# Intelligent Hypermedia Learning System on the Distributed Environment

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**Abstract :** This paper suggests using a hypermedia learning system which has the ability to extract intelligent instruction on the world wide web. The proposed system is designed for supporting individual instruction on the web. The system is composed of expert module, student module, instructional strategy module and network interface module. To implement this system on the world wide web, we use CORBA-based CGI application for user interaction. To diagnose students' responses and generate evaluations, we use several linguistic variables.
The advantages of using this system are intelligence and distribution of resources. Intelligence of the system is dynamic generation of problems and the ability to provide a dynamic instruction strategy. In addition to showing instructional unit network and students' learning paths, we can overcome disorientation problem that have frequently occurred on the web. We use CORBA to overcome the disadvantage of WWW, passive protocol, HTTP.

## 1. Introduction

The WWW(World Wide Web) has been spread world-wide as a standard of distributing multimedia/hypermedia information. There are many applications based on the WWW, such as video on demand, distance learning, home shopping, and so on[Kappe 91]. The advantage of using distance learning on the WWW is apparent. We can provide instructional information using a hypertext form, the same as students' cognitive structure. Many studies in progress have interactive instruction made achievement[Dwyer et al. 95, Ibrahim & Franklin 95, Carver & Gregory 95]. Distance learning is available by exchanging instructional information via network among students and instructors at a distance. But WWW users ask for many extensions : integrating new kinds of web resources, extending web browsers, changing stateless web protocol. These problems can be overcome with a uniform model of resource interfaces, and transportable front-ends, that could be generically integrated in WWW. A uniform paradigm to encapsulate and structure web components can be achieved thanks to the OMG(Object Management Group)'s CORBA(Common Object Request Broker Architecture)[OMG 95].
Despite the WWW is able to access distributed information and services on Internet, it does not present individualized information to students[Jonassen & Mandl 90]. In addition, unlike existing stand-alone ITS(Intelligent Tutoring System)[Yoon & Wang 94], students must have the ability to study freely and search related information easily. Therefore the system must overcome potential disorientation problems[Kappe 91] that could burden accessibility.
In this paper, we suggest an intelligent hypermedia learning system that can make intelligent instruction and individual instruction on the CORBA/WWW. Our system can support concurrent learning and dynamic lesson planning for each student by using linguistic variables[Yoon & Wang 94]. In addition, our system provides instructional units in which students' response are diagnosed, and compared, thereby allowing dynamic instructional strategies to develop in step with the students' progress.

## 2. World Wide Web for ITS

In this chapter, we survey the merits and the defects of the WWW as an environment for ITS, while examining ITS' present approach on the WWW.
There are several merits to using the WWW for the environment of ITS. It is possible to study in a human way when the ITS is implemented on the hypermedia based on the WWW. Also, it is possible for many students to share the same tutoring material on the WWW. The growth of web sites has also given the student the opportunity to utilize information from all over the world[Lee et al. 97].

However, several problems do exist when using the WWW as an instructional device. Due to the limitless nature and sheer size of the WWW, it is often difficult to verify or diagnose a given student. The disorientation resulting from the great vastness of the WWW must also be overcome. In addition, students have difficulty obtaining the overall courseware structure of the ITS on the WWW.

CALAT is the present ITS on the WWW[Nakabayashi et al. 95]. This ITS is composed of the WWW and an individual tutoring system. In CALAT, the developers intended to solve the student verification, diagnosis and disorientation problem on the WWW. Using CALAT, an expert module decides the instruction path in order to prevent the disorientation. This decreases the effect which can occur while using the vast WWW for tutorial material. However, CALAT developers utilized their previous stand-alone ITS which suffers from heavy user loads as well as recognition loads due to the vastness of the WWW.

In this paper, we describe the design and implementation of a hypermedia learning system with intelligent factors. This suggested system can support concurrent learning, dynamic lesson planning and individual instruction for each student. Our system can provide the various path to the students so as to utilize the educational merits of the WWW. When a student becomes disoriented, our system provides advice to the student. We designed our system as a multiprocessing system so the loads of our system can be reduced when there are many students connected to our system. Finally, we provide the overall courseware structure to the students so as to reduce the recognition loads of students.

## 3. Design of the System

[Fig. 1] represents the configuration of the intelligent hypermedia learning system. This configuration, similar to a stand-alone ITS, is composed of the expert module, student module, and the instructional strategy module. In addition, our system includes the HTTP demon and CORBA-based CGI(Common Gateway Interface) application for the interaction between students and the student module, and IIOP to HTTP Gateway module for transmitting HTML document to student.

