Insurance Referee Assignment Project Report

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Abstract

The main aim of the project is to solve the issue of insurance referee assignment using answer set programming solver Clingo. Each problem has a set of cases for a particular region and type of car. Also, each problem mentions a set of referees which have their own preference for the region and the type of car. Finally, by using clingo, the optimal solution is found which shows the most appropriate referee to be assigned based on different criteria such that each case is solved by exactly one referee.

Problem Statement

An insurance company allocates various internal and external referees for different car incidents such that they can inspect the cases. The allocation of the referee is based on various hard and weak constraints.

Given a set of cases and referees, assign most appropriate referee to each case. The ranking of the referees for each case will be done based on the different criteria. While each case will have the information about the effort, damage, type of car, postal area and amount of money that will be given to any external referee if they will handle the case.

Each referee will have the information about the maximum workload they can do in a particular day, the amount of work they did previously, amount of money they have earned till date, the type of referee that is internal or external and their preference for different types of cars and region. The preference is given in the range of 0 to 3, where 3 is the highest preference of a referee towards the type of car or the region. Since internal referees are given a fixed salary each money, there isn't any additional cost given to them when a case is assigned. While the money earned by the external referee depends upon the cases they are assigned to.

The problem statement also defines different rules by which certain referees are removed from assignment of a particular case. These are known as the hard constraints. Hard constraints defined for the problem are:

• Since the preference value of zero is the lowest preference, a referee can have for the type of car or the region mentioned in the case, no referee is allocated a case who have zero preference. Similarly, if no information is given about the referee for that configuration, then it is considered zero preference. All such referees are removed while assignment of cases.

• Each case mentions the total damage of the case. The problem instance also mentions a threshold value which is used to determine if the cases can be given to external referees or not. In case the total damage is more than the threshold limit, those cases are only given to the internal referees. All external referees are not considered for such cases.

• Also, each referee has a limit of maximum workload they can handle in each day. While each case can be assigned to only a single referee, multiple cases can be handled by a single referee. Any cases which will cross the maximum workload limit of the referee is not given to them.

By applying the rules for the hard constrain multiple referees can be eliminated and different solutions for the case assignment can be general if applicable. But to rank such assignments to different referees is done using the weak constraints. The rules written for the weak constrain help to consider the cost of assignment and priority of each referee.

The problem statements defined different rules for applying weak constraints that help to apply different penalties to different assignments based on the type of referee and their priority. Different conditions considered for the weak constrain of the problem are:

• Internal referees are preferred to the external referees. Since external referees are paid based on the case payment for each case are assigned to, internal referees are preferred to reduce the cost. The weightage given to the penalty cost should be 16.

• The overall payment made to the external referees should be distributed evenly. Penalty cost was given based

on the divergence of the payment given to the external referees. The weightage given to the penalty cost should be 7.

• The overall workload among both internal and external referees needs to be distributed evenly. Penalty cost was given based on the divergence of the workload after the case assignment among the referees. The weightage given to the penalty cost should be 9.

• For each referee, an additional information about their type of preference is provided such that 3 is the highest preference and 0 is the minimum. A penalty cost is applied when the preference is less than 3. The weightage given to the penalty cost should be 34.

• For each referee, an additional information about their region of preference is provided such that 3 is the highest preference and 0 is the minimum. A penalty cost is applied when the preference is less than 3. The weightage given to the penalty cost should be 34.

Different level of penalty cost denotes different priority of the weak constrain such that higher value means higher priority.

Solution Approach

To solve such issues where given a set of rules or knowledge about a problem, the aim is to find a stable solution to the problem, answer set programming is useful. The solver used for this problem was Clingo. The environment in which the program ran needed python 3.6 version and clingo version 5.3.0. For the ease of programming the hard constrains and weak constrains were written in separate files and were executed in terminal in the correct environment with the use of clingo command.

A bunch of rules and constraints were written such that they could help to find a solution for different instances of the problem. Each instance contained different set of case details, referee details and their preference. Another program was written such that they could read these details and execute the rule and constrains mentioned to find a solution.

Firstly, for the to start with the solution of the insurance referee assignment problem, for each cases a single referee was assigned such that no two referees can solve a single case. In terms of function, it is termed as one to one assignment was done for each case. By this method a single referee could be assigned different cases in a day of they don't violate any constrains.

Secondly, all the hard constrains mentioned in the problem statement were implemented such that any referee that could violate these constrains could be removed while finding the optimum and stable solution.

For the first hard constrain i.e., the amount of work which is the total working minutes of a referee shouldn't exceed the maximum working minutes given in the description of the referee. For that summation of the total working minutes is calculated from the cases assigned to the referee. Later it is compared with the maximum working load mentioned for the referee. If the value exceeds the total working minute, then that referee is not considered for the assignment of the case, which violated the constrain. Only if the total workload is below or equal to the max working load, those assignments are considered towards the output.

