An Automation Instructor System using Finite State Machine within Web services

Khalid Aldriwish
K.aldriwish@mu.edu.sa
Department of Computer Science,
College of Science and Humanities of Alghat,
Majmaah University,
Majmaah 11952, Saudi Arabia

Summary
The majority of the Web's success can be related to its productivity and flexibility. Web Services (WSs) have the means to create new patterns for the delivery of software capabilities. The WS easily provides the use of existing components available via the Internet. WSs are a new trend that shares ubiquitous systems with others, so the popularity of the Web is increased day by day with their associated systems. This paper will explore and adopt the possibility of developing a technique that will automate instructors' scheduling of timetables within a Web services environment. This technique has an advantage that facilitates users to reduce the time cost and effort by reducing errors and costs for institutes. Providing dependable tables to avoid mistakes related to instituting schedules is ensured by an automated repetitive manual procedure. Automated systems are increasingly developed based on organizations and their customers. Still, the setting's difficulty of automation systems increases to rise as the system architecture and applications must accomplish various requirements and specifications of ever-demanding project scenarios. The automation system is composed of an operating system, platforms, devices, machines, control system, and information technology. This architecture provides more productivity and optimized services. The main purpose of this paper is to apply an automation system to enhance both quality and productivity. This paper also covers an agile method of proving an automation system by Finite State Machine (FSM) and Attributed Graph Grammar (AGG) tool.

Key words:
Web services, automation; control systems, UML, MAS, FSM, AGG.

1. Introduction

The innovation of technologies and the growth of automation systems technologies can be enhanced and improved by Web services. With the revolution of widespread technology and computer infrastructures, it isn't easy to present an essential automated system, and thus, numerous automated systems have been designed and built. In the scope of growth of industrialization, automation is a pace beyond mechanization. Whereas mechanization shows and provides human operators with machinery supporting them with work's muscular specifications and requirements. Therefore, automation reduces the demand for human sensory and mental needs while increasing load capability, performance, and repeatability. Automation is an active key that plays and shows an increasingly important role for industries and in global technologies.

The inspiration for the term automation has been discovered very early (coming from automaton). Usually, automation is used to increase and enhance quality in the manufacturing process and substantially support quality. The biggest advantage of automation is the rising throughput of productivity and quality in the field of technology.

The rest of the paper is organized as follows. The problematics and contributions are presented in section 2. Section 3 represents related works and the background. The model of the proposed technique is detailed in section 4. The testing phase and the implementation is discussed in section 5 and 6. The paper is concluded in section 7.

3. Statement and achievement

This research has set out on creating an automation schedule timetable system based on Web services environment, which should reduce time and effort for users and their education institutes and support the design of their schedule timetables. Consequently, the achievement will be as follows:

1. Propose the design of an automation system by creating and designing a technique-based FSM and AGG tool, which will increase the examination of institutes' scheduled timetables.
2. Customize the design difficulty of the automation systems by leaving significant degrees of freedom concerning their design and structure, granting them

Manuscript received July 5, 2021
Manuscript revised July 20, 2021
https://doi.org/10.22937/IJCSNS.2021.21.7.27

some characteristics, and using them for dynamically changing environments.

3. Validate the automation system by FSM and AGG tools to prove and address the suggested approach to obtain the optimal solution.
4. Perform a systematic method through a prototype system to manage and tame the system requirements.

3. Related Works

Creating institute timetables for lecturers and subjects is still complex and needs to support duplication for each semester during a year.This is as well as to the potential for the occurrence of errors and delays in delivery. The building and creating of an integrated system require collaborative works that necessitate distributing tasks to those specialists and users. In this work, we have proposed and arranged the tasks based on the traditional software life cycle to support the growth of the timetable system

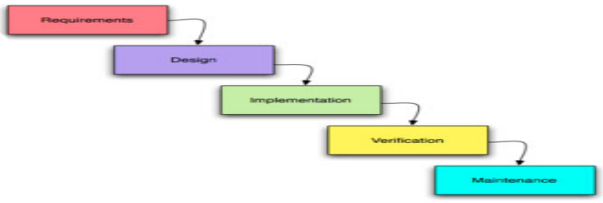


Fig 1. The Automation system diagram of life cycle

Course timetables do not allow overlaps in the schedule. Therefore, timetables of institutes entail assigning courses to classrooms and time slots. For example, two courses can be defined in the same location on a similar period.

