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A Petri Net Computational Model for Web-based Students Attendance Monitoring

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Abstract

Monitoring student's attendance in classes is necessary for proper assessment of their understanding and performance in a course module. Attendance monitoring in a manual teaching and learning setting is easier than in web-based. The major reason for the inherent difficulty is that the latter provides virtual teaching and learning relationship in which students are not seen, whereas the former involves physical or face-to-face teaching and learning. Research and evidence showed that good attendance has a direct impact on student's success in a course module. The paper presents an overview of student-teacher relationship in an educational environment. Subsequently, a mathematical model description using Petri nets is provided to capture web- based student attendance. The empirical example and corresponding output using Microsoft Excel justified the modeling power of Petri nets. The framework presented can be embedded into custom online academic programme to track student attendance in course modules.

Key words: *Web based student attendance, Petri nets, computational model, monitoring*

1.0 Introduction

The increasingly rate at which access is being provided through networked education worldwide is due among others to a growth in the Internet technology and its application in education. The issue of global education, i.e., the strive of global community, especially the technologically advanced world to attain global information age and man's pre-occupation to collect, store and retrieve information and more importantly distribute or communicate it by fastest means possible across the globe has made Internet a useful teaching aid in distance education. Colyer [1] described the Internet as a land of infinite possibilities. He stated "that the Internet provides the opportunity to connect learners, resources and teachers in ways our predecessors may have only dreamed about". The Internet and World Wide Web (WWW) have become pervasive in the academic realm particularly in the coursework required to achieve higher education [2]. Courses developed for the Internet and the WWW are delivered within a computer-based information system [3]. Virtually, all the learning tools and forms of interaction that exist in the traditional classroom also exist in this virtual classroom known as distance education. The word "distance education", is a method of learning at a distance rather than in a classroom [4]. The word was coined within the context of a continuing communications revolution largely replacing a hitherto confusing mixed nomenclature-home study, independent study, external study, and most common though restricted in pedagogic means, correspondence study. Distance education is the term used to cover various forms of study at all levels where students are not in direct physical contact with their teachers. Learners do not necessarily have to travel to an educational site at a specified time but participate by interacting with a personal computer connected to the Internet. In any case, activities and interactions are predicated by computer software and Internet browsers, instead of face-to-face interaction [5]. Standard course module usually includes presentation of course content, assignments, quizzes, seminars, projects and research papers. According to research and investigation into student's retention and progression, poor retention was variously attributed to lack of preparedness, poor integration, wrong course choice, lack of feedback, problems with finance and accommodation amongst others [6]. Some of these factors resulted in dropout, some in failure or delayed progression. One common finding of all such studies, however has been that poor attendance generally links to poor retention [6, 7]. The actual control of learning process in an educational setup consists of two interconnected processes namely [8];

(i) Curriculum development and teaching;
(ii) Monitoring (or evaluation process).

