Agents Based Modeling of Distant Biology Practical Work

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ABSTRACT

In order to demonstrate the use of our virtual laboratory platform, which has an agent based architecture proposed in our previous work, we have chosen one of the applied sciences: biochemistry. Among the practical works required in this course is an experiment to determine the protein concentration by colorimetric. The objective of this work is to design and implement the remote practical work that we are interested in. The use of agent technology is beneficial to us since the agent is a natural metaphor of human and is well suited for distributed systems. MaSE (Multi agent System Engineering) methodology is used to develop this system. In this context, the tool has to support the creation of digital work environment where learners collaborate and cooperate among themselves to achieve the various stages of this practical work (PW).

Key Words: Virtual labs, Distant Practical Works, Biology PW & MaSE.

1. Introduction

Our research is concerned with distance teaching and more precisely the virtual laboratories. The latter are digital environments aiming to simulate the training experiments that help in understanding the practical aspect of discipline such as Physics, Chemistry…etc. They also offer explanations and clarification of the concepts and the laws used to describe and explain the covered phenomena in the simulated experiments. A virtual laboratory is defined according to [1] as a digital work space where distance collaboration is allowed and research experimentation to produce and deliver results using distributed information of the new communication technologies.

Our first attempt which is based on an intuitive approach was the development of the general design of a virtual laboratory prototype for the remote experimentation and telemetry on the Web [2].

In order to achieve the goals aimed to by this general structure, the analysis and design phase is seen as very important step which makes the agent methodologies essential. Consequently, in [3], we proposed a generic architecture based on agents which allow the learners to carry out distance PW and experiment with virtual devices.

The aim of this work consists in developing a specific virtual laboratory for a particular discipline and a specific PW based on our generic virtual laboratory. In order to validate the multidisciplinary agents based architecture suggested in our previous research [3, 4], the work in this paper is focused on the application of MaSE [5] to biochemistry PW which is concerned with determination of the protein concentration using the dosage colorimetric technique. This methodology is composed of two phases: the analysis phase and the design phase. Each phase has its own diagrams describing the static and dynamic aspects of the system.

In this article, we start by describing the agent based architecture proposed in our earlier work [4]. Also a short description of the PW to be modeled is given. Then we present a conceptual view, using MaSE methodology, of a digital work environment for virtual laboratory intended for learners to perform distant PW. The collaboration/co-operation aspect is very important and is taken into account by this research.

2. Application Of Agent Architecture In Biology PW

2.1. Distant PW Multi- Agent Architecture

Figure 1 shows the agents based generic architecture of a platform for virtual laboratory. In this architecture, one distinguishes two categories of agents. The first category is the set of agents that handle action related to (interact with) human users: learners and teachers. A learner user interacts with three artificial agents: Interface-Agent, Navigator-Agent and Assistant-Agent. The teacher interacts with two artificial agents: Interface-Agent, and Navigator-Agent. The second category is the set of agents that manage and control the virtual objects and the virtual environment where the experiment will take place: Workspace-Agent, Captor-Agent, Archivor-Agent, Supervisor-Agent and Server-Agent [4].

In this work, we will show how can we use this architecture for a specific PW in Biochemistry to demonstrate its effectiveness.

