

Intelligent Scheduler

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Abstract

This project describes the design and the implementation of the *Intelligent Scheduler* which is an information system that aims to facilitate educational timetabling. Specifically, we use as our case study the course scheduling that occurs in the Information and Communication Technology (ICT) Program at Mahidol University. Our Intelligent Scheduler takes into account a set of constraints involving the instructors' time and assign course then produces different timetables for different classes and different levels.

The Intelligent Scheduler's components have been developed as Web-Services so that other applications can ask for the public services provided by the components. The Intelligent Scheduler also provides a user-interface which is Web-based. The user-interface supports processes of constraint gathering and timetable reporting.

Keywords: *Educational Scheduling, Timetabling.*

1. Introduction

Scheduling is a process of allocating activities and specifying resources to available time slots with respect to some constraints. It has seen as a part of many applications such as business meeting arrangements, business appointments, manufacturing production and educational timetabling.

In this project, we are focusing on the educational timetabling. As our case-study, we use the course scheduling in the Information and Communication Technology (ICT) Program at Mahidol University which currently manually creates the course schedules for each academic year. This requires a significant amount of work and cost to draw current course schedules by using general-purpose software tools such as spreadsheet programs.

We have developed a software system, named *Intelligent Scheduler*, which aims to facilitate scheduling process. With our Intelligent Scheduler, the amount of work can be significantly reduced. The Intelligent Scheduler can automatically perform the scheduling process and generate a sample course schedule which can be reviewed and approved by administration. The automatic

process can also allow for larger and more complex schedules than the manual process.

Web-Service technology is used to develop the Intelligent Scheduler's components. Each component provides a public service which can be invoked by other applications. The Intelligent Scheduler also provides a user-interface which is Web-based. The user-interface supports processes of constraint gathering and timetable reporting.

2. Literature Review

We have studied fundamental concepts of scheduling which include scheduling models and Web-Service Technology.

2.1 Scheduling Models

A simple scheduling model [1] consists of a set of time slots, a set of activities, a set of resources and a set of constraints. Time slots are specified on a regular period of time. Time slots can be of fixed-length or variable-length. Activities are positioned in time and may allocate resources. Resources can be broadly classified as human and non-human resources. Constraints describe restrictions of activities, resources and time preferences. Constraints can be classified broadly as hard constraints which

cannot be violated and soft constraints which are described by users' wishes. The degree of precedence may be used to specify the hardness of constraints.

In this project, the time slots are specified on a weekly-basis with a fixed-length of interval. The basic activities are the lectures. The human resources mainly include instructors who teach the lectures/labs and teaching assistants who help teachers in the lectures/labs. The non-human resources include classes for which the lectures/labs are given, classrooms where the lectures/labs take place and other specific equipment which is used for the lectures/labs. The constraints include time preferences of instructors, the resource restriction for each lecture and the time preferences of each lecture.

2.2 Web Service Technology

The W3C has described Web Service as "a software system designed to support interoperable machine-to-machine interaction over a network" [3]. Web Service provides a set of application interfaces (APIs) that can be invoked by a remote system hosting the requested services. Web Services can be seen as components of Service Oriented Architecture (SOA) which describes all aspects of creating and (re)using business processes. Web services communicate with each other by coordinating an activity between two or more services, or by passing data from one service to another via XML messages which follow the Simple Object Access Protocol (SOAP). The operations supported by a Web Service may be described and published to other Web Services. The service description has to be written in the standard Web Services Description Language (WSDL). The service description is optional to a SOAP endpoint but it is a prerequisite for automated code generation and service collaboration.

In this project, we develop the system regarding the SOA. The core component of the system is developed as a Web Service so that other applications can ask for the public services provided by the component. Our Web Service will automatically generate course timetables with taking constraints into account.

3. System Analysis and Design

The Intelligent Scheduler supports three types of users: Officers, Instructors and Students.

- *Officers* are the primary users who configure the system and maintain information about resources. They can specify constraints on activities and resources. They may be able to relax constraints when constraints are conflict. A specific type of officer has an authority to approve the outcome schedule.
- *Instructors* are the secondary users who can specify time preferences. They are considered as a type of human resources. Instructors are classified as university instructors, invited instructors and faculty instructors.
- *Students* are the tertiary users who can view the approved class timetables and browse general information about lectures/labs, instructors, classrooms and equipment.

In this project, the collected data requirements normally come together with constraints. The constraints can be classified broadly into hard and soft constraints. The *hard constraints* cannot be violated whereas *soft constraints* are described by users' requirement. Each constraint may be associated with a degree of precedence.

The requirements coming together with the hard constraints can be described as follows:

- Each instructor cannot teach more than one class at the same time slot
- Each classroom cannot be used for more than one class at the same time.
- The regular time period is a week which is divided into seven days each of which has two slots: morning and afternoon.
- The time slots on Wednesday afternoon and Sunday are reserved, i.e., there is no class in such time slots.
- The system will come up with a number of timetables each of which is for each class, i.e., the number of timetables is the number of classes.

