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Solving Course Timetable Problem by using Integer Linear Programming (Case Study IE Department of ITS)

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***Abstract*–Making IE department of ITS course timetable by determine the hard and soft constraints then develop an integer programming (ILP) model method to solve this NP-complete problem of Timetabling for solving Hard constraints Assignment problem and to solve the Soft constraints use Penalty Algorithm. Use LINGO software for solving suggested mathematical model to get the final results. Then do numerical analyzes for that results. Finally it achieves the goal for solving the Course Timetable. And get feasible solution of timetable as well as it gets the best required objective what it can get from the case study which is 356 events and it reduces the time of getting one timetable to be just one hour after it was at least 2 weeks.**

***Index Terms*-Apply ILP in LINGO software, Assignment Problem, Course Timetable Problem, Integer Linear Programming (ILP), Penalty Algorithm.**

INDTRODUCTION

Many institutions (academic, health, transportation, sport, etc.) in the world face timetabling problems (see Figure 1 Timetable classification), Timetabling consists in identifying an optimal allocation of a given set of events (courses, exams, surgeries, sport events) and resources (teachers, exam proctors, nurses, medical doctors) over space (classrooms, operating rooms, sport fields) and time.

The university course timetabling problem is the process of assigning lectures, which are covered by lecturers and attended by students, into 'room–time' slots, taking into account hard and soft constraints.

Timetabling requirements are separated into hard and soft ones. By hard requirements we mean those that must be satisfied, while soft requirements are those that may be violated, but should be satisfied whenever possible. Soft requirements have different levels of importance and are oftentimes conflicting with each other. Thus, it may be impossible to satisfy all of them. Typically, the quality of a solution is associated directly to the satisfaction of soft requirements. The more soft requirements are satisfied, the better a solution is considered[1]

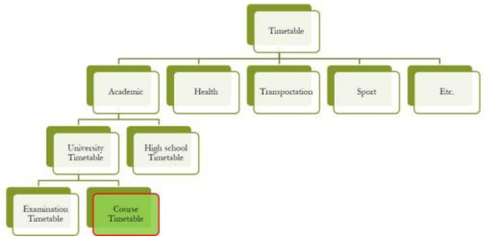

Figure 1. Timetable classifications.

In IE-ITS course timetable problem in that department is solved manually therefore it is taking long time and efforts to finish one timetable each semester which may take 2 weeks' time to finish it beside of that may be there are reviews and corrections after finish it during the semester begging, To Solve this problem we will make automated course timetabling of Industrial Engineering Department (IE) – ITS university and measure how do that feasible solution of that suggested timetable is satisfying the maximum of soft constraints requirements and satisfying also the whole hard constraints.

And to recognize the gab of our research we reviewed several paper journals which is solving the educational course timetables problem so we found some of them concentrated in solving just hard constraints timetable [2] and others they solved just soft constraints timetables [3, 4] as well as others they solved both hard and soft constraints [5-7] etc.

Therefore for summary of gab of our research we will choose:

Problem: University Course Timetable.
Methodology: Integer Linear Programming (ILP) (Assignment Problem & Penalty Algorithm)
Case of Study: IE department of ITS
Constraints: Hard and Soft constraints
Objective Function: Minimization

Design Mathematical Model:

- Notation of the mathematical model: Indexes and their resources:

I=COURSE index, And ENORLMENT its resource.
J=CLASSROOM index, And CAPACITY its resource.
K=DAYS index.
L=TIMESLOTNO index.

Decision variables:

$$X_{(I,J,K,L)} \text{ and } Y_{(I,J,K,L)}$$

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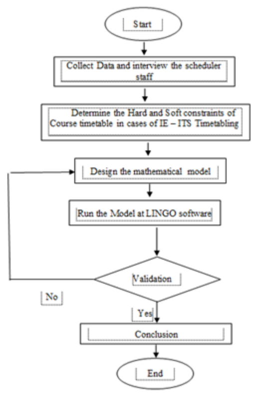

Determine the Hard and Soft Constraints:
As shown in research methodolgy figure 2 we started determining Hard Constraints of IE department of ITS: For example each classroom has limited seats capacity which will be given as data input. And for determining Soft Constraints of IE department of ITS: For example the lecturers time wishes to be considered during making the timetable.

Figure 2. Research Methodology.

Every X/Y =1 Means there is event (In that Course, In that Classroom, In that Day, At that Time slot Number)

And if X/Y=0 Means there is no event.

Z=PENALTY decision variable of not applying the soft constraint:

$$Z_{(M)}$$

If Z=1 there is Penalty at that soft constraint.

Otherwise Z=0 there is no Penalty.

M= Soft Constraint no. where each S.C. is numbered.

$$X_{(I,J,K,L)}, Y_{(I,J,K,L)} And\ Z_{(M)} = Binary\ 0/1.$$

- Mathematical model of Hard Constraints:

Classroom Capacity constraint:

$$\sum_{I}\sum_{K}\sum_{L} Y_{(I,J,K,L)} \geq 0\ ;\ \forall J\ if\ CAPACITY(J) \geq ENORLMENT(I);$$

- Mathematical model of soft constraints:

Preferred course time(e.g. We want to course number 3 to be at Monday and starting at time slot no. 1:

$$\sum_{J}\sum_{K}\sum_{L} Y_{(I,J,K,L)} + Z(M) = 1;\ \forall I\ if\ I = 3, \forall J, K\ if\ K = 1, \forall L\ if\ L = 1, \forall M\ if\ M = 1$$

Validation and Numerical Analysis:

- Hard constraints validation:

Classroom capacity: validation (e.g. Enrolment at the course CO6=40 students and Capacity of the classroom TI108=50 :

Courses	Class	Day	1	2	3
CO6	TI108	TEU	1	1	1

Explanation for the results this event could be held in that classroom because Capacity ≤ Enrolment.

- Soft constraints numerical analyzing:

Preferred Course time (e.g. CO3 at MON at Time slot 1):

Courses	Class	Day	1	2	3
CO3	ID103	MON	1	1	0

Explanation of the result we have event for Course (CO3) in Classroom (ID103) in Day (Monday) and starting at Time slot no. (1).

CONCLUSION

1. For Hard constraints we used Assignment Problem method and to solve the Soft constraints we used Penalty Algorithm method and both of them consider as (0 – 1) implications of Integer Linear.
2. After one Hour of Running the IE-ITS Model we interrupted it and we got results of that timetable which was not the Best Feasible Solution(BFS) but we got our best required objective for our model: 356 without any Penalties(Z=0) of not applying the Soft Constraints and the Results displayed that we applied the maximum of Soft constraints and whole Hard constraints with Number of Constraints: 71704 and the total of decision variables of: 156013 which is distributed between (X, Y and Z) and number of Nonzeros was: 562706 and the last Iteration was: 5428124.
3. Numerical Analyzing of Results shown that whole H.C. is working, And S.C. is working, But Some of it is not working properly.
4. Reduce spending time and efforts of IE-ITS timetable to be just 1 hour after it was at least 2 weeks.

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