Most obstacles likely seem when institutions, i.e., college or university, create course timetables beginning in any semester. Furthermore, institutions must often expend significantly and comprehensive time and effort in creating and generating suitable timetables for their classes and students.

In the meantime, many solutions and ideas, including heuristic course algorithms, have been proposed and showed to solve and figure out the complex difficulty of automated scheduling timetables and their courses. Many bases offer logic on color graphics, which produce usable timetables, but can ignore essential factors, for instance, the number of seats in a classroom.

Genetic algorithms became the best solution to automating course schedule timetables and saving institutions both time, effort, and cost [6,7,8,9].

A. Timetabling process

Timetable Concept:

While sometimes used, "timetabling" is more accurately portrayed with the word "scheduling." Scheduling, as examined and implemented by educational institutions, entails four essential aspects:

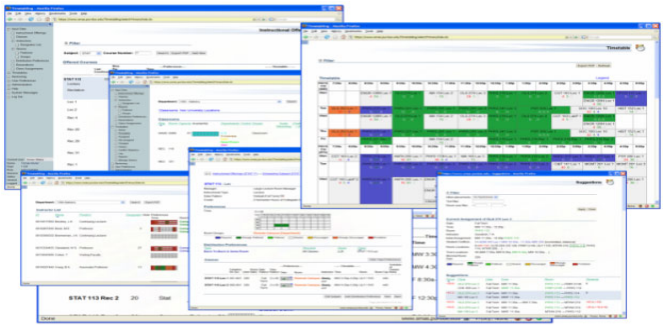


Fig 2. Timetable system concept

Curriculum:

The curriculum of the institute considers the number of instructors and classrooms available for students. It was also, considering the number of students that enrolled for any particular period in the department.

Analysis:

The analysis attempted to study the curriculum feasibility based on a comparison between the disposition of an educational institution and other institutions.

Timetable tests:

Although creating schedule timetables, difficulties arise in most institutes. The educational institution's experience such these issues, they can efficiently resolve them. It should do its best not to compromise the integrity of the scheduled timetable to find the best solution.

The educational institution could discover other issues impossible to resolve based on their criteria. In these cases, starting over could be the only ideal solution, and the need of the institution to go back to the start and recreate the initial curriculum may drive the scheduled timetable.

Scheduling:

The schedule is generated and considered based on the five key inputs: instructors, subjects, student numbers, classrooms, and timeslots of the educational institutes.

The stages mentioned above are used to manually created and generate schedules timetable, and are well known among educational institutions. Currently, developments are facilitating the automation of these processes.

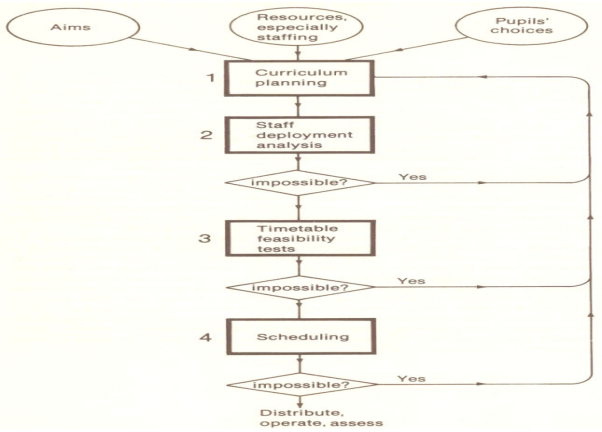


Fig 3. Timetable flowchart

B. Automating Timetables Processes:

The automation of scheduling functions is ensured by entail automation of all manual and repetitive systems. Therefore, the definition of education-oriented institution's requirements is presented as follows: (1) Reliability, (2) Repeatability, (3) efficiency, (4) and Testing.