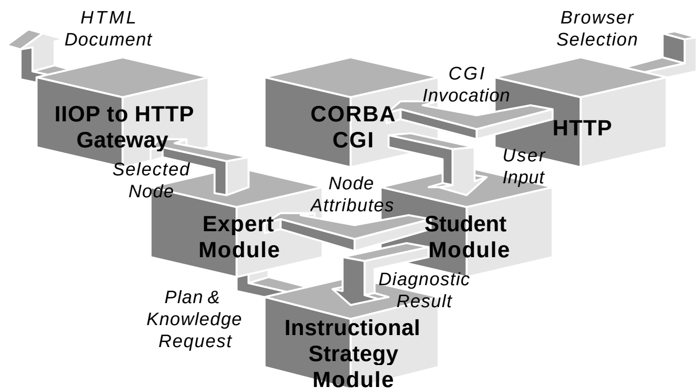


**Figure 1: Configuration of system**

In our system, many students can learn within the provided courseware. Student module diagnoses, infers learning state of present student according to the student database which store the information of each student. By using this diagnosed result the student instructional strategy module decides the next lesson, and transmits the courseware in HTML form. Thus the individual learning can be provided.

The courseware which exists in the WWW is transmitted to the student through IIOP to HTTP Gateway, then sent to HTTP so that the students can learn by using general WWW browser. Student module uses CGI application in order to receive the data for learning because the standard HTTP cannot receive the input of the user. All the input of the student is collected through the CGI application. And this information would be used to decide the instructional strategy.

### 3.1 Interface modules

Our system use the CORBA ORB and the CORBA CGI applications. Therefore, we need protocols, HTTP and IIOP. When a student selects some link, that selection send to HTTP demon using HTTP. Then HTTP demon invokes CORBA CGI application. The codes of CGI application are distributed over servers using CORBA object implementation.

During some object implementations are executed, the student module diagnoses student's selections. The student module sends diagnosed result to the instructional strategy module and current state of that student to the expert module. Then the instructional strategy module plans that student's next lesson. And the expert module selects appropriate materials and creates HTML document from them. This document the expert module creates, is not in web

server machine. Because of that, we need some other method to send materials in HTML form to student's web browser.
The CORBA ORB uses IIOP, that we cannot use to send HTML documents to student directly. Then we implement the IIOP to HTTP gateway to distribute all the material and student information. The IIOP to HTTP gateway module converts protocol from IIOP to HTTP.

### 3.2 Expert module

The domain knowledge will be used in coaching the students, diagnosing possible misconceptions after a student has made an error, and providing appropriate remedial materials. This domain model has dual representation network, the IUN(Instructional Unit Network) and the CN(Conceptual Network).
The IUN is a knowledge network which includes the materials to be shown to the student and the information concerned with learning sequence. The IUN is configured as a hierarchical network, and each node of it has the link to the subordinate unit and the subordinate unit denotes the prerequisite knowledge of the super unit.
Within the IUN, each node represents a learning unit, and it includes the theme of units, learning aim, the link of the concepts related to the learning units, the links to the problems, and the links to the subordinate units.
There are two types of the instructional unit. One is the explain unit, the other is the problem unit. The explain unit has instructional materials that have various media types such as text, graphic, still image, sound, and moving picture. The problem unit has two major concept to diagnosing the student's state, difficulty and importance. These concepts are used when lesson planning and gradual instruction objective creating. [Fig. 2(a)] represents an example of the IUN.
[Fig. 2(b)] represents an example of the CN. The CN is a knowledge network which piles up the knowledge of being contained in subject domain to be learned by the student. The CN is a data structure, which is a set of collected knowledge concerned with the declaring concept of domain knowledge, but independent upon the instructional knowledge. Each node within the CN represents the instructional concept, and the links between the concepts indicate the relationship of them. Using this relations, it is possible to generate problem dynamically, and to diagnose the student's error.

