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Design and Implementation of a Web-Based Timetable System for Higher Education Institutions

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Abstract

Timetabling concerns sets of activities geared towards the production of a timetable that must be open to various constraints. A timetable for higher education institution timetable refers to a temporary structure of a lecture series and lecture halls or classrooms where all presented constraints are met or satisfied. Currently, several administrative activities and services for higher educational institutions have been automated with the neglect of timetable for lecturing because of the challenges associated with its automation. Over the years, consultations with stakeholders such as students and staff in departments, faculty lasting several weeks coupled with adjustments due to feedback has characterized the timetable preparation process. The processes and procedure involved in creating timetables of such nature in a manual way is regarded as demanding, complex and time-consuming process. A computer assisted timetable generator is a time saver for administrators tasked with the job of course and timetable creation and management. Because every organization has its own timetabling dilemma, the software programs that are available on the market may not meet the needs of every organization. Therefore, a realistic approach to building a timetabling program for lecture courses must be created, which can be tailored to suit any problem with higher education timetabling. Due to the need for flexibility, adaptability to future requirements, and the possibility of producing the deliverables within a limited time frame to address the stated challenges, the Rapid Application Development (RAD) software development model was used. This project aims to produce a practically oriented timetable algorithm capable of addressing the challenges posed by weak and strong constraints in an automated timetable package.

Keywords

Academic Timetable, Academic Scheduling, Web-based Timetable

1. Introduction

Due to the increase in course offerings and enrollment surges, the demand placed on facilities of academic institutions has become relentlessly high. The ability to work within the given constraints of time, facilities and resource persons becomes the greatest asset of any institution [7].

School timetabling problems vary between different institutions in terms of the constraints specified by the educational system [17]. In most schools, timetables are manually designed and Lecturers usually set aside a week or a weekend for this, thus taking up valuable time in the process. In addition to being a time-consuming process, the manual design of a timetable is subject to human error and may not satisfy all the constraints.

However, because of its inherent challenges, timetable scheduling is still handled manually. For each semester or term, universities, colleges, high schools and several other educational institutions are obliged to produce time tables. It is a very repetitive, tedious and painful job to build timetables manually, and the need to automate this exhausting operation.

Failure to address timetable problems will lead to schedules with a maximum number of disputes that fail to meet a number of side restrictions, allotted times and rooms within a restricted period of time. It is within this context that this project seeks to assess and fill this gap by designing and implementing a timetable system at higher education institutions in Ghana.

1.1. Specific Objectives

The specific objective of this project is to design and implement a web-based timetable system for higher education institutions that;

1. Allows multiple user access to input and output
2. Enforces permissions and privileges to restricted access
3. Can be integrated into an existing school management system
4. Can manage substitution automatically with assign values

1.2. Scope of Study

The project is mainly focused on resolving the issue of school lecture timetabling and therefore will not address scheduling of exams. It will be assessed at University of Cape Coast in different departments and will also consider different criteria based on the form of classes, lecturers, rooms and laboratories affiliated with the relevant department. Efforts would be placed in motion to ensure that the method built is sufficiently generic to satisfy the different limitations that come with each individual educational institution. Consequently, at University of Cape Coast, this method is supposed to operate with most if not all departments.

1.3. Significance of the Study

Management will produce conflict-free timetables with less commitment and greater performance, thus meeting all the challenging constraints concerned with far less duration.

Lecturers, students and other users can work and view the timetables on various devices simultaneously due to the portable nature of the system. The simple web-based interface will facilitate ease of use.

The outcomes of this project would provide stakeholders and future researchers in the field of education, information systems and other related technologies useful information which should lead to the generation of new ideas for better implementation of a timetable management system.

1.4. Methodology

The evaluation of the existing system will be carried out using the Joint Application Design (JAD) approach. JAD will facilitate cooperation among all stakeholders to enhance understanding and build upon teamwork. JAD will ensure that both the users and developer have a shared vision of the outcome of the new system.

The life cycle of system creation (SDLC) is a logical structure used in project management that defines the stages involved in the development of an information system project, from a preliminary feasibility analysis to the product lifecycle management.

The type of SDLC to be used for this project is Rapid Application Development(RAD). RAD is an incremental design model for software creation that stresses an incredibly brief period of development. Again RAD being a ‘high speed’ adaptation of the linear sequential model would rapidly develop and achieve the goal of this system by using component-based construction. The justifications for using RAD for this project include;

1. The RAD process would enable me to build a completely operational program within very brief periods of time, after understanding requirements well and the project scope constraints
2. RAD as a software or an organizational tool available provides consistent collaboration in an interactive electronic system for a given activity where users can quickly access it.
3. It is designed to continue providing access to information, directions and support instantly.
4. RAD system provides a selection of tools that allow the design of graphical user interfaces which might usually take a great effort to build.

The tools to be used in the development of the proposed system include;

1) MYSQL for the Backend database.
2) PHP as the main programming language.
3) JQUERY as a java script library for special effects.
4) HTML as complementary programming language

1.5. Study Deliverables

The end product of the project will be as follows

1. A timetable software that allows multiple users and simultaneous logins
2. A timetable software that allow various departments to make inputs into final timetable allocations
3. A timetable software that can be easily integrated into a school management system
4. A timetable software that can substitute schedules with assigned values
5. Documentation on its features and how users can perform specific tasks with it.

2. Literature Review

2.1. Definition of Timetable

A timetable is an ordered collection that contains details on activities that are scheduled to be held. Timetabling can be divided into many categories, including timetabling for school, scheduling of employees, timetabling for athletics and timetabling for travel [6, 4]. The composition, constraints and specifications of any of these timetabling concerns vary [11]. Timetabling research continues to draw researchers' interest because of constantly enforced additional requirements/restrictions and with the end consumer insisting on more and better solutions.

In the words of Suresh et al. [15], time tabling is the assignment of a given resource to objects that are put in space time, subject to constraints, in such a way as to achieve a collection of desired goals as nearly as practicable"

Another definition given by Burke & Carter [2], is that: "A timetabling problem is a problem with four parameters: T, a finite set of times; R, a finite set of resources; M, a finite set of meetings and C a finite set of constraints. The problem is to assign times and resources to the meetings so as to satisfy constraints as far as possible".

Based on these definitions, timetabling challenges include allocating activities into appropriate time slots and services whiles fulfilling the constraints with the objective of improving the problem's fitness function.