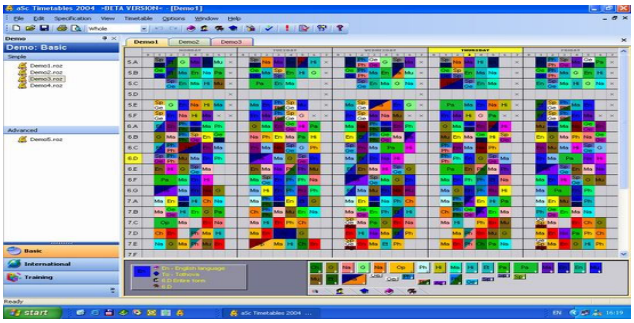


Fig 4. Automation timetable systems

C. Developing methods:

Finding out solutions for such problems related to timetables has attracted worldwide attention for solving them. Experts and their technologies in this field from several different countries are looking for feasible solutions to timetables on these problems. The "*International Conference on the Practice and Theory of Automating Timetabling*" (PATA) is held every two years to tame and address this topic.

One of the large conferences is the PATA conference which publishes and issues several articles and studies to tame, address and solve timetable issues, also; it has presented some techniques providing the generation of the timetable, consisting of [6,7,8,9]: Ant Colony Optimization, Genetic Algorithms, Memetic Algorithms, Variable Neighborhood Search (VNS), and Great Deluge.

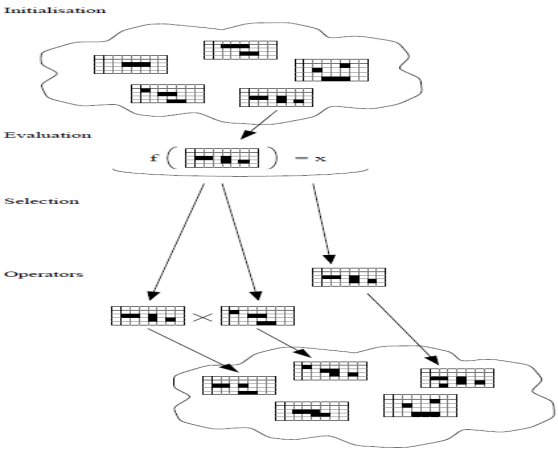


Fig 5. Genetic Algorithms

The Genetic Algorithms (GA) is considered a powerful tool designed for complex problems. It provides an optimized solution by mixing coded solutions and then being used for the next generation [1,2].

D. Validation of the automation system by FSM and AGG Tools

A proposal technique of the automation system has tackled and addressed most problems and demonstrates a proper solution that is reusable in similar contexts. The most significant advantage of this technique is to prove and share the feasibility of the suggested approach over the Web environment by examining them via FSM, JFLAP, and AGG tools. The proposed technique shows the possibility to accomplish adaptability and flexibility to the progress system performance of institutional schedule timetable in various environments by professionally using the available resources and monitoring any activities.

E. Multi-Agent System (MAS)

An agent is an active tool in modern technology. It is a software application program that can communicate with other software programs, interact and respond to behavior, act, and link with available resources on demand. Every single agent has a set of attributes, e.g., size, capability, and speed. Also, it should consider each agent environment in MAS to handle and coordinate the activities between numbers of agents. MAS is the part and sub eld of artificial intelligence that aims to provide principles for building complex and heterogeneous systems involving several interacting agents. MAS has prompted more interest in research pace because of the high advantages found within such systems. For instance, they can deal with too significant problems, for a single-agent system is faster and more reliable. Moreover, they can cope and handle uncertain knowledge and data. They can solve problems focusing on communication, coordination, and

negotiation [12][13].