Note that the first two are common constraints which are defined in most educational timetabling applications. The system configures these constraints by default.

The last three constraints can be configured differently for different applications.

The requirements coming together with the soft constraints are the following:

- Instructor precedence is defined regarding the instructor types; the university instructors have higher precedence than the invited instructors and invited instructors have higher precedence than the faculty instructors.
- Instructors have time preferences which are specified into three groups: Prefer, Not prefer and OK.
- Each instructor can teach different classes at different time slots.
- Courses can be categorized into four academic levels regarding the year of the undergraduate studies.
- Courses can also be counted as either regular courses or special courses (i.e., major courses)
- A course can be assigned to many classes. However, a special course normally has only one special class.
- A class contains a group of students. It is called a section.
- A special class consists of a group of students from different sections. It is called a major. Specifically, there are four majors: Database and Intelligent Systems, E-Business Systems, Multimedia Systems and Computer Science.

4. System Architecture

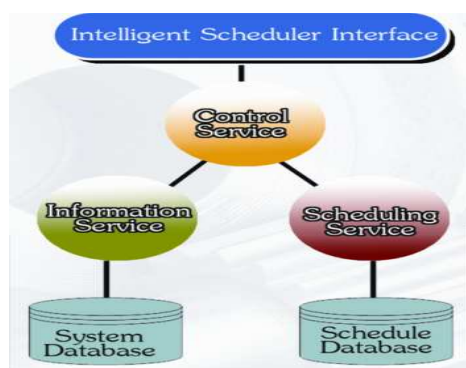


Figure 4-1: Intelligent Scheduler Architecture

Figure 4-1 shows the system architecture of the Intelligent Scheduler which consists of three main Web-Services that connect to two

databases and a Web-based user interface. The three Web-Services can be described as:

Information service provides functions that are used to manipulate information needed for scheduling. Such information is stored in the *system database* which maintains information needed about course, class, room, instructor, as well as instructor's time and assign the course. The functions provided by the information service include the user authorization, the fact-and-constraint loading and the assign course specification.

Scheduling service provides functions that are used to come up with a timetable regarding the given constraints. The resulted timetables are stored in the *schedule database* so that they can be accessed whenever having a request. These functions include the timetable conflict detection, the timetable modification and storing.

Control service provides functions that coordinate the Information and the Scheduling Services. User can specify constraints and other information via a Web-based user interface. Such constraints and information are passed through the Information Service. The interface is also used to display the resulted timetables obtained from the Scheduling Service.

5. User Interface

The Intelligent Scheduler has Web-based interface which have been designed as Web pages. Different Web pages are for different types of users.

5.1 Login Page



Figure 5-1: Login Page

Figure 5-1 shows the login page which is used by all kinds of users. Every user has to log into the system in order to manipulate data and constraints. Only authorized users can use the system.

5.2 Officer Pages

Officer pages are shown when the officer logs into the system. The officer is allowed to manipulate the course information, the instructor information, the user information, and the scheduler information.

5.2.1 Course Information Page



Figure 5-2: Course Information Page

Figure 5-2 illustrates the course information page which shows a list of courses. The officer is allowed to add a new course, remove an existing course, update the course information, and search the course from the list of all courses.

5.2.2 Instructor Information Page

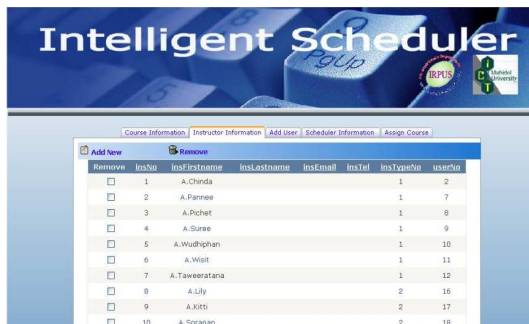


Figure 5-3: Instructor Information Page

Figure 5-3 illustrates the instructor information page which shows a list of instructors. The officer is allowed to add a new instructor, remove an existing instructor, update the instructor information and search the instructor from the list of all instructors.

5.2.3 User Information Page

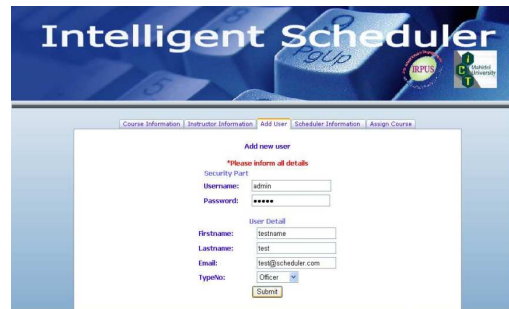


Figure 5-4: User Information Page

Figure 5-4 shows the User Information Page which is used to add a new user. This page provides a form for the officer to fulfill the two parts of user information which includes the security part and the user detail part. The security part consists of the username and the password while the user detail part consists of the user first name, the user last name, the user email and the user type number.