2.2. Classification of University Timetabling Problems

There are quite a wide number of differences in the literature based on the nature of organisations and the kind of restrictions or constraints that are inherent in the timetabling problems. Problems of timetabling are divided into three key groups [12].

School timetable is really a weekly calendar for all of a school's students, prohibiting two classes from being attended at the same time by lecturers, and vice versa.

Course timetabling on the other hand is a weekly calendar with all lectures for a variety of university classes, eliminating the gap between lectures of popular students.

Examination timetabling is the scheduling of a series of university courses for examinations, preventing the duplication of examinations of courses with popular students, and extending the examinations as far as practicable to the students.

2.3. Methodologies for Timetable Development

Many methodologies can also be found for developing time tables [9]. The various algorithms for designing time tables have been illustrated below.

2.3.1. Graph Heuristics

The use of graph colouring which has been identified as an efficient and fastest algorithm where Colors are assigned to vertices, such that no neighboring vertices attains exact or similar color [16]. Other scholars have concluded that graph heuristics, according to their own, are not really suitable techniques for solving global timetabling problems and they have not even created feasible solutions for some of the problem cases [10]. Latest evidence, however, has shown that they are successful in generating an actual meta-heuristics remedy [1].

2.3.2. Hill Climbing (HC)

Hill Climbing (HC) or simple climbing is a classical local quest technique. Hill climbing is fast and quick to execute. The downside, however, is that the localized Optima is quickly attained. Recently Hamed et al. [5], suggested a late acceptance technique for scaling the HC. The mechanism postpones the step of comparison between the candidate solution and the actual (best) response.

2.3.3. Tabu Search (TS)

Tabu search suggested by Glover [18], works in a manner comparable to HC but adding a memory to enable analysis of the differentiation of search space. Tabu search has been enforced as a search algorithm that generates course schedules by minimizing losses heuristically over an utterly impossible solution [8].

2.3.4. Simulated Annealing (SA)

Simulated annealing (SA) has been suggested by Kirkpatrick, Gelatt Jr. and Vecchi [20]. It was inspired by the physical annealing mechanism to heat up a solid to an extreme temperatures and cool it off slowly until everything crystallizes and there are no more changes. SA begins with an initial solution built using a positive heuristic and an optimal solution are always approved, whereas a much worse solution is only acknowledged with certain probabilities [14].

2.3.5. Genetic Algorithms (GA)

Genetic Algorithms is a population-based search that produces appropriate results from one generation to another through the theory of biological evolution [19]. In order to avoid infeasible solutions Esraa & Ghada [3], advised using only the mutation operator to produce solutions for the offspring. Experimental results found that the genetic algorithm used by a generic crossover operator was less effective than their approach. Because of the direct chromosome representation that created infeasible offspring solutions, they introduced a repair mechanism to solve the infeasibility.

2.4. Existing Timetabling Software

There are numerous free and commercial application that enables the user to automate or semi-automatically generate timetables (iteratively). Many applications provide us with graphical interface to direct the user through the timetable development process that allows users to quickly identify school resources and timetable constraints. The most widely used programs and their internal workings are discussed in this section.

2.4.1. ActiveTimetable 2003

ActiveTimetable 2003 is a timetable preparation application for a variety of educational establishments. Absolute automated scheduling of all the most difficult timetables in a limited period is the biggest advantage. From data input, one can schedule many different timetables and then choose the best suited to the institution's specifications. The data entry method is streamlined by the schedule wizard, which helps you to easily construct the skeleton of the schedule.

The main features for the iMagic application are as follows;

1. Schedule blocks and multi-classes lessons
2. Spreads each topic's lessons equally throughout the week
3. Allows one to specify the full amount of hours a day for lecturers and classes.
4. Permit the timetable to be exported to html

However, the following limitations have be identified

1. Lack of multiuser use
2. Lack of independent platform
3. No accessibility from remote locations
4. Students cannot view timetable schedules by

themselves

2.4.2. CMIS Scheduler (CCM)

An event-based planner that is able to coordinate not just the school schedule, but any kind of activities, such as workshops, conferences, visits and other school activities, it is also possible to use as a professional resource manager. The preparation matrices allow a user to conveniently organize the school curriculum by appointing lecturers and facilities, from developing the initial timetable to ensuring that certain rules or constraints are not violated. The features for CMIS Scheduler include;

1. Color coding for displaying blocked and allocated routine status
2. Ordering of user-controlled courses, lecturers, subjects and facilities
3. Different planning layout
4. There is a drag and drop from one class to another in order to copy curricular elements

However, the following limitations have be identified

1. No support for other languages
2. Lacks export to other file-based applications
3. Lacks capabilities to combining multiple classes for a given period
4. No accessibility from remote locations

2.4.3. Cyber-Matrix Class Scheduler

Cyber-Matrix Class Scheduler is a perfect application for universities and other colleges that need to plan classes easily. Block scheduling encourages classmates to be arranged instead of only single students. A narrower resource footprint was also substituted by the database engine. The features for Cyber-Matrix class scheduler include;

1. It is possible to join a group of required classes and pick a list of potential schedules from.
2. You can schedule complete classes of students at one time.
3. Share scheduling details for all of your students and lecturers across ones network.
4. A search mechanism allows all students taking a single class or sharing a similar classification, such as band students, to be found.
5. Non-English speaking users can quickly translate the text of the app into the equivalents of their very own language.

However, the following limitations have be identified;

1. Lacks export to other file-based applications
2. Lacks capabilities to combining multiple classes for a given period
3. No accessibility from remote locations
4. Students cannot view timetable schedules by themselves

2.4.4. iMagic

iMagic Timetable allows one to build schedules for academic institutions. The main features for the iMagic application are as follows

1. Save time inserting details manually
2. Has a search and replacement of entered data
3. Easy to use interfaces
4. Functionality to export output to CSV file format or a web page

However, the following limitations have be identified

1. Lack of multiuser use
2. No support for other languages
3. No accessibility from remote locations
4. Students cannot view timetable schedules by themselves

2.4.5. Summary of Literature Review

The review of literature shows that features of the reviewed timetable applications differ with instances where they are non-existence. Features such as report generation, printing capabilities, export of inputs appears to be a key component of all the reviewed systems. The ability to schedule other activities such as field trips, examination, support for multiple languages and searching functions differs from one system to the other. However, features such as multiple user access, multiple views of report, substitution management, easy to use interactive user interfaces, web-based capabilities with remote access as well as portable integration into existing school management systems were missing. It is within this context that the proposed Timetable Systems needs to be developed to address the challenges/weaknesses/limitations in the reviewed timetable applications.

