# Scaffolding for Activity Supervision and Self-Regulation in Virtual University

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## Abstract

Distance education has been an important research issue of multimedia computing and communication. Since the instructional activities are implemented on cyberspace, how to control behaviors of students and to increase the degree of communication awareness has been a challenging issue. This paper presents an advanced Petri Net model to analyze the workflow of a web-based multiple participants virtual environment. The presented approach not only can conspicuously help the developer to comprehend the interaction relationship between the client-server virtual environments but also to easily construct a shared virtual world. We proposed a system based on the scaffolding theory. Behaviors of students are supervised by an intelligent control system, which is programmed by the instructor under our generic interface. The interface is built based on virtual reality and real-time communication technologies. Students and instructors have their individual avatars that are controlled by a video game like navigation. Those behaviors that violate virtual campus regulations are detected and interceptive actions are performed. Problems of providing the multi-user interaction on the Web and the solutions proposed by the Petri Net model are fully elaborated here. This paper can be used as a basic/fundamental research framework and tools to study and understand the characteristics of e-learning and to explore its optimal education application.

***Key Words***: Virtual Reality, Distance Learning, Scaffolding Theory, Animation, Behavior Supervision, Real-time Communication

## 1. Introduction

In line with the growing popularity of distance education, we developed a series of distance learning software systems [1-4] based on Internet and Web browsers. These systems were used in our university among different departments. On the other hand, three-D graphics and the associated real-time communication technologies were developed and used in video games. Video games appeal to our younger generation. In addition, virtual reality and computer graphics techniques have been used in education and training [5-7]. Virtual reality can also help constructivist learning [8,9]. We tried to combine virtual reality and communication technologies with an educational theory to develop a VR-based situated learning environment, which facilitates and encourages students to use on-line discussions. We integrated our distance learning systems under a generic VR-based communication interface.

The network is constantly evolving and changing as applications they are developed especially in it facility for information communication and processing. The im-

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pact of network on media used in distance learning is illustrated in Figure 1 [10]. The diagram illustrates the various educational technologies used in distance education. It roughly situates each of technologies on the vertical access by the degree of interaction supported by the technology and on the horizontal access by the degree of freedom of time and distance allowed to participants in the interaction. It also shows the comprehensive power of the network to subsume almost all of the discrete capabilities of earlier technologies. The [11] expected that the virtual university itself will also be distinguished from

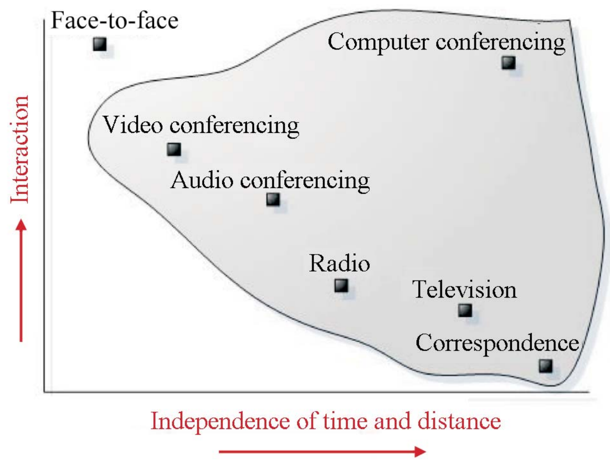


**Figure 1.** The impact of network on media used in distance learning.

the traditional universities along the following lines (As shown in Table 1).

We aim to develop an integrated distance learning system, which includes several frontier technologies to meet the needs of communication, analysis, and retrieval of e-learning related activities. The project is based on virtual reality (VR) and distributed computing, as well as the semantics analysis of French-based communication, which is based on a link grammar and corpus for an ontology construction. Toward the end of a three-year joint project among the participating universities, the group will deliver a runnable system, which can be used in a synchronized/asynchronized multilingual e-learning environment. Preliminary results of this joint project can be found at ELResearch.mine.tku.edu.tw.

This is also a joint project with the National Research Council, Canada. In the past few years, our team has a joint research project entitled "An E-learning Infrastructure for Mobile Virtual University" with NRC, Canada. It is a three-year project under the international collaborative program of the National Science Council, Taiwan and the National Research Council, Canada. Preliminary accomplishments and contributions of this project were presented in the 5th Anniversary Event of NSC-NRC Collaborative Research Program, Monday, June 24 – 25, 2002. Demonstration of our project in the conference is available at: http://www.mine.tku.edu.tw/

**Table 1.** Distinguishes between traditional university and virtual university

| | Traditional University | Virtual University |
|---|---|---|
| Instructional Pattern | Course credits, class schedules, contact hours | Competency exams, tutorials, certification |
| Classroom formats | Instructor meets same group of students during class period, courses held at 'central campus' | Instructor interacts with students over networks and face-to-face at ad hoc times and places, courses 'online' and at various locations |
| Administrative structure | Universities divided into schools and departments, which reflect divisional specialties, and programs | Universities built around 'pathways of study' and certification programs, faculty clustered in 'learning centers' and professional groups, as in medical and law practice |
| Student life | Baccalaureate and graduate degrees with majors and minors, residency or commuter campuses, student services geared to physical concentration of enrollees | Competency-related degrees and certification programs, 'virtual campuses' that make attendance in physical classrooms less frequent as well as crucial, increasing integration of school with the workplace |
| Economic structure | Income mostly from credit-hour tuition and sponsored research in large schools | Income from flat-rate, modular charges for degree progress and information industry 'entrepreneurship' |

NSC-NRC5/.