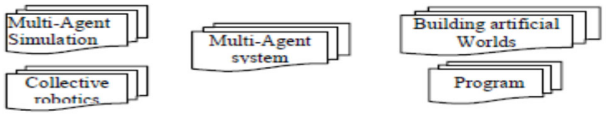


Fig 6. Application domains in MAS

F. Finite State Machine

The Finite State Machine (FSM) method is a mathematical model for computation. It is used for several automation applications, which are composed of sequential digital hardware. The FSM or state chart defines the mechanism of a state from moving from one state to another. Then, the FSM performs the output symbols based on the input symbols generated by the environment. The FSM model defines a mathematical model to describe the needed behavior. The FSM model is based on data structure to explain actions with a sequence of events [12].

The FSM method aims to verify the feasibility of the model before the validation and implementation phases. The following section details the FSM with JFLAP to highlight coding by Sun Java computer programming language.

G. JFLAP

JFLAP-Java Formal Languages and Automata Package- is a set of instructional software used to experiment with grammar automata accurately. The most advantage of JFLAP is that it can experiment with grammars and theoretical machines[12][13]. It also permits experimentation with applications and proofs.

H. JFLAP with Design FSM

JFLAP with design FSM model is designed by five states. The first one searches states and objects; more than one can be searched simultaneously. Next, all the services have to register with *SReg* to be allocated. And every single student can find out a course that needs to enroll with its department and lecturer.
Therefore, any registration will be shown in their schedule or timetable regardless conflict happened or not. So, whatever is monitored will result in students' timetables in their department after assessing it regarding registration policy.

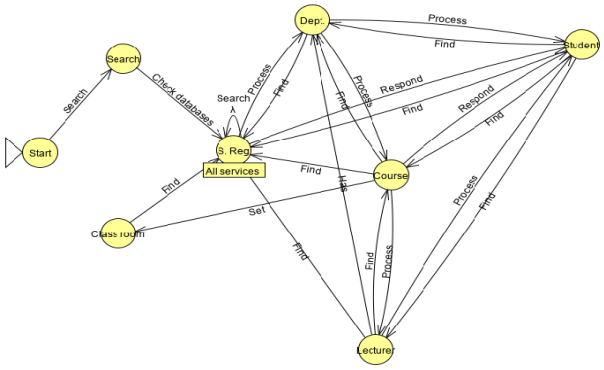


Fig 7. The automation diagram by an FSM and JFLAP

Figure 7 shows the automation system and observes the progress to reach an accurate solution. The FSM method aimed to enable the proposed approach. The FSM reduces the complexity of the system by searching steps to ensure high visualization of the model. The model verified with JFLAP defines states through two main tests: multiple run tests and step test-by-state. The model's feasibility is studied according to the described tests. A green sign is associated with typical results. States are testing via test methods to achieve expected outcomes.

Test Step by State

The Step by state testing method is used in moving from one state to another state. When the state is green, it indicates the final state. When a problem is occurred between each state, the state will be red.

The proposed approach is performed by the Attributed Graph Grammar (AGG) tool, see figure 8. The purpose is to verify the feasibility of the system and to prove the AGG's facility. The AGG is defined as a set of specification techniques. It provides a complex and heterogeneous system to ensure the collection of particular kinds especially when the state is composed of many structures. The complex behavior involves a large number of parallelism [13].

Moreover, figure 8 describes the scenario of all these components are joining and chatting with each other, so the student, lecturer, department, course, and classroom are services that interact with each other for progress. Every student must register for a course within his department and respond in the database.

One student enrolled in a course, and the system will book an exam for that course with associated parts, e.g., a lecturer, campus, etc., based on registration requirements. So, the AGG is a set of rules-based visual language using an algebraic approach to graph transformation. AGG provides the implementation based on the requirement, and the

specification of applications with complex graph-structured data. Therefore, we have used this tool to transfer the suggested approach method to graph grammar by analyzing these rules based on registration requirements to validate and satisfy the proposed approach's best solution.

