Time-Table Scheduling

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Group 514

INFO 6205 Final Project Report

Problem Statement

To design a timetable for classes in a college, we have to arrange classes and come up with a timetable so that there are no clashes between classes. So task is to search for the optimum timetable schedule. In this project, we are going to solve schedule problem by using genetic algorithm.

This category of problem relates to problems, which have a set of variables that need to be assigned in such a way that they avoid violating a defined set of constraints.

Constraints fall into two categories:

Hard constraints— constraints which need to be satisfied to produce a functional solution

Soft constraints—constraints which are preferred but not at the expense of the hard constraints

Some typical hard constraints are:

- Classrooms must contain any required equipment
- Classrooms need to be big enough to host the class

- Professors can only be in one class at any given time
- Classrooms can only host one class at any given time

Some typical soft constraints may be:

- Room capacity should be suitable for the class size
- Preferred classroom of the professor
- Preferred class time of the professor

Sometimes multiple soft constraints may conflict and the algorithm should provide suitable solution for this case. For example, if the classroom has capacity of 50 students but it is only a 10 students class lecture, this is not a good solution. The hard constraints conditions need to be satisfied, in order to produce a functional solution.

The class scheduling problem will stop at a generation which would produce a zero conflict timetable schedule. It is because that our program is based the data we create. Once the schedule contains zero conflicts, the program will stop mutation and print result.

Model Detail Design

Implementation:

Each class will be assigned a department, meeting time slot, a instructor, a room and a course. The Schedule generated based on the courses present in the each department.

Hard Constraints:

- Classroom should big enough to hold the class
- Professor can only be in one class at any given time
- Classroom can only hold one class at any given time

Soft Constraints:

- Preferred classroom of the professor

- Preferred class time of the professor

Chromosome Design

Chromosome is an important factor in the genetic algorithm where the design of chromosome will affect how the crossover implemented. We could assign several ID to each professor, classroom and timeslot. Form of gene are as below.

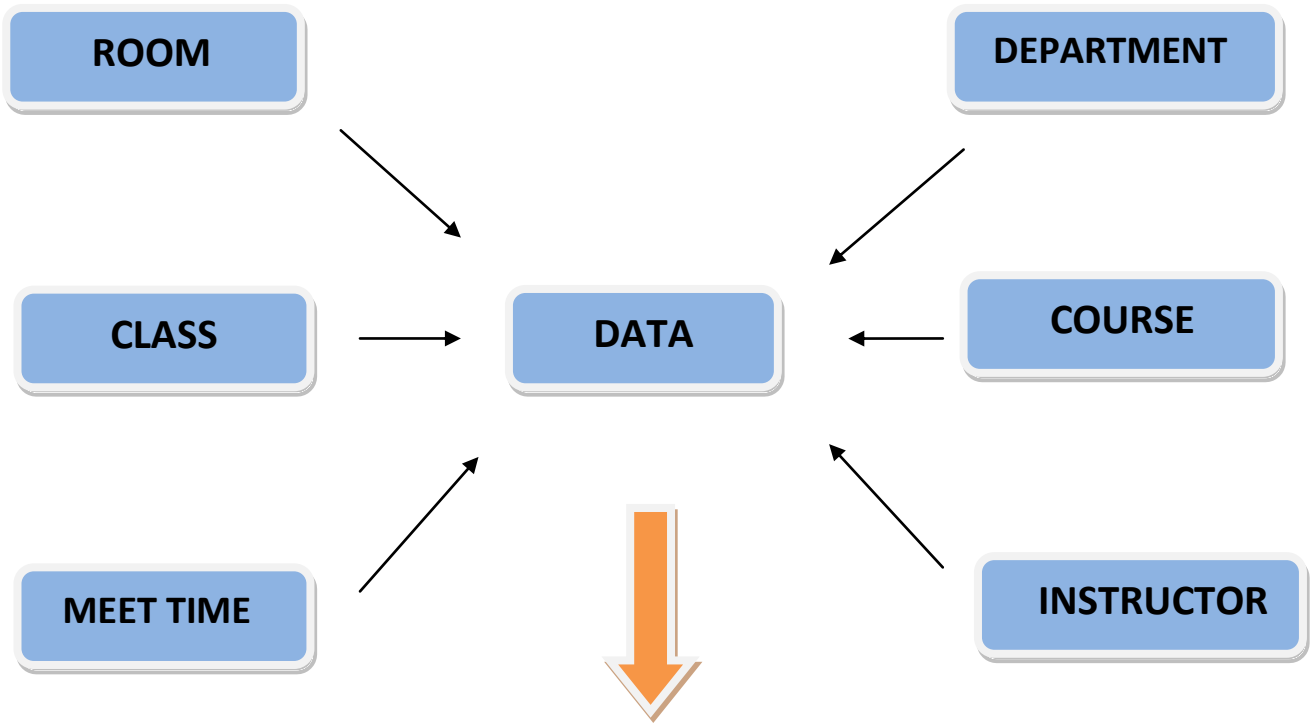
		Class A					Class B		
1	4	5	3	5	1	4	3	4	1