In the past few years, we have developed several distance learning related tools. Some tools are for synchronized distance learning while others are for asynchronized Web-based learning. For an overview, please visit our Web site: http://www.mine.tku.edu.tw/acm-mm-02-tutorial/. The distance learning tools developed include:

- An administration system
- A Web document development environment
- A mobile interface agent for persistent look-and-feel
- Course development and student assessment tools
- A courseware design tool using decision science principles
- Communication and annotation tools
- A video presentation and recording tool
- An augmented video conferencing Tool
- A Virtual Reality-based learning environment
- A mobile media server
- An on-line exam surveillance tool
- A wireless mobile learning tool

Figure 2 illustrates our conception of how these tools can be integrated into the generic system architecture. In general, the software architecture is divided into three layers - the application, the database, and the server layers. The application layer includes an administration system, which is an ordinary e-learning platform, to allow system administrators, instructors, and students to manage student records and courseware. On the left

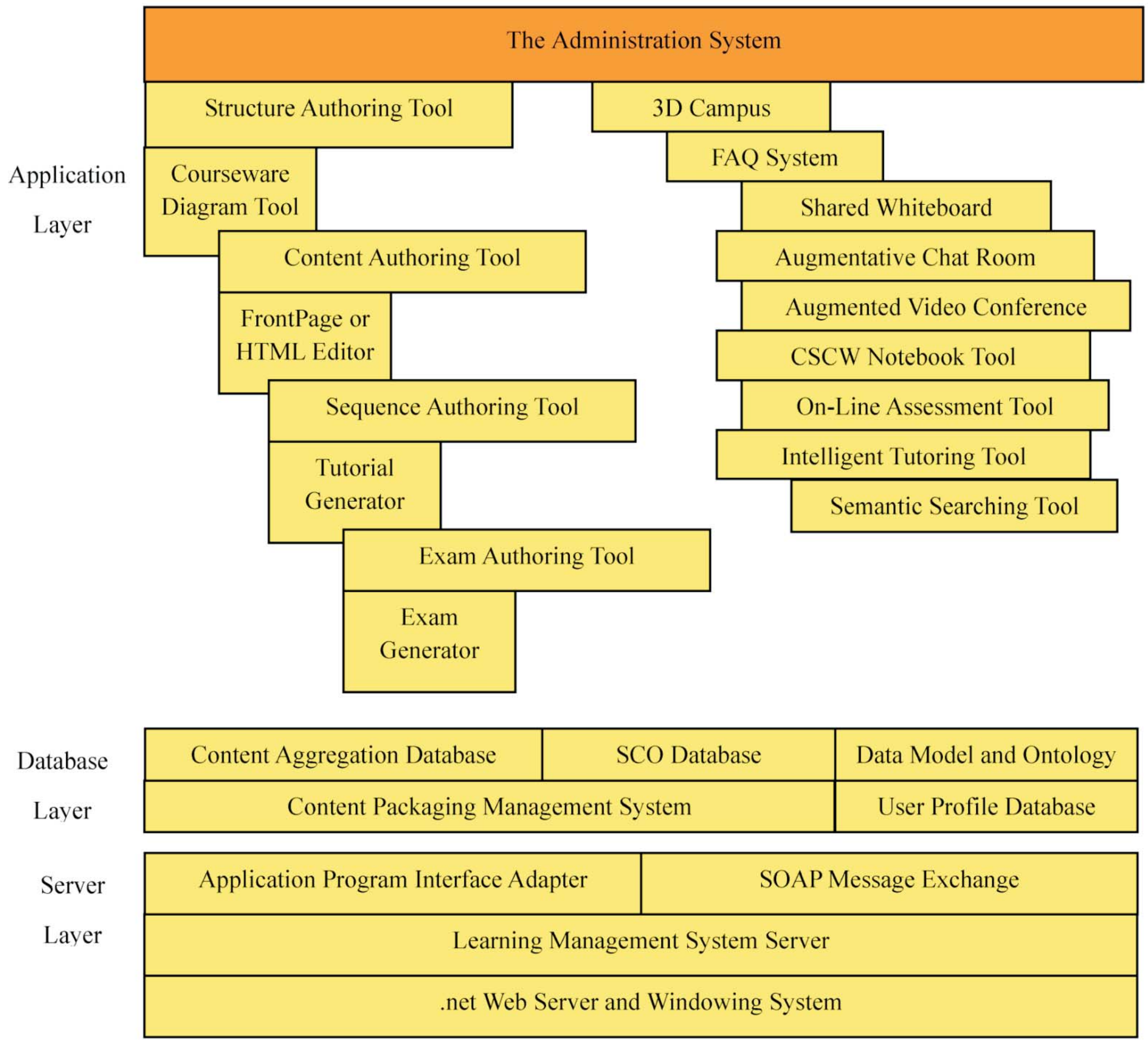


**Figure 2.** An Integrated e-learning platform based on SCORM and SOAP.

side blow the administration system, asynchronized distance learning tools will be incorporated. According to the standard of distance learning (i.e., SCORM), content aggregation (course structure) should be separated form the content. Thus, the structure authoring tool is separated from the content authoring. Another issue, which is not addressed completely in the SCORM 1.2 specification, is sequencing and navigation. Sequencing means a topological order an instructor prescribes to deliver his/her presentations. Navigation reflects an individual behavior of a student, w. r. t. an instructional sequence prepared by an instructor. We are investigating the sequencing and navigation of the SCORM standard (i.e., SCORM 1.3 released in the end of year 2002) to develop proper tools for the facilitation of content delivery. Assessment is another important issue in distance learning. IMS (i.e., IMS Global Learning Consortium, Inc. http://www.imsglobal.org/) has developed a specification proposal for assessment. Yet, the current SCORM specification (version 1.3) does not include much assessment information. Thus, it is necessary to look at the criteria of assessment from different perspectives, namely, the instructor, the student, and the administrator. An exam tool was developed in our team, with its mobility shown on a PDA. The developed system will be revised to follow the SCORM standard in the near future (i.e., version 1.3 and the above), and will be integrated into the proposed system.

On the right side of the big picture, below the administration system, this joint project will include synchronized distance learning tools. Yet, a few systems such as shared whiteboard, augmented videoconference, CSCW notebook, on-line assessment, and intelligent tutoring tools were developed. These applications will be integrated one by one into our big picture so as to form the complete distance education system.