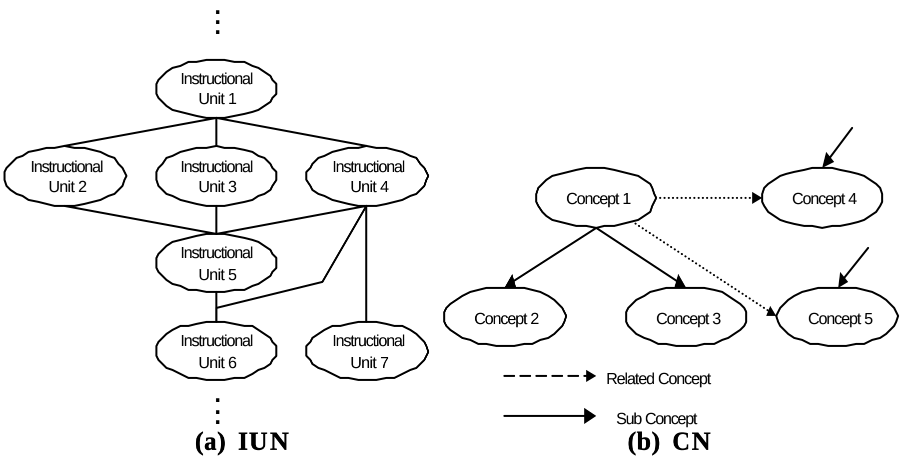


**Figure 2: Examples of the IUN and the CN**

According to environments of the CORBA, expert module can access CORBA ORB(Object Request Broker) to assist easy retrieval of materials, and URL indexing and caching demon to improve performance of system.
Unlike existing stand-alone ITS, user verification have to be supported so as to provide the individual learning according to the rate of each student. But HTTP can't support the method of user verification. When the first node is transmitted to the student, student account and password which are transmitted to the authorizing processor is transmitted into explaining node as a hidden tag. When the student requests the next node, the system can verify the students by the student account and password tag which are transmitted to student module.

### 3.3 Student module

This diagnostic result generated by student module is used by the instructional strategy module in order to inference the basis for determination of learning progress, supplying advice, and selecting comments.
In this paper, the student module is based on the overlay model. The student's knowledge has been learned is saved at the database within the student module, and the learning path can be shown in parallel with the learning achievement. As the learning proceeds, the student knowledge network in the database has the network form which is similar to the IUN as a knowledge base of the expert system. The diagnostic results of the student, problem type, and examples are

saved at nodes in the student knowledge network. And the form of student knowledge network represents the learning path.
When the domain knowledge expert constructs the IUN and the CN by means of authoring interface, the two networks contain slots represented by linguistic variables for holding importance and difficulty which are the attributes of each problem and instructional unit. The linguistic variables used in input are shown in [Table 1].

**Table 1: Linguistic Variable for Diagnosis**

| | Instructional unit | Diagnosis result |
|---|---|---|
| difficulty | D, M, E | G, M, B |
| importance | I, M, Ni | |
| modifier | [Very]*, [Less]* | |

* where D = Difficult, M = Medium, E = Easy,
I = Important, Ni = Not Important, G = Good, B = Bad

The linguistic variables about the problem are used for diagnosing student's response. Using the linguistic variables, the domain expert can input at more user-friend environment because of being able to use linguistic variable and no need to decide special real number for attributes of all learning elements. The linguistic variable is the kernel of fuzzy theory which makes use of the fuzzy representation of human-being in computer. Using the concentration and dilation in the fuzzy theory, we can define the function which diagnoses the student's current knowledge. The function of concentration and dilation are as follows.

$$CON(A) = A^2 = \sum_{i=1}^{n} \{x_i, m_A(x_i)^2\}, \forall x_i \subset U$$

$$DIL(A) = A^{\frac{1}{2}} = \sum_{i=1}^{n} \{x_i, m_A(x_i)^{\frac{1}{2}}\}, \forall x_i \subset U$$

The membership functions upon Good, Medium, and Bad may be changed by the author, and the diagnostic results can also vary according to the membership function applied. Hence, the author can control the diagnostic results by changing these three membership functions.
The difficulty and the importance of [Table 1] are defined as the dilation of Medium(the default membership function of M is M=x), and both Easy and Not Important are defined as the concentration of Medium.

$$D = I = M^{\frac{1}{2}} = DIL(M)$$

$$E = Ni = M^2 = CON(M)$$

Therefore, we can define the DV(Diagnostic Value) function as follows.

$$DV(R_{1-n}) = norm\left(\sum_{i=1}^{n} (R_c / R_n)^k\right)$$

norm : normalization function that makes the result in the range of [0,1]
R1-n : The problem from start to n that was responded by student.
Rc : The number of correct answer according to linguistic variable
Rn : Total number of problems presented to student
k : The number of powers according to linguistic variable, defined as follows: I or D : ½, M : 1, Ni or E : 2

