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Referee Assignment Problem
Case: Italian Volleyball Championships

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To my grandfather
Luis Leonardo Linfati Cantergiani

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Referee Assignment
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Branch-and-Cut
Clique - Graph

Abstract

This thesis addresses the formulation of a referee assignment problem for the Italian Volleyball Serie A Championships. The problem has particular constraints such as a referee must be assigned to different teams in a given period of times, and the minimal/maximal level of workload for each referee is obtained by considering cost and profit in the objective function. The problem has been solved through an exact method by using an integer linear programming formulation and a clique based decomposition for improving the computing time. Extensive computational experiments on real-world instances have been performed to determine the effectiveness of the proposed approach.

This work is organised as follows:

- Chapter 1 describes the work of others authors about the Referee Assignment Problem.
- Chapter 2 describes the problem, its objectives and its constraints.
- Chapter 3 describes the mathematical model and the procedure proposed for determining the objective function.
- Chapter 4 presents a procedure to add cutting planes.
- Chapter 5 presents a decomposition method based on a clique structure.
- Chapter 6 shows the results and computational experiments.
- Chapter 7 discusses the conclusions and future research area.

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Chapter 1

Introduction and Background

The more important examples of sport event around the world are the Olympics Games, the Football World Cup and the Super Bowl. Scheduling is an important aspect for developing a successful sport event. The logistics to develop a sport event should include the championships schedule and the assignment the referees to each match. In the recent years, many researchers have shown a growing interest on all areas of sport scheduling.

1.1 Background

According to Duarte et al. [2006], the Referee Assignment Problem (RAP) is defined as the problem of assigning a referee to each match (referee slot) in a fixed schedule. The number of referees depends on the type of game; for example, in football soccer we have: the head referee, two assistant referees (also known as linesmen) and the fourth referee (only in professional leagues). There are a number of rules and objectives that should be taken into account when the referees are assigned to the matches, for example, each referee slot must be filled with a referee who has a minimum skill level.

The RAP, introduced by Evans and Hebert [1984], Evans [1988], was applied to the American League of Professional Baseball Clubs as a com-

plex, multi criteria optimization problem. It was solved using optimization techniques, heuristic rules and human judgment with the help of a decision support system. The constraints considered were based on the rest time of each referee between assignments, that is, if the referee should travel from the east coast to the west coast, the scheduling must include a day off between the two matches.

A model for the scheduling of the England cricket referees (umpires) with various objective functions has been solved by Wright [1991] using a heuristic method. The number of hours for solving manually this problem was reduced from 150 hours to 4-5 hours using the proposed decision support system.

An integer programming model for the RAP was presented by Duarte et al. [2007a]. The proposed solution approach is a heuristic which includes three phases. The first phase uses a greedy heuristic procedure to find an initial solution with the possibility to violate some constraints. If the initial solution is not feasible, the second phase repairs the solution using an Iterated Local Search metaheuristic (ILS). Finally, the third phase improves the quality of the solution with another ILS-based metaheuristic. The approach was tested with random instances. An extension was presented by Duarte et al. [2007b] using a MIP Local Search for the swap and replace movements in the third phase. In addition, an integer programming model is proposed and the NP-completeness of the associated decision problem of the assignment of the referees ($DRAP$) is shown.

Duarte and Ribeiro [2008] proposed a multi-criteria objective function formulated as a bi-objective set partition problem. The complete minimum Pareto set was calculated using ILOG CPLEX for medium sized problems. In addition, an extension of the three phrase approach of Duarte et al. [2007b] for bi-objective referee assignment problem ($biRAP$) was presented.

An integer programming model for a fair assignment for the Turkey football soccer leagues was presented by Yavuz et al. [2008]. This formulation avoids the frequent assignment of a referee to matches with the same team. The model includes relaxed soft constrains and a minimization objective

function. The complexity of the problem and tight lower bounds are presented. The problem was solved using a constructive heuristic and a Local Search procedure.

Lamghari and Ferland [2005, 2007, 2010] presented the problem of assigning referees to the *John Molson International Case Competition* a mathematical formulation is described and the problem is solved using a Tabu Search algorithm with structured neighbourhood and diversification strategies.

Finally, Ordonez and Knowles [1998] solved the American League umpire crew scheduling problem using Constraint Programming with ILOG Solver. A comparison between the tournament scheduling problems and the *maximum empty subarray Room squares* considered was performed in Dinitz and Stinson [2005]. Farmer et al. [2007] the problem of assigning umpires crew to the tennis tournaments. The corresponding integer programming model was solved using ILOG CPLEX and the solution is compared with a two phase heuristic.

An annotated bibliography of Sport Scheduling and Referee Assignment Problems can be found section 4.7 of Kendall et al. [2010]. All the works present in the literature consider a particular problem, with objectives and constraints for a specific sport and a specific league.

Chapter 2

Problem Description

This work describes the assignment problem of referees to the Italian Volleyball League and shows an Integer Linear Programming (ILP) formulation to solve it. In the chapter 1 was described the work of others authors about the Referee Assignment Problem (RAP) on different type of sports. The current chapter 2 describe the problem, its objectives and its constraints. In the chapter 3 is described the mathematical model and how the objective function is determined. In the chapter 4 is described the procedure to add cutting planes. In the chapter 5 is presented a decomposition method based on the clique structure present in the model for improving the computing time. In the chapter 6 shows the results and computational experiments. Finally the chapter 7 shows the conclusions and future research area.

2.1 Italian Volleyball League

The Italian Volleyball League is organized by *Lega Pallavolo Serie A* and are divided in:

- Serie A1 Male.
- Serie A1 Female.

- Serie A2 Male.
- Serie A2 Female.

In the 2009/2010 season the championship *Serie A1 Male* had 15 teams, the championship *Serie A1 Female* had 12 teams, the championship *Serie A2 Male* had 15 teams and the championship *Serie A2 Female* had 16 teams.

The season is divided in two phases: Regular Season (double Round-Robin Tournament) and the Play-Off Tournament. The total number of regular games for the regular season 2009/2010 was 792 matches. The first half of the Season is the *andata* and the other half is the *ritorno*.

The referees are classified in four groups according to their skill and the championships which they can be assigned. The number of available referees for the season 2009/2010 was 90. The general rule is for each game are needed to assign two referees (one of them as first role and another one as second role). The referee in the 2009/2010 season was divided in:

- Group 1: 24 referee for the championships A1M, A1F and A2M (rarely)
- Group 2: 29 referee for the championships A1F, A2M and A1M (sometimes)
- Group 3: 32 referee for the championships A2F, A2M and A1F (sometimes)
- Group 4: 5 referee for the championships A2F and A2M (sometimes)

The scheduling has another special characteristic. There are not games all weeks for all championships and not all championships start or end on the same week. For example, in the 2009/2010 season, the A1M and A2M started on the last week of September, the A2F started two week after that and the A2F started three weeks after. Finally, the A2F must end one month after the end of the A1M. Indeed, the championships are not aligned, and during the season could be there one, two, three or four championships. The Table 2.1 shows the scheduling for each championship of the Serie A. The first column is the number of the week, the next columns shows the round of

Table 2.1: Scheduling of season 2009/2010

Week	A1M	A1F	A2M	A2F	Week	A1M	A1F	A2M	A2F
1	1		1		22	18	11	15	14
2	2		2		23	19		16	
3	3				24			17	
4	4		3	1	25	20	12	18	15
5	5				26	21	13	19	16
6	6	1	4	2	27	22		20	17
7	7				28		14		18
8	8	2	5	3	29	23	15	21	19
9		3			30	24	16	22	20
10	9	4	6	4	31	25	17	23	21
11	10		7	5	32	26	18	24	
12	11		8	6	33	27	19	25	22
13		5	9	7	34			26	23
14	12	6		8	35	28	20	27	24
15	13	7	10	9	36	29			
16	14	8	11	10	37	30	21	28	25
17			12		38		22	29	26
18	15	9	13	11	39			30	27
19				12	40				28
20	16	10	14	13	41				29
21	17				42				30

the championships.

The hypothesis is that exist a lineal programming model that describe the problem and the computational time can be improved using the specific knowing about of the problem.

2.2 Constraints

The general constrains for this problem are:

- The assignment of two referees to every game
- The assignment of one or zero game to every referee, every week.

The others constraints can be classified in two types: independent of the historical information and dependent of the historical information.

2.2.1 Constraints Independent of the historical information

Examples of these kind of constrains are:

- Incompatibility between referee and week: the referee could be sickness or could be assigned to an international championships, the referee could have disciplinary penalty, etc. This situation can be modelled deleting the games g from G_r for the week when the referee is unavailable.
- Incompatibility between referee and game: the referee can be incompatible with a team, a stadium or championships based on past conflicts. Even, the referee could not have the skills in order to be assigned to games of championships. This situation can be modelled deleting the games g from G_r for all games with conflict.
- Incompatibility between referees: based on past conflict, the assignment of two or more referees can be banned at the same game.

  These types of constraints can be pre-processed before of solve the model.

2.2.2 Constraints Dependent on the historical information

Examples of these incompatibilities are:

- Non repetitions of a team in a period of time: a referee can not be assigned to the same team in a period of $M1$ weeks. If the team plays in its local (own) stadium the period is $M2$ weeks with $M1 \leq M2$. These

constrains avoid preferences of a referee with a team. This situation can be modelled as graph of incompatibilities, for details see the next section 2.3.

- Alternation between work and rest: the referee must work between a minimal and maximal level called Q_r^{min} and Q_r^{max} respectively. These constraints avoid that referees rest all championships or work all championships. These constraints also avoid solutions that are completely not balanced, that is, if a solution with a referee who works mostly at start or at the end of the championships, the constraints must be imposed in overlaps intervals of size Δ.

- Alternation between championships: the referee must be assigned to a championships c between a minimal and maximal level called P_{rc}^{min} and P_{rc}^{max} respectively. These constraints avoid that a referee is assigned to only one championship. These kinds of constraints also avoid solutions that are not balanced, that is, a solution which is not balanced occurs when the referee was assigned at the start to the more important championships and at the end the referee was assigned to the less important championships. These constraints impose overlaps intervals of size Δ.

- Alternation between roles: two referees must be assigned to a game, one as first role and another one as second role between a minimal and maximal level called L_r^{min} and L_r^{max} respectively. These constraints are relaxed on the model because it is really easy, that is, in short CPU time are able to found a feasible solution that define the role of every referee in a second step, when the assignment of two referees to each game is already fixed and only are necessary to determine the role of both referee. The role, first or second, of a referee has not impact in the objective function, that means, a feasible solution is also an optimal solution. This simplification reduces the number of variables and constraints of our model.

2.3 Non-repetitions

The non-repetitions of a referee are modelled as a graph $\Theta_r = (G_r, E_r)$ with each vertex is a game and each arc is an incompatibility. For every referee r exist a graph Θ_r associated. The arc can be of three types:

- Same week game: for each game $g \in D^d$ in a specific week, there is an arc that connect each others. If the number of games at the week d are $n = \|D^d\|$, then the number of arcs for every date are $\frac{n(n-1)}{2}$. In fact, if the number of teams in a championship c are t_c, then the number of games in the championship c are $n_c = \lfloor \frac{t_c}{2} \rfloor$ every week for a Round-Robin Tournament.
- Repetition of a team in a period of time: for each game $g \in G$ there are two arcs for each one of the next $M1$ weeks. Then, the number of arcs of this type must be lest or equal to $\|G\|(2 * M1)$. In fact, the $\|G\|$ is equal to sum over all championships of the number of weeks by the half of the number of teams.
- Repetition of a local team in a period of time: it is analogue to the previous type in a period of $M2$ weeks with $M1 \leq M2$. The arcs only should exist if the team plays on its local (own) stadium.

Finally, the number of arcs must be:

- Linear for the number of championships
- Quadratic for the number of rounds.
- Quadratic for the number of teams.
- Quadratic for the number of games.

The first type of arc of the graph Θ_r (Same week game) represent the assignment of one or zero game to every referee, every week, that is, the second general constraint.

In the model, constrains are made using the maximal cliques of the graph Θ_r for every referee r instead of each arc of the graph separately, that is, for

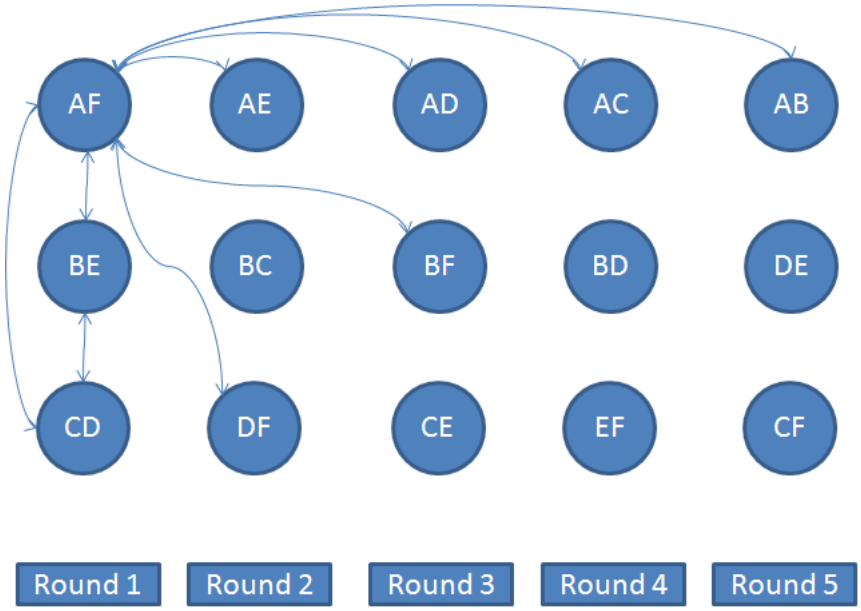

Figure 2.1: Example of incompatibilities for the games associated with the first vertex

reducing the number of constraints of the incompatibility and non-repetition. The graph is different for each referee r because historical information and the different championships associated according to their referee skills.

An example to show the graph Θ_r and their cliques is presented below. Considered only one championship with six teams (A, B, C, D, E, F) distributed in a Simple Round-Robin Tournament. For the first vertex AF connect the others vertex on the same round, also connect the vertex of the next $M1$ round when A plays in their stadium and finally connect the vertex of the next $M2$ round when A or F plays with other team. The incompatibilities for the first vertex is show the figure 2.1

Now repeat the same procedure for each vertex of the first round and the result is show in the figure 2.2

Finally repeat the same procedure for each round and the result is show in the figure 2.3

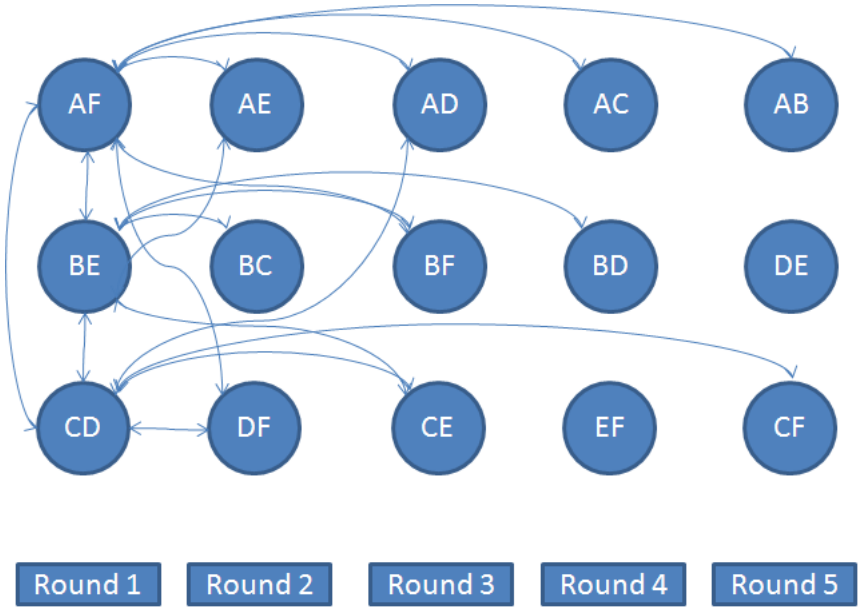

Figure 2.2: Example of incompatibilities for the games associated with the first round

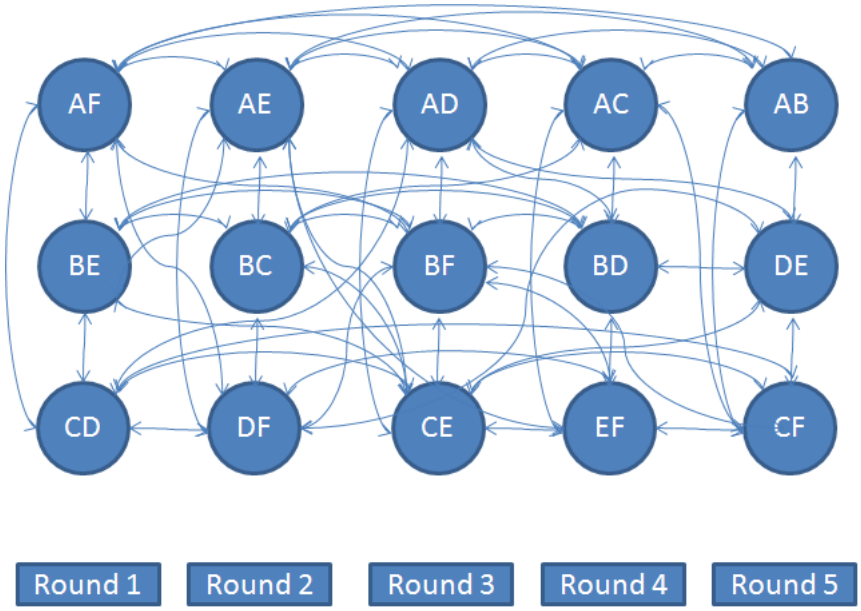

Figure 2.3: Example of incompatibilities for all games

2.4 Round Scheduling

Because the problem size is really big to solve all rounds and the parameters and incompatibilities could change from round to round, the model was solved only for the next $b + 1$ rounds starting from the current round as is described in the algorithm (1). The b additional rounds are required to maintain the feasibility of the solution. The past rounds have historical information for the constraints.

Examples of parameters which could change from round to round are:

- Importance of teams during the season.
- The referee could be sick.
- The referees can not be available.
- Others unplanned constrains.

Procedure 1 Round Scheduling Algorithm

Input: Updated information of the current season
Output: Solution of the next b+1 round for all championships

1: **for all** $t \in \{1, \ldots, round\}$ **do**
2: Update the parameters (Importance of teams, etc.)
3: Fix the historical information from round 1 to $t - 1$
4: Solve the model from round 1 to $\max\{\Delta, t + b\}$
5: Execute the schedule for the current round t
6: **end for**

Chapter 3

Integer Linear Programming Model

The problem of assign two referees to each game (RAP) described in the previous chapter 2 can be modelled as an Integer Linear Programming (ILP) presented in this chapter.

3.1 Parameters and Sets

Notations used in the Integer Linear Programming (ILP) model are presented below.

- $C :=$ set of championships (A1M, A1F, A2M, A2F).
- $\Delta :=$ size of the range of rounds to balance the work/rest and championships.
- $h_c :=$ number of rounds of the championships $c \in C$ to schedule.
- $h := \max\{\min_{c \in C}\{h_c\}, \Delta\}$.
- $b :=$ number of additional round to schedule.
- $G :=$ set of games g to schedule.

- $C^c \subset G$: set of games g in championships $c \in C$.
- $D^d \subset G$: set of games g in round $d = 1, \ldots, h$.
- $G^{cd} \subset G$: set of games g in championships $c \in C$ **and** in the round $d = 1, \ldots, h_c$.
- $R :=$ set of available referees r to assign a game.
- $G_r \subset G$: set of games g compatible with referee $r \in R$.
- $R_g \subset R$: set of referees r compatibles with game $g \in G$.
- $G_r^{cd} \subset G$: set of games g in championship $c \in C$ **and** in the round $d = 1, \ldots, h_c$ **and** compatible with referee $r \in R$.
- $\Theta_r :=$ graph that represents the incompatibilities of games $g \in G_r$ for every referee $r \in R$; $\Theta_r = (G_r, E_r)$.
  $G_R :=$ set of games g compatible with referee $r \in R$
  $E_r :=$ $(g_1, g_2) \in G_r$; such that g_1 **and** g_2 can not be assigned to referee r at the same time
  Note: E_r includes the incompatibilities of games in the same week and the non-repetitions rule.
- $\mathcal{K}(\Theta_r) :=$ set of maximal cliques of Θ_r
- $Q_r^{min}, Q_r^{max} :=$ min/max number of games that should be assigned to referee r in Δ rounds.
- $P_{rc}^{min}, P_{rc}^{max} :=$ min/max number of games in championships $c \in C$ that should be assigned to referee r in Δ rounds.
- $c_{rg} :=$ cost to assign referee r to game g. This includes the cost of transport, hotel, etc.
- $p_{rg} := w_r * k_g$ technical profit to assign referee r to game g. It is based on the importance of game g and the skills of referee r.
- $\alpha_r :=$ balance between cost and profit for referee r calculated over the full championships.

An example of the set R and their parameters $Q_r^{min}, Q_r^{max}, P_{rc}^{min}, P_{rc}^{max}$ and w_r can be found in the appendix A.

An example of the set G and their parameters c, d and k_g can be found in the appendix B.

3.2 Variables

$$y_{rg} = \begin{cases} 1 & \text{if referee } r \in R \text{ is assign to the game } g \in G_r \\ 0 & \text{otherwise} \end{cases}$$

The variable y_{rg} is a binary variable that represent the assignment of a referee r to the game g if their value is 1, otherwise the variable take the value 0.

3.3 Integer Programming Model

$$\min \quad \sum_{r \in R} \sum_{g G_r} (c_{rg} - \alpha_r * p_{rg}) * y_{rg} \tag{3.1}$$

Subject to:

$$\sum_{r \in R_g} y_{rg} = 2 \qquad g \in G \tag{3.2}$$

$$\sum_{g \in K} y_{rg} \leq 1 \qquad r \in R, \quad K \in \mathcal{K}(\Theta_r) \tag{3.3}$$

$$Q_r^{min} \leq \sum_{l=d}^{d+\Delta-1} \sum_{g \in D^l \cap G_r} y_{rg} \leq Q_r^{max} \qquad r \in R, \quad d = 1, \ldots, h+1-\Delta \tag{3.4}$$

$$P_{rc}^{min} \leq \sum_{l=d}^{d+\Delta-1} \sum_{g \in G_r^{cl}} y_{rg} \leq P_{rc}^{max} \quad r \in R, \quad c \in C, \quad d = 1, \ldots, h_c+1-\Delta \tag{3.5}$$

$$y_{rg} \in \{0, 1\} \qquad r \in R, \qquad g \in G_r \tag{3.6}$$

The equation (3.1) is the objective function that represents the minimization of the cost minus profit, for details see the follow section 3.4.

The equations (3.2) for each game g are the assignation of two different referees to each game.

The equations (3.3) represent the incompatibility between a set of games $g \in K$ calculated as cliques of the graph of Θ_r for each referee r. The number of constraints are large because these include incompatibilities of non-repetitions for the same team in $M1 = 4$ weeks, or if the team plays in its local (own) stadium $M2 = 7$ weeks. It avoid preferences of a referee for a team. The other types of incompatibilities are between each game of a week, that is, the referee can be assigned to only one game every week.

The equations (3.4) and (3.5) represent the balance between the assignment of work/rest and the different championships; these constraints are imposed in a range of Δ overlapped round.

Finally, the equations (3.6) represent the variable y_{rg} only can take the value 0 or 1.

3.4 Generation of costs and profits

The objective function is the minimization of cost c_{rg} minus profit p_{rg} with the proportion constant α_r for all referee-game assigned. The generation of these values is described below.

3.4.1 Generation of costs

The cost c_{rg} represent the cost of travel from referee home city to the city where the game g will be developed by the referee r, plus cost of the accommodation in a hotel and others. The cost is based on real data for the assigned referee-game in the past championships. The missing values are calculated randomly using an uniform distribution with a confidence level of 0.99 with the real data as sample.

3.4.2 Generation of profits

The profit p_{rg} is calculated as the multiplication of the profit of referee r (w_r) by the profit of the game g (k_g).

The profit of referee r (w_r) are based on the skills of the referee. Therefore, the set of referees are rated in 10 different levels and an each level has an associated profit w_r.

The profit of the game g (k_g) are based on:

- The championship of the game g, for example, an average game of A1M is more important that an average game of A1F.
- The standing of the teams (change every round).
- The round of the game g, for example, the first round is less important than the final rounds of the championship.

- The games with teams near of the 8^{th} rank of the standing at the end of the first half (*Andata*) are more important because the first eight teams will participate in the *Final Eight* of *Coppa Italia*.
- Some high important games of a less important championship can has a bigger profit that less important games of a high important championship.

Then, each game $g \in C^c$ can be classified according to the difficulty level as hard, medium-hard, medium, medium-soft or soft; hence the set of games are rated in 20 different levels (difficulty and championship) and each level has an associated profit k_g.

3.4.3 Generation of Alpha

The α_r is the balance between the cost and the profit for the referee r based in:

- The average cost of the referee r.
- The average profit of the referee r.
- The cost should be a 30% of importance and the profit a 70% importance in the objective function.

Then α_r can be calculated for each referee r as:

$$\alpha_r = \frac{7 \sum_{g \in G_r} c_{rg}}{3 \sum_{g \in G_r} p_{rg}} \tag{3.7}$$

The value of α_r is fixed a priori with the information available when is used the model.

3.5 Determination of the referee role

Since the role of a referee (first or second) is relaxed, its can determine it in a second step using an auxiliary Integer Linear Programming (ILP) model. This model presented below is solved after the main model and use the values of the variable x_{rg} to determine the role when are already fixed the assignments referee-game.

3.5.1 Variables

$$x_{rg} = \begin{cases} 1 & \text{if referee } r \in R \text{ is assign as first role to the game } g \in \hat{G}_r \\ 0 & \text{if referee } r \in R \text{ is assign as second role to the game } g \in \hat{G}_r \end{cases}$$

The variable x_{rg} is a binary variable that represent the role of a referee r on the game g. if their value is 1 the referee acts as first role, else the variable take the value 0 and the referee acts as second role.

The variable x_{rg} only exist if the variable y_{rg} take the value of 1, that is, the referee r is assigned to the game g and is needed to determine the role. If the variable y_{rg} take the value of 0 then, the variable x_{rg} is not included in the model.

s_r^{min} = Slack variable associated to the referee r and the parameter L_r^{min}.

s_r^{max} = Slack variable associated to the referee r and the parameter L_r^{max}.

The variables s_r^{min} and s_r^{max} are continuous and implicitly between 0 and 1.

3.5.2 Parameters and Sets

Notations used in the Integer Linear Programming (ILP) model are presented below.

L_r^{min}, L_r^{max} := min/max number of games that should be assigned as first role the referee r.

$\hat{G_r} \subset G_r$: set of games g assigned to the referee $r \in R$.

$\hat{R_g} \subset R_g$: set of referees r assigned to the game $g \in G$, only two referee are assigned to each game g, that is, $\|\hat{R_g}\| = 2$

3.5.3 Integer Programming Model

$$\min \quad \sum_{r \in R} s_r^{min} + \sum_{r \in R} s_r^{max} \tag{3.8}$$

Subject to:

$$x_{r_1,g} + x_{r_2,g} = 1 \qquad g \in G, \qquad r_1, r_2 \in \hat{R_g}, \qquad r_1 \neq r_2 \tag{3.9}$$

$$\sum_{g \in \hat{G_r}} x_{rg} \geq L_r^{min} - L_r^{min} s_r^{min} \qquad r \in R \tag{3.10}$$

$$\sum_{g \in \hat{G_r}} x_{rg} \leq L_r^{max} + (|\hat{G_r}| - L_r^{max}) s_r^{max} \qquad r \in R \tag{3.11}$$

$$x_{rg} \in \{0, 1\} \qquad r \in R, \qquad g \in \hat{G_r} \tag{3.12}$$

$$s_r^{min}, s_r^{max} \geq 0 \qquad r \in R \tag{3.13}$$

The equation (3.8) is the objective function that represents the minimization of the all slack variables.

The equations (3.9) are the assignation of the role (first or second) for the two different referees of each game g.

The equations (3.10) and (3.11) represent the balance between the assignment of first/second role for each referee r with a slack variable s_r to avoid infeasibility.

The equations (3.12) represent the variable x_{rg} only can take the value 0 or 1.

The equations (3.13) represent the variables s_r^{min} and s_r^{max} are continuous and non-negative.

When the optimal solution is found, the value of the objective function (3.8) for the instances tested was always zero, that is, the constraints (3.10) and (3.11) not need the slack variable and the solution of the model to determine the role satisfies the minimal number L_r^{max} and the maximal number L_r^{max} of games assigned to the referee r as first role.

As well, the time to solve this model was less of 1 second. Because all of that was focused on reduce the CPU time of the main model in the section 3.3

Chapter 4

Clique-Based Cutting plane

The model described in the chapter 3 includes the constrains of non repetitions (3.3), incompatibilities are imposed only in a subset of maximal clique of the graph Θ_r. In fact, the model can be stronger separating these cutting planes (new cliques) during the branch-and-cut procedure of ILOG CPLEX.

The library CLIQUER 1.21 was used for separating the maximum weight clique constraints as it is described in the algorithm (2). The library used calculate the maximum weight clique on an exact way as is described in Niskanen and Östergård [2003].

The weight of each vertex is the value of the variable y_{rg} at the current node of the branch-and-cut algorithm of ILOG CPLEX, the sets of weight for each vertex of the graph Θ_r are called W_r. If the maximum weight clique of the graph Θ_r violates the constraint (3.3) then, the clique is added as a new cutting-plane to the model.

The algorithm (2) adds at most one new cutting plane for each referee. For the referee r, the weight of the vertex $g \in G_r$ of the graph Θ_r is the current value of the variable y_{rg}, these values are fractional between 0 and 1.

This procedure was tried in the first nodes, nodes of depth d or less and the first n nodes explored by ILOG CPLEX during the branch-and-cut, etc. This procedure was applied only to the first node because it is able to generate

Procedure 2 Clique Cutting Plane Generator

Input: Value of the variable y_{rg}
Output: New cutting planes

1: **for all** $r \in referee$ **do**
2: Calculate $\Theta_r = (G_r, E_r, W_r)$.
3: Select the maximum weight clique k from Θ_r.
4: **if** $\sum_{g \in k} y_{rg} > 1$ **then**
5: Add $\sum_{g \in k} y_{rg} \leq 1$ to the model as cutting plane.
6: **end if**
7: **end for**

an high number of new cutting planes only in the first nodes, after the first nodes the procedure generates a low number of cutting plane.

To implement this procedure was used the *UserCutCallback* callback of ILOG CPLEX.

Chapter 5

Clique-Based Decomposition

The model described in section 3.3 has two type of constraint, the first type of constraints are the classical constraints (3.2), (3.4), (3.5), (3.6) and the second one are the clique based constraints (3.3).

The proposed approach is similar to Benders' Decomposition, described in Benders [1962], for solving this type of model. A special Benders' cuts that use the clique structure of the model.

This kind of approach solves a reduced programming model that corresponds to the original model minus constraints (3.3), and generates new constraints during the branch-and-cut procedure of ILOG CPLEX for ensuring the feasibility of the original model. In fact, the reduced model does not verify all constraints of non-repetition (3.3), because they are generated only if they are required to satisfy the feasibility for the original model.

The constraints generated during the branch-and-cut process are not built by using a linear programming model such as in Benders' decomposition. Indeed, they are built by using the graph Θ_r on their weighted form, where the weight of each vertex of the graph w_r, has the value of the variable y_{rg} at the current node of the branch-and-cut process, that is, the value of the vertex g associated to the graph Θ_r is the value of y_{rg}.