5.2.4 Scheduler Information Page



Figure 5-5: Scheduler Information Page

Figure 5-5 shows the Scheduler Information Page which is used to make a request for timetabling regarding given condition (e.g., schedule year, semester, and class year). The resulted timetable can be shown in either a *list* or a *table* views.

5.3 Instructor Pages

Instructor pages are shown when the instructor logs into to the system. Instructors are allowed to view their status, edit their password, manipulate their time preference, and view their current schedule.

5.3.1 Instructor Status Page

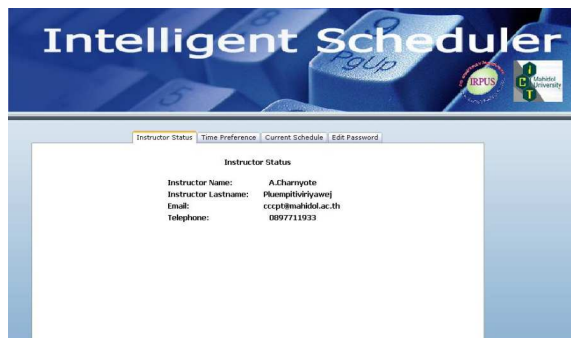


Figure 5-6: Instructor Status Page

Figure 5-6 illustrates the Instructor Status Page which shows the instructor information. This page provides the instructor profile which includes the instructor first name, instructor last name, instructor telephone number and instructor email.

5.3.2 Edit Password Page



Figure 5-9: Edit Password Page

Figure 5-9 illustrates the Edit Password Page which is used for instructors to edit their password. This page provides a form for the instructors to send the new password to the Intelligent Scheduler system.

5.3.3 Time Preference Page



Figure 5-7: Time Preference Page

Figure 5-7 illustrates the Time Preference Page which is used to specify time preference.

The page shows the time slots in the form of a timetable. The instructors' unavailable time slots will be specified as "not prefer." The instructors' available time slots and he wants to have the class in those time slots will be specified as "not prefer." Other time slots will be specified as "ok."

5.3.4 Current Timetable Page

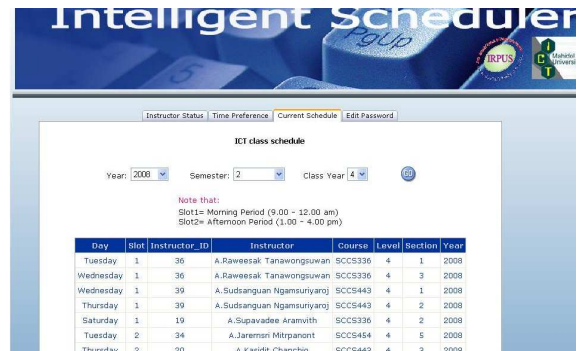


Figure 5-8: Current Timetable Page

Figure 5-8 illustrates the Current Timetable Page which is showed on the instructor page is the same page as view list schedule in the officer page.

5.4 Students Pages

Student pages are shown when the student logs into to the system. Students are allowed to view the course description in each semester and in each year, and they can also view the current schedule.

5.4.1 Course Description Page



Figure 5-10: Course List Page

Figure 5-10 illustrates the Course List Page which shows the list of the courses in each year. In addition, the student can view more details as shown in Figure 5-11.



Figure 5-11: Course Description Page

6. Conclusion

In this project, an information system, namely Intelligent Scheduler, has been developed. It facilitates the automatic scheduling which can reduce significant amount of work done by the manual scheduling. Out Intelligent Scheduler can speed up the scheduling process by generating a sample class schedule with human approval. To come up with the class schedule, the system requires information about courses, instructors, classes, and constraints which involve with the instructors' time preferences. The Intelligent Scheduler is intelligent in such a way that it can detect conflicts of the schedule. However, it needs human to resolve such conflicts. The Intelligent Scheduler's components have been developed as Web-Services so that other applications can ask for the public services provided by the components. The Intelligent Scheduler also provides a user-interface which is Web-based. The user-interface supports processes of constraint gathering and timetable reporting.

The Intelligent Scheduler can be extended in many ways. Additional constraints (e.g., the limited number of courses assigned to each instructor and the limited number of rooms) can be taken into account. To automatically resolve the conflicts, a new conflict resolution service can be added. To support other kinds of scheduling (e.g., meeting), a new information service can be plugged into the system. Constraint programming languages (e.g., Prolog) can be used to implement the scheduler to come up with an appropriate course schedule in which a large number of constraints are satisfied at the same time.

7. Acknowledgement

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