OPTIMIZATION AND AUTOMATION OF TIMETABLING FOR PGP2S IN IIM CALCUTTA

TERM PAPER

Ejas Mudar
PGDM batch of 2012-14
Indian Institute of Management Calcutta
Joka, Diamond Harbour Road
Kolkata -700104, India
ejasm2014@email.iimcal.ac.in

Debraj Mandal
PGDCM batch of 2012-14
Indian Institute of Management Calcutta
Joka, Diamond Harbour Road
Kolkata -700104, India
debrajm2014@email.iimcal.ac.in

Under the Guidance of

Megha Sharma
Assistant Professor, Operations Management
Joka, Diamond Harbour Road
Kolkata- 700 104, India
megha@iimcal.ac.in

Abstract

The objective of this paper is to automate the process of timetabling for 2nd year students (PGP2s) in IIM Calcutta. Timetabling in this case involves finding subject-timeslot-classroom combinations such that violation of constraints like professor preference, student preference, class room availability, etc. are minimized. Currently in IIMC, this process is being done manually by the PGP Office staff. This is a highly complex and iterative process due to the large number of hard and soft constraints involved. As a result, it is very time consuming and error-prone when performed manually. Our aim with this term paper is to provide an algorithm to optimize and automate this process. After from increasing efficiency of the process, the aim is also to increase effectiveness, which is to say that the timetable developed would be better than the manual solution being prepared by the PGP Office.

Introduction

The registration process at IIM Calcutta involves multiple phases, the first of which involves students declaring interest in a few subjects according to their interest. Then a timetable is prepared keeping the students' choices in mind such that it inconveniences the least number of students. The final phase in registrations is the bidding process where subject allocations are done according to how students value the subjects relative to each other. Our objective with this term paper is to automate the process of timetable generation. This would ensure that maximum choices are open to students and they are free to take as many subjects as they are interested in as possible.

The timetable template used in IIM Calcutta is as follows. A sample real timetable manually prepared by the PGP Office is given in Appendix B.

Table 1: Timetable Template

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
8.30 AM							
10.15 AM							
12.00 AM							
2.30 PM							
4.15 PM							
6.00 PM							

There are seven days and 6 class times, making a total of 42 available timeslots. Subjects are to be put together into these timeslots. Two subjects come together when there is minimal overlap between them.

The overlaps between two subjects is the number of students declaring interest in that subject in the pre-registration phase of the registration process. Subjects coming together this way are grouped together into slots, so that a student can take only one subject out of a single slot. Thus the more the slots, the more the choice offered to students. The objective is to minimize the grouping together of subjects into slots such that students have the maximum freedom to choose subjects according to their interests, rather than being dictated to by the timetable constructions.

The obstacles in this process are the various constraints introduced into this problem by the real limiting factors to the different variables. Some of these constraints are inviolable and some are to be only followed up to a certain limit, after which other constraints take priority.

Hard Constraints

1. A classroom cannot have two classes at the same time.
2. A professor cannot teach two classes at the same time
3. A student cannot be present in two classes/classrooms at the same time.
4. A class cannot be held in a classroom whose capacity is less than the number of students enrolled in the class.
5. Some professors may only be able to take classes in a particular day and/or time.

Soft Constraints

1. Minimize Student demand overlap: Based on the pre-registration data, find out courses that have maximum student overlap and avoid putting them together.
2. No back-to-back classes: Professors generally do not prefer to have classes on consecutive days. They prefer to have one or two days between classes. They also usually wish to avoid a Monday and Friday class scenario (i.e. 3 day gap). This constraint is based on personal preference but can be taken as a thumb rule.
3. If a professor takes multiple subjects/sections, he would prefer to take the multiple sections/classes on the same day. But they prefer at least 1 session break between the back-to-back classes.
4. Professor preference for particular slots: Some professors would have preference for particular time-slots. It may be for a particular Time and/or day combination. The preference may even be for a particular classroom.

Timetabling as a mathematical problem

The university Timetabling Problem is a very well-known and well-studied NP-Complete problem. Given the extensive literary interest in this topic already, there have been plenty of attempts in other universities to implement a viable timetabling solution. There have been competitions on timetabling. As a starting point, we studied the various methodologies being followed in various colleges around the world. We looked at competition entrants. We analysed the various ways and approaches to the problem of timetabling and identified which ones were viable candidates for us to implement on our system. We studied the advantages and disadvantages and according to the expertise on hand and the various constraints being placed upon the system, a lot of them being unstructured in nature and requiring manual intervention, we were to decide whether to simply implement an existing algorithm or to design an entirely new system from the ground up to suit our purposes.

Literature Review

The first step was to study the current methodologies followed being followed elsewhere in the world extensively. A review of existing university timetabling methods and examinations of winning entries in timetabling competitions showed that there were altogether too many approaches which had been attempted and proven to be provide workable solutions to the timetabling problem. Types of algorithms included but were not limited to Integer Programming, graph-colouring meta-heuristics, Logic Programming, and Genetic Algorithms.