Dept ID Instruct ID Room ID Course ID Time ID

Each class has five components, 1 gene for Time, 1 gene for Instructor, 1 gene for Department, 1 gene for Course and 1 gene for Room

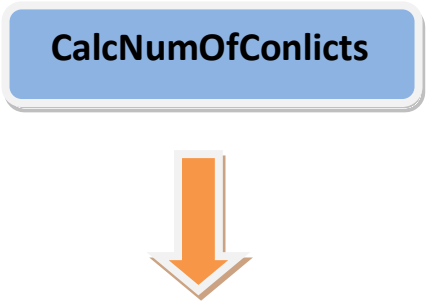
Initialization

First of all, we have to initialize some information including class, classroom, professor, timeslot, group and module. Forms of each Java class are as below



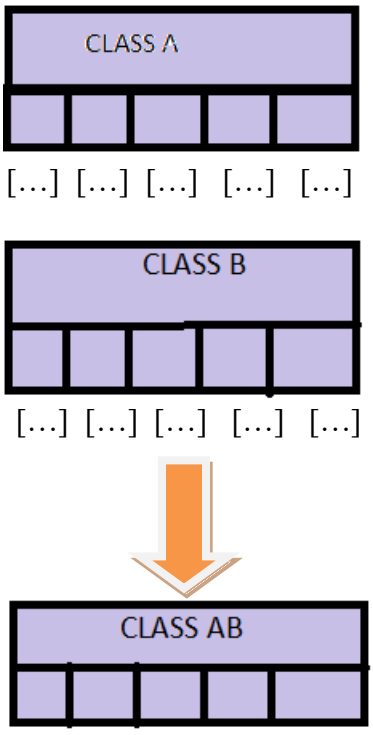
Evaluation

The goal is to optimize our class timetable in a way that will avoid breaking as many constraints as possible.



If any hard constraints or soft constraints are violated, for example, if the selected room is too small, if there is a scheduling conflict for the room, the method returns the total number of conflicts it found.

Mutation



Result and Conclusion

It can be predicted that the first generation could perform really bad because they have such a small amount of good genes generated by list of random number. Under such circumstance, the functional schedule could not make a right class timetable.

With generation increasing, the fitness gets better. The generation stops changing when the conflicts in a timetable schedule are zero. Unlike the others genetic algorithm problem, most solutions in this scenario are invalid and we stop only when we find the first valid solution or run out of time. Unlike the others genetic algorithm problem, most solutions in this scenario are invalid and we stop only when we find the first valid solution

When considering on, it is easy to stop at significantly less number of generations which provides a zero conflict schedule timetable. This is because the database we create is too small that means there are no complex situations. It is enough for program to find valid results. The conclusion has been drawn for varying size of population as well.

The below observation is shown:

OUTPUT RESULT:

