Scheduling the Brazilian Soccer Championship

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1 Introduction

The yearly Brazilian Football Championship is the most important sport event in Brazil. It is organized by CBF (the Brazilian Football Confederation) and its major sponsor is TV Globo, the largest media group and television network in Brazil.

The competition is structured as a compact mirrored double round robin (MDRR) tournament [1]. The tournament is played by n teams, where n is an even number. There are $2n-2$ rounds and each team plays exactly once in each round. Each team faces every other team twice: one at home and the other away. If team a plays against team b in round k, with $k < n$, at home (resp. away), then team a plays against team b away (resp. at home) in round $k+n-1$.

The organizers and the sponsors search for a schedule optimizing two different objectives. CBF wants to minimize the number of breaks (a team playing two consecutive home or away games, see e.g. [3]) along the tournament (break minimization objective). TV Globo aims to maximize its revenues, by maximizing the number of relevant games it is able to broadcast (broadcast objective). The schedule must also satisfy a number of hard constraints.

2 Problem statement

We consider the 2005 edition of the competition, with $n = 22$ participating teams. Every team has a home city and several cities have more than one team. Some of the teams are considered and handled as *elite teams* due to their number of fans and to the value of their players. There are *weekend rounds* and *mid-week rounds*.

São Paulo and Rio de Janeiro are the two largest cities in Brazil (with more fans and, consequently, generating larger revenues from advertising) and both

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of them have several elite teams. Games cannot be broadcast to the same city where they take place and only one game per round can be broadcast to each city. Consequently, TV Globo wants to broadcast to São Paulo (resp. Rio de Janeiro) games in which an elite team from São Paulo (resp. Rio de Janeiro) plays away against another elite team from another city.

Belém is a city very far away from São Paulo and Rio de Janeiro. TV Globo is not willing to broadcast games taking place at Belém, due to the high logistical costs.

Besides following the structure of a MDRR tournament, the schedule should also satisfy other hard constraints:

- Every team playing home (resp. away) in the first round plays away (resp. home) in the last round.
- Every team plays once at home and once away in the two first rounds and in the two last rounds.
- Some pairs of teams with the same home city have complementary patterns, i.e. when one of them plays at home the other plays away and vice versa.
- After any number of rounds, the difference between the number of home games and away games played by any team is either zero or one (i.e., the number of home and away games is always balanced.
- Regional games between teams from the same city are not to be played in mid-week rounds or in the last six rounds.
- There is at least one elite team from Rio de Janeiro playing outside Rio de Janeiro and one elite team from São Paulo playing outside São Paulo in every round.
- If in some round there is only one elite team from Rio de Janeiro (resp. São Paulo) playing outside Rio de Janeiro (resp. São Paulo), then this game should not be held in Belém.
- Flamengo and Fluminense have complementary patterns in the last four rounds (Flamengo and Fluminense are two elite teams from Rio de Janeiro that share the same stadium for home games).

The two objectives that must be optimized are the minimization of breaks and the maximization of the number of rounds in which there is at least one relevant game to be broadcast to São Paulo plus the number of rounds in which there is at least one relevant game to be broadcast to Rio de Janeiro. Therefore, the broadcast objective regards the number of relevant games that TV Globo is able to broadcast. The break minimization objective establishes the home-away equilibrium in the sequence of games played by each team.

3 Solution strategy and numerical results

To tackle this bi-objective problem, we enforce the break minimization objective to be equal to a tight lower bound and search for a solution optimizing the

broadcast objective. The proof of the tightness of the lower bound is performed experimentally.

The structure of the constraints is such that $4(n-2)$ is a lower bound to the number of breaks. On the other hand, the broadcast objective is bounded by twice the number of rounds $(4n-4)$ (one game from Rio de Janeiro and another from São Paulo at every round) and by the number of away games of elite teams from Rio de Janeiro against elite teams from other cities plus the number of away games of elite teams from São Paulo against elite teams from other cities.

To solve the problem, we used a strategy similar to the three-phase approach used e.g. in [2]. In fact, we use a four-phase strategy involving complete enumeration, linear programming, and integer programming. We were able to compute an optimal schedule for the 2005 edition of the tournament in less than ten minutes on a standard Pentium IV processor with 256 Mbytes of RAM.

The solution produced by this four-phase approach is better than those produced by the current human scheduler. A quick comparison shows that three constraints were not fully satisfied in the official schedule of the 2005 edition, the number of breaks was equal to 152 and the value of the broadcast objective was equal to 43. In the schedule computed by the four-phase approach proposed in this work, all hard constraints were satisfied, the number of breaks was reduced to 80 and the broadcast objective was also improved to 56 (which is optimal). The software system is able to generate a collection of same cost solutions to be evaluated and compared by the user. The use of the schedules created with the approach proposed in this work is under consideration by the organizers.

References

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