Normalization is defined as follows: suppose that all problem is correct, then, calculate the DV and divide into the result of calculation about correct answer. If the importance and the difficulty are applied at the same time to the same problem, select one that minimizes the membership degree and applies it.
To use more various values for representing the importance or the difficulty, we must consider modifiers applicable to the linguistic variables. In this paper we define two modifiers, Very and Little, as follows

$$V^n D = M^{\frac{1}{2^{n+1}}},\ L^n D = M^{\frac{1}{\sqrt[n+1]{2}}},\ V^n E = M^{2^{n+1}},\ L^n E = M^{\sqrt[n+1]{2}}$$

The equations above always hold the relation

$$V^n E \le L^n E \le M \le L^n D \le V^n D \quad (n \ge 0)$$

regardless of its number of repetition. Hence, the inconsistency of diagnostic result caused by repeated applications of the modifier is removed. For example, Easy is never less than Very Easy in spite of the number of Little modifier's applications.
The calculation result by DV function for the diagnosis of student's response is a real number which ranges between zero and one. To execute fuzzy inference using linguistic variable, result obtained by the DV function has to be fuzzified. Fuzzified result is one of the linguistic variable that consists of Good, Medium, Bad, and the modifier [Very]*, [Less]*.
If we fuzzify the diagnostic results into the linguistic variables, then they can be used together with the inference rules

using the linguistic variables. [Fig. 3] represents the district graph of diagnostic value to fuzzify diagnosed result.

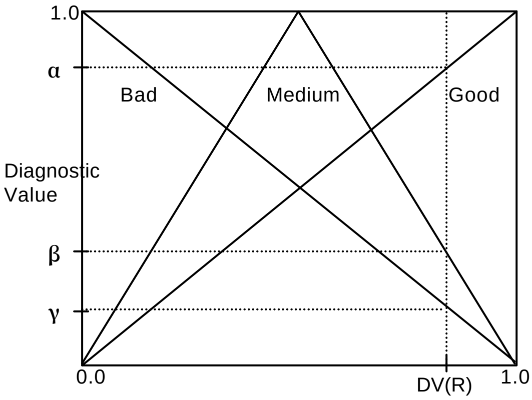


**Figure 3: District graph of DV**

If the author input the inference rule and there was conflicting among those rules, that is, different result is input at the same condition, the author is presented the condition and is asked what result should be used. The result of learning, whether well or poor, is determined according to what deterministic variable is input by the author. This shows that the author's intention is able to be reflected to inference rule.

### 3.4 Instructional strategy module

The instructional strategy module mediates and develops the learning of the students through the planning of a curriculum to order the domain knowledge that must be supplied to students, and the planning of teaching to decide the presentation method, re-planning to construct proper planning and monitor the action of students.
Among the contents of a lesson which are taught to the students, the total contents of a lesson are composed of the network of the main objectives of instructions that are relatively independent each other.
Lesson plan presents the evaluation problem and the instructional material of instructional unit, decided by the curriculum planning to students in the proper level. The Instructional strategy module offers students the instructional material on the instruction unit and the evaluation problem by means of the method divided by the curriculum planning.
The gradual instruction objective must be created by considering the student level that has acquired the degree of difficulty of instruction unit and students' records obtained previously. For an efficient instruction, problem presentation order must be planned dynamically by according to the students' level. The instructional strategy module can create dynamically the problem about the concept learning and the discrimination learning using the CN.
Also instructional strategy module can dynamically limit the number of links which the student can select, according to the level of each student. This module have functions which provide the students for advice when the students refer the irrelevant to the present learning content frequently or when disorientation problem occurs.

## 4. Conclusion

Existing distance learning systems has poor support for not only interaction with students, but also individual instructions. And researches that overcome disorientation problem in vast hypermedia space are very few. In this paper, we have designed and implemented intelligent distance learning system which supports interaction with students, can create dynamic instructional strategies. Our system consists of expert module, student module and instructional strategy module. Because our system has data structure and method that diagnoses students' knowledge, it is possible to plan lessons dynamically.
Student module can support interaction with students using CGI applications on the WWW, diagnose each student's knowledge using private student's information and students' response. In instructional strategy module, evaluation problem can be created dynamically according to the diagnosed result, individual instruction can be supported by deciding further instructional strategy. In expert module, student can recognize himself in courseware WWW on instructional unit network. So, we can overcome disorientation problem.

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