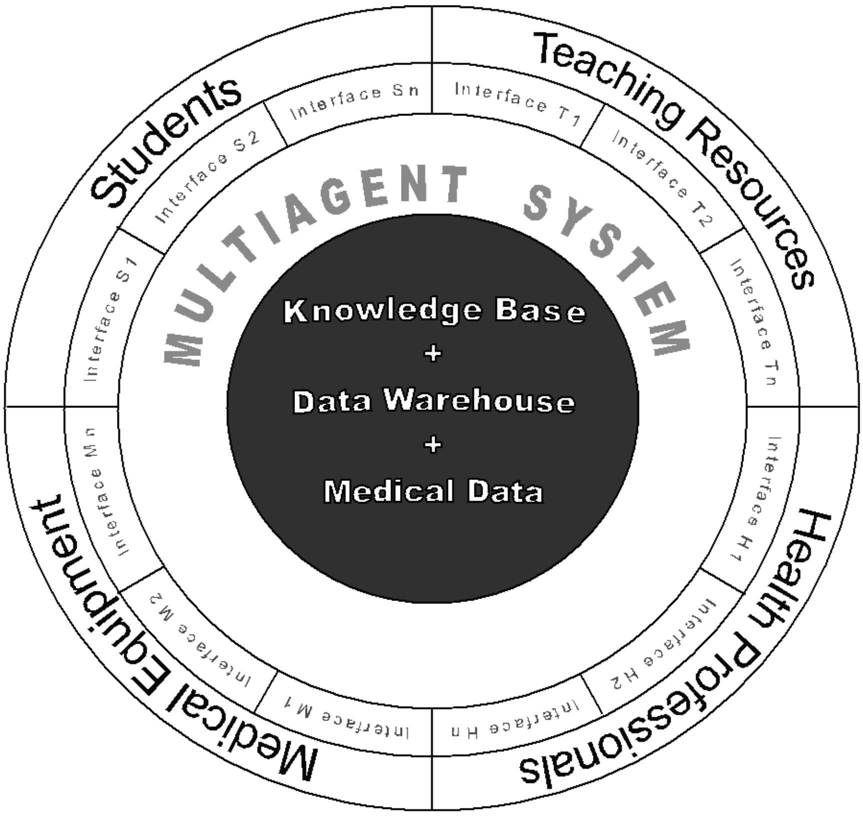


**Figure 5**- Software structure layout

In terms of the internal representation of the information, suitable formats are available. At this early stage of the project, several options are kept open, but only when medical standards are not available. It is mandatory to have great flexibility in the automated database manipulation process, avoiding the risk of fixation on certain vendors of software and/ or hardware, and scaling well as the project grows.

### VII. MEDICAL DATA

The options in terms of implementation were to cover the medical imaging field going from data acquisition and storage to physicians, teachers and student's interfaces. The AIDA system, an Agency for Integration, Archive and Diffusion of Medical Information [5], and is at work at several main health care facilities in the north region of Portugal (Figure 6). It stores imaging studies linked to the radiologist's reports, which resulted in a huge database. This data is, an immensely valuable resource for teaching. This work takes also under consideration the problems related with the protection of the patient's data: images and all other medical data therefore must be anonymised before it can be used in a teaching system.

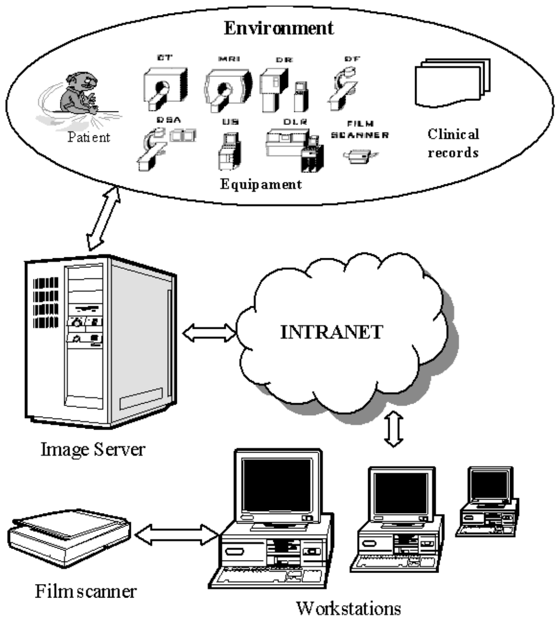


**Figure 6**- Archiving and communication system

The development of our tutoring agents was initiated with the intention to convert this huge repository of information into a knowledge base for e-learning. This knowledge base will form the foundation of a digital network based teaching system in the area of medicine.