Generation 0:

```
Available departments ==>
name: MIScourses: [INFO6100, INFO6300]
name: CSEcourses: [INFO6200, INFO6400, INFO6500]
name: EMcourses: [INFO6600, INFO6700]
Available Courses ==>
 course: c1 name: INFO6100 max number of students: 25 instructor: [kal, Robin]
 course: c2 name: INFO6200 max number of students: 35 instructor: [kal, Robin, vishal]
 course: c3 name: INFO6300 max number of students: 25 instructor: [kal, Robin]
 course: c4 name: INFO6400 max number of students: 30 instructor: [vishal, yusuf]
 course: c5 name: INFO6500 max number of students: 35 instructor: [yusuf]
 course: c6 name: INFO6600 max number of students: 45 instructor: [kal, vishal]
 course: c7 name: INFO6700 max number of students: 45 instructor: [Robin, yusuf]

 Available rooms:
room: Room1 maximum seating capacity: 25
room: Room2 maximum seating capacity: 45
room: Room3 maximum seating capacity: 35

 Available instructor:
Instructor id: I1name: kal
Instructor id: I2name: Robin
Instructor id: I3name: vishal
Instructor id: I4name: yusuf

 Available Meeting times:
id: MT1meeting time: MWF 09:00 - 10:00
id: MT2meeting time: MWF 10:00 - 11:00
id: MT3meeting time: TTH 09:00 - 10:30
id: MT4meeting time: TTH 10:30 - 12:00
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generation: 0
 0    |MIS, c1, Room3, yusuf, MT2,MIS, c3, Room3, kal, MT2,CSE, c2, Room1, Robin, MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room2, yusuf, MT3,EM, c6, Room2, vishal, MT4,EM, c7, Room2, Rob
 1    |MIS, c1, Room2, yusuf, MT4,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, kal, M
 2    |MIS, c1, Room1, Robin, MT3,MIS, c3, Room1, vishal, MT4,CSE, c2, Room2, vishal, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room2, vishal, MT1,EM, c6, Room3, Robin, MT3,EM, c7, Room1,
 3    |MIS, c1, Room2, yusuf, MT1,MIS, c3, Room2, vishal, MT1,CSE, c2, Room1, yusuf, MT3,CSE, c4, Room1, kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room2, Robin, MT2,EM, c7, Room1, Robin,
 4    |MIS, c1, Room1, kal, MT1,MIS, c3, Room1, yusuf, MT3,CSE, c2, Room2, yusuf, MT1,CSE, c4, Room2, yusuf, MT2,CSE, c5, Room1, vishal, MT2,EM, c6, Room3, yusuf, MT1,EM, c7, Room1, kal,
 5    |MIS, c1, Room3, kal, MT3,MIS, c3, Room2, Robin, MT1,CSE, c2, Room3, vishal, MT1,CSE, c4, Room1, Robin, MT3,CSE, c5, Room1, yusuf, MT2,EM, c6, Room2, yusuf, MT1,EM, c7, Room1, Robi
 6    |MIS, c1, Room3, vishal, MT4,MIS, c3, Room3, yusuf, MT2,CSE, c2, Room1, Robin, MT4,CSE, c4, Room2, vishal, MT2,CSE, c5, Room1, yusuf, MT1,EM, c6, Room2, Robin, MT2,EM, c7, Room3, R
 7    |MIS, c1, Room3, Robin, MT2,MIS, c3, Room1, kal, MT1,CSE, c2, Room2, kal, MT3,CSE, c4, Room3, kal, MT1,CSE, c5, Room2, Robin, MT3,EM, c6, Room2, Robin, MT2,EM, c7, Room1, kal, MT3
 8    |MIS, c1, Room3, yusuf, MT1,MIS, c3, Room3, yusuf, MT1,CSE, c2, Room3, Robin, MT3,CSE, c4, Room1, Robin, MT3,CSE, c5, Room1, vishal, MT4,EM, c6, Room1, vishal, MT2,EM, c7, Room2, v

Class # | dept | Course (number , max # of students) | Room (capacity) | Instructor (id) | Meeting Time (ID)
---------------------------------------------------------------------------------------------------------
     01  |  MIS |    INFO6100 (c1, 25)     | Room3 (35)  |     yusuf (I4)    | MWF 10:00 - 11:00 (MT2)
     02  |  MIS |    INFO6300 (c3, 25)     | Room3 (35)  |       kal (I1)    | MWF 10:00 - 11:00 (MT2)
     03  |  CSE |    INFO6200 (c2, 35)     | Room1 (25)  |     Robin (I2)    | MWF 09:00 - 10:00 (MT1)
     04  |  CSE |    INFO6400 (c4, 30)     | Room1 (25)  |    vishal (I3)    | TTH 09:00 - 10:30 (MT3)
     05  |  CSE |    INFO6500 (c5, 35)     | Room2 (45)  |     yusuf (I4)    | TTH 09:00 - 10:30 (MT3)
     06  |   EM |    INFO6600 (c6, 45)     | Room2 (45)  |    vishal (I3)    | TTH 10:30 - 12:00 (MT4)
     07  |   EM |    INFO6700 (c7, 45)     | Room2 (45)  |     Robin (I2)    | MWF 10:00 - 11:00 (MT2)
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om3, kal, MT2,CSE, c2, Room1, Robin, MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room2, yusuf, MT3,EM, c6, Room2, vishal, MT4,EM, c7, Room2, Robin, MT2      |0.25000      |3
om3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, kal, MT3  |0.25000      |3
om1, vishal, MT4,CSE, c2, Room2, vishal, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room2, vishal, MT1,EM, c6, Room3, Robin, MT3,EM, c7, Room1, kal, MT4    |0.20000      |4
om2, vishal, MT1,CSE, c2, Room1, yusuf, MT3,CSE, c4, Room1, kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room2, Robin, MT2,EM, c7, Room1, Robin, MT4        |0.20000      |4
1, yusuf, MT3,CSE, c2, Room2, yusuf, MT1,CSE, c4, Room2, yusuf, MT2,CSE, c5, Room1, vishal, MT2,EM, c6, Room3, yusuf, MT1,EM, c7, Room1, kal, MT4         |0.20000      |4