The most violated constraint of each referee from the original model which

are not present in the reduced model can be calculated as the maximum weight clique of the graph $\Theta_r := (G_r, E_r, W_r)$, where the violated cliques have a weight greater than 1 as is show in the constraint (3.3). The library CLIQUER 1.21 was used as is described in Niskanen and Östergård [2003] for separating the maximum weight clique in a exact way.

The violated constraints were generated only when they were necessary, that is, we wanted to maintain the feasibility of the original model. The procedure to use the reduced model and the cliques of the graph is described in algorithm (3), this procedure is used during the branch-and-cut process of ILOG CPLEX.

Procedure 3 Clique Based Decomposition

Input: Value of the variable y_{rg}
Output: New Constraints

for all $r \in referee$ **do**
  if not $\exists$ feasible solution yet **then**
    Calculate $\Theta_r = (G_r, E_r, W_r)$.
    Select the maximum weight clique k from Θ_r.
    if $\sum_{g \in k} y_{rg} > 1$ **then**
      Add $\sum_{g \in k} y_{rg} \leq 1$ to the reduced model as new constraint.
    end if
  end if
  if new integer solution is found **then**
    Calculate $\Theta_r = (G_r, E_r, W_r)$.
    Select the maximum weight clique k from Θ_r.
    if $\sum_{g \in k} y_{rg} > 1$ **then**
      Add $\sum_{g \in k} y_{rg} \leq 1$ to the reduced model as new constraint.
      reject the integer solution found
    end if
  end if
end for

The procedure (3) is executed on each node of the branch-and-cut process. If doesn't exist a feasible solution on the previous nodes, it generates a clique based Benders' cuts to help to found a feasible solution such that the solution does not violate the feasibility of the original model. Otherwise, it checks if the new integer solution is feasible or not for the original model. If the new

integer solution violates a constraint, then it constraint is added to the reduce model according with the largest value violated and the solution is rejected and marked as infeasible, otherwise the new integer solution is accepted as feasible.

The algorithm (3) adds at most one new constraint for each referee. For the referee r, the weight of the vertex $g \in G_r$ of the graph Θ_r is the current value of the variable y_{rg}, this values are fractional between 0 and 1.

This approach generates less or equal new constraints that generate the full list of maximal clique of the graph Θ_r. In fact, the time to found the constraint which has the largest violated value using the graph structure is less of the time to verify the full clique list of the original model.

The procedure was implemented by using the *LazyConstraintCallback* callback of ILOG CPLEX. In addition, two auxiliary callback are used: *Branch-Callback* and *IncumbentCallback*.

Chapter 6

Results

The model was implemented in Visual C++ 2008 by using ILOG CPLEX 10, the test was performed on a computer using a CPU Intel Pentium 4 of 3.4 GHz which includes Microsoft Windows XP operating system.

6.1 Instances

The instances are based on the schedule of the 2009/2010 and 2010/2011 season with 7 macro-instances each one with 42 instances doing a total of 294 instances.

The parameters of constraints (3.4), (3.5), (3.10) and (3.11) are based on the real information of past season. The coefficient of the function objective (3.1) was generated following the criteria described in section 3.4 using a random standing for each instance.

The parameter b was set to 8 because with a small values the model will become infeasible after some iterations of the round-scheduling procedure described in the procedure 1 since the non-repetitions constraints (3.3). On the other hand, if the parameter b has a big values, the computing time will increase and the global quality of the solution will not be improved.

The parameter $M1$ and $M2$ present in the constraints (3.3) was set to 4 and 7 respectively based in the requirements for the problem.

In addition, it is determined the number of nodes to apply the cutting plane generator like the first 50 nodes for the method *Cutgen*. The time limit was set to 5 hours. All experiments were running with these parameters and *ceteris paribus* assumption.

Five methods were compared, the first method *Default* solves the model with ILOG CPLEX with the default parameters and without any algorithm to help the solver. This is the control method, that allows to validate that the procedures described in the previous sections improve the computational time, validating this hypothesis.

The second method called *Meo*, is the *Default* method with the parameter *MIPEmphasis* configured to had a branch and bound emphasis in the optimality over feasibility of the solution. This configuration was selected because improve the computational time only changing parameters of ILOG CPLEX.

The third method called *Cutgen*, is the *Meo* method with the clique cutting plane generator described in the section 4.

The fourth method called *Delayed*, is the *Default* method by using the reduced model and clique based decomposition described in section 5. This method is based in *Default* because the computational time is better that if the parameter *MIPEmphasis* is changed as is in the method *Meo*.

Finally the fifth method called *Weight*, is the *Default* method with an objective function with major emphasis on a scheduling for the nearest weeks using a weight associated to the week of the game.

The new objective function for the *Weight* method show in the equation 6.1 with $w_g \in [0, 1[\,, \forall g \in G$, the games of the current week has a weight w_g of 1, the games for the next weeks have less weight that the previous week, until the week Δ with a weight of 0. The following weeks of Δ have also a

weight w_g equal to 0.

$$\min \quad \sum_{r \in R} \sum_{g \in G_r} w_g (c_{rg} - \alpha_r p_{rg}) y_{rg} \tag{6.1}$$

6.2 Numerical Results

For validate our proposed procedure improve the computational that using only ILOG CPLEX is tested the five methods with all the instances. The value of the objective function is not compared because the solution was found by using an exact method, that is, the optimal solution always has the same value when the gap are closed.

The model of the step two to determine the role of each referee is not presented because the value of the objective value is always zero, that is, the assignment of the referees always satisfies the minimal and maximal level for the first role; also the computational time was less of 1 second and because that reasons our focus was in the main model. The idea of separate the decision of what referee use and the role of the referee has not impact in the quality of the solution because is not present on the objective function but help us to reduce the number of variable and constraints on the main model.

The tables 6.1, 6.2, 6.3, 6.4, 6.5, 6.6 and 6.7 show information about the CPU time in seconds to found the first solution ($tUBI$), the CPU time in seconds to found the last solution ($tUBF$), the CPU time in seconds when CPLEX founds the optimal solution ($Tcplex$), the percent of instances that reach the time limit of five hours ($5hours$), the percent of instances that was solved between 1 and 5 hours ($1 - 5hours$), the percent of instances that was solved between 5 minutes and 1 hour ($5 - 60mins$), the percent of instances solved in less of 5 minutes ($0 - 5mins$), the improvement of the last solution (final upper bound) respect to the first solution (initial upper bound) ($\%F - I/F$), the gap between the final upper and lower bound ($\%LB - UB$) only for the case where the optimal solution was not found

Table 6.1: Numerical Results: Macro Instance 1

MacroInstance 1	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	13,36	3.489,71	5.520,98	19,05	19,05	30,95	30,95	0,42	0,03	0	0
Meo	17,74	3.287,51	4.377,76	14,29	19,05	38,10	28,57	0,43	0,03	0	0
Cutgen	16,33	2.826,14	3.807,58	9,52	21,43	40,48	28,57	0,51	0,02	48	31,91
Delayed	113,64	1.779,76	3.232,53	9,52	16,67	28,57	45,24	0,09	0,02	859	84,74
Weight	7,56	188,84	195,67	0,00	0,00	14,29	85,71	0,39	0	0	0

Table 6.2: Numerical Results: Macro Instance 2

MacroInstance 2	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	13,26	3.836,71	5.503,45	19,05	19,05	23,81	38,10	0,49	0,02	0	0
Meo	18,87	3.029,10	4.607,42	14,29	11,90	42,86	30,95	0,49	0,03	0	0
Cutgen	22,89	3.394,29	4.413,43	14,29	14,29	40,48	30,95	0,54	0,01	51	36,98
Delayed	124,48	2.812,65	4.239,09	9,52	16,67	30,95	42,86	0,09	0,02	867	95,35
Weight	8,29	486,27	503,10	0,00	2,38	35,71	61,90	0,49	0	0	0

because the time limit, the number of cutting planes (for the *Cutgen* method) or new constraints (for the *Delayed* method) generated ($Ncuts$) and finally, the computational time in seconds to generate these cutting planes or new constraints ($Tcuts$).

Note, the average gap is calculated only when the time limit was reached.

The table 6.1 shows the average times, and the measures of the quality of the first and last solutions found for the macro instance 1. The improvement of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and the *Cutgen* method, the drop was of a 13,02 %. Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 41,45%.

The table 6.2 shows the average times, and the measures of the quality of the first and last solutions found for the macro instance 2. The improvement of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and the *Cutgen* method, the drop was of a 4,21 %. Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 22,97%.

The table 6.3 shows the average times, and the measures of the quality of the first and last solutions found for the macro instance 3. The improvement

Table 6.3: Numerical Results: Macro Instance 3

MacroInstance 3	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	14,48	3.667,04	5.720,97	14,29	30,95	26,19	28,57	0,52	0,03	0	0
Meo	23,89	3.647,60	4.792,05	9,52	33,33	28,57	28,57	0,56	0,05	0	0
Cutgen	30,73	3.457,26	4.190,41	9,52	26,19	35,71	28,57	0,37	0,03	55	35,99
Delayed	117,16	2.787,80	3.740,68	9,52	19,05	35,71	35,71	0,08	0,02	866	87,59
Weight	7,79	230,72	237,76	0,00	0,00	30,95	69,05	0,39	0	0	0

Table 6.4: Numerical Results: Macro Instance 4

MacroInstance 4	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	11,25	2.215,83	2.833,77	4,76	11,90	42,86	40,48	0,40	0,04	0	0
Meo	11,24	1.437,96	1.911,60	4,76	9,52	50,00	35,71	0,40	0,04	0	0
Cutgen	15,82	1.547,31	1.926,31	4,76	7,14	54,76	33,33	0,53	0,02	49	35,36
Delayed	107,39	1.557,65	1.773,15	4,76	7,14	35,71	52,38	0,12	0,03	849	80,35
Weight	7,63	209,38	215,31	0,00	0,00	23,81	76,19	0,57	0	0	0

of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and the *Cutgen* method, the drop was of a 12,55 %. Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 34,61%.

The table 6.4 shows the average times, and the measures of the quality of the first and last solutions found for the macro instance 4. The improvement of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and the *Cutgen* method, the drop was of a -0,77 %. Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 37,43%.

The table 6.5 shows the average times, and the measures of the quality of the first and last solutions found for the macro instance 5. The improvement of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and the *Cutgen* method, the

Table 6.5: Numerical Results: Macro Instance 5

MacroInstance 5	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	12,53	2.499,10	2.793,47	4,76	14,29	40,48	40,48	0,30	0,02	0	0
Meo	17,11	1.146,68	1.478,61	2,38	9,52	50,00	38,10	0,31	0,01	0	0
Cutgen	31,80	1.314,36	1.425,03	0,00	11,90	47,62	40,48	0,60	0	46	31,32
Delayed	100,98	1.053,83	1.374,33	2,38	11,90	30,95	54,76	0,12	0,02	823	74,98
Weight	18,55	195,12	199,66	0,00	0,00	19,05	80,95	0,27	0	0	0

Table 6.6: Numerical Results: Macro Instance 6

MacroInstance 6	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	10,80	2.485,04	3.973,41	11,90	16,67	30,95	40,48	0,36	0,01	0	0
Meo	10,83	2.245,77	2.830,62	2,38	19,05	42,86	35,71	0,36	0,00	0	0
Cutgen	24,33	2.333,99	2.778,42	4,76	16,67	45,24	33,33	0,30	0,01	47	33,03
Delayed	99,66	1.760,46	2.682,01	2,38	21,43	23,81	52,38	0,12	0,00	818	79,62
Weight	6,84	157,60	162,19	0,00	0,00	11,90	88,10	0,45	0	0	0

Table 6.7: Numerical Results: Macro Instance 7

MacroInstance 7	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	11,20	1.366,20	2.045,59	2,63	15,79	26,32	55,26	0,44	0,02	0	0
Meo	11,19	1.434,18	1.580,43	2,63	5,26	52,63	39,47	0,44	0,00	0	0
Cutgen	12,54	1.006,47	1.181,86	0,00	5,26	55,26	39,47	0,57	0	43	30,66
Delayed	98,65	977,08	1.122,01	0,00	5,26	26,32	68,42	0,08	0	903	68,94
Weight	5,47	122,61	126,31	0,00	0,00	2,63	97,37	0,69	0	0	0

drop was of a 3,62 %. Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 50,80%.

The table 6.6 shows the average times, and the measures of the quality of the first and last solutions found for the macro instance 6. The improvement of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and the *Cutgen* method, the drop was of a 1,84 %. Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 32,50%.

The table 6.7 shows the average times, and the measures of the quality of the first and last solutions found for the macro instance 7. The improvement of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and the *Cutgen* method, the drop was of a 25,22 %. Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 45,15%.

The table 6.8 show the average times for all macro instances, and measures of the quality of the first and last solutions found for all macro instances.

The global improvement of the use of cutting plane for the model could be measured as the difference of the computational time between the *Meo* and

Table 6.8: Numerical Results: Average Instance

Average	t-UBI	t-UBF	T-Cplex	5 hours	1-5 hours	5 - 60 mins	0 - 5 min	% F-I/F	% LB-UB	Ncuts	Tcuts
Default	12,41	2.794,23	4.055,95	10,92	18,24	31,65	39,19	0,42	0,03	0	0
Meo	15,84	2.318,40	3.082,64	7,18	15,38	43,57	33,87	0,43	0,02	0	0
Cutgen	22,06	2.268,55	2.817,58	6,12	14,70	45,65	33,53	0,49	0,02	48,37	33,61
Delayed	108,85	1.818,46	2.594,83	5,44	14,02	30,29	50,25	0,10	0,02	854,80	81,65
Weight	8,88	227,22	234,29	0,00	0,34	19,76	79,90	0,46	0	0	0

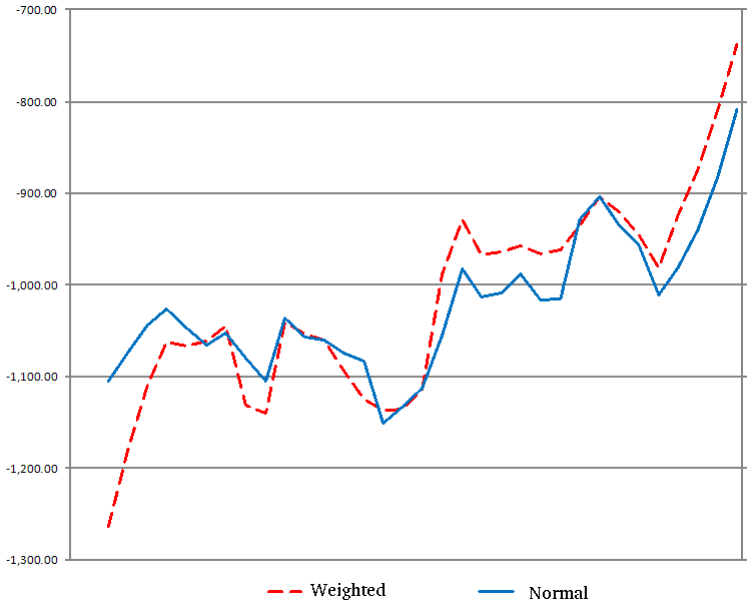

Figure 6.1: Normal vs Weight Objective Function

the *Cutgen* method, the drop was of a 8,60 % as average for all instances.

Similarly the improvement of the use of decomposition can be measured between the *Default* and the *Delayed* method, the drop was of a 36,02% as average for all instances.

The computational time to found the first solution ($tUBI$) is worst for the method *Delayed* (108,85 seconds in average), but also is the method with the better quality for the first solution ($\%F/I - 1$).

The number of cutting planes for the *Cutgen* method and the number of new constraints for the *Delayed* method are zero for the others methods since was only used ILOG CPLEX without additional procedures.

The figure 6.1 show the evolution of $SOLF$ on each round, that is, the part of the objective function that represent only the current round. The value was normalized with the number of games of the respective round and show as rolling average of size Δ. The figure helps to compare the balance of two different objective functions, the first one is the normal objective function (3.1) show as the continuous line and the second one is the weighted objective function (6.1) show as the dashed line. At the x-axis are the round and at the y-axis are $SOLF$. This objective functions are minimized, then at begin the dashed line show better assignment that the continuous line, but at end of the season the dashed line show a poor assignment. The weighted objective function causes a less balanced solution because at the start of the season does very good assignment, but this carry that the final games of the season be poorly assigned. Remember that the non-repetitions constraint implies that if is used a referee his can not be used in the upcoming weeks for the same teams.

This method with small computational time is not chosen because the non balanced behaviour. With the weighted objective function (6.1) the importances of a referee in futures games are underrated.

The real instances tested are very large to solve the problem from the first round to the last round in one-step, then to have a measure of the global quality of the solution was generated a smallest instances with 12 teams per championships and 2 championships with 22 rounds in total and 28 referees. The global quality is calculated as the contribution of the current round ($SOLF$) to the objective function over all round solving the model round-by-round (our current approach described in 2.4) and solving the model in one-step ($SOLFULL$) as is presented in the table 6.9.

This Experiments show that comparing the global quality of the solution solving the model round-by-round versus solving the model in one-step have a difference near to 2%. Solving using the round-by-round procedure 1 the computational time was about of one minute per round to reach the optimal solution on the small instance; otherwise, the time to solve in one-step was over three days with only a feasible solution. In fact, the parameters of the

Table 6.9: Numerical Results: Small Instance

Small Instance	tUBI	tUBF	T-cplex	%F-I/F	SOLF	SOLFull
Round1	6,2	336,0	336,2	0,33%	-15.149,8	-15.478,6
Round2	3,4	3,8	30,5	0,32%	-10.583,0	-10.824,3
Round3	0,4	0,4	0,4	0,00%	-13.368,0	-13.615,6
Round4	2,6	37,6	37,7	0,25%	-9.387,4	-10.145,9
Round5	2,6	59,7	59,8	0,43%	-14.086,4	-14.458,0
Round6	1,2	68,5	68,8	3,07%	-13.940,0	-14.095,0
Round7	3,0	50,0	52,1	0,15%	-10.763,1	-11.155,9
Round8	3,8	43,1	52,5	0,74%	-12.283,7	-12.725,3
Round9	4,2	156,1	181,2	0,54%	-13.722,7	-13.727,5
Round10	3,4	98,1	98,1	0,34%	-16.372,5	-17.205,6
Round11	3,4	74,8	77,0	0,21%	-11.214,6	-11.714,7
Round12	3,2	38,8	53,2	0,17%	-15.889,9	-15.595,9
Round13	1,7	112,1	125,1	2,40%	-11.661,5	-11.785,1
Round14	3,8	113,9	115,1	0,26%	-13.987,2	-13.401,8
Round15	4,1	105,2	105,7	0,71%	-13.491,1	-14.245,1
Round16	1,7	1,7	19,6	0,00%	-14.748,6	-14.383,9
Round17	0,4	0,4	0,4	0,00%	-12.052,2	-12.143,1
Round18	0,2	0,2	0,2	0,00%	-11.918,2	-12.142,7
Round19	0,2	0,2	0,2	0,00%	-10.589,5	-10.921,2
Round20	0,1	0,1	0,1	0,00%	-17.528,6	-18.401,1
Round21	0,1	0,1	0,1	0,00%	-11.762,1	-11.886,3
Round22	0,1	0,1	0,1	0,00%	-12.442,8	-12.760,6
max	6,2	336,0	336,2	3,07%		
average	2,3	59,1	64,3	0,45%	-13.042,9	-13.309,7
< 1 min	22	14	14			
< 1 hour	0	8	8			

model as the availability of a referee can change during the season being necessary resolve the model, because that was selected a round-by-round approach.

Chapter 7

Conclusions

This work presents a formulation for the referee assignment problem for the Italian Volleyball Serie A Championships which was tested with real data.

The proposed clique cutting plane generator obtains better CPU time to solve the model by exact way respect to the case without the clique cutting plane generator. In addition, the computing time between ILOG CPLEX is able to found the final solution, and when the lower bound is equal to upper bound was reduced. The average times to found the optimal solution are less of 1 hour. The quality of the first solution is really high, but the lower bound runs slowly. The clique cutting plane generator helps to improve the bound. Almost all the instances are solved finding the optimality status, but when the time limit is reached the gap was close to zero.

The proposed clique decomposition is an enhancement to the cutting plane generator. The computing time to solve to optimal is less than the time used by the original model or the time used by the original model with a clique based cutting plane. Otherwise the time to found the last feasible solution, the quality of the first feasible solution and the number of cases when the time limit is reached were also improved.

In the clique decomposition, the time to found the first feasible solution is greater than others methods, but the quality is improved, that means, the

percentage gap is 4 to 5 times smaller. In fact, the difference between the first solution feasible and the last solution feasible are small by using the decomposition technique presented. It can be used the first feasible solution because has a very high quality and the computing time is reduced. A good idea is to do some iterations of the branch-and-cut after the first solution for few minutes because the improvements happen more frequently at begin of the branch-and-cut procedure. The 79,3% of the instances are solved in less than 1 hour with the clique decomposition method. The number of instances that reach the time limit are reduced to the half with the clique decomposition method.

The number of constraints for each round are around of $2 * 10^4$ for the original model, but the reduced model is only 10^3 plus 10^3 clique based constraints generated during the decomposition. The model is small and the time to process each node is decreased, but the size of the branch-and-cut tree explored is bigger, but always the total computing time are better than not use decomposition.

The computing time can be improved by using a weighted objective function, but the quality of the solution is affected because the assignments for the last weeks are less important. Considering the contribution to the objective function of the current round, $SOLF$, over all scheduled round and compare as a measure of the global quality was found the methods are similar in quality level but the worst is the method with the weighted objective function. Other problem of these bad assignments are a less balance of the solution. If we want to allocate a referee to a specific game, in the previous rounds can not be used for teams of that game, then with a weighted objective function the importance of a referee in futures games are underrated.

In others experiments was determined that the high number of constraints of non-repetition increase the computational time. In fact, if are reduced (artificially) $M1$ or $M2$, the number of arcs of the graph Θ_r will be reduced and also the CPU time.

The parameter b has impact on the CPU time, if is reduced it (artificially)

the CPU time will be decreased but the next round can be infeasible.

Appendix A

Information about Referees

An example of referees, group, W_r, $\%P^{min}_{A1M}$, $\%P^{max}_{A1M}$, $\%P^{min}_{A1F}$, $\%P^{max}_{A1F}$, $\%P^{min}_{A2M}$, $\%P^{max}_{A2M}$, $\%P^{min}_{A2F}$, $\%P^{max}_{A2F}$, $\%Q^{min}$, $\%Q^{max}$, $\%L^{min}$ and $\%L^{max}$ are show in the table A.1 for the season 2010/2011.

The referees are classified in four groups according to their skill and the championships which they can be assigned. The available referees for the season 2010/2011 were divided in:

- Group 1: 23 referee for the championship A1M, A1F and A2M (rarely)
- Group 2: 25 referee for the championship A1F, A2M and A1 (sometimes)
- Group 3: 29 referee for the championship A2F, A2M and A1F (sometimes)
- Group 4: 14 referee for the championship A2F and A2M (sometimes)

Table A.1: Referees of season 2010/2011

Referee	Group	W_r	$\%P_{A1M}^{min}$	$\%P_{A1M}^{max}$	$\%P_{A1F}^{min}$	$\%P_{A1F}^{max}$	$\%P_{A2M}^{min}$	$\%P_{A2M}^{max}$	$\%P_{A2F}^{min}$	$\%P_{A2F}^{max}$	$\%Q^{min}$	$\%Q^{max}$	$\%L^{min}$	$\%L^{max}$
Referee 1	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 2	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 3	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 4	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 5	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 6	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 7	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 8	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 9	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 10	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 11	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 12	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 13	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 14	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 15	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 16	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 17	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 18	1	13	75	100	0	25	0	0	0	0	50	75	40	60
Referee 19	1	11	50	75	25	50	0	0	0	0	50	75	40	60
Referee 20	1	11	50	75	25	50	0	0	0	0	50	75	40	60
Referee 21	1	11	50	75	25	50	0	0	0	0	50	75	40	60
Referee 22	1	11	50	75	25	50	0	0	0	0	50	75	40	60
Referee 23	1	11	50	75	25	50	0	0	0	0	50	75	40	60
Referee 24	2	9	33	66	25	50	25	50	0	0	50	75	40	60
Referee 25	2	9	33	66	25	50	25	50	0	0	50	75	40	60
Referee 26	2	9	33	66	25	50	25	50	0	0	50	75	40	60
Referee 27	2	9	33	66	25	50	25	50	0	0	50	75	40	60
Referee 28	2	9	33	66	25	50	25	50	0	0	50	75	40	60
Referee 29	2	9	33	66	25	50	25	50	0	0	50	75	40	60
Referee 30	2	9	33	66	25	50	25	50	0	0	50	75	40	60
Referee 31	2	8	0	25	33	66	33	66	0	0	50	75	40	60
Referee 32	2	8	0	25	33	66	33	66	0	0	50	75	40	60
Referee 33	2	8	0	25	33	66	33	66	0	0	50	75	40	60
Referee 34	2	8	0	25	33	66	33	66	0	0	50	75	40	60
Referee 35	2	8	0	25	33	66	33	66	0	0	50	75	40	60
Referee 36	2	8	0	25	33	66	33	66	0	0	50	75	40	60
Referee 37	2	8	0	25	33	66	33	66	0	0	50	75	40	60
Referee 38	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 39	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 40	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 41	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 42	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 43	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 44	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 45	2	7	0	0	33	66	50	75	0	0	50	75	40	60

Referee	Group	W_r	$\%P_{A1M}^{min}$	$\%P_{A1M}^{max}$	$\%P_{A1F}^{min}$	$\%P_{A1F}^{max}$	$\%P_{A2M}^{min}$	$\%P_{A2M}^{max}$	$\%P_{A2F}^{min}$	$\%P_{A2F}^{max}$	$\%Q^{min}$	$\%Q^{max}$	$\%L^{min}$	$\%L^{max}$
Referee 46	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 47	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 48	2	7	0	0	33	66	50	75	0	0	50	75	40	60
Referee 49	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 50	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 51	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 52	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 53	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 54	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 55	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 56	3	5	0	0	0	25	50	75	0	25	50	75	40	60
Referee 57	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 58	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 59	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 60	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 61	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 62	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 63	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 64	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 65	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 66	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 67	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 68	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 69	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 70	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 71	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 72	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 73	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 74	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 75	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 76	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 77	3	4	0	0	0	0	33	66	33	66	50	75	40	60
Referee 78	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 79	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 80	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 81	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 82	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 83	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 84	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 85	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 86	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 87	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 88	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 89	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 90	4	2	0	0	0	0	33	66	66	100	50	75	40	60
Referee 91	4	2	0	0	0	0	33	66	66	100	50	75	40	60

Appendix B

Information about Games

An example of games, city of the local team, championship of the teams, round number and K_g are show in the table B.1 for the season 2010/2011.

The Serie A of Italian Volleyball Championships was divided in:

- Serie A1 Male with 14 teams and 26 rounds.
- Serie A1 Female with 12 teams and 22 rounds.
- Serie A2 Male with 16 teams and 30 rounds.
- Serie A2 Female with 14 teams and 26 rounds.

Table B.1: Games of season 2010/2011

Local Team	Guest Team	City	Championship	Round	Kg
ScavoliniPesaro	RisoScottiPavia	Pesaro	A1F	1	24
MCCarnaghiVillaCortese	Chateaud'AxUrbinoVolley	Castellanza	A1F	1	25
SpesConegliano	NordaFoppapedrettiBergamo	Conegliano	A1F	1	23
LIUJOVolleyModena	DesparPerugia	Modena	A1F	1	31
FlorensCastellanaGrotte	YamamayBustoArsizio	CastellanaGrotte	A1F	1	30
AsystelVolleyNovara	RebecchiNordmeccanicaPiacenza	Novara	A1F	1	18
SisleyTreviso	YogaForlì	Villorba	A1M	1	37
BreBancaLannuttiCuneo	RPALuigiBacchiitSanGiustino	Cuneo	A1M	1	37
CopraMorphoPiacenza	AcquaParadisoMonzaBrianza	Piacenza	A1M	1	33
ItasDiatecTrentino	BCCNEPCastellanaGrotte	Trento	A1M	1	30
LubeBancaMarcheMacerata	TonnoCallipoViboValentia	Macerata	A1M	1	32
AndreoliLatina	CasaModena	Latina	A1M	1	30
MRomaVolley	MarmiLanzaVerona	Roma	A1M	1	39
BancaRealeYoyogurtGiaveno	LavoroDocPontecagnano	Parma	A2F	1	6
BiancofornoSantaCroce	EssetiLoreto	Parma	A2F	1	6
RDMPomezia	FamilaGeneraliChieri	Parma	A2F	1	12
MasterGroupPanediMatera	DahliaTvBusnago	Parma	A2F	1	10
IcosCrema	Cedat85SanVito	Parma	A2F	1	5
FrigorcarniSoverato	VeronaVolleyFemminile	Parma	A2F	1	8
CariparmaSiGradeParma	InfotelForlì	Parma	A2F	1	8
CheBanca!Milano	CanadiensMantova	CiniselloBalsamo	A2M	1	15
PallavoloPineto	SirSafetyPerugia	Pineto	A2M	1	19
EnergyResourcesCariloLoreto	NGMMobileSCroce	Loreto	A2M	1	20
CarigeGenova	GloboBancaPopFrusinateSora	Genova	A2M	1	19
GeotecIsernia	EurogroupGela	Isernia	A2M	1	12
ClubItaliaAMRoma	MarcegagliaCMCRavenna	Bracciano	A2M	1	12
EdilesseConadReggioEmilia	PhytoPerformancePadova	ReggionellEmilia	A2M	1	18
VolleySegrate1978	GherardiSVICittàDiCastello	Segrate	A2M	1	18
RebecchiNordmeccanicaPiacenza	MCCarnaghiVillaCortese	Piacenza	A1F	2	26
Chateaud'AxUrbinoVolley	AsystelVolleyNovara	Urbino	A1F	2	26
RisoScottiPavia	SpesConegliano	Pavia	A1F	2	26
NordaFoppapedrettiBergamo	LIUJOVolleyModena	Bergamo	A1F	2	27
DesparPerugia	FlorensCastellanaGrotte	Perugia	A1F	2	25
YamamayBustoArsizio	ScavoliniPesaro	BustoArsizio	A1F	2	25
CasaModena	SisleyTreviso	Modena	A1M	2	38
YogaForlì	BreBancaLannuttiCuneo	Forlì	A1M	2	30
AcquaParadisoMonzaBrianza	LubeBancaMarcheMacerata	Monza	A1M	2	31
BCCNEPCastellanaGrotte	AndreoliLatina	CastellanaGrotte	A1M	2	34
MarmiLanzaVerona	CopraMorphoPiacenza	Verona	A1M	2	35
TonnoCallipoViboValentia	MRomaVolley	ViboValentia	A1M	2	35
RPALuigiBacchiitSanGiustino	ItasDiatecTrentino	SanGiustino	A1M	2	37
EssetiLoreto	CariparmaSiGradeParma	Loreto	A2F	2	7
FamilaGeneraliChieri	FrigorcarniSoverato	Chieri	A2F	2	7
DahliaTvBusnago	BiancofornoSantaCroce	Busnago	A2F	2	8
Cedat85SanVito	BancaRealeYoyogurtGiaveno	SanVitodeiNormanni	A2F	2	8
VeronaVolleyFemminile	RDMPomezia	Verona	A2F	2	5
LavoroDocPontecagnano	MasterGroupPanediMatera	Bellizzi	A2F	2	6
InfotelForlì	IcosCrema	Forlì	A2F	2	6
GherardiSVICittàDiCastello	CheBanca!Milano	CittàdiCastello	A2M	2	11
EurogroupGela	PallavoloPineto	Gela	A2M	2	19
GloboBancaPopFrusinateSora	EdilesseConadReggioEmilia	Frosinone	A2M	2	10
NGMMobileSCroce	VolleySegrate1978	SantaCrocesullArno	A2M	2	16
PhytoPerformancePadova	GeotecIsernia	Padova	A2M	2	11
MarcegagliaCMCRavenna	EnergyResourcesCariloLoreto	Ravenna	A2M	2	14
CanadiensMantova	ClubItaliaAMRoma	Mantova	A2M	2	22
SirSafetyPerugia	CarigeGenova	Perugia	A2M	2	13