Ben Paechter and Andrew Cumming, Henri Luchian, Mihai Petriuc. 1994. Two solutions to the general timetabling problems using evolutionary methods.

The methods produce not only feasible timetables but it is claimed that they are also “good” ones. They use evolutionary algorithm because this approach is underused when it comes to timetabling. This method was different from the ones that came before it because of the methodology used which focuses on the fact that the chromosomes give instructions for building timetables, rather than being direct representations of the timetables themselves. The chromosomes are evaluated by keeping in mind two things: the number of events placed and the customized measure of the “poorness” of the partial or complete timetable that the chromosomes leads to. Each chromosome thus gets a penalty according to how “poor” it is and the fitness score assigned is the inverse of the adjusted penalty score. Evolutions are then carried out based on replacements, crossovers and mutations. The work concludes that it is indeed a viable method of generating generic “good” timetables. However, it recognizes that more work is required to search through all parameters to ensure maximized efficiency. Not enough testing has been done yet.

Le Kang, George H. von Schoenberg, and George M. White. 1991. Complete university timetabling using logic.

The relatively newer approach of Logic Programming is utilised here. University timetabling is tackled here exclusively, and appropriate constrains are in play. WPROLOG as a logic programming language has been used. The general timetabling problem has been modelled into a Constraint Satisfaction Problem, in which logic programming has some characteristics \which are very powerful. Logic systems try all possible combinations to try to prove the goal, or to find all possible ways in which the goal can be proven using a feature called backtracking. Basically, methods of logic programming which are well-proven in areas of artificial intelligence are applied to timetabling. The paper claims that a timetable produced would take into account university-specific hard and soft constraints.

Patrick De Causmaecker, Peter Demeester, Greet Vanden Berghe. 2008. A decomposed metaheuristic approach for a real-world university timetabling problem.

Here also a specific university timetabling problem is tackled and a decomposed meta-heuristic approach is adopted to solve it. However, a further complication is introduced here of overlapping timeslots and irregular weekly timetables. In the first stage, to reduce complexity a system of tiles to pillars similar to the IIM Calcutta subject slots is adopted. The effective search space for these pillars is hence much smaller. The next stage involves the algorithm trying to solve the constraints sequentially rather than solving the whole problem at once, with the obtained solution at the end of the first stage is applied to the beginning of the next stage as the starting solution. The paper claims that this sequential approach produces better results that the comprehensive method.

Olivia Rossi-Doria, Michael Sampels, Mauro Birattari, Marco Chiarandini, Marco Dorigo, Luca M. Gambardella, Joshua Knowles, Max Manfrin, Monaldo Mastrolilli, Ben Paechter, Luis Paquette, Thomas Stutzle. 2002. A comparison of the performance of different meta-heuristics on the timetabling problem.

This paper compares various algorithms to obtain best/most optimal solution for timetabling problem, viz. Evolutionary Algorithm, Ant Colony Optimization, Iterated Local Search, Simulated Annealing and Tabu Search. A mathematical model is designed in which first the class-time combination is generated and then the class room matching is taken into consideration. Hard Constraints are given much higher penalties than soft constraints. However, in this model, the Professor as a variable is completely ignored. The paper concludes that performance of ILS is much better than the other algorithms for small sized problems (where events are less than 100 in number).

S. Daskalaki, T. Birbas,E. Housos. 2004. An integer programming formulation for a case study in university timetabling

This paper models a university timetabling problem as a binary IP problem. The various parameters taken into account are the day, time, student group, professor, courses and classroom. Here, only the Class-Teacher combination is considered and students are considered to be homogenous groups. This can be equivalent to first creating a timetable and then asking students to choose their courses based on the timetable. First, the hard constraints are considered, and then after that only soft constraints are taken into account with a penalty as a function of the objective function. The complexity of the problem is reduced by reducing the search space. i.e. the variables are split, grouped together, etc. This model cannot be used directly in our problem as in our case the students groups taking courses in second year are not homogenous groups. However, concepts from this paper have been adapted in our model.

Approach and Methodology

Our purpose was to determine whether the manual system of timetabling currently being practised in the PGP Office could be improved upon. The current system focused on feasibility rather than actual optimization of overlaps.

We extensively audited the current scheduling process being practised in IIM Calcutta to gain an overall idea of the administrative steps being followed. We studied the current manual method of timetabling being carried out. We examined the registration process top-to-bottom and researched the thought processes, practices and difficulties encountered. We encountered certain peculiarities in the IIMC system that called for specific implementation issues within the PGP Office. We determined the method most compatible with the current system. The Integer Programming approach would give us the best possible solution given the constraints being faced by the PGP Office while preparing a manual timetable.