3. Analysis of the Proposed System

3.1. Overview of the Proposed System

In order to overcome the timetabling challenges affecting universities, the proposed web-based schedule systems will be built. The system would include the option to input the different classes, course codes, lecture rooms, departments, programs, facilities, lecturers, and the identification of a few constraints.

3.2. Stakeholders

They are key people, groups of people who are interested in a project or initiative or that may be influenced actively or passively by the process or the outcomes. The list of stakeholders are explained below

As the sponsor for the project, the Vice Chancellor will be responsible for monitoring the progress of the project to ensure that they meet the stated goals and objectives as well as general mission of the academic institution.

The Dean/ Head of Department are responsible for ensuring that lectures and students under them comply with schedule policies and are identified as key stakeholders.

Lectures are going to be the active users of the output from the proposed System and are identified as key stakeholders.

Student are required to adhere to the schedules specified in timetables and are identified as a stakeholder

3.3. Requirement Gathering

The method for the requirement gathering will be a Joint Application Design (JAD) to facilitated cooperation among all relevant stakeholders

The JAD session facilitated discussion among stakeholder in order to elicit requirements. Below are some of the discussion topics or tools used in the session.

1. What is the effect of the inability to solve the problem?
2. What is your guess about how the new system will solve the current problem?
3. What features do you think when added to the web-based timetable system will solve the current problem?
4. Where would the user be located physically when using the web-based timetable System?

3.3.1. Functional Requirements

Functional requirements describe what the proposed Web-based timetable system should do or the behaviors of the system and below are the requirements it should satisfy.

1. The proposed system should provide a login interface through which only authorized users are allowed to use based on their roles (Administrators, Heads of departments (HOD), Lecturers, students etc.).
2. The system should allow administrators to manage, that is add, modify, delete lecturers, rooms, departments, time, dates
3. The proposed system should be online to allow access from anywhere
4. The proposed system should support any device that can access a webpage online
5. The system should handle multiple users simultaneously
6. The proposed system will allow administrators to monitor activities of logon users
7. The system will support all web browsers with cookies and JavaScript enabled.
8. The proposed system will use MySQL as the DBMS for database.
9. The propose system will use PHP as the server side script and run using Apache web server software

3.3.2. Non-functional requirements

A non-functional requirement places constraints on how the proposed web-based timetable system should work or elaboration of the performance characteristics of the system. Below are the requirements it must satisfy

1. The proposed system should have an interface that is user friendly, easy to follow and indicate the name and subject of the authorized user
2. The proposed system should have an interface that produces relevant error messages related to user login and system usage
3. Access to features such as marks entry and backup of database should depend on users designated role The web server software should offer good performance by employing server-side caching
4. The proposed system should be available 24 hours, 7 days a week and can be accessed anytime
5. The proposed system should have a server side backup of 12 hours duration and UPS support for 24 hours, 7 days a week to limit server down times
6. The proposed system should not cost more than ¢70,000 and web hosting for a year should not cost more than ¢10,000.
7. The proposed system should implement SSL (https) and RSA encryption to secure the contents of the system
8. The proposed system should use MySQL version 5.6 and above as the DBMS for database.
9. The proposed system should contain a minimum of 70 lecturer’s details by using MD5 to encrypt records stored in the MySQL DBMS
10. The proposed system should use HTML, CSS, JSP, PHP, etc. which are platform independent and can be implemented with minimal efforts
11. The propose system should use PHP version 5.5 as the server side script and run using Apache version 2 as web server software
12. The proposed system should run on a Linux-based cloud system with at least 4GB RAM and 100 GB hard disk space

3.4. Major features/Components of the Proposed System

The key components of the system that seeks to replace the manual way of timetable preparation have been outlined below.

A backend database is an essential component of the proposed system. MySQL is a common database of open sources used in the Unix world. Its success derives from the potential to reuse the code of several other user groups, which boosts DBMS performance and efficiency. The proposed web-based timetable system will maintain MySQL database to store information relating to timetable building. Tables will be created for the various assets that are required in timetable preparation such as lectures details, faculties, departments, lecture rooms, room size etc. For this new system, this DBMS would be a reasonable alternative and the current mechanism could then be used, removing a need to implement a new structure.

Again, an interactive user interface design will ensure that actors easily make choices on the system. Relevant feedback on the status of processing will be communicated to ensure a user friendly application usage.

The architecture and structural design component will leverage on programming languages which are architecture independent to guarantee successful integration into other applications. The primary programming language for the system will be PHP, a server-side, cross-platform HTML embedded scripting language. It allows accurate dynamic web pages to be generated connectively via database even though there are several other advantages of using PHP. A Linux environment is a preferred choice for the web-based system due to its secure architecture.