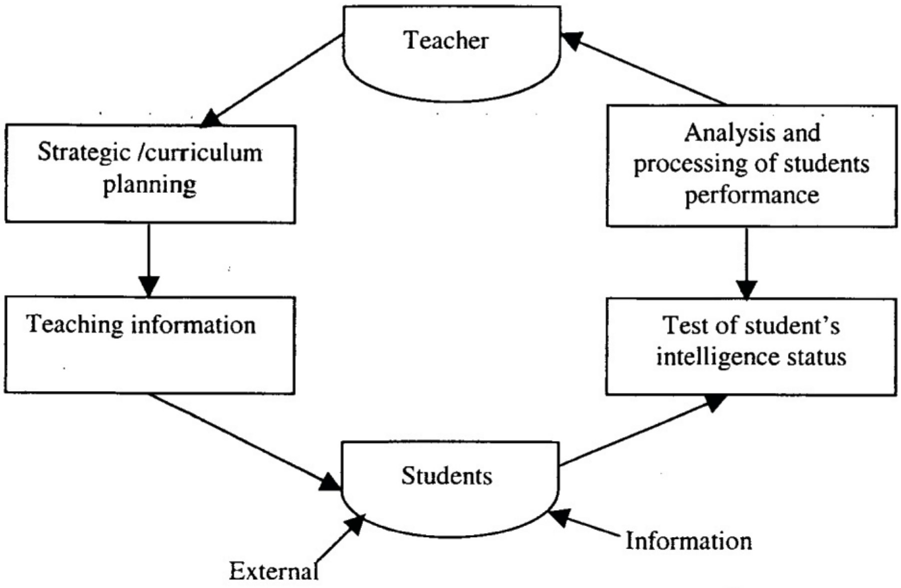

Figure 1: Teacher - Student relationship

The teacher-student relationship is shown in figure 1. The teacher provides the strategic curriculum planning and presents course materials, seminars to the students based on the stipulated curriculum. Furthermore, the students' intelligent quotients are evaluated through continuous assessments, quizzes, examinations and performance computed. In some educational institutions, a student must make a minimum of 75% attendance to be eligible to take an examination. In such institutions, student attendance must be monitored systematically with an auditable mechanism. Where a student has failed to attend a module for three consecutive weeks or meet up a specified threshold, academic staff must inform the programme advisory service of this continuing absence. The 75% or monitoring over three consecutive weeks is a minimum requirement and schools may prefer to make the initial contact after one- or two-weeks absence in order to establish a more staged process. Where such an absence occurs, the student must then be contacted to discover why he/she is failing to attend adequately. If this student then fails to respond to this approach, the Dean must then send a University-wide letter, which will state that unless the student responds within seven working days he/she will be deemed to have withdrawn from the University on the grounds of non-attendance.

2.0 Related Petri Net Works

The theory of Petri nets has its origin in Carl Adam Petri's dissertation "Kommunikation mit Automation", submitted in 1962 to the Faculty of Mathematics and Physics at the Technische Universitat Darmstadt, Germany [9]. A Petri net is defined by a 4 -tuple (P, T, A, M) where: P is a set of places; T is a set of transitions; $A \subseteq (P \times T) \cup (T \times P)$ is a set of arcs; and $M: P \rightarrow I$, $I = \{0, 1, 2, \ldots\}$ is a marking (the number of tokens) in places in the net. A Petri net structure is shown in figure 2.

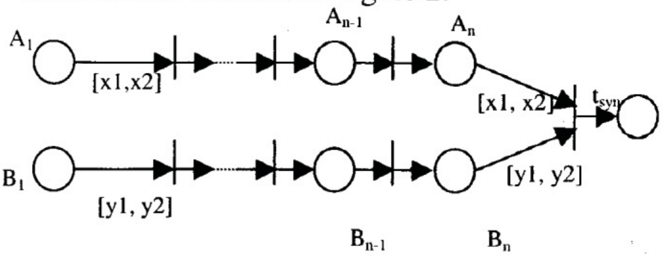

Fig. 2: Structure of a Petri net

Other extensions of Petri nets that are suitable for time-critical applications include Object Composition Petri Net (OCPN), Time Stream Petri Net (TSPN) and Fuzzy Timing Petri Net (FTPN). These extensions are briefly reviewed below.

2.1Object Composition Petri Net (OCPN)

OCPN is an object level model, where places are associated with resources and

durations [10]. The durations are fixed playout time for the object represented by each place while transitions represent inter-object synchronization points. The OCPN is defined as a 6-tuple (P, T, A, M, D, R), where:
(P, T, A, M) is a Petri net, D: $P \rightarrow Q^+$ is a mapping from places to durations where Q^+ is the set of non-negative real numbers; and R: $P \rightarrow \{r_1, r_2, r_3, \ldots, r_k\}$ represents the resources required at each place. OCPN can specify all of the basic thirteen interval relationships (before, meet, overlap, during, start, finish, equal, and their inverses) between multimedia objects [11].

2.2 Time Stream Petri Net (TSPN)

TSPN is a fine-grained temporal model for modeling isochronous data synchronization [10]. In the TSPN, arcs leaving places are labeled with a 3-tuple $[\alpha, n, \beta]$, where α represents the earliest firing time (EFT), n the nominal firing time (NFT) and β the latest firing time (LFT), respectively. This is used to define the maximum tolerable jitter (temporal deviation of each information unit). Each place is a processing time-point of the corresponding multimedia information unit. A TSPN is defined as a 6-tuple (P, T, A, M, IM, SYN), where (P, T, A, M) is a Petri net; IM: $B \rightarrow Q^+ \times Q^+ \times (Q^+ \cup \infty)$ is a mapping from B (the set of arcs leaving places) into $[\alpha, n, \beta]$ (3-tuples of real numbers) explained above; and SYN: T→{or, strong-or, and, weak-and, master, or-master, and-master, weak-master, strong-master} is a mapping from the set of inter-stream synchronization transitions into a type of firing rule. The following three basic transition firing rules are defined: strong-or, weak-and, and master. The strong-or strategy means that the synchronization is driven by the earliest stream, and the presentation of later streams will be stopped. The weak-and strategy means that the synchronization is driven by the latest stream. And the master strategy means that the synchronization is driven by the master stream.

