Referee Assignment

Problem specification
for the project of the course
Advanced Scheduling Systems (2019-20)

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Introduction

The *referee assignment* is one of the classical problems in sport scheduling. We consider a variant of this problem arising from an amateur basketball league with many divisions. The problem consists in assigning a *variable* number of referees to each game of every division for the full season, according to a set of constraints and objectives.

In our formulation, a referee receives a lump sum for the performance plus a mileage allowance for the distance travelled. For this reason, the minimisation of the total amount of kilometres travelled is one of the main aspects of our problem.

Input data

For each referee we consider: address (in terms of geographic coordinates), qualification, experience, incompatible teams and referees, and unavailabilities (in terms of days and time intervals).

A match is represented by the following data: home team, away team, division, date, starting time, venue, and total required experience. For each game, there is also a number of mandatory and optional referees, which however are the same for all games of the same division. The (maximum) duration of a game is fixed, and assumed to be equal to two hours, independently of the division.

Regarding game venues, an arena may be shared by different teams, and a team can use different ones in different games. Therefore, for each single game, the input data includes the specific arena of that game.

Distances among arenas and between referees' homes and venues are calculated in Euclidean terms (*as the crow flies*) using the geographic coordinates.

Solutions, constraints and objectives

A solution is a list of assignments of referees to games so that the following hard constraints are satisfied and the total penalty of the soft ones is minimised. The hard constraints are:

MinimumReferees: The number of mandatory referees must always be assigned to each game.

FeasibleTravelDistance: A referee cannot be assigned to two games that overlap in time; the notion of overlapping considers also the travel time of the referee between the two arenas.

RefereeAvailability: A referee cannot be assigned to a game when she/he is not available.

The soft constraints are the following ones:

RefereeLevel: The level of the referee should be at least equal to the level of the division.

LackOfExperience: The sum of the experience of the referees must be at least equal to the requested one for the game.

GamesDistribution: The total number of games assigned to a referee should be as much as possible equal to the average value (suitably rounded).

TotalDistance: The total travelling distance should be minimised. The travel is computed from the referee home to the arena and back home. If a referee is assigned to two or more games in the same day, she/he is assumed to move directly from one arena to the other (and back home at the end).

OptionalReferee: The absence of an optional referee is a penalty.

AssignmentFrequency: The number of times a referee is assigned to the same team should not be to much higher than the average value (suitably rounded).

RefereeIncompatibility: Two incompatible referees cannot be assign to the same game.

TeamIncompatibility: A referee cannot be assigned to a game played by an incompatible team.

The precise modelling of the soft constraints and their weights are left free to be chosen by the students. In order to simplify the problem, some of the soft constraints can be neglected.

File formats

The input file is in text-only format, with the syntax that can be deduced from the following toy example, with one division, 4 teams and 5 referees.

```
Divisions = 1;
Referees = 5;
Arenas = 2;
Teams = 4;
Games = 12;

DIVISIONS % code, min referees, max referees, level, teams
D1: 1, 2, 4, 4

REFEREES % code, level, coordinates, experience, incompatible referees, incompatible teams, unavailabilities
R1, 3, (18.8463, 3.70572), 5, [], [T2], [7/2/2019 18:00-21:30]
R2, 4, (11.6754, 46.893), 5, [R5], [], [8/7/2019 13:45-16:00, 12/7/2019 16:30-22:00]
R3, 4, (38.6606, 41.3067), 9, [], [], [30/11/2019 14:30-16:30, 7/7/2019 20:00-22:00, 5/6/2019 16:45-19:45]
R4, 3, (39.7763, 49.3069), 7, [], [T3], [10/2/2019 16:30-19:00, 15/3/2019 13:45-18:45]
R5, 3, (26.2307, 32.8272), 10, [R2], [], [27/11/2019 12:00-18:00]

ARENAS % code, coordinates
A1 (41.9115, 20.3591)
A2 (40.1892, 41.9326)

TEAMS % name, division
T1 D1
T2 D1
T3 D1
T4 D1

GAMES % Home team, guest team, division, date, time, arena, experience
T1 T4 D1 6/1/2019 19:30 A1 6
T2 T3 D1 5/1/2019 17:00 A2 8

T4 T2 D1 11/1/2019 20:30 A2 4
T3 T1 D1 12/1/2019 19:30 A1 6

T3 T4 D1 20/1/2019 20:45 A1 4
T1 T2 D1 19/1/2019 21:00 A1 4

T4 T1 D1 26/1/2019 20:15 A2 4
T3 T2 D1 26/1/2019 17:45 A1 5

T2 T4 D1 1/2/2019 19:45 A2 5
```

```
T1 T3 D1 1/2/2019 19:15 A1 4

T4 T3 D1 8/2/2019 17:00 A2 4
T2 T1 D1 9/2/2019 18:30 A2 6
```

The output file is an unordered list of games, and the set of assigned referees. It is assumed that the same pair of teams cannot match twice in the same order, therefore each game can be identified by the two teams.

As an example, consider the following solution to the toy instance.

```
T2 T3 2 R1 R3
T1 T4 1 R5
T4 T2 2 R2 R5
T3 T1 1 R2
T1 T2 2 R2 R5
T3 T4 1 R1
T3 T2 2 R5 R4
T4 T1 2 R2 R1
T1 T3 2 R1 R5
T2 T4 2 R3 R5
T4 T3 1 R2
T2 T1 2 R2 R3
```

We can see that the solution proposed has a few (soft) violations. For example, referee `R4` is incompatible with team `T3`, but she/he is assigned to the match `T3-T2`. Referees `R2` and `R5` are incompatible, nonetheless the are assigned together to the match `T4-T2`. In addition, many games have only one referee, whereas the optimal number is 2.

Instances are obtained using the generator developed in [1].

References

[1] Alessio Dal Bo'. Un generatore di istanze casuali ed un validatore di soluzioni per un problema di assegnazione di arbitri per un insieme di campionati sportivi Bachelor thesis, University of Udine. In Italian, 2018.