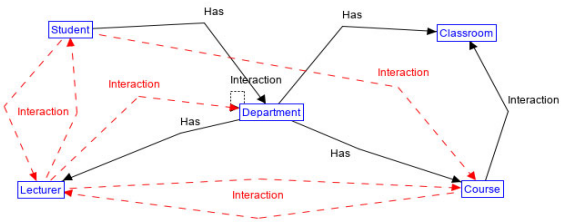


Fig 8. The automation diagram by an AGG tool

4. Implementation tools

In this section, the implementation of the system using object-oriented Sun Java programming language is presented. The system is considered a distributed system and provides a multi-use from the client and server sides. The MySQL database engine cooperates with JavaDatabase Connectivity (JDBC) to ensure database connection.

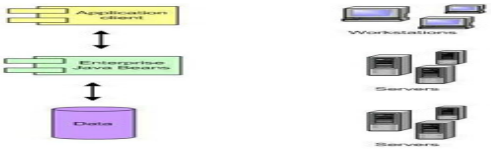


Fig 9. Java and database work

A. Domain Problem

The major schedule of classes for an educational institution is the university timetable. It consists of all class information, and every class has its lists, e.g., names, instructors, timeslots, and location or campus. The scheduling process is limited based on the resources available, and one must efficiently use these resources as cost-effectively as possible. Additionally, a new timetable must be created and provided for the whole year based on institute's regulations [5].

The modern timetable systems should know how to avoid conflicts when designing manual or computerized timetables. Some problems may appear throughout the entire year if conflicts are injected into the scheduled timetable at the beginning of the year and should be corrected immediately. Conflicts are challenging to resolve, especially if the educational institution is large and complex and has vast students [5].

B. Use Case

The model is designed using Unified Modeling Language (UML). It is defined as a modeling approach for general purposes. The UML permits visualization of the system's design dynamically through diagrams.

The use case diagram explains timetable system processes. Many organizations have used use case diagrams to create timetable systems. The main advantage is that it helps to define the approach scope. [5].

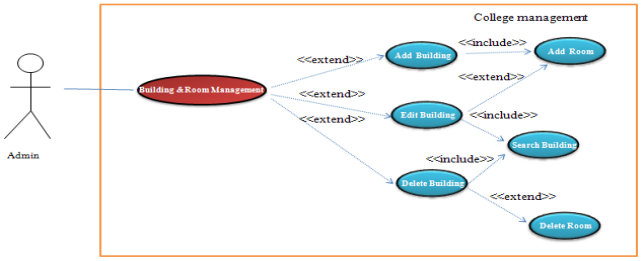


Fig 10. Use case of building and room management

However, having the ability to recover a system from failure is most critical. Backup systems can help and take significant time, in particular for large systems and data or applications. As well as critical are incremental dumps and restoring a system to a certain point in time, particularly for time-sensitive data or applications. Many database vendors' backup solutions efficiently manage granularity levels by dumping out transaction/activity logs. [3]

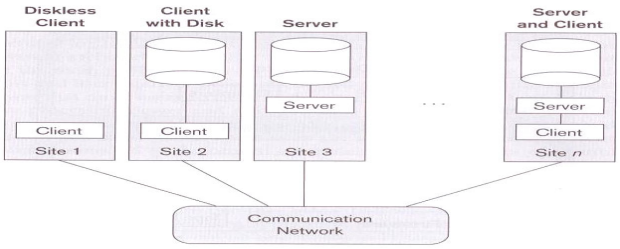


Fig 11. The Client/Server Architectures designing database

C. My SQL Database as engine

One of the most popular open-source databases is MySQL. MySQL is free, dynamic, and simple used to run on different platforms and runs well even with significant loads. [4]

D. Designing the Database

The database is built according to the system requirements. It ensures storing data by regular way. The number of tables in database is defined based on system's needs.