2.3 Fuzzy Timing Petri Net (FTPN)

FTPN introduces four fuzzy time functions called the fuzzy timestamp, fuzzy enabling time, fuzzy occurrence time, and fuzzy delay to Petri net [10, 12, 13]. The FTPN is defined as a 6-tuple (P, T, A, M, D, FT), where; (P, T, A, M) is a Petri net; D is the set of all fuzzy delays $d_{tp}(\tau)$ associated with arcs (t, p) from transitions t to places P; and FT is the set of all fuzzy timestamps, where a fuzzy timestamp $\pi(\tau) \in FT$ is associated with each token and each place. A fuzzy timestamp $\pi(\tau)$ is a fuzzy time function or possibility distribution giving the numerical estimate of the possibility that a particular token arrives at time τ in a particular place. For simplicity, the trapezoidal or triangular possibility distribution specified by the 4-tuple $h_i(\pi_1, \pi_2, \pi_3, \pi_4)$ may be used as shown in figure 3, where the height h_i is set to the default value one and the triangular form in figure 3(b) is a special case ($\pi_2 = \pi_3$) of the trapezoidal form in figure 3(b).

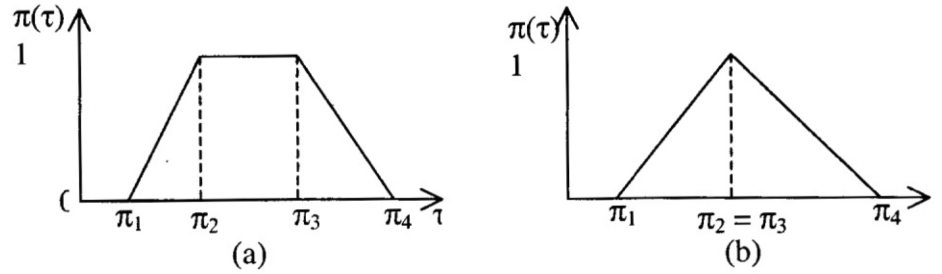

Fig. 3: Trapezoidal and triangular possibility distribution

3.0 The Petri Net Model of Web-based Attendance Process

In this section, the attendance process and the corresponding computational model using Petri nets are presented.

3.1 The Attendance Monitoring Process

Attendance is a critical factor in academic success and school completion for students. Consistent class attendance is part of the self-discipline expected of students to enable them act as responsible members of the society. An educational process requires continuity of instruction in which students participate in class discussion, debate and independent study in order to increase achievement, critical thinking, communication skills and responsibility. Absences, for any reason are disruptive to the learning process and to the achievement of the student. Attendance reporting is therefore an integral part of the attendance process and follows similar guidelines to those used for students attending a class on campus. Any absence, tardy or early dismissal must be accounted for. The web-based student attendance monitoring process is shown in figure 4.

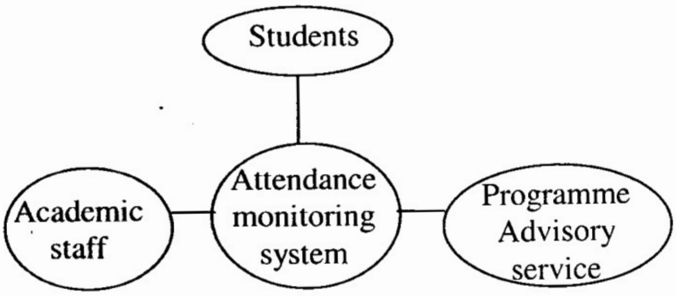

Fig. 4: Attendance monitoring process

The system consists of three components: the students, academic staff and programme advisory service.

Students: To be eligible, a student must register by paying the necessary school fees and thereafter given a username and password, timetable and other necessary documents. Any registered student is allowed to attend classes in the course for which he/she enrolled.

Academic Staff: Provides and delivers the multimedia lecture modules, assignments, topics for class debates, seminars, etc. He also maintained attendance data and conduct examinations.

Advisory Service: Offers necessary advice to students and to the school administration on student's progress. Notification of student absence and tardiness from Advisory service to parents is done via the registered email address.

3.2 The Petri Net Computational Model for Web-based Attendance Monitoring

To show that Petri nets can be used to model web-based attendance, we first provided a system translation from an arbitrary attendance process to a suitable Petri net topology. For this reason, we map typical web-based attendance parameters such as click-stream, earliest (or starting) click-time, latest (or ending) click-time, and timetable timestamp onto places and transitions. As noted in section 2, the FTPN added a time interval with a possibility value P in the form of $p[\alpha, \beta]$ to each transition. This implies that each transition is associated with a firing interval $p[\alpha, \beta]$, where the default interval is 1[0, 0] (a transition definitely fires as soon as it is enabled) and each place acts as a starting/ending place of the multimedia presentation or class. If a transition t is enabled at time instant τ, it may not fire before time instant $\tau + \alpha$, and must fire before or at time instant $\tau + \beta$.

