Activity Supervision and Behavior Understanding Model in Distance Education

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Abstract: -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. 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: - E-Learning, Distance Education, Virtual University, Scaffolding Theory, Behavior Supervision, Activity Supervision

1 Introduction

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[1, 2, 3, 4]. 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. In virtual university system, the size of each of these units of learning is referred to as its level of granularity [6, 7].

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 manages the whole development and administration of learning. Another option is the learning content management system, 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.

In support of the needed learning types, we integrate a set of tools into a web-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 [7, 8]. Scaffolding, proposed by L. S. Vygotsky, 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.

The Scaffolding-by-Design Model [8] describes a process of mainly social interactions, as state in vygotsky's work. Further it builds on aspects of cognitive apprenticeship, which is chosen as a pedagogy to support student learning. As a model for learner support, one of the aims of this model is that the learner learns to self-regulate learning. Some suggestion for learning to self-regulate were found that are applied in this model. One of the means to learn to self-regulate can be the application of Scaffolding. The two main components that define Scaffolding, support of the learner and fading, are emphasized in the Scaffolding-by-Design Model. In this paper, we based on this model then propose an activities supervision and behavior understanding model for Virtual University System. Our approaches can let the learner, instructor period to check reports and manually adapts their course/curriculum by re-configure the weight, progress and tests.

In this paper, we outline the philosophical perspective and social constructivism that frame our understanding of e-learning. The section 2 outlines the activity supervision and behavior understanding modeli. The implementation consideration of the virtual university system is discussed in section 3. Finally, we will make a brief conclusion in section 4.

2 Petri Net Model for Activity Supervision and Behavior Understanding

- 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 [9] which attempts to develop a formal methodology to describe and analyze a system behavior. The Petri Net model [10, 11] is a graphical and mathematical modeling tool which is especially useful to capture the synchronization characteristic among modules of a system.

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 form 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 2.1: 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,

●$T = \{T_1, T_2, \ldots\ldots\ldots., Ti\}$ is a finite set and a sequence of transitions,

●$A \subseteq (P \times T) \cup (T \times P)$ is a set of arcs,

●$K = \{\alpha, \beta, \ldots\ldots..\zeta\} \in$ 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,

●$P \cap T = \varnothing$ and $P \cup T \neq \varnothing$.

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 attributed can be extracted form 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 2.2: The retrieving operation, ρk(PN'{P'1, P'2, …, P'm}, PN{P1, P2, …, 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 $P_i \in PN'$, and $k_1 \in P_1, k_2 \in P_2, \ldots, kn \in Pn$, where $P'_i \in PN$.

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

In abstraction operation, we defined the attributes "significance weight" to achieve user demand. Significance weight attributed 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 2.3: 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 2.4.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 $Dt1 \in (\forall(P1 \exists Lx)), Dt2 \in (\forall(P2 \exists Lx)), \ldots, Dtn \in (\forall(Pn \exists Lx))$, where $P_i \in PN$.

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

$\gamma c(PN\{Dt_1, Dt_2, \ldots, Dt_n\}) = PN\{Dt_1, Dt_2, \ldots, Dtm\} \rightarrow \gamma c(PN\{P_1, P_2, \ldots, Pn\}) = PN\{P_1, P_2, \ldots, Pm\} \exists Lx \rightarrow \sum(Dt_1, Dt_2, \ldots, Dt_m)$,where the P'i in $PN\{P_1, P_2, \ldots, Pm\} \exists Lx$.

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 $Fs_1 \in (\forall(P_1 \exists Lx)), Fs_2 \in (\forall(P_2 \exists Lx)), \ldots, Fs_n \in (\forall(P_n \exists Lx))$, 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

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

3. The Establishment of Activity Supervision Model

We use The Petri Net model to establish the activity supervision in Virtual University. It includes the following five stages:

The Registration stage: this stage is the first step to apply for admission to a school. For the web-based virtual university, the user should be able to log into the virtual university system and then follow the registration subsystem guidance.

The Curriculum stage: this stage is the selecting courses step for learner. The curriculum subsystem should provide and record the user chooses. The Virtual University may provide the courses that contain on-line courses and off-line courses.

The Authoring stage: this stage is the course design step for the teacher. The authoring subsystem should provide the course creating and editing function module.

The Examination stage: this stage is the one of the important evaluation/examination function for the learner or education training. The examination subsystem should provide the various examination styles, such as questionnaire, question-and-answer drill or the collaboration examination.

The Assessment stage: this stage is important index for learner's leaning achievements. The assessment subsystem keeps track two learner's learning records:

curriculum and examination records. Curriculum records contain the learning activities and workflows. Learning activities could represent the histories and behaviors that could be understood some certain extent of the learning acquisition.

The Petri Net model of these five stages are then elaborated as follows.

3.1 Registration Stage

As shown in Figure 1, user uses the web browser to access the main page of the Virtual University System, Transition T_{r1}, to load the login page. When the login page is replied from the server, user should input the personal identification information into the desired fields respectively (Transition T_{r2}).