The second layer in the big architecture consists of several database systems. The separation of content aggregations from Sharable Content Objects (SCO) is to follow the reusability methodology of SCORM. But, a content packaging management server should be built to enable reusable lectures to be packed into a Package Interchange File (PIF). These technologies rely on the SCORM standard. In addition, the ontology of courseware and user profiles (including student learning profiles) are stored as different database. The database layer can be implemented in a heterogeneous database environment through the open database architecture (such as ODBC or JDBC, connected to a SQL database server).

The third layer is a server layer, which also includes a Learning Management System (LMS, according to SCORM). We follow the SCORM specification, to deliver a run-time environment with a number of Application Program Interface (API) functions implemented under an API adapter. On the other hand, since SCORM is mainly developed for asynchronized distance learning, we need to adopt other standards in the development of synchronized tools. Fortunately, SOAP is an XML-based message protocol developed by W3C (http://www.w3.org). The SOAP envelope allows us to embed contents for communication through a standard manner. We aim to develop the system on a .net server, even though other open platform can also be considered.

E-learning system can create asynchronous communities of inquiry which have the potential to support the development of collaborative communities of learning, while still allow "anytime-anywhere" access by learners. There is every reason to believe it will transform teaching and learning. In this paper, we outline the philosophical perspective and social constructivism that frame our understanding of e-learning. The section 2 outlines the educational professional perspective and theoretical concepts that frame our understanding of e-learning. It also outlines a set of principles that guide a deep and meaning approach to e-learning. Activity supervision and behavior understanding model is proposed in section 3. The implementation consideration of the virtual university system is discussed in section 4. Finally, we will make a brief conclusion in section 5.

## 2. The Social Constructivism and the Scaffolding Theory

While we were looking for the essential needs of professional educators and students, in terms of "the useful distance learning tools," we found that lots of distance learning tools were developed by computer scientists. Most of these tools lack an underlying educational theory to support their usability. However, software is built for people to use. In spite of its advanced functionality and outstanding performance, any system will be useless if no one use it. Thus, we believe that educational professionals, with the help of computer scientists, should make the specification of a distance learning system. In this joint project, we strictly follow this principle.

Figure 3 [10] illustrated the multiple ways in which the network supports educational interaction, that present a diagram of six interactive dyads possible among three important actors in a formal educational context-students, teachers, and content.

Teacher-student interaction: the common and significant classroom behavior, many researches suggests that many of the qualities of interaction in e-learning context can be both defined and measured and have impact on learning outcomes.

Student-student interaction: collaborative and cooperative learning is available involved in modern virtual university. However, it is also known that some students actively choose distance learning forms-including e-learning - that allow for study that is independent of intense contact and the temporal restraints associated with paced and interactive forms of education delivery. E-learning expands the rich tradition of independent study associated with earlier generations of distance education and provides a variety of synchronous and asynchronous learning activities.

Student-content interaction: content can be expressed in text for reading on screen or on paper, but content is often supplemented with a rich variety of computer assisted

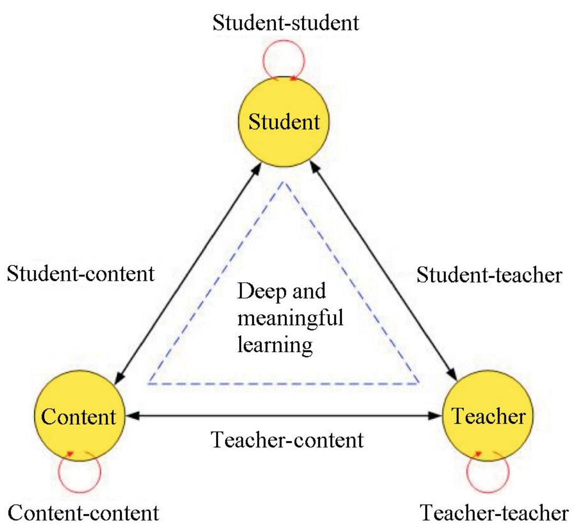


**Figure 3.** A diagram of six interactive dyads possible.

instruction, simulations, micro worlds, and presentation creation tools. Content can be animated and given agent-like properties of autonomy, volition, and can be programmed to take a more active part in student-content interactions. The development of learning heuristics that allow for adaptation by content in response to student performance and request allows for an individualized form of student-content interaction.

Teacher-content interaction: the development and application of content object has become an increasingly important component of the teacher's role in distance education. The semantic network provides facilities for teachers to find, utilize, and in some cases, create learning objects that are automatically updated by other content agents, or by emerging/integrating data. For example, content agents can also be built that will monitor, report, and create new content automatically.

Teacher-teacher interaction: the ubiquitous of communication tools (both synchronous and asynchronous forms) are providing unprecedented opportunities for teacher-teacher interaction.

Content-content interaction: computer scientists and educators are creating 'intelligent' programs or agents, that 'differ from traditional software in that they are long-lived'. Agents are currently being developed and employed to retrieve information, operating other programs, making decisions, and monitoring other resources on the network. In the future, we can envision that content is automated to update itself from various inputs and then to notify students and teachers when these modifications reach a significant level. Teachers will create and use learning resources that frequently improve themselves through the interaction of other intelligent agents.

We recognized the paradigm shift of learning theories from behaviorism, cognitivism, constructivism, to social constructivism. Social constructivism views that human knowledge is socially constructed through social interactions and meaning sharing. Knowledge is a product out of interaction. Thus, the importance of interaction with other people is strongly emphasized in the learning process. In a traditional educational environment, interactions mainly rely on face-to-face discussions; while in a distance educational environment, communication tools should be carefully designed so that the process of knowledge construction can be traced in a systematic manner to facilitate future analysis. A few types of computer-based learning were proposed:

1. Simulation-based Learning by Doing allows students to perform on-line experiments and learn from the consequence.
2. Incidental Learning attracts students to pay attention to instructions. Thus, learning becomes easier.
3. Learning by Reflection encourages students to be engaged in the process of inquiry. Responses or answers will be provided by computer programs or by a human instructor.
4. Case-based Teaching proposes situated based course content for particular topics.
5. Learning by Exploring allows students to learn from interaction, whether it is human-computer interaction or human-human interaction.