## VIII. The Multiagent System

An architecture is then envisaged to support the medical teaching in terms of electronic learning systems, a form of a web spider of an intelligent information processing system, its major subsystems, their functional roles, and the flow of information and control among them, with adjustable autonomy[19][20][7]. Indeed, many complex systems are made up of specialized subsystems which are understood as intelligent entities or agents that interact in flexible, goal-directed manners, and are understood as theories [21]; i.e., the intelligence of such a system as a whole arises from the interactions among all the system's entities [22]. The general architecture of such a system is given below, through a brief description of the different types of agents involved:

- the Proxy Agents (PAs) which provide the bridges between the users and the system in terms of the questions that may be formulated, explanations that may be required, decisions that may have to be taken and/or view of final results. The system's interfaces are based on Web-related front-ends using HTML pages, that can be accessed using a standard Web browser (Figures 3,4);
- the Decision Agents (DAs) which present mediating capabilities, act by accepting a task from the PAs. They may decompose it in sub-tasks, sending them to be processed in the CAs, integrating later the results (returned by the CAs) (Figure 7);
- the Computing Agents (CAs) which accept requests for specific tasks from the DAs, returning the results;
- the Resource Agents (RAs) which present all the necessary knowledge to access a specific data resource (Figure 8); and
- the Interaction and Explanation Agents (IEAs) which act based on argumentative proceedings which are fed with data and/or knowledge coming either from the PAs or the DAs. Note that the execution plans received from the DAs may be partial, so that only upon a completion of a task a trace can be compiled and an explanation can be delivered to the PAs and/or DAs (Figure 7).