Local Team	Guest Team	City	Championship	Round	Kg
ScavoliniPesaro	NordaFoppapedrettiBergamo	Pesaro	A1F	3	24
MCCarnaghiVillaCortese	DesparPerugia	Castellanza	A1F	3	21
RisoScottiPavia	AsystelVolleyNovara	Pavia	A1F	3	25
RebecchiNordmeccanicaPiacenza	YamamayBustoArsizio	Piacenza	A1F	3	26
SpesConegliano	Chateaud'AxUrbinoVolley	Conegliano	A1F	3	19
LIUJOVolleyModena	FlorensCastellanaGrotte	Modena	A1F	3	33
SisleyTreviso	BreBancaLannuttiCuneo	Villorba	A1M	3	40
BCCNEPCastellanaGrotte	MarmiLanzaVerona	CastellanaGrotte	A1M	3	38
ItasDiatecTrentino	AcquaParadisoMonzaBrianza	Trento	A1M	3	38
LubeBancaMarcheMacerata	RPALuigiBacchiitSanGiustino	Macerata	A1M	3	34
CopraMorphoPiacenza	CasaModena	Piacenza	A1M	3	31
MRomaVolley	YogaForlì	Roma	A1M	3	32
AndreoliLatina	TonnoCallipoViboValentia	Latina	A1M	3	36
CariparmaSiGradeParma	Cedat85SanVito	Parma	A2F	3	4
BiancofornoSantaCroce	FamilaGeneraliChieri	SantaCrocesullArno	A2F	3	12
FrigorcarniSoverato	DahliaTvBusnago	Soverato	A2F	3	3
IcosCrema	EssetiLoreto	Crema	A2F	3	9
BancaRealeYoyogurtGiaveno	InfotelForlì	Giaveno	A2F	3	8
MasterGroupPanediMatera	VeronaVolleyFemminile	Matera	A2F	3	5
RDMPomezia	LavoroDocPontecagnano	Pomezia	A2F	3	8
CheBanca!Milano	SirSafetyPerugia	CiniselloBalsamo	A2M	3	17
PallavoloPineto	PhytoPerformancePadova	Pineto	A2M	3	11
EnergyResourcesCariloLoreto	GloboBancaPopFrusinateSora	Loreto	A2M	3	18
CarigeGenova	NGMMobileSCroce	Genova	A2M	3	19
GeotecIsernia	CanadiensMantova	Isernia	A2M	3	11
VolleySegrate1978	MarcegagliaCMCRavenna	Segrate	A2M	3	11
ClubItaliaAMRoma	GherardiSVICittàDiCastello	Bracciano	A2M	3	12
EdilesseConadReggioEmilia	EurogroupGela	ReggionellEmilia	A2M	3	19
NordaFoppapedrettiBergamo	RebecchiNordmeccanicaPiacenza	Bergamo	A1F	4	24
AsystelVolleyNovara	MCCarnaghiVillaCortese	Novara	A1F	4	25
FlorensCastellanaGrotte	ScavoliniPesaro	CastellanaGrotte	A1F	4	21
DesparPerugia	RisoScottiPavia	Perugia	A1F	4	29
YamamayBustoArsizio	SpesConegliano	BustoArsizio	A1F	4	24
Chateaud'AxUrbinoVolley	LIUJOVolleyModena	Urbino	A1F	4	34
LubeBancaMarcheMacerata	ItasDiatecTrentino	Macerata	A1M	4	36
CasaModena	TonnoCallipoViboValentia	Modena	A1M	4	34
SisleyTreviso	CopraMorphoPiacenza	Villorba	A1M	4	31
BreBancaLannuttiCuneo	AndreoliLatina	Cuneo	A1M	4	37
AcquaParadisoMonzaBrianza	MRomaVolley	Monza	A1M	4	33
RPALuigiBacchiitSanGiustino	MarmiLanzaVerona	SanGiustino	A1M	4	33
YogaForlì	BCCNEPCastellanaGrotte	Forlì	A1M	4	35
BancaRealeYoyogurtGiaveno	MasterGroupPanediMatera	Giaveno	A2F	4	12
DahliaTvBusnago	FamilaGeneraliChieri	Busnago	A2F	4	13
Cedat85SanVito	BiancofornoSantaCroce	SanVitodeiNormanni	A2F	4	10
VeronaVolleyFemminile	CariparmaSiGradeParma	Verona	A2F	4	8
EssetiLoreto	FrigorcarniSoverato	Loreto	A2F	4	9
LavoroDocPontecagnano	IcosCrema	Bellizzi	A2F	4	11
InfotelForlì	RDMPomezia	Forlì	A2F	4	6
EurogroupGela	SirSafetyPerugia	Gela	A2M	4	23
GherardiSVICittàDiCastello	MarcegagliaCMCRavenna	CittàdiCastello	A2M	4	20
VolleySegrate1978	ClubItaliaAMRoma	Segrate	A2M	4	13
GeotecIsernia	NGMMobileSCroce	Isernia	A2M	4	14
PallavoloPineto	GloboBancaPopFrusinateSora	Pineto	A2M	4	14
PhytoPerformancePadova	CarigeGenova	Padova	A2M	4	15
CanadiensMantova	EdilesseConadReggioEmilia	Mantova	A2M	4	23
CheBanca!Milano	EnergyResourcesCariloLoreto	CiniselloBalsamo	A2M	4	18

Local Team	Guest Team	City	Championship	Round	Kg
ScavoliniPesaro	Chateaud'AxUrbinoVolley	Pesaro	A1F	5	27
MCCarnaghiVillaCortese	FlorensCastellanaGrotte	Castellanza	A1F	5	25
RisoScottiPavia	NordaFoppapedrettiBergamo	Pavia	A1F	5	31
SpesConegliano	AsystelVolleyNovara	Conegliano	A1F	5	31
RebecchiNordmeccanicaPiacenza	DesparPerugia	Piacenza	A1F	5	26
LIUJOVolleyModena	YamamayBustoArsizio	Modena	A1F	5	19
CopraMorphoPiacenza	AndreoliLatina	Piacenza	A1M	5	28
RPALuigiBacchiitSanGiustino	YogaForlì	SanGiustino	A1M	5	40
AcquaParadisoMonzaBrianza	BreBancaLannuttiCuneo	Monza	A1M	5	39
TonnoCallipoViboValentia	SisleyTreviso	ViboValentia	A1M	5	32
CasaModena	ItasDiatecTrentino	Modena	A1M	5	31
MarmiLanzaVerona	LubeBancaMarcheMacerata	Verona	A1M	5	35
BCCNEPCastellanaGrotte	MRomaVolley	CastellanaGrotte	A1M	5	34
FamilaGeneraliChieri	Cedat85SanVito	Chieri	A2F	5	7
DahliaTvBusnago	VeronaVolleyFemminile	Busnago	A2F	5	12
CariparmaSiGradeParma	LavoroDocPontecagnano	Parma	A2F	5	14
RDMPomezia	IcosCrema	Pomezia	A2F	5	8
FrigorcarniSoverato	BancaRealeYoyogurtGiaveno	Soverato	A2F	5	10
BiancofornoSantaCroce	InfotelForlì	SantaCrocesullArno	A2F	5	13
MasterGroupPanediMatera	EssetiLoreto	Matera	A2F	5	9
PhytoPerformancePadova	EurogroupGela	Padova	A2M	5	19
EdilesseConadReggioEmilia	VolleySegrate1978	ReggionellEmilia	A2M	5	20
SirSafetyPerugia	GherardiSVICittàDiCastello	Perugia	A2M	5	18
MarcegagliaCMCRavenna	CheBanca!Milano	Ravenna	A2M	5	13
CarigeGenova	EnergyResourcesCariloLoreto	Genova	A2M	5	20
ClubItaliaAMRoma	GeotecIsernia	Bracciano	A2M	5	17
GloboBancaPopFrusinateSora	CanadiensMantova	Frosinone	A2M	5	8
NGMMobileSCroce	PallavoloPineto	SantaCrocesullArno	A2M	5	12
DesparPerugia	NordaFoppapedrettiBergamo	Perugia	A1F	6	33
LIUJOVolleyModena	MCCarnaghiVillaCortese	Modena	A1F	6	25
AsystelVolleyNovara	ScavoliniPesaro	Novara	A1F	6	19
YamamayBustoArsizio	RisoScottiPavia	BustoArsizio	A1F	6	30
Chateaud'AxUrbinoVolley	RebecchiNordmeccanicaPiacenza	Urbino	A1F	6	27
FlorensCastellanaGrotte	SpesConegliano	CastellanaGrotte	A1F	6	24
BreBancaLannuttiCuneo	CasaModena	Cuneo	A1M	6	35
SisleyTreviso	AcquaParadisoMonzaBrianza	Villorba	A1M	6	38
LubeBancaMarcheMacerata	BCCNEPCastellanaGrotte	Macerata	A1M	6	38
CopraMorphoPiacenza	YogaForlì	Piacenza	A1M	6	35
MRomaVolley	RPALuigiBacchiitSanGiustino	Roma	A1M	6	33
AndreoliLatina	MarmiLanzaVerona	Latina	A1M	6	31
ItasDiatecTrentino	TonnoCallipoViboValentia	Trento	A1M	6	33
LavoroDocPontecagnano	Cedat85SanVito	Bellizzi	A2F	6	7
VeronaVolleyFemminile	BiancofornoSantaCroce	SanBonifacio	A2F	6	5
BancaRealeYoyogurtGiaveno	CariparmaSiGradeParma	Giaveno	A2F	6	8
MasterGroupPanediMatera	RDMPomezia	Matera	A2F	6	3
IcosCrema	FrigorcarniSoverato	Crema	A2F	6	11
InfotelForlì	FamilaGeneraliChieri	Forlì	A2F	6	10
EssetiLoreto	DahliaTvBusnago	Loreto	A2F	6	5
EnergyResourcesCariloLoreto	EdilesseConadReggioEmilia	Loreto	A2M	6	23
CanadiensMantova	PhytoPerformancePadova	Mantova	A2M	6	17
PallavoloPineto	MarcegagliaCMCRavenna	Pineto	A2M	6	17
GeotecIsernia	VolleySegrate1978	Isernia	A2M	6	18
GherardiSVICittàDiCastello	NGMMobileSCroce	CittàdiCastello	A2M	6	18
EurogroupGela	CarigeGenova	Gela	A2M	6	22
CheBanca!Milano	GloboBancaPopFrusinateSora	CiniselloBalsamo	A2M	6	20
SirSafetyPerugia	ClubItaliaAMRoma	Perugia	A2M	6	13

Local Team	Guest Team	City	Championship	Round	Kg
NordaFoppapedrettiBergamo	MCCarnaghiVillaCortese	Bergamo	A1F	7	20
SpesConegliano	LIUJOVolleyModena	Conegliano	A1F	7	25
YamamayBustoArsizio	AsystelVolleyNovara	BustoArsizio	A1F	7	30
ScavoliniPesaro	DesparPerugia	Pesaro	A1F	7	26
RisoScottiPavia	Chateaud'AxUrbinoVolley	Pavia	A1F	7	23
RebecchiNordmeccanicaPiacenza	FlorensCastellanaGrotte	Piacenza	A1F	7	30
AndreoliLatina	LubeBancaMarcheMacerata	Latina	A1M	7	34
YogaForlì	CasaModena	Forlì	A1M	7	37
MRomaVolley	ItasDiatecTrentino	Roma	A1M	7	36
TonnoCallipoViboValentia	BreBancaLannuttiCuneo	ViboValentia	A1M	7	35
MarmiLanzaVerona	SisleyTreviso	Verona	A1M	7	32
RPALuigiBacchiitSanGiustino	CopraMorphoPiacenza	SanGiustino	A1M	7	32
BCCNEPCastellanaGrotte	AcquaParadisoMonzaBrianza	CastellanaGrotte	A1M	7	31
CariparmaSiGradeParma	RDMPomezia	Parma	A2F	7	6
FrigorcarniSoverato	MasterGroupPanediMatera	Soverato	A2F	7	8
FamilaGeneraliChieri	IcosCrema	Chieri	A2F	7	10
BiancofornoSantaCroce	LavoroDocPontecagnano	SantaCrocesullArno	A2F	7	12
DahliaTvBusnago	InfotelForlì	Busnago	A2F	7	5
VeronaVolleyFemminile	BancaRealeYoyogurtGiaveno	Verona	A2F	7	6
Cedat85SanVito	EssetiLoreto	SanVitodeiNormanni	A2F	7	14
MarcegagliaCMCRavenna	EurogroupGela	Ravenna	A2M	7	13
GloboBancaPopFrusinateSora	GeotecIsernia	Frosinone	A2M	7	12
EnergyResourcesCariloLoreto	GherardiSVICittàDiCastello	Loreto	A2M	7	11
EdilesseConadReggioEmilia	PallavoloPineto	ReggionellEmilia	A2M	7	12
ClubItaliaAMRoma	PhytoPerformancePadova	Bracciano	A2M	7	17
NGMMobileSCroce	SirSafetyPerugia	SantaCrocesullArno	A2M	7	17
CarigeGenova	CanadiensMantova	Genova	A2M	7	11
VolleySegrate1978	CheBanca!Milano	Segrate	A2M	7	14
MCCarnaghiVillaCortese	ScavoliniPesaro	Castellanza	A1F	8	24
SpesConegliano	RebecchiNordmeccanicaPiacenza	Conegliano	A1F	8	29
LIUJOVolleyModena	RisoScottiPavia	Modena	A1F	8	23
FlorensCastellanaGrotte	NordaFoppapedrettiBergamo	CastellanaGrotte	A1F	8	32
AsystelVolleyNovara	DesparPerugia	Novara	A1F	8	32
Chateaud'AxUrbinoVolley	YamamayBustoArsizio	Urbino	A1F	8	31
CasaModena	LubeBancaMarcheMacerata	Modena	A1M	8	30
ItasDiatecTrentino	AndreoliLatina	Trento	A1M	8	33
TonnoCallipoViboValentia	YogaForlì	ViboValentia	A1M	8	35
BreBancaLannuttiCuneo	MRomaVolley	Cuneo	A1M	8	33
SisleyTreviso	RPALuigiBacchiitSanGiustino	Villorba	A1M	8	29
CopraMorphoPiacenza	BCCNEPCastellanaGrotte	Piacenza	A1M	8	33
AcquaParadisoMonzaBrianza	MarmiLanzaVerona	Monza	A1M	8	38
RDMPomezia	FrigorcarniSoverato	Pomezia	A2F	8	12
IcosCrema	CariparmaSiGradeParma	Crema	A2F	8	9
MasterGroupPanediMatera	FamilaGeneraliChieri	Matera	A2F	8	11
BancaRealeYoyogurtGiaveno	BiancofornoSantaCroce	Giaveno	A2F	8	11
LavoroDocPontecagnano	DahliaTvBusnago	Bellizzi	A2F	8	8
InfotelForlì	Cedat85SanVito	Forlì	A2F	8	8
EssetiLoreto	VeronaVolleyFemminile	Loreto	A2F	8	11
PallavoloPineto	GeotecIsernia	Pineto	A2M	8	11
PhytoPerformancePadova	GloboBancaPopFrusinateSora	Padova	A2M	8	12
MarcegagliaCMCRavenna	CarigeGenova	Ravenna	A2M	8	16
GherardiSVICittàDiCastello	EdilesseConadReggioEmilia	CittàdiCastello	A2M	8	16
CanadiensMantova	EnergyResourcesCariloLoreto	Mantova	A2M	8	14
EurogroupGela	NGMMobileSCroce	Gela	A2M	8	11
CheBanca!Milano	ClubItaliaAMRoma	CiniselloBalsamo	A2M	8	20
SirSafetyPerugia	VolleySegrate1978	Perugia	A2M	8	22

Local Team	Guest Team	City	Championship	Round	Kg
FlorensCastellanaGrotte	Chateaud'AxUrbinoVolley	CastellanaGrotte	A1F	9	22
RebecchiNordmeccanicaPiacenza	RisoScottiPavia	Piacenza	A1F	9	19
ScavoliniPesaro	LIUJOVolleyModena	Pesaro	A1F	9	29
NordaFoppapedrettiBergamo	AsystelVolleyNovara	Bergamo	A1F	9	30
MCCarnaghiVillaCortese	YamamayBustoArsizio	Castellanza	A1F	9	23
DesparPerugia	SpesConegliano	Perugia	A1F	9	30
LubeBancaMarcheMacerata	CopraMorphoPiacenza	Macerata	A1M	9	35
RPALuigiBacchiitSanGiustino	TonnoCallipoViboValentia	SanGiustino	A1M	9	35
AndreoliLatina	SisleyTreviso	Latina	A1M	9	34
BCCNEPCastellanaGrotte	BreBancaLannuttiCuneo	CastellanaGrotte	A1M	9	35
MRomaVolley	CasaModena	Roma	A1M	9	30
MarmiLanzaVerona	ItasDiatecTrentino	Verona	A1M	9	36
YogaForlì	AcquaParadisoMonzaBrianza	Forlì	A1M	9	33
FrigorcarniSoverato	CariparmaSiGradeParma	Soverato	A2F	9	13
FamilaGeneraliChieri	LavoroDocPontecagnano	Chieri	A2F	9	9
DahliaTvBusnago	IcosCrema	Busnago	A2F	9	9
BiancofornoSantaCroce	MasterGroupPanediMatera	SantaCrocesullArno	A2F	9	5
EssetiLoreto	BancaRealeYoyogurtGiaveno	Loreto	A2F	9	5
Cedat85SanVito	RDMPomezia	SanVitodeiNormanni	A2F	9	8
VeronaVolleyFemminile	InfotelForlì	SanBonifacio	A2F	9	10
GeotecIsernia	CheBanca!Milano	Isernia	A2M	9	14
GloboBancaPopFrusinateSora	MarcegagliaCMCRavenna	Frosinone	A2M	9	20
EnergyResourcesCariloLoreto	PallavoloPineto	Loreto	A2M	9	16
NGMMobileSCroce	PhytoPerformancePadova	SantaCrocesullArno	A2M	9	21
CarigeGenova	GherardiSVICittàDiCastello	Genova	A2M	9	15
EdilesseConadReggioEmilia	SirSafetyPerugia	ReggionellEmilia	A2M	9	15
ClubItaliaAMRoma	EurogroupGela	Bracciano	A2M	9	18
VolleySegrate1978	CanadiensMantova	Segrate	A2M	9	16
RisoScottiPavia	MCCarnaghiVillaCortese	Pavia	A1F	10	25
Chateaud'AxUrbinoVolley	NordaFoppapedrettiBergamo	Urbino	A1F	10	30
AsystelVolleyNovara	FlorensCastellanaGrotte	Novara	A1F	10	27
SpesConegliano	ScavoliniPesaro	Conegliano	A1F	10	26
YamamayBustoArsizio	DesparPerugia	BustoArsizio	A1F	10	20
RebecchiNordmeccanicaPiacenza	LIUJOVolleyModena	Piacenza	A1F	10	27
ItasDiatecTrentino	CopraMorphoPiacenza	Trento	A1M	10	33
CasaModena	RPALuigiBacchiitSanGiustino	Modena	A1M	10	31
BreBancaLannuttiCuneo	LubeBancaMarcheMacerata	Cuneo	A1M	10	37
SisleyTreviso	MRomaVolley	Villorba	A1M	10	34
AcquaParadisoMonzaBrianza	AndreoliLatina	Monza	A1M	10	32
YogaForlì	MarmiLanzaVerona	Forlì	A1M	10	32
TonnoCallipoViboValentia	BCCNEPCastellanaGrotte	ViboValentia	A1M	10	30
CariparmaSiGradeParma	FamilaGeneraliChieri	Parma	A2F	10	9
FrigorcarniSoverato	Cedat85SanVito	Soverato	A2F	10	7
IcosCrema	BiancofornoSantaCroce	Crema	A2F	10	2
BancaRealeYoyogurtGiaveno	DahliaTvBusnago	Giaveno	A2F	10	8
LavoroDocPontecagnano	VeronaVolleyFemminile	Bellizzi	A2F	10	6
RDMPomezia	EssetiLoreto	Pomezia	A2F	10	7
MasterGroupPanediMatera	InfotelForlì	Matera	A2F	10	10
PallavoloPineto	ClubItaliaAMRoma	Pineto	A2M	10	10
GherardiSVICittàDiCastello	GeotecIsernia	CittàdiCastello	A2M	10	10
MarcegagliaCMCRavenna	EdilesseConadReggioEmilia	Ravenna	A2M	10	12
PhytoPerformancePadova	VolleySegrate1978	Padova	A2M	10	12
EurogroupGela	EnergyResourcesCariloLoreto	Gela	A2M	10	18
SirSafetyPerugia	GloboBancaPopFrusinateSora	Perugia	A2M	10	22
CanadiensMantova	NGMMobileSCroce	Mantova	A2M	10	17
CheBanca!Milano	CarigeGenova	CiniselloBalsamo	A2M	10	16

Local Team	Guest Team	City	Championship	Round	Kg
ScavoliniPesaro	RebecchiNordmeccanicaPiacenza	Pesaro	A1F	11	27
MCCarnaghiVillaCortese	SpesConegliano	Castellanza	A1F	11	28
YamamayBustoArsizio	NordaFoppapedrettiBergamo	BustoArsizio	A1F	11	32
DesparPerugia	Chateaud'AxUrbinoVolley	Perugia	A1F	11	23
LIUJOVolleyModena	AsystelVolleyNovara	Modena	A1F	11	26
FlorensCastellanaGrotte	RisoScottiPavia	CastellanaGrotte	A1F	11	26
ItasDiatecTrentino	SisleyTreviso	Trento	A1M	11	35
LubeBancaMarcheMacerata	MRomaVolley	Macerata	A1M	11	34
MarmiLanzaVerona	BreBancaLannuttiCuneo	Verona	A1M	11	39
CopraMorphoPiacenza	TonnoCallipoViboValentia	Piacenza	A1M	11	33
AndreoliLatina	YogaForlì	Latina	A1M	11	37
BCCNEPCastellanaGrotte	CasaModena	CastellanaGrotte	A1M	11	40
AcquaParadisoMonzaBrianza	RPALuigiBacchiitSanGiustino	Monza	A1M	11	31
FamilaGeneraliChieri	BancaRealeYoyogurtGiaveno	Chieri	A2F	11	12
Cedat85SanVito	MasterGroupPanediMatera	SanVitodeiNormanni	A2F	11	9
IcosCrema	VeronaVolleyFemminile	Crema	A2F	11	12
LavoroDocPontecagnano	FrigorcarniSoverato	Bellizzi	A2F	11	12
InfotelForlì	EssetiLoreto	Forlì	A2F	11	7
CariparmaSiGradeParma	DahliaTvBusnago	Parma	A2F	11	14
RDMPomezia	BiancofornoSantaCroce	Pomezia	A2F	11	6
GherardiSVICittàDiCastello	CanadiensMantova	CittàdiCastello	A2M	11	16
GloboBancaPopFrusinateSora	ClubItaliaAMRoma	Frosinone	A2M	11	11
GeotecIsernia	SirSafetyPerugia	Isernia	A2M	11	17
CarigeGenova	PallavoloPineto	Genova	A2M	11	12
EnergyResourcesCariloLoreto	PhytoPerformancePadova	Loreto	A2M	11	19
NGMMobileSCroce	MarcegagliaCMCRavenna	SantaCrocesullArno	A2M	11	15
EdilesseConadReggioEmilia	CheBanca!Milano	ReggionellEmilia	A2M	11	15
VolleySegrate1978	EurogroupGela	Segrate	A2M	11	11
RisoScottiPavia	ScavoliniPesaro	Pavia	A1F	12	25
Chateaud'AxUrbinoVolley	MCCarnaghiVillaCortese	Urbino	A1F	12	22
NordaFoppapedrettiBergamo	SpesConegliano	Bergamo	A1F	12	22
DesparPerugia	LIUJOVolleyModena	Perugia	A1F	12	27
YamamayBustoArsizio	FlorensCastellanaGrotte	BustoArsizio	A1F	12	32
RebecchiNordmeccanicaPiacenza	AsystelVolleyNovara	Piacenza	A1F	12	27
SisleyTreviso	LubeBancaMarcheMacerata	Villorba	A1M	12	36
BreBancaLannuttiCuneo	CopraMorphoPiacenza	Cuneo	A1M	12	34
MRomaVolley	AndreoliLatina	Roma	A1M	12	38
YogaForlì	ItasDiatecTrentino	Forlì	A1M	12	33
CasaModena	MarmiLanzaVerona	Modena	A1M	12	33
TonnoCallipoViboValentia	AcquaParadisoMonzaBrianza	ViboValentia	A1M	12	34
RPALuigiBacchiitSanGiustino	BCCNEPCastellanaGrotte	SanGiustino	A1M	12	36
VeronaVolleyFemminile	Cedat85SanVito	Verona	A2F	12	4
BancaRealeYoyogurtGiaveno	IcosCrema	Giaveno	A2F	12	7
MasterGroupPanediMatera	CariparmaSiGradeParma	Matera	A2F	12	12
BiancofornoSantaCroce	FrigorcarniSoverato	SantaCrocesullArno	A2F	12	6
EssetiLoreto	FamilaGeneraliChieri	Loreto	A2F	12	13
DahliaTvBusnago	RDMPomezia	Busnago	A2F	12	6
InfotelForlì	LavoroDocPontecagnano	Forlì	A2F	12	11
PhytoPerformancePadova	GherardiSVICittàDiCastello	Padova	A2M	12	10
MarcegagliaCMCRavenna	CanadiensMantova	Ravenna	A2M	12	17
ClubItaliaAMRoma	EdilesseConadReggioEmilia	Bracciano	A2M	12	15
CarigeGenova	GeotecIsernia	Genova	A2M	12	13
PallavoloPineto	VolleySegrate1978	Pineto	A2M	12	21
SirSafetyPerugia	EnergyResourcesCariloLoreto	Perugia	A2M	12	18
EurogroupGela	GloboBancaPopFrusinateSora	Gela	A2M	12	17
CheBanca!Milano	NGMMobileSCroce	CiniselloBalsamo	A2M	12	15

Local Team	Guest Team	City	Championship	Round	Kg
MCCarnaghiVillaCortese	RebecchiNordmeccanicaPiacenza	Castellanza	A1F	13	21
AsystelVolleyNovara	Chateaud'AxUrbinoVolley	Novara	A1F	13	29
SpesConegliano	RisoScottiPavia	Conegliano	A1F	13	30
LIUJOVolleyModena	NordaFoppapedrettiBergamo	Modena	A1F	13	23
FlorensCastellanaGrotte	DesparPerugia	CastellanaGrotte	A1F	13	25
ScavoliniPesaro	YamamayBustoArsizio	Pesaro	A1F	13	27
ItasDiatecTrentino	BreBancaLannuttiCuneo	Trento	A1M	13	32
CopraMorphoPiacenza	MRomaVolley	Piacenza	A1M	13	32
BCCNEPCastellanaGrotte	SisleyTreviso	CastellanaGrotte	A1M	13	39
LubeBancaMarcheMacerata	YogaForlì	Macerata	A1M	13	38
AndreoliLatina	RPALuigiBacchiitSanGiustino	Latina	A1M	13	32
AcquaParadisoMonzaBrianza	CasaModena	Monza	A1M	13	32
MarmiLanzaVerona	TonnoCallipoViboValentia	Verona	A1M	13	35
Cedat85SanVito	DahliaTvBusnago	SanVitodeiNormanni	A2F	13	4
CariparmaSiGradeParma	BiancofornoSantaCroce	Parma	A2F	13	4
FamilaGeneraliChieri	VeronaVolleyFemminile	Chieri	A2F	13	11
RDMPomezia	BancaRealeYoyogurtGiaveno	Pomezia	A2F	13	6
IcosCrema	MasterGroupPanediMatera	Crema	A2F	13	9
LavoroDocPontecagnano	EssetiLoreto	Bellizzi	A2F	13	11
FrigorcarniSoverato	0	Soverato	A2F	13	9
SirSafetyPerugia	PhytoPerformancePadova	Perugia	A2M	13	12
EnergyResourcesCariloLoreto	VolleySegrate1978	Loreto	A2M	13	19
ClubItaliaAMRoma	CarigeGenova	Bracciano	A2M	13	18
EurogroupGela	CheBanca!Milano	Gela	A2M	13	14
CanadiensMantova	PallavoloPineto	Mantova	A2M	13	10
NGMMobileSCroce	EdilesseConadReggioEmilia	SantaCrocesullArno	A2M	13	13
GeotecIsernia	MarcegagliaCMCRavenna	Isernia	A2M	13	15
GloboBancaPopFrusinateSora	GherardiSVICittàDiCastello	Frosinone	A2M	13	10
NordaFoppapedrettiBergamo	ScavoliniPesaro	Bergamo	A1F	14	25
DesparPerugia	MCCarnaghiVillaCortese	Perugia	A1F	14	24
AsystelVolleyNovara	RisoScottiPavia	Novara	A1F	14	21
YamamayBustoArsizio	RebecchiNordmeccanicaPiacenza	BustoArsizio	A1F	14	28
Chateaud'AxUrbinoVolley	SpesConegliano	Urbino	A1F	14	27
FlorensCastellanaGrotte	LIUJOVolleyModena	CastellanaGrotte	A1F	14	32
YogaForlì	SisleyTreviso	Forlì	A1M	14	32
RPALuigiBacchiitSanGiustino	BreBancaLannuttiCuneo	SanGiustino	A1M	14	36
AcquaParadisoMonzaBrianza	CopraMorphoPiacenza	Monza	A1M	14	36
BCCNEPCastellanaGrotte	ItasDiatecTrentino	CastellanaGrotte	A1M	14	35
TonnoCallipoViboValentia	LubeBancaMarcheMacerata	ViboValentia	A1M	14	31
CasaModena	AndreoliLatina	Modena	A1M	14	33
MarmiLanzaVerona	MRomaVolley	Verona	A1M	14	35
LavoroDocPontecagnano	BancaRealeYoyogurtGiaveno	Bellizzi	A2F	14	9
EssetiLoreto	BiancofornoSantaCroce	Loreto	A2F	14	12
FamilaGeneraliChieri	RDMPomezia	Chieri	A2F	14	12
DahliaTvBusnago	MasterGroupPanediMatera	Busnago	A2F	14	3
Cedat85SanVito	IcosCrema	SanVitodeiNormanni	A2F	14	10
VeronaVolleyFemminile	FrigorcarniSoverato	Verona	A2F	14	10
InfotelForlì	CariparmaSiGradeParma	Forlì	A2F	14	13
CheBanca!Milano	PallavoloPineto	CiniselloBalsamo	A2M	14	18
GherardiSVICittàDiCastello	EurogroupGela	CittàdiCastello	A2M	14	14
MarcegagliaCMCRavenna	PhytoPerformancePadova	Ravenna	A2M	14	18
CanadiensMantova	SirSafetyPerugia	Mantova	A2M	14	20
EdilesseConadReggioEmilia	CarigeGenova	ReggionellEmilia	A2M	14	17
VolleySegrate1978	GloboBancaPopFrusinateSora	Segrate	A2M	14	16
NGMMobileSCroce	ClubItaliaAMRoma	SantaCrocesullArno	A2M	14	16
EnergyResourcesCariloLoreto	GeotecIsernia	Loreto	A2M	14	13