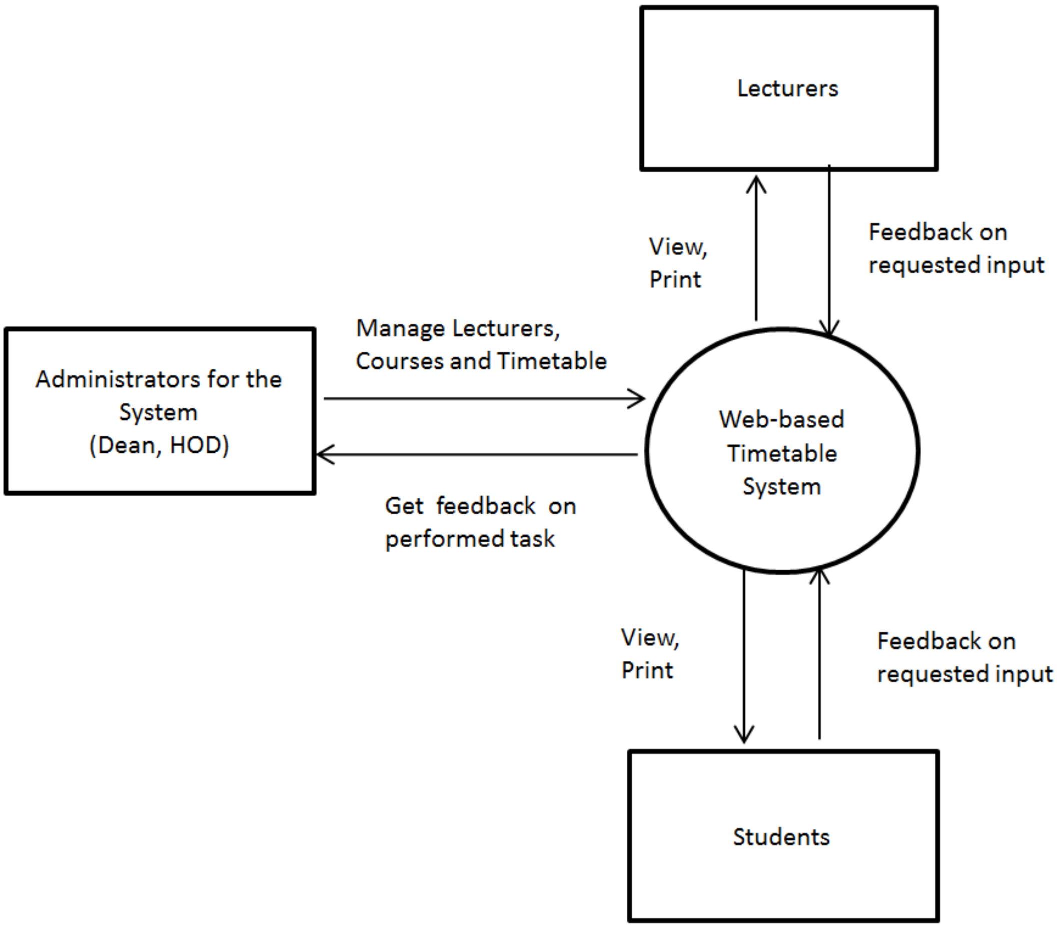

Figure 1. *Context Diagram for the Web-based Timetable system.*

3.5. Advantages of the Proposed System

The web-based timetable system is proposed to solve the problem of paper and manual way of preparing time table. The benefits to be derived from the new system are outlined below.

1. The system provides consistency, with the exception of the manual timetabling system.
2. It almost eliminates paperwork by utilizing minimal processing/computing power.
3. It greatly reduces the time needed to generate timetables.
4. With an intuitive interface, it offers a simple means for entering data and modification.
5. It simplifies the timetabling process.
6. It has a One-click total system backup and restore across different servers
7. Generate ready-to-print timetable image snapshots.
8. It possess fully automated installer which prevents going through source code to provide required credentials
9. Create routine backup copies of database.
10. Secure management and use of passwords for authentication purposes.
11. Restrict access to administrative interfaces

4. Detailed Design of the Proposed System

The functional processes of this system are the major features that the system has or performs. A functional model or functional process in system development is a structured representation of the functions, behaviors, activities or processes of the system or subject area. The functional process of the system include all the working and operational processes of the entire system

4.1. Use Case Diagrams

Use case diagrams are used to describe the main processes and functionality of the proposed Web-based Timetable System. The main objective for the use case diagram is to outline the scope of the system. Use case diagrams have been created for the various actors of the proposed Web-based Timetable system that is lecturers, administrators and students of the system.

The key actors for the proposed Web-based Timetable System include lecturers, administrators and students. The clients for the system include students and lecturers. The secondary actors for the system include Head of

Departments, Dean and the Examination Committee. The service providers for the proposed Web-based Timetable is the System Developer.

The governing bodies for the system include the Board of Governors for the University, Academic Board and the Student Representative Council.

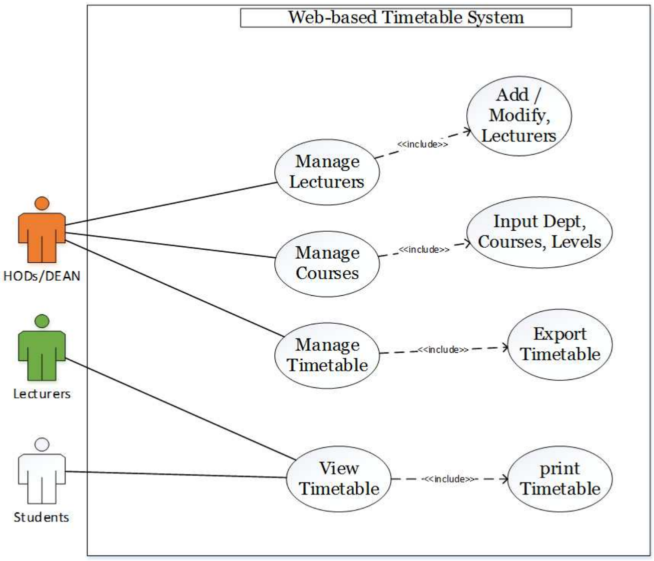

Figure 2. *Use Case Diagram for the Web-based Timetable System.*

4.2. Activity Diagram

Unified Modeling Language like activity diagrams is purposely designed to model out both computational and organizational process [13]. The essence of Activity Diagram for the proposed Web-based Timetable System is to model the workflow of its Use Case to show paths within it. It will show the sequence of an activity from the other. The Activity Diagram will illustrate existing functionalities and how those functionalities coordinate with other pieces functionalities of the system. The general overview or description of the for the Timetable System activity diagram is depicted in figure 3 below.