2, Robin, MT1,CSE, c2, Room3, vishal, MT1,CSE, c4, Room1, Robin, MT3,CSE, c5, Room1, yusuf, MT2,EM, c6, Room2, yusuf, MT1,EM, c7, Room1, Robin, MT1       |0.16667      |5
oom3, yusuf, MT2,CSE, c2, Room3, Robin, MT4,CSE, c4, Room2, vishal, MT2,CSE, c5, Room1, yusuf, MT1,EM, c6, Room2, Robin, MT2,EM, c7, Room3, Robin, MT2    |0.14286      |6
om1, kal, MT1,CSE, c2, Room2, kal, MT3,CSE, c4, Room3, kal, MT1,CSE, c5, Room2, Robin, MT1,EM, c6, Room2, Robin, MT2,EM, c7, Room1, kal, MT1     |0.14286      |6
om3, yusuf, MT1,CSE, c2, Room3, Robin, MT3,CSE, c4, Room1, Robin, MT3,CSE, c5, Room1, vishal, MT4,EM, c6, Room1, vishal, MT2,EM, c7, Room2, vishal, MT4  |0.12500      |7

ents) | Room (capacity) | Instructor (id) | Meeting Time (ID)
-----------------------------------------------------------------
   | Room3 (35)   |     yusuf (I4)    | MWF 10:00 - 11:00 (MT2)
   | Room3 (35)   |       kal (I1)    | MWF 10:00 - 11:00 (MT2)
   | Room1 (25)   |     Robin (I2)    | MWF 09:00 - 10:00 (MT1)
   | Room1 (25)   |    vishal (I3)    | TTH 09:00 - 10:30 (MT3)
   | Room2 (45)   |     yusuf (I4)    | TTH 09:00 - 10:30 (MT3)
   | Room2 (45)   |    vishal (I3)    | TTH 10:30 - 12:00 (MT4)
   | Room2 (45)   |     Robin (I2)    | MWF 10:00 - 11:00 (MT2)
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Generation 1:

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|
> generation: 1
  Schedule # |                        classes [dept,class,room,instructor,meeting-time]                        | fitness | conflicts
------------------------------------------------------------------------------------------------------------------------------------
 0    | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, M
 1    | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, M
 2    | MIS, c1, Room3, yusuf, MT2,MIS, c3, Room1, kal, MT2,CSE, c2, Room1, Robin, MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room2, yusuf, MT3,EM, c6, Room2, vishal, MT4,EM, c7, Room2, R
 3    | MIS, c1, Room1, Robin, MT3,MIS, c3, Room3, kal, MT2,CSE, c2, Room3, Robin, MT1,CSE, c4, Room2, Robin, MT4,CSE, c5, Room2, yusuf, MT4,EM, c6, Room2, vishal, MT4,EM, c7, Room2, Ro
 4    | MIS, c1, Room2, yusuf, MT1,MIS, c3, Room2, vishal, MT1,CSE, c2, Room1, yusuf, MT3,CSE, c4, Room1, kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room2, Robin, MT2,EM, c7, Room1, Robi
 5    | MIS, c1, Room2, yusuf, MT4,MIS, c3, Room1, vishal, MT4,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room1, kal, MT1,EM, c6, Room1, Robin, MT2,EM, c7, Room1, ka
 6    | MIS, c1, Room2, yusuf, MT1,MIS, c3, Room1, vishal, MT4,CSE, c2, Room2, vishal, MT3,CSE, c4, Room1, kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room3, Robin, MT3,EM, c7, Room1, kal
 7    | MIS, c1, Room2, vishal, MT1,MIS, c3, Room1, vishal, MT4,CSE, c2, Room1, Robin, MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room2, vishal, MT1,EM, c6, Room2, vishal, MT4,EM, c7, Roo
 8    | MIS, c1, Room2, yusuf, MT1,MIS, c3, Room2, Robin, MT1,CSE, c2, Room1, yusuf, MT3,CSE, c4, Room1, Robin, MT3,CSE, c5, Room3, kal, MT3,EM, c6, Room2, yusuf, MT1,EM, c7, Room1, Rob

Class # | dept | Course (number , max # of students) | Room (capacity) | Instructor (id) | Meeting Time (ID)
---------------------------------------------------------------------------------------------------------
     01  |  MIS |    INFO6100 (c1, 25)     | Room3 (35)  |       kal (I1)    | TTH 09:00 - 10:30 (MT3)
     02  |  MIS |    INFO6300 (c3, 25)     | Room3 (35)  |       kal (I1)    | MWF 09:00 - 10:00 (MT1)
     03  |  CSE |    INFO6200 (c2, 35)     | Room2 (45)  |     yusuf (I4)    | TTH 09:00 - 10:30 (MT3)
     04  |  CSE |    INFO6400 (c4, 30)     | Room2 (45)  |    vishal (I3)    | TTH 10:30 - 12:00 (MT4)
     05  |  CSE |    INFO6500 (c5, 35)     | Room3 (35)  |       kal (I1)    | TTH 10:30 - 12:00 (MT4)
     06  |   EM |    INFO6600 (c6, 45)     | Room2 (45)  |     yusuf (I4)    | MWF 09:00 - 10:00 (MT1)
     07  |   EM |    INFO6700 (c7, 45)     | Room2 (45)  |       kal (I1)    | TTH 09:00 - 10:30 (MT3)
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                              | fitness | conflicts
----------------------------------------------------
l, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.33333 | 2
l, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.33333 | 2
hal, MT3,CSE, c5, Room2, yusuf, MT3,EM, c6, Room2, vishal, MT4,EM, c7, Room2, Robin, MT2 | 0.25000 | 3
in, MT4,CSE, c5, Room2, yusuf, MT4,EM, c6, Room2, vishal, MT4,EM, c7, Room2, Robin, MT2 | 0.25000 | 3
kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room2, Robin, MT2,EM, c7, Room1, Robin, MT4 | 0.20000 | 4
Robin, MT4,CSE, c5, Room1, kal, MT1,EM, c6, Room1, Robin, MT2,EM, c7, Room1, kal, MT4 | 0.16667 | 5
 kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room3, Robin, MT3,EM, c7, Room1, kal, MT4 | 0.16667 | 5
 vishal, MT3,CSE, c5, Room2, vishal, MT1,EM, c6, Room2, vishal, MT4,EM, c7, Room2, Robin, MT2 | 0.16667 | 5
obin, MT3,CSE, c5, Room3, kal, MT3,EM, c6, Room2, yusuf, MT1,EM, c7, Room1, Robin, MT1 | 0.10000 | 9


------------------------------------------------------
0:30 (MT3)
0:00 (MT1)
0:30 (MT3)
2:00 (MT4)
2:00 (MT4)
0:00 (MT1)
0:30 (MT3)
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Generation 2:

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> generation: 2
  Schedule # |                              classes [dept,class,room,instructor,meeting-time]                                                   | fitness | conflicts
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   0     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, vishal,
   1     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, M
   2     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, M
   3     | MIS, c1, Room3, kal, MT3,MIS, c3, Room1, kal, MT4,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, M
   4     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room1, kal, MT4,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robin, M
   5     | MIS, c1, Room3, yusuf, MT2,MIS, c3, Room1, kal, MT2,CSE, c2, Room1, Robin, MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robi
   6     | MIS, c1, Room2, yusuf, MT1,MIS, c3, Room3, kal, MT1,CSE, c2, Room1, yusuf, MT3,CSE, c4, Room1, kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room2, Robin, MT2,EM, c7, Room1, Robin,
   7     | MIS, c1, Room1, Robin, MT3,MIS, c3, Room3, kal, MT2,CSE, c2, Room1, yusuf, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room3, vishal, MT2,EM, c6, Room3, vishal, MT2,EM, c7, Room1, R
   8     | MIS, c1, Room2, yusuf, MT1,MIS, c3, Room2, Robin, MT1,CSE, c2, Room1, yusuf, MT3,CSE, c4, Room1, Robin, MT3,CSE, c5, Room3, kal, MT3,EM, c6, Room2, yusuf, MT1,EM, c7, Room1, Rob

Class # | dept | Course (number , max # of students) | Room (capacity) | Instructor (id) | Meeting Time (ID)
------------------------------------------------------------------------------------------------------------
      01  |   MIS |      INFO6100 (c1, 25)       | Room3 (35)       |        kal (I1)     | TTH 09:00 - 10:30 (MT3)
      02  |   MIS |      INFO6300 (c3, 25)       | Room3 (35)       |        kal (I1)     | MWF 09:00 - 10:00 (MT1)
      03  |   CSE |      INFO6200 (c2, 35)       | Room2 (45)       |      yusuf (I4)     | TTH 09:00 - 10:30 (MT3)
      04  |   CSE |      INFO6400 (c4, 30)       | Room2 (45)       |      Robin (I2)     | TTH 10:30 - 12:00 (MT4)
      05  |   CSE |      INFO6500 (c5, 35)       | Room1 (35)       |        kal (I1)     | TTH 10:30 - 12:00 (MT4)
      06  |    EM |      INFO6600 (c6, 45)       | Room1 (25)       |      Robin (I2)     | MWF 10:00 - 11:00 (MT2)
      07  |    EM |      INFO6700 (c7, 45)       | Room2 (45)       |     vishal (I3)     | MWF 10:00 - 11:00 (MT2)
------------------------------------------------------------------------------------------------------------
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tor,meeting-time]                                               | fitness | conflicts
-----------------------------------------------------------------------------------------
m2, yusuf, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, vishal, MT2 | 0.50000 | 1
m2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.33333 | 2
m2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.33333 | 2
m2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.25000 | 3
m1, kal, MT4,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robin, MT2 | 0.25000 | 3
oom1, Robin, MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robin, MT2 | 0.25000 | 3
oom1, yusuf, MT3,CSE, c4, Room1, kal, MT1,CSE, c5, Room3, kal, MT3,EM, c6, Room2, Robin, MT2,EM, c7, Room1, Robin, MT4 | 0.20000 | 4
oom1, yusuf, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room3, vishal, MT2,EM, c6, Room3, vishal, MT2,EM, c7, Room1, Robin, MT4 | 0.10000 | 9
 Room1, yusuf, MT3,CSE, c4, Room1, Robin, MT3,CSE, c5, Room3, kal, MT3,EM, c6, Room2, yusuf, MT1,EM, c7, Room1, Robin, MT1 | 0.10000 | 9

Instructor (id) | Meeting Time (ID)
----------------------------------------------------------------------------
       kal (I1)      | TTH 09:00 - 10:30 (MT3)
       kal (I1)      | MWF 09:00 - 10:00 (MT1)
     yusuf (I4)      | TTH 09:00 - 10:30 (MT3)
     Robin (I2)      | TTH 10:30 - 12:00 (MT4)
       kal (I1)      | TTH 10:30 - 12:00 (MT4)
     Robin (I2)      | MWF 10:00 - 11:00 (MT2)
    vishal (I3)      | MWF 10:00 - 11:00 (MT2)
----------------------------------------------------------------------------
```

