

# A DYNAMIC ASSOCIATIVE E-LEARNING MODEL BASED ON A SPREADING ACTIVATION NETWORK

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## Abstract

*Presenting information to an e-learning environment is a challenge, mostly, because of the hypertext/hypermedia nature and the richness of the context and information provides. This paper proposes a dynamic semantic model for e-learning system based on the psycholinguistic theories of human memory; Spreading Activation Network (SAN). This work employs a SAN as a technique to provide the interface's action selection mechanism in an uncertain environment. The paper combines the SAN with the temporal logic to provide an e-learning system that a learning activity level evolves according to their expected contextual relevance. The system differs from the other e-learning by representing dynamic associations between learning activities and the relevance subjects. This system equipped with an Event-Triggered learning interface (context) adaptation component. This component provides multiple parallel processes for perception. These processes provide context screen selection and learning task operation based upon the user current situation. The SAN attempts to achieve a number of goals in an unpredictable complex dynamic environment. Spreading activation explains the predictive top-down effect of knowledge. It supports general heuristics which may be used as the first step of more elaborated methods. This model is suited to deal with the interaction between semantic and episodic memories, as well as many other practical issues regarding e-learning, including the retroactive effect of semantics over perception. The system uses the SAN to activate the most suitable interface screen (context) in response to the current conditions (learning activities) while the system continues working towards the learning objective goal. The paper presents our efforts to realize such e-learning system. The proposed paradigm has been implemented to develop a prototypical system, and the experiments also illustrate the robustness of such an e-learning framework.*

**Keywords:** E-Learning, Human-Machine Interaction.

## 1. Introduction

An electronic learning (e-learning) system is an approach to facilitate and enhance learning through the use of information and communication technology. The e-learning allow teachers and students to communicate, transfer information and interact via computer networks, CDRoms, television, Personal Digital Assistants (PDAs), mobile phones, Web-based systems, etc. A typical study style is usually based-on classroom-liked system. However, the education has rapidly changed from classroom-

liked learning to electronic learning (e-learning) through the online network, Internet, and multimedia device. The e-learning could cover a spectrum of activities from online lecture, to supported learning (the Internet, email, discussion forums, and collaborative software). This e-learning could improve education and overcome the spatial barriers. Additionally, it provides the simplicity and flexibility not only for classroom lecture but also for other alternative learning, such as home school, industrial training, and distant education.

Past works in e-learning have been focused on implementing learning tools to improve the education process. Such systems include Intelligent Tutoring Systems (ITS) [1] and online distance education [2]. Many systems usually contain the learning content management, course delivery system, user interface, etc. Nevertheless, none of these works are equipped with content configurable adaptation that allows the system to dynamically adjust the course content and service to fit with the user current learning state. Some system may include the user profile or learning tree, but these still not efficient enough to offer adaptive interaction to the user. For example, two students may interact differently during the same course with the same learning status. Even the same student may have different behaviors during the same course interaction. This research presents a dynamic semantic model for e-learning system based on the psycholinguistic theories of human memory; Spreading Activation Network (SAN), and the temporal model for dynamic interactive multimedia of the web browser. The e-learning system is able to collaborate the user activities with the learning state as well as to provide the appropriate content to the user.

This paper is organized as follows: Section 2 presents the system architecture. Section 3 describes the competency-base e-learning system. Section 4 discusses the system implementation. Section 5 presents the experiment and preliminary results. Finally, Section 6 summarizes our contribution and discusses the future work.

## 2. System Architecture

The system architecture is implemented as a distributed set of processing components each of which operates independently and performs distinct functions. The system has

two major parts with six primary components. The first part is the e-learning interaction system that includes the user action/command monitoring component, the user model and command generator component, the event-triggering adaptation, and the content display manager. The second part is the action selection manager that includes the course planning/scheduling component, the SAN, and the database.

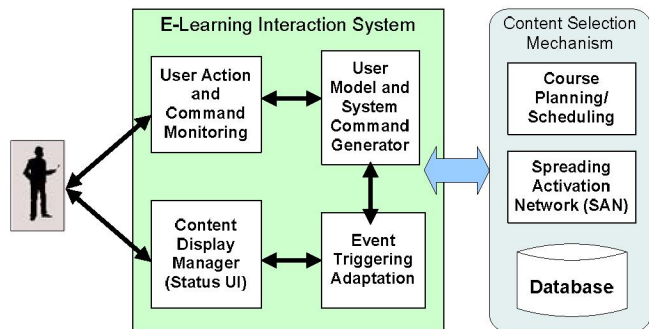


Figure 1. System architecture.

The user action/command monitoring component collects the activities of the user and determines the user action as well as the activation command. The user model stores the user profile. The system command generator mediates human-machine interaction as well as enables the user to converse with and assist the e-learning system. The event-triggering adaptation adjusts the course content based on events triggered by the user actions and the course plans. The content display manager (status UI) component provides the course data to the user, such as the content, the learning status and the message sent by the system. The action selection manager composes of a course planning/scheduling component, the spreading activation network, and the database. It generates the course plan and selects appropriate learning module to display to the user. This action selection manager dynamically forms the learning activation network (learning schedule) according to course content and user capabilities. The action selection mechanism employed the Spreading Activation Network (SAN) that could activate the proper learning module according to the user behavior and the course situation [5]. The database stores the content and learning module, the user data, and the course specifications.