Having decided upon the methodology of solution we were going to follow, we researched the various software packages available which would best suit our requirements. We decided on the IBM ILOG CPLEX Optimization Studio, for which our esteemed faculty guide obtained an educational license, so that we could run the optimization involving the large number of variables involved in our case. We prepared a mathematical model using integer programming and coded it in the CPLEX suite's Optimization Programming Language (OPL). Alongside the optimization algorithm itself, the data set acting as the input to the optimization system had to be prepared. We acquired past registration data on term IV and term V for the batch of 2012-14. That excel data was manipulated to create an input and output space in excel which was set up in a way to as to be standardized and readable as text to be fed into the optimization engine.

The Solution

Mathematical Model

Based on our extensive study of the existing scheduling process conducted by the PGP Office, we developed a mathematical model of an integer program to automate the scheduling process so as to minimize overlap while satisfying all the constraints.

Variables Used

Given below is a list of all the variables used in the mathematical model. They are grouped according to their purpose.

Identifier Variables

These variables are used as identifiers. These are of the type: *integer*

i, j	Subject ID
d	Day ID
t	Time ID
m	Classroom ID
n	Professor ID

Data Variables

These variables are taken from a data source (eg: spreadsheet). These are of the type: *integer*

θ_{ij}	Overlap between subject i and j
SC_i	Enrolment Cap for Subject i
CC_m	Capacity of Classroom m
P_{in}	Prof n takes subject i *(binary)*

Decision Variables

These are the variables which will be manipulated by the program so as to satisfy the objective and constraints. They are of the type: *binary*

S_{idt}	Subject i takes place in timeslot d, t
C_{im}	Subject i takes place in classroom m

Variables based on Decision Variables

These variables are based on the values of the decision variables. They are of the type: *binary*

P'_{nd}	Prof n has class on day d

$$P'_{nd} = \begin{cases} 1\ if\ \sum_{i,t} P_{in}.S_{idt} \geq 1\ \forall\ n, d \\ 0\ if\ \sum_{i,t} P_{in}.S_{idt} = 0\ \forall\ n, d \end{cases}$$

Objective Function:

The objective function is designed to minimize overlap between subjects in each slot.

$$Minimize\ Z = \sum_{i,j,k,d_1,t_1,d_2,t_2} (\theta_{ij}\ .S_{id_1t_1}.S_{jd_1t_1} + \theta_{ik}\ .S_{id_2t_2}.S_{kd_2t_2}) *\ \tau_{ijk}$$

Where

$t_1 \neq t_2\ AND\ d_1 \neq d_2,$

$$\tau_{ijk} = \begin{cases} 1 & if\ j \neq k \\ 0.5 & if\ j = k \end{cases}$$

Constraints

As discussed earlier, we have divided the constraints into two types. The hard constraints which cannot be violated in any case and soft constraints which can be violated on penalty.

Hard Constraints

1. Each subject has 2 classes per week

The course structure in IIM Calcutta is designed in such a way that each course has only two classes each week.

$$\sum_d \sum_t S_{idt} = 2\ \ \forall\ i$$

2. Classroom allocation

A subject can be taken in a class room only if the Subject Cap of that Subject is less than that classroom's capacity.

$$C_{im} = 0 \quad if \;\; CC_i \leq SC_m \;\; \forall\, i$$

3. Classroom Usage

In a timeslot (day/time combo), one classroom can be used only once. i.e. multiple subjects cannot be held in the same classroom at the same time.

$$\sum_i C_{im} * S_{idt} \leq 1 \quad \forall\, m, d, t$$

4. Professor Conflict

A professor can only take one class at a time.

$$\sum_i P_{in} * S_{idt} \;\leq\; 1 \quad \forall\, n, d, t$$

Soft Constraints

These are constraints that simulate the general preferences of professors. It can be broken on penalty.

1. No multiple Classes of same subject in the same day

Professors generally do not wish to have both weekly classes of a subject in the same day. The usually prefer the two classes to be spread out across the week.

$$\sum_t S_{idt} \leq 1 \; \forall\, i, d$$

2. No classes on consecutive days for a professor

Professors do not prefer consecutive day classes

$$P'_{nd} + P'_{n(d+1)} \leq 1 \; \forall\, n, d$$

3. No large gap between classes

Professors also do not like a large break between their two classes. i.e. the classes ideally should not be at the two ends of the week.

$$P'_{nd} + P'_{n(d+4)} \leq 1 \; \forall\, n, d$$

4. Multiple subjects/sections of the same Professor in the same day

If a professor takes multiple subjects/sections in a term, he/she would prefer to take them on the same days.

$$\sum_{i,t} P_{in} \,.\, S_{idt} = \sum_{i} P_{in} \quad \forall\, n, d$$

5. At-least 1 break between classes of the same Professor

If a professor is taking multiple subjects/sections in a term, while he/she prefers to take them on the same day, he/she would like to have a break between classes.

$$\sum_{i} P_{in}.\, S_{idt} \; + \sum_{i} P_{in}.\, S_{id(t+1)} \leq 1 \; \forall\, n, d, t$$