E. Normalization

Normalization is a set of processes to sort and organize data in a database, this meaning that the database system is prepared for programming. The advantage of Normalization is that making the database more flexible by reducing redundancy. Normalization benefits the database with the following pros: (1) improve the data consistency, (2) improve the database security, and (3) avoid data redundancy.

F. Entity Relationship Diagrams for ISS

The Entity-Relationship Diagrams (ERD) are used for the ISS system to sort data into tables and entities. The ERD also defines the relations between entities. According to the ERD, the database structure is built.

5. Testing the database

The database system has been examined and tested by adding and searching (query) about data to evaluate that all tables' relations and attributes work properly. The following test shows how the database tables were examined and tested.

A. Checking all database Tables

The first step shown in figure 12 aimed to check errors during the database analysis.

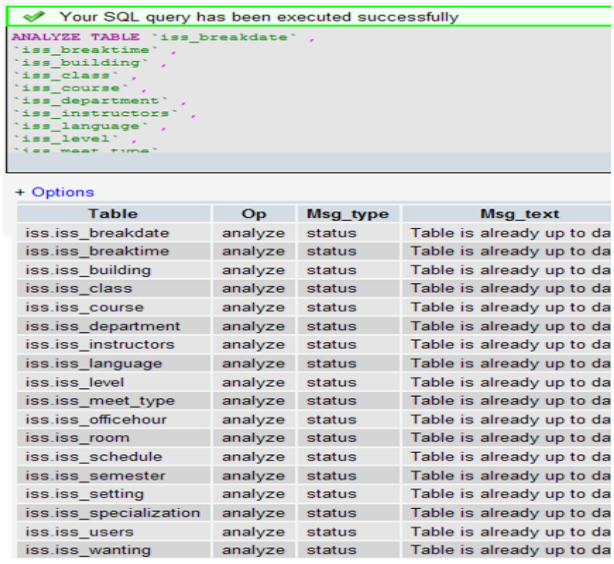


Fig 12. Database tables analysis test

B. Inserting data

In testing phase, the data with the same field and value is inserted. But, since the primary key is used, the bui_id field can hold only unique value.

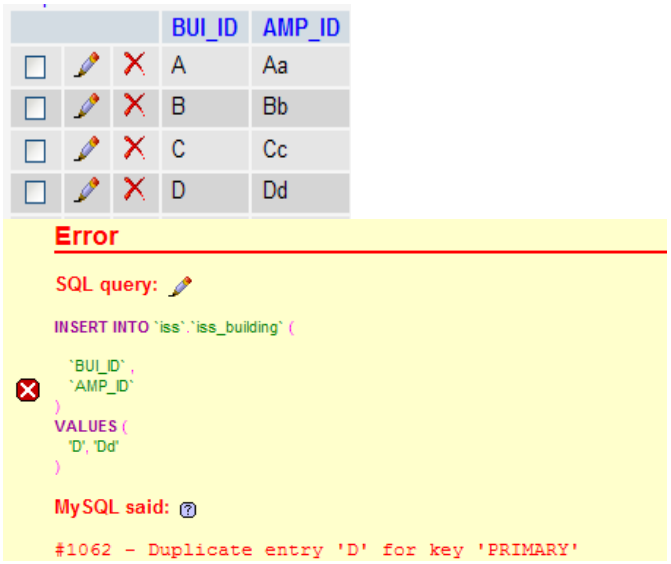


Fig 13. Insert a duplicate data on the primary key field case

In Figure 14, the inserting statement window prove that there is no issue to insert data.