After finished the applying for admission confirmation procedures (Transition T_{r3}), learner could check the registration demands (e.g. Academic Background, payment voucher) that were filled the bill or not. After admission demands confirmation step (Transition T_{r4}) were done by the applicant, they could modify the personal information (Transition T_{r5}) or change the login password. After the above registration procedures, server will auto apply the re-login page (Transition T_{r6}), and then the user can be granted the legal authorization (Transition T_{r7}).

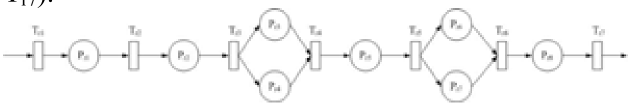

Figure 1: The Petri model for registration stage

T_{r1}: Accessing the main page of the Virtual University System
T_{r2}: Login page for the user
T_{r3}: Applying for Admission Confirmation
T_{r4}: Admission Demands Confirmation
T_{r5}: Personal Information modification
T_{r6}: Re-login with Granted Authorization
T_{r7}: Confirm and Update into Database
P_{r1}: Registration Subsystem View
P_{r2}: Registration Procedure Information
P_{r3}: Paying Subsystem
P_{r4}: Academic Background
P_{r5}: Registering Into Database
P_{r6}: Responding the registration information to the user
P_{r7}: Email the registration information to the user
P_{r8}: Registration Confirmation

3.2 The Curriculum stage (for Student)

The curriculum subsystem should provide and record the user chooses (the curriculum and courses levels). This subsystem is important to keep the core function of Learning Management System (LMS) and the Learning Content Management System (LCMS). The Virtual University System may provide the courses that contain on-line courses, off-line courses, as well as collaborative events and online meeting.

First of all, the learner login with granted authorization (Transition T_{c1}) is illustrated in Figure 2. The curriculum subsystem presents a menu and catalog of courses (Transition T_{c2} for selecting the curriculum, Transition T_{c3} for selecting the courses). Learners can see a list of courses in which they are enrolled. Some suggested courses are based on a learner's profiles; some analysis a learner's progress at the level of individual objectives or the instructor manually adapts content to individual learners (Transition T_{c4} for selecting the demanded tools and checking the curriculum certifications is sufficient or not). After finished and passed the above procedures, the learner's curriculum activities records and degrees certification could be confirmed (Transition T_{c5}).

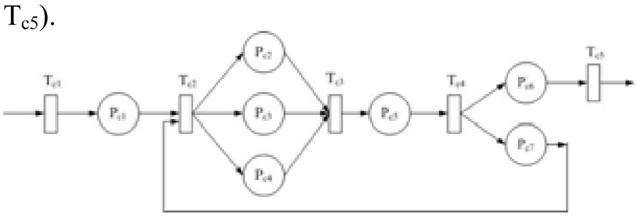

Figure 2: The Petri Net model for curriculum stage

T_{c1}: Login with Granted Authorization
T_{c2}: Select Curriculum Subsystem
T_{c3}: Starting a Select with Curriculum Subsystem
T_{c4}: Tools Select Subsystem (Communication Tools)
T_{c5}: Curriculum Activities Record or Degree Confirmation
P_{c1}: Curriculum Subsystem
P_{c2}: Retrieval Curriculum
P_{c3}: Online Curriculum
P_{c4}: Offline Curriculum
P_{c5}: Syllabus Information
P_{c6}: Curriculum Activities Record Subsystem
P_{c7}: Insufficient the Curriculum criteria Record

3.3 Authoring Stage

For developers of Virtual University System, authoring tools make it possible to create and manage large numbers of independent pages and their assets. The authoring subsystem should provide the instructor to work on the site as a whole, rather than just a collection of independent pages. In Figure 3, with granted authorization (Transition T_{au1}), instructor could creating/updating a course page by specifying characteristics (Transition T_{au2}) such as where to put it on the server and what content database connection it will use. Authors are not limit to editing/creating individual pages. They can organize the entire site and link individual pages in a virtual map (Transition T_{au3}). Authors can make changes throughout a site without having to open and change individual pages or learning objects (Transition T_{au4}). In order to analysis the learner's learning achievements (for individual learner's progress), instructors can configure/adapt the weight for individual learning objects (Transition T_{au5}).

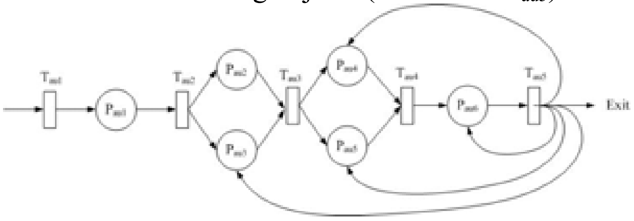

Figure 3: The Petri Net model for authoring stage

T_{au1}: Login with Granted Authorization
T_{au2}: Selecting a Course
T_{au3}: Course Organization Design
T_{au4}: Content Object Editing
T_{au5}: Weigh-bearing Point Configuration
P_{au1}: Authoring Course Subsystem
P_{au2}: Creating a Course
P_{au3}: Updating a Course
P_{au4}: Course for Lecture
P_{au5}: Course for Examination
P_{au6}: Course Preview

3.4 Examination Stage

The examination subsystem measures the effectiveness of learning. Learner may rely on tests to gauge their learning progress in a course. Instructor can use test scores to assign subsequent learning activities or to measure the effectiveness of the distance learning. In Virtual University, tests often usually find their way onto pages created with authoring tools.