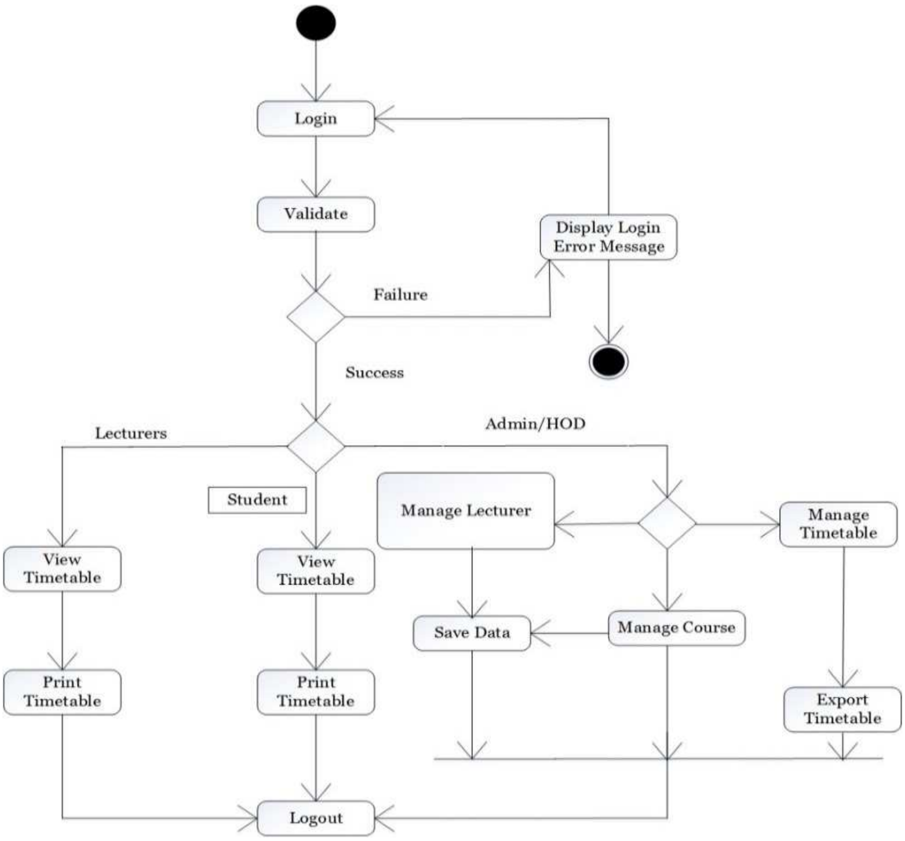

Figure 3. *Activity Diagram for the Web-based Timetable System.*

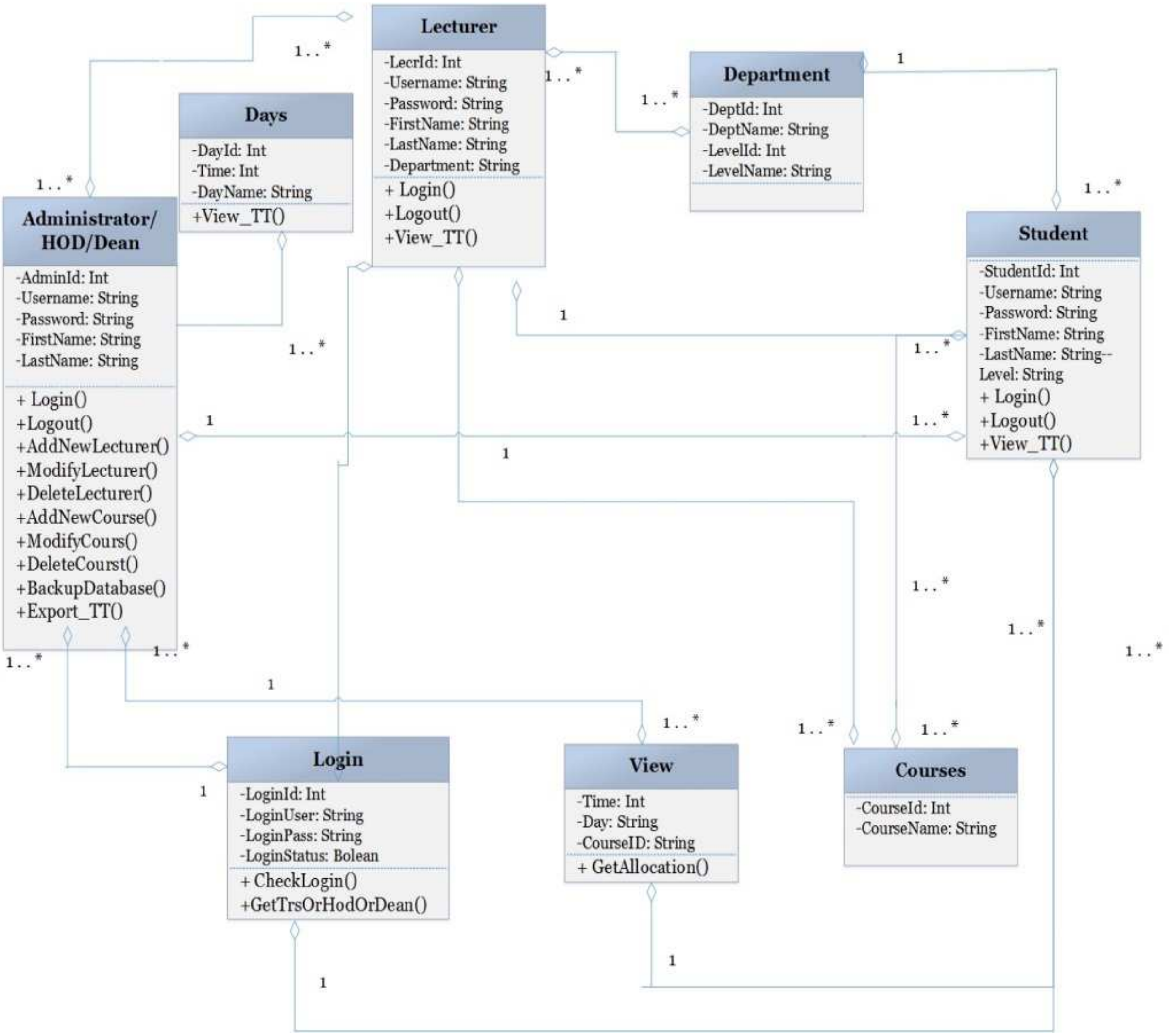

Figure 4. Class Diagram for the Web-based Timetable System.

4.3. Class Diagram

A sort of static structure diagram is a class diagram in objects oriented modeling that illustrates the component or structure of a system depicting attributes, operations as well as the relationships that exist among the classes of that system. The relevance of Class diagram in the Online Result System is to graphically show what the various objects will perform by showing the interactions amongst the various classes on the system. The web-based timetalbe System has been divided into classes with strong coherence. The main system shows the existence of the following classes;

1. Administrator/HOH/Dean class
2. Lecturers class
3. Student class
4. View class
5. Courses class
6. Department class
7. Days class

The Administrator/HOD/Dean class is responsible for adding, modifying and deleting lecturers, courses, departments, rooms and levels. The class can also generate timetable and backup information from the whole system. The attributes are AdminId, Username, Password and Name. The operations or methods include login(), logout(), AddNewLecturer(), ModifyLecturer(), DeleteLecturer(), AddNewCourse(), ModifyCourse(), DeleteCourse(), SetupTT(), AllocateTT(), BackupDatabase() and View_TT(). Administrator class is associated with Lecturers and students in a many-to-many relationship because there can be more than one administrator with many Lecturers and students

The lecturer class is responsible for viewing of the completed timetable and printing them out. The attributes are LecturerID, Username, Password, FirstName, LastNAme, Gender, Department and LevelTeaching. The operations or methods include login(), logout() and View_TT(). The Lecturer class is associated with students, levels, courses and login classes. Lecturers have one-to-many relationship to students because single lecturers can teach many students.

