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ABSTRACT

This paper presents a model of an intelligent computer network that provides real-time evaluation of students' performance by incorporating intelligence into the application layer protocol. Specially designed drills allow students to independently solve a number of problems based on current lecture material; students are switched to the most appropriate assignment level (regular, advanced, or simplified) based on computer evaluation of performance. The state of each network is defined as a function of a student's performance during the course of the drill. The analysis of a state of the nodes in real-time permits algorithmic reconfiguration of the network resources. As a consequence of this reconfiguration, the instructor will monitor only those students who are behind the schedule. This, in turn, allows the instructor to concentrate on the analysis of the students' problems and the ability to provide real-time help rather than attempting to identify those students who are experiencing difficulty. Figures present the matrix of student performance, graphs of a students' performance and overall class performance, and the algorithm of real-time performance analysis. (AEF)

Development of a Real-Time Intelligent Network Environment.

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Introduction.

The traditional computer network offers instructors the ability to share data, applications, and files with their students. Students can create group projects by sharing code and ideas utilizing this network. E-mail, file transfer protocols, and the Internet can be found in most laboratory environments and can be used for classroom activities. In general, all of these network related activities may be described as "sharing and communication". Benefits of employing networks in the classrooms include student access to sharable resources, enhancing communication between student and professor, between students inside a working group, between working groups, etc. As a result of this enhanced communication, an instructor has to process more information during the class hours. The ability to quickly analyze incoming data and issue an appropriate response to the students may considerably enhance the quality of teaching. Obviously, the faster the response the better results it produces. Ideally, we want to achieve real-time help, where an instructor may offer assistance to students at the time at which the problem arises. Intervention at this time is most beneficial to a student because he/she is currently thinking about the problem and is highly motivated to solve it.

To provide real-time help the instructor needs to have the information about the students' performance. The solution may be found in introducing new intelligent functions which are incorporated into the classroom network environment and provide real-time evaluation of the students' performance. Based on this evaluation, the network filters out the information about the students who currently do not need help. It delivers to the instructor only the data about the students who really need help. This relieves the burden of continuous class monitoring and allows the instructor to concentrate on his/her responses. Moreover, this approach allows the instructor to offer help to some students even if these students, for some reason, did not seek assistance.

An intelligent network capable of monitoring each station and able to determine which questions or topics are causing difficulty would be a pedagogically valuable tool. By providing real-time performance analysis and dynamically reconfiguring the question package, the intelligent network would be able to customize the drill for each class [1,2,3]. Using the instructor supplied timings, students encountering difficulty can be offered a review of the material and step-by-step solutions. Students who have mastered the lesson can be offered more challenging work.

Model of an Educational Intelligent Network.

The educational intelligent network model helps us offer new network functions that can be very useful to an instructor in his/her efforts to evaluate students' performance. Provided in the real-time, this evaluation may become a beneficial source of information about both the students' performance and quality of the instructor's materials (tests, drills, etc.). As an example for our analysis in this paper, we consider specially designed drills. The main goal of these drills is to allow students to independently solve a number of problems based on current lecture material. Drill assignments reveal problems and misunderstandings which students may have. An assignment is presented to a student on his/her screen, and the solution is evaluated by a computer. The structure of a drill includes three variants of each assignment: regular, advanced, and simplified. By default, a drill starts on a regular level. If a student is lost, makes too many mistakes, and/or spends too much time to find the correct answer, he/she may be temporarily switched to a lower level; and then (may be with the instructor's help) return back to a regular level. The best students in the group may be switched to a more advanced level.

Let us consider a model of the network in which these drills are implemented. In general, any network may be presented as a set of nodes interconnected through a communication medium. Let $P = \{ P_i \}$ a set of network nodes where $i = 1,...,N$, N represents the number of the nodes in the network. We are considering a classroom equipped with N student stations and a teacher station. Assume that any node may be in one of two states:

- 0 corresponds to the situation when a student makes too many mistakes or spends too much time on some problems compared to a schedule assigned by the instructor.
- 1 means that the student's achievement is on schedule.

Let $F = \{ F_i \}$ - a set of boolean state functions. Each F_i corresponds to P_i. Let S(t) be a schedule function. S(t) defines the minimum number of problems a student is to solve at time t. S(t) is defined by the instructor before a drill starts.