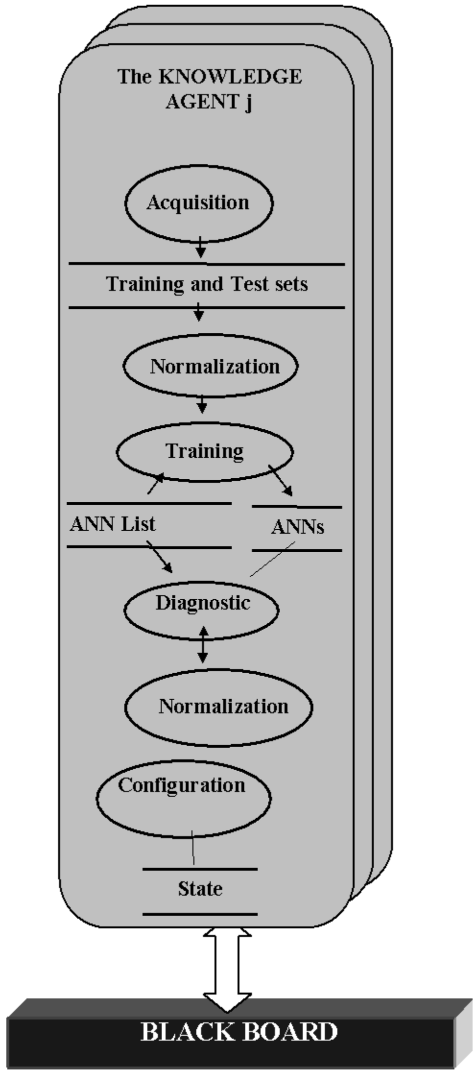


**Figure 7**- Decision Agents

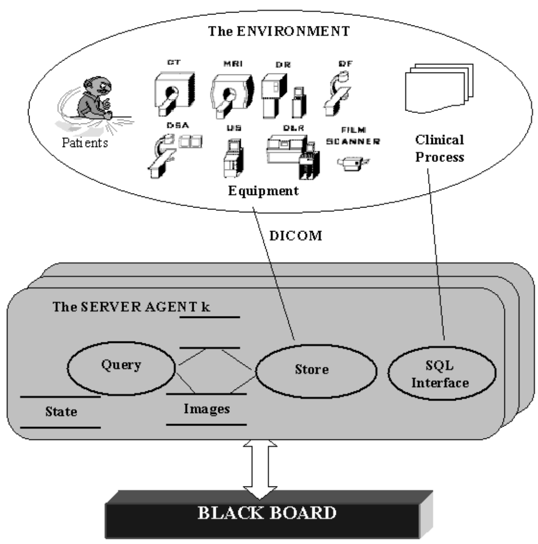


**Figure 8**- Resource Agents

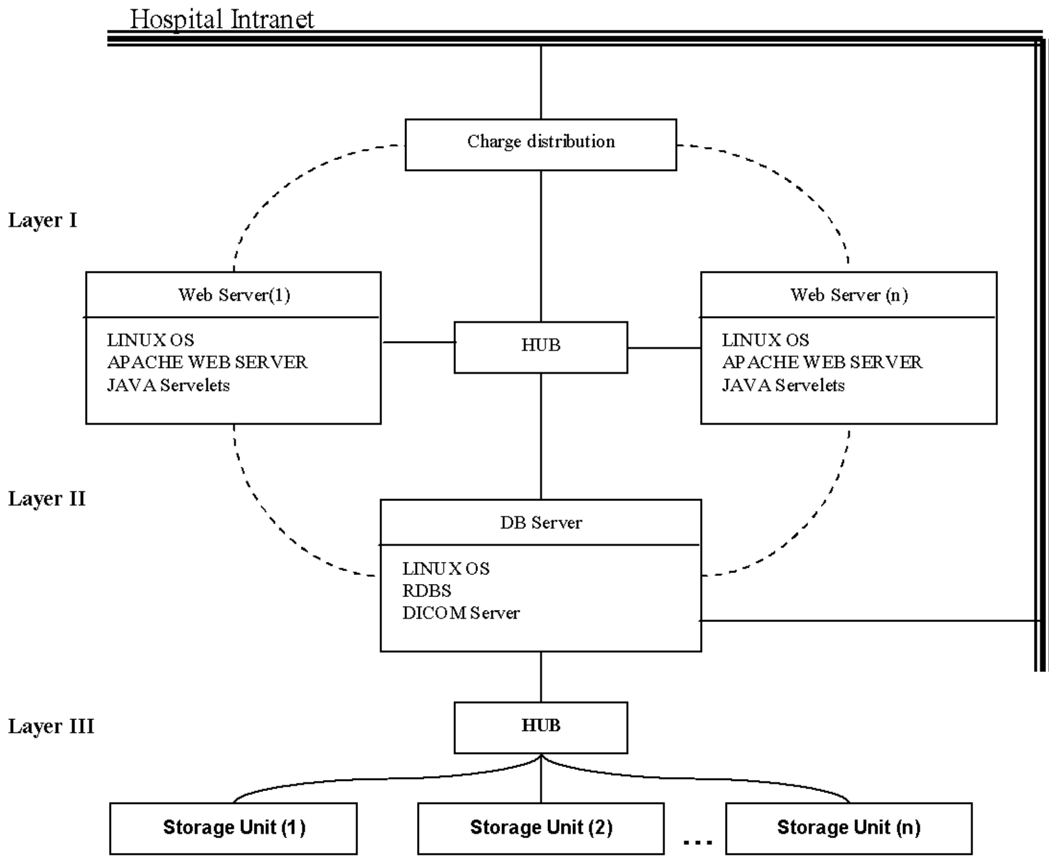


**Figure 9**- A three layer computational architecture

Here are critical features like system's failure or system's breakdowns, so that a scalable three layer computational architecture was conceived (Figure 9):

- **Layer I** - Web applications server's layer where the users interface and the system's software will run;
- **Layer II** - Data Base and application server's layer where the medical data acquisition and handling software will run; and
- **Layer III** - Storage server's layer where the data will be archived (e.g., medical images, clinical data, reports).

In the table below it is given an overview of the technologies used.

**Table I**- Development technologies used

| Technology | Objective |
|---|---|
| Oracle version 9, Tools: WebDB | Relational Database |
| Linux | Operating System |
| PHP for Oracle | Web programming language |
| Apache | Web server |
| Adobe Acrobat (PDF) | Document format |
| Java Servelets | Web programming language |
| C (GTK) | Server, Knowledge and resource agents programming language |
| CGI and PERL | Monitor and Tutoring agents programming language |
| DICOM Services | Storage, Send and Plug-in |

## IX. Conclusions

This work discusses the impact of recent advances in problem solving methodologies that use multiagent systems when applied to the development and evolution of e-learning systems in the medical arena.

Currently, the development of these type of systems enables the supervision of user actions in a data processing environment to provide aid. In this context, the recent advances in the multiagent field has been reviewed and an example of its use in medical imaging teaching, has been presented.

## X. Acknowledgements

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