Program Model

Based on the above mathematical model, we have used CPLEX ILOG to build an integer program model. The schematics of the model is shown below:

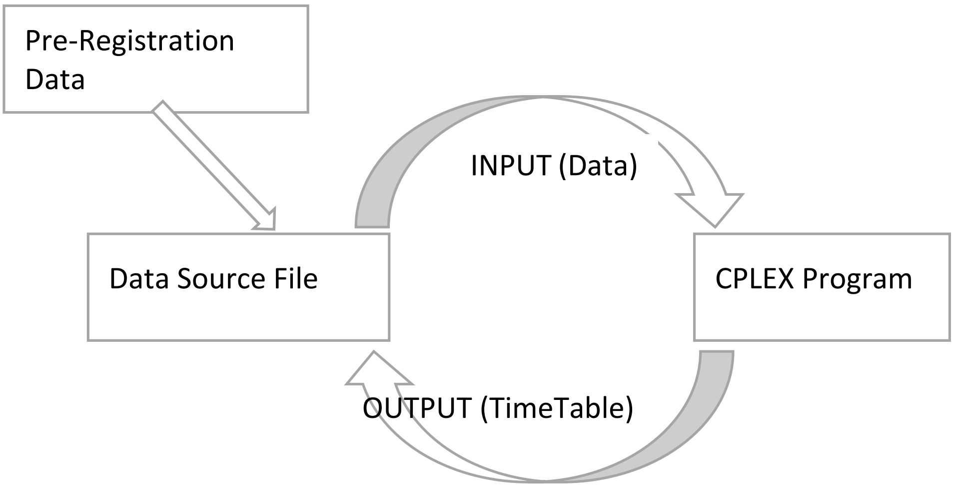

Figure 1 Program Schematics

The CPLEX program takes data from a source file, which in turn uses excel macros to read subject, overlap and professor information from the pre-registration data file. The optimization algorithm is then run and when the best feasible solution is obtained, the result is out putted back to the data source file in the form of a time table.

Sourcing the Data

Raw data available on the registration process as obtained. Registration data for terms IV and V were in unstandardized form. We had to set that up so that data in text form could be read from an excel file and fed into the optimization engine. The main inputs from the excel file are:

1. The number of subjects, rooms available, and professors
2. Overlap Matrix – Contains pairwise subject overlaps
3. Capacities of the room
4. Capacities of the subjects
5. Subject to Professor mapping

After the optimization process is run, the prototype timetable was also to be output in excel format. The next task was again in excel: identify and prepare the slots that the engine generated and then calculate the total overlap based on the prepared slots.