As shown in Figure 4, if the learner login with granted authorization (Transition T_{e1}), they can choose desire course to exam. Anyway, the instructor may set some qualification for some tests. So the learners may be qualified/compares with some curriculum records (e.g. rate of attendance). After finishing that contingent qualification (Transition T_{e2}), learners can take the tests for course or curriculum level assessments (Transition T_{e4} for disqualification, Transition T_{e3} for qualification). Tests and quizzes are usually tracked as separate activities that may not as part of a specific lesson. The results reported to the learner and if specified by the test's author, sent back to the server (Transition T_{e5}). The instructor can check results stored on the server to see how learners are progressing in the course/curriculum.

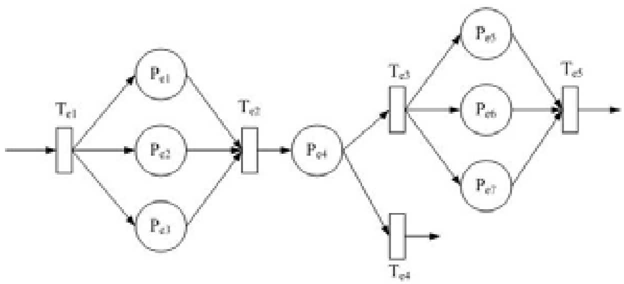

Figure 4: The Petri Net model for Examination Stage

T_{e1}: Login with Granted Authorization
T_{e2}: Test Selecting
T_{e3}: Qualified and Starting Examination
T_{e4}: Disqualified, confirmation and Exit
T_{e5}: Hand in the Examination
P_{e1}: Examination Information Retrieval
P_{e2}: Online Examination
P_{e3}: Offline Examination
P_{e4}: Curriculum Record Qualification
P_{e5}: Questionnaire
P_{e6}: Question-and-Answer drill or exercise
P_{e7}: Team Work/Collaboration Examination

3.5 Assessment Stage

In this stage, we propose the assessment subsystem for measuring the learner's progress. The assessment subsystem keeps track two learner's learning records: curriculum and examination records. Curriculum records contain the learning activities and workflows. Learning activities could represent the histories and behaviors that could be understood some certain extent of the learning acquisition. We could evaluate and produce the reports: learners, curriculums, courses, tests, activities, and online meetings.

As shown in Figure 5, with granted authorization (Transition T_{au1}), instructors and course's authors can periods check reports/results of the course or examination (Transition T_{au2}). If the instructor set some qualification for some tests (Transition T_{au3}) and if the learner was disqualified then he will not be allowed to take some test (Transition T_{au5}). If the instructor didn't set any qualification for some tests or the learners was qualified (Transition T_{au4}) then they will get the examination results (Transition T_{au6} for pass, Transition T_{au5} for fail); however, the completed reports of the learner will be produced (Transition
T_{au8}).

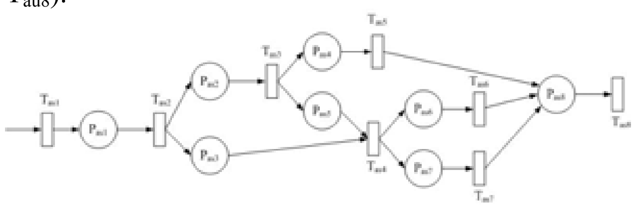

Figure 5: The Petri Net model for Assessment Stage

T_{as1}: Login with Granted Authorization
T_{as2}: Selecting Curriculum or course
T_{as3}: Selecting Students for Curriculum/course Record
T_{as4}: Selecting Students for Examination Record
T_{as5}: Email the Record to Student for Notification/Remedy
T_{as6}: Email the Record to Student for Notification/Remedy
T_{as7}: Email the Record to Student for Notification/Encourage
T_{as8}: Degree Confirmation
P_{as1}: Assessment Subsystem
P_{as2}: Curriculum Record Subsystem
P_{as3}: Examination Record Subsystem
P_{as4}: Disqualification in Curriculum Attendance
P_{as5}: Qualification in Curriculum Attendance
P_{as6}: Disqualification in Examination
P_{as7}: Qualification in Examination
P_{as8}: School Report Subsystem

4 Conclusion

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 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. We have implemented the generic user interface as well as a state machine engine which runs the specification language. Interactions via communication tools, such as video conferencing and chat room discussion are possible due to the support from the underlying system provided by Microsoft. 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.

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