This joint project incorporates the above types of learning. We aim to develop a virtual reality-based environment to make learning easier. In one international conference, one of the keynote speakers indicated that it is possible to incorporate video game technology into distance learning. For younger generations, virtual reality based learning environment is attractive and friendly. Incidental learning is one of the solutions that we will try to realize. On the other hand, students pose questions from time to time during the learning process. The questions can be automatically answered by our tool except those in some ambiguous situations. Our FAQ auto-replier facilitates learning by reflection. We will develop case-based courses (e. g., French Literature and Data Structures), and create a situated environment to encourage on-line discussions among students. Finally, our semantics-based search system will allow students to explore WWW through human-computer interactions.

In support of the above learning types, we integrate a set of tools into a VR-based system. We carefully look at user requirements from the perspective of educational professionals. We realize that, it is possible to design an integrated learning environment to support the application of the scaffolding theory [12,13]. Scaffolding, proposed by L. S. Vygotsky [14], was viewed as social constructivism. The theory suggests that students take the leading role in the learning process. Instructors provide necessary materials and support. And, students construct their own understanding and take the major responsibility. Between the real level of development and the potential level of development, there exists a zone of proximal development. This zone can be regarded as an area where scaffolds are needed to promote learning. Scaffolds to be provided include vertical and horizontal levels as a temporary support in the zone of proximal development. Scaffolding is essential for cognitive development. It also plays an important role in the process of social negotiation. There are three properties of the scaffold:

1. The scaffold is a temporary support for the learner to ensure the success of a learning activity.
2. The scaffold is extensible (i.e., to be used in other knowledge domains) and can be offered through interactions between the learner and the learning environment.
3. The scaffold should be removed in time after the learner is able to accomplish the learning task independently.

The scaffolding theory indicates three key concepts. Firstly, in the zone of proximal development, the relationship between the scaffolds providers and the receivers are reciprocal. That means that the instructor and learners should negotiate a mutual beneficial interactive process. Secondly, the responsibility is transferred from the instructor to the learner during the learning process. Depending on the learning performance, the instructor gradually gives more control of the learning activities to the learner for the attainment of the ultimate goal of self-regulation. Finally, interaction is essential to facilitate learners to organize their own knowledge. Hence the use of language or discourse is crucial to promote reflection and higher-order thinking. In summary, the scaffolding theory implies the following instructional approaches:

- Learner-centered instruction
- Reciprocal collaborative instruction between instructors and learners
- Use of discourse and negotiation
- Scaffolds provided to support learning
- Increases of the level of motivation and learning abilities for self-regulated learning

As an instructor, there are several kinds of responsibilities:

- Selecting proper learning tasks
- Promoting common learning objectives

- Diagnosing learners' understanding and needs
- Providing suitable supports (e. g., inquiring, cueing, prompting, coaching, modeling, informing, discussion)
- Maintaining learners' motivation
- Monitoring the learning progress and providing feedback
- Encouraging experiments and managing frustration
- Facilitating internalization and transfer of learning

However, there are a few challenging issues for the instructor:

- Identifying the zone of proximal development for each individual learner
- Providing suitable support for the individual learner
- Specifying learning objectives for the individual learner
- Recognizing possible misconceptions and problems in the learning process
- Adopting dynamic evaluation of student learning
- Acquiring adequate class time to promote social negotiation and collaboration

## 3. Activity Supervision and Behavior Understanding Model

The goal of the shared Web system is to support interaction among clients over the existent WWW environment. By the seamless integration of the network-based virtual reality system into the WWW architecture, the shared Web system provides a boundless way to retrieve information over the web environment while the users are interacting with each other. Because of the distinct characteristics of the HTTP protocol, the existent WWW server uses the request-and-response technique for its clients to retrieve information. That is, the link between the server and the client is established only when a client issues a request to the server. In addition, this link is broken and forgotten immediately by the server after the requested information is sent to that client. Hence, there are intrinsic problems that must be solved to support the multi-user interaction over the WWW environment. They are Client-Information Recording, Server-to-Client Callback, Excessive Network Loading, and Virtual World Entrance. We will solve these problems while we develop the shared Web system.

The infrastructure of the shared Web system has two types of nodes: the server site and the browser site. The browser site is composed of four modules: Multiple Participants Interface, 3D Render Engine, Chat Phase, and WWW Homepage Viewer modules. The server site is built on top of the existent WWW server with two modules: a CGI program and the shared Web server. The server and the browser are communicated by the shared Web Communication Protocol (SWCP). We will implement the system on Windows-based machine, with a possible extension to an open source environment.

Students in virtual university have individual learning profiles, which may include exam records, Web site navigations, chat room discussions, and even their behaviors in a virtual campus. Motion detection of students in a 3-D campus can be easily obtained. However, it is difficult to analyze the semantics of student motion. We aim to develop a behavior supervision machine, based on Petri Net, to properly guide students while they are in the campus. The main goal of this paper is to model the workflow of an integrated web-based multi-user environment so that the researcher can easily design such a system on the Web. Hence, in the following subsections, the definition of the integration is introduced first and followed by the proposed Petri Net model to monitor the user's activities. A multi-user interaction virtual reality system on the Web architecture must provide mechanisms for the multi-user server to "remember" the information of the registered participants and to process the messages communicated among them [15,16]. However, in order to take full advantage of the Web environment, the supported multi-user virtual reality system must be seamlessly integrated with the Web architecture. For a distributed multi-user system to be seamlessly integrated with the Web environment, it must have the following characteristics:

1. The user can download a scene file from any Web server with the HyperText Transfer Protocol (HTTP). That is, the user can select a scene file from any supported HTML document and access the virtual world.
2. The multi-user system must provide the hyperlink feature to retrieve various media resources that are supported by the Web environment. With the help

of this feature, the user of the network-based virtual environment can easily access any media resource, such as video, sound or image file, hyperlinked by objects inside the virtual world.

