

Professional Match Scheduling for Sports Leagues

A *match schedule* is the allocation of matches among teams during the match days of a tournament. In *round-robin tournaments*, each team plays a set number k of games against every other team. The match days correspond to the so-called *rounds*, in which *every* team plays (or – in the event that an odd number of teams is participating – one team sits out). A tournament with n teams, in which every team plays *exactly once* against every other team ($k=1$), thus consists of $n-1$ rounds, so that every team plays against a different opponent in every round. In each match, one team plays at its respective home stadium. For that team, this is called a *home game*, while for the opposing team it is an *away game*.

This sort of tournament – especially when it involves every team playing *exactly twice* against every other team – is quite common in sports such as soccer, ice hockey, basketball, handball, etc. Specifically, a round-robin series of matches takes place with $n-1$ rounds, until all the teams have played all other teams *once* (the *first half-season*). This is then followed by a second round-robin tournament with $n-1$ rounds and in reverse home-game order (the *second half-season*), so that each team has an opportunity to play against every other team in a home game.

Round	1	2	3	4	5
D:A	A:F	A:C	B:A	A:E	
E:B	B:D	D:E	D:C	C:B	
F:C	C:E	F:B	E:F	F:D	

	Round 1	2	3	4	5
Team					
A	A	H--H	A	H	
B	A	H	A	H	A
C	A	H	A--A	H	
D	H	A	H--H	A	
E	H	A--A	H	A	
F	H	A	H	A	H

Figure 1: A match schedule

Figure 1 shows a match schedule involving 6 teams: A, B, C, D, E, and F. In the first round, D plays in a home game against A (match D:A), E against B (match E:B) and F against C (match F:C). At the end of 5 rounds, all the teams have played all the others *exactly once*, as you can easily see. The home game order is listed in the table on the right in Figure 1. This indicates that Team A, for example, plays away (A) in the first round, then at home (H) in rounds 2 and 3, and then away (A) again during the fourth round and again at home (H) in the final fifth round. One says, then, that Team A has a *break* in the third round, because the alternating home/away sequence was interrupted by two consecutive home games.

In practice, there are a variety of options for the sequence in which the second half-season games are played – the so-called *game modes*. One of the most popular is the *Mirroring System* (Figure 2). Here the second-season rounds are played in the same sequence as the first-season round, but with the home-game order reversed.

Round	1	2	3	4	5	6	7	8	9	10
D:A	A:F	A:C	B:A	A:E	A:D	D:B	E:D	A:B	B:C	
E:B	B:D	D:E	D:C	C:B	B:E	F:A	C:A	C:D	E:A	
F:C	C:E	F:B	E:F	F:D	C:F	E:C	B:F	F:E	D:F	

Figure 2: A match schedule with first and second half-seasons (mirroring system)

Another option, though not as prevalent, is the *Inverse System*, in which second round games take place in the reverse sequence (Illustration 3).

Round	1	2	3	4	5	6	7	8	9	10
A:E	A:B	C:A	A:F	C:F	F:C	F:A	A:C	B:A	C:B	
B:C	D:C	D:E	B:D	D:A	A:D	D:B	E:D	C:D	E:A	
F:D	E:F	F:B	E:C	E:B	B:E	C:E	B:F	F:E	D:F	

Figure 3: Match schedule with first and second half-seasons (inverse system)

A third option is the *English System*. As in the Mirroring System, the second half-season is played in the same sequence as the first half-season -- except for the first round of the second half-season, which mirrors play in the last round of the first half-season (Figure 4).

Round	1	2	3	4	5	6	7	8	9	10
	A:E	A:B	C:A	A:F	C:F	F:C	E:A	B:A	A:C	F:A
	B:C	D:C	D:E	B:D	D:A	A:D	C:B	C:D	E:D	D:B
	F:D	E:F	F:B	E:C	E:B	B:E	D:F	F:E	B:F	C:E

Figure 4: Match schedule with first and second half-seasons (English System)

A fourth option is the *French System*. Here, too, the second half-season is played in the same sequence as the first half-season (Mirroring System) – except for the last round of the second half-season, which mirrors the first round of the half-season (Figure 5).

Round	1	2	3	4	5	6	7	8	9	10
	C:F	A:C	B:A	A:F	A:D	D:E	A:B	F:A	C:B	F:C
	D:B	E:D	C:E	C:D	B:C	C:A	E:C	D:C	D:A	B:D
	E:A	F:B	D:F	E:B	F:E	B:F	F:D	B:E	E:F	A:E

Figure 5: Match schedule with first and second half-seasons (French System)

The most general variant is the *Arbitrary System*. Here the second half-season can occur in any sequence. However, it must first be determined how many rounds will separate a particular match-up.

Round	1	2	3	4	5	6	7	8	9	10
	D:B	A:D	C:B	A:C	A:B	D:A	A:F	C:A	B:A	A:E
	E:A	B:F	E:D	B:E	C:D	E:C	B:C	E:B	D:C	B:D
	F:C	C:E	F:A	D:F	F:E	F:B	D:E	F:D	E:F	C:F

Figure 6: Match schedule with first and second half-seasons (arbitrary system)

Round(Matchday)	All teams play exactly once during a round.
Round Robin	All n teams play in $n-1$ rounds against all others exactly <i>once</i> , making for exactly $n(n-1)/2$ match-ups. If all teams play against each other <i>twice</i> , then $n-1$ first half-season matches are followed by $n-1$ second half-season matches, with the sequence of home-games reversed respectively.
Dummy Team	In the event that there is an uneven number of teams, a fictitious team is created (called a “dummy”) so that all the teams can play in each round. In each case, one team plays against the “dummy” team – in other words, they take a break.
Game Modes	The manner in which the second half-season rounds are played. Most prevalent are the Mirroring System, the Inverse System, the English and French Systems and the Arbitrary System.
Break-Round / No-Break Round	When a team plays two consecutive home- or away-games during two consecutive rounds, it is called a break . It’s said, then, that the team has a break during the second of the two rounds. When each team gets a break during two consecutive rounds, this is called a break-round . In the event that no team has a break during two consecutive rounds, this is called a no-break round .
Fix Match	A specific match that must take place during a round or subset of rounds.
Home-Away Pattern	A listing of home- and away-games by round and team, set in a matrix (see Figure 1 on right).
Complementary Teams	Two different teams with opposite home-away patterns in all the rounds, i.e., when the first team has a home-game, the second has an away-game and vice-versa.
Relaxed Complementary	Complementarity need not be strictly adhered to in all rounds.
Solver	A high-performance software program for calculating match schedules (cost: approx. 10,000€).
Internet Solver	An additional service provided by Virtual-Optima that calculates a match schedule via the internet using its own solver.

Requirements for game schedules

In principle, it's quite easy to put together a round-robin tournament schedule. It suffices if the teams are simply "rotated" through the individual rounds. Figure 7 provides an example using six teams numbered from 1 to 6. This method can generate a variety of schedules.

Round	1	2	3	4	5
	1 : 2	1 : 6	1 : 5	1 : 4	1 : 3
	6 : 3	5 : 2	4 : 6	3 : 5	2 : 4
	5 : 4	4 : 3	3 : 2	2 : 6	6 : 5

Figure 7: Manual generation of a tournament schedule by “rotation”

Whether or not a schedule such as this actually serves one's needs is a different matter entirely, however. In recent years there has been a move toward an increased professionalization in scheduling, owing to the growing demands placed on the