Scaffolding Supervision and Behavior Understanding

Yung-Hui Chen [1] and Lawrence Y. Deng [2]
[1]Department of Computer Information and Network Engineering
Lunghwa University of Science and Technology, Taiwan, R.O.C.
cyh@mail.lhu.edu.tw
[2]Department of Computer Science and Information Engineering
St. John's University, Taiwan, R.O.C.
Lawrence@mail.sju.edu.tw

Abstract

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 and supervise of the web-based multiple participants in virtual environment. 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.

Keywords: distance learning, scaffolding theory, animation, behavior supervision, Petri Net

1. Introduction

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 [1, 2, 3], 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

The student's activities supervision and behavior understanding in virtual environment by using Petri Net model was addressed in section 2. The establishment stages with activity supervision model were illustrated in section 3. The conclusion and future work were presented in section 4.

2. Petri Net Model for Activity Supervision and Behavior Understanding

We re-defined the 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:

- $P = \{P_1, P_2, \ldots\ldots\ldots, P_m\}$ is a finite set of places,
- $T = \{T_1, T_2, \ldots\ldots\ldots\ldots, T_i\}$ is a finite set and a sequence of transitions,
- $A \subseteq (P \times T) \cup (T \times P)$ is a set of arcs,
- $K = \{\alpha, \beta, \ldots\ldots\ldots\zeta\} \in$ 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 $P \cup T \neq \varnothing$.

The generic components of Petri net include a finite set of places and a finite set of transitions [4]. 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 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, $\rho k(PN'\{P'_1, P'_2, \ldots, P'_m\}, PN\{P_1, P_2, \ldots, P_n\})$ extracts from $PN\{P_1, P_2, \ldots, P_n\}$ all the keyword k of the virtual university place P'_i that are similar to $PN'\{P_1, P_2, \ldots, P_m\}$ with respect to the similarities threshold keywords.

Let the set of keyword $k'_1 \in P'_1, k'_2 \in P'_2, ..., k'_m \in P'_m$, where $P_i \in PN'$, and $k_1 \in P_1, k_2 \in P_2, ..., k_n \in P_n$, where $P'_i \in PN$.

$\rho k(PN'\{k'_1, k'_2, \ldots, k'_m\}, PN\{k'_1, k'_2, \ldots, k'_n\}) = PN\{k'_1, k'_2, \ldots, k'_m\}$

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

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, $\alpha Sw\ (PN\{P_1, P_2, \ldots, P_n\})$ compares all the virtual university place P_i 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 $P_i \in PN$.

$\alpha Sw\ (PN\{Sw_1, Sw_2, \ldots, Sw_n\}) = PN\{Sw_1, Sw_2, \ldots, Sw_m\}$

$\rightarrow \alpha Sw\ (PN\{P_1, P_2, \ldots, P_n\}) = PN\{P'_1, P'_2, \ldots, P'_m\}$, 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, $\gamma c\ (PN\{P_1, P_2, \ldots, P_n\})$ sums all the virtual university place Pi with specific learner had been visited ($\exists$ Lx).

Let the set of duration time $Dt_1 \in (\forall(P_1 \exists Lx))$, $Dt_2 \in (\forall(P_2 \exists Lx))$,….. ,$Dt_n \in (\forall(P_n \exists Lx))$, 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
```

$\gamma c\ (PN\{Dt_1, Dt_2, \ldots, Dt_n\}) = PN\{Dt_1, Dt_2, \ldots, Dt_m\}$

$\rightarrow \gamma c\ (PN\{P_1, P_2, \ldots, P_n\}) = PN\{P_1, P_2, \ldots, P_m\} \exists$ 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 2.4.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
```

$\gamma c\ (PN\{Fs_1, Fs_2, \ldots, Fs_n\}) = PN\{Fs'_1, Fs'_2, \ldots, Fs'_m\}$

$\rightarrow \gamma c\ (PN\{P_1, P_2, \ldots, P_n\}) = PN\{P_1, P_2, \ldots, P_m \exists$ Lx

$\rightarrow \sum(Fs'_1, Fs'_2, \ldots, Fs'_m)$, where the P'_i in $PN\{P_1, P_2, \ldots, P_m\} \exists$ Lx .

