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Designing of Virtual Laboratories Based on Extended Event Driving Simulation Method

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***Abstract*—**Here are many methods for designing and implementation of virtual laboratories, because of their special features. The most famous architectural designs are based on the events. This model of architecting is so efficient for virtual laboratories implemented on a local network. Later, service-oriented architecture, gave the remote access ability to them and Peer-To-Peer architecture, hired to exchanging data with higher quality and more speed. Other methods, such as Agent-Based architecting, are trying to solve the problems of distributed processing in a complicated laboratory system.

This study, at first, reviews the general principles of designing a virtual laboratory, and then compares the different methods based on EDA, SOA and Agent-Based architecting to present weaknesses and strengths of each method. At the end, we make the best choice for design, based on existing conditions and requirements.

***Keywords*—**Virtual Laboratory, Software Engineering, Simulation, EDA, SOA, Agent-Based Architecting.

I. Introduction

A virtual laboratory is a simulated environment which enables students and professionals to do the exercises and experiments of the classroom, or to perform research experiments virtually [12][1]. Using virtual laboratory has several benefits including the followings:

- Low level of cost: with the use of a virtual laboratory, we can build up the laboratory and its materials - which are expensive by themselves- at a low level of costs [2][3].
- Safety during experiments: it is possible using virtual laboratory to work with dangerous and toxic materials without any danger for the user or environment [2].
- Flexibility: using virtual laboratory enable us to make changes in the work environment, procedures, or the type of the experiments, as fast as possible and with low cost [12][2].
- Accessibility: with the use of internet and computer networks, we can access to the virtual laboratories from anywhere and in any time [12][3].
- Collaboration: it is possible to perform distant team cooperation in a virtual laboratory, so that individuals who are geographically distributed can share their experiences [3].

Virtual laboratories are classified into two major categories named "virtual reality" and "Telerobotic". Laboratorial systems which are based on the concept "remote control of the robot", are usually used for performing experiments which are dangerous for the personnel (like microbial experiments) or experiments in which access to the laboratory environment is hard for the personnel (like space experiments). The greatest branch of the "virtual reality" knowledge is simulators, which are used widely due to their several benefits [12][4].

In a survey on students of the University of Charles Sturt who were using virtual laboratories, the following statistical results were obtained [5].

Table I
Research Results Of Using VL In University Of Charles Sturt

Question	Average
The virtual lab helped you to become familiar with the layout of the lab building.	5.7
The virtual lab helped you to be able to identify items of apparatus.	5.5
The virtual lab helped you to be able to locate items within the lab.	5.1
In its current form, you would recommend that new students use the virtual lab prior to their first laboratory experiment.	5.2
If the virtual lab allowed you to carry out virtual experiments, you would use it prior to laboratory sessions to practice the experiments.	5.4

As we can see from the results, most of the students were agree to use virtual laboratories before doing experiments in a real one. In addition, most of them were agree to use virtual laboratories for doing their exercises and obtaining experiences.

II. Virtual Laboratories Architecting

Generally it is not possible to present comprehensive regulations for designing and implementing virtual laboratory software [6]. The first experience in the field of virtual laboratories is the one of Wolf (1996) who mentioned the fundamental requirements in them, based on computer networks. In 1997, Johnson et al conducted researches in order to collect the requirements of a virtual laboratory and suggest an integrated structure for it. They identified descriptive characteristics of a virtual laboratory as an open environment and suggested a theory for designing it. By using workflow diagrams, Czerkierda suggested a CORBA-based multi-layer architecture based on operation separation of a piece [7]. Pataso et al introduced JOpera and added automatic

computing techniques to optimize the virtual laboratory. In JOpera, there is a graphical environment for monitoring and debugging the distributed computing operation.
The general design of virtual laboratory architecture is shown in fig.2 [6].

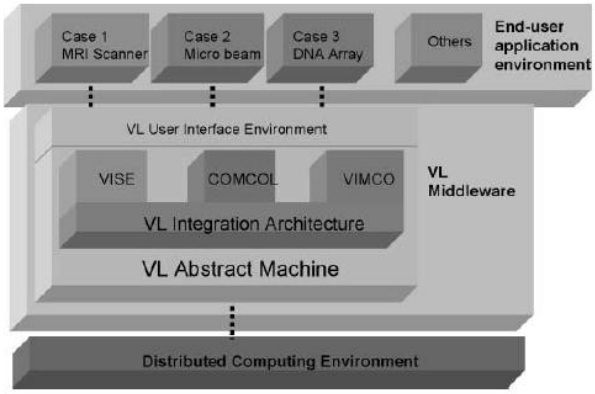

Fig. 1 The general design of virtual laboratory architecture

Based on this architecture, a virtual laboratory is made up of following components:
• End-user application environment: end-user application environment is comprised of all application software and environments (experimental scenarios) in the experiment in hand. The task of this layer is to support operations and functions of the experiments. In environment based programs, this layer provides required tools and equipments to design, develop, and create a virtual laboratory. In addition, it provides an interface for developing several parts of a virtual laboratory, in an independent and parallel manner. This improves scalability and openness characteristics of the laboratories. In addition, providing ability to use a common language for developing and applying different parts of a virtual laboratory is one of the tasks of the layer.
• Middleware: middleware is a virtual machine which helps users to define and apply their experiments. This environment acts as an interface environment between distributed computing environment and programs of end-user, and makes the vastness of the environment invisible to the end user. This layer performs the task of request management, process distribution, and system transparency.
• Distributed computing environment: the task of this layer is to support the effectiveness of services and equipments, based on a wide architecture and optimal usage of available resources. Computational and communicational parts of this layer create a network of short delay and wide band tools and resources to store, recover, and process the information.