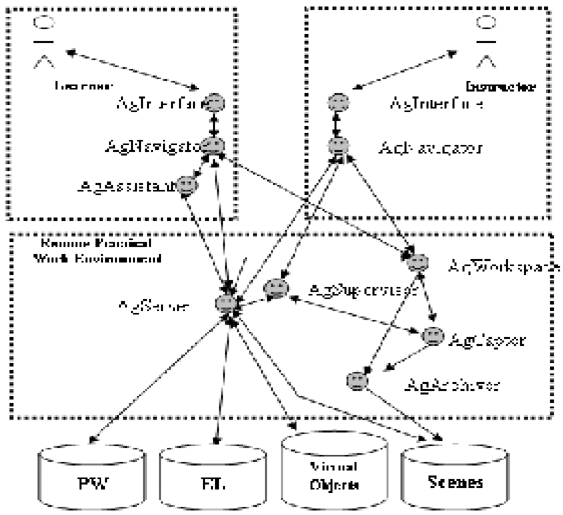

Figure 1: Agent Based Generic Architecture of a Distant PW

2.2. PW Description

The PW objective is to determine the concentration of a solution of a given protein. For that, the PW must be composed of two parallel phases one is called the range standard and the other the sample to be used. Each phase is made up of several steps which require a solution of a known concentration of the considered protein as a reference or a standard compared to the protein which one wants to determine its concentration and a reagent solution is used to develop a coloring while reacting with specific amino-acids of these proteins. The range standard makes it possible to plot a straight line standard: absorbance = F (quantity) using a series of tubes that contain an identical volume of water but known quantities (different values that increase from one tube to the other) for reference protein. In parallel; a series of tubes that contain various volumes protein specimen, which we want to determine their concentration (the sample to be tested), is prepared. The reagent's solution is added at the same time in all the tubes so that coloring develops under the same conditions for the range standard and the sample to be tested. The absorption of all the tubes is then measured. The proportionality absorption/Quantity makes it possible to determine the quantity of protein contained in a volume of the sample specimen. From this we deduce the protein concentration.

2.3. Modeling using MASE

2.3.1 Goals Hierarchy Diagram

The principal objective of the goals hierarchy diagram is to summarize and organize the system functionalities in a tree structure form of the main and secondary objectives [6]. The main aims of our MAS are shown in the diagram below [Figure 2].
This system offers to the learner the possibility of consulting the PW statement, performing the experiment as a purpose to determine the protein concentration. As it was stated previously, this experiment is done in two parallel phases which leads to the aspect collaborative/co-operative between learners from the same group.

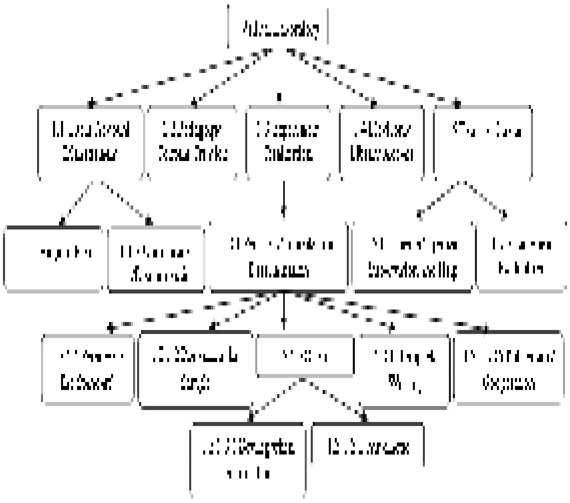

Figure 2: Goals Hierarchy Diagram

Also, this system makes it possible for learners to write reports about their PW. They can also save the various scenes that occur when they are performing the PW. In addition, it allows the teachers to supervise the activities of groups of learners in real or differed time. In order to do this, the teachers consult a database of the scenes which were archived systematically.

2.3.2 Use Cases Diagram

The use cases define basic scenarios that the system supports. They reflect the vision of the MAS behavior offered to the user. They are extracted from the initial functionalities, the users' remarks or any other existing source.
The various use cases, deduced from our system, classified based on the kind of user are shown in the figures below [Figure 3, Figure 4].