3. The Establishment of Activity Supervision Model

We used the Petri Net model to establish the activity supervision in Virtual University [5]. 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.

3.1. Registration Stage

In this stage, the client site accesses the HTML or 3D VRML files from the server site. 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}).

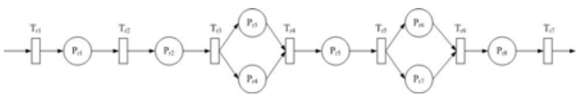

Figure 1: The Petri model for registration stage

3.2. The Curriculum stage

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}).

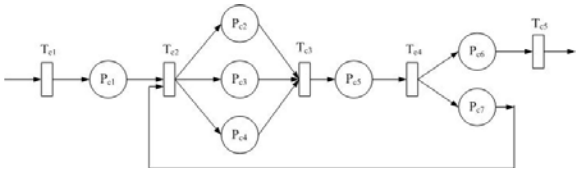

Figure 2: The Petri Net model for curriculum stage

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}).

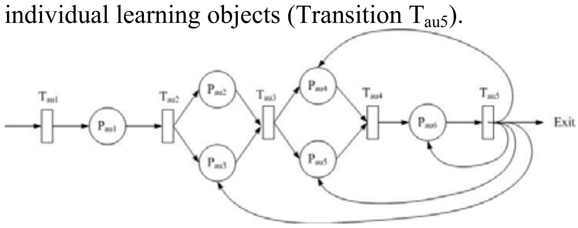

Figure 3: The Petri Net model for authoring stage

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.

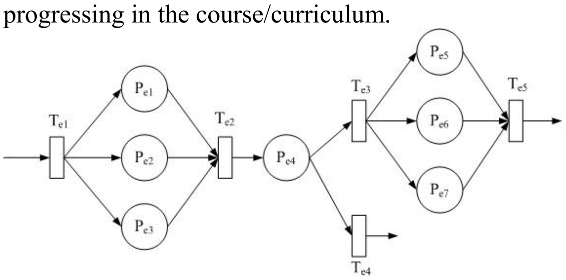

Figure 4: The Petri Net model for Examination Stage

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.

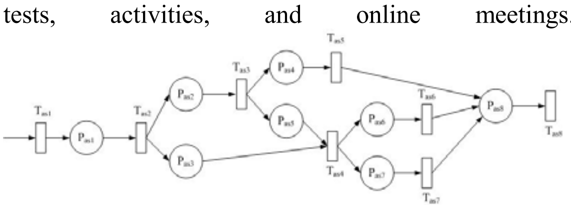

Figure 5: The Petri Net model for Assessment Stage

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}).

4. 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. 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.

5. References

[1] Timothy K. Shih, "Individualized Web Course Generation in Distance Learning," in Proceedings of the 2001 IEEE International Conference on Multimedia and Expo (ICME2001), pp. 1184 -- 1187, Tokyo, Japan, August 22 - 25, 2001.

[2] Lawrence Y. Deng, Timothy K. Shih, Teh-Sheng Huang, Yi-Chun Liao, Ying-Hong Wang and Hui-Huang Hsu, "A Distributed Mobile Agent Framework for Maintaining Persistent Distance Education," in the Journal of Information Science and Engineering(JISE), Special Section on Parallel and Distributed Systems, Vol. 18, No. 4, pp. 489 -- 506, July 2002.

[3] T. K. Shih and F. Chia-I Chang, "Strategic Assessment: Using Influence Diagrams to Design Distance Learning Courseware," in the Operational Research: An International Journal, Vol. 1, No. 2, pp. 97 -- 113, May-August, 2001.

[4] Peterson, J. L., "Petri Net Theory and the Modeling of Systems," Englewood Cliffs, NJ:Prentice-Hall, Inc., (1981).

[5] Jiung-Yao Huang and Lawrence Y. Deng, "The Petri Net Model for the Collaborative Virtual Environment on the Web", Tamkang Journal of Science and Engineering, Vol. 3, No. 4, pp. 267 -- 281, 2000.