3. The multi-user system must be able to handle information exchange between the data on an HTML document and an object inside a virtual world. That is, the user can easily control an object inside the virtual world by filling data into forms on an HTML document. Similarly, the contents of an HTML document can be modified by the status change of an object inside the virtual world. Since an HTML document provides a more convenient way to display information, this feature is very important for a multi-user system to be completely integrated into the Web architecture. The most obvious application is to support a distributed 3D war-gaming environment [17].
4. The multi-user server itself is an add-on function of an existent Web server. This characteristic makes the multi-user interaction a part of the WWW services and allows the multi-user server to easily access the database provided by the virtual university server.
5. The user can directly enter a virtual world from a virtual university server from which the scene file is downloaded. With this feature, since the virtual university server takes the role of the user's login process, the multi-user server can be easily replaced and upgraded. In addition, the fault tolerance and the load balance features among the servers of the multi-user virtual reality system can also be easily implemented.

In summary, the seamless integration implies that the user can download a virtual scene file from any supporting virtual university server and navigate to other virtual worlds, which is managed by other Web servers without the awareness of the user. At the same time, the user can fully explore the services provided by the Web environment.

Before we begin to introduce the Petri Net model for the multi-user collaboration on the Web, the basic concept of the Petri Net is given as follows. The Petri Net was originally proposed by C. A. Petri [18] which attempts to develop a formal methodology to describe and analyze a system behavior. The Petri Net model is a graphical and mathematical modeling tool which is especially useful to capture the synchronization characteristic among modules of a system. With the help of the netted representation by the Petri Net, the researcher can easily discover the potential problem of a running system and adjust its design to maintain the validity of this system. Petri Net and workflow both support graphics representation, nesting structure, verification, and simulation. Petri Net can also be evaluated and analyzed by a simulation tool. A Petri Net model can be formally denoted as a 4-tuple, PN = (P, T, F, Mo) where:

- $P = \{P_1, P_2, \ldots, P_m\}$ is a finite set of places.
- $T = \{T_1, T_2, \ldots, T_m\}$ is a finite set of transitions.

Most importantly, P and T must satisfy the properties of $P \cap T = \phi$ and $P \cup T \neq \phi$. That is, at least one of these two sets P and T must be nonempty.

- $F \subseteq (P \times T) \cup (T \times P)$ is a set of arcs (flow relation) that network places and transitions. That is, $(P \times T)$ represents the set of arcs that flow from places to transitions whereas $(T \times P)$ is the set of arcs flowing in opposite directions.
- Mo: $P \rightarrow \{M_0, M_1, M_2, \ldots, M_m\}$ is the set of initial marking of each place. For the definition of the Petri Net model, $M_{ij}$ represents the token number on place $P_j$ at time i and a token can be a resource of a system or control of a program.

According to the definition of the Petri Net, The generic components of a Petri Net include a finite set of places and a finite set of transitions. A Petri Net is a finite bipartite graph that places are netted with transitions, which in turn are connected to output places. The distribution of tokens over places is called a marking of the net. A transition may enable or fire when each of its input places contains at least one token. The firing of a transition results in removing tokens from their input places and adding to output places via transition. A marking represents the state of a system, which is removed from its place when a transition fired and a new marking is then generated to the output places of this transition.

We define learning behavior based on the characteristics of the Petri net. As a graphical tool of Petri net, the followings are basic properties of a Petri net and the description of learning objects:

**Definition 3.1:** A learning behavior Petri net is a 8-tuple, PN = (P, T, A, K, Sw, Dt, F, ID) where:

- $P = \{P_1, P_2, \ldots\ldots\ldots, Pm\}$ is a finite set of places,
- $T = \{T_1, T_2, \ldots\ldots\ldots\ldots, Ti\}$ is a finite set and a sequence of transitions,
- $A \subseteq (P \times T) \cup (T \times P)$ is a set of arcs,
- $K = \{\alpha, \beta, \ldots\ldots., \xi\} \in$ String is a set of Keyword,
- $Sw = \{0, 1, 2, \ldots\ldots\}$ is a set of significance weight,
- $Dt : P \rightarrow \{0, 1, 2, \ldots\ldots\}$ is the duration of time tags,
- $Fs : P \rightarrow \{0, 1, 2, \ldots\ldots\}$ is the frequency of the learning objects to be stayed,
- $ID: P \rightarrow \{0, 1, 2, \ldots\ldots\}$ is the identifier of a learning object,
- $P \cap T = \emptyset$ and $P \cup T \neq \emptyset$.

The generic components of Petri net include a finite set of places and a finite set of transitions. Petri net is a finite bipartite graph. Its places are linked with transitions in turn are connected to the output places. For a given place, there are input and output transitions defined.

By retrieval we mean the virtual university system can satisfy the storage and retrieval requirements of a very large number of atomic learning objects (by learning tasks) where a learning progress can have a storage requirement of several hundred gigabytes. Therefore, this is very difficult to query in virtual university system by using content-based image/video retrieval techniques. In our approach, we defined the attributes "keyword" to achieve user demand. Keyword attributes can be extracted from the title or teacher's specified of the teaching materials. Queries are expressed in terms of high-level declarative constructs that allow users to qualify what they want to retrieve from the virtual university system. The retrieval definition is defined as follow.

**Definition 3.2:** The retrieving operation, $\rho k(PN'\{P'1, P'2, \ldots, P'm\}, PN\{P1, P2, \ldots, Pn\})$ extracts from PN{P1, P2, …, Pn} all the keyword k of the virtual university place P'i that are similar to PN'{P1, P2, …, Pm} with respect to the similarities threshold keywords.

Let the set of keyword $k'_1 \in P'_1, k'_2 \in P'_2, \ldots, k'm \in P'm$, where $\exists\, P\, i \in PN'$, and $k_1 \in P_1, k_2 \in P_2, \ldots, kn \in Pn$, where $\exists\, P'i \in i\, PN$.