$F_i(t_0) = \{0$, if $X_i(t_0) < S(t_0)$ or 1 if $X_i(t_0) \geq S(t_0)$ where $X_i(t_0)$ represents the number of problems solved at time t_0 by a student i $\}$.

At any moment, we have a state vector:

$F(t) = \{ F_1(t), F_2(t), \ldots F_n(t)\}$ defines the state of the network at the moment t. It shows which nodes (students) are currently on schedule and which are not. Because F is a binary vector, the network will be split into two subsets of nodes: one - for the students who have normal performance and the other - for the students who are currently behind the schedule.

Given m performance evaluation points for which S(m) has been defined and n nodes, the dynamics of the student performance can be represented in the matrix (figure 1).

For each F_{ij} $1 \leq i \leq m$, the number of performance evaluation points, $1 \leq j \leq n$, the number of nodes.

Each line of this matrix corresponds to a particular moment and constitutes a snapshot of the network state. Each column shows the dynamics for every participating student during the drill.

Let us assume that the number of problems to be solved in a drill is also m. In this case, the schedule function S(t) may be specified at the moments $t_1, t_2, \ldots t_m$, and it will show how many problems are to be solved by a moment t_i (see figure 2). X_j (t) represents the real-time performance of a student who works on the node # j. The comparison of S(t) and X_j (t) defines the state function of the node # j. The situation when $F_j = 0$ will be displayed to the instructor in order to notify him/her about the students who are currently behind the schedule. The instructor may provide some real-time help to a student or a group of the students related to the problem in question. One of the most efficient ways to provide the real-time help is to employ Analog/Digital Video Network (ADViNet) [2,5]. ADViNet allows the instructor to send images from teacher screen to any designated group of student screens in the classroom without disturbing the rest of the class.

In the above analysis, we deal with the information about a particular student (network node). It allows us to understand the individual student's problems and provide real-time help.

Unfortunately, the information about the individual student's performance does not enable us to provide more general in-depth analysis of the overall class performance.

Let us introduce variable Z which can take any value from the set $\{ Z_1, Z_2, \ldots Z_m \}$ where $Z_i = \sum^{n}_{j=1} F_{ij}$; $0 \leq i \leq m$. Z shows the overall performance of the class. $Z = Z_i$ displays how many students are on schedule at the moment t_i. If Z is too small, this would indicate that the work is too hard, or the material has not been thoroughly explained; if Z is too large, a more difficult problem set has to be supplied. Thus, the value of Z permits us to analyze the quality of the test or drill. An example of using variable Z for the evaluation of the overall class performance is shown in figure 3. There are several zones which should be considered separately. Zone A ($Z \leq Z_{MIN}$) shows that the current problem(s) is (are) too complicated for the majority of the students in the class, and real-time help from the instructor is needed. Zone B ($Z \geq Z_{MAX}$) reveals the opposite situation when the problem(s) is (are)too simple. In this case, the network can be automatically or manually switched by the instructor to the level with higher requirements. These several levels are specified in the information structure which defines a drill.

If we consider two consequent moments t_i and t_{i+1} and $Z_i - Z_{i+1} > \Delta Z_{MAX}$ (zone C), then the current problem is too hard for the class, and help is required. Although it may be the time schedule that should be changed.

If $Z_{i+1} - Z_i > \Delta Z_{MAX}$ (zone D), then a problem is probably too simple, and a higher level should be used. The algorithm of real-time performance analysis is shown in figure 4.

The algorithm of real-time performance evaluation is included in the application layer communication protocol. The goal of this protocol is to make the software for real-time class assistance more structural and standardize the "ground" for the future development. The incorporation of state computation and performance analysis in the protocol allows the network to derive control operations from the algorithmic steps of network subfunctions and make the necessary dynamic reconfiguration. The reconfiguration may involve automatic real-time hardware reconnection and set up and/or the alteration of data in the Management Information Base that will effect the network functioning. In other words, after the reconfiguration, the number of nodes involved in a session or the way (or order) of their communication may be changed [4].