The student class is responsible for accessing the generated timetable. The attributes of the student class include StudentId, Username, Password, FirstName, LastName and level. The operations or methods are login(), logout(), View_TT(). The student class is associated with Lecturers, administrator, levels, courses and login classes

The view class is accessed by administrators, lecturers and students to view the completed timetable. The attributes of the view class include Time, Day, CourseId. The operations or methods of the generate report class are GetAllocation(). It is associated with students in a one-to-one relationship because a student is entitled to a view of the timetable.

The course class holds the data for the various subjects or courses. The attributes of the subject class are CourseID and CourseName. Courses have a one-to-many relationship with students and a one-to-one relationship with Lecturers.

The Department Class holds the data for the various classes under the Online Result System. The attributes of the class are DeptID, LevelID, DeptName and LevelName. It has a one-to-one relationship with students and a one-to-many relationship with Lecturers

The login class is responsible for verifying login details of users. The attributes include LoginId, Login Username, LoginPassword, LoginStatus. The operations or methods are CheckLogin(), GetLecORHODOrDean(). It has a one-to-many relationship with students, Lecturers and administrators because many students, Lecturers and administrators can have only one login details.

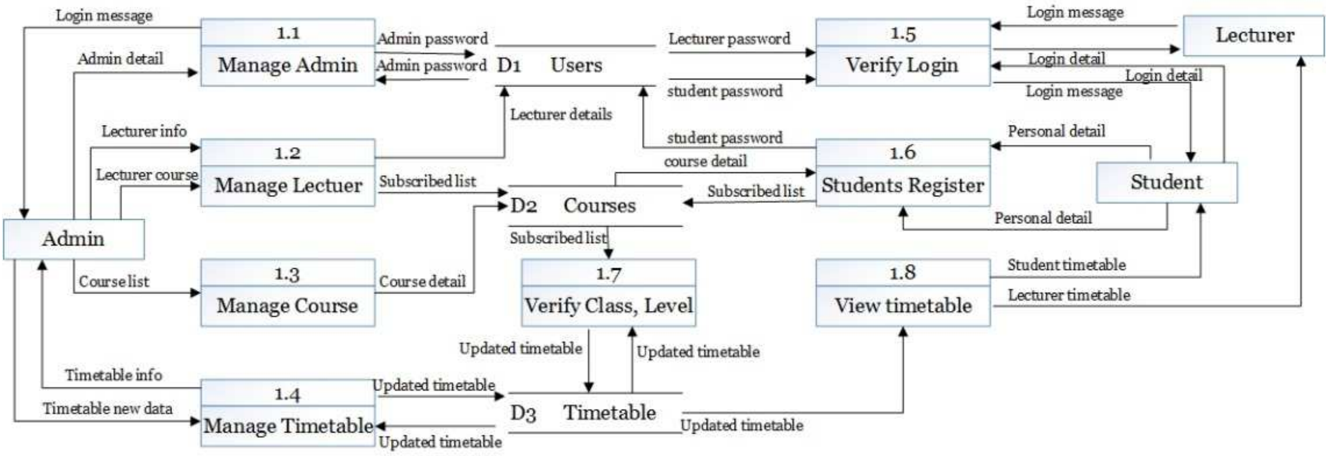

Figure 5. Data Flow Diagram level 1 for Web-based Timetable System.

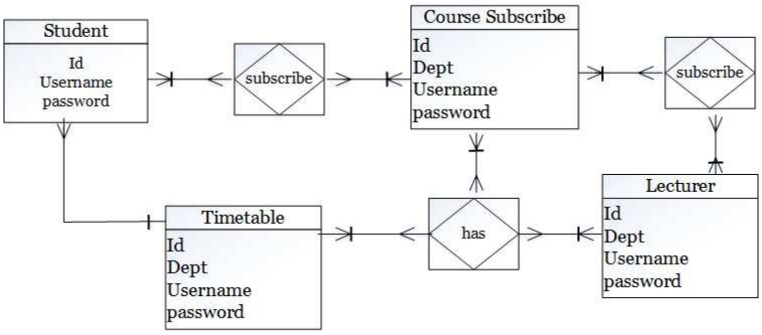

Figure 6. Entity Relationships of the Web-based Timetable System.

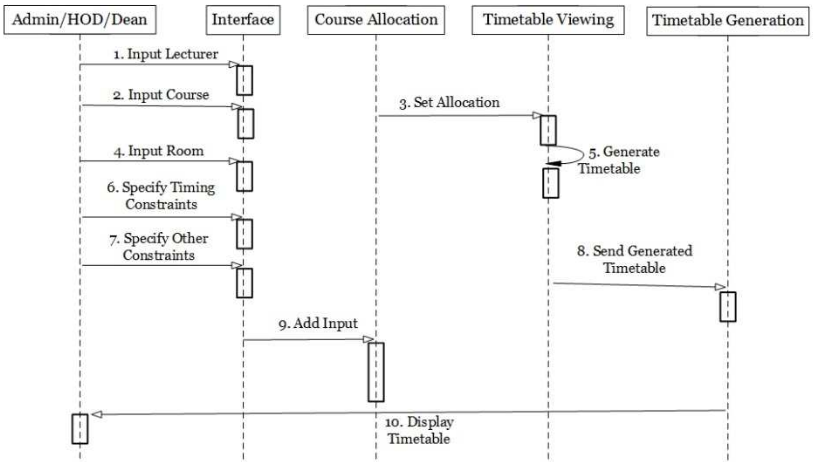

Figure 7. Sequence Diagram of the Web-based Timetable System.

5. Implementation of System Design and Testing

5.1. Implementation

The implementation of the system presents the development, installation, testing and deployment of the system proposed. The implementation of the system integrates all other development steps to build a functioning system after detailed study and design of the system.

5.2. System Requirements

The hardware needed for the timetable to operate are as follows; The Processor should be Pentium 4 and above, a minimum of 4 Gigabyte of RAM and a hard disk space of 50 Gigabyte and above. The software requirements are listed below;

1. Linux, Windows, Operating Systems
2. SSL certificate (https) and AES encryption to secure the contents of the system (online mode)
3. MySQL version 5.6 as the DBMS for database.
4. PHP version 5.5 as the server side script
5. Apache version 2 as web server software
6. Mozilla, Google Chrome, Internet Explorer, Safari web browsers

5.3. How to Install

1. The method of installing the application requires the web application to be hosted live on either a public or a private web server.
2. For a local web server, the XAMPP application version 3.2.2 and above which comprise of all the required software can be installed by adhering to its manual
3. All the files contained in the application must be extracted and placed in the htdoc/www folder and the appropriate permissions set for it.
4. The database along with the required tables must be created whiles ensuring a connection of the application to the database.
5. The administrator visits the url for the application to ensure the setup was successful.
6. The web application will be ready for use when it has been hosted and installed without challenges.