$\rho k(PN'\{k'_1, k'_2, \ldots, k'm\}, PN\{k'_1, k'_2, \ldots, k'n\}) = PN\{k'_1, k'_2, \ldots, k'm\}$

$\rightarrow \rho k(PN'\{P'_1, P'_2, \ldots, P'm\}, PN\{P_1, P_2, \ldots, Pn\}) = PN\{P'_1, P'_2, \ldots, P'm\}$

In abstraction operation, we defined the attributes "significance weight" to achieve user demand. Significance weight attributes can be remarked by the learning objectives or teacher's specified of the learning objects in her teaching materials. Abstractions are expressed in terms of high-level declarative constructs that allow both learner and teacher to match somehow "assessing qualify" what they want to abstract from the virtual university system. The abstraction operation definition is defined as follow.

**Definition 3.3:** The abstracting operation, $\alpha Sw(PN\{P_1, P_2, \ldots, Pn\})$ compares all the virtual university place Pi with Sw.

Let the set of Significance weight $Sw_1 \in P_1, Sw_2 \in P_2, \ldots, Sw_n \in P_n$, where $Pi \in PN$.

$\alpha Sw(PN\{Sw_1, Sw_2, \ldots, Sw_n\}) = PN\{Sw_1, Sw_2, \ldots, Sw_m\}$
$\rightarrow \alpha Sw(PN\{P_1, P_2, \ldots, Pn\}) = PN\{P'_1, P'_2, \ldots, P'm\}$
, where the Sw of P'i in $PN\{P'_1, P'_2, \ldots, P'm\}$ is equal to or greater than Sw.

In assessing participation operation, there are two additional time factors in our model: duration time and frequency time. Firstly, we defined the attributes "duration" to achieve user demand. The purpose of the duration factor is one the critical characteristic in learning environment. It records how long with the place (learning object) to be stayed and the total time by the learner took.

**Definition 3.4.a**: The duration assessing participation operation, $\gamma c(PN\{P_1, P_2, \ldots, Pn\})$ sums all the virtual university place Pi with specific learner had been visited ($\exists$ Lx).

Let the set of duration time $Dt1 \in (\forall(P\,1 \exists Lx)), Dt\,2 \in (\forall(P\,2 \exists Lx)), \ldots, Dtn \in (\forall(Pn \exists Lx))$, where $P\,i \in PN$.

```
Process:
FOR i = 1 to i < = n DO
IF (Pi ∃ Lx) THEN
    Dt = Dt + Dti
  END IF
Return Dt
  End FOR
End Process
```

$\gamma c(PN\{Dt_1, Dt_2, \ldots, Dtn\}) = PN\{Dt_1, Dt_2, \ldots, Dtm\}$
$\rightarrow \gamma c(PN\{P'_1, P'_2, \ldots, P'n\}) = PN\{P_1, P_2, \ldots, Pm\} \exists Lx$

$\rightarrow \sum (Dt_1, Dt_2, \ldots, Dt\,m)$
,where the P'i in PN $\{P'_1, P'_2, \ldots, P'm\} \exists Lx$.

Secondary, we defined the attributes "frequency" to achieve "number-of-posting" as indicator for assessing participation operation. The purpose of the frequency is the other critical characteristic in learning environment. It records how many times with the place (learning object) to be stayed.The remained processes are same as the duration assessing participation operation.

**Definition 3.4.b**: The frequency assessing participation operation

Let the set of frequency $Fs_1 \in (\forall(P_1 \exists Lx))$, $Fs_2 \in (\forall(P_2 \exists Lx))$,… , $Fs_n \in (\forall(P_n \exists Lx))$, where $P_i \in PN$.

Process:
FOR i = 1 to i < = n DO
IF (Pi ∃ Lx) THEN
Fs = Fs + Fsi
END IF
Return Fs
End FOR
End Process

$\gamma c\,(PN\{Fs_1, Fs_2, \ldots, Fsn\}) = PN\{Fs_1, Fs_2, \ldots, Fsm\}$
$\rightarrow \gamma c\,(PN\{P_1, P_2, \ldots, Pn\}) = PN\{P'_1, P'_2, \ldots, P'm\} \exists Lx$
$\rightarrow \sum (Fs_1, Fs_2, \ldots, Fsm)$
,where the $P'_i$ in $PN\{P'_1, P'_2, \ldots, P'm\} \exists Lx$.

## 4. Implementation of the Virtual University System

In virtual university system, the size of each of these units of learning is referred to as its level of granularity [19]. A complete virtual university system solution is illustrated in Figure 4. The levels of learning products are arranged vertically in rows. The processes are arranged horizontally in columns. Everyone in virtual university system needs tools: the teacher/producer creating the content, the host hosting it, and the learner accessing it. In addition, tools are required for each level of learning product. At the top is the curriculum. The curriculum is a collection of learning product, for example, an academic program including related courses in a subject area. Courses are composed of several lessons; each organized to accomplish one of the major objectives of the course as a whole. At lower level are the individual web pages content, each designed to accomplish a single objective. At the bottom level are media components. These are the individual images, block of text, animation sequences, and