Generation 3:

```
> generation: 3
  Schedule # |                              classes [dept,class,room,instructor,meeting-time]                                                   | fitness | conflicts
---------------------------------------------------------------------------------------------------------------------------------------------------------------------
   0     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, vishal
   1     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robin,
   2     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, vishal,
   3     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, M
   4     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, yusuf, MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, M
   5     | MIS, c1, Room3, yusuf, MT2,MIS, c3, Room2, yusuf, MT4,CSE, c2, Room3, yusuf, MT3,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, vi
   6     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room1, kal, MT4,CSE, c4, Room1, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3
   7     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room2, Robin, MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, yusuf, MT1,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robi
   8     | MIS, c1, Room3, kal, MT3,MIS, c3, Room3, kal, MT1,CSE, c2, Room1, kal, MT4,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room3, Robin, MT3,EM, c7, Room2, Robin, M

Class # | dept | Course (number , max # of students) | Room (capacity) | Instructor (id) | Meeting Time (ID)
------------------------------------------------------------------------------------------------------------
      01  |   MIS |      INFO6100 (c1, 25)       | Room3 (35)       |        kal (I1)     | TTH 09:00 - 10:30 (MT3)
      02  |   MIS |      INFO6300 (c3, 25)       | Room3 (35)       |        kal (I1)     | MWF 09:00 - 10:00 (MT1)
      03  |   CSE |      INFO6200 (c2, 35)       | Room2 (45)       |      yusuf (I4)     | TTH 09:00 - 10:30 (MT3)
      04  |   CSE |      INFO6400 (c4, 30)       | Room2 (45)       |     vishal (I3)     | TTH 10:30 - 12:00 (MT4)
      05  |   CSE |      INFO6500 (c5, 35)       | Room3 (35)       |        kal (I1)     | TTH 10:30 - 12:00 (MT4)
      06  |    EM |      INFO6600 (c6, 45)       | Room2 (45)       |      yusuf (I4)     | MWF 09:00 - 10:00 (MT1)
      07  |    EM |      INFO6700 (c7, 45)       | Room2 (45)       |     vishal (I3)     | MWF 10:00 - 11:00 (MT2)
> solution found in 4generations
------------------------------------------------------------------------------------------------------------
```