In the web-base attendance process, a registered student attending a class must have his/her personal computer connected to the Internet, logon to the website of the University running the online academic programme and sign-in with username and password and other necessary authentication facilities. Each signing-in comprises of the earliest and latest click-time is known as click-stream. A clickstream may be identified with two parameters: the earliest (starting) and latest (ending) click- time. We defined the following notations for computational purposes:

α_e – *earliest click-time (or starting firing time);*

β_f – *latest click-time (or ending firing time);*

$\Delta_i = \beta_{fi} - \alpha_{ei}$ – *duration in attendance or duration of a clickstream;*

N – *total number of credit hours per course;*

t_i – *timestamp of a scheduled class on timetable.*

Each presentation is a multimedia object, which has its duration of show, starting and ending of show. A valid multimedia object must obey the following relation: $\Delta_i = T_i$. This means that for duration of click-stream to be valid, it must map to a timestamp T_i of activity scheduled on the lecture timetable. Figure 5, shows trapezoidal possibility distribution of student attendance.

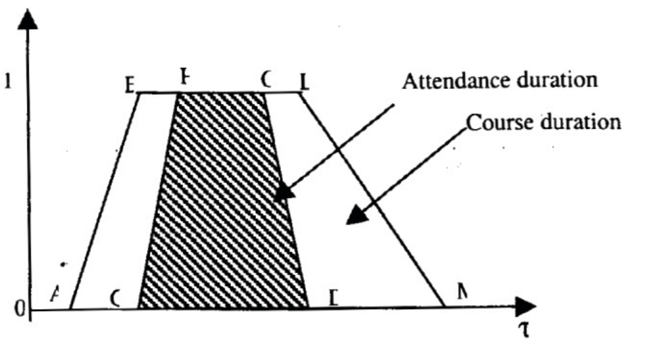

Fig. 5: Trapezoidal possibility distribution of attendance

Given two fuzzy dates *e* and *f* the ***possibility*** of date *e* being before date *f* is computed by:

$$\Psi(e \leq f) = \frac{\text{Area (trapezoid}_{GHCD} \cap \text{trapezoid}_{GHLM})}{\text{Area (trapezoid}_{GHLM})}$$

$$= \frac{\text{Area (trapezoid}_{GHCD})}{\text{Area (trapezoid}_{GHLM})}$$

Thus, $\% \text{ Attendance} = \frac{\sum \Delta_i}{N} \text{x } 100\%$

Numerical illustration: The following is a procedure to compute the percentage of attendance to an 8- credit hour class module (see figure 6):

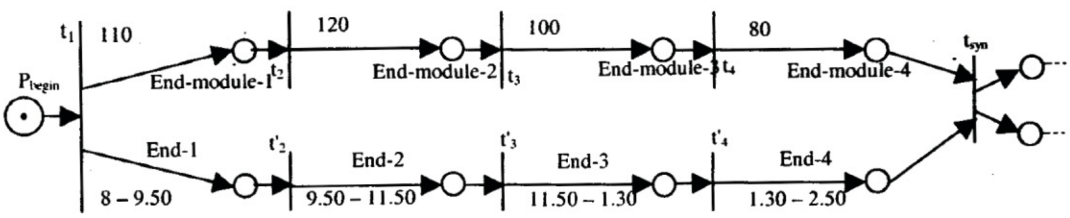

Fig. 6: Fuzzy time Petri net numerical example

Step 1: The series of unit processing transitions for each click-stream can be fused according to the post-fussion of transitions rule discussed in [10]. The resulting duration (410) is the sum of the durations in each unit processing (110, 120, 100, 80). For illustrative purposes this durations refers to duration of four class modules presented in an 8 - credit hours course. Figure 7 shows the reduced FTPN model resulting from the one shown in figure 6.