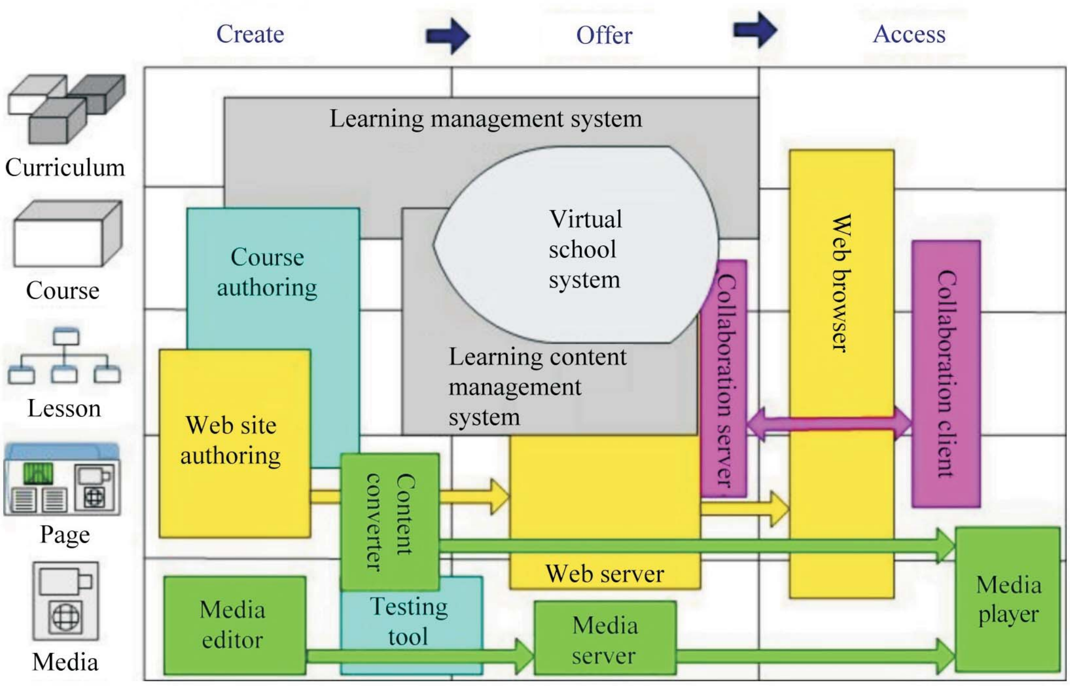


**Figure 4.** A diagram of the Virtual University System including Teacher Creating, Host Offering, and Learner Accessing phases.

video passages that contribute to the web page.

Virtual university system comprises the integration of the classroom structure to the Web. Such systems combine learning management capabilities with collaboration features to provide online analogs for common classroom learning events, e.g. lectures, discussions, and grade books (course management system). Learning Management System (LMS) manages the whole development and administration of learning. Another option is the learning content management system (LCMS), which manages the development of complex courses or the learning object for the needs if individual learners by assembling reusable units of education. Audio, video, animation, and other media may require specific authoring and editing tool. These media may also require media server to ensure that they play efficiently over the network. The content converter is also needs to make existing media content available online. Project involving collaboration among distant learners may rely on collaboration tools. Collaboration tools usually consist of a server component that transport messages among users.

While a student navigates through the virtual campus, a few items will be recorded:

- The international states visited in the Petri Net
- The type of communication tools used, including the frequency and duration
- The SCO (course units) visited, including the frequency and duration
- The values of state variables

The declarative rule fired by the action, which includes

- Completeness of state transitions
- The Campus Alert types of agent triggers
- The Student Violation types of agent triggers
- The control buttons of virtual campus navigation pushed

In addition, chat room logs and question-answer logs were recorded. A statistic summary will be generated after each session of navigation of each student (for an optional review by the student). This information can be used to find out what are the popular locations (such as which class and which discussion room), which communication channels are popular, type of triggers fired by the system, and others.

Virtual University systems usually comprise an extensive depository that tracks all aspects of learning with a collection of collaboration tools. They records and tracks connections among classes which are defined in the system as learner enroll in particular courses [19]. Courses are defined in terms of lower level course objects, which may contain specific media. Another, courses involve tests and meeting events, which may include media (e.g. presentation slides…), and may also involve some collaboration tools such as chat room, audio/video conferencing, whiteboard, application sharing, discussion forum, and e-mail.

The effectiveness of learning is measured by the tests and assessments tools. Teacher could use test scores to assign subsequent learning activities or just to measure achievement of learning. A good distance education experience contains a balanced set of learning activities that work individually and together to induce engagement, discourse, and higher-order learning within the learning community (as illustrated in Figure 5). The virtual university environment can support a growing number of potential activities such as synchronous/asynchronous multimedia interaction and co-working activities. Consistent with the increased emphasis on active learning and authentic assessment is increased use of portfolios of learner products, or artifacts, in e-learning. Assessment strategies should consider with the assessing quality and the assessing participation [19].

Assessing quality: Assessment must be link to, and be congruent with, course objectives and activities if it is to produce intended outcomes. Many of us have had the experience of devising "enrichment" or "suggested activities' for students, only to realize that most students are too instrumentally focused and too busy with other commitments to undertake many discredited extra tasks. Thus, assessment activities must be integrated within the e-learning activities.

Assessing participation: More and more teachers give student grades for participation on-line. Such reward for participation is unlike most classroom education, where it is common to provide very low or no marks for attendance and participation. Many e-learning systems provide tracking features that allow teachers to monitor the number of log-ons and contributions to online discussions. Thus, it is possible to quickly determine manifest data about student participation. Anyway, it is danger of using number-of-postings as an indicator of learning is that one is only measuring quantity, and not quality, of posting.

The Figure 6 [19] shows an example of testing process. (1) Author usually starts to create a test. (2) The authors then upload the test to a server. (3) Learners access the test as part of learning activities. (4) A learner takes a test. (5) The testing result are reported to the learner or if teacher can check answer, sent back to the server. (6) The course teacher can review results that stored on the server to see how learners are progressing in their courses.