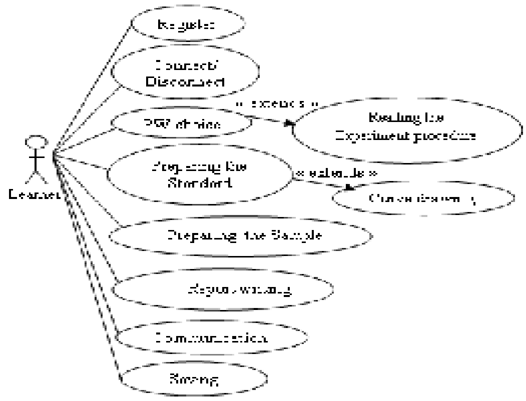

Figure 3: Learner's Use Cases Diagram

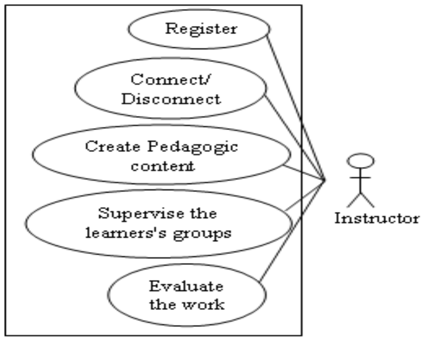

Figure 4: Instructor's Use Cases Diagram

2.3.3 Sequence Diagrams

Our sequence diagrams describe the use cases, for each use case previously established a corresponding sequence diagram must be built. This makes it possible to specify how the system functionalities are implemented from the collaborative and temporal point of view. The sequence diagrams in MaSE according to [6] indicate the interactions between the roles. These interactions are described as messages sending.

For the set of our use cases, we defined the following roles:

- The role R_Interf (Learner/Teacher): concerned with the tasks of access to the interfaces between the user (learner or teacher) and the system: to load the appropriate interface, to transmit information to the various agents and ensure the communication between agents.
- The role R_Server: is responsible for the set of tasks concerning the database access.
- The role R_ Assistant: takes care of the help tasks of a user (learner/teacher), assist the learner in the PW realization and the teacher in his/her tasks.

- § The role R_ Captor: collects the processes invoked by the learner user.
- § The role R_Archivor: is responsible for recording tasks (Scenes of work/report).
- § The role R_Workspace: creates a workspace and allow its use when learner wants to perform a PW.
- § The role R_Supervisor: supervises the groups of learners who are performing a distant PW.

Figures 5 and 6 show, respectively, the sequence diagram of the PW preparation phase and the diagram which describes the learner's manipulation process and the collection of the obtained results. The roles taking part in these sequences are: R_Workspace, R_Server, R_Assistant, R_Captor, and R_Archivor.