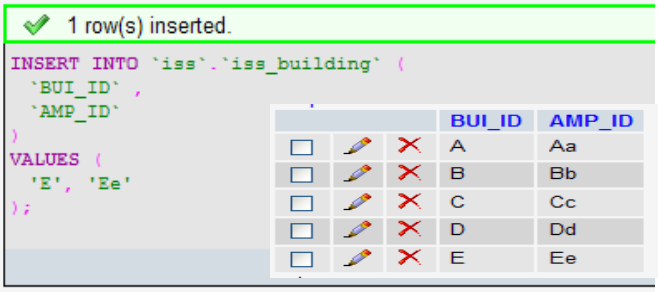
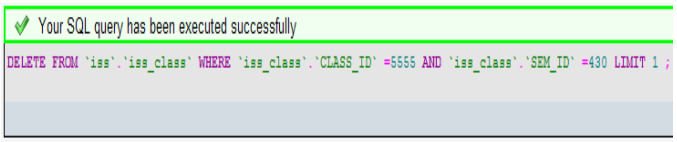


Fig 14. Inserting data to the table

C. Deleting data

The ability to delete data from a row on any table needs to select and specify the table name and then name the row that will be deleted.

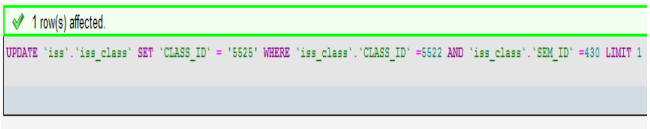


CLASS_ID	COU_ID	INS_ID	SEM_ID	CLASS_STA
4521	4	0	430	2009-08-01
5521	1	2	430	2009-08-01
5522	1	5	430	2009-08-01

Fig 15. Deleting data in a specific row

D. Editing data

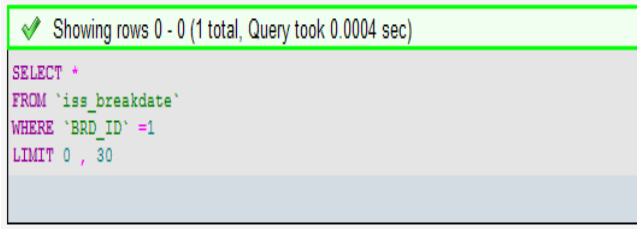
Ability to modify data for a row that already exists can be done by the UPDATE command. This command will be permitted to modify data on the selected row.



CLASS_ID	COU_ID	INS_ID	SEM_ID	CLASS_S
4521	4	0	430	2009-08-01
5521	1	2	430	2009-08-01
5525	1	5	430	2009-08-01

Fig 16. Modifying data for a specific row

In addition, the ability to query to check the database whether searching for a selective and specific value working correctly and can retrieve the true results



BRD_ID	BRD_DESC_AR	BRD_DESC_EN	BRD_START	BRD_LONG	SEM_ID
1	FAT	Fter	2009-08-01	15	430

Fig 17. Query statement for searching data

6. Testing the database

The most difficult things are to create an educational institute schedule, which is a problematic NP problem, but may solve by using heuristic search algorithms, e.g., FSM…to find the optimal solution – for simple cases. If the inputs, specifications, and requirements become complicated, it may not be able to find a good solution, and genetic algorithms may need to be used.

A. Coding Issues

The written code project should follow the criteria and the requirements of other software packages. The developer has to use standard coding conventions, objects, plans name, and variables.

The coding is extensible and sustainable and may require further changes, and should write code that other developers can understand and modify easily by using documentation of the code.

B. Important Code

Features and functionality in the case of educational institutes are distinct. Many constraints are considered for institutes scheduling software such as location, number of instructors, classrooms, subjects, timeslots. These constraints are classified based on importance.

The situation and application requirements define hard and soft constraints. In our system, only hard constraints are implemented. Figure 18 describes objects comprise a class schedule.