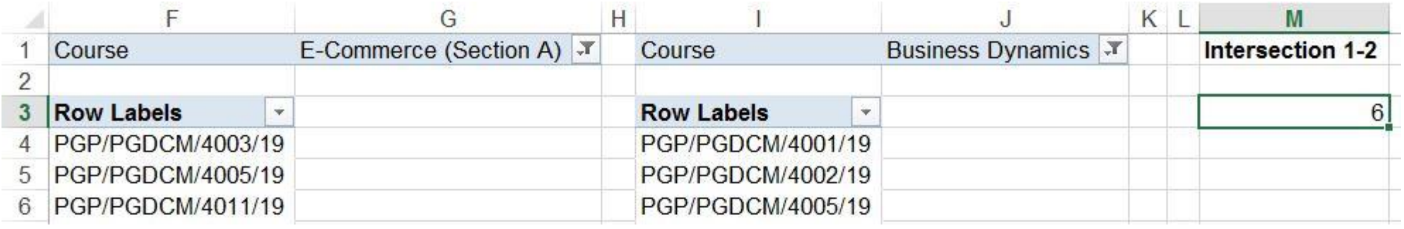

Figure 2 Pre-Registration Data: From where the input set is prepared

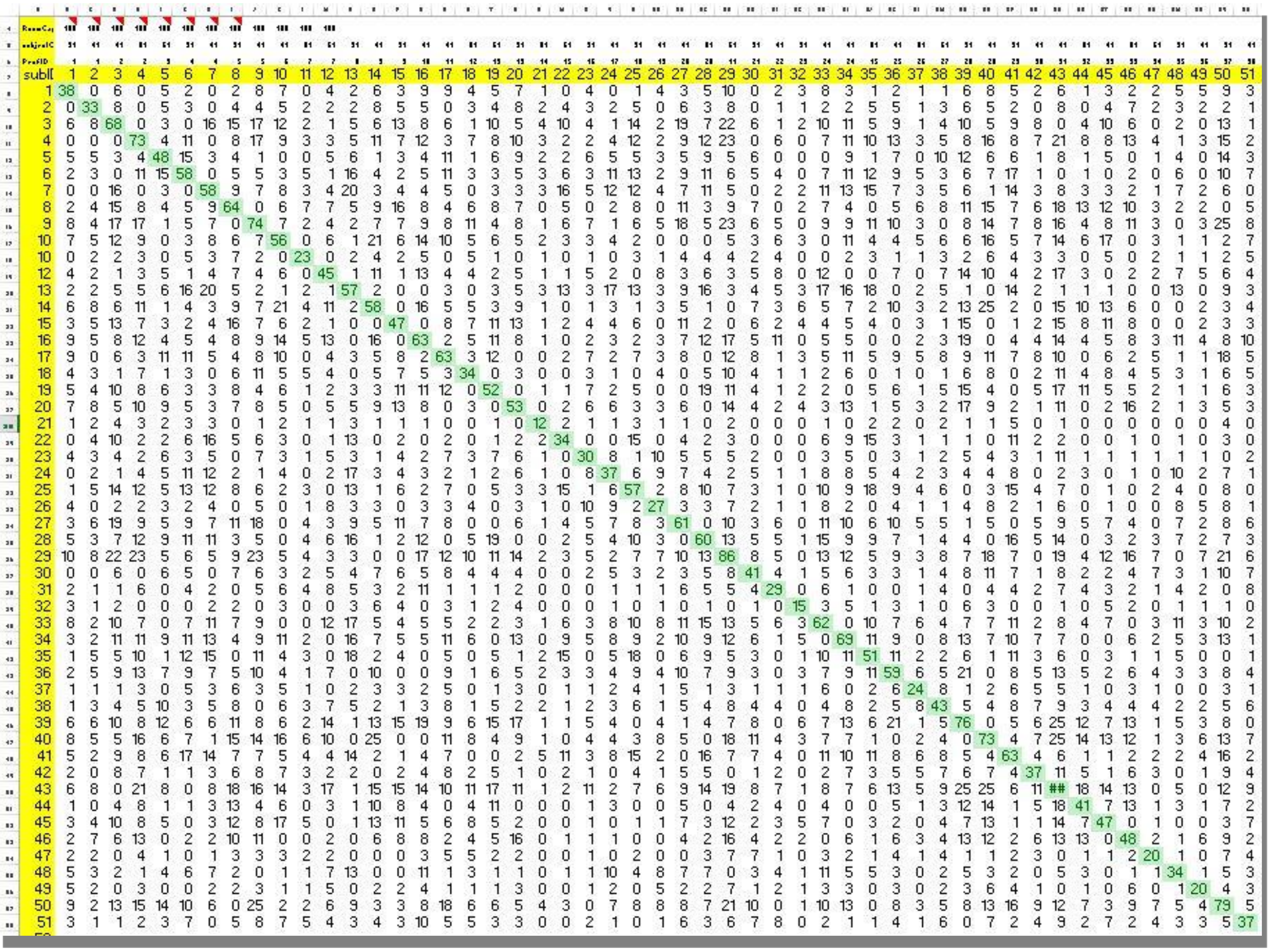

Figure 3 The Overlap Matrix: Contains pairwise subject overlaps, part of the input set

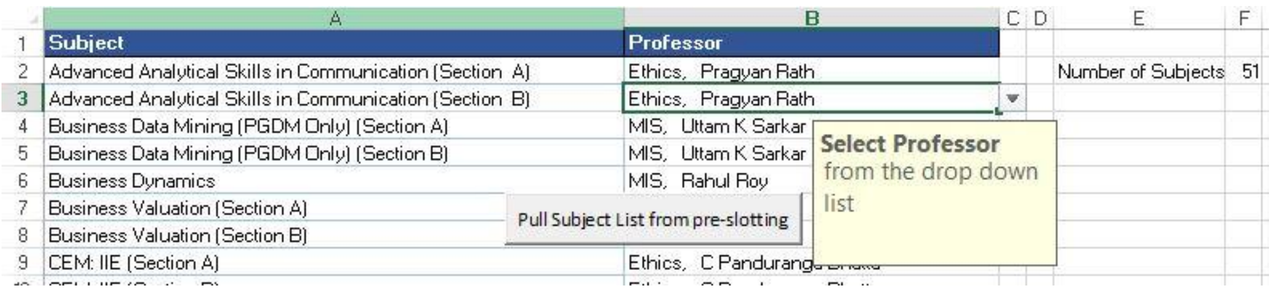

Figure 4 Professor Mapping: Manual setting of the professors to subjects

The CPLEX Model

The CPLEX Program consists of two files: timetabling.mod, which contains the logic flow and algorithms, and timetabling.dat, which contains the data information.