Local Team	Guest Team	City	Championship	Round	Kg
RebecchiNordmeccanicaPiacenza	NordaFoppapedrettiBergamo	Piacenza	A1F	15	29
MCCarnaghiVillaCortese	AsystelVolleyNovara	Castellanza	A1F	15	23
ScavoliniPesaro	FlorensCastellanaGrotte	Pesaro	A1F	15	21
RisoScottiPavia	DesparPerugia	Pavia	A1F	15	24
SpesConegliano	YamamayBustoArsizio	Conegliano	A1F	15	22
LIUJOVolleyModena	Chateaud'AxUrbinoVolley	Modena	A1F	15	23
SisleyTreviso	CasaModena	Villorba	A1M	15	37
BreBancaLannuttiCuneo	YogaForlì	Cuneo	A1M	15	33
LubeBancaMarcheMacerata	AcquaParadisoMonzaBrianza	Macerata	A1M	15	37
AndreoliLatina	BCCNEPCastellanaGrotte	Latina	A1M	15	37
CopraMorphoPiacenza	MarmiLanzaVerona	Piacenza	A1M	15	35
MRomaVolley	TonnoCallipoViboValentia	Roma	A1M	15	31
ItasDiatecTrentino	RPALuigiBacchiitSanGiustino	Trento	A1M	15	38
CariparmaSiGradeParma	EssetiLoreto	Parma	A2F	15	8
FrigorcarniSoverato	FamilaGeneraliChieri	Soverato	A2F	15	8
BiancofornoSantaCroce	DahliaTvBusnago	SantaCrocesullArno	A2F	15	13
BancaRealeYoyogurtGiaveno	Cedat85SanVito	Giaveno	A2F	15	4
RDMPomezia	VeronaVolleyFemminile	Pomezia	A2F	15	7
MasterGroupPanediMatera	LavoroDocPontecagnano	Matera	A2F	15	5
IcosCrema	InfotelForlì	Crema	A2F	15	9
GloboBancaPopFrusinateSora	NGMMobileSCroce	Frosinone	A2M	15	8
PhytoPerformancePadova	CheBanca!Milano	Padova	A2M	15	20
PallavoloPineto	GherardiSVICittàDiCastello	Pineto	A2M	15	21
EurogroupGela	CanadiensMantova	Gela	A2M	15	13
SirSafetyPerugia	MarcegagliaCMCRavenna	Perugia	A2M	15	21
ClubItaliaAMRoma	EnergyResourcesCariloLoreto	Bracciano	A2M	15	13
CarigeGenova	VolleySegrate1978	Genova	A2M	15	21
GeotecIsernia	EdilesseConadReggioEmilia	Isernia	A2M	15	16
Chateaud'AxUrbinoVolley	ScavoliniPesaro	Urbino	A1F	16	28
FlorensCastellanaGrotte	MCCarnaghiVillaCortese	CastellanaGrotte	A1F	16	29
NordaFoppapedrettiBergamo	RisoScottiPavia	Bergamo	A1F	16	24
AsystelVolleyNovara	SpesConegliano	Novara	A1F	16	20
DesparPerugia	RebecchiNordmeccanicaPiacenza	Perugia	A1F	16	24
YamamayBustoArsizio	LIUJOVolleyModena	BustoArsizio	A1F	16	22
BreBancaLannuttiCuneo	SisleyTreviso	Cuneo	A1M	16	34
MarmiLanzaVerona	BCCNEPCastellanaGrotte	Verona	A1M	16	38
AcquaParadisoMonzaBrianza	ItasDiatecTrentino	Monza	A1M	16	40
RPALuigiBacchiitSanGiustino	LubeBancaMarcheMacerata	SanGiustino	A1M	16	38
CasaModena	CopraMorphoPiacenza	Modena	A1M	16	35
YogaForlì	MRomaVolley	Forlì	A1M	16	35
TonnoCallipoViboValentia	AndreoliLatina	ViboValentia	A1M	16	35
Cedat85SanVito	CariparmaSiGradeParma	SanVitodeiNormanni	A2F	16	7
FamilaGeneraliChieri	BiancofornoSantaCroce	Chieri	A2F	16	7
DahliaTvBusnago	FrigorcarniSoverato	Busnago	A2F	16	5
EssetiLoreto	IcosCrema	Loreto	A2F	16	8
InfotelForlì	BancaRealeYoyogurtGiaveno	Forlì	A2F	16	12
VeronaVolleyFemminile	MasterGroupPanediMatera	Verona	A2F	16	11
LavoroDocPontecagnano	RDMPomezia	Bellizzi	A2F	16	5
CanadiensMantova	CheBanca!Milano	Mantova	A2M	16	17
SirSafetyPerugia	PallavoloPineto	Perugia	A2M	16	18
NGMMobileSCroce	EnergyResourcesCariloLoreto	SantaCrocesullArno	A2M	16	23
GloboBancaPopFrusinateSora	CarigeGenova	Frosinone	A2M	16	14
EurogroupGela	GeotecIsernia	Gela	A2M	16	9
MarcegagliaCMCRavenna	ClubItaliaAMRoma	Ravenna	A2M	16	14
PhytoPerformancePadova	EdilesseConadReggioEmilia	Padova	A2M	16	10
GherardiSVICittàDiCastello	VolleySegrate1978	CittàdiCastello	A2M	16	16

Local Team	Guest Team	City	Championship	Round	Kg
NordaFoppapedrettiBergamo	DesparPerugia	Bergamo	A1F	17	32
MCCarnaghiVillaCortese	LIUJOVolleyModena	Castellanza	A1F	17	25
ScavoliniPesaro	AsystelVolleyNovara	Pesaro	A1F	17	29
RisoScottiPavia	YamamayBustoArsizio	Pavia	A1F	17	28
RebecchiNordmeccanicaPiacenza	Chateaud'AxUrbinoVolley	Piacenza	A1F	17	29
SpesConegliano	FlorensCastellanaGrotte	Belluno	A1F	17	23
ItasDiatecTrentino	LubeBancaMarcheMacerata	Trento	A1M	17	34
TonnoCallipoViboValentia	CasaModena	ViboValentia	A1M	17	38
CopraMorphoPiacenza	SisleyTreviso	Piacenza	A1M	17	31
AndreoliLatina	BreBancaLannuttiCuneo	Latina	A1M	17	31
MRomaVolley	AcquaParadisoMonzaBrianza	Roma	A1M	17	33
MarmiLanzaVerona	RPALuigiBacchiitSanGiustino	Verona	A1M	17	37
BCCNEPCastellanaGrotte	YogaForlì	CastellanaGrotte	A1M	17	37
MasterGroupPanediMatera	BancaRealeYoyogurtGiaveno	Matera	A2F	17	9
FamilaGeneraliChieri	DahliaTvBusnago	Chieri	A2F	17	10
BiancofornoSantaCroce	Cedat85SanVito	SantaCrocesullArno	A2F	17	5
CariparmaSiGradeParma	VeronaVolleyFemminile	Parma	A2F	17	9
FrigorcarniSoverato	EssetiLoreto	Soverato	A2F	17	11
IcosCrema	LavoroDocPontecagnano	Crema	A2F	17	3
RDMPomezia	InfotelForlì	Pomezia	A2F	17	6
CheBanca!Milano	GherardiSVICittàDiCastello	CiniselloBalsamo	A2M	17	13
PallavoloPineto	EurogroupGela	Pineto	A2M	17	15
EdilesseConadReggioEmilia	GloboBancaPopFrusinateSora	ReggionellEmilia	A2M	17	19
VolleySegrate1978	NGMMobileSCroce	Segrate	A2M	17	16
GeotecIsernia	PhytoPerformancePadova	Isernia	A2M	17	13
EnergyResourcesCariloLoreto	MarcegagliaCMCRavenna	Loreto	A2M	17	19
ClubItaliaAMRoma	CanadiensMantova	Bracciano	A2M	17	19
CarigeGenova	SirSafetyPerugia	Genova	A2M	17	14
MCCarnaghiVillaCortese	NordaFoppapedrettiBergamo	Castellanza	A1F	18	32
LIUJOVolleyModena	SpesConegliano	Modena	A1F	18	23
AsystelVolleyNovara	YamamayBustoArsizio	Novara	A1F	18	20
DesparPerugia	ScavoliniPesaro	Perugia	A1F	18	20
Chateaud'AxUrbinoVolley	RisoScottiPavia	Urbino	A1F	18	26
FlorensCastellanaGrotte	RebecchiNordmeccanicaPiacenza	CastellanaGrotte	A1F	18	19
AndreoliLatina	CopraMorphoPiacenza	Latina	A1M	18	32
YogaForlì	RPALuigiBacchiitSanGiustino	Forlì	A1M	18	37
BreBancaLannuttiCuneo	AcquaParadisoMonzaBrianza	Cuneo	A1M	18	38
SisleyTreviso	TonnoCallipoViboValentia	Villorba	A1M	18	38
ItasDiatecTrentino	CasaModena	Trento	A1M	18	32
LubeBancaMarcheMacerata	MarmiLanzaVerona	Macerata	A1M	18	35
MRomaVolley	BCCNEPCastellanaGrotte	Roma	A1M	18	32
Cedat85SanVito	FamilaGeneraliChieri	SanVitodeiNormanni	A2F	18	6
VeronaVolleyFemminile	DahliaTvBusnago	Verona	A2F	18	11
LavoroDocPontecagnano	CariparmaSiGradeParma	Bellizzi	A2F	18	12
IcosCrema	RDMPomezia	Crema	A2F	18	6
BancaRealeYoyogurtGiaveno	FrigorcarniSoverato	Giaveno	A2F	18	7
InfotelForlì	BiancofornoSantaCroce	Forlì	A2F	18	9
EssetiLoreto	MasterGroupPanediMatera	Loreto	A2F	18	11
SirSafetyPerugia	CheBanca!Milano	Perugia	A2M	18	21
PhytoPerformancePadova	PallavoloPineto	Padova	A2M	18	12
GloboBancaPopFrusinateSora	EnergyResourcesCariloLoreto	Frosinone	A2M	18	16
NGMMobileSCroce	CarigeGenova	SantaCrocesullArno	A2M	18	20
CanadiensMantova	GeotecIsernia	Mantova	A2M	18	16
MarcegagliaCMCRavenna	VolleySegrate1978	Ravenna	A2M	18	13
GherardiSVICittàDiCastello	ClubItaliaAMRoma	CittàdiCastello	A2M	18	14
EurogroupGela	EdilesseConadReggioEmilia	Gela	A2M	18	11

Local Team	Guest Team	City	Championship	Round	Kg
ScavoliniPesaro	MCCarnaghiVillaCortese	Pesaro	A1F	19	30
RebecchiNordmeccanicaPiacenza	SpesConegliano	Piacenza	A1F	19	20
RisoScottiPavia	LIUJOVolleyModena	Pavia	A1F	19	19
NordaFoppapedrettiBergamo	FlorensCastellanaGrotte	Bergamo	A1F	19	31
DesparPerugia	AsystelVolleyNovara	Perugia	A1F	19	24
YamamayBustoArsizio	Chateaud'AxUrbinoVolley	BustoArsizio	A1F	19	29
CasaModena	BreBancaLannuttiCuneo	Modena	A1M	19	32
AcquaParadisoMonzaBrianza	SisleyTreviso	Monza	A1M	19	36
BCCNEPCastellanaGrotte	LubeBancaMarcheMacerata	CastellanaGrotte	A1M	19	36
YogaForlì	CopraMorphoPiacenza	Forlì	A1M	19	37
RPALuigiBacchiitSanGiustino	MRomaVolley	SanGiustino	A1M	19	32
MarmiLanzaVerona	AndreoliLatina	Verona	A1M	19	28
TonnoCallipoViboValentia	ItasDiatecTrentino	ViboValentia	A1M	19	34
Cedat85SanVito	LavoroDocPontecagnano	SanVitodeiNormanni	A2F	19	6
BiancofornoSantaCroce	VeronaVolleyFemminile	SantaCrocesullArno	A2F	19	14
CariparmaSiGradeParma	BancaRealeYoyogurtGiaveno	Parma	A2F	19	12
RDMPomezia	MasterGroupPanediMatera	Pomezia	A2F	19	11
FrigorcarniSoverato	IcosCrema	Soverato	A2F	19	12
FamilaGeneraliChieri	InfotelForlì	Chieri	A2F	19	8
DahliaTvBusnago	EssetiLoreto	Busnago	A2F	19	7
SirSafetyPerugia	EurogroupGela	Perugia	A2M	19	17
MarcegagliaCMCRavenna	GherardiSVICittàDiCastello	Ravenna	A2M	19	10
ClubItaliaAMRoma	VolleySegrate1978	Bracciano	A2M	19	16
NGMMobileSCroce	GeotecIsernia	SantaCrocesullArno	A2M	19	19
GloboBancaPopFrusinateSora	PallavoloPineto	Frosinone	A2M	19	16
CarigeGenova	PhytoPerformancePadova	Genova	A2M	19	15
EdilesseConadReggioEmilia	CanadiensMantova	ReggionellEmilia	A2M	19	8
EnergyResourcesCariloLoreto	CheBanca!Milano	Loreto	A2M	19	14
Chateaud'AxUrbinoVolley	FlorensCastellanaGrotte	Urbino	A1F	20	21
RisoScottiPavia	RebecchiNordmeccanicaPiacenza	Pavia	A1F	20	27
LIUJOVolleyModena	ScavoliniPesaro	Modena	A1F	20	30
AsystelVolleyNovara	NordaFoppapedrettiBergamo	Novara	A1F	20	21
YamamayBustoArsizio	MCCarnaghiVillaCortese	BustoArsizio	A1F	20	31
SpesConegliano	DesparPerugia	Conegliano	A1F	20	23
LubeBancaMarcheMacerata	AndreoliLatina	Macerata	A1M	20	32
CasaModena	YogaForlì	Modena	A1M	20	40
ItasDiatecTrentino	MRomaVolley	Trento	A1M	20	31
BreBancaLannuttiCuneo	TonnoCallipoViboValentia	Cuneo	A1M	20	35
SisleyTreviso	MarmiLanzaVerona	Villorba	A1M	20	36
CopraMorphoPiacenza	RPALuigiBacchiitSanGiustino	Piacenza	A1M	20	29
AcquaParadisoMonzaBrianza	BCCNEPCastellanaGrotte	Monza	A1M	20	38
RDMPomezia	CariparmaSiGradeParma	Pomezia	A2F	20	4
MasterGroupPanediMatera	FrigorcarniSoverato	Matera	A2F	20	9
IcosCrema	FamilaGeneraliChieri	Crema	A2F	20	11
LavoroDocPontecagnano	BiancofornoSantaCroce	Bellizzi	A2F	20	9
InfotelForlì	DahliaTvBusnago	Forlì	A2F	20	3
BancaRealeYoyogurtGiaveno	VeronaVolleyFemminile	Giaveno	A2F	20	8
EssetiLoreto	Cedat85SanVito	Loreto	A2F	20	11
EurogroupGela	PhytoPerformancePadova	Gela	A2M	20	17
VolleySegrate1978	EdilesseConadReggioEmilia	Segrate	A2M	20	22
GherardiSVICittàDiCastello	SirSafetyPerugia	CittàdiCastello	A2M	20	17
CheBanca!Milano	MarcegagliaCMCRavenna	CiniselloBalsamo	A2M	20	13
EnergyResourcesCariloLoreto	CarigeGenova	Loreto	A2M	20	20
GeotecIsernia	ClubItaliaAMRoma	Isernia	A2M	20	18
CanadiensMantova	GloboBancaPopFrusinateSora	Mantova	A2M	20	21
PallavoloPineto	NGMMobileSCroce	Pineto	A2M	20	12

Local Team	Guest Team	City	Championship	Round	Kg
MCCarnaghiVillaCortese	RisoScottiPavia	Castellanza	A1F	21	24
NordaFoppapedrettiBergamo	Chateaud'AxUrbinoVolley	Bergamo	A1F	21	33
FlorensCastellanaGrotte	AsystelVolleyNovara	CastellanaGrotte	A1F	21	25
ScavoliniPesaro	SpesConegliano	Pesaro	A1F	21	26
DesparPerugia	YamamayBustoArsizio	Perugia	A1F	21	20
LIUJOVolleyModena	RebecchiNordmeccanicaPiacenza	Modena	A1F	21	26
LubeBancaMarcheMacerata	CasaModena	Macerata	A1M	21	34
AndreoliLatina	ItasDiatecTrentino	Latina	A1M	21	39
YogaForlì	TonnoCallipoViboValentia	Forlì	A1M	21	36
MRomaVolley	BreBancaLannuttiCuneo	Roma	A1M	21	32
RPALuigiBacchiitSanGiustino	SisleyTreviso	SanGiustino	A1M	21	29
BCCNEPCastellanaGrotte	CopraMorphoPiacenza	CastellanaGrotte	A1M	21	31
MarmiLanzaVerona	AcquaParadisoMonzaBrianza	Verona	A1M	21	32
FrigorcarniSoverato	RDMPomezia	Soverato	A2F	21	2
CariparmaSiGradeParma	IcosCrema	Parma	A2F	21	5
FamilaGeneraliChieri	MasterGroupPanediMatera	Chieri	A2F	21	8
BiancofornoSantaCroce	BancaRealeYoyogurtGiaveno	SantaCrocesullArno	A2F	21	9
DahliaTvBusnago	LavoroDocPontecagnano	Busnago	A2F	21	6
Cedat85SanVito	InfotelForlì	SanVitodeiNormanni	A2F	21	9
VeronaVolleyFemminile	EssetiLoreto	Verona	A2F	21	8
EdilesseConadReggioEmilia	EnergyResourcesCariloLoreto	ReggionellEmilia	A2M	21	14
PhytoPerformancePadova	CanadiensMantova	Padova	A2M	21	18
MarcegagliaCMCRavenna	PallavoloPineto	Ravenna	A2M	21	9
VolleySegrate1978	GeotecIsernia	Segrate	A2M	21	9
NGMMobileSCroce	GherardiSVICittàDiCastello	SantaCrocesullArno	A2M	21	19
CarigeGenova	EurogroupGela	Genova	A2M	21	21
GloboBancaPopFrusinateSora	CheBanca!Milano	Frosinone	A2M	21	8
ClubItaliaAMRoma	SirSafetyPerugia	Bracciano	A2M	21	14
RebecchiNordmeccanicaPiacenza	ScavoliniPesaro	Piacenza	A1F	22	23
SpesConegliano	MCCarnaghiVillaCortese	Conegliano	A1F	22	27
NordaFoppapedrettiBergamo	YamamayBustoArsizio	Bergamo	A1F	22	18
Chateaud'AxUrbinoVolley	DesparPerugia	Urbino	A1F	22	23
AsystelVolleyNovara	LIUJOVolleyModena	Novara	A1F	22	27
RisoScottiPavia	FlorensCastellanaGrotte	Pavia	A1F	22	24
CopraMorphoPiacenza	LubeBancaMarcheMacerata	Piacenza	A1M	22	36
TonnoCallipoViboValentia	RPALuigiBacchiitSanGiustino	ViboValentia	A1M	22	33
SisleyTreviso	AndreoliLatina	Villorba	A1M	22	34
BreBancaLannuttiCuneo	BCCNEPCastellanaGrotte	Cuneo	A1M	22	32
CasaModena	MRomaVolley	Modena	A1M	22	28
ItasDiatecTrentino	MarmiLanzaVerona	Trento	A1M	22	33
AcquaParadisoMonzaBrianza	YogaForlì	Monza	A1M	22	34
CariparmaSiGradeParma	FrigorcarniSoverato	Parma	A2F	22	6
LavoroDocPontecagnano	FamilaGeneraliChieri	Bellizzi	A2F	22	11
IcosCrema	DahliaTvBusnago	Crema	A2F	22	10
MasterGroupPanediMatera	BiancofornoSantaCroce	Matera	A2F	22	9
BancaRealeYoyogurtGiaveno	EssetiLoreto	Giaveno	A2F	22	10
RDMPomezia	Cedat85SanVito	Pomezia	A2F	22	3
InfotelForlì	VeronaVolleyFemminile	Forlì	A2F	22	9
EurogroupGela	MarcegagliaCMCRavenna	Gela	A2M	22	17
GeotecIsernia	GloboBancaPopFrusinateSora	Isernia	A2M	22	14
GherardiSVICittàDiCastello	EnergyResourcesCariloLoreto	CittàdiCastello	A2M	22	12
PallavoloPineto	EdilesseConadReggioEmilia	Pineto	A2M	22	16
PhytoPerformancePadova	ClubItaliaAMRoma	Padova	A2M	22	9
SirSafetyPerugia	NGMMobileSCroce	Perugia	A2M	22	13
CanadiensMantova	CarigeGenova	Mantova	A2M	22	13
CheBanca!Milano	VolleySegrate1978	CiniselloBalsamo	A2M	22	15

Local Team	Guest Team	City	Championship	Round	Kg
CopraMorphoPiacenza	ItasDiatecTrentino	Piacenza	A1M	23	38
RPALuigiBacchiitSanGiustino	CasaModena	SanGiustino	A1M	23	35
LubeBancaMarcheMacerata	BreBancaLannuttiCuneo	Macerata	A1M	23	35
MRomaVolley	SisleyTreviso	Roma	A1M	23	34
AndreoliLatina	AcquaParadisoMonzaBrianza	Latina	A1M	23	30
MarmiLanzaVerona	YogaForlì	Verona	A1M	23	38
BCCNEPCastellanaGrotte	TonnoCallipoViboValentia	CastellanaGrotte	A1M	23	36
FamilaGeneraliChieri	CariparmaSiGradeParma	Chieri	A2F	23	9
Cedat85SanVito	FrigorcarniSoverato	SanVitodeiNormanni	A2F	23	6
BiancofornoSantaCroce	IcosCrema	SantaCrocesullArno	A2F	23	12
DahliaTvBusnago	BancaRealeYoyogurtGiaveno	Busnago	A2F	23	7
VeronaVolleyFemminile	LavoroDocPontecagnano	Verona	A2F	23	7
EssetiLoreto	RDMPomezia	Loreto	A2F	23	13
InfotelForlì	MasterGroupPanediMatera	Forlì	A2F	23	8
GeotecIsernia	PallavoloPineto	Isernia	A2M	23	12
GloboBancaPopFrusinateSora	PhytoPerformancePadova	Frosinone	A2M	23	11
CarigeGenova	MarcegagliaCMCRavenna	Genova	A2M	23	16
EdilesseConadReggioEmilia	GherardiSVICittàDiCastello	ReggionellEmilia	A2M	23	20
EnergyResourcesCariloLoreto	CanadiensMantova	Loreto	A2M	23	17
NGMMobileSCroce	EurogroupGela	SantaCrocesullArno	A2M	23	20
ClubItaliaAMRoma	CheBanca!Milano	Bracciano	A2M	23	17
VolleySegrate1978	SirSafetyPerugia	Segrate	A2M	23	21
SisleyTreviso	ItasDiatecTrentino	Villorba	A1M	24	38
MRomaVolley	LubeBancaMarcheMacerata	Roma	A1M	24	28
BreBancaLannuttiCuneo	MarmiLanzaVerona	Cuneo	A1M	24	36
TonnoCallipoViboValentia	CopraMorphoPiacenza	ViboValentia	A1M	24	37
YogaForlì	AndreoliLatina	Forlì	A1M	24	34
CasaModena	BCCNEPCastellanaGrotte	Modena	A1M	24	36
RPALuigiBacchiitSanGiustino	AcquaParadisoMonzaBrianza	SanGiustino	A1M	24	33
BancaRealeYoyogurtGiaveno	FamilaGeneraliChieri	Giaveno	A2F	24	10
MasterGroupPanediMatera	Cedat85SanVito	Matera	A2F	24	5
VeronaVolleyFemminile	IcosCrema	Verona	A2F	24	4
FrigorcarniSoverato	LavoroDocPontecagnano	Soverato	A2F	24	5
EssetiLoreto	InfotelForlì	Loreto	A2F	24	9
DahliaTvBusnago	CariparmaSiGradeParma	Busnago	A2F	24	7
BiancofornoSantaCroce	RDMPomezia	SantaCrocesullArno	A2F	24	8
CheBanca!Milano	GeotecIsernia	CiniselloBalsamo	A2M	24	17
MarcegagliaCMCRavenna	GloboBancaPopFrusinateSora	Ravenna	A2M	24	13
PallavoloPineto	EnergyResourcesCariloLoreto	Pineto	A2M	24	12
PhytoPerformancePadova	NGMMobileSCroce	Padova	A2M	24	16
GherardiSVICittàDiCastello	CarigeGenova	CittàdiCastello	A2M	24	18
SirSafetyPerugia	EdilesseConadReggioEmilia	Perugia	A2M	24	20
EurogroupGela	ClubItaliaAMRoma	Gela	A2M	24	19
CanadiensMantova	VolleySegrate1978	Mantova	A2M	24	18

Local Team	Guest Team	City	Championship	Round	Kg
LubeBancaMarcheMacerata	SisleyTreviso	Macerata	A1M	25	38
CopraMorphoPiacenza	BreBancaLannuttiCuneo	Piacenza	A1M	25	37
AndreoliLatina	MRomaVolley	Latina	A1M	25	37
ItasDiatecTrentino	YogaForlì	Trento	A1M	25	34
MarmiLanzaVerona	CasaModena	Verona	A1M	25	33
AcquaParadisoMonzaBrianza	TonnoCallipoViboValentia	Monza	A1M	25	35
BCCNEPCastellanaGrotte	RPALuigiBacchiitSanGiustino	CastellanaGrotte	A1M	25	29
Cedat85SanVito	VeronaVolleyFemminile	SanVitodeiNormanni	A2F	25	9
IcosCrema	BancaRealeYoyogurtGiaveno	Crema	A2F	25	9
CariparmaSiGradeParma	MasterGroupPanediMatera	Parma	A2F	25	11
FrigorcarniSoverato	BiancofornoSantaCroce	Soverato	A2F	25	7
FamilaGeneraliChieri	EssetiLoreto	Chieri	A2F	25	7
RDMPomezia	DahliaTvBusnago	Pomezia	A2F	25	11
LavoroDocPontecagnano	InfotelForlì	Salerno	A2F	25	9
ClubItaliaAMRoma	PallavoloPineto	Bracciano	A2M	25	16
GeotecIsernia	GherardiSVICittàDiCastello	Isernia	A2M	25	18
EdilesseConadReggioEmilia	MarcegagliaCMCRavenna	ReggionellEmilia	A2M	25	15
VolleySegrate1978	PhytoPerformancePadova	Segrate	A2M	25	12
EnergyResourcesCariloLoreto	EurogroupGela	Loreto	A2M	25	16
GloboBancaPopFrusinateSora	SirSafetyPerugia	Frosinone	A2M	25	14
NGMMobileSCroce	CanadiensMantova	SantaCrocesullArno	A2M	25	22
CarigeGenova	CheBanca!Milano	Genova	A2M	25	10
BreBancaLannuttiCuneo	ItasDiatecTrentino	Cuneo	A1M	26	34
MRomaVolley	CopraMorphoPiacenza	Roma	A1M	26	30
SisleyTreviso	BCCNEPCastellanaGrotte	Villorba	A1M	26	33
YogaForlì	LubeBancaMarcheMacerata	Forlì	A1M	26	33
RPALuigiBacchiitSanGiustino	AndreoliLatina	SanGiustino	A1M	26	30
CasaModena	AcquaParadisoMonzaBrianza	Modena	A1M	26	31
TonnoCallipoViboValentia	MarmiLanzaVerona	ViboValentia	A1M	26	39
DahliaTvBusnago	Cedat85SanVito	Busnago	A2F	26	7
BiancofornoSantaCroce	CariparmaSiGradeParma	SantaCrocesullArno	A2F	26	9
VeronaVolleyFemminile	FamilaGeneraliChieri	Verona	A2F	26	11
BancaRealeYoyogurtGiaveno	RDMPomezia	Giaveno	A2F	26	9
MasterGroupPanediMatera	IcosCrema	Matera	A2F	26	14
EssetiLoreto	LavoroDocPontecagnano	Loreto	A2F	26	6
InfotelForlì	FrigorcarniSoverato	Forlì	A2F	26	9
CanadiensMantova	GherardiSVICittàDiCastello	Mantova	A2M	26	22
ClubItaliaAMRoma	GloboBancaPopFrusinateSora	Bracciano	A2M	26	12
SirSafetyPerugia	GeotecIsernia	Perugia	A2M	26	13
PallavoloPineto	CarigeGenova	Pineto	A2M	26	9
PhytoPerformancePadova	EnergyResourcesCariloLoreto	Padova	A2M	26	15
MarcegagliaCMCRavenna	NGMMobileSCroce	Ravenna	A2M	26	18
CheBanca!Milano	EdilesseConadReggioEmilia	CiniselloBalsamo	A2M	26	13
EurogroupGela	VolleySegrate1978	Gela	A2M	26	17

Local Team	Guest Team	City	Championship	Round	Kg
GherardiSVICittàDiCastello	PhytoPerformancePadova	CittàdiCastello	A2M	27	17
CanadiensMantova	MarcegagliaCMCRavenna	Mantova	A2M	27	12
EdilesseConadReggioEmilia	ClubItaliaAMRoma	ReggionellEmilia	A2M	27	16
GeotecIsernia	CarigeGenova	Isernia	A2M	27	18
VolleySegrate1978	PallavoloPineto	Segrate	A2M	27	14
EnergyResourcesCariloLoreto	SirSafetyPerugia	Loreto	A2M	27	15
GloboBancaPopFrusinateSora	EurogroupGela	Frosinone	A2M	27	15
NGMMobileSCroce	CheBanca!Milano	SantaCrocesullArno	A2M	27	18
PhytoPerformancePadova	SirSafetyPerugia	Padova	A2M	28	15
VolleySegrate1978	EnergyResourcesCariloLoreto	Segrate	A2M	28	11
CarigeGenova	ClubItaliaAMRoma	Genova	A2M	28	15
CheBanca!Milano	EurogroupGela	CiniselloBalsamo	A2M	28	14
PallavoloPineto	CanadiensMantova	Pineto	A2M	28	21
EdilesseConadReggioEmilia	NGMMobileSCroce	ReggionellEmilia	A2M	28	15
MarcegagliaCMCRavenna	GeotecIsernia	Ravenna	A2M	28	21
GherardiSVICittàDiCastello	GloboBancaPopFrusinateSora	CittàdiCastello	A2M	28	10
PallavoloPineto	CheBanca!Milano	Pineto	A2M	29	19
EurogroupGela	GherardiSVICittàDiCastello	Gela	A2M	29	21
PhytoPerformancePadova	MarcegagliaCMCRavenna	Padova	A2M	29	10
SirSafetyPerugia	CanadiensMantova	Perugia	A2M	29	23
CarigeGenova	EdilesseConadReggioEmilia	Genova	A2M	29	13
GloboBancaPopFrusinateSora	VolleySegrate1978	Frosinone	A2M	29	16
ClubItaliaAMRoma	NGMMobileSCroce	Bracciano	A2M	29	18
GeotecIsernia	EnergyResourcesCariloLoreto	Isernia	A2M	29	14
NGMMobileSCroce	GloboBancaPopFrusinateSora	SantaCrocesullArno	A2M	30	12
CheBanca!Milano	PhytoPerformancePadova	CiniselloBalsamo	A2M	30	11
GherardiSVICittàDiCastello	PallavoloPineto	CittàdiCastello	A2M	30	10
CanadiensMantova	EurogroupGela	Mantova	A2M	30	20
MarcegagliaCMCRavenna	SirSafetyPerugia	Ravenna	A2M	30	18
EnergyResourcesCariloLoreto	ClubItaliaAMRoma	Loreto	A2M	30	16
VolleySegrate1978	CarigeGenova	Segrate	A2M	30	18
EdilesseConadReggioEmilia	GeotecIsernia	ReggionellEmilia	A2M	30	23

Appendix C

Detailed Numerical Results

This appendix presents the detailed tables with results for all experiments and all methods.

The follows tables show detailed information about the CPU time in seconds to found the first solution ($tUBI$), the CPU time in seconds to found the last solution ($tUBF$), the CPU time in seconds when CPLEX founds the optimal solution ($Tcplex$), the number of nodes at the branch and bound procedure of ILOG CPLEX ($Nodes$), the average CPU time in seconds for each node of the branch and bound of ILOG CPLEX ($sec/Nodes$), the gap between the final upper and lower bound ($\%LB-UB$) only for the case where the optimal solution was not found because the time limit, the improvement of the last solution (final upper bound) respect to the first solution (initial upper bound) ($\%F-I/F$), the number of cutting planes (for the *Cutgen* method) or new constraints (for the *Delayed* method) generated ($Ncuts$) and finally, the computational time in seconds to generate these cutting planes or new constraints ($Tcuts$).