III. Event Driven Architecting and VLs

EDA (event driven architecting) is a pattern of software architecture which is based on creating, discovering, transmitting, and responding to the events [7]. An event in this architecture can be defined as “being aware of changes in states” [7]. Event driven architecting naturally has the synchronization characteristics [8]. Therefore, designing programs based on event driven architecting enables the systems to perform parallel and non sequential processing and so have better operation and shorter response time.

Event driven architecting is suitable for control systems of equipments like sensors, controllers, or environmental operators which sense the changes in the environment or system, and reports them to the related system or service by sending the events. The most applicable fields for EDA are user graphical interface, synchronization, real-time systems, and parallel processing [7][11]..

IV. Service Oriented Architecting and VLs

In order to exploit the benefits of SOA (service oriented architecture) in designing a virtual laboratory, we need a framework for designing of a virtual laboratory, which is based on SOA. This framework, which is suggested by Dick Penn, can be described as Figure2 [9].

In this architecture, repository has the task of an information management system with the architecture of knowledge based systems. Virtual laboratory information, including information and structures related to attributes, domains, and executive contexts of all units are kept and managed in this unit. As one of requirements of SOA, a service selector has the task of evaluating, measuring, selecting, and introducing an active optimal service as service provider, which provides the required services. Register unit has the task of gathering and providing a list of available services, just like in traditional systems which is presented in UDDI standard[9].

V. Agent Oriented Architecture and VLs

EDA is not suitable for systems with many decision points [1][11], because it is needed to identify scenarios and reaction chains for every path, which is impossible for huge simulating systems. Nowadays, to overcome this drawback of EDA, agent oriented systems are being used in systems with many decision points [1].

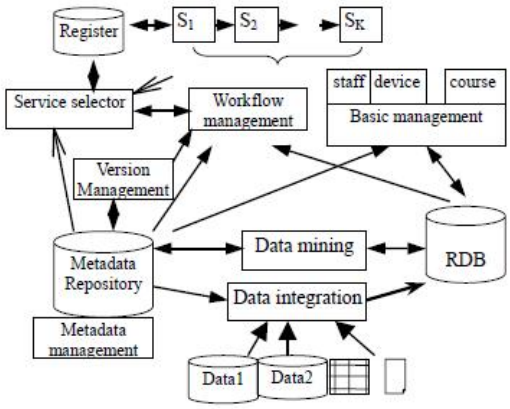

Fig. 2 A VL framework based on SOA

This method uses agents with ability to making decisions, analyzing, and performing logical reactions in their operation area. In this method, making decisions in each point gets done by its own agent. Therefore, decision problem, which is a centralized problem, becomes a distributed one. Since a web based virtual laboratory is of open distributed environment type [2][3], we can effectively use agents in it [1]. In event driven systems, moves and decisions of the system are typically predetermined. But in agent oriented systems, these predetermined decisions of the system as a hole are confined to defining regulations, operations, and borders which system should follow. Therefore, this being predetermined is not as solid as for event driven systems [8]. In addition, nowadays due to the differences and distributions of the systems, it is impossible to control them by a centralized structure, and so it seems necessary to use agent oriented architecture in all systems [10]. Agent oriented system proposed by Mackta et al for a virtual laboratory is shown in the following figure [3]:

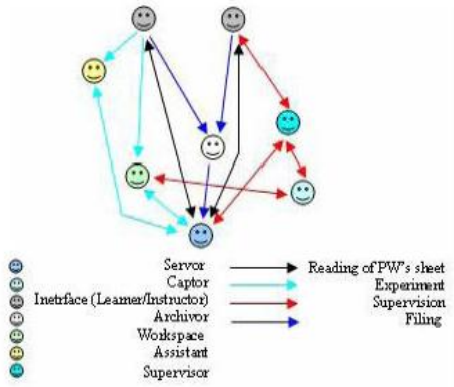

Fig. 3 A VL framework based on Agent Oriented Architecture

Based on this design, each agent has the following tasks:

• Interface agent: managing, creating, and displaying pages suitable for each user

• Help agent: helping and guiding the student during performing an experiment

• Supervisor agent: controlling and managing the acts of a group of students, based on logs taken by capture agent

• Capture agent: logs several stages of an experiment performed by a student

• Archive agent: keeping traces of the students, for future uses by teachers or editors, in order to update the experiments and identify the amount of progress of a group of students

• Workspace agent: providing a suitable environment for performing the experiments and controlling them

• System agent: managing user profiles and reports of the teachers, classifying application projects, managing databases, and controlling accessibilities

VI. Conclusion

Based on several studies, the best architecture for a virtual laboratory is an event driven architecture. Major strengths of this architecture are synchronization and parallel processing, and its drawback is limitation of decision points in a system. With the use of service oriented architecture, it is possible to establish a web based virtual laboratory and to connect it to the internet. In order to overcome the problem of establishing a virtual laboratory in a complicated system with many calculations and decision points, the best choice is to use agent oriented architecture.

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