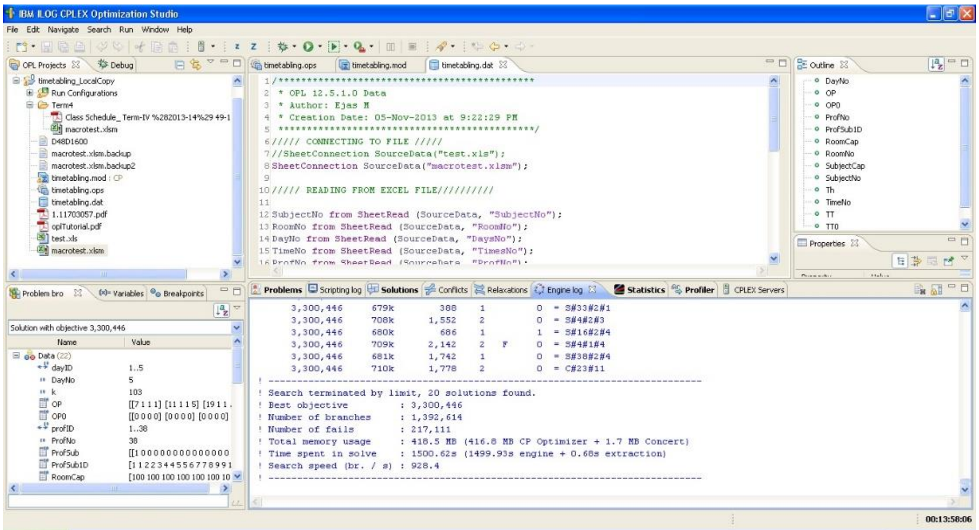

Figure 4 CPLEX running the Model

At the time of writing this paper, we have not been able to completely develop the mathematical model in CPLEX. The model currently developed takes care of all the hard constraints, but not the soft constraints. This is because, the free version of CPLEX has a limitation on the size of the search space, and using penalties for soft constraints violates this. The academic version of CPLEX with no limitation has been obtained by Prof. Megha Sharma and we will continue to work on improving this program and provide the PGP Office with a finalised software package.

Results & Conclusion

The model was run based on the pre-slotting data of Term –IV (2013). The final timetable that was obtained was as follows:

Table 2 Generated Time-Table

	MONDAY	**TUESDAY**	**WEDNESDAY**	**THURSDAY**	**FRIDAY**	**SAT**	**SUN**
8.30 AM	26 19 11 7	23 21 13	44 35 6 1	37 34 14	29 8 5		
10.15 AM	39 27 25	33 28 17 10	37 34 14	47 41 38 15	20 18 9		
12.00 AM	50 46 24	48 40 31 22	39 27 25	43 42 16 3	26 19 11 7		
2.30 PM	23 21 13	32 30 12	48 40 31 22	32 30 12	47 41 38 15		
4.15 PM	44 35 6 1	33 28 17 10	50 46 24	49 4 2	43 42 16 3		
6.00 PM	29 8 5	51 45 36	49 4 2	20 18 9	51 45 36		

Table 3 Generated Slots

Slot 1	26	19	11	7
Slot 2	23	21	13	
Slot 3	44	35	6	1
Slot 4	37	34	14	
Slot 5	29	8	5	
Slot 6	39	27	25	
Slot 7	33	28	17	10
Slot 8	47	41	38	15
Slot 9	20	18	9	
Slot 10	50	46	24	
Slot 11	48	40	31	22
Slot 12	43	42	16	3
Slot 13	32	30	12	
Slot 14	49	4	2	
Slot 15	51	45	36	

The Subject-Subject ID mapping is given in Appendix A

The CPLEX Engine Log is given below:

```
! ----------------------------------------------------------------------------
 ! Search terminated by limit, 20 solutions found.
 ! Best objective         : 3,300,446
 ! Number of branches     : 1,392,614
 ! Number of fails        : 217,111
 ! Total memory usage     : 418.5 MB (416.8 MB CP Optimizer + 1.7 MB Concert)
 ! Time spent in solve    : 1500.62s (1499.93s engine + 0.68s extraction)
 ! Search speed (br. / s) : 928.4
 ! ---------------------------------------------------------------------------
```

.

The overlap obtained from this model is 239.

In comparison, the real term IV timetable (given in Appendix B) had 251 overlaps. Thus we see that our model is about 4.5% better than the real timetable. This can be partly explained by the fact that the real model had classes scheduled on Saturdays and Sundays as well.

Although the timetable generated by our model at the time of writing is only slightly better than the real timetable, it has the advantage of time savings. The process that earlier took about 10 days is now reduced to about 15 minutes at maximum. Also, the results can be improved by further tweaking the minimization algorithm.

Thus we see that the model developed is viable and we have also satisfied the objectives of our term paper. We would, however, be continuing this further as a personal project to fine tune the algorithm and provide PGP Office with a usable software package to generate the time table from the pre-registration data. We would also be extending this model to generate a combined timetable for PGP1 and PGP2 students. An easy GUI to be used by the PGP Office is also in development.

