An application of the traveling tournament problem: the Argentine volleyball league

Flavia Bonomo[1], Alejandro Burzyn[1], Andrés Cardemil[1],
Guillermo Durán[2,3,*], Javier Marenco[1,4]

[1] Departamento de Computación, FCEyN, Universidad de Buenos Aires, Argentina
[2] Departamento de Matemática, FCEyN, Universidad de Buenos Aires, Argentina
[3] Departamento de Ingeniería Industrial, FCFM, Universidad de Chile, Chile
[4] Instituto de Ciencias, Universidad Nacional de General Sarmiento, Argentina

{fbonomo,aburzyn,acardemil,jmarenco}@dc.uba.ar, gduran@dm.uba.ar

Since the scheduling of sports leagues involves many kinds of constraints and the minimization of costs or travel distances, sports scheduling has become a very active field, providing both interesting and challenging problems to the combinatorial optimization community.

In this work we describe the automatic scheduling of the regular phase of the Argentine first division volleyball league and further research on related topics. The regular phase involves 12 teams located across the country, which play against each other following a mirrored double round-robin pattern (each team plays twice against each other, once at home and once away). In this league, the teams are grouped into 6 pairs of teams, in such a way that each pair is composed by two teams located close to each other.

The matches are held on Thursdays and Saturdays, and these two matches within the same week are called a *weekend*. The regular phase spans 12 weekends. In each weekend, the two teams from a pair play against the two teams from another pair (two matches take place on Thursday and the two remaining matches take place on Saturday). During the weekends 1 and 7 the two teams from each pair play against themselves. Furthermore, no team can play more than two home or away weekends in a row, and every team must play at least one home weekend between weekends 2 and 3. It is important to note that, due to the involved travel distances, if a team must play two consecutive away weekends, then it does not return to its home city between these weekends, but performs a two-weekend tour instead. Finally, there are some additional constraints regarding the availability of stadiums.

Our main goal was to come up with a schedule for the regular phase satisfying all the constraints and minimizing the sum of the total travel distances. This problem is a particular variation of the so-called *traveling tournament problem* (Easton, 2001), which has shown to be a very hard optimization problem, most of its instances still being open.

On one hand, we present a natural integer programming model for this problem, which allowed to successfully generate a schedule for the Argentine first division volleyball league, that was used in the 2007/2008 Season. This result is in line with previous attempts on the traveling tournament problem based on integer programming techniques, which were able to solve to optimality instances with at most 6 teams in reasonable running times (Easton, 2003).

*Corresponding author. Address: Int. Güiraldes y Av. Cantilo, Pabellón I (1428) Buenos Aires, Argentina. Tel/Fax: +5411 4576-3335.

We also consider two further variations of this problem, namely asking to minimize the distance of the "most traveler" team and the gap between the "most traveler" and the "less traveler" teams, respectively. The goal of these two alternative models is to create a schedule such that the travel distances of the teams are as evenly distributed as possible. To the best of our knowledge, these variations to the traveling tournament problem have not been previously addressed in the literature. We are able to obtain the optimal solution for the first alternative model, but the solution time for the second alternative model is too large for practical purposes.

On the other hand, we have implemented a tabu-search heuristic algorithm for this problem, based on previous experience on the application of this kind of techniques to the traveling tournament problem (Cardemil, 2002; Di Gaspero, 2005; Di Gaspero, 2007). We were able to obtain solutions within 1%-5% from the optimal values in short running times. These experiments allow to successfully tackle leagues with more than 6 pairs of teams, where the approaches based on integer programming fail to find optimal solutions in reasonable times.

Finally, we are currently exploring two new formats for the league, which consider more relaxed constraints for team pairings. The first such alternative maintains the idea of a pair of teams facing another pair in each weekend, but allowing the dynamical recombination of the pairs along the league. In this way, the pairs of geographically close teams are not fixed beforehand but are dynamically determined during the schedule. The objective of this model is to reduce the total travel distances even more, maintaining at the same time the paired format of the league.

The second alternative model does not include team pairs at all, but forces a team to play at home on Thursday if and only if it plays at home the following Saturday. Due to the inherent complexity of such an approach with 12 teams, we plan to generate feasible solutions for this problem with a tabu-search-based heuristic. We expect these models to provide better results, as there are some groups of teams which are reasonably close to each other, hence the fixing of pairs beforehand may be harmful to the minimization of the total travel distance.

KEYWORDS: combinatorial optimization, integer programming, sports scheduling, tabu search, traveling tournament problem, volleyball league

References

[1] CARDEMIL A. (2002) *Optimización de fixtures deportivos: Estado del arte y un algoritmo tabu search para el traveling tournament problem* (in spanish). MSc Thesis, Universidad de Buenos Aires.

[2] DI GASPERO L. and SCHAERF A. (2005) *A tabu search approach to the traveling tournament problem*. Computer Science Group Technical Report CS-2005-03, Dipartimento di Ingegneria, Universitá di Ferrara, Italy: 23–27.

[3] DI GASPERO L. and SCHAERF A. (2007) *A composite-neighborhood tabu search approach to the traveling tournament problem*. Journal of Heuristics 13-2: 189–207.

[4] EASTON K., NEMHAUSER G., and TRICK M. (2001) *The traveling tournament problem: description and benchmarks*. In Proceedings of the 7th. International Conference on Principles and Practice of Constraint Programming: 580–584.

[5] Easton K., Nemhauser G., and Trick M. (2003) *Solving the traveling tournament problem: A combined integer programming and constraint programming approach.* Lecture Notes in Computer Science 2740: 100–109.