

Referee Assignment in Sports Leagues

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Abstract. Optimization in sports is a field of increasing interest. Combinatorial optimization techniques have been applied, for example, to game scheduling and playoff elimination. A common problem usually found in sports management is the assignment of referees to games already scheduled. There are a number of rules and objectives that should be taken into account when referees are assigned to games. We address a simplified version of a referee assignment problem common to many amateur leagues of sports such as soccer, baseball, and basketball. The problem is formulated by integer programming and its decision version is proved to be NP-complete. To tackle real-life large instances of the referee assignment problem, we propose a three-phase heuristic approach based on a constructive procedure, a repair heuristic to make solutions feasible, and a local search heuristic to improve feasible solutions. Numerical results on realistic instances are presented and discussed.

1 Introduction

Optimization in sports is a field of increasing interest. Some applications have been reviewed by Ribeiro and Urrutia [16]. Combinatorial optimization techniques have been applied, for example, to the traveling tournament problem [1,6,15,18], to playoff elimination [17], and to the scheduling of a college basketball conference [14]. Easton et al. [7] reviewed scheduling problems in sports.

A common problem usually found in amateur sports management is the assignment of referees to games already scheduled. Sport games are regulated by rules that depend on the sport and tournament. The *officiating crew* is a group of referees that is responsible to ensure that all rules are respected in a game. The number of referees compounding a crew may vary, depending on the sport, league, and tournament: soccer games usually require three referees, while basketball games require two. Each member of an officiating crew is said to occupy a *refereeing position* in a game. For example, in a regular soccer game, there

are one head umpire and two side judges, totaling three refereeing positions to be filled with referees. In some applications, managers make pre-assignments to satisfy some specific requirements. The referee assignment problem consists in assigning referees to the empty refereeing positions (not yet assigned) for all games of a league or tournament.

There are a number of rules and objectives that should be taken into account when referees are assigned to games. Games in higher divisions may require higher-skilled referees. Since referees may officiate several games during the day, travel feasibility and travel times between the facilities where the games take place have to be considered. Additionally, and especially in some amateur children leagues, some of the referees are players or their relatives. In this case, a natural constraint is that a referee cannot officiate a game in which he/she or a relative is scheduled to play.

Real-life versions of this problem appear in regional amateur leagues in the United States. Amateur leagues of several sports, such as baseball, basketball and soccer, 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, to be refereed by hundreds of certified referees. 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, totaling 396 games every Sunday.

Referee assignment problems in other contexts have been addressed in [8,9,19]. Dinitz and Stinson [4] considered a problem involving referee assignment to tournament schedules, connecting room squares and balanced tournament designs. We address a basic version of a referee assignment problem common to many amateur leagues of sports such as soccer, basketball, and baseball, among others. In the next section, we state the problem considered in this work. Section 3 presents an integer programming formulation to this referee assignment problem. The decision version of the problem is proved to be NP-complete in Section 4. The proposed solution strategy is described in Section 5. In Section 6, computational results illustrating the application of the proposed approach to solve real-size randomly generated instances are shown. Concluding remarks and further extensions of this work are reported in the last section.

2 Problem Statement

We consider the general problem, in which each game has a number of refereeing positions to be assigned to referees. The games are previously scheduled and the facilities and the time in which each game takes place are known beforehand. In our approach, referees are assigned to empty (i.e., not pre-assigned) refereeing positions, not to games. This allows us not only to handle referee assignment problems in sports requiring different numbers of referees, but also in tournaments where games of the same sport may need different numbers of referees due to the game division or importance. Games with pre-assigned referees to some refereeing positions can also be handled by this approach. Each refereeing position to be filled by a referee is called an empty refereeing slot.