### 3. Competency-base E-learning System

This paper presents a dynamic semantic model for e-learning system based on the psycholinguistic theories of human memory; Spreading Activation Network (SAN). This research employs a SAN as a technique to provide the content's action selection mechanism in an uncertain environment. The system combines the SAN with the temporal logic to provide an e-learning system that a learning activity level evolves according to their expected contextual relevance. The system uses the SAN to activate the most suitable interface screen (context) in response to the current conditions (learning activities) while the system continues working towards the learning objectives.

### 3.1. Spreading Activation Network

Even if an e-learning has a course command, it requires an action selection mechanism to select the appropriate content or learning module in order to accomplish the course objective goal. In this work, the spreading activation network (SAN), is employed as the learning activity selection mechanism. SAN not only favors actions that accomplish several goals simultaneously, but also tends to follow the plan given by the lecturer or any other planning component. Therefore, it provides the capability of both deliberative and reactive action planning.

A spreading activation network consists of competency modules that are interconnected via their conditions. The competency module (CM) is a representation of the task in a spreading activation network. The pre-conditions related to a particular CM must be satisfied before that module can be activated. After a particular CM has been executed, certain conditions become true. These conditions are called "post-conditions". If a competency module has all of its pre-conditions satisfied by the current state, then it is executable. In the case when there is more than one executable CM, the algorithm selects the executable CM with the highest activation and then the process of the SAN is repeated. An example of SAN is provided in Figure 3.

The main challenges involved in generating a SAN automatically are in correlating the primitive task representation of a courser objective and user action command with the system primitive learning modules and in interconnecting the modules to formulate an action selection network (context selection network). The algorithm that generates the SAN is implemented as a loop of four operational stages.

- The system receives the course command from the user or obtains the course outline from the database.
- It obtains the course constraints from the database (i.e., learning objectives, the pre- and post-conditions, the learning module).
- It generates a correlation table of the user's selected course and the e-learning competency module. For example, it maps the planned command to the e-learning's primitive content module, translates the learning condition to proposition nodes (pre- and post-conditions), and converts the command operators (i.e. and, or, then) to the competency links (successor, or predecessor link).
- The process of generating the network is a combination of backward propagation from the mission's goal, forward propagation from the initial state, and then merging these two propagated networks to become the SAN.

Any competency module (CM) becomes active if it can fulfill the following conditions:



- All the pre-conditions need to be satisfied (executable competency module).
- The CM must have the activation energy higher than threshold.
- The CM must have the highest activation among other executable modules.

### 3.2. Event-based Temporal Behavior

The e-learning system will monitor the user activities to determine the user command as well as the course accomplishment via the online action, the pre-test, and the post-test. These user activities could be interpreted as the system event-based behavior. For example, a learning course of totally  $x$  pages (or  $x$  activities) following from  $x1 \rightarrow x2 \rightarrow x3$  involved with time consuming, learning process, and score. We can condense it and write in time frame of adaptive or non-adaptive event. In addition to the fundamental events, starting from first page  $x1$  on event line forward to next page  $x2$  and  $x3$ , and to the end of topic. The  $x1$  and  $x3$  are different information type but same category type that happen on same event line. If some of them want to back, moving backward to previous page (or previous content) as  $x3 \rightarrow x2 \rightarrow x1$ , thus they may be taken long period of time to finish the topic.

Thus, we can apply the temporal logic [6] and form as  $X$  where

$$X = \{x1, x2, x3, x4, x5\} \quad (1)$$

Each page contains individual content type, such as  $x1$  is general course information, and the next page,  $x2$ , is a mathematic formula. Both contents will display in different time events. The activities start from  $x1$  to  $x5$  consequently. The events of all content have to formulate according to the course outline and will not overlapped to each other. Figure 2 shows an example of a designed e-learning course with student behavior scheduling.

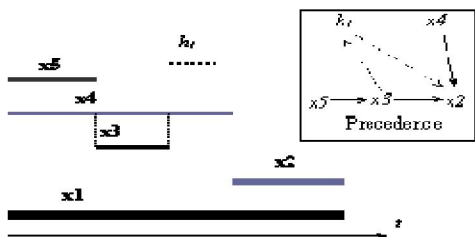


Figure 2. An example of a designed learning temporal.