For the second hard constrain i.e., a referee shouldn't be any case whose region of which they are not in charge of. If the preference is set as 0 then it is considered as that the referee is not charge of that region. Once the initial assignment is done, later it is checked in the program if the assignment violates the constrain. All the referees are not considered from the assignment of the case for which they have set the region preference as 0. Suppose the referee REF1 has set the region preference for R1 region as 0, no cases with region type R1 will be assigned to the referee REF1.

For the third hard constrain i.e., a referee shouldn't be any case whose type is not preferred by the referee. If the preference is set as 0 then it is considered as that the referee doesn't prefers that type at all. Once the initial assignment is done, later it is checked in the program if the assignment violates the constrain. All the referees are not considered from the assignment of the case for which they have set the type preference as 0. Suppose the referee REF1 has set the type preference for T1 car types as 0, no cases with car type T1 will be assigned to the referee REF1.

For the fourth hard constrain i.e., to make sure that only if the damage of the case is below the threshold, then only it can be assigned to external referee. If the damage of the case is above the threshold value, then only internal referees can handle the case. After the initial assignment of the cases, the damage of the case is compared with the threshold value to keep/eliminate the external referees from assignment to the case.

Once the hard constrains are applied on the instance it produces a list of stable models that do not violate any hard constrains. The only thing left is the ordering of these models/answers such that the optimal solution has the least penalty based on the weak constrains.

For the first weak constrain i.e., to prefer internal referee over external one to reduce the cost given to the external referees as penalty cost based on the case payment value of each case assigned to external referee should be applied. This cost is further multiplied by 16 so set its priority as 16. The level for the weak constrain is set at the default level.

For the second weak constrain i.e., to balance the payment done to the external referee, a penalty cost of the

absolute difference of the total payment received by the external referee on assignment of the case from the average payment value received by every external referee is applied. This cost is further multiplied by 7 to set the priority of the penalty cost at 7, with the level set at the default level.

For the third weak constrain i.e., to balance the workload among all the referees. To do so a penalty cost of the absolute difference of the total workload of the assigned referee with the average workload among all the referees is calculated. The cost is further multiplied by 9 to set the priority of the penalty cost at 9, with the level set at the default level.

For the fourth weak constrain i.e., to make sure that the optimal solution makes sure that referee with higher preference for the type of case should be given lesser penalty, a difference of preference from 3 is calculated such that if they have higher preference, they have lesser penalty cost. The penalty cost is further multiplied by 34, being the highest priority among all the other penalty cost weightage. The level again is set as the default one.

For the fifth weak constrain i.e., to make sure that the optimal solution makes sure that referee with higher preference for the region of the case should be given lesser penalty, a difference of preference from 3 is calculated such that if they have higher preference, they have lesser penalty cost. The penalty cost is further multiplied by 34, being the highest priority among all the other penalty cost weightage. The level again is set as the default one.

All the weak constrains are set at same level as the priority of different penalty cost is set by multiplying them by different factors. The aim was to calculate cost based on the formula 16*CostA + 7*CostB + 9*CostC + 34*CostD + 34*CostE where CostA, CostB, CostC, CostD and CostE are different penalty cost based on different criterias discussed above.

Main Result and Analysis

To test the result of the insurance referee problem, different instances of the problem was run to test the result. The output seen for the first instance file run for the problem, was:

```
(py3.6) shivanipriya@Shivanis-MacBook-Air simpleInstances % clingo hard_constrains.asp weak_constrains.asp instance1.asp
clingo version 5.3.0
Reading from hard_constrains.asp ...
Solving...
Answer: 1
assign(4,5)
Optimization: 1420
OPTIMUM FOUND

Models       : 1
  Optimum    : yes
Optimization : 1420
Calls        : 1
Time         : 0.016s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s)
CPU Time     : 0.008s
```

Output for Instance1

For the instance1 file, there were 3 referees as an option for the assignment of a single case. Among them there were 2 internal and 1 external referee. One of the internal referees had preference as zero for the type of case and hence the assignment violated the hard constrain. While total damage of the case was more than the threshold limit for the cases, hence the external referee was removed from consideration for stable models. Thus, the internal referee 5 was assigned the case as they didn't violate any hard constrain and was the only option left for the optimum solution.