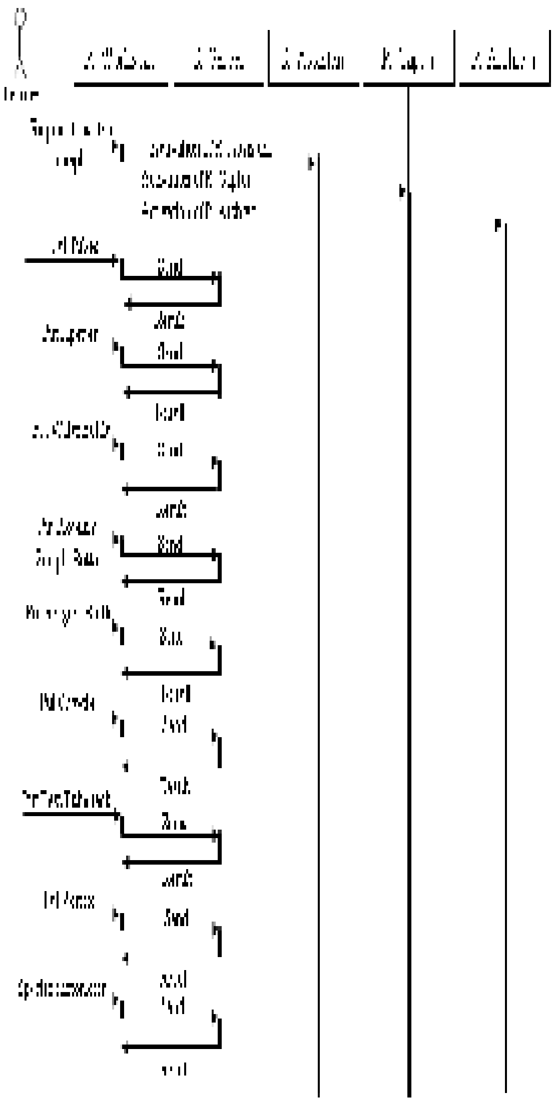

Figure 5: PW Preparation Phase

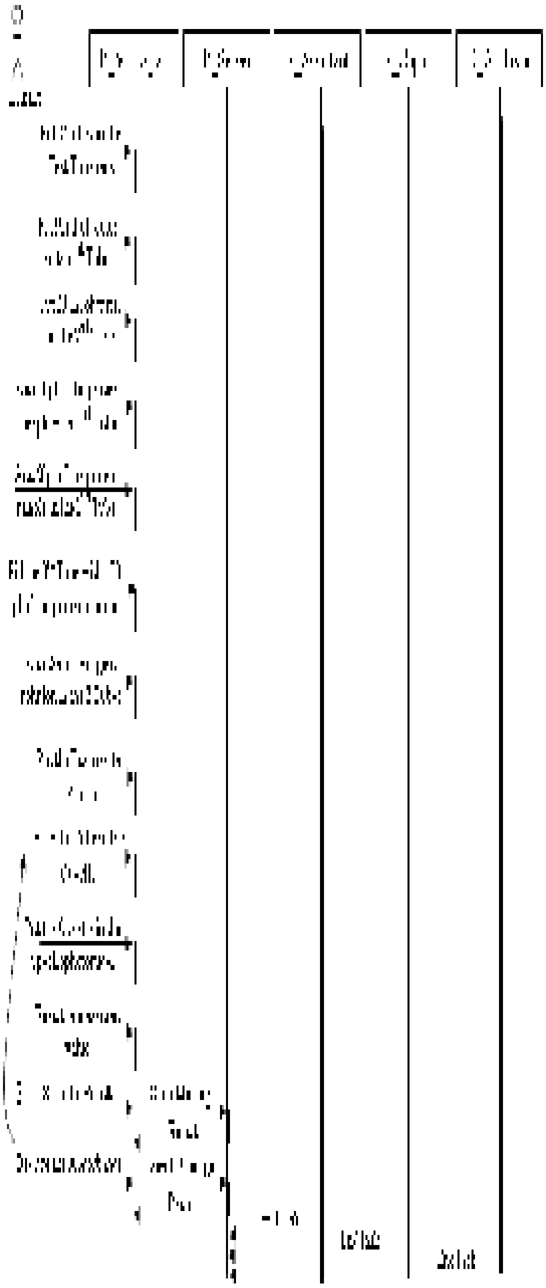

Figure 6: Learner's Manipulation Process (Sample Preparation)

2.3.4 Interaction Diagram

The concurrent tasks describe the means for the roles to achieve their goals. They are defined by finite state automata (or Petri networks) in which the roles will become the agents during the implementation phase [6]. An example illustrating the various transition states through which the workspace role goes while manipulating virtual objects involved in the experiment is shown in figure 7.

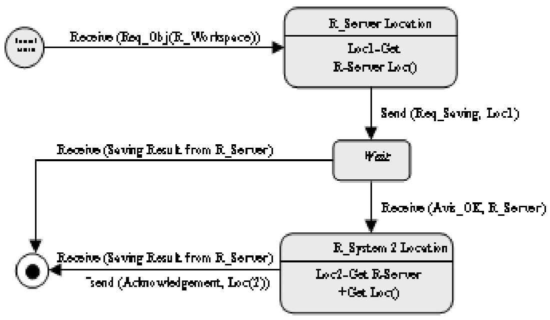

Figure 7: R_Workspace Transition State

2.3.5 Agents Classes Diagram

The agents' classes are created based on the roles identified and specified during the analysis phase. An agent class is defined as being an extension of an object class which can play several roles, and has attributes and methods. In our MAS, we associated each role to a different agent class. The agents obtained in our system are those proposed in the MAS architecture [4].

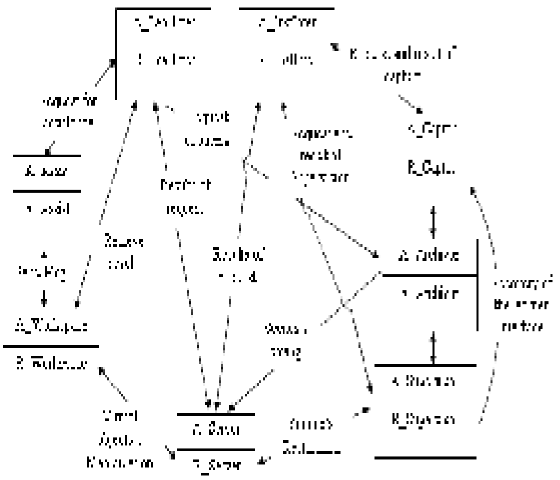

Figure 8: Agent Class Diagram

3. Data Model

The static aspect of this system is presented by a data model describing the manipulated databases. The diagram is composed of two distinct parts: educational organization structure and the part connected to the modeled PW. It is sufficient to describe only the second part. We consider a PW as being a composition of several phases; each phase is composed of several steps. A set of virtual objects is made available for the learners. These virtual objects have two types: material and solution.