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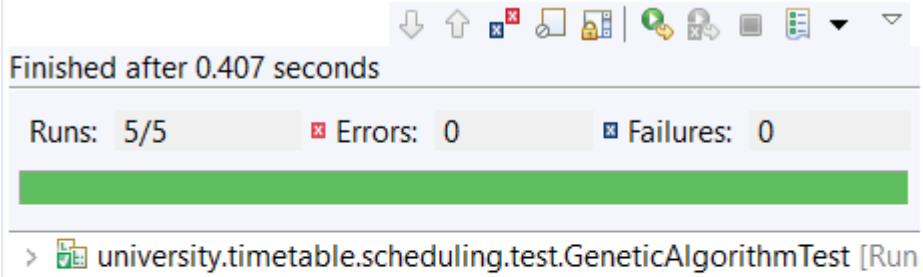
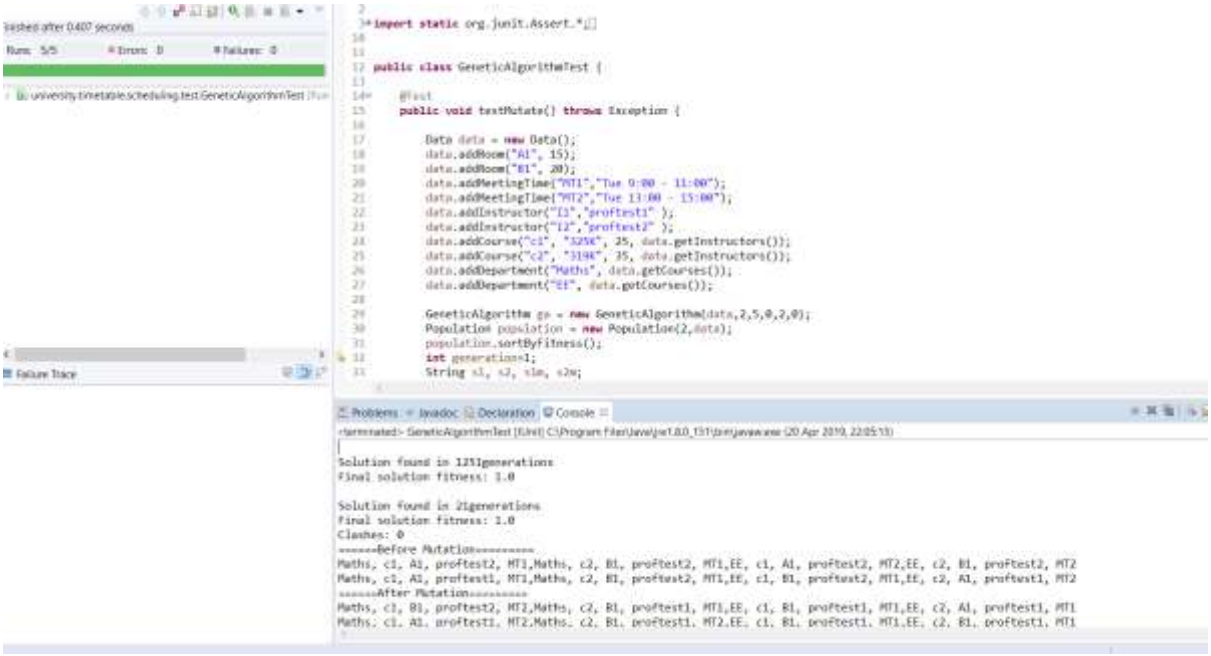
-time]                                               | fitness | conflicts
-----------------------------------------------------------------------------------------
MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, vishal, MT2 | 1.00000 | 0
MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robin, MT2 | 1.00000 | 0
MT3,CSE, c4, Room2, Robin, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, vishal, MT2 | 0.50000 | 1
MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.33333 | 2
MT3,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.33333 | 2
uf, MT3,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room1, Robin, MT2,EM, c7, Room2, vishal, MT2 | 0.33333 | 2
4,CSE, c4, Room2, vishal, MT4,CSE, c5, Room3, kal, MT4,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, kal, MT3 | 0.25000 | 3
MT1,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, yusuf, MT1,EM, c6, Room2, yusuf, MT1,EM, c7, Room2, Robin, MT2 | 0.20000 | 4
4,CSE, c4, Room1, vishal, MT3,CSE, c5, Room3, kal, MT4,EM, c6, Room3, Robin, MT3,EM, c7, Room2, Robin, MT2 | 0.16667 | 5