The virtual campus should have a few types of pa-

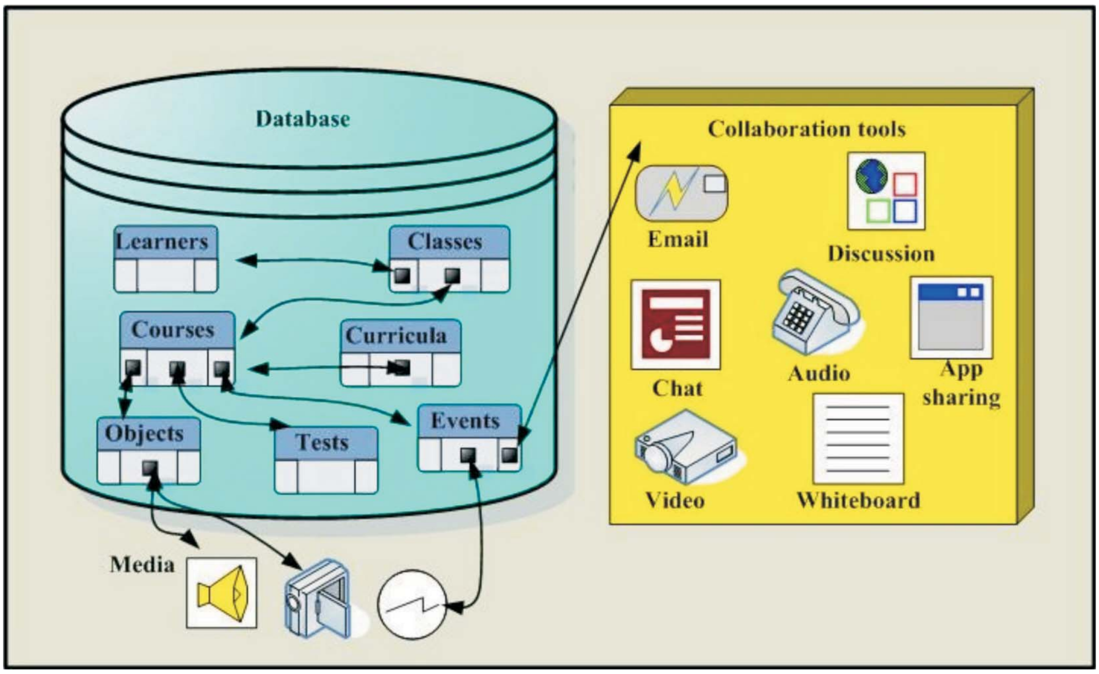


**Figure 5.** A diagram of extensive database for tracking all aspect of learning.

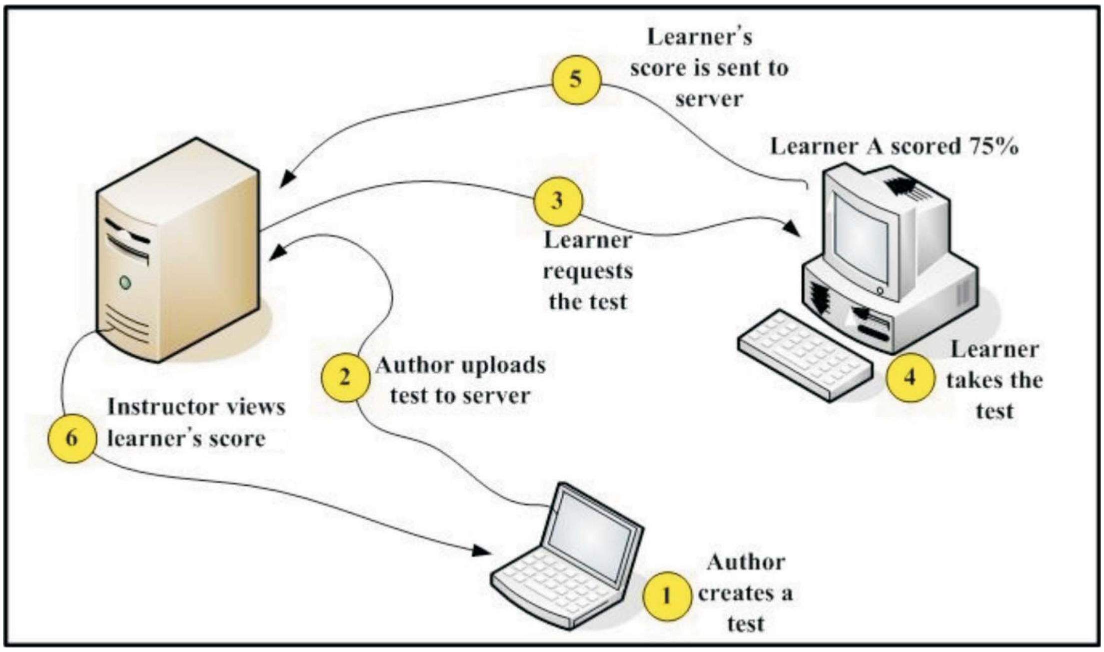


**Figure 6.** A common cycle of testing process (developing, conducting and reporting).

trols. The concept is similar to the one used in a traditional university. For instance, an overdue periodical checkout is not returned, an assignment is not turned in, skipping class, impolite discussions in a char room session, missing an appointment with a professor (or a student), and so on. A set of virtual campus regularity will be designed. Yet, these are university policies. The actual definition of campus regularity is an open issue. However, as long as a rule is defined, there must be an underlying virtual patrol (as an intelligent agent program) running under the system. The virtual patrols can send an on-line message to a student (or instructor), or send an off-line e-mail. More seriously, a virtual campus may prohibit the action of an individual. For instance, if a student always come to the virtual university and just talk to friends, without attending any class, the student may be restricted to the access of chat room. Regularity violation will be summarized, and analyzed as well. The outcome can be used as a reference for us to re-design virtual campus facility and policy.

## 5. Conclusions

This paper contributes a meaningful framework and approach to the understanding of the fundamental of e-learning and explains why it is proliferating throughout a rapidly evolving learning society. This is the important comprehensive and coherent framework to guide our understanding of e-learning in education and society. It is to the purpose of mapping the territory of e-learning, then providing directional choices for higher education and specific guidelines to reach worthwhile destinations, that this book makes its contribution. This paper can be used as a basic/fundamental research framework and tool to study and understand the characteristics of e-learning and to explore its optimal education application. The proposed system demonstrates the preliminary results of an on-going distance learning research project among several universities. Preliminary system shows the feasibility of using scaffolding theory in distance education, which is considered the most important contribution of this paper. Behavior supervision is another contribution of this research. We are working on a French literature courseware to use the proposed system. A few tools developed before needs to be integrated. The FAQ auto-reply system and the chat room participation tools are still underdevelopment. We hope that, in the near future, virtual reality technology can be used as another channel for distance learning communication.

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