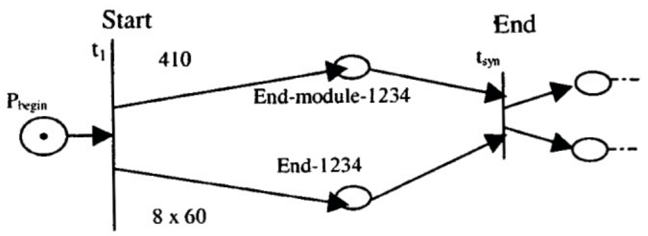

Fig. 7: The reduced FTPN model

$$\% \text{ Attendance} = \frac{\sum \Delta_i}{N} = \frac{110+120+100+80}{8\text{x}60} \text{x} \frac{100}{1}$$

$$= \frac{410}{480} \text{x} \frac{100}{1} = 85.4\%$$

Step 2: In order to be allowed to sit for an examination in any course, a student must attend the course module a minimum of 75% of the credit hour. Based on this threshold value, the system may trigger on sporadic or low attendance and thereafter authorize attendance into an examination or invoke necessary intervention strategies such as staging of follow - ups, send emails, SMS or mount action plans/progress meetings with the students. The table 1 shows an empirical web-based attendance roster:

Table 1: Web based attendance roster

Dept	Computer Science
Module	COS 502
Semester	2nd
Credit hours	8

Key:

√	Present
X	Absent
–	Authorized Absence

S/No	Name	Week No.				Attendance Duration Δ_i	% Attendance
		1	2	3	4		
1	Adibe, Rose	√	√	√	√	110+120+100+80 = 410	**85.4**
2	Agu, Paul J.	√	√	√	X	120+100+120+0 = 340	**70.8**
3	Chukwuma, I.	√	√	X	√	120+110+0+120 = 350	**72.9**
4	Chike, Jose	X	X	√	X	0+0+120+0 = 120	**25.0**
5	Dubem, Philips	√	√	√	√	120+120+120+120 = 480	**100**
6	Eze, Francis	√	√	√	√	120+110+115+110 = 455	**94.8**
7	Ede, Moses	√	√	X	X	110+120+0+0 = 230	**47.9**
8	Onyema, John	√	√	√	√	110+100+100+120 = 430	**89.6**
9	Onyemachi, D.	–	√	√	X	0+120+120+0 = 240	**50.0**
10	Utazi, Rosemary	–	√	√	√	0+120+120+80 = 320	**66.7**

Using a simple Microsoft Excel package, the above data can be captured and represented as shown in figure 8 as follows:

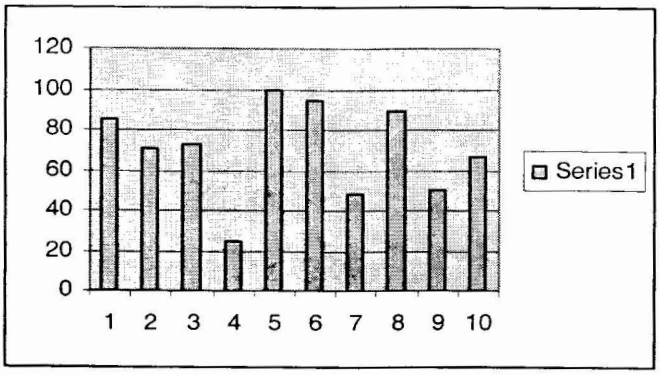

Fig. 8a Sample screen displaying attendance result in bar chart

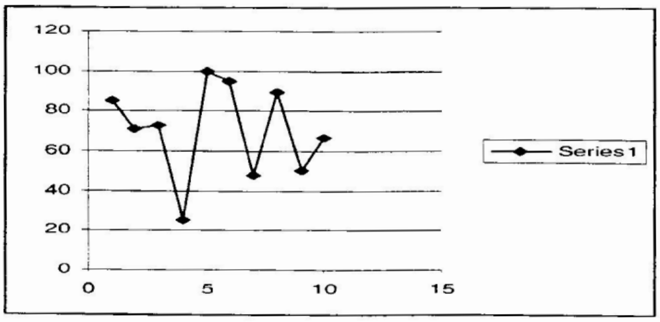

Fig. 8b Sample screen displaying attendance result in curve

Thus, from figure8a-8b, it is easy to see at a glance the number of students who satisfied the 75% attendance requirement in a course module. These include Adibe Rose with 85.4%, Dubem Philips with 100%, Eze Francis with 94.8% and Onyema John with 89.6%.

4.0 Conclusion

The paper presents a model of Petri nets that can be used to monitor web-based students' attendance. The approach presented and discussed showed that it is possible to track student's attendance in class modules on a real-time basis. The empirical example used and results from Microsoft Excel both testified to the modeling power of the theory of Petri net in this application area. Modeling web-based attendance using Petri net most importantly helps to ratify conflicting schedules in advance, provide insight into anticipated improvements and finally provided a new area for further research.

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