Appendix A – Subject to Subject ID Mapping

Sub ID	Subject
1	Advanced Analytical Skills in Communication (Section A)
2	Advanced Analytical Skills in Communication (Section B)
3	Business Data Mining (PGDM Only) (Section A)
4	Business Data Mining (PGDM Only) (Section B)
5	Business Dynamics
6	Business Valuation (Section A)
7	Business Valuation (Section B)
8	CEM: IIE (Section A)
9	CEM: IIE (Section B)
10	Constraint Management
11	Consumer Behaviour (Section A)
12	Consumer Behaviour (Section B)
13	Corporate Restructuring
14	Corporate Social Responsibility : Perspectives and Practices(A)
15	Corporate Social Responsibility : Perspectives and Practices(B)
16	Creating Managing and Leading Social Enterprises
17	Decision Support Systems
18	Designing Corporate Citizenship Initiatives
19	E-Commerce (Section A)
20	E-Commerce (Section B)
21	Econometric Methods
22	Fixed Income Markets
23	Green Business Environment : IT Operations and Innovation
24	Infrastructure and Project Finance
25	Investment Analysis & Portfolio Management
26	Leading the Family Business (Post Mid Term)
27	Logistics and Supply Chain Management (Section A)
28	Logistics and Supply Chain Mgmt (Section B)
29	Management Information Systems (PGDM Only)

30	Management of Change
31	Managing Strategy Implementation and Business Transformation
32	Marketing Data Analytics
33	MLREIB (Section A)
34	MLREIB (Section B)
35	Options Futures & Derivatives
36	OR in Marketing
37	Production and Inventory Control
38	Project Management
39	Sales and Distribution Management (Section A)
40	Sales and Distribution Management (Section B)
41	Selected Aspects of Macroeconomics
42	Social Development and Social Policy
43	Sports Entertainment and Media Marketing
44	Strategic Brand Management
45	Strategic Business Intelligence (SBI) (PGDM Only) (A)
46	Strategic Business Intelligence (SBI) (PGDM Only) (B)
47	Strategic Human Resource Management in Services
48	Strategic Leadership
49	Strategies For The New Media Industries
50	The Economics of Human Resources
51	WTO Law and Policy

Appendix B – Term IV TimeTable

INDIAN INSTITUTE OF MANAGEMENT CALCUTTA
POST GRADUATE PROGRAMME IN MANAGEMENT & POST GRADUATE PROGRAMME IN COMPUTER AIDED MANAGEMENT

PGP: II
PGDM 49th, PGDCM 19th BATCH & FELLOWSHIP

CLASS SCHEDULE (TERM-IV) : 2013 - 2014

(w.e.f. June 10, 2013 to August 30, 2013)

Time	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
8.30 am – 10.00 am	Investment Analysis & Portfolio Management (NS) L-1 Sales and Distribution Management (A) (RMS-CC/KD-PTVF) L-4 WTO Law and Policy (RRB) L-2	Creative Excellence in Management: Insights from Indian Ethos (B) (CPB) MCHV Marketing Data Analytics (AKP) L-51 Project Management (Sm) A-105	Options, Futures & Derivatives (BBC) L-2	Creative Excellence in Management: Insights from Indian Ethos (B) (CPB) MCHV Marketing Data Analytics (AKP) L-51 Project Management (Sm) A-105	Constraint Management (DSM) L-1 Managing the legal & Regulatory Environment of Indian Business (A) (VKU) L-4 Strategic Business Intelligence (Sec. B) (AM) N-22		
10.15 am – 11.45 am	Corporate Restructuring (ABJ) N - 22 Corporate Social Responsibility : Perspectives and Practices (Sec. **B**) (NB-CC/RMT) L-2 Creating, Managing, and Leading Social Enterprises (DV) L-3 Sales and Distribution Management (B) (RMS-CC/KD-PTVF) L-4 OR in Marketing (MS) L-1	Creative Excellence in Management: Insights from Indian Ethos (A) (CPB) MCHV Green Business Environment : IT, Operations, and Innovation (IB) L-51 **(Post-Mid Term)** Managing Strategy Implementation and Business Transformation (PKS) A-105 Options, Futures & Derivatives (BBC) L-2 The Economics of Human Resources (DB) L-4	Decision Support Systems (SDV) N-22 Econometric Methods (MC) L-51 E-Commerce (Sec. B) (PSD-CC/ DS) L-1 Logistics and Supply Chain Management (B) (BA-CC/PB) L-4 Strategic Brand Management (RM) L-2	Creative Excellence in Management: Insights from Indian Ethos (A) (CPB) MCHV Green Business Environment : IT, Operations, and Innovation (IB) L-51 **(Post-Mid Term)** Managing Strategy Implementation and Business Transformation (PKS) A-105 The Economics of Human Resources (DB) L-4	Econometric Methods (MC) L-51 E-Commerce (Sec. B) (PSD-CC/ DS) L-1 Logistics and Supply Chain Management (B) (BA-CC/PB) L-4 Strategic Brand Management (RM) L-2	Leading the Family Business (ARC-PTVF) L-4 **(Post-Mid Term)**	Fixed Income Markets (BBC-CC / GCN-PTVF) Finance Lab Infrastructure and Project Finance (PSen-CC/ HSR-PTVF) L-2 [Pre-Mid Term]
12.00 noon – 1.30 pm	Advanced Analytical Skills in Communication (A) (PR) L-51 Business Valuation (B) (KSen) L-4 Business Data Mining (B) (UKS-CC/AS) L-2 Management of Change (VJ) L-52	Business Dynamics (RR-CC/BS) L-51 Consumer Behaviour **(A)** (KR-CC/**PM**) L-2 Constraint Management (DSM) L-1 Managing the legal & Regulatory Environment of Indian Business (A) (VKU) L-4 Strategic Business Intelligence (Sec. B) (AM) N-22	Advanced Analytical Skills in Communication (A) (PR) L-51 Business Valuation (B) (KSen) L-4 Business Data Mining (B) (UKS-CC/AS) L-2 Management of Change (VJ) L-52	Corporate Restructuring (ABJ) N - 22 Corporate Social Responsibility : Perspectives and Practices (Sec. **B**) (NB-CC/RMT) L-2 Creating, Managing, and Leading Social Enterprises (DV) L-3 Sales and Distribution Management (B) (RMS-CC/KD-PTVF) L-4 OR in Marketing (MS) L-1	Consumer Behaviour **(B)** **(KR-CC**/PM) L-2 Managing the legal & Regulatory Environment of Indian Business (B) (VKU) L-4 Production and Inventory Control (AKC) A-105 Strategic Business Intelligence (Sec. A) (AM) N-22		Fixed Income Markets (BBC-CC / GCN-PTVF) Finance Lab Infrastructure and Project Finance (PSen-CC/ HSR-PTVF) L-2 [Pre-Mid Term]
1.30 pm – 2.15 pm	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch

T i m e	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
2.15 pm – 3.45 pm	Corporate Social Responsibility : Perspectives and Practices (Sec. A) (NB-CC/RMT) L-2 Management Information Systems : The Strategic Dimensions (SDV) L-4 Social Development and Social Policy (KSM) L-51 Strategic Leadership (AP) L-52	Advanced Analytical Skills in Communication (B) (PR) L-51 Decision Support Systems (SDV) N-22	Designing Corporate Citizenship Initiatives (NPJ) L-51 E-Commerce (Sec. A) (PSD-CC/ DS) L-1 Logistics and Supply Chain Management (A) (BA-CC/PB) L-4 Selected Aspects of Macroeconomics (AB/ss-CC) L-2	Corporate Social Responsibility : Perspectives and Practices (Sec. A) (NB-CC/RMT) L-2 Management Information Systems : The Strategic Dimensions (SDV) L-4 Social Development and Social Policy (KSM) L-51 Strategic Leadership (AP) L-52	Designing Corporate Citizenship Initiatives (NPJ) L-51 E-Commerce (Sec. A) (PSD-CC/ DS) L-1 Logistics and Supply Chain Management (A) (BA-CC/PB) L-4 Selected Aspects of Macroeconomics (AB/ss-CC) L-2	Fixed Income Markets (BBC-CC / GCN-PTVF) Finance Lab Infrastructure and Project Finance (PSen-CC/ HSR-PTVF) L-2 [Pre-Mid Term]	Strategies For The New Media Industries (SK-CC/PG-PTVF) A-105
4.00 pm – 5.30 pm	Business Valuation (A) (KSen) L-4 Business Data Mining (A) (UKS-CC/AS) L-2 Strategic Human Resource Management in Services (AD) L-51 Strategies For The New Media Industries (SK-CC/PG-PTVF) A-105 Sports Entertainment and Media Marketing (PM-CC/CDM-PTVF) L-1	Consumer Behaviour (**B**) (**KR-CC**/PM) L-2 Managing the legal & Regulatory Environment of Indian Business (B) (VKU) L-4 Production and Inventory Control (AKC) A-105 Strategic Business Intelligence (Sec. A) (AM) N-22	Business Valuation (A) (KSen) L-4 Business Data Mining (A) (UKS-CC/AS) L-2 Strategic Human Resource Management in Services (AD) L-51	Investment Analysis & Portfolio Management (NS) L-1 Sales and Distribution Management (A) (RMS-CC/KD-PTVF) L-4 WTO Law and Policy (RRB) L-2	Leading the Family Business (ARC-PTVF) L-4 **(Post-Mid Term)** Advanced Analytical Skills in Communication (B) (PR) L-51	Fixed Income Markets (BBC-CC / GCN-PTVF) Finance Lab Infrastructure and Project Finance (PSen-CC/ HSR-PTVF) L-2 [Pre-Mid Term]	Strategies For The New Media Industries (SK-CC/PG-PTVF) A-105
5.45 pm – 7.15 pm	Strategies For The New Media Industries (SK-CC/PG-PTVF) A-105 Sports Entertainment and Media Marketing (PM-CC/CDM-PTVF) L-1		Consumer Behaviour **(A)** (KR-CC/**PM**) L-2 Business Dynamics (RR-CC/BS) L-51				

Dated: May 3, 2013

(Prof. Subir Bhattacharya)
Chairperson - PGP