5.4. Testing

The following are the perquisite quality aspects adhered to in the processing of testing the Web-based Timetable System. The contents were evaluated at both syntactic and semantic level.

Syntactic standard tests for text-based records covered spelling, grammar and punctuation. The evaluation of semantic evaluated information provided, consistency among the whole object of the content and linked objects and absence of information uncertainty.

The functionality of the system was tested for consistency, instability and general conformity with acceptable levels of execution.

The structure has been reviewed to ensure that the content and operation of the Web Application is adequately delivered and expandable and can be supported if additional content or functionality is introduced.

Usability test aims to verify that the user interface is friendly and will permit easy navigation as well as understanding instructions provided.

To guarantee that both syntax and semantics required to navigate are applied to detect possible navigational errors, navigability has been tested. Dead links, improper connections or erroneous connections are detected and amended

In a range of operating conditions, configurations, and processing performance was checked to ensure that the system is sensitive to user input and thus manages extensive loading without excessive operational deterioration.

Compatibility has been tested by running the Web application both on client and server side in a number of different host environments (Linux, Windows). The motive is to detect errors associated with a given configuration of the host.

Interoperability has been checked to determine that the Web Application interacts appropriately with other software and backend databases.

Security was evaluated by determining and striving to exploit possible vulnerabilities. Any successful penetration attempt is known to be a security breach.

5.5. Implementation Method

This involves the manner in which the system is implemented. It consists of activities relating to the development and programming of the system, system review, and migration from the legacy regime to the current system. Change over procedure is the transition from the legacy or previous practices to the new web-based timetable application

The direct changeover method is primarily used where design and implementation of the new framework is highly trusted. This is primarily used when there is a deep faith in the new system's creation and delivery. It requires a complete overhaul of the old system when the new system is introduced.

The Pilot changeover method includes pre-testing the newly acquired system using the same type of data in a different or isolated testing environment. This technique offers a chance to assess the operating stability of the systems and the possibility of changing all at once.

In a phased changeover method, before the end of the complete conversion, changeover is carried out gradually. This is used when traditional and new systems are identical in appearance.

However, the changeover or conversion approach was the parallel method. This is to accommodate for some time the running of both the new and old system concurrently to ensure that the new system satisfies the specifications to which it is implemented.

5.6. Review and Maintenance of the System

The new system must be regularly tested to present unintended problems that may occur in the function of the system's use and to give space for system upgrade if necessary. File maintenance operations includes the deletion, insertion as well as rearrangement and modification or amendment of records.

File maintenance works are easily performed due to the various advantages provided to this new system by its index sequential file access process.

6. System Documentation

6.1. Documentation

For the new system to be successful there is the need for documentations or manuals aimed at the following

1. Educating users on the current system's objectives and advantages.
2. Educating users of the current system on management roles or tasks and obligations.
3. Educating users on the procedure for undertaking tasks and functionalities on the new system
4. Most importantly, making the system documentations available to users.

6.1.1. Launching the Web-based Timetable System

Please follow the sequence of steps to launch the application

1. Double click on a web browser icon
2. Locate the address bar and type https://localhost/tt
3. Press on go button or press enter on the keyboard

6.1.2. Login Using Usernames and Passwords

Please follow the sequence of steps to enter access credentials for validation.

1. Click on login hyperlink
2. Locate and enter usernames and passwords in their appropriate fields
3. Click on Login button or press enter on the keyboard
4. Wait for the credentials to be validated to access the interface.

6.2. Adding/Modifying Lecturers

Please follow the sequence of steps to enter access credentials for validation;

1. Click on 'Manage Lecturer' hyperlink
2. Fill the form that appears by inputting the full name, department, username, password and role played at the department
3. The entries can be deleted by selecting it from the delete form
4. Click on the save button to complete the task

6.2.1. Adding/Modifying Departments

Please follow the sequence of steps to add a department to the system

1. Click on 'Manage Department' hyperlink
2. Fill the form that appears by inputting a numeric code and a name for the department (eg 002, Mathematics and Science Education)
3. The entries can be deleted by selecting it from the delete form
4. Click on the save button to complete the task

6.2.2. Adding/Modifying Courses

Please follow the sequence of steps to include courses on the system

1. Click on 'Manage Courses' hyperlink
2. Click and select the name of a lecturer
3. Fill the form that appears under add course by inputting the course id, course name, allowed levels and whether conflict allocations are allowed for that course
4. Click on the save button to complete the task
5. Existing courses can be deleted from the delete course form by selecting the appropriate course and clicking on the delete button.

6.2.3. Adding/Modifying Rooms

Please follow the sequence of steps to include rooms for lectures

1. Click on 'Manage Rooms' hyperlink
2. Fill the form that appears under 'add room' by inputting the room name and the capacity
3. Click on the 'Add' button to complete the task
4. Existing rooms can be deleted from the 'delete room' form by selecting the appropriate room and clicking on the delete button.

6.2.4. Adding/Modifying Levels

Please follow the sequence of steps to add levels under the various departments

1. Click on 'Manage Levels' hyperlink
2. Fill the form that appears under 'add level' by inputting the level name, selecting the department it falls under and an anticipated size for that level.
3. Click on the 'Add' button to complete the task
4. Existing levels can be deleted from the 'delete level' form by selecting the appropriate level and clicking on the delete button.

6.2.5. Adding/Modifying Timetables

Please follow the sequence of steps to configure a new timetable

1. Click on 'Manage Timetables' hyperlink
2. Under configure timetable, type the name of the timetable or select existing timetables.
3. Under Number of slots enter the total number of hours the timetable can span and specifying the exact time under the 'Start Time' form including AM or PM
4. Under Number of Days, input the total days the

timetable will be used

5. Conflict allocations and current active timetable, freeze timetable checkboxes can checked depending on the needs of an administrator
6. The save button is used to save current configurations
7. The 'Update' button implements effected changes on the interface
8. The 'Download' button is used to backup the database
9. The 'Restore' button is used to load an existing backup file by clicking on the 'Browse' button and locating the file on a harddisk or resource

6.3. Allocating Timetable

Please follow the sequence of steps to assign lecturers, courses and rooms to lecturers.