The set of the virtual objects used for the realization of this PW is shown in figure 9.

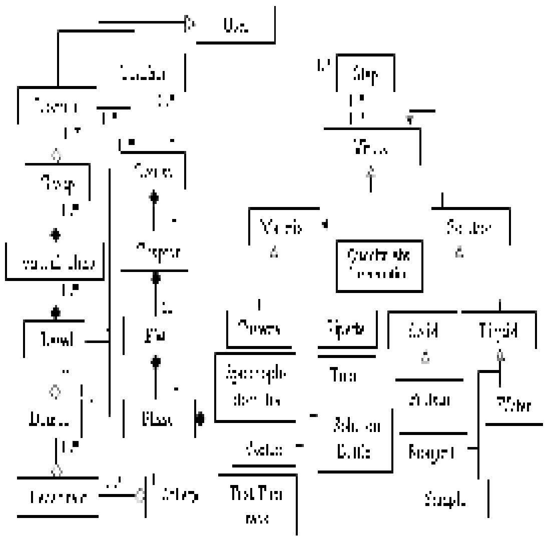

Figure 9: Data Model

4. Cooperation/Collaboration Aspect in this PW

The processes of co-operative work and collaborative work constitute two interesting concepts. When the students' team is confronted with a common task, however a distinction, between these two concepts, should be mentioned to clarify the matter. Researchers generally agree that there is a main distinction between collaborative work and co-operative work based on the concept of task sharing. In the case of co-operative work, usually the understanding is that the main task is divided into sub-tasks and each team member will take care of one of these sub-tasks. But for the case of collaborative work usually it means a participation of the team members to accomplish the common activities [7] [8] [9].

The aspect of collaboration/co-operation is one of the principal characteristics of the PW being considered. First, learners from the same group cooperate among themselves to realize the PW; each learner is individually responsible to execute the various steps of the concerned phase (The standard or Sample to be measured). After finishing the two phases, the learners, in a collaborative way, combine the intermediate results to write the PW report which will be submitted to the teacher for an eventual evaluation. The co-operation/collaboration points of this PW are illustrated in figure 10.

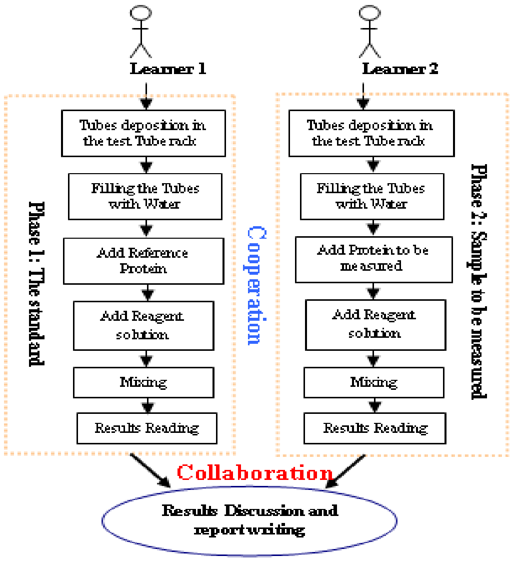

Figure 10: Collaboration/cooperation points

5. Conclusion

In this paper, we presented a specification of a virtual laboratory generic architecture. It is a model based on agents of a biochemistry PW using MaSE agent methodology. The choice of the PW is based on the fact that it is divided into two parallel phases which allow the groups of learners to work in collaboration/co-operation. Based on this work, we could deduce that this architecture is well adapted to biology discipline. In the future we will study the possibility to use this architecture in other practical disciplines such as Physics, Automatic… and so on.

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