The output seen for the second instance file run for the problem was:

```
(py3.6) shivanipriya@Shivanis-MacBook-Air simpleInstances % clingo hard_constrains.asp weak_constrains.asp instance2.asp
clingo version 5.3.0
Reading from hard_constrains.asp ...
Solving...
Answer: 1
assign(5,7)
Optimization: 1661
OPTIMUM FOUND

Models       : 1
  Optimum    : yes
Optimization : 1661
Calls        : 1
Time         : 0.020s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s)
CPU Time     : 0.007s
```

Output for Instance2 file

For the instance2 file, there are 3 referees as option for a single case. Among them two of them has no preference for the region of the case. Thus, they violated the hard constrain and were removed from the list of stable models. Hence, referee 7 was assigned case 5 as it didn't violate any hard constrain and was the only optimum solution.

The output seen for the third instance file run for the problem was:

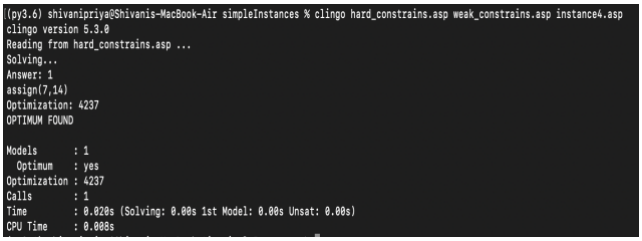
```
(py3.6) shivanipriya@Shivanis-MacBook-Air simpleInstances % clingo hard_constrains.asp weak_constrains.asp instance3.asp
clingo version 5.3.0
Reading from hard_constrains.asp ...
Solving...
Answer: 1
assign(6,11)
Optimization: 3792
OPTIMUM FOUND

Models       : 1
  Optimum    : yes
Optimization : 3792
Calls        : 1
Time         : 0.016s (Solving: 0.00s 1st Model: 0.00s Unsat: 0.00s)
CPU Time     : 0.008s
```

Output for Instance3 file

For the instance3 file, there are 3 referees as an option for the assignment of a single case. Among them all three were external referees and none of them violated any hard constrains mentioned above. While referee 10 had highest preference for the type of case and region of the case, they had received large payment earlier and previously did lark amount of workload, while referee 11 did comparatively very less work and received small payment earlier which caused them to get the new case so that both payment among the external referees and workload can be fairly distributed.

The output seen for the fourth instance file run for the problem was:



Output for Instance4 file

For the instance4 file, there are 3 referees as an option for the assignment of single case. None of the referees violated any hard constrains. Among the 2 internal and 1 external referee, referee 14 was an internal referee with minimum previous workload and previous payment. Thus, it had the minimum penalty cost among the other 2 referees making it the optimum solution for the problem.

The output seen for the fifth instance file run for the problem was:

Output for Instance5 file

For the instance5 file, there are 3 referees as an option for the assignment of single case. One of the referees violated the hard constrain of having type of case preference as zero. While among the other two referees, both were external referees with same workload and previous payment. Based on the higher region preference referee 17 was assigned the case 8. Thus, based on lesser penalty cost, referee 17 gave the optimum solution.

Similarly, the testing was done for other examples given in the problem statement to see the correct of the solution provided. It was noted that even for multiple cases the rules written for the problem statement was able to handle it very effectively.

Conclusion

The insurance referee assignment problem clearly deals with multi-criteria optimization application. By providing different weightage to different penalty cost helped to define the importance of different criterias for evaluation. Since for answer set programming while defining the optimal solution, the level given for each constrain play a role, the feature was used in best of its ability in the program.

With the help of hard constrains it helped to reduce the search space for the referees appropriate for the assignment of the case. By considering the previous workload and previous payment given to referees helped to have an overall consideration of workload and payment given to each referee, which would help to provide a wholesome solution to the case assignment. The project helped to understand how nicely real world paradigms can be easily incorporated in form of rules and constrains. Thus, showing the real world application of knowledge representation.

Overall, with the help of answer set programming, finding the solution of problem with known background knowledge becomes easier to search for possible solutions. Not only it helped to decrease the solution search space by utilizing hard constrains, but it also helped to rank the solution based on different weight and levels by utilizing the weak constrains. The availability of aggregate functions helps to make sure that different conditions can be implemented effectively. While the optimization function can be utilized to check that the overall penalty cost for each stable solution is minimum. By setting the optimization mode as enum, one can easily analyze the output of other possible solutions available for the problem.

The project helped me to learn the basics of answer set programming and practical use of various features offered by it. It also helped me to learn about the edge cases that needs to be considered while searching for solution. The whole set by set incremental approach towards the solution helped me understand the key concepts of knowledge representation.

Opportunities For Future Work

The insurance referee assignment problem can further be extended to include more real life parameters while a referee is assigned to case. These expansions will include:

- Instead of showing output as unsatisfiable, assignment of referees to maximum of cases possible. Which can also include prioritizing cases based on different criterias like damage and cost.
- Scheduling of the referees in case of multiple case assignment on a single day. Which can include prioritizing case handling in the same region together.
- Preference based on the skill of the referee, which can include their experience or rating while handling previous such cases.