1. Click on 'Allocate Timetables' hyperlink
2. Under 'lecturer', select and click the name of a lecturer.
3. Under Courses, drag and drop course at appropriate day and time on the timetable preview.
4. Under 'Assign Room' select and click a room to be used for the lecture.
5. Click on the save button to store the current timetable.
6. The 'Freeze' or 'Disable' buttons can be clicked to prevent modification on the timetable

6.4. View Timetable

Please follow the sequence of steps to view the completed timetable

1. Click on 'View Timetables' hyperlink
2. Under 'Timetable', select and click the name of a timetable.
3. Under Department, click and select the department you wish to view its timetable
4. Under 'Lecturer' select and click a name for a lecturer.
5. Under 'Level', select the level you wish to view the timetable for.
6. The 'Freeze' or 'Disable' buttons can be clicked to prevent modification on the timetable
7. The 'Export' button can be used to export the final timetable in an image format.

7. Conclusion and Recommendations

This study was undertaken to minimize the intensive manual effort that is being made to establish and build timetables for school lectures. The Web-based Timetable system is capable of producing near-optimal schedules depending on courses with reduced course constraints. The system timetable system allows multiple users access (administrators, HOD, Dean Lectures, students) irrespective of their location, provided there is an internet enabled device. The login requirement secures the system from unauthorized users and modifications. With this approach, timetable management has been made simpler as it a web application to generate and export timetable in image format that can be easily shared on internet enabled devices.

The following was recommended after having understudied the difficulties found in the manual timetable system.

1. The timetable system built should be extended to handle the timetable management in the higher institution of the entire department (academic) and made available to all students.
2. In order to use the incremental model of software development, further work on developing a timetable system should be based on this research study.
3. A shared timetabling system model should be developed that uses mobile operating systems.

References

[1] Ahmed, K., & Keedwell, E. (2017). "A Hidden Markov Model Approach to the Problem of Heuristic Selection in Hyper Heuristics with a Case Study in High School Timetabling Problems," Massachusetts Institute of Technology, 2017.

[2] Burke & Carter (1998). Practice and Theory of Automated Timetabling: *Selected Papers from the 2nd International Conference. Lecture Notes in Computer Science*, 14 (08), 115 129.

[3] Esraa, A., & Ghada, E., K. (2016). "A Utilization-based Genetic Algorithm for Solving the University Timetabling Problem (UGA)," *Alexandria Engineering Journal*, vol. 55, no. 2, pp. 1395-1409, 2016.

[4] Fatih, C. & Merve, K. (2015). "A Fuzzy Logic and Binary-Goal Programming-Based Approach for Solving the Exam Timetabling Problem to Create a Balanced-Exam Schedule," *International Journal of Fuzzy Systems*, pp. 119-129.

[5] Hamed, B., Jaber, K. & Amin, H. (2019). "Generating an optimal timetabling for multi-departments common lecturers using hybrid fuzzy and clustering algorithms," *Methodologies and Application*, vol. 23, p. 4735–4747.

[6] Iosif, K., Ioannis, T. & Grigorios, B. (2015). "A Comparative Study of Modern Heuristics on the School," *Algorithms,* vol. 8, no. 3, pp. 723-742.

[7] Joselynn, H., F. (2019). "The Effect of the Gainful Employment Regulatory Uncertainty on Student Enrollment at For Profit Institutions of Higher Education," *Research in Higher Education*, p. 1 25.

[8] Kheiri, A., & Ed, K. (2017) "A Hidden Markov Model Approach to the Problem of Heuristic Selection in Hyper Heuristics with a Case Study in High School Timetabling Problems," *Evolutionary Computation*, vol. 25, no. 3, pp. 473-501.

[9] Mahmoud, S., Mahmoud, N., & Mohammad, M., M. (2020). "Optimal Localization of Shopping Centers Using Metaheuristic Genetic Algorithm," *Journal of Optimization in Industrial Engineering*, vol. 13, no. 1, pp. 167 176.

[10] Nelishia, P., & Ender, O. (2019). "Automated generation of constructive ordering heuristics for educational timetabling," *Annals of Operations Research*, vol. 275, no. 1, p. 181–208.

[11] Rakesh, B., Gupta & Pallav, I., (2014). "A new hybrid algorithm for university course timetabling problem using events based on groupings of students," Computers & Industrial Engineering, vol. 78, pp. 12-25.

[12] Schaerf A. (1999). A survey of automated timetabling. Artificial Intelligence Review, 13 (2), 87-127.

[13] Siau, K., & Tian, Y. (2009). A Semiotics Analysis of UML Graphical Notations. *Requirements Engineering*, 14 (1), 15 26.

[14] Suliadi, S., Ahmad, I., Maselan, A., & Siti, R. (2018). "A Heuristics Approach for Classroom Scheduling Using Genetic Algorithm Technique," *Journal of Physics*: Conference Series, vol. 995.

[15] Suresh, L., Ajinkya, K., Akash, T., Manasi, M., & Yogesh, C. (2014). "Genetic Algorithm: Paradigm Shift over a Traditional Approach of Timetable Scheduling," *in Proceedings of the 3rd International Conference on Frontiers of Intelligent Computing: Theory and Applications* (FICTA) 2014, Switzerland, 2014.

[16] Tan, L., Joe, O., Yu-Beng, L. and Jetol, B. (2018). "Implementation of Constraint Programming and Simulated Annealing for Examination Timetabling Problem," *Computational Science and Technology*, vol. 481, pp. 175 184.

[17] Zekang, L., Shiwei, H., Rui S., & Sijia, H. (2019). "Optimizing Vehicle Scheduling Based on Variable Timetable by Benders-and-Price Approach," *Journal of Advanced Transportation*, vol. 2019, pp. 1 13.

[18] Glover, F. (1986) “Future Paths for Integer Programming and Links to Artificial Intelligence,” *Computers and Operations Research*, Vol. 13, pp. 533-549.

[19] E. K. Burke, M. Hyde, G. Kendall, G. Ochoa, E. Ozcan, and J. Woodward. Exploring hyperheuristic methodologies with genetic programming. In C. Mumford and L. Jain, editors, *Collaborative Computational Intelligence*. Springer, 2009.

[20] Kirkpatrick, S., Gelatt Jr., C. D. and Vecchi, M. P. (1983) Optimization by Simulated Annealing. Science, 220, 671-680. https://doi.org/10.1126/science.220.4598.671