Table C.1: Macro Instance 1 - Default

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i1w1	27,1	10.939,0	11.440,1	27.534,0	0,41	0	1,36
i1w2	24,1	738,0	746,9	1.966,0	0,35	0	0,21
i1w3	17,5	244,9	254,0	624,0	0,32	0	0,10
i1w4	20,7	408,5	415,6	1.176,0	0,30	0	0,29
i1w5	13,2	367,0	410,6	2.136,0	0,17	0	0,08
i1w6	15,2	426,7	590,5	3.033,0	0,18	0	0,15
i1w7	12,0	729,4	737,0	4.809,0	0,14	0	0,14
i1w8	11,6	655,8	909,1	5.457,0	0,16	0	0,15
i1w9	16,0	1.880,7	4.255,1	22.011,0	0,19	0	0,56
i1w10	17,5	17.663,5	18.000,0	82.901,0	0,22	0,01	0,60
i1w11	16,2	16.905,9	18.000,0	90.793,0	0,20	0,03	0,71
i1w12	14,9	13.094,6	18.000,0	82.731,0	0,22	0,06	0,11
i1w13	19,8	6.498,3	18.000,0	77.159,0	0,23	0,02	0,81
i1w14	19,9	6.233,0	18.000,0	90.460,0	0,20	0,04	1,24
i1w15	16,3	904,9	916,6	4.200,0	0,21	0	0,45
i1w16	13,4	901,2	1.010,0	5.886,0	0,16	0	0,10
i1w17	15,3	2.081,5	18.000,0	99.808,0	0,18	0,04	0,43
i1w18	16,7	6.726,6	18.000,0	85.887,0	0,21	0,03	0,72
i1w19	15,9	2.520,5	4.218,0	28.745,0	0,14	0	0,22
i1w20	66,4	3.876,5	5.203,5	32.666,0	0,16	0	0,15
i1w21	16,3	3.460,4	12.552,2	81.575,0	0,15	0	1,01
i1w22	15,3	835,3	857,7	3.968,0	0,20	0	0,52
i1w23	14,4	2.136,4	11.765,2	86.079,0	0,14	0	1,04
i1w24	15,7	2.292,1	3.082,6	20.523,0	0,15	0	0,53
i1w25	15,8	7.744,4	8.282,7	47.381,0	0,17	0	0,45
i1w26	18,9	16.549,8	18.000,0	87.571,0	0,20	0,01	0,83
i1w27	17,8	1.396,4	1.545,5	10.419,0	0,14	0	1,40
i1w28	14,8	397,9	465,9	2.469,0	0,17	0	0,37
i1w29	14,8	17.284,3	17.406,8	108.202,0	0,16	0	0,49
i1w30	12,5	620,5	758,4	5.502,0	0,13	0	0,87
i1w31	6,1	23,8	26,9	42,0	0,14	0	0,05
i1w32	2,2	2,2	2,3	0,0	0,00	0	0,00
i1w33	1,9	1,9	1,9	0,0	0,00	0	0,00
i1w34	2,1	15,2	15,2	91,0	0,07	0	0,03
i1w35	1,1	7,0	7,1	21,0	0,06	0	0,40
i1w36	0,6	2,4	2,4	0,0	0,00	0	1,13
i1w37	0,7	0,7	1,0	0,0	0,00	0	0,11
i1w38	0,2	0,2	0,2	0,0	0,00	0	0,00
i1w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i1w40	0,1	0,1	0,1	0,0	0,00	0	0,00
i1w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i1w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	13,4	3.489,7	5.521,0	28.662,5	0,15	0,03	0,42

Table C.2: Macro Instance 1 - Meo

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i1w1	27,2	7.360,4	8.503,4	14.779,0	0,55	0	1,36
i1w2	24,1	757,4	760,1	390,0	1,26	0	0,21
i1w3	17,5	380,1	388,2	175,0	0,98	0	0,10
i1w4	20,7	611,5	612,0	537,0	0,70	0	0,29
i1w5	13,2	520,8	536,7	909,0	0,42	0	0,08
i1w6	15,2	460,7	460,9	579,0	0,46	0	0,15
i1w7	12,1	439,7	448,0	1.014,0	0,28	0	0,14
i1w8	11,6	769,0	773,3	1.801,0	0,35	0	0,15
i1w9	16,0	3.664,2	3.781,0	11.184,0	0,32	0	0,56
i1w10	17,5	9.981,5	12.869,8	46.920,0	0,27	0	0,60
i1w11	16,2	16.874,9	18.000,0	55.222,0	0,32	0,01	0,71
i1w12	14,9	13.037,2	18.000,0	44.629,0	0,40	0,06	0,08
i1w13	19,7	7.650,2	18.000,0	41.927,0	0,42	0,04	0,78
i1w14	19,8	15.790,4	18.000,0	51.868,0	0,34	0,02	1,23
i1w15	16,0	817,4	845,4	1.670,0	0,38	0	0,45
i1w16	13,4	1.027,8	1.030,9	2.504,0	0,33	0	0,10
i1w17	15,3	6.051,7	18.000,0	57.076,0	0,31	0,04	0,41
i1w18	16,7	9.371,1	18.000,0	54.340,0	0,33	0,01	0,72
i1w19	15,8	2.150,3	2.150,4	7.553,0	0,26	0	0,22
i1w20	251,2	4.109,5	4.156,8	13.760,0	0,29	0	0,38
i1w21	16,3	3.471,5	3.480,8	10.668,0	0,30	0	1,01
i1w22	15,2	327,8	729,2	2.071,0	0,25	0	0,52
i1w23	14,4	7.136,0	7.873,3	30.410,0	0,25	0	1,04
i1w24	15,8	997,9	1.643,9	6.213,0	0,23	0	0,53
i1w25	15,8	5.942,7	5.949,5	16.383,0	0,35	0	0,45
i1w26	18,8	8.436,1	8.669,2	29.894,0	0,28	0	0,84
i1w27	17,8	1.666,5	1.691,7	7.476,0	0,20	0	1,40
i1w28	14,8	669,6	670,4	1.052,0	0,44	0	0,37
i1w29	14,7	6.870,6	7.102,1	27.683,0	0,25	0	0,49
i1w30	12,5	585,7	586,0	1.966,0	0,22	0	0,87
i1w31	6,1	88,8	96,0	20,0	0,79	0	0,05
i1w32	2,2	2,2	2,3	0,0	0,00	0	0,00
i1w33	1,9	1,9	1,9	0,0	0,00	0	0,00
i1w34	2,1	34,2	34,3	48,0	0,22	0	0,03
i1w35	1,0	14,5	14,5	2,0	0,02	0	0,40
i1w36	0,6	2,5	2,5	0,0	0,00	0	1,13
i1w37	0,7	0,7	1,0	0,0	0,00	0	0,11
i1w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i1w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i1w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i1w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i1w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	17,7	3.287,5	4.377,8	12.922,0	0,30	0,03	0,43

Table C.3: Macro Instance 1 - Cutgen

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i1w1	31,5	3.766,4	3.767,8	5.091,0	0,67	0	0,17	70	15,53
i1w2	22,4	619,2	621,6	297,0	1,08	0	0,06	48	13,56
i1w3	18,9	393,0	393,0	151,0	1,28	0	0,13	45	13,36
i1w4	18,4	607,5	609,3	430,0	0,86	0	0,39	59	15,16
i1w5	13,5	561,7	567,1	895,0	0,43	0	0,25	56	16,27
i1w6	14,7	596,6	615,6	1.031,0	0,42	0	0,05	50	15,59
i1w7	12,6	397,7	399,8	649,0	0,35	0	0,08	42	16,64
i1w8	16,2	911,2	913,3	2.238,0	0,33	0	0,51	47	18,44
i1w9	16,2	374,6	1.371,8	4.937,0	0,23	0	0,42	85	24,67
i1w10	18,9	5.573,7	5.841,7	18.882,0	0,30	0	0,67	79	22,94
i1w11	20,5	8.198,1	18.000,0	80.901,0	0,22	0,00	0,31	74	24,14
i1w12	22,9	6.536,7	18.000,0	49.884,0	0,36	0,02	1,43	78	33,14
i1w13	19,4	12.991,1	13.267,6	37.028,0	0,35	0	0,15	73	30,86
i1w14	21,8	15.318,7	15.489,3	57.183,0	0,27	0	0,42	80	34,97
i1w15	23,2	768,4	796,9	1.173,0	0,46	0	0,85	71	37,08
i1w16	19,2	883,5	898,6	1.443,0	0,46	0	0,41	74	40,62
i1w17	19,6	14.081,5	18.000,0	57.191,0	0,31	0,01	0,48	60	42,41
i1w18	20,5	6.269,1	18.000,0	46.755,0	0,38	0,04	0,53	61	41,89
i1w19	20,3	2.054,0	2.200,5	6.080,0	0,32	0	0,42	63	54,19
i1w20	23,4	3.642,3	3.644,0	9.381,0	0,36	0	0,65	51	44,70
i1w21	24,1	3.622,8	4.167,0	12.421,0	0,31	0	0,29	73	52,17
i1w22	20,8	787,0	797,1	1.327,0	0,42	0	0,54	67	56,09
i1w23	21,5	4.420,7	5.846,3	22.814,0	0,25	0	0,27	71	64,20
i1w24	21,1	2.554,7	2.562,9	8.037,0	0,29	0	0,18	73	65,02
i1w25	25,6	2.974,1	3.008,0	6.581,0	0,42	0	0,44	88	75,34
i1w26	33,5	10.361,5	10.386,5	24.015,0	0,42	0	1,58	79	72,72
i1w27	23,1	1.346,6	1.587,2	5.557,0	0,25	0	0,32	51	70,47
i1w28	24,5	711,4	715,6	833,0	0,57	0	0,46	56	72,66
i1w29	26,6	6.604,6	6.658,2	18.318,0	0,35	0	1,40	57	81,44
i1w30	18,5	525,6	531,1	816,0	0,41	0	0,34	54	81,73
i1w31	12,0	113,1	116,0	8,0	3,30	0	0,04	22	16,47
i1w32	4,8	4,8	4,8	0,0	0,00	0	0,00	9	2,23
i1w33	4,2	4,2	4,2	0,0	0,00	0	0,00	8	2,22
i1w34	7,8	79,0	84,7	23,0	1,82	0	0,18	25	35,39
i1w35	8,6	11,0	16,8	0,0	0,00	0	0,09	13	9,05
i1w36	4,0	12,2	13,3	0,0	0,00	0	2,71	3	11,28
i1w37	5,2	13,7	14,9	1,0	2,28	0	4,25	0	10,14
i1w38	1,3	1,3	1,3	0,0	0,00	0	0,00	0	1,12
i1w39	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i1w40	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i1w41	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i1w42	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
Average	16,3	2.826,1	3.807,6	11.485,0	0,49	0,02	0,51	47,98	31,91

Table C.4: Macro Instance 1 - Delayed

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i1w1	55,4	553,7	557,8	10.724,0	0,05	0	0,03	1239	28,02
i1w2	55,0	191,6	192,0	2.516,0	0,07	0	0,05	1152	32,17
i1w3	37,6	67,8	67,9	674,0	0,08	0	0,08	1020	21,25
i1w4	45,4	116,4	122,4	2.147,0	0,05	0	0,02	1096	22,83
i1w5	59,3	175,0	198,0	3.903,0	0,05	0	0,03	1158	36,34
i1w6	36,2	143,7	154,8	2.901,0	0,05	0	0,14	1151	21,58
i1w7	46,6	129,1	130,2	2.912,0	0,04	0	0,03	1054	31,98
i1w8	49,0	193,2	216,8	4.827,0	0,04	0	0,03	1096	32,03
i1w9	89,6	444,1	990,7	20.698,0	0,05	0	0,06	1264	63,56
i1w10	98,1	2.498,1	2.661,6	50.493,0	0,05	0	0,07	1235	65,00
i1w11	127,1	14.585,0	18.000,0	275.892,0	0,07	0,00	0,05	1263	80,20
i1w12	150,8	1.010,0	18.000,0	243.769,0	0,07	0,04	0,11	1212	103,78
i1w13	136,9	2.342,9	5.993,7	86.107,0	0,07	0	0,08	1179	89,53
i1w14	169,0	5.806,3	18.000,0	219.887,0	0,08	0,02	0,07	1208	111,33
i1w15	171,0	643,7	646,5	5.609,0	0,11	0	0,10	1098	120,39
i1w16	127,9	518,3	913,3	11.373,0	0,08	0	0,02	985	75,31
i1w17	108,7	13.407,8	13.648,6	237.358,0	0,06	0	0,26	986	69,75
i1w18	198,8	6.390,0	18.000,0	224.830,0	0,08	0,02	0,21	1079	144,02
i1w19	185,5	596,0	1.031,0	12.868,0	0,08	0	0,07	1006	127,00
i1w20	178,2	5.502,9	5.522,6	72.941,0	0,08	0	0,27	1042	140,64
i1w21	232,1	1.365,7	7.222,8	97.435,0	0,07	0	0,23	1078	173,05
i1w22	161,0	972,1	993,5	12.455,0	0,08	0	0,11	992	123,34
i1w23	220,1	2.751,7	3.920,8	54.268,0	0,07	0	0,10	1051	167,38
i1w24	201,5	1.119,7	1.718,4	24.061,0	0,07	0	0,04	1042	150,47
i1w25	232,6	590,9	2.897,1	35.215,0	0,08	0	0,14	1118	174,94
i1w26	259,1	3.934,2	3.997,6	43.707,0	0,09	0	0,22	1117	205,91
i1w27	202,2	952,1	1.081,4	11.409,0	0,09	0	0,16	1014	167,19
i1w28	220,6	502,1	567,6	4.325,0	0,12	0	0,12	1025	177,94
i1w29	358,6	6.394,4	7.293,8	99.492,0	0,07	0	0,25	1112	302,53
i1w30	241,5	514,7	681,9	7.776,0	0,08	0	0,11	931	203,20
i1w31	59,8	62,5	62,6	31,0	0,82	0	0,00	666	43,70
i1w32	25,6	25,6	28,4	0,0	0,00	0	0,00	506	22,20
i1w33	22,4	22,4	24,2	0,0	0,00	0	0,00	450	19,98
i1w34	74,2	74,2	75,1	42,0	1,16	0	0,00	430	66,03
i1w35	46,7	46,7	47,9	14,0	1,51	0	0,00	355	43,02
i1w36	15,5	23,0	23,1	3,0	0,39	0	0,21	210	21,45
i1w37	23,4	32,4	32,4	23,0	0,28	0	0,14	198	30,44
i1w38	12,7	12,7	12,7	0,0	0,00	0	0,00	112	12,42
i1w39	12,5	12,5	12,5	0,0	0,00	0	0,00	62	12,44
i1w40	9,0	9,0	9,0	0,0	0,00	0	0,00	36	8,98
i1w41	9,0	9,0	9,0	0,0	0,00	0	0,00	25	8,97
i1w42	6,8	6,8	6,8	0,0	0,00	0	0,00	11	6,73
Average	113,6	1.779,8	3.232,5	44.825,8	0,15	0,02	0,09	858,67	84,74

Table C.5: Macro Instance 1 - Weight

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i1w1	14,8	189,6	190,3	502,0	0,23	0	0,14
i1w2	14,2	180,8	201,0	416,0	0,27	0	0,45
i1w3	9,4	94,9	95,5	34,0	0,68	0	1,87
i1w4	11,9	120,0	124,6	21,0	0,83	0	0,17
i1w5	8,2	96,4	107,0	40,0	0,74	0	0,18
i1w6	11,0	213,4	214,9	186,0	0,51	0	0,13
i1w7	12,2	623,7	635,9	973,0	0,44	0	0,25
i1w8	16,0	851,0	862,7	1.840,0	0,36	0	0,27
i1w9	10,2	225,8	229,1	116,0	0,83	0	0,10
i1w10	13,0	297,9	302,4	359,0	0,44	0	0,20
i1w11	11,9	830,6	924,8	3.347,0	0,23	0	0,52
i1w12	10,3	234,6	235,8	132,0	0,70	0	0,26
i1w13	9,9	222,7	224,3	108,0	0,94	0	0,04
i1w14	8,8	172,6	174,7	159,0	0,46	0	0,23
i1w15	8,3	88,5	88,6	25,0	0,59	0	0,76
i1w16	7,7	113,4	113,4	44,0	0,82	0	0,11
i1w17	6,2	104,3	104,3	26,0	0,90	0	0,06
i1w18	8,0	122,0	126,8	97,0	0,45	0	0,25
i1w19	6,1	63,4	64,8	10,0	1,35	0	0,02
i1w20	6,6	116,2	117,5	93,0	0,51	0	0,15
i1w21	9,4	121,9	122,6	33,0	0,55	0	0,44
i1w22	11,1	200,7	200,8	91,0	0,81	0	1,57
i1w23	10,2	208,0	219,3	173,0	0,45	0	1,19
i1w24	13,3	481,6	533,1	1.084,0	0,32	0	1,87
i1w25	8,3	276,2	276,3	352,0	0,38	0	0,02
i1w26	10,4	898,3	903,7	3.054,0	0,24	0	0,13
i1w27	8,8	144,5	144,7	11,0	12,57	0	0,09
i1w28	9,5	195,7	195,8	304,0	0,24	0	0,13
i1w29	11,3	184,6	187,2	101,0	0,55	0	0,31
i1w30	6,9	126,3	127,4	60,0	0,53	0	0,38
i1w31	4,5	66,2	66,4	27,0	0,74	0	0,04
i1w32	3,1	37,9	38,0	6,0	5,81	0	0,55
i1w33	1,9	3,1	30,0	9,0	3,06	0	0,74
i1w34	1,3	19,7	20,1	9,0	0,56	0	2,06
i1w35	1,4	1,4	10,5	1,0	9,20	0	0,00
i1w36	0,6	2,5	2,5	2,0	0,00	0	0,05
i1w37	0,6	0,7	1,2	0,0	0,00	0	0,57
i1w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i1w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i1w40	0,0	0,0	0,1	0,0	0,00	0	0,00
i1w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i1w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	7,6	188,8	195,7	329,6	1,15	0	0,39

Table C.6: Macro Instance 2 - Default

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i2w1	27,0	5.991,5	6.441,6	22.443,0	0,28	0	0,32
i2w2	20,4	98,9	304,6	975,0	0,24	0	0,77
i2w3	16,8	73,1	73,5	78,0	0,30	0	0,16
i2w4	17,6	147,1	149,1	427,0	0,24	0	0,15
i2w5	16,1	154,0	161,9	545,0	0,22	0	0,66
i2w6	15,6	728,0	730,9	2.639,0	0,26	0	0,18
i2w7	12,8	71,7	206,9	794,0	0,20	0	0,19
i2w8	15,6	6.212,5	6.318,3	37.156,0	0,17	0	1,80
i2w9	15,2	3.488,0	3.499,6	17.212,0	0,20	0	0,48
i2w10	15,9	11.086,4	14.728,8	85.006,0	0,17	0	0,59
i2w11	16,5	11.180,4	18.000,0	79.628,0	0,23	0,04	0,38
i2w12	17,1	2.045,7	18.000,0	82.339,0	0,22	0,01	0,65
i2w13	16,9	14.110,3	17.310,4	93.350,0	0,18	0	0,22
i2w14	18,1	14.500,5	18.000,0	93.798,0	0,19	0,02	1,14
i2w15	15,7	685,8	739,1	4.040,0	0,17	0	1,22
i2w16	20,5	7.229,5	18.000,0	86.601,0	0,21	0,02	2,10
i2w17	15,0	9.931,7	18.000,0	111.142,0	0,16	0,02	0,40
i2w18	14,5	17.695,1	18.000,0	95.569,0	0,19	0,02	0,74
i2w19	12,7	1.014,4	1.200,5	7.228,0	0,16	0	0,30
i2w20	16,0	607,6	768,0	5.447,0	0,13	0	1,49
i2w21	15,0	2.343,6	3.019,3	17.712,0	0,17	0	0,24
i2w22	14,9	8.721,4	9.000,4	71.482,0	0,13	0	0,76
i2w23	15,2	2.347,6	2.348,5	15.170,0	0,15	0	0,31
i2w24	16,0	1.468,4	2.530,7	15.716,0	0,16	0	0,93
i2w25	69,6	5.592,5	5.647,6	29.164,0	0,19	0	0,32
i2w26	16,9	12.215,6	18.000,0	86.773,0	0,21	0,02	0,94
i2w27	15,7	1.910,1	2.577,6	10.965,0	0,23	0	0,87
i2w28	14,4	3.680,1	3.872,3	22.561,0	0,17	0	0,56
i2w29	14,5	15.025,2	18.000,0	78.725,0	0,23	0,03	0,51
i2w30	11,5	657,5	5.381,5	43.895,0	0,12	0	0,43
i2w31	6,9	74,3	75,3	577,0	0,09	0	0,12
i2w32	2,8	19,9	21,7	47,0	0,14	0	0,61
i2w33	3,1	14,2	15,1	40,0	0,11	0	0,09
i2w34	2,3	16,8	17,6	92,0	0,08	0	0,11
i2w35	1,2	1,2	3,1	0,0	0,00	0	0,00
i2w36	0,3	0,3	0,3	0,0	0,00	0	0,00
i2w37	0,3	0,3	0,3	0,0	0,00	0	0,00
i2w38	0,2	0,2	0,2	0,0	0,00	0	0,00
i2w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i2w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i2w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i2w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	13,3	3.836,7	5.503,5	29.031,8	0,15	0,02	0,49

Table C.7: Macro Instance 2 - Meo

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i2w1	27,3	1.482,9	1.634,0	2.320,0	0,55	0	0,32
i2w2	20,4	495,1	504,6	166,0	1,22	0	0,77
i2w3	16,8	252,8	252,9	48,0	5,03	0	0,16
i2w4	17,7	314,9	314,9	112,0	1,05	0	0,15
i2w5	16,1	357,5	359,1	179,0	1,02	0	0,66
i2w6	15,6	646,1	646,7	720,0	0,60	0	0,18
i2w7	12,8	349,3	349,5	137,0	1,07	0	0,19
i2w8	15,6	2.363,2	2.370,0	7.034,0	0,31	0	1,80
i2w9	15,1	1.585,3	1.587,5	3.791,0	0,35	0	0,48
i2w10	15,8	10.704,3	13.809,7	66.441,0	0,20	0	0,59
i2w11	16,5	1.710,3	18.000,0	46.379,0	0,38	0,07	0,33
i2w12	18,6	12.978,1	16.045,8	65.131,0	0,24	0	0,65
i2w13	16,8	13.996,1	14.017,1	41.556,0	0,33	0	0,22
i2w14	18,1	8.589,8	18.000,0	49.161,0	0,36	0,02	1,13
i2w15	15,9	544,4	743,3	1.993,0	0,28	0	1,22
i2w16	20,4	8.781,4	18.000,0	54.465,0	0,33	0,04	2,07
i2w17	15,0	4.732,2	18.000,0	61.182,0	0,29	0,02	0,39
i2w18	14,5	5.341,0	10.338,7	51.122,0	0,20	0	0,74
i2w19	12,8	731,0	785,4	2.380,0	0,25	0	0,30
i2w20	16,0	572,3	637,7	2.057,0	0,23	0	1,49
i2w21	15,1	2.593,1	2.758,0	10.922,0	0,23	0	0,24
i2w22	14,8	7.125,9	7.125,9	32.024,0	0,22	0	0,76
i2w23	15,3	1.842,0	1.843,5	6.629,0	0,25	0	0,31
i2w24	15,9	1.315,5	1.356,0	2.990,0	0,38	0	0,93
i2w25	303,8	2.463,4	2.477,4	7.921,0	0,29	0	0,09
i2w26	16,7	14.912,0	18.000,0	64.644,0	0,27	0,00	0,94
i2w27	15,6	2.426,6	2.426,7	5.092,0	0,43	0	0,87
i2w28	14,5	1.742,0	2.222,9	7.212,0	0,28	0	0,56
i2w29	14,6	15.619,9	18.000,0	52.048,0	0,34	0,01	0,50
i2w30	11,5	378,9	623,9	2.680,0	0,17	0	0,43
i2w31	6,8	147,3	147,5	245,0	0,26	0	0,12
i2w32	2,8	66,2	66,6	82,0	0,27	0	0,61
i2w33	3,0	32,5	33,7	14,0	0,35	0	0,09
i2w34	2,3	26,6	27,1	41,0	0,62	0	0,11
i2w35	1,2	1,2	4,5	0,0	0,00	0	0,00
i2w36	0,3	0,3	0,3	0,0	0,00	0	0,00
i2w37	0,3	0,3	0,3	0,0	0,00	0	0,00
i2w38	0,2	0,2	0,2	0,0	0,00	0	0,00
i2w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i2w40	0,1	0,1	0,1	0,0	0,00	0	0,00
i2w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i2w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	18,9	3.029,1	4.607,4	15.450,4	0,44	0,03	0,49

Table C.8: Macro Instance 2 - Cutgen

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i2w1	31,2	2.254,3	2.269,0	3.484,0	0,54	0	0,90	69	15,55
i2w2	24,2	594,5	596,1	241,0	1,26	0	0,23	61	14,80
i2w3	14,5	231,8	236,5	36,0	6,24	0	0,38	38	8,58
i2w4	18,2	338,7	339,6	89,0	1,60	0	0,25	42	13,78
i2w5	16,3	363,5	366,8	142,0	1,25	0	0,23	49	14,72
i2w6	16,5	673,4	674,3	903,0	0,50	0	0,21	56	16,98
i2w7	9,4	341,7	341,8	126,0	1,15	0	1,43	46	16,91
i2w8	14,9	1.517,3	1.578,6	3.963,0	0,34	0	0,14	66	19,45
i2w9	18,6	2.112,2	2.125,7	5.120,0	0,36	0	0,43	62	22,23
i2w10	17,3	15.119,9	16.740,8	74.360,0	0,22	0	0,96	64	23,33
i2w11	19,3	12.429,1	18.000,0	56.971,0	0,31	0,01	0,68	79	26,16
i2w12	18,0	4.345,3	18.000,0	45.585,0	0,39	0,01	0,54	71	27,83
i2w13	25,1	3.033,8	6.842,6	26.689,0	0,25	0	1,96	81	30,33
i2w14	298,4	17.827,2	18.000,0	45.597,0	0,39	0,01	0,29	80	34,25
i2w15	19,4	985,1	1.012,5	2.033,0	0,40	0	0,70	82	36,27
i2w16	22,4	16.516,7	18.000,0	44.987,0	0,39	0,02	0,52	74	39,56
i2w17	21,6	17.518,5	18.000,0	49.078,0	0,36	0,01	0,57	72	45,62
i2w18	21,1	11.267,2	11.504,2	38.711,0	0,29	0	0,36	76	47,67
i2w19	20,2	814,2	827,2	1.949,0	0,32	0	0,46	57	45,64
i2w20	18,1	765,4	794,7	2.016,0	0,30	0	0,66	53	46,66
i2w21	23,5	2.313,5	2.399,2	7.398,0	0,29	0	3,80	81	57,89
i2w22	21,3	5.376,1	5.501,7	18.326,0	0,29	0	0,40	70	59,80
i2w23	22,5	1.755,2	1.757,5	3.649,0	0,42	0	0,40	76	68,69
i2w24	21,7	898,8	1.154,1	2.245,0	0,41	0	0,44	79	69,92
i2w25	26,1	3.478,6	3.502,7	7.931,0	0,41	0	0,67	89	76,80
i2w26	25,5	3.371,1	18.000,0	42.628,0	0,42	0,03	0,53	77	75,47
i2w27	27,2	1.954,4	1.955,1	2.816,0	0,59	0	0,69	77	85,03
i2w28	24,3	3.909,8	4.128,4	11.270,0	0,34	0	1,21	71	84,28
i2w29	21,0	9.014,7	9.243,8	27.541,0	0,33	0	0,71	66	82,20
i2w30	19,5	873,1	877,0	1.772,0	0,39	0	0,48	58	84,16
i2w31	15,2	254,1	258,9	198,0	0,76	0	0,53	47	84,02
i2w32	9,2	103,7	119,1	40,0	1,64	0	0,22	22	53,67
i2w33	10,1	84,4	86,9	26,0	1,69	0	0,30	18	44,42
i2w34	9,6	67,1	72,3	26,0	1,59	0	0,02	24	40,95
i2w35	7,7	43,6	44,8	15,0	2,66	0	0,19	13	28,36
i2w36	2,6	2,6	2,6	0,0	0,00	0	0,00	1	2,27
i2w37	2,6	2,6	2,6	0,0	0,00	0	0,00	1	2,28
i2w38	2,4	2,4	2,4	0,0	0,00	0	0,00	1	2,25
i2w39	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i2w40	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,11
i2w41	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i2w42	1,1	1,1	1,1	0,0	0,00	0	0,00	0	1,11
Average	22,9	3.394,3	4.413,4	12.570,5	0,69	0,01	0,54	51,17	36,98

Table C.9: Macro Instance 2 - Delayed

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i2w1	79,8	555,2	570,4	12.022,0	0,05	0	0,08	1349	49,02
i2w2	33,3	43,5	57,4	725,0	0,05	0	0,01	1109	13,92
i2w3	29,4	35,3	35,4	154,0	0,12	0	0,00	1007	13,27
i2w4	25,1	25,1	36,5	463,0	0,04	0	0,00	998	10,72
i2w5	38,9	65,3	65,7	621,0	0,08	0	0,03	1062	20,78
i2w6	67,0	121,2	126,7	1.668,0	0,06	0	0,06	1174	37,05
i2w7	65,1	98,7	98,7	720,0	0,11	0	0,13	1136	41,59
i2w8	74,5	670,3	751,0	15.812,0	0,05	0	0,26	1168	48,73
i2w9	81,2	931,2	1.150,2	15.706,0	0,07	0	0,05	1145	50,89
i2w10	138,0	3.386,2	7.841,5	150.286,0	0,05	0	0,09	1188	90,17
i2w11	123,2	16.595,0	18.000,0	221.311,0	0,08	0,03	0,05	1190	77,20
i2w12	166,5	15.879,1	16.371,2	248.213,0	0,07	0	0,29	1223	118,92
i2w13	195,1	4.625,6	13.950,4	219.602,0	0,06	0	0,28	1204	122,02
i2w14	176,1	9.694,7	18.000,0	218.101,0	0,08	0,02	0,05	1135	111,16
i2w15	112,9	670,4	715,2	9.267,0	0,07	0	0,13	998	67,94
i2w16	190,2	8.451,8	18.000,0	215.547,0	0,08	0,01	0,13	1089	130,27
i2w17	222,3	13.305,6	13.587,7	192.458,0	0,07	0	0,26	1167	174,42
i2w18	218,3	9.301,2	13.041,7	192.416,0	0,07	0	0,14	1136	161,09
i2w19	158,7	460,8	508,2	6.518,0	0,07	0	0,06	973	114,72
i2w20	162,8	610,3	615,2	7.793,0	0,07	0	0,09	988	124,25
i2w21	141,5	2.050,0	2.225,4	29.972,0	0,07	0	0,22	1014	107,22
i2w22	181,7	3.562,4	5.783,6	88.707,0	0,06	0	0,09	1075	156,28
i2w23	197,9	1.221,8	1.626,5	19.844,0	0,08	0	0,05	1064	153,78
i2w24	192,8	366,0	667,6	5.442,0	0,11	0	0,12	1056	149,41
i2w25	243,5	2.193,9	2.425,5	25.692,0	0,09	0	0,12	1073	181,73
i2w26	271,7	1.792,6	18.000,0	220.301,0	0,08	0,02	0,09	1129	243,39
i2w27	316,6	1.000,7	1.827,2	15.242,0	0,12	0	0,18	1124	251,08
i2w28	297,7	3.277,4	3.418,9	36.975,0	0,09	0	0,14	1133	246,27
i2w29	319,5	15.987,8	17.162,3	220.929,0	0,08	0	0,31	1181	291,66
i2w30	278,4	689,7	900,6	8.880,0	0,10	0	0,23	1005	251,88
i2w31	126,8	146,7	159,9	670,0	0,18	0	0,02	720	111,48
i2w32	63,2	67,6	70,7	141,0	0,26	0	0,04	571	55,50
i2w33	75,4	79,4	80,1	60,0	0,92	0	0,01	529	69,73
i2w34	70,3	71,8	72,1	44,0	0,99	0	0,06	386	64,61
i2w35	20,5	24,5	25,7	17,0	0,28	0	0,06	295	22,69
i2w36	14,3	14,3	14,3	0,0	0,00	0	0,00	202	13,61
i2w37	14,5	14,5	14,5	0,0	0,00	0	0,00	178	13,55
i2w38	14,1	14,1	14,1	0,0	0,00	0	0,00	103	13,55
i2w39	10,3	10,3	10,3	0,0	0,00	0	0,00	71	10,17
i2w40	11,3	11,3	11,3	0,0	0,00	0	0,00	36	11,22
i2w41	3,4	3,4	3,4	0,0	0,00	0	0,00	11	3,38
i2w42	4,5	4,5	4,5	0,0	0,00	0	0,00	2	4,48
Average	124,5	2.812,7	4.239,1	57.198,1	0,12	0,02	0,09	866,60	95,35

