Scheduling the Brazilian Soccer Championship: A Simulated Annealing Approach

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Abstract. The present research deals with the sports timetabling problem. It relates an experience with the application of Simulated Annealing Metaheuristic, enhanced with a post solution investigation, in the elaboration of the Brazilian Soccer Championship's schedule of 2004. The objective is to minimize the total distance travelled by the teams during the championship and to minimize the difference between the largest and the smallest distance travelled by the teams, satisfying a given set of constraints. The automatic schedule has proved the efficiency of the algorithm, by reducing 12.8% of total costs, when compared to manual solution.

Keywords: Sports Timetabling, Simulated Annealing, Travelling Tournament Problem.

1 Introduction

In this paper, we consider the 2004 First Division of Brazilian Soccer Championship, a specialization of the Travelling Tournament Problem (TTP) proposed by Easton et al. (see [2] and [3]). The TTP has been studied for many researches, and another algorithm based on Simulated Annealing for that problem has presented the best results for many instances in literature, found in Anagnostopoulos et al. [1]. A complete definition for the TTP and main instances can be obtained in http://mat.gsia.cmu.edu/TOURN/.

The present proposed problem has a few more constraints and a different objective function. The Brazilian Soccer Schedule Problem (BSSP) is a double round robin tournament for twenty-four teams, composed by two halves schedules, each one consisting of twenty-three rounds where every team plays against all others once. The double round robin schedule will be mirrored from the first half to the second. If A plays at B in the first half of the schedule, then B plays at A in the corresponding slot in the second half.

2 The Constraints and Objective Function

As mentioned before, there are more constraints related to the BSSP, and an additional term in the objective function. They may be enumerated as follows:

1. Each team will play once at each round;
2. Two teams will play twice, but in different halves of the schedule, alternating the city that will host the game (if they are different);
3. Each team will alternate playing one game at home and the other on the road, at the first two rounds of each half of the schedule;
4. The two last rounds of each half of the schedule will have the inverse configuration of the two first rounds, related to home and on the road games;
5. Two teams from the same State will not play against each other on the last round (46^{th}) of the schedule;
6. The difference between home and road games must be equal to one, in each half of the schedule;
7. There won't be more than two consecutive home or two consecutive road games for any team;

The main objective is to minimize the total distance travelled, plus the difference between that one who travels the most and the one who travels the least (teams begin in their home city and must return there after the championship ending).

3 The Methodology

The methodology used to solve the problem is based on the Simulated Annealing Metaheuristic. The algorithm starts from a random initial schedule which is obtained using a simple backtracking search. The next step follows the traditional simulated annealing algorithm schema. Given a temperature t, the algorithm randomly selects one of the moves to a neighborhood and computes the variation of the main objective function. If it improves the current solution the move is accepted, otherwise there is a probability of acceptance that is lower in low temperatures.

3.1 The Neighborhood

Three different moves have been defined to compose distinct kinds of neighborhood, named N1, N2 and N3, from a schedule s. The first one is obtained by changing the home/away attribute of a game, that means swapping the slots between the two occurrences of that game in each half schedule. The second move is obtained by swapping two different games between two rounds in the same half of the schedule. The third move is obtained by swapping all games from a couple of teams, that means, changing team A to team B and vice-versa in all games where those teams are involved.

3.2 The Objective Function

Let's consider D as the total distance travelled by all teams, d the difference between the largest and the smallest distances travelled by the teams. Let's also consider that each component $f_i(s)$ computes the violation of the i^{th} constraint listed in Section 2; α and β_i are multipliers for the values d and f_i. In that way, a schedule is evaluated by the following objective function:

$$f(s) = D + \alpha d + \sum_{i \in C} \beta_i f_i(s)$$

Obs: For the results presented ahead, the multipliers were set to $\alpha = 1$, $\beta_1 = \beta_3 = \beta_4 = 1,000,000,000$, $\beta_5 = 2,000,000,000$, $\beta_6 = 10,000,000$, $\beta_7 = 1,000,000$. By the used representation (The double round robin schedule is mirrored from the first half to the second), the constraint 2 in Section 2 is automatically satisfied.

3.3 Refinement Procedure

After the schedule is ready, there are a lot of symmetric solutions that can be obtained, just swapping the teams from different cities on the schedule. The unique constraint that must be observed is that related to same State teams confronts at the last round of the championship.

In fact, there is a permutation of twenty-four teams with repetition that can decrease the objective function value, and keeping the constraints respected. The specific problem for the 2004 schedule, has five teams from CGH city airport, four from SDU, three from POA, three from CWB, two from FLN, two from PLU, two from VCP, one from BEL, one from GYN and one from SSA. The different solutions we can obtain permutating those teams, for any final schedule, can be expressed by the formula:

$$P^{24}_{5,4,3,3,2,2,2} = \frac{24!}{5!4!3!3!2!2!2!} = 748,032,891,750,144,000$$

Obviously the entire number of permutations cannot be whole enumerated, but we can investigate a large number of them, mainly if we have a lot of time to produce the schedule, which is usual to happen in that kind of problems.

4 Conclusions

The manual schedule made by the Brazilian Soccer Confederation (CBF) and the schedule generated by the Simulated Annealing algorithm have obeyed all constraints, and Table 1 shows the results. The automatic schedule have proved the efficiency of the algorithm, by reducing 12.8% of the total costs involved, and balancing the distances among the teams, 38.4% better.

The refinement procedure by limited enumeration of symmetric solutions have decreased the final solution in values greater than 2%, in few minutes, after

Table 1. Manual and Algorithm Schedules

Schedule	*D*	*d*	*f(s)*
CBF	905,316	86,610	991,926
SA	789,480	53,309	842,789

the Simulated Annealing stops running (approximately 45 minutes of computation in a microcomputer with an AMD Atlhon 1.5 GHz processor, 256 megabytes of RAM running the Windows XP operating system), and its implementation is quite simple.

All data set, including teams information, table of distances between the cities airports, solutions history, the best current solution, and other related data can be found at http://www.optline.com.br/bssp.html or http://www.decom.ufop.br/prof/marcone/projects/ttp/bssp.html. All results are being regularly updated.

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