(id) | Meeting Time (ID)
----------------------------------------------------------------------------
(I1)      | TTH 09:00 - 10:30 (MT3)
(I1)      | MWF 09:00 - 10:00 (MT1)
(I4)      | TTH 09:00 - 10:30 (MT3)
(I3)      | TTH 10:30 - 12:00 (MT4)
(I1)      | TTH 10:30 - 12:00 (MT4)
(I4)      | MWF 09:00 - 10:00 (MT1)
(I3)      | MWF 10:00 - 11:00 (MT2)
----------------------------------------------------------------------------
```

Junit Test Cases:





JUnit Test Cases:

```
Solution found in 1251generations
Final solution fitness: 1.0

Solution found in 21generations
Final solution fitness: 1.0
Clashes: 0
======Before Mutation=========
Maths, c1, A1, proftest2, MT1,Maths, c2, B1, proftest2, MT1,EE, c1, A1, proftest2, MT2,EE, c2, B1, proftest2, MT2
Maths, c1, A1, proftest1, MT1,Maths, c2, B1, proftest2, MT1,EE, c1, B1, proftest2, MT1,EE, c2, A1, proftest1, MT2
======After Mutation=========
Maths, c1, B1, proftest2, MT1,Maths, c2, B1, proftest1, MT1,EE, c1, B1, proftest1, MT1,EE, c2, A1, proftest1, MT1
Maths, c1, A1, proftest1, MT2,Maths, c2, B1, proftest1, MT2,EE, c1, B1, proftest1, MT1,EE, c2, B1, proftest1, MT1
-1
-1
======Before Crossover=========
Maths, c1, B1, proftest1, MT1,Maths, c2, A1, proftest2, MT2,EE, c1, A1, proftest2, MT1,EE, c2, B1, proftest1, MT1
Maths, c1, B1, proftest1, MT2,Maths, c2, B1, proftest2, MT2,EE, c1, B1, proftest2, MT1,EE, c2, A1, proftest2, MT1
======After Crossover=========
Maths, c1, B1, proftest1, MT1,Maths, c2, A1, proftest2, MT2,EE, c1, A1, proftest2, MT1,EE, c2, B1, proftest1, MT1
Maths, c1, B1, proftest2, MT2,Maths, c2, A1, proftest1, MT2,EE, c1, B1, proftest2, MT1,EE, c2, B1, proftest2, MT2
0
-1
```