From Figure 2, we could assume  $X$  consists of member  $\{x1, x5\}$  and can write the equations (2)-(4). Equation (3) shows the possible relations between two interval of the sequential relation “ $<$ ” of activities. For instant, from Figure 2, the learning module  $x3$  need to be satisfied before  $x2$  can be activated, thus the temporal formula is “ $<(x3, x2)$ ”. Equation (4) shows the inclusion relation “ $\subseteq$ ” of activities that could activate in the same interval time, such as “ $(x5, x1)$ ” means  $x5$  and  $x1$  are activated synchronously.

$$X = \{x1, x2, x3, x4, x5\} \quad (2)$$

$$< = \{(x5, x3), (x3, x2), (x5, x2), (x4, x2)\} \quad (3)$$

$$\subseteq = \{(x5, x1), (x5, x4), (x3, x4), (x2, x1), (x2, x1), (x4, x1), (x3, x1)\} \quad (4)$$

From this example, the temporal frame of the above example system could be transformed into the following logic formula:

$$(\forall x4)(\forall x5)((x4 \subseteq x5) \vee (\exists h1)((h1 \subseteq x4) \wedge \neg O(h1, x5))) \quad (5)$$

The intervals events for  $x3$  and  $x5$  can swap to each other depend on content. If student finished (F) the course that means F state happened and the course module has been accomplished.

### 4. System Implementation

The system is developed as a web-based e-learning using JAVA and PHP nude. The design focuses on a single e-learning course for multiple users. The prototype system contains 30 learning modules for a single chapter of an engineering course. These learning modules include pre-tests, a chapter overview, 5 main topics with 10 sub-topics, quizzes and post-tests. Additionally, the system provides learning help and suggestions. Moreover, it equips with situation awareness and dynamic action selection mechanism. Figure 3 shows the implemented e-learning of a robot training course.

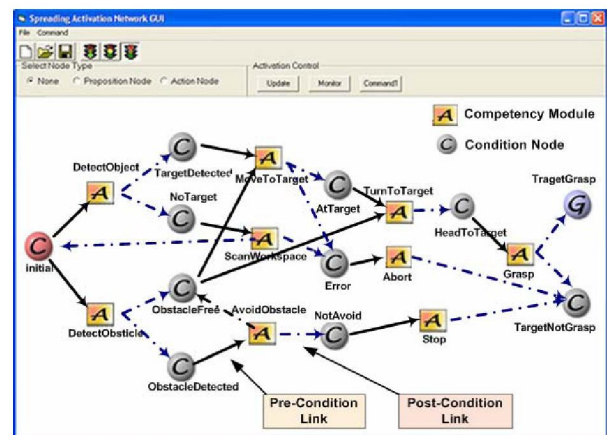


Figure 3. An example of the SAN for a robot training course.

A few e-learning systems have incorporated the adaptive user interface and dynamic content selection network (SAN) into their work. The spreading activation network (SAN) maps the intended learning goals with the current learning conditions and forms a network of learning module (possible learning plan). This network could describe the predictive top-down effect of knowledge of the course. The system also includes a temporal-based content presentation that governs the flow of the course context. The system supports general heuristics which could be used as the first step of more elaborated methods. The implemented system is suited to deal with the

interaction between semantic and episodic memories, as well as many other practical issues regarding e-learning, including the retroactive effect of semantics over perception. The SAN combined with temporal logic is able to activate the most suitable learning module and select the best-fit interface (context) in response to the current learning situations while the system continues working towards the learning goal.

## 5. Experiment and Result

### 5.1. Experiment

An experiment was designed to verify the proposed e-learning and demonstrate the reliability and robustness of the system.

In the experiment, five users were trained by using the implemented e-learning course via a computer. The experiment is composed of 5 topics of a network theory course. It started with the course overview and the training outline. Then, it presents the pre-test before provides the detail of the course in network theory, and problem solving. Finally, the e-learning assigned a post-test. The training period, the time taken to complete each course module, the achievement rate of each assignment, and the accomplishment of the course were recorded to evaluate the system.

### 5.2. Preliminary Results

The e-learning period ranging from 25 minutes to 120 minutes that due to the differences in background, and knowledge of each person. Nevertheless, after training, all subjects were able to accomplish the assignment in each learning module. On an average, the training consumed 60% of the 20 min/module time. These results indicate that the e-learning is simple enough for people to learn and use the system. In order to analyze the success rate of e-learning system, we classified the results into three categories: satisfied, unsatisfied, and ambiguous. For example, Satisfied is when the user was able to complete the post-test and assignments (more than 70%). Unsatisfied is when the user could not complete assignments less than 30%. Ambiguous is when the user could complete some of the course modules but not others with success rate between 30-70%. The experimental results are provided in Table 1.

Table 1. Experimental results

Satisfaction	Unsatisfied	Satisfied	Ambiguous
Course Contents	15.62%	71.87%	12.5%
Suggestion	9.37%	75.00%	15.62%
Online Help	12.5%	71.87%	15.62%

## 6. Conclusion and Discussion

This paper has presented a novel a dynamic associative e-learning system. We employed the spreading activation network (SAN) and the temporal logic to implement the framework. The system is able to provide bi-directional interaction between human and e-learning system. A content selection mechanism that includes the course planner and the action-selection mechanism also have been developed. It can form the course plan and execute the intended learning module autonomously. The preliminary experimental result demonstrates the usability and the capability of the system. This combined capability of SAN and temporal logic makes this approach unique and potentially very useful for electronic learning applications. The future work includes performing further experiments with more user evaluation. This evaluation is a need to determine the usability of the designed system that includes a comparison of this approach with other e-learning.

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