Timetabling and field assignment for training youth football teams in amateur leagues

Renatha O. Capua · Simone L. Martins · Celso C. Ribeiro

Received: date / Accepted: May 16, 2012

1 Introduction

Professional sport leagues involve millions of fans and significant investments in players, broadcast rights, and advertising. Although amateur leagues usually do not have access to the same amounts of resources, the number of tournaments and competitors can be very large, also requiring coordination and logistical efforts [2,4,6,8]. Amateur leagues of sports such as baseball and football have hundreds of games every weekend in different divisions. In a single league in California there might be up to 500 soccer games in a weekend. In the MOSA (Monmouth & Ocean Counties Soccer Association) league, New Jersey, boys and girls of ages 8 to 18 make up six divisions per age and gender group with six teams per division, totalizing 396 games every Sunday.

Amateur leagues face the problem of assigning fields and practice time to youth football teams. Players in these teams are young and are not free for training at any time of the day. They can only practice at off-school time. Low age children cannot train in the evening. Some coaches are hired by several teams, which must have compatible times and places for training. We present next the problem definition, including its constraints and objective function. This is followed by the description of a three-phase heuristic developed to find high-quality feasible solutions. Preliminary computational results are reported.

2 Problem definition

The problem of timetabling and field assignment for training youth football teams involves different constraints and several objectives. In this section, we describe the specific scheduling requirements addressed in this work.

R.O. Capua E-mail: rcapua@ic.uff.br · S.L. Martins E-mail: simone@ic.uff.br · C.C. Ribeiro E-mail: celso@ic.uff.br
Universidade Federal Fluminense, Institute of Computing, Niterói, RJ 24210-240, Brazil.

We first describe the input data and the main assumptions. We consider a set T of teams that are coached by a set C of trainers and require training time at any of the fields in a set F of sports facilities available in a given region. Each facility has a specific number of fields available for training every weekday. The daily period of time available for training at each facility is partitioned in timeslots with the same duration (say, one hour or 90 minutes each). At the beginning of the season, each team requires some specific weekly training time. Each team may be assigned to one or more timeslots per week according to its training requirements, but at no more than one timeslot a day.

Each coach may train one or more teams in different divisions (or even in different leagues). In case two teams share the same coach, then they must be assigned to different timeslots. Due to mobility constraints, teams with the same coach cannot be scheduled for training at consecutive timeslots in different facilities. Teams and coaches may express their preferences about timeslots and facilities, and may be unavailable for training in some specific timeslots. Therefore, the main scheduling requirements are:

1. Every team must be assigned to a number of timeslots that fulfills its weekly training time.
2. No team can be assigned to a timeslot for which it is not available.
3. Teams sharing the same coach cannot be assigned to the same timeslot.
4. Teams sharing the same coach cannot be assigned to consecutive timeslots in different facilities.
5. The number of teams assigned to the same timeslot at any facility must not exceed its number of fields.
6. Each team can be assigned to at most one timeslot per day.
7. Each team must train always at the same facility and time of the day.

There are a number of objectives to be optimized. In this work, we seek to maximize coach and team preferences, assigning them as much as possible to their preferred timeslots and facilities. A second relevant objective consisting of minimizing coaches' idle time will be handled by a biobjective extension of this problem.

3 Solution approach

This combined timetabling [1, 7] and facility assignment problem was formulated as an integer programming problem that could not be solved by standard codes in reasonable times.

Due to the hardness of the problem, we developed a three-phase heuristic to find high-quality feasible solutions. In its first phase, a constructive randomized heuristic builds an initial solution. If this solution is not feasible, then a repair procedure is applied to make it feasible. If no feasible solution is obtained, then a new attempt is made and another initial solution is built. Otherwise, an improvement heuristic is applied to the current solution. Both the repair and improvement heuristics are based on the principles of the Iterated Local Search metaheuristic [5] and follow a similar approach to that described in [2].

Each iteration of the construction phase starts by randomly selecting a coach among those with more teams. The heuristic attempts to assign timeslots and training facilities to all teams of this coach. Teams are ranked by predefined weight preferences. The next team to be handled is randomly selected from a candidate list formed by those with higher rankings. The heuristic makes an initial attempt to assign this team to its preferred timeslots. If this cannot be done, then other timeslots are considered. If this team cannot be assigned to any timeslot after some attempts, then it is discarded and the algorithm moves to another team trained by the same coach. Finally, all unassigned teams are randomly assigned to some facility and timeslot.

If this solution is not feasible, then an ILS repair procedure is applied to minimize the number of constraint violations in the incumbent.

If no feasible solution is found, then the algorithm stops. Otherwise, an ILS improvement heuristic is applied to this feasible solution. Each iteration of this phase starts by a VND [3] local search, based on three different neighborhoods: reassignment of teams to new timeslots, swap of the timeslots of teams with the same weekly requirements, and exchange of the timeslots assigned to teams with the same starting time at the same facility. Next, a perturbation consisting of reassigning half of the teams to empty timeslots is applied to the current local optimum. A new iteration resumes and the heuristic stops after a given number of iterations is performed without updating the best solution.

This approach was applied to ten test instances with up to 150 teams, eight facilities, 24 training fields, and 25 coaches. We performed ten runs for each instance. The constructive heuristic found feasible solutions for 64 out of the 100 runs. The repair heuristic obtained feasible solutions in 24 additional runs. On average, the improvement procedure increased the solution values by 9,6%. Detailed numerical results will be reported in the final version of this paper, together with additional results regarding its bicriteria version.

References

1. Colorni, A., Dorigo, M., Maniezzo, V.: Metaheuristics for high school timetabling. Computational Optimization and Applications **9**, 275–298 (1998)
2. Duarte, A.R., Ribeiro, C.C., Urrutia, S., Haeusler, E.H.: Referee assignment in sports leagues. In: E.K. Burke, H. Rudová (eds.) Practice and Theory of Automated Timetabling VI, *Lecture Notes in Computer Science*, vol. 3867, pp. 158–173. Springer, Berlin (2007)
3. Hansen, P., Mladenović, N.: Variable neighbourhood search. In: F. Glover, G. Kochenberger (eds.) Handbook of Metaheuristics, pp. 145–184. Kluwer (2001)
4. Kendall, G., Knust, S., Ribeiro, C.C., Urrutia, S.: Scheduling in sports: An annotated bibliography. Computers & Operations Research **37**, 1–19 (2010)
5. Lourenço, H.R., Martin, O.C., Stutzle, T.: Iterated local search. In: F. Glover, G. Kochenberger (eds.) Handbook of Metaheuristics, pp. 320–353. Kluwer (2001)
6. Melo, R.A., Urrutia, S., Ribeiro, C.C.: The traveling tournament problem with predefined venues. Journal of Scheduling **12**, 607–622 (2009)
7. Qu, R., Burke, E.K., McCollum, B., Merlot, L.T.G., Lee, S.Y.: A survey of search methodologies and automated system development for examination timetabling. Journal of Scheduling **12**, 55–89 (2009)
8. Ribeiro, C.: Sports scheduling: Problems and applications. International Transactions in Operational Research **19**, 201–226 (2012)