Table C.10: Macro Instance 2 - Weight

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i2w1	18,9	294,7	298,9	787,0	0,24	0	0,49
i2w2	11,9	331,2	370,9	2.080,0	0,13	0	3,79
i2w3	12,4	162,3	166,6	270,0	0,40	0	0,18
i2w4	12,1	164,0	166,6	50,0	1,00	0	0,28
i2w5	11,8	130,1	135,1	57,0	2,21	0	0,33
i2w6	13,9	270,0	277,1	274,0	0,51	0	0,31
i2w7	10,3	362,9	364,8	516,0	0,40	0	0,25
i2w8	11,8	532,9	533,1	1.096,0	0,32	0	0,12
i2w9	13,1	673,3	675,0	1.311,0	0,40	0	1,36
i2w10	14,0	2.499,9	2.590,2	9.658,0	0,25	0	0,59
i2w11	11,9	636,7	649,5	1.459,0	0,32	0	0,50
i2w12	11,0	1.415,5	1.818,9	10.768,0	0,15	0	0,36
i2w13	11,6	498,4	498,4	1.148,0	0,32	0	0,39
i2w14	7,9	120,4	120,5	46,0	2,48	0	0,14
i2w15	7,3	203,3	203,6	277,0	0,39	0	0,23
i2w16	7,9	171,8	172,0	214,0	0,34	0	0,46
i2w17	7,3	122,1	122,1	108,0	1,08	0	0,05
i2w18	10,4	337,9	338,1	945,0	0,22	0	1,76
i2w19	7,5	162,2	162,5	89,0	0,50	0	0,11
i2w20	7,6	184,8	186,6	316,0	0,25	0	0,25
i2w21	9,1	129,3	139,0	79,0	0,48	0	0,89
i2w22	12,2	211,9	216,7	122,0	0,72	0	0,77
i2w23	10,4	388,4	391,3	898,0	0,30	0	0,30
i2w24	13,0	4.634,1	4.703,8	22.993,0	0,20	0	0,30
i2w25	11,4	3.335,6	3.344,3	16.654,0	0,19	0	0,36
i2w26	16,6	776,8	781,3	2.078,0	0,27	0	1,61
i2w27	11,1	522,4	526,2	1.269,0	0,28	0	1,03
i2w28	10,7	321,2	327,6	478,0	0,39	0	1,20
i2w29	11,1	369,5	371,2	335,0	0,57	0	0,21
i2w30	7,1	256,9	257,5	674,0	0,20	0	0,10
i2w31	5,5	95,4	107,7	82,0	0,38	0	0,27
i2w32	3,0	36,0	36,2	10,0	3,36	0	0,00
i2w33	2,4	50,3	52,0	48,0	0,36	0	1,12
i2w34	2,0	19,2	19,4	16,0	1,11	0	0,07
i2w35	1,0	1,1	4,9	0,0	0,00	0	0,27
i2w36	0,3	0,3	0,3	0,0	0,00	0	0,00
i2w37	0,3	0,3	0,3	0,0	0,00	0	0,00
i2w38	0,2	0,2	0,2	0,0	0,00	0	0,00
i2w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i2w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i2w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i2w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	8,3	486,3	503,1	1.838,2	0,49	0	0,49

Table C.11: Macro Instance 3 - Default

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i3w1	35,4	7.203,2	18.000,0	46.412,0	0,39	0,03	2,08
i3w2	24,1	2.187,5	14.860,8	73.322,0	0,20	0	0,13
i3w3	19,4	287,5	300,4	945,0	0,26	0	0,18
i3w4	19,3	779,5	1.042,0	4.018,0	0,24	0	0,27
i3w5	17,1	6.062,7	6.668,4	32.223,0	0,21	0	0,08
i3w6	17,0	2.737,4	3.486,9	14.677,0	0,23	0	0,07
i3w7	13,2	286,5	496,8	2.538,0	0,18	0	0,24
i3w8	14,3	6.347,8	7.503,4	43.145,0	0,17	0	0,49
i3w9	16,2	723,0	7.908,0	48.589,0	0,16	0	0,72
i3w10	13,9	1.282,2	1.965,5	11.538,0	0,17	0	0,19
i3w11	14,6	3.492,4	3.589,8	24.543,0	0,14	0	0,37
i3w12	17,8	4.505,4	18.000,0	77.661,0	0,23	0,04	0,57
i3w13	15,4	6.874,8	8.181,3	42.022,0	0,19	0	0,18
i3w14	58,2	13.552,2	16.257,5	103.664,0	0,16	0	0,14
i3w15	66,5	5.844,5	7.321,1	43.466,0	0,17	0	0,39
i3w16	20,3	1.826,5	6.030,4	42.135,0	0,14	0	3,33
i3w17	12,8	1.202,6	1.451,6	9.007,0	0,16	0	0,26
i3w18	13,9	2.111,3	2.149,5	12.684,0	0,17	0	0,35
i3w19	15,6	8.967,4	8.967,5	53.327,0	0,17	0	0,46
i3w20	14,9	6.467,2	6.757,6	45.642,0	0,15	0	1,18
i3w21	13,2	1.251,2	2.470,6	13.000,0	0,19	0	0,13
i3w22	19,0	333,4	5.203,4	40.126,0	0,13	0	3,40
i3w23	14,0	4.798,0	7.802,3	54.054,0	0,14	0	0,63
i3w24	15,5	2.602,4	3.501,9	21.762,0	0,16	0	0,57
i3w25	14,3	12.472,8	18.000,0	87.201,0	0,21	0,03	0,30
i3w26	18,8	16.977,9	18.000,0	74.892,0	0,24	0,08	1,04
i3w27	15,1	3.836,6	5.935,6	38.620,0	0,15	0	0,55
i3w28	14,0	12.178,8	18.000,0	100.350,0	0,18	0,01	0,59
i3w29	13,7	14.485,1	18.000,0	120.972,0	0,15	0,00	1,33
i3w30	11,9	2.234,5	2.292,4	12.240,0	0,18	0	0,92
i3w31	6,2	6,7	18,3	5,0	2,66	0	0,05
i3w32	4,7	64,5	82,8	782,0	0,08	0	0,15
i3w33	3,2	16,7	16,7	25,0	0,21	0	0,05
i3w34	2,7	13,5	16,1	71,0	0,09	0	0,51
i3w35	0,8	0,8	0,8	0,0	0,00	0	0,00
i3w36	0,5	0,5	0,5	0,0	0,00	0	0,00
i3w37	0,4	0,4	0,4	0,0	0,00	0	0,00
i3w38	0,2	0,2	0,2	0,0	0,00	0	0,00
i3w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i3w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i3w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i3w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	14,5	3.667,0	5.721,0	30.849,0	0,21	0,03	0,52

Table C.12: Macro Instance 3 - Meo

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i3w1	34,9	1.929,3	18.000,0	31.324,0	0,56	0,02	2,08
i3w2	24,2	11.498,4	13.589,3	51.412,0	0,26	0	0,13
i3w3	19,4	503,1	503,2	385,0	0,75	0	0,18
i3w4	19,3	888,2	902,3	1.452,0	0,44	0	0,27
i3w5	17,1	3.239,8	3.458,1	9.598,0	0,34	0	0,08
i3w6	17,0	4.831,4	4.851,0	11.865,0	0,39	0	0,07
i3w7	13,1	683,9	687,1	1.182,0	0,41	0	0,24
i3w8	14,3	2.047,8	2.973,3	11.424,0	0,24	0	0,49
i3w9	16,2	7.322,3	7.839,3	32.352,0	0,24	0	0,72
i3w10	13,9	1.472,7	1.625,1	5.819,0	0,24	0	0,19
i3w11	14,5	1.294,6	1.295,0	4.403,0	0,25	0	0,37
i3w12	17,8	17.987,7	18.000,0	45.032,0	0,39	0,02	0,57
i3w13	15,4	7.868,3	7.919,2	24.153,0	0,32	0	0,18
i3w14	263,0	6.113,6	6.566,7	30.503,0	0,21	0	0,37
i3w15	257,9	5.322,7	5.385,3	17.196,0	0,30	0	1,86
i3w16	20,2	9.457,3	9.497,5	34.144,0	0,27	0	3,33
i3w17	12,8	863,2	1.131,7	4.337,0	0,21	0	0,26
i3w18	14,0	2.274,3	2.274,4	6.744,0	0,30	0	0,35
i3w19	15,7	6.417,1	7.058,1	29.960,0	0,23	0	0,46
i3w20	14,9	4.869,6	4.881,6	20.733,0	0,23	0	1,18
i3w21	13,2	1.693,7	1.713,9	5.114,0	0,29	0	0,13
i3w22	19,0	4.023,7	4.062,0	17.241,0	0,22	0	3,40
i3w23	13,7	5.755,7	5.996,7	33.466,0	0,17	0	0,63
i3w24	15,5	3.312,7	3.517,7	12.718,0	0,26	0	0,57
i3w25	14,3	1.920,3	18.000,0	48.471,0	0,37	0,08	0,23
i3w26	18,7	14.667,8	18.000,0	40.619,0	0,44	0,06	1,03
i3w27	15,1	4.983,4	4.996,7	20.885,0	0,23	0	0,55
i3w28	13,9	15.838,5	17.253,6	83.462,0	0,20	0	0,59
i3w29	13,6	3.238,2	8.342,4	48.003,0	0,17	0	1,33
i3w30	11,9	677,6	682,9	1.159,0	0,43	0	0,92
i3w31	6,2	6,7	61,8	0,0	0,00	0	0,05
i3w32	4,6	108,3	110,7	249,0	0,23	0	0,15
i3w33	3,2	47,9	49,0	18,0	0,56	0	0,05
i3w34	2,7	37,6	38,6	52,0	0,35	0	0,51
i3w35	0,8	0,8	0,8	0,0	0,00	0	0,00
i3w36	0,5	0,5	0,5	0,0	0,00	0	0,00
i3w37	0,4	0,4	0,4	0,0	0,00	0	0,00
i3w38	0,1	0,1	0,2	0,0	0,00	0	0,00
i3w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i3w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i3w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i3w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	23,9	3.647,6	4.792,1	16.320,8	0,25	0,05	0,56

Table C.13: Macro Instance 3 - Cutgen

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i3w1	31,3	13.821,5	18.000,0	24.159,0	0,73	0,02	0,14	109	18,70
i3w2	24,1	10.135,5	10.175,3	27.176,0	0,36	0	0,11	89	16,47
i3w3	25,1	524,7	527,0	395,0	0,76	0	0,68	62	14,55
i3w4	20,4	729,7	764,1	1.025,0	0,52	0	0,10	73	15,56
i3w5	19,2	3.398,8	4.500,0	15.138,0	0,28	0	0,14	80	19,77
i3w6	23,2	2.423,9	2.523,1	5.395,0	0,42	0	0,29	60	16,36
i3w7	14,0	814,5	831,7	1.490,0	0,43	0	0,57	50	17,86
i3w8	15,3	2.645,8	2.677,5	7.467,0	0,33	0	0,16	87	21,25
i3w9	16,2	1.651,3	2.150,1	8.234,0	0,23	0	0,24	85	23,55
i3w10	15,4	1.661,5	1.738,6	4.249,0	0,36	0	0,17	60	23,06
i3w11	16,4	1.151,5	1.151,7	3.397,0	0,27	0	2,16	65	25,97
i3w12	18,5	13.492,7	18.000,0	42.818,0	0,41	0,03	0,20	85	27,55
i3w13	18,7	3.508,5	3.585,2	10.454,0	0,32	0	0,40	67	30,91
i3w14	18,5	6.367,0	6.398,7	20.018,0	0,31	0	0,82	66	32,94
i3w15	340,4	4.587,2	4.704,2	13.270,0	0,34	0	0,17	74	36,08
i3w16	22,6	4.877,5	4.878,2	16.594,0	0,28	0	0,58	71	40,30
i3w17	19,3	964,0	1.130,3	3.523,0	0,25	0	0,30	75	51,42
i3w18	17,3	1.946,4	1.947,5	6.149,0	0,28	0	0,08	70	43,83
i3w19	20,8	7.075,3	7.121,0	23.434,0	0,29	0	0,36	81	52,14
i3w20	21,1	3.804,0	3.889,2	12.901,0	0,28	0	0,73	67	51,02
i3w21	22,0	1.747,9	2.008,1	5.803,0	0,31	0	0,60	68	54,36
i3w22	27,6	2.833,0	2.848,0	7.904,0	0,33	0	1,19	69	70,92
i3w23	19,3	4.832,1	5.464,2	24.977,0	0,21	0	0,44	66	56,58
i3w24	21,6	2.585,4	2.699,2	8.970,0	0,28	0	0,41	72	66,50
i3w25	311,7	16.589,5	18.000,0	40.744,0	0,44	0,03	1,40	80	67,95
i3w26	23,5	2.550,3	18.000,0	37.819,0	0,47	0,06	0,53	71	76,22
i3w27	21,7	7.809,1	7.810,3	23.981,0	0,32	0	0,10	62	74,50
i3w28	21,9	12.436,1	12.465,1	40.467,0	0,30	0	0,20	68	82,50
i3w29	24,0	7.022,1	8.707,1	34.808,0	0,24	0	0,50	68	84,27
i3w30	20,0	803,3	803,4	1.049,0	0,56	0	0,34	57	85,47
i3w31	6,7	12,3	75,0	0,0	0,00	0	0,63	15	5,47
i3w32	13,6	205,6	205,8	147,0	0,93	0	0,07	51	88,81
i3w33	11,0	83,5	94,6	16,0	2,57	0	0,47	31	37,83
i3w34	8,6	93,6	103,3	46,0	1,60	0	0,31	27	63,88
i3w35	7,0	7,0	7,0	0,0	0,00	0	0,00	9	5,69
i3w36	2,8	2,8	2,8	0,0	0,00	0	0,00	4	2,25
i3w37	2,7	2,7	2,7	0,0	0,00	0	0,00	4	2,25
i3w38	2,4	2,4	2,4	0,0	0,00	0	0,00	0	2,25
i3w39	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,11
i3w40	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i3w41	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i3w42	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
Average	30,7	3.457,3	4.190,4	11.286,1	0,38	0,03	0,37	54,71	35,99

Table C.14: Macro Instance 3 - Delayed

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i3w1	70,4	15.120,2	18.000,0	412.310,0	0,04	0,01	0,08	1311	39,50
i3w2	76,0	2.577,5	2.680,0	88.792,0	0,03	0	0,05	1242	45,92
i3w3	34,7	95,4	102,3	1.744,0	0,05	0	0,03	1041	17,83
i3w4	56,4	296,8	299,6	6.431,0	0,04	0	0,08	1164	31,14
i3w5	72,9	460,5	2.163,8	56.701,0	0,04	0	0,04	1201	41,02
i3w6	65,9	1.741,2	1.756,3	48.062,0	0,04	0	0,03	1176	38,78
i3w7	65,3	101,3	164,8	2.456,0	0,06	0	0,07	1130	40,23
i3w8	82,5	460,4	724,5	15.669,0	0,04	0	0,05	1189	54,84
i3w9	87,6	3.165,7	3.231,5	85.151,0	0,04	0	0,08	1183	58,39
i3w10	71,2	305,5	556,5	12.900,0	0,04	0	0,09	1156	47,38
i3w11	111,8	2.024,9	2.037,3	28.357,0	0,07	0	0,05	1167	67,72
i3w12	169,2	942,5	18.000,0	255.184,0	0,07	0,01	0,11	1251	114,66
i3w13	125,1	7.277,0	9.642,1	134.141,0	0,07	0	0,05	1166	81,94
i3w14	111,3	3.781,3	4.008,7	67.541,0	0,06	0	0,20	1102	73,53
i3w15	239,5	2.669,7	2.687,9	33.678,0	0,08	0	0,26	1211	169,81
i3w16	174,8	3.746,0	3.873,3	61.541,0	0,06	0	0,09	1076	116,33
i3w17	144,6	2.204,8	2.238,0	31.696,0	0,07	0	0,05	986	98,16
i3w18	173,2	2.021,8	2.413,8	36.822,0	0,06	0	0,15	1010	117,75
i3w19	218,1	3.484,2	3.828,5	54.475,0	0,07	0	0,16	1112	160,36
i3w20	176,0	3.116,7	3.699,3	61.305,0	0,06	0	0,28	1068	127,98
i3w21	226,2	1.430,7	1.607,5	17.822,0	0,09	0	0,14	1078	169,75
i3w22	159,5	2.369,5	2.782,7	40.140,0	0,07	0	0,05	965	114,39
i3w23	183,5	1.926,0	2.988,5	53.009,0	0,06	0	0,14	1030	141,11
i3w24	324,1	7.484,7	7.913,6	104.134,0	0,08	0	0,15	1103	258,89
i3w25	232,7	16.649,7	18.000,0	195.413,0	0,09	0,02	0,08	1101	179,66
i3w26	249,4	16.402,5	18.000,0	181.048,0	0,10	0,05	0,04	1124	197,91
i3w27	248,2	1.531,2	1.548,8	18.425,0	0,08	0	0,09	1074	218,78
i3w28	223,3	4.465,1	9.482,0	133.866,0	0,07	0	0,02	1044	182,34
i3w29	174,2	8.069,4	11.455,0	204.441,0	0,06	0	0,04	987	147,17
i3w30	154,3	706,5	760,1	7.742,0	0,09	0	0,34	927	138,73
i3w31	62,0	62,0	62,5	29,0	0,91	0	0,00	663	43,73
i3w32	108,1	135,6	137,3	489,0	0,22	0	0,06	615	104,27
i3w33	55,4	55,4	56,3	23,0	1,19	0	0,00	504	46,58
i3w34	98,7	107,9	108,0	128,0	0,60	0	0,08	420	97,95
i3w35	28,5	31,4	31,4	0,0	0,00	0	0,04	272	29,47
i3w36	18,8	18,8	18,9	0,0	0,00	0	0,00	197	18,08
i3w37	18,8	18,8	18,8	0,0	0,00	0	0,00	175	18,12
i3w38	9,3	9,3	9,3	0,0	0,00	0	0,00	76	9,16
i3w39	5,7	5,7	5,7	0,0	0,00	0	0,00	28	5,64
i3w40	5,7	5,7	5,7	0,0	0,00	0	0,00	23	5,62
i3w41	4,5	4,5	4,5	0,0	0,00	0	0,00	14	4,48
i3w42	3,5	3,5	3,5	0,0	0,00	0	0,00	7	3,48
Average	117,2	2.787,8	3.740,7	58.373,0	0,11	0,02	0,08	865,93	87,59

Table C.15: Macro Instance 3 - Weight

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i3w1	16,7	195,4	200,5	532,0	0,20	0	0,19
i3w2	12,4	249,3	252,9	709,0	0,24	0	0,69
i3w3	9,6	124,4	124,5	71,0	0,67	0	0,46
i3w4	13,1	371,3	385,2	569,0	0,46	0	1,23
i3w5	10,3	185,0	185,0	108,0	0,93	0	0,21
i3w6	17,5	591,6	592,9	884,0	0,44	0	0,29
i3w7	15,8	234,6	236,6	175,0	0,79	0	0,15
i3w8	14,2	711,8	711,9	1.475,0	0,35	0	0,48
i3w9	11,8	472,5	473,4	884,0	0,36	0	0,23
i3w10	10,8	247,3	254,2	160,0	0,61	0	0,33
i3w11	9,2	364,0	380,6	994,0	0,24	0	0,19
i3w12	11,4	471,2	472,1	1.230,0	0,29	0	0,40
i3w13	9,6	281,0	281,0	519,0	0,28	0	0,38
i3w14	10,3	231,0	231,2	283,0	0,50	0	1,85
i3w15	8,9	173,6	174,0	132,0	0,52	0	0,26
i3w16	7,6	113,6	125,3	69,0	0,50	0	0,19
i3w17	7,9	254,3	254,7	524,0	0,31	0	0,62
i3w18	9,0	638,2	644,8	2.345,0	0,21	0	0,29
i3w19	7,7	149,5	149,7	102,0	0,56	0	0,21
i3w20	6,8	6,8	94,7	0,0	0,00	0	0,00
i3w21	8,1	144,9	152,6	108,0	0,50	0	0,43
i3w22	9,2	332,4	340,8	689,0	0,30	0	0,30
i3w23	6,6	262,6	267,9	893,0	0,21	0	0,27
i3w24	8,8	186,7	189,5	83,0	0,74	0	0,07
i3w25	11,1	244,0	339,4	449,0	0,35	0	0,19
i3w26	11,1	771,4	772,4	1.998,0	0,30	0	0,44
i3w27	9,1	381,6	381,8	360,0	0,62	0	0,12
i3w28	10,9	378,4	381,9	403,0	0,45	0	0,48
i3w29	9,1	277,8	278,0	145,0	0,82	0	0,67
i3w30	8,5	455,0	455,0	926,0	0,34	0	0,56
i3w31	5,2	94,0	102,6	32,0	0,91	0	0,04
i3w32	2,8	27,8	27,9	3,0	0,02	0	0,00
i3w33	1,5	26,8	26,9	14,0	0,38	0	0,38
i3w34	2,4	32,0	32,0	33,0	0,17	0	0,61
i3w35	1,1	6,3	6,3	5,0	0,28	0	0,03
i3w36	0,3	0,7	2,5	0,0	0,00	0	0,59
i3w37	0,4	0,8	3,1	0,0	0,00	0	1,70
i3w38	0,1	0,1	0,2	0,0	0,00	0	0,00
i3w39	0,1	0,1	0,1	0,0	0,00	0	0,27
i3w40	0,0	0,0	0,0	0,0	0,00	0	0,74
i3w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i3w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	7,8	230,7	237,8	426,3	0,35	0	0,39

Table C.16: Macro Instance 4 - Default

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i4w1	27,1	2.637,3	15.110,8	51.455,0	0,29	0	0,21
i4w2	24,3	877,0	879,3	2.342,0	0,35	0	0,28
i4w3	14,8	191,2	209,8	624,0	0,26	0	0,12
i4w4	19,5	860,0	868,4	2.813,0	0,29	0	0,37
i4w5	16,5	517,9	526,8	2.049,0	0,23	0	0,55
i4w6	18,0	1.759,5	1.862,2	8.548,0	0,21	0	0,26
i4w7	9,4	43,2	78,2	338,0	0,13	0	0,96
i4w8	10,5	138,3	146,7	541,0	0,20	0	0,35
i4w9	11,0	280,0	288,9	1.817,0	0,14	0	0,35
i4w10	12,0	276,3	335,5	1.555,0	0,19	0	0,02
i4w11	15,4	371,4	853,0	4.123,0	0,20	0	1,69
i4w12	15,7	6.995,1	7.342,4	37.768,0	0,19	0	0,80
i4w13	19,2	17.337,1	18.000,0	66.337,0	0,27	0,04	0,31
i4w14	17,1	17.171,4	17.882,3	91.203,0	0,20	0	0,24
i4w15	14,7	540,9	592,8	3.088,0	0,18	0	0,44
i4w16	14,5	1.395,2	1.673,4	9.156,0	0,18	0	0,15
i4w17	12,3	2.111,6	2.117,4	13.756,0	0,15	0	0,14
i4w18	13,0	2.102,5	4.078,9	28.185,0	0,14	0	0,33
i4w19	14,1	891,8	929,3	8.187,0	0,11	0	0,99
i4w20	13,0	645,8	1.864,4	12.273,0	0,15	0	0,11
i4w21	12,8	712,8	719,1	4.755,0	0,14	0	1,92
i4w22	13,1	719,4	844,8	4.577,0	0,18	0	0,68
i4w23	15,6	859,3	862,5	4.451,0	0,18	0	0,63
i4w24	14,7	1.972,8	1.989,9	11.072,0	0,17	0	0,55
i4w25	14,5	1.426,9	1.888,1	12.066,0	0,15	0	0,70
i4w26	14,3	244,5	631,6	4.462,0	0,13	0	0,80
i4w27	14,1	2.275,4	2.276,6	11.323,0	0,20	0	0,42
i4w28	15,8	13.357,7	18.000,0	81.797,0	0,22	0,04	0,64
i4w29	15,5	14.141,7	15.914,4	99.552,0	0,16	0	0,49
i4w30	10,4	70,8	85,8	225,0	0,25	0	0,29
i4w31	6,7	54,3	54,8	241,0	0,13	0	0,24
i4w32	5,1	39,5	62,8	665,0	0,07	0	0,49
i4w33	3,3	28,5	29,5	257,0	0,07	0	0,11
i4w34	2,1	10,2	10,3	66,0	0,06	0	0,02
i4w35	1,4	6,0	6,0	3,0	0,17	0	0,32
i4w36	0,6	0,6	0,6	0,0	0,00	0	0,00
i4w37	0,6	0,6	0,6	0,0	0,00	0	0,00
i4w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i4w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i4w40	0,1	0,1	0,1	0,0	0,00	0	0,00
i4w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i4w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	11,3	2.215,8	2.833,8	13.849,3	0,15	0,04	0,40

Table C.17: Macro Instance 4 - Meo

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i4w1	27,9	4.919,4	5.039,2	12.700,0	0,36	0	0,21
i4w2	24,2	693,7	713,5	488,0	0,91	0	0,28
i4w3	14,7	261,2	321,6	141,0	0,83	0	0,12
i4w4	19,4	897,0	917,0	1.418,0	0,47	0	0,37
i4w5	16,4	640,9	644,0	675,0	0,58	0	0,55
i4w6	17,9	955,5	1.100,5	2.174,0	0,40	0	0,26
i4w7	9,4	244,3	244,4	125,0	0,84	0	0,96
i4w8	10,4	256,9	257,5	143,0	0,77	0	0,35
i4w9	10,9	363,3	372,2	602,0	0,36	0	0,35
i4w10	12,0	426,9	434,9	745,0	0,35	0	0,02
i4w11	15,3	1.409,7	1.415,6	4.624,0	0,26	0	1,69
i4w12	15,7	4.034,2	4.036,5	11.925,0	0,32	0	0,80
i4w13	19,1	5.463,5	18.000,0	37.836,0	0,47	0,07	0,26
i4w14	17,0	4.171,9	4.384,9	12.403,0	0,34	0	0,24
i4w15	14,7	530,7	645,4	1.440,0	0,32	0	0,44
i4w16	14,5	711,6	929,8	2.743,0	0,26	0	0,15
i4w17	12,2	1.532,5	1.624,5	5.259,0	0,28	0	0,14
i4w18	13,0	2.849,9	2.856,4	11.812,0	0,23	0	0,33
i4w19	13,9	692,5	703,6	1.937,0	0,28	0	0,99
i4w20	13,0	643,2	651,0	2.182,0	0,23	0	0,11
i4w21	12,7	559,4	591,5	1.436,0	0,29	0	1,92
i4w22	13,1	794,3	794,8	1.730,0	0,37	0	0,68
i4w23	15,6	689,3	761,3	1.866,0	0,30	0	0,63
i4w24	14,6	1.245,8	1.323,5	4.238,0	0,26	0	0,55
i4w25	14,6	1.137,6	1.139,5	3.125,0	0,30	0	0,70
i4w26	14,2	720,8	741,5	1.781,0	0,30	0	0,80
i4w27	14,1	1.677,0	1.699,7	4.901,0	0,31	0	0,42
i4w28	15,6	12.095,1	18.000,0	51.259,0	0,35	0,01	0,65
i4w29	15,5	9.267,3	9.395,3	27.097,0	0,34	0	0,49
i4w30	10,4	221,4	222,6	100,0	0,91	0	0,29
i4w31	6,7	136,4	136,9	70,0	0,57	0	0,24
i4w32	5,1	64,0	100,4	257,0	0,20	0	0,49
i4w33	3,2	56,0	56,4	104,0	0,20	0	0,11
i4w34	2,1	20,2	20,2	18,0	0,33	0	0,02
i4w35	1,3	9,3	9,3	2,0	0,02	0	0,32
i4w36	0,6	0,6	0,6	0,0	0,00	0	0,00
i4w37	0,5	0,5	0,6	0,0	0,00	0	0,00
i4w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i4w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i4w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i4w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i4w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	11,2	1.438,0	1.911,6	4.984,7	0,33	0,04	0,40

Table C.18: Macro Instance 4 - Cutgen

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i4w1	36,1	5.017,2	5.096,0	9.862,0	0,48	0	1,12	86	16,75
i4w2	23,0	607,6	608,1	309,0	0,96	0	0,20	65	14,80
i4w3	18,3	270,2	369,3	232,0	0,67	0	0,14	50	13,55
i4w4	19,6	749,6	752,6	875,0	0,58	0	0,10	65	14,95
i4w5	19,5	489,6	490,3	400,0	0,74	0	1,08	58	17,58
i4w6	19,6	1.137,4	1.137,5	1.672,0	0,53	0	0,23	71	18,97
i4w7	8,3	219,6	220,3	129,0	0,73	0	1,62	33	16,16
i4w8	12,6	247,8	248,9	105,0	0,92	0	0,10	48	18,09
i4w9	13,0	348,5	387,5	520,0	0,41	0	0,28	57	21,50
i4w10	15,7	460,0	530,8	861,0	0,37	0	0,07	60	20,70
i4w11	20,8	919,7	938,3	1.897,0	0,38	0	1,13	68	26,11
i4w12	20,6	2.292,2	2.293,6	5.600,0	0,36	0	0,45	73	27,98
i4w13	23,4	7.587,9	18.000,0	34.367,0	0,52	0,04	0,70	95	34,14
i4w14	20,6	6.891,0	6.917,7	16.036,0	0,42	0	2,24	69	35,09
i4w15	21,5	544,8	545,2	640,0	0,53	0	1,34	69	36,73
i4w16	18,0	1.359,8	1.367,4	2.505,0	0,46	0	0,07	52	32,62
i4w17	19,4	1.503,3	1.609,7	4.801,0	0,29	0	0,21	76	45,42
i4w18	19,1	2.867,7	2.991,8	10.495,0	0,27	0	0,31	68	43,83
i4w19	17,2	644,2	724,2	1.554,0	0,35	0	0,50	52	47,41
i4w20	17,5	668,9	669,0	2.031,0	0,24	0	0,20	52	49,75
i4w21	18,5	668,6	670,0	1.153,0	0,43	0	0,29	61	48,94
i4w22	9,3	813,5	814,3	1.017,0	0,58	0	1,76	71	61,38
i4w23	21,3	1.151,0	1.151,8	1.566,0	0,58	0	0,54	54	59,03
i4w24	21,3	1.370,4	1.406,9	2.833,0	0,42	0	0,57	57	56,05
i4w25	22,0	1.083,6	1.095,8	2.606,0	0,34	0	0,70	63	62,69
i4w26	19,8	828,6	933,1	1.962,0	0,36	0	0,53	60	63,22
i4w27	21,5	2.018,2	2.144,7	5.155,0	0,37	0	0,48	60	79,72
i4w28	26,2	13.605,9	18.000,0	50.298,0	0,35	0,01	1,20	78	89,33
i4w29	27,3	7.772,4	7.856,8	18.644,0	0,41	0	2,32	91	102,30
i4w30	19,5	263,1	314,2	55,0	2,61	0	0,13	59	66,86
i4w31	19,8	194,5	198,1	35,0	1,93	0	1,06	36	45,72
i4w32	12,4	209,3	210,4	215,0	0,65	0	0,16	35	79,27
i4w33	11,2	143,9	145,2	98,0	0,99	0	0,15	32	82,17
i4w34	7,1	8,6	30,6	3,0	0,40	0	0,02	17	10,58
i4w35	6,2	9,9	15,0	0,0	0,00	0	0,26	10	8,25
i4w36	6,7	7,9	7,9	0,0	0,00	0	0,01	6	6,97
i4w37	4,3	4,3	5,9	0,0	0,00	0	0,00	5	4,59
i4w38	1,4	1,4	1,4	0,0	0,00	0	0,00	0	1,16
i4w39	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i4w40	1,3	1,3	1,3	0,0	0,00	0	0,00	0	1,20
i4w41	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,11
i4w42	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,19
Average	15,8	1.547,3	1.926,3	4.298,4	0,49	0,02	0,53	49,10	35,36