Conclusion

We believe that the use of traditional computer networks in a classroom can provide real-time assistance to the instructor. In this paper, we tried to analyze one possible implementation of an intelligent network by incorporating intelligence into the application layer protocol. As an example, we have considered specially developed drills. The state of each network node is defined as a function of a student's performance during the course of the drill. The analysis of a state of the nodes in real-time permits algorithmic reconfiguration of the network resources. As a consequence of this reconfiguration, the instructor will monitor only those students who are behind the schedule. This, in turn, allows the instructor to concentrate on the analysis of the students' problems and the ability to provide real-time help rather than attempting to identify those students who are experiencing difficulty.

This paper introduces work in progress. In the future, we are going to extend intelligent network functions to other instructor's activities.

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$$M = \begin{pmatrix} F_{11} & F_{12} & \dots & F_{1n} \\ F_{21} & F_{22} & \dots & F_{2n} \\ \dots & \dots & \dots & \dots \\ F_{m1} & F_{m2} & \dots & F_{mn} \end{pmatrix}$$

Figure 1

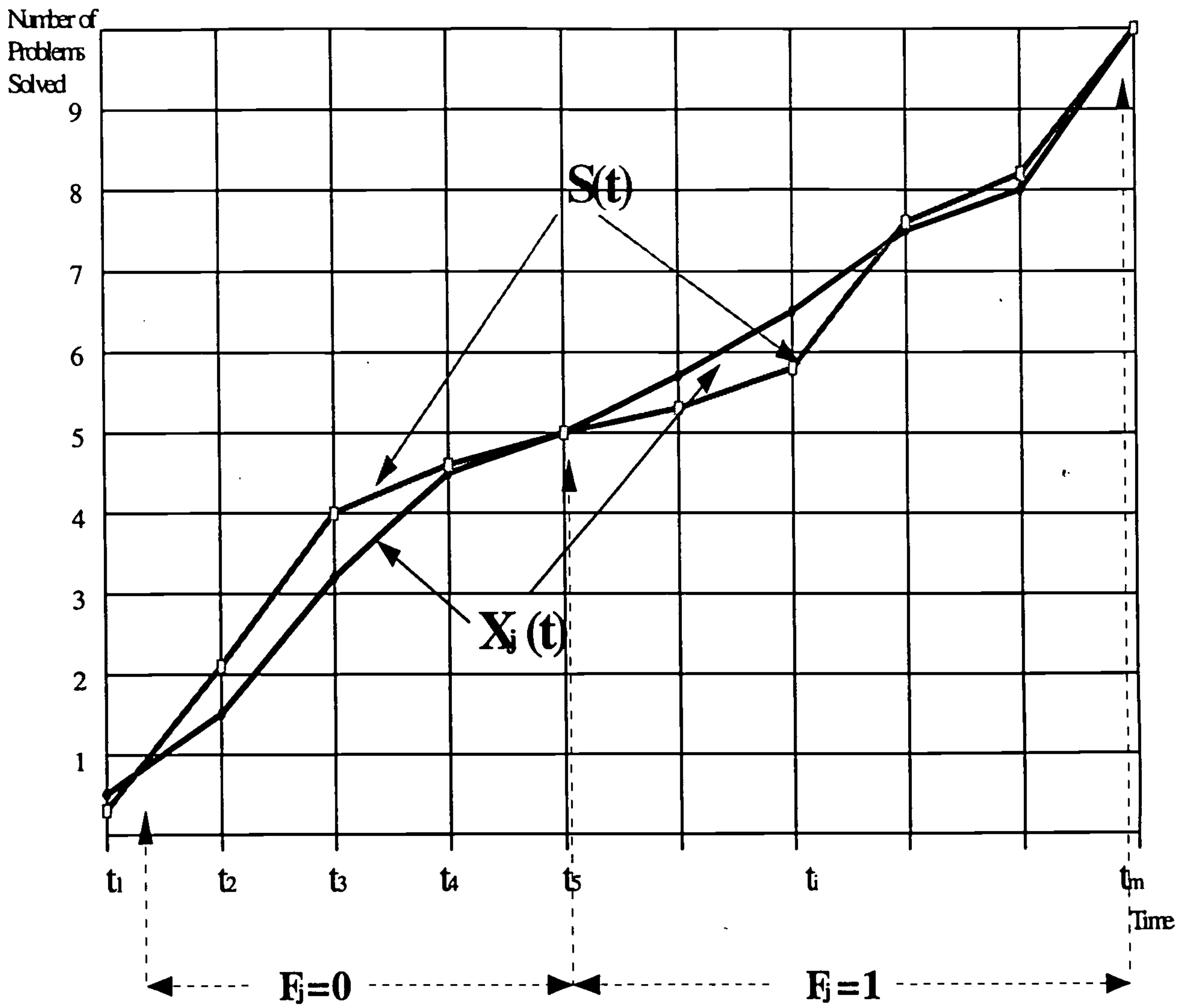

Figure 2. A Student's Performance

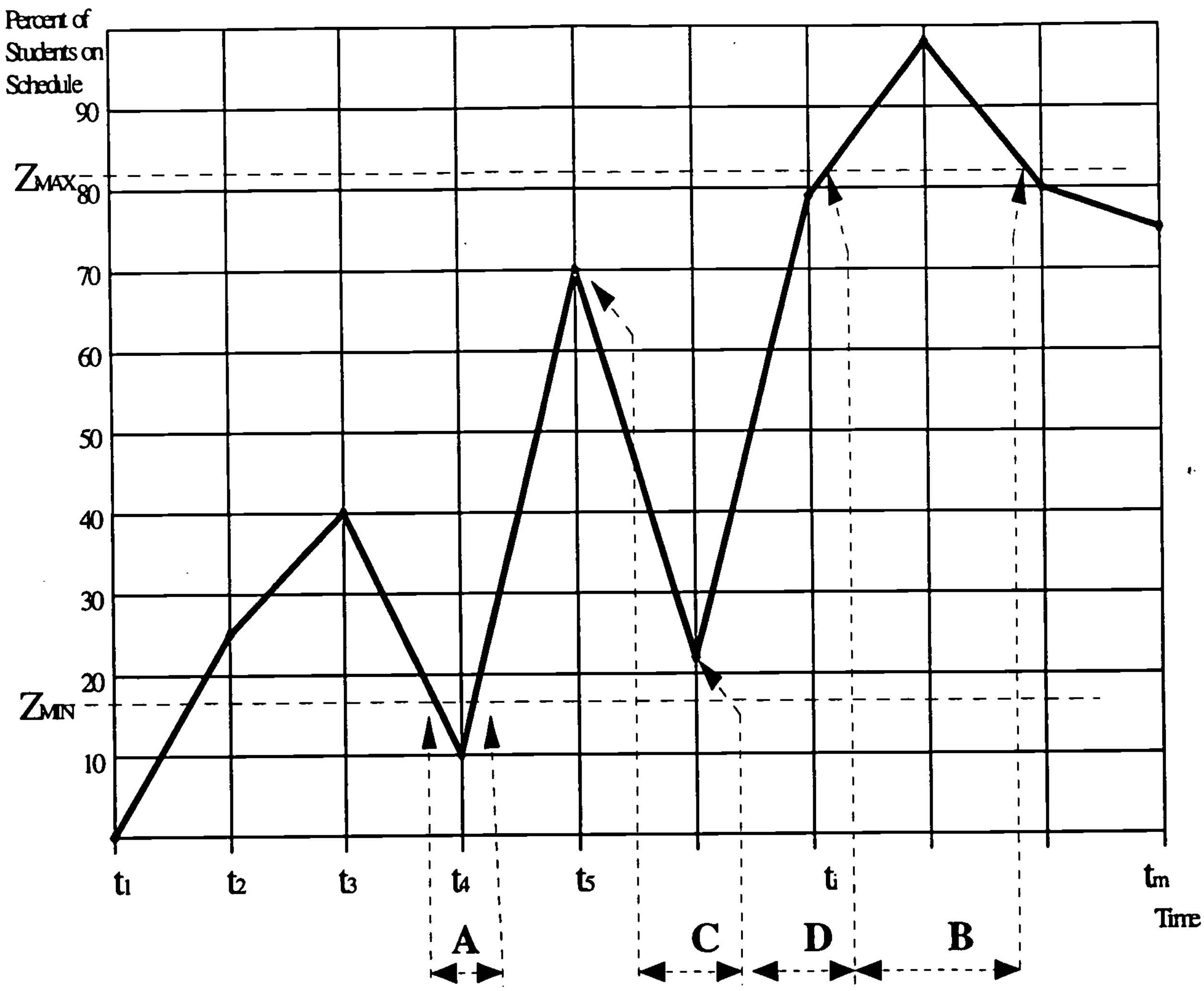

Figure 3. Overall class performance

Algorithm of Real-Time Performance Analysis

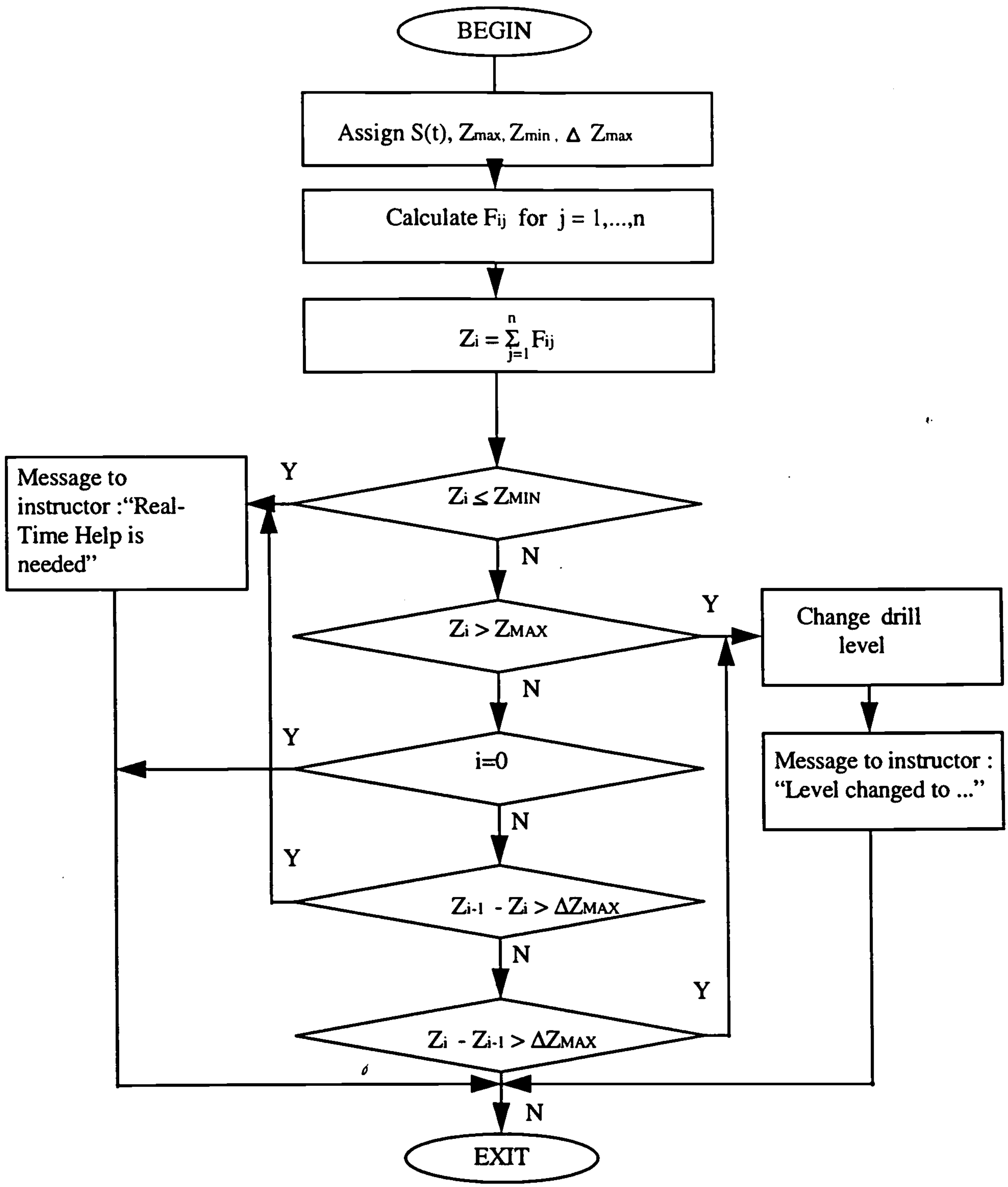

Figure 4