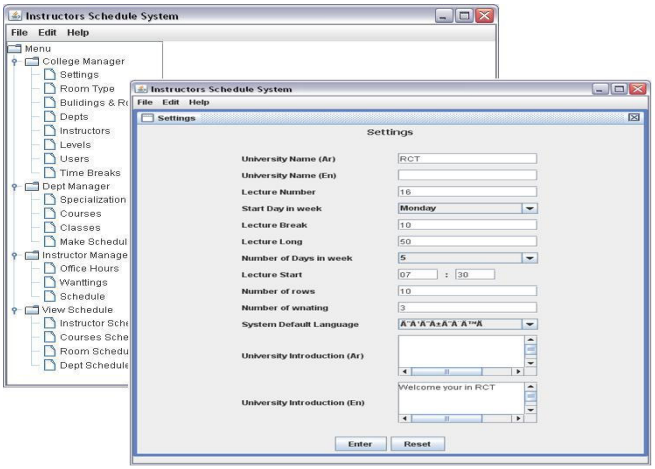


Fig 18. The implementation of comparison a class schedule

7. Conclusion

Building an automated instructor system is difficult due to the computation complexity and the variety of services. These systems depend on the programming language, desired services, and human aspect. The validation of an automated instructor system is tied to humanitarian matters.

To achieve the purpose presented during this paper, the ISS project team ensures cooperation and systematics. However, the design and analyze the ISS's Database is built according to the institute's requirements.

Conducted experimentation proves the performance of the proposed ISS system compared with previous works. The time cost and space need required by the proposed is sufficient for the ISS system. The ISS system associated with the database provides the requirements of the institute.

The proposed system would be improved to support future needs based on future requirements and specifications. Predict problems and maintain the efficacy of the system could be considered as future work.

References

[1] Johnson K., TimeTabler 3. Nelson Thornes Limited, 1994.

[2] Burke E. Elliman D. and Weare R. "A Genetic Algorithm Based University Timetable System," East-West Conference on Computer Technologies in Education, Crimea, Ukraine, pp.35-40, Mar 1994.

[3] Leyton R. "A Quick Introduction to Database System," Database systems, vol. 26, no. 8, Dec 2001.

[4] Anley C.,. "Hackproofing MySQL," An NGSSoftware Insight Security Research (NISR) Publication, Jul 2004.

[5] Alharbi H. "Instructors Schedule System," MSc. Dissertation, De Montfort University, Leicester, UK, 2009.

[6] Aljagthamy N. "Instructors Schedule System," MSc. Dissertation, De Montfort University, Leicester, UK, 2009.

[7] Technology For All, "Technology For All - Steps in designing database," [Online], Available: http://www. technologyforall.com/TechForAll/datadesigning.htm. [Accessed: 24/08/2009].

[8] Wren, A. "Scheduling, Timetabling and Rostering - A Special Relationship?," In Selected Papers From the First international Conference on Practice and theory of Automated Timetabling (August 29 - September 01, 1995). E. K. Burke and P. Ross, Eds. Lecture Notes In Computer Science, vol. 1153. Springer-Verlag, London, pp.46-75,1996.

[9] Abdullah S. "Heuristic Approaches for University Timetabling Problems," PhD. Thesis, The University of Nottingham, Nottingham, UK, 2006.

[10] Al-Ajlan, A., Service Oriented Computing for Dynamic Virtual Learning Environments (Moodle), in STRL. 2008, De Montfort: Leicester,UK.

[11] K. Aldrawiesh, F. Siewe, and H. Zedan. An Observation Model to Detect Security Violations in Web Services Environment. in The International conference on Intelligent Semantic Web-Services and Applications (ISWSA 2011). 2011. Amman, Jordan: Isra University (ISWSA 2011).

[12] Y. Alsaawy, A. Alajlan, K.Aldrawiesh and A. Bajahzar, The Development of Multi-agent system using FSM, in proceedings of the IEEE on the New Trends in Information and servcie science, June 30-2 July-2009, Beijing NISS, Sep 09.

[13] K.Aldriwiesh, Security Policy Architecture for Web Services Environment, PhD dissertation theses , June 19-2012, De Montfort university, Leicester, UK.