Table C.19: Macro Instance 4 - Delayed

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i4w1	73,8	727,1	2.134,3	52.831,0	0,04	0	0,05	1319	40,38
i4w2	70,6	130,7	142,6	1.527,0	0,08	0	0,05	1261	38,09
i4w3	33,1	47,3	49,3	524,0	0,06	0	0,00	1043	13,14
i4w4	58,8	271,5	273,0	6.147,0	0,04	0	0,06	1156	34,48
i4w5	57,0	150,1	157,8	2.482,0	0,06	0	0,26	1155	34,62
i4w6	55,8	267,5	271,0	5.153,0	0,05	0	0,11	1230	34,19
i4w7	28,0	41,3	45,7	391,0	0,07	0	0,08	996	17,52
i4w8	41,5	53,6	54,6	399,0	0,09	0	0,01	1016	25,06
i4w9	52,1	128,0	132,2	2.366,0	0,05	0	0,02	1077	33,50
i4w10	54,2	125,1	145,5	2.490,0	0,05	0	0,13	1076	32,52
i4w11	63,6	337,8	494,3	6.960,0	0,07	0	0,08	1070	37,20
i4w12	179,6	1.654,3	1.750,1	24.280,0	0,07	0	0,16	1261	115,66
i4w13	192,1	17.067,2	18.000,0	193.680,0	0,09	0,01	0,12	1233	129,98
i4w14	184,4	6.162,7	6.843,3	83.111,0	0,08	0	0,09	1184	119,12
i4w15	135,1	545,9	636,8	6.968,0	0,09	0	0,25	1045	85,38
i4w16	159,3	849,1	870,6	8.530,0	0,10	0	0,09	1050	103,86
i4w17	173,4	1.200,4	2.013,4	31.883,0	0,06	0	0,27	1104	127,80
i4w18	165,1	7.711,0	8.183,2	142.401,0	0,06	0	0,09	1067	126,08
i4w19	123,9	346,4	380,5	4.759,0	0,07	0	0,02	956	79,19
i4w20	157,2	459,0	471,1	6.078,0	0,07	0	0,06	934	112,38
i4w21	137,3	430,6	452,0	4.683,0	0,09	0	0,08	939	100,11
i4w22	167,9	693,8	1.144,5	15.385,0	0,07	0	0,24	966	127,75
i4w23	189,7	611,7	617,8	5.779,0	0,10	0	0,22	970	145,55
i4w24	183,7	1.859,6	1.901,3	23.125,0	0,08	0	0,08	968	147,52
i4w25	198,2	1.312,0	1.412,5	18.290,0	0,07	0	0,04	1002	148,95
i4w26	179,8	309,8	460,0	4.274,0	0,10	0	0,06	977	138,30
i4w27	229,3	1.440,3	1.441,3	14.334,0	0,10	0	0,73	1016	209,78
i4w28	321,9	16.718,3	18.000,0	195.542,0	0,09	0,04	0,40	1150	289,67
i4w29	252,4	3.036,2	5.233,3	58.684,0	0,09	0	0,05	1083	194,61
i4w30	179,2	238,8	250,6	830,0	0,24	0	0,20	926	141,83
i4w31	75,4	88,8	92,2	264,0	0,20	0	0,18	745	59,06
i4w32	69,9	115,9	124,2	1.205,0	0,08	0	0,29	657	74,14
i4w33	85,9	101,4	105,2	633,0	0,12	0	0,20	528	83,11
i4w34	54,1	54,1	54,6	32,0	0,76	0	0,00	430	47,61
i4w35	31,1	34,8	34,8	8,0	0,16	0	0,10	359	31,69
i4w36	18,8	21,8	21,8	3,0	0,40	0	0,20	232	20,30
i4w37	33,7	33,7	33,8	4,0	2,57	0	0,00	225	31,69
i4w38	10,5	10,5	10,5	0,0	0,00	0	0,00	112	10,12
i4w39	9,1	9,1	9,1	0,0	0,00	0	0,00	57	9,03
i4w40	7,9	7,9	7,9	0,0	0,00	0	0,00	35	7,88
i4w41	9,0	9,0	9,0	0,0	0,00	0	0,00	27	8,98
i4w42	6,8	6,8	6,8	0,0	0,00	0	0,00	9	6,73
Average	107,4	1.557,6	1.773,1	22.048,5	0,16	0,03	0,12	848,71	80,35

Table C.20: Macro Instance 4 - Weight

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i4w1	12,6	121,4	121,5	73,0	0,41	0	3,46
i4w2	12,5	394,1	413,4	996,0	0,31	0	0,31
i4w3	9,2	344,9	345,6	848,0	0,28	0	4,99
i4w4	10,2	209,7	212,7	240,0	0,44	0	0,35
i4w5	10,6	287,9	288,7	614,0	0,27	0	0,38
i4w6	15,8	604,0	635,3	1.297,0	0,35	0	0,63
i4w7	9,2	158,7	158,8	57,0	0,77	0	0,64
i4w8	11,6	280,5	282,6	216,0	0,69	0	0,15
i4w9	10,5	242,6	244,2	322,0	0,33	0	0,18
i4w10	9,0	186,5	221,8	156,0	0,47	0	0,19
i4w11	9,5	176,4	177,5	139,0	0,46	0	0,10
i4w12	8,6	431,4	449,6	1.798,0	0,19	0	0,23
i4w13	10,5	255,8	256,2	326,0	0,41	0	1,13
i4w14	10,0	503,3	504,0	1.550,0	0,24	0	0,32
i4w15	10,4	304,1	305,1	543,0	0,34	0	0,45
i4w16	9,5	154,0	154,2	126,0	0,64	0	0,20
i4w17	8,2	165,0	165,1	94,0	0,64	0	0,34
i4w18	8,7	141,0	163,0	74,0	0,54	0	0,50
i4w19	4,7	60,1	60,1	13,0	0,64	0	0,16
i4w20	6,5	121,9	125,5	163,0	0,25	0	0,11
i4w21	6,1	144,4	144,5	182,0	0,33	0	1,47
i4w22	8,5	252,9	253,8	308,0	0,40	0	0,63
i4w23	10,6	232,1	233,0	361,0	0,31	0	0,63
i4w24	11,8	219,5	248,0	84,0	0,79	0	0,72
i4w25	10,4	476,5	477,6	820,0	0,39	0	0,18
i4w26	10,3	414,6	430,9	1.188,0	0,23	0	0,31
i4w27	9,4	236,2	243,5	308,0	0,38	0	0,21
i4w28	12,6	217,2	240,9	115,0	0,82	0	0,99
i4w29	12,4	684,0	693,7	1.525,0	0,32	0	0,59
i4w30	9,8	399,4	402,4	775,0	0,33	0	0,28
i4w31	8,9	221,8	223,9	307,0	0,39	0	2,01
i4w32	4,0	78,5	89,0	76,0	0,52	0	0,14
i4w33	3,1	47,7	47,9	38,0	0,42	0	0,81
i4w34	1,9	22,4	22,8	32,0	0,66	0	0,08
i4w35	1,2	1,5	1,5	0,0	0,00	0	0,09
i4w36	0,7	0,7	1,3	0,0	0,00	0	0,00
i4w37	0,9	1,0	2,8	0,0	0,00	0	0,14
i4w38	0,2	0,2	0,2	0,0	0,00	0	0,00
i4w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i4w40	0,1	0,1	0,1	0,0	0,00	0	0,00
i4w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i4w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	7,6	209,4	215,3	375,3	0,36	0	0,57

Table C.21: Macro Instance 5 - Default

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i5w1	23,4	7.084,9	8.071,7	27.586,0	0,29	0	0,10
i5w2	16,2	96,9	102,3	105,0	0,43	0	0,11
i5w3	17,0	45,2	45,7	8,0	0,84	0	0,79
i5w4	13,1	64,0	64,6	74,0	0,31	0	0,10
i5w5	14,3	1.738,0	1.775,4	10.767,0	0,16	0	0,34
i5w6	14,8	620,7	659,9	2.968,0	0,20	0	0,23
i5w7	10,9	36,0	39,2	47,0	0,17	0	1,06
i5w8	10,7	523,9	538,3	3.694,0	0,14	0	0,29
i5w9	8,5	88,8	115,3	632,0	0,14	0	0,09
i5w10	10,8	223,7	371,2	2.285,0	0,15	0	0,24
i5w11	13,4	1.255,3	2.421,2	18.920,0	0,13	0	0,29
i5w12	14,7	15.775,0	18.000,0	105.021,0	0,17	0,02	0,34
i5w13	80,4	14.183,0	15.861,8	80.490,0	0,20	0	0,15
i5w14	18,1	17.232,3	18.000,0	86.280,0	0,21	0,01	0,24
i5w15	14,3	354,9	393,9	1.894,0	0,18	0	0,36
i5w16	17,0	816,4	1.319,7	7.965,0	0,16	0	0,46
i5w17	16,2	4.643,3	4.786,1	23.901,0	0,20	0	0,52
i5w18	17,4	10.172,3	11.875,3	76.905,0	0,15	0	0,57
i5w19	12,6	284,0	705,2	5.339,0	0,12	0	0,41
i5w20	12,3	1.158,5	1.223,8	7.530,0	0,16	0	0,35
i5w21	14,7	739,5	782,2	3.646,0	0,20	0	0,94
i5w22	14,9	490,0	740,8	3.752,0	0,19	0	0,19
i5w23	14,6	1.912,6	1.924,1	14.512,0	0,13	0	0,28
i5w24	14,8	622,3	653,8	4.033,0	0,15	0	0,36
i5w25	13,8	971,4	1.051,6	6.655,0	0,15	0	0,35
i5w26	15,5	13.936,0	14.338,2	86.862,0	0,16	0	0,25
i5w27	16,6	6.888,4	6.933,9	38.567,0	0,18	0	0,51
i5w28	18,3	328,7	386,3	1.551,0	0,21	0	0,63
i5w29	16,7	1.601,9	1.845,8	10.012,0	0,18	0	1,11
i5w30	12,1	999,9	2.211,2	16.359,0	0,13	0	0,41
i5w31	7,0	33,6	37,8	57,0	0,27	0	0,08
i5w32	4,2	23,6	24,1	86,0	0,12	0	0,10
i5w33	3,0	3,3	11,1	30,0	0,06	0	0,06
i5w34	2,0	12,1	12,1	44,0	0,09	0	0,15
i5w35	0,8	0,8	0,8	0,0	0,00	0	0,00
i5w36	0,3	0,3	0,3	0,0	0,00	0	0,00
i5w37	0,2	0,2	0,3	0,0	0,00	0	0,00
i5w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i5w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i5w40	0,0	0,0	0,1	0,0	0,00	0	0,00
i5w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i5w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	12,5	2.499,1	2.793,5	15.442,3	0,16	0,02	0,30

Table C.22: Macro Instance 5 - Meo

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i5w1	26,1	3.408,9	3.441,9	7.056,0	0,43	0	0,10
i5w2	16,3	300,8	317,0	39,0	1,77	0	0,11
i5w3	17,0	161,2	161,4	3,0	2,83	0	0,79
i5w4	13,2	206,8	208,0	41,0	0,94	0	0,10
i5w5	14,4	1.002,3	1.058,6	3.210,0	0,26	0	0,34
i5w6	14,9	640,0	643,0	817,0	0,50	0	0,23
i5w7	11,0	134,2	135,1	45,0	0,47	0	1,06
i5w8	10,8	361,6	388,7	932,0	0,27	0	0,29
i5w9	8,5	169,4	206,8	265,0	0,38	0	0,09
i5w10	10,9	384,6	404,4	676,0	0,38	0	0,24
i5w11	13,5	1.545,0	1.555,2	5.777,0	0,24	0	0,29
i5w12	14,7	6.888,6	18.000,0	67.093,0	0,27	0,01	0,34
i5w13	269,2	2.717,7	3.798,3	15.825,0	0,23	0	0,89
i5w14	18,2	6.841,5	6.857,7	20.043,0	0,33	0	0,24
i5w15	14,3	588,9	591,2	945,0	0,42	0	0,36
i5w16	17,0	1.243,2	1.244,2	3.274,0	0,33	0	0,46
i5w17	16,3	1.772,2	2.071,0	6.262,0	0,29	0	0,52
i5w18	17,4	2.286,3	2.959,1	11.357,0	0,24	0	0,57
i5w19	12,6	1.047,3	1.050,4	3.229,0	0,28	0	0,41
i5w20	12,4	1.165,7	1.166,9	4.147,0	0,24	0	0,35
i5w21	14,7	738,2	743,7	1.547,0	0,36	0	0,94
i5w22	14,9	927,3	928,3	2.241,0	0,33	0	0,19
i5w23	14,7	730,3	836,6	2.334,0	0,27	0	0,28
i5w24	14,8	227,6	305,5	291,0	0,45	0	0,36
i5w25	14,0	458,0	666,8	2.006,0	0,23	0	0,35
i5w26	15,6	3.622,0	3.665,2	13.927,0	0,25	0	0,25
i5w27	16,6	4.103,2	4.124,8	15.948,0	0,24	0	0,51
i5w28	18,3	599,4	605,4	626,0	0,58	0	0,63
i5w29	16,7	2.488,9	2.533,6	8.040,0	0,28	0	1,11
i5w30	12,0	1.207,5	1.216,5	3.290,0	0,32	0	0,41
i5w31	7,1	110,9	112,8	19,0	1,57	0	0,08
i5w32	4,1	59,0	59,7	33,0	0,51	0	0,10
i5w33	3,0	3,3	25,0	1,0	22,42	0	0,06
i5w34	2,0	17,2	17,2	6,0	0,28	0	0,15
i5w35	0,8	0,8	0,8	0,0	0,00	0	0,00
i5w36	0,2	0,2	0,3	0,0	0,00	0	0,00
i5w37	0,3	0,3	0,3	0,0	0,00	0	0,00
i5w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i5w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i5w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i5w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i5w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	17,1	1.146,7	1.478,6	4.793,9	0,93	0,01	0,31

Table C.23: Macro Instance 5 - Cutgen

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i5w1	30,5	3.222,2	3.298,3	5.839,0	0,50	0	1,89	77	14,84
i5w2	18,4	289,9	292,6	19,0	3,10	0	0,29	56	5,97
i5w3	15,5	164,0	164,3	8,0	2,75	0	0,19	34	3,33
i5w4	18,2	237,4	237,8	35,0	1,72	0	1,07	42	8,83
i5w5	14,9	711,6	747,5	1.727,0	0,33	0	0,59	60	16,94
i5w6	17,0	577,6	584,2	584,0	0,64	0	0,66	55	17,23
i5w7	12,1	142,3	144,3	56,0	0,95	0	1,66	39	14,16
i5w8	15,8	285,1	331,8	674,0	0,29	0	1,35	62	17,45
i5w9	13,3	243,6	244,2	234,0	0,57	0	0,29	40	17,20
i5w10	13,2	318,1	334,2	422,0	0,45	0	0,20	51	22,00
i5w11	19,0	1.324,6	1.387,5	5.603,0	0,21	0	1,39	72	25,47
i5w12	18,5	12.329,1	14.765,1	73.924,0	0,20	0	1,31	71	30,36
i5w13	343,3	6.130,4	6.133,4	17.854,0	0,33	0	0,75	63	28,22
i5w14	22,8	3.885,0	4.412,2	12.197,0	0,34	0	0,21	78	36,72
i5w15	19,9	731,6	731,7	881,0	0,57	0	0,69	54	31,36
i5w16	21,7	978,9	985,4	1.835,0	0,42	0	0,63	68	38,17
i5w17	25,1	3.084,5	3.120,0	6.674,0	0,43	0	0,95	81	45,92
i5w18	22,8	3.468,4	3.904,9	10.272,0	0,35	0	0,45	69	43,84
i5w19	19,1	791,1	792,3	1.658,0	0,35	0	0,15	66	46,69
i5w20	21,5	1.410,6	1.422,6	4.064,0	0,30	0	0,46	63	48,41
i5w21	19,7	620,4	647,1	745,0	0,57	0	0,07	75	54,53
i5w22	21,5	981,1	991,3	2.282,0	0,33	0	0,48	67	50,88
i5w23	26,4	814,7	827,3	1.570,0	0,39	0	3,27	67	60,03
i5w24	21,4	597,0	599,3	354,0	0,96	0	1,69	53	55,33
i5w25	22,3	993,6	997,0	1.196,0	0,62	0	0,62	78	75,06
i5w26	20,7	3.379,7	3.446,3	9.871,0	0,33	0	0,32	61	63,72
i5w27	25,4	3.479,6	4.084,9	12.966,0	0,30	0	0,81	61	66,39
i5w28	26,1	529,0	635,9	632,0	0,57	0	1,63	62	77,59
i5w29	370,5	1.266,4	1.273,4	3.019,0	0,34	0	0,17	61	87,42
i5w30	20,8	1.909,5	1.920,2	5.444,0	0,32	0	0,22	44	76,80
i5w31	17,5	160,9	182,8	31,0	2,36	0	0,09	25	37,59
i5w32	11,8	79,8	118,8	41,0	1,45	0	0,06	27	50,61
i5w33	10,1	11,4	37,2	4,0	7,45	0	0,02	17	13,36
i5w34	6,7	42,2	43,4	11,0	3,44	0	0,80	12	22,84
i5w35	3,2	3,2	3,2	0,0	0,00	0	0,00	5	2,27
i5w36	1,4	1,4	1,4	0,0	0,00	0	0,00	0	1,14
i5w37	1,4	1,4	1,4	0,0	0,00	0	0,00	0	1,12
i5w38	1,3	1,3	1,3	0,0	0,00	0	0,00	0	1,12
i5w39	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,11
i5w40	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,11
i5w41	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i5w42	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
Average	31,8	1.314,4	1.425,0	4.350,6	0,81	0	0,60	45,62	31,32

Table C.24: Macro Instance 5 - Delayed

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i5w1	52,3	319,5	352,5	9.094,0	0,04	0	0,03	1167	27,23
i5w2	28,6	28,6	31,1	53,0	0,22	0	0,00	1046	9,25
i5w3	17,1	17,1	17,3	15,0	0,31	0	0,00	902	6,48
i5w4	22,5	24,3	25,2	80,0	0,13	0	0,01	986	9,17
i5w5	46,8	175,0	231,8	6.936,0	0,03	0	1,29	1155	30,81
i5w6	55,1	124,8	126,1	2.115,0	0,05	0	0,05	1149	34,62
i5w7	27,9	30,7	30,8	73,0	0,16	0	0,06	949	13,64
i5w8	55,3	171,6	172,8	3.959,0	0,04	0	0,04	1048	38,00
i5w9	37,1	68,3	68,9	1.229,0	0,04	0	0,03	965	24,53
i5w10	56,8	94,6	100,1	1.105,0	0,07	0	0,17	1097	42,44
i5w11	87,6	603,0	2.219,5	57.826,0	0,04	0	0,04	1115	55,41
i5w12	176,8	16.834,6	18.000,0	285.905,0	0,06	0,02	0,09	1244	121,44
i5w13	143,2	2.489,4	2.579,3	34.388,0	0,07	0	0,11	1183	92,47
i5w14	129,0	2.471,7	4.544,6	66.530,0	0,07	0	0,07	1079	76,61
i5w15	174,6	697,4	765,5	6.293,0	0,11	0	0,38	1148	118,67
i5w16	110,5	581,0	1.190,9	19.895,0	0,06	0	0,04	935	67,22
i5w17	188,4	2.231,4	3.740,3	43.805,0	0,08	0	0,14	1053	121,16
i5w18	161,1	2.296,2	4.355,8	57.349,0	0,08	0	0,04	994	102,06
i5w19	113,9	692,2	747,1	10.394,0	0,07	0	0,03	954	80,98
i5w20	163,5	607,6	656,5	7.941,0	0,08	0	0,07	1032	119,02
i5w21	200,9	407,1	413,0	2.426,0	0,15	0	0,39	1048	147,59
i5w22	186,1	352,9	594,3	5.565,0	0,10	0	0,08	1011	137,20
i5w23	176,7	771,4	794,5	7.757,0	0,10	0	0,07	1019	144,66
i5w24	102,6	298,4	299,0	2.402,0	0,10	0	0,23	961	75,80
i5w25	175,5	555,4	575,4	5.483,0	0,09	0	0,07	1007	123,03
i5w26	271,3	3.932,5	4.128,2	52.600,0	0,08	0	0,41	1106	245,22
i5w27	337,6	4.378,0	7.844,9	100.520,0	0,08	0	0,31	1167	298,75
i5w28	122,5	167,5	243,1	1.491,0	0,13	0	0,10	920	76,75
i5w29	218,8	1.243,5	1.251,8	15.473,0	0,08	0	0,03	1038	173,03
i5w30	309,2	1.257,3	1.282,9	12.067,0	0,10	0	0,19	1024	269,89
i5w31	102,2	110,2	110,3	107,0	0,65	0	0,06	742	79,94
i5w32	30,2	59,1	59,4	219,0	0,09	0	0,21	572	34,31
i5w33	48,1	48,1	48,5	15,0	1,19	0	0,00	449	41,00
i5w34	23,7	32,8	32,8	73,0	0,09	0	0,06	380	26,00
i5w35	19,2	19,2	19,2	0,0	0,00	0	0,00	306	18,14
i5w36	14,4	14,4	14,4	0,0	0,00	0	0,00	206	13,56
i5w37	14,3	14,3	14,3	0,0	0,00	0	0,00	183	13,58
i5w38	9,1	9,1	9,1	0,0	0,00	0	0,00	94	9,03
i5w39	10,2	10,2	10,2	0,0	0,00	0	0,00	56	10,14
i5w40	7,9	7,9	7,9	0,0	0,00	0	0,00	39	7,89
i5w41	7,9	7,9	7,9	0,0	0,00	0	0,00	19	7,84
i5w42	4,5	4,5	4,5	0,0	0,00	0	0,00	5	4,50
Average	101,0	1.053,8	1.374,3	19.552,0	0,12	0,02	0,12	822,69	74,98

Table C.25: Macro Instance 5 - Weight

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i5w1	19,9	269,7	273,3	139,0	1,13	0	1,82
i5w2	11,8	120,6	120,7	50,0	0,79	0	0,18
i5w3	10,5	81,7	92,9	24,0	1,13	0	0,29
i5w4	13,1	216,5	217,5	134,0	0,71	0	0,21
i5w5	10,4	172,7	180,1	147,0	0,46	0	1,20
i5w6	14,7	239,7	245,1	165,0	0,56	0	0,04
i5w7	11,4	360,5	363,2	553,0	0,34	0	0,44
i5w8	11,0	518,7	524,9	1.114,0	0,34	0	0,21
i5w9	11,3	297,5	298,1	173,0	0,78	0	0,20
i5w10	9,5	374,7	376,9	781,0	0,31	0	0,03
i5w11	11,0	333,3	334,5	554,0	0,34	0	0,38
i5w12	10,2	239,8	243,5	351,0	0,39	0	0,22
i5w13	8,7	104,1	104,5	10,0	1,48	0	0,07
i5w14	9,0	170,9	170,9	101,0	0,78	0	0,04
i5w15	8,0	122,8	123,1	51,0	0,84	0	0,15
i5w16	7,3	123,4	125,5	256,0	0,47	0	0,04
i5w17	7,6	143,5	144,7	77,0	0,77	0	0,83
i5w18	10,8	242,7	248,7	309,0	0,37	0	1,58
i5w19	4,6	60,6	60,6	53,0	1,07	0	0,03
i5w20	7,1	141,2	146,0	231,0	0,26	0	0,29
i5w21	7,3	136,4	139,3	304,0	0,22	0	0,18
i5w22	9,7	176,5	176,5	224,0	0,33	0	0,59
i5w23	7,0	121,0	121,4	119,0	0,39	0	0,02
i5w24	7,5	125,1	125,4	104,0	0,46	0	0,08
i5w25	10,5	157,4	164,1	33,0	1,18	0	0,14
i5w26	11,4	339,0	340,7	473,0	0,38	0	0,22
i5w27	256,4	707,9	736,4	1.819,0	0,30	0	0,12
i5w28	225,4	637,0	723,8	2.205,0	0,25	0	0,91
i5w29	12,5	949,0	952,0	2.878,0	0,26	0	0,29
i5w30	8,5	288,3	288,4	203,0	0,68	0	0,15
i5w31	6,2	129,7	129,7	61,0	0,44	0	0,22
i5w32	3,5	61,9	61,9	25,0	0,84	0	0,22
i5w33	2,0	15,5	15,5	5,0	0,14	0	0,00
i5w34	1,5	10,3	10,3	2,0	0,02	0	0,05
i5w35	1,0	4,8	4,8	2,0	0,01	0	0,01
i5w36	0,3	0,3	0,3	0,0	0,00	0	0,00
i5w37	0,3	0,3	0,3	0,0	0,00	0	0,00
i5w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i5w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i5w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i5w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i5w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	18,6	195,1	199,7	326,9	0,46	0	0,27

Table C.26: Macro Instance 6 - Default

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i6w1	24,3	8.394,1	18.000,0	64.407,0	0,28	0,01	0,17
i6w2	12,3	208,7	221,2	532,0	0,32	0	2,07
i6w3	12,7	38,6	40,2	15,0	0,39	0	0,06
i6w4	11,4	79,7	91,8	257,0	0,22	0	0,01
i6w5	17,3	358,3	361,6	1.258,0	0,24	0	0,29
i6w6	15,5	396,7	398,3	1.871,0	0,18	0	0,80
i6w7	10,1	45,8	57,2	66,0	0,32	0	0,17
i6w8	11,2	841,7	882,3	5.515,0	0,15	0	0,13
i6w9	12,2	393,6	395,3	2.042,0	0,18	0	0,11
i6w10	13,2	180,1	184,1	835,0	0,17	0	0,09
i6w11	16,6	1.946,9	18.000,0	88.786,0	0,20	0,01	0,62
i6w12	17,2	17.807,5	18.000,0	94.621,0	0,19	0,01	0,68
i6w13	14,0	1.056,9	1.929,8	11.561,0	0,16	0	0,58
i6w14	14,9	4.734,5	18.000,0	107.532,0	0,17	0,01	0,64
i6w15	15,3	639,2	811,8	4.654,0	0,16	0	1,00
i6w16	14,6	634,2	1.064,4	7.136,0	0,14	0	0,73
i6w17	12,5	282,8	404,3	2.101,0	0,17	0	0,26
i6w18	15,0	1.258,8	1.273,3	6.909,0	0,18	0	0,50
i6w19	14,7	325,8	326,8	1.722,0	0,16	0	0,16
i6w20	11,9	1.926,1	1.965,2	14.077,0	0,14	0	0,28
i6w21	17,4	6.264,0	12.439,8	70.651,0	0,18	0	1,44
i6w22	17,2	14.500,3	14.509,7	96.144,0	0,15	0	0,72
i6w23	12,5	517,9	601,1	3.861,0	0,14	0	0,16
i6w24	15,1	17.165,7	18.000,0	95.573,0	0,19	0,03	0,22
i6w25	13,9	664,6	2.811,7	15.652,0	0,18	0	0,53
i6w26	14,5	3.415,6	7.687,9	39.584,0	0,19	0	0,21
i6w27	15,2	5.496,9	6.063,7	32.674,0	0,18	0	0,52
i6w28	15,6	859,4	6.565,2	40.850,0	0,16	0	0,71
i6w29	14,7	2.584,5	4.436,7	31.392,0	0,14	0	0,42
i6w30	12,0	11.231,0	11.231,2	75.940,0	0,15	0	0,44
i6w31	7,5	86,8	88,1	489,0	0,13	0	0,18
i6w32	4,0	15,1	15,8	37,0	0,13	0	0,07
i6w33	3,8	16,1	16,7	81,0	0,08	0	0,31
i6w34	1,9	1,9	6,5	1,0	4,73	0	0,00
i6w35	0,8	0,8	0,8	0,0	0,00	0	0,00
i6w36	0,2	0,2	0,2	0,0	0,00	0	0,00
i6w37	0,2	0,2	0,2	0,0	0,00	0	0,00
i6w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i6w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i6w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i6w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i6w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	10,8	2.485,0	3.973,4	21.876,8	0,26	0,01	0,36

Table C.27: Macro Instance 6 - Meo

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i6w1	24,8	5.834,9	18.000,0	46.588,0	0,38	0,00	0,17
i6w2	12,4	394,0	395,6	123,0	1,33	0	2,07
i6w3	12,6	161,3	161,6	11,0	2,11	0	0,06
i6w4	11,5	233,2	236,6	110,0	0,79	0	0,01
i6w5	17,3	494,6	496,9	389,0	0,74	0	0,29
i6w6	15,5	501,0	501,1	775,0	0,34	0	0,80
i6w7	10,1	178,1	185,0	28,0	1,65	0	0,17
i6w8	11,2	518,0	584,0	1.415,0	0,30	0	0,13
i6w9	12,2	322,3	380,7	531,0	0,40	0	0,11
i6w10	13,2	332,4	352,9	431,0	0,40	0	0,09
i6w11	16,6	2.845,0	12.067,5	64.892,0	0,18	0	0,62
i6w12	17,2	15.364,3	15.501,6	57.743,0	0,26	0	0,68
i6w13	14,0	2.091,8	2.095,4	7.000,0	0,27	0	0,58
i6w14	15,0	7.776,3	9.447,9	44.703,0	0,21	0	0,64
i6w15	15,3	822,2	890,5	1.956,0	0,34	0	1,00
i6w16	14,7	1.135,5	1.157,0	3.394,0	0,29	0	0,73
i6w17	12,5	666,3	666,8	1.095,0	0,44	0	0,26
i6w18	15,0	959,2	959,2	2.085,0	0,35	0	0,50
i6w19	14,8	442,3	442,5	447,0	0,56	0	0,16
i6w20	11,9	814,3	880,5	2.757,0	0,25	0	0,28
i6w21	17,5	10.342,1	10.533,4	40.999,0	0,25	0	1,44
i6w22	17,3	1.878,2	1.897,1	5.243,0	0,32	0	0,72
i6w23	12,5	469,9	470,6	820,0	0,35	0	0,16
i6w24	15,1	12.102,1	12.105,5	47.944,0	0,25	0	0,23
i6w25	13,9	2.039,8	2.042,8	7.021,0	0,26	0	0,53
i6w26	14,6	6.185,8	6.212,8	17.992,0	0,33	0	0,21
i6w27	15,3	2.772,3	3.095,9	10.147,0	0,28	0	0,52
i6w28	15,7	9.998,5	10.081,9	33.434,0	0,30	0	0,71
i6w29	14,7	2.637,5	2.641,2	8.519,0	0,29	0	0,42
i6w30	12,0	3.741,9	4.117,7	21.027,0	0,19	0	0,44
i6w31	7,5	183,2	183,5	149,0	0,48	0	0,18
i6w32	3,9	39,9	41,9	16,0	2,41	0	0,07
i6w33	3,8	40,6	42,5	33,0	0,37	0	0,31
i6w34	1,9	1,9	14,1	0,0	0,00	0	0,00
i6w35	0,8	0,8	0,8	0,0	0,00	0	0,00
i6w36	0,2	0,2	0,2	0,0	0,00	0	0,00
i6w37	0,2	0,2	0,2	0,0	0,00	0	0,00
i6w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i6w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i6w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i6w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i6w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	10,8	2.245,8	2.830,6	10.233,7	0,42	0,00	0,36

Table C.28: Macro Instance 6 - Cutgen

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i6w1	28,3	17.768,8	18.000,0	42.770,0	0,41	0,00	0,30	60	15,31
i6w2	14,5	401,0	407,0	123,0	1,39	0	2,41	48	13,89
i6w3	14,9	203,8	216,4	23,0	1,67	0	0,02	29	5,41
i6w4	14,7	299,4	300,7	153,0	0,93	0	0,07	48	13,86
i6w5	15,2	531,5	532,4	381,0	0,80	0	0,30	58	17,94
i6w6	18,0	559,0	559,1	594,0	0,54	0	0,25	54	16,08
i6w7	11,0	171,5	182,4	19,0	2,78	0	0,38	35	8,27
i6w8	13,5	261,8	477,0	1.034,0	0,30	0	0,06	64	18,52
i6w9	13,7	411,0	412,4	392,0	0,64	0	0,12	56	17,95
i6w10	15,7	359,7	367,7	332,0	0,53	0	0,05	62	21,48
i6w11	19,4	10.030,8	10.280,4	35.718,0	0,28	0	0,49	57	25,48
i6w12	20,2	2.150,0	18.000,0	47.287,0	0,38	0,02	0,29	59	25,34
i6w13	18,5	1.474,0	1.574,2	4.063,0	0,33	0	0,28	61	27,31
i6w14	18,7	8.223,8	8.358,3	31.940,0	0,25	0	0,41	70	35,98
i6w15	17,9	712,1	734,9	1.174,0	0,42	0	0,15	64	33,56
i6w16	18,2	999,4	1.074,5	2.860,0	0,31	0	0,32	52	39,98
i6w17	20,5	597,2	642,5	979,0	0,40	0	0,55	61	46,38
i6w18	20,6	1.139,7	1.148,8	1.917,0	0,46	0	0,61	59	45,42
i6w19	17,0	390,2	394,6	227,0	0,89	0	0,06	52	41,55
i6w20	19,1	1.152,4	1.158,5	2.850,0	0,32	0	0,33	65	53,47
i6w21	396,6	12.802,8	13.064,8	35.712,0	0,36	0	0,47	83	58,98
i6w22	25,0	3.385,6	3.431,5	7.752,0	0,40	0	0,90	70	56,42
i6w23	25,9	589,0	589,1	754,0	0,47	0	0,13	73	62,91
i6w24	22,1	5.503,9	6.283,1	21.345,0	0,28	0	0,37	78	61,56
i6w25	26,5	2.020,4	2.039,4	3.876,0	0,46	0	0,55	80	71,22
i6w26	25,2	4.028,7	4.119,1	10.394,0	0,38	0	0,50	70	72,45
i6w27	22,3	2.888,7	2.995,9	7.361,0	0,37	0	0,19	76	76,22
i6w28	26,3	6.526,2	6.776,8	21.651,0	0,30	0	0,59	76	83,56
i6w29	26,0	2.227,5	2.232,4	6.284,0	0,32	0	0,63	86	91,03
i6w30	19,8	9.906,9	9.907,4	31.586,0	0,31	0	0,64	62	85,36
i6w31	13,4	203,9	253,6	143,0	0,87	0	0,07	41	68,98
i6w32	11,2	12,9	66,9	15,0	3,90	0	0,01	17	21,42
i6w33	10,8	73,1	87,5	27,0	1,54	0	0,19	28	36,95
i6w34	7,8	7,8	10,9	0,0	0,00	0	0,00	8	5,69
i6w35	4,6	4,6	4,6	0,0	0,00	0	0,00	7	3,39
i6w36	1,4	1,4	1,4	0,0	0,00	0	0,00	0	1,12
i6w37	1,4	1,4	1,4	0,0	0,00	0	0,00	0	1,12
i6w38	1,3	1,3	1,3	0,0	0,00	0	0,00	0	1,12
i6w39	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i6w40	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i6w41	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
i6w42	1,2	1,2	1,2	0,0	0,00	0	0,00	0	1,12
Average	24,3	2.334,0	2.778,4	7.660,4	0,57	0,01	0,30	46,88	33,03

Table C.29: Macro Instance 6 - Delayed

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i6w1	59,7	4.353,8	10.758,7	271.424,0	0,04	0	0,04	1300	36,02
i6w2	44,5	46,0	51,3	151,0	0,21	0	0,06	1114	21,56
i6w3	23,8	29,3	29,3	116,0	0,13	0	0,01	969	10,91
i6w4	32,4	53,7	54,1	596,0	0,07	0	0,02	1048	19,14
i6w5	49,1	95,8	96,3	1.136,0	0,07	0	0,03	1132	29,45
i6w6	69,1	133,2	136,8	2.008,0	0,06	0	0,06	1171	48,16
i6w7	32,8	34,0	34,6	59,0	0,32	0	0,02	972	18,08
i6w8	63,2	147,7	173,0	3.717,0	0,04	0	0,07	1088	43,81
i6w9	45,9	104,4	104,5	1.590,0	0,05	0	0,01	1007	28,98
i6w10	45,7	84,2	93,9	1.131,0	0,06	0	0,62	1062	25,98
i6w11	143,1	8.326,3	18.000,0	280.180,0	0,06	0,00	0,08	1226	94,91
i6w12	111,4	8.826,5	10.733,0	170.818,0	0,06	0	0,15	1169	75,98
i6w13	129,6	642,7	904,4	11.733,0	0,07	0	0,05	1095	85,55
i6w14	132,4	5.303,5	7.262,8	104.576,0	0,07	0	0,15	1073	91,58
i6w15	154,4	786,9	790,6	8.398,0	0,09	0	0,16	1070	113,89
i6w16	116,7	565,4	664,6	8.958,0	0,07	0	0,04	967	84,75
i6w17	166,2	590,2	630,8	7.255,0	0,08	0	0,11	972	127,25
i6w18	159,7	779,8	837,2	9.154,0	0,09	0	0,19	1045	133,27
i6w19	116,5	257,7	258,9	2.184,0	0,10	0	0,04	899	76,41
i6w20	146,9	1.785,6	1.795,8	26.639,0	0,07	0	0,07	959	123,47
i6w21	142,9	10.140,0	10.203,4	148.112,0	0,07	0	0,17	956	102,86
i6w22	187,3	1.725,1	1.759,3	22.352,0	0,08	0	0,15	1029	158,61
i6w23	157,4	449,1	479,1	3.988,0	0,11	0	0,24	971	124,58
i6w24	182,9	7.948,2	9.090,2	153.536,0	0,06	0	0,15	982	148,89
i6w25	248,9	1.699,7	2.123,0	25.589,0	0,08	0	0,29	1120	218,80
i6w26	185,3	3.270,3	3.570,7	44.421,0	0,08	0	0,34	993	146,17
i6w27	230,7	719,7	3.869,6	50.014,0	0,08	0	0,05	1005	180,05
i6w28	292,8	5.055,0	11.423,1	161.106,0	0,07	0	0,11	1069	266,56
i6w29	200,5	1.483,3	5.040,3	66.303,0	0,08	0	0,17	1038	191,48
i6w30	243,7	8.076,6	11.246,9	177.914,0	0,06	0	0,10	916	227,20
i6w31	75,8	189,7	192,4	2.082,0	0,07	0	0,43	718	78,30
i6w32	57,8	64,0	64,1	53,0	0,64	0	0,02	542	52,31
i6w33	30,4	61,2	61,2	129,0	0,17	0	0,52	485	49,72
i6w34	23,4	27,7	27,7	4,0	0,36	0	0,18	364	24,97
i6w35	22,6	22,6	22,7	0,0	0,00	0	0,00	294	22,64
i6w36	11,3	11,3	11,3	0,0	0,00	0	0,00	173	11,30
i6w37	13,4	13,4	13,4	0,0	0,00	0	0,00	162	13,55
i6w38	9,8	9,8	9,8	0,0	0,00	0	0,00	94	10,12
i6w39	7,6	7,6	7,6	0,0	0,00	0	0,00	56	7,89
i6w40	7,5	7,5	7,5	0,0	0,00	0	0,00	39	7,86
i6w41	6,4	6,4	6,4	0,0	0,00	0	0,00	23	6,73
i6w42	4,3	4,3	4,3	0,0	0,00	0	0,00	8	4,48
Average	99,7	1.760,5	2.682,0	42.081,6	0,09	0,00	0,12	818,45	79,62

Table C.30: Macro Instance 6 - Weight

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i6w1	20,2	500,0	519,8	663,0	0,59	0	0,56
i6w2	12,6	80,0	107,5	193,0	0,20	0	0,23
i6w3	10,6	140,8	144,1	137,0	0,55	0	0,42
i6w4	10,9	145,1	148,9	195,0	0,27	0	0,40
i6w5	8,7	51,8	51,8	0,0	0,00	0	0,00
i6w6	12,6	221,1	221,2	195,0	0,60	0	0,09
i6w7	7,5	156,0	159,1	63,0	0,47	0	0,87
i6w8	9,9	132,0	134,4	21,0	0,67	0	0,09
i6w9	10,1	381,0	399,4	1.013,0	0,25	0	0,13
i6w10	7,1	289,4	298,5	558,0	0,32	0	3,62
i6w11	9,7	294,1	296,2	424,0	0,35	0	0,12
i6w12	7,9	119,2	147,7	130,0	0,34	0	0,03
i6w13	2,8	493,5	496,8	1.700,0	0,21	0	1,95
i6w14	10,5	238,3	239,3	207,0	0,46	0	0,55
i6w15	8,7	236,5	240,5	578,0	0,23	0	0,46
i6w16	3,8	158,8	158,9	218,0	0,33	0	2,48
i6w17	5,7	98,8	101,4	48,0	0,50	0	0,11
i6w18	7,9	158,0	158,1	77,0	1,04	0	0,22
i6w19	5,4	44,7	44,8	5,0	0,29	0	0,03
i6w20	7,2	103,5	103,6	44,0	0,70	0	0,18
i6w21	6,9	82,1	86,2	34,0	2,36	0	0,03
i6w22	8,0	165,3	165,3	55,0	0,59	0	0,10
i6w23	9,0	171,0	171,5	48,0	0,96	0	0,34
i6w24	10,2	291,8	291,9	163,0	0,76	0	0,32
i6w25	10,8	225,9	242,9	132,0	0,74	0	0,51
i6w26	10,8	505,9	507,8	1.544,0	0,23	0	1,21
i6w27	7,9	131,2	133,4	39,0	0,61	0	0,31
i6w28	8,8	164,1	172,1	27,0	1,76	0	0,13
i6w29	9,9	336,7	351,4	723,0	0,28	0	0,45
i6w30	8,5	236,3	237,5	324,0	0,33	0	0,29
i6w31	6,5	169,1	169,1	205,0	0,30	0	2,38
i6w32	3,6	51,0	51,5	48,0	0,22	0	0,15
i6w33	3,3	42,7	43,1	21,0	0,37	0	0,30
i6w34	1,8	2,0	14,8	0,0	0,00	0	0,00
i6w35	0,7	0,7	0,7	0,0	0,00	0	0,00
i6w36	0,2	0,2	0,2	0,0	0,00	0	0,00
i6w37	0,2	0,2	0,2	0,0	0,00	0	0,00
i6w38	0,1	0,1	0,1	0,0	0,00	0	0,00
i6w39	0,1	0,1	0,1	0,0	0,00	0	0,00
i6w40	0,0	0,0	0,0	0,0	0,00	0	0,00
i6w41	0,0	0,0	0,0	0,0	0,00	0	0,00
i6w42	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	6,8	157,6	162,2	234,1	0,43	0	0,45

Table C.31: Macro Instance 7 - Default

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i7w1	26,7	9.829,7	16.589,5	57.044,0	0,29	0	0,08
i7w2	23,6	935,7	942,8	3.474,0	0,25	0	0,87
i7w3	10,4	41,6	42,1	10,0	0,49	0	0,22
i7w4	8,4	35,5	36,9	74,0	0,26	0	0,17
i7w5	7,2	122,5	286,9	1.668,0	0,14	0	1,57
i7w6	12,0	74,2	74,7	104,0	0,29	0	0,07
i7w7	15,3	580,5	738,5	3.412,0	0,20	0	0,03
i7w8	18,7	3.028,5	3.659,3	20.354,0	0,18	0	0,16
i7w9	11,3	125,1	147,4	562,0	0,19	0	0,11
i7w10	15,7	374,4	404,7	1.722,0	0,21	0	1,17
i7w11	12,9	750,2	761,4	4.084,0	0,17	0	0,13
i7w12	13,3	195,6	199,7	807,0	0,19	0	0,16
i7w13	14,0	273,0	274,9	1.055,0	0,22	0	0,35
i7w14	3,6	219,4	219,8	895,0	0,20	0	2,61
i7w15	15,3	469,5	507,6	2.824,0	0,16	0	0,24
i7w16	17,1	877,6	1.243,1	5.887,0	0,20	0	0,12
i7w17	21,7	3.136,1	3.858,7	18.759,0	0,20	0	0,89
i7w18	20,4	5.824,3	5.866,0	25.385,0	0,23	0	0,30
i7w19	17,5	1.838,3	1.843,0	7.047,0	0,25	0	0,98
i7w20	19,0	12.291,9	12.324,6	52.853,0	0,23	0	0,34
i7w21	19,3	3.104,8	18.000,0	57.456,0	0,31	0,02	0,61
i7w22	16,2	277,7	285,6	1.200,0	0,20	0	0,08
i7w23	15,8	1.267,3	2.137,4	11.919,0	0,17	0	0,27
i7w24	15,1	3.549,6	3.949,3	20.365,0	0,19	0	0,20
i7w25	17,1	1.725,0	2.353,1	9.135,0	0,25	0	0,28
i7w26	15,1	731,6	732,4	2.651,0	0,26	0	0,32
i7w27	9,3	67,1	68,6	343,0	0,12	0	0,05
i7w28	7,2	41,6	44,1	161,0	0,15	0	0,22
i7w29	3,7	123,1	126,9	1.373,0	0,08	0	1,26
i7w30	0,9	2,4	11,1	58,0	0,16	0	1,70
i7w31	0,9	1,2	1,2	0,0	0,00	0	0,41
i7w32	0,3	0,4	0,4	0,0	0,00	0	0,55
i7w33	0,2	0,2	0,2	0,0	0,00	0	0,00
i7w34	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w35	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w36	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w37	0,0	0,0	0,0	0,0	0,00	0	0,00
i7w38	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	11,2	1.366,2	2.045,6	8.228,4	0,17	0,02	0,44

Table C.32: Macro Instance 7 - Meo

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i7w1	26,6	5.697,7	6.291,8	12.781,0	0,46	0	0,08
i7w2	23,6	631,9	632,6	521,0	0,55	0	0,87
i7w3	10,4	196,2	196,4	5,0	3,17	0	0,22
i7w4	8,5	80,8	86,2	17,0	2,11	0	0,17
i7w5	7,1	446,1	446,2	822,0	0,30	0	1,57
i7w6	12,0	235,4	255,8	39,0	6,32	0	0,07
i7w7	15,3	889,6	890,3	1.705,0	0,39	0	0,03
i7w8	18,7	1.656,2	1.789,4	4.961,0	0,31	0	0,16
i7w9	11,3	312,0	317,9	180,0	0,84	0	0,11
i7w10	15,7	445,8	452,8	260,0	0,93	0	1,17
i7w11	12,9	598,3	612,2	990,0	0,39	0	0,13
i7w12	13,4	400,8	400,8	372,0	0,60	0	0,16
i7w13	14,0	376,4	382,7	304,0	0,65	0	0,35
i7w14	3,6	390,2	397,3	385,0	0,58	0	2,61
i7w15	15,3	250,6	515,5	1.065,0	0,31	0	0,24
i7w16	17,1	1.074,8	1.183,0	2.923,0	0,34	0	0,12
i7w17	21,6	2.021,8	2.025,6	4.922,0	0,36	0	0,89
i7w18	20,3	2.727,7	2.761,5	5.995,0	0,42	0	0,30
i7w19	17,4	1.161,8	1.166,9	2.012,0	0,46	0	0,98
i7w20	19,0	14.315,0	14.769,1	48.258,0	0,30	0	0,34
i7w21	19,3	14.439,6	18.000,0	42.894,0	0,41	0,00	0,61
i7w22	16,2	340,8	355,6	270,0	0,62	0	0,08
i7w23	15,8	1.555,2	1.575,0	5.153,0	0,26	0	0,27
i7w24	15,1	2.077,5	2.155,8	4.648,0	0,41	0	0,20
i7w25	17,1	1.148,6	1.333,7	2.248,0	0,48	0	0,28
i7w26	15,1	549,4	553,6	529,0	0,67	0	0,32
i7w27	9,3	163,1	166,0	101,0	0,47	0	0,05
i7w28	7,2	117,6	120,4	88,0	0,59	0	0,22
i7w29	3,7	193,5	195,4	442,0	0,25	0	1,26
i7w30	0,9	2,4	24,7	37,0	0,61	0	1,70
i7w31	0,9	1,2	1,2	0,0	0,00	0	0,41
i7w32	0,3	0,4	0,5	0,0	0,00	0	0,55
i7w33	0,2	0,2	0,2	0,0	0,00	0	0,00
i7w34	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w35	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w36	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w37	0,0	0,0	0,0	0,0	0,00	0	0,00
i7w38	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	11,2	1.434,2	1.580,4	3.813,9	0,65	0,00	0,44

Table C.33: Macro Instance 7 - Cutgen

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i7w1	31,2	2.579,9	2.856,1	5.024,0	0,49	0	0,19	79	13,30
i7w2	20,7	631,9	632,2	302,0	0,98	0	0,04	67	11,95
i7w3	11,3	176,9	177,3	7,0	1,62	0	0,02	32	3,17
i7w4	9,3	63,2	63,6	6,0	9,35	0	0,00	13	2,12
i7w5	13,5	485,8	490,5	710,0	0,38	0	0,04	42	12,64
i7w6	13,5	215,8	229,3	27,0	1,47	0	0,02	41	7,17
i7w7	18,0	670,4	773,4	1.423,0	0,36	0	0,21	46	17,09
i7w8	19,1	900,3	921,4	1.965,0	0,36	0	0,17	60	19,39
i7w9	14,5	317,8	317,9	107,0	1,42	0	0,42	41	20,22
i7w10	7,7	480,6	481,8	247,0	1,10	0	1,28	51	24,62
i7w11	15,6	473,6	489,1	826,0	0,35	0	0,07	45	23,58
i7w12	16,2	384,5	404,1	353,0	0,66	0	0,97	45	26,78
i7w13	7,2	338,6	344,6	217,0	0,74	0	1,22	45	26,28
i7w14	4,1	417,3	418,0	299,0	0,80	0	2,61	72	39,02
i7w15	17,8	783,7	785,2	1.069,0	0,53	0	0,51	62	40,23
i7w16	20,3	934,1	1.007,0	2.652,0	0,30	0	0,26	57	39,86
i7w17	21,5	919,0	1.017,6	1.847,0	0,41	0	0,82	56	40,86
i7w18	14,0	2.549,5	2.703,7	5.650,0	0,43	0	2,82	91	52,00
i7w19	21,0	1.252,9	1.257,8	1.749,0	0,57	0	0,11	74	51,94
i7w20	23,3	7.305,2	7.425,5	17.567,0	0,41	0	0,16	80	56,55
i7w21	12,2	9.753,8	15.346,6	47.304,0	0,32	0	2,02	65	60,81
i7w22	12,2	421,6	436,3	253,0	0,94	0	1,81	63	55,08
i7w23	20,8	1.236,9	1.296,1	4.291,0	0,25	0	0,53	52	63,12
i7w24	24,3	1.778,9	1.788,1	2.955,0	0,52	0	0,50	65	72,95
i7w25	21,9	1.894,4	1.918,7	2.685,0	0,62	0	0,30	63	72,22
i7w26	21,0	546,6	565,9	396,0	0,92	0	0,20	58	71,92
i7w27	14,3	234,0	234,1	121,0	0,97	0	0,03	42	57,64
i7w28	13,1	157,6	176,7	103,0	0,80	0	0,05	39	55,67
i7w29	4,6	268,9	273,2	467,0	0,37	0	1,22	49	78,64
i7w30	1,9	57,4	64,1	24,0	1,49	0	1,70	29	35,59
i7w31	2,9	5,1	5,2	0,0	0,00	0	0,89	9	3,83
i7w32	1,3	3,4	3,4	0,0	0,00	0	0,55	5	2,94
i7w33	1,1	1,1	1,2	0,0	0,00	0	0,00	0	0,95
i7w34	1,1	1,1	1,1	0,0	0,00	0	0,00	0	0,95
i7w35	1,0	1,0	1,0	0,0	0,00	0	0,00	0	0,97
i7w36	1,0	1,0	1,0	0,0	0,00	0	0,00	0	0,97
i7w37	1,0	1,0	1,0	0,0	0,00	0	0,00	0	0,97
i7w38	1,0	1,0	1,0	0,0	0,00	0	0,00	0	0,97
Average	12,5	1.006,5	1.181,9	2.648,6	0,79	0	0,57	43,11	30,66

Table C.34: Macro Instance 7 - Delayed

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F	Ncuts	Tcuts
i7w1	64,7	897,3	916,5	25.684,0	0,03	0	0,03	1254	28,55
i7w2	55,6	91,8	136,4	2.182,0	0,05	0	0,04	1175	26,25
i7w3	17,6	17,6	18,1	22,0	0,24	0	0,00	937	6,80
i7w4	22,0	24,0	24,0	64,0	0,21	0	0,01	922	10,62
i7w5	46,7	89,2	98,3	1.528,0	0,05	0	0,04	1089	25,67
i7w6	32,8	32,8	34,0	34,0	0,33	0	0,00	1018	12,64
i7w7	60,5	222,5	231,3	5.546,0	0,04	0	0,01	1132	35,30
i7w8	67,4	258,8	260,7	4.523,0	0,05	0	1,06	1225	40,50
i7w9	50,3	50,3	64,6	314,0	0,13	0	0,00	1032	23,97
i7w10	136,3	213,0	214,7	1.384,0	0,13	0	0,11	1182	75,84
i7w11	81,7	201,9	204,5	2.408,0	0,07	0	0,05	1089	49,42
i7w12	83,7	100,3	133,4	883,0	0,12	0	0,04	1039	47,78
i7w13	83,6	141,4	153,9	953,0	0,13	0	0,04	1079	49,34
i7w14	82,1	156,6	174,6	1.000,0	0,14	0	0,26	1091	55,84
i7w15	130,3	415,2	415,4	4.397,0	0,09	0	0,04	1157	100,83
i7w16	126,0	369,0	382,0	3.930,0	0,09	0	0,19	1147	75,34
i7w17	135,2	2.158,0	2.160,2	28.352,0	0,07	0	0,34	1196	96,78
i7w18	319,6	3.166,6	3.234,0	30.405,0	0,10	0	0,14	1371	231,25
i7w19	281,6	1.257,2	1.723,3	16.963,0	0,10	0	0,11	1356	205,80
i7w20	154,8	6.418,3	8.570,2	116.051,0	0,07	0	0,08	1232	119,70
i7w21	223,3	16.418,2	16.625,6	205.664,0	0,08	0	0,14	1282	172,80
i7w22	185,0	271,0	278,9	1.075,0	0,21	0	0,04	1160	134,41
i7w23	233,5	574,1	854,2	9.288,0	0,09	0	0,03	1177	170,19
i7w24	241,2	452,9	2.274,3	25.641,0	0,09	0	0,03	1172	169,36
i7w25	192,8	2.351,1	2.540,6	26.417,0	0,09	0	0,02	1148	135,20
i7w26	175,1	220,3	321,7	1.440,0	0,18	0	0,02	1122	119,86
i7w27	101,4	101,4	113,6	232,0	0,29	0	0,00	922	68,23
i7w28	87,9	92,3	99,6	238,0	0,24	0	0,00	907	64,58
i7w29	169,0	232,7	244,0	1.446,0	0,14	0	0,18	850	149,55
i7w30	24,5	46,6	46,7	148,0	0,12	0	0,11	599	34,58
i7w31	20,5	24,4	24,4	4,0	0,27	0	0,03	458	22,06
i7w32	15,1	15,1	15,1	0,0	0,00	0	0,00	295	14,39
i7w33	11,9	11,9	11,9	0,0	0,00	0	0,00	203	11,50
i7w34	8,8	8,8	8,8	0,0	0,00	0	0,00	116	8,64
i7w35	7,8	7,8	7,8	0,0	0,00	0	0,00	74	7,70
i7w36	7,8	7,8	7,8	0,0	0,00	0	0,00	58	7,73
i7w37	4,8	4,8	4,8	0,0	0,00	0	0,00	19	4,80
i7w38	5,8	5,8	5,8	0,0	0,00	0	0,00	12	5,73
Average	98,6	977,1	1.122,0	13.637,3	0,11	0	0,08	902,55	68,94

Table C.35: Macro Instance 7 - Weight

Instances	tUBI	tUBF	TCplex	# Nodes	sec/Nodes	LB-UB	%(F-I)/F
i7w1	15,8	283,6	284,0	147,0	0,69	0	0,06
i7w2	12,1	220,6	232,2	205,0	0,42	0	0,16
i7w3	7,3	138,0	140,8	102,0	0,45	0	1,20
i7w4	4,7	85,9	86,5	25,0	0,54	0	1,48
i7w5	6,3	6,3	6,5	0,0	0,00	0	0,00
i7w6	8,1	148,8	151,6	131,0	0,56	0	0,05
i7w7	10,6	241,9	242,5	215,0	0,57	0	0,29
i7w8	9,0	210,9	211,0	156,0	0,56	0	0,20
i7w9	7,6	175,9	188,5	394,0	0,25	0	0,23
i7w10	11,2	232,6	233,5	110,0	0,74	0	0,31
i7w11	10,2	177,4	179,8	26,0	1,07	0	0,29
i7w12	10,1	231,8	234,9	133,0	0,60	0	0,10
i7w13	8,0	157,2	157,3	53,0	0,92	0	0,02
i7w14	5,0	101,5	101,5	64,0	0,69	0	1,19
i7w15	4,3	112,2	112,3	35,0	0,86	0	1,21
i7w16	4,0	144,4	159,9	48,0	0,79	0	1,83
i7w17	7,4	288,3	316,7	200,0	0,66	0	1,84
i7w18	2,4	211,9	211,9	122,0	0,72	0	1,80
i7w19	4,0	106,3	106,7	61,0	1,66	0	1,02
i7w20	6,8	176,2	181,0	81,0	0,78	0	2,97
i7w21	2,8	203,8	204,6	65,0	0,91	0	2,94
i7w22	8,1	96,4	104,8	20,0	0,99	0	0,04
i7w23	8,9	175,7	209,4	156,0	0,57	0	0,12
i7w24	5,6	143,9	150,0	112,0	0,49	0	0,48
i7w25	7,4	64,4	64,6	6,0	0,88	0	0,10
i7w26	8,0	110,7	112,8	17,0	1,82	0	0,23
i7w27	3,4	166,2	166,3	180,0	0,39	0	1,22
i7w28	4,5	152,8	153,1	108,0	0,45	0	1,19
i7w29	2,0	68,2	68,3	32,0	0,41	0	1,73
i7w30	0,8	23,2	23,5	42,0	0,28	0	1,69
i7w31	1,1	1,2	2,7	2,0	0,77	0	0,06
i7w32	0,2	0,2	0,2	0,0	0,00	0	0,00
i7w33	0,2	0,2	0,2	0,0	0,00	0	0,00
i7w34	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w35	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w36	0,1	0,1	0,1	0,0	0,00	0	0,00
i7w37	0,0	0,0	0,0	0,0	0,00	0	0,00
i7w38	0,0	0,0	0,0	0,0	0,00	0	0,00
Average	5,5	122,6	126,3	80,2	0,57	0	0,69

Bibliography

J.F. Benders. Partitioning procedures for solving mixed-variables programming problems. *Numerische Mathematik*, 4(1):238–252, 1962.

J.H. Dinitz and D.R. Stinson. On assigning referees to tournament schedules. *Bulletin of the Institute of Combinatorics and its Applications*, 44:22–28, 2005.

A.R. Duarte and C.C. Ribeiro. Referee assignment in sports leagues: approximate and exact multi-objective approaches. In *19th international conference on multiple criteria decision making, Auckland*, pages 58–60, 2008.

A.R. Duarte, C.C. Ribeiro, and S. Urrutia. Referee assignment in sports tournaments. In *Proceedings of the 6th International Conference on the Practice and Theory of Automated Timetabling*, pages 580–584, 2006.

A.R. Duarte, C.C. Ribeiro, S. Urrutia, and E. Haeusler. Referee assignment in sports leagues. *Practice and Theory of Automated Timetabling VI*, pages 158–173, 2007a.

A.R. Duarte, C.C. Ribeiro, and S. Urrutia. A hybrid ILS heuristic to the referee assignment problem with an embedded MIP strategy. In *Proceedings of the 4th international conference on Hybrid metaheuristics*, pages 82–95. Springer-Verlag, 2007b.

J.R. Evans. A microcomputer-based decision support system for scheduling umpires in the American baseball league. *Interfaces*, 18(6):42–51, 1988.

J.R. Evans and J.E. Hebert. Play Ball!–The Scheduling of Sports Officials. *Perspectives in Computing: Applications in the Academic and Scientific Community*, 4(1):18–29, 1984.

A. Farmer, J.S. Smith, and L.T. Miller. Scheduling umpire crews for professional tennis tournaments. *Interfaces*, 37(2):187–196, 2007.

G. Kendall, S. Knust, C.C. Ribeiro, and S. Urrutia. Scheduling in sports: An annotated bibliography. *Computers & Operations Research*, 37(1):1–19, 2010.

A. Lamghari and J.A. Ferland. Heuristic techniques to assign judges in competitions. In *Proc. of the third international conference on computational intelligence, robotics and autonomous System (CIRAS), Singapore*, 2005.

A. Lamghari and J.A. Ferland. Structured neighborhood Tabu search for assigning judges to competitions. In *Computational Intelligence in Scheduling*, pages 238–245. IEEE, 2007.

A. Lamghari and J.A. Ferland. Metaheuristic methods based on Tabu search for assigning judges to competitions. *Annals of Operations Research*, 180 (1):33–61, 2010.

S. Niskanen and P.R.J. Östergård. Cliquer User's Guide, Version 1.0. Technical Report 48, Communications Laboratory, Helsinki University of Technology, Espoo, Finland, 2003.

R. Ordonez and T.W. Knowles. Solving the American League umpire crew scheduling problem as a constraint satisfaction problem. In *Proceedings of the 29th Annual Meeting of the Decision Sciences Institute*, volume 2, pages 1058–1061, 1998.

M.B. Wright. Scheduling English cricket umpires. *Journal of the Operational Research Society*, 42(6):447–452, 1991.

M. Yavuz, U.H. İnan, and A. Fığlalı. Fair referee assignments for professional football leagues. *Computers & Operations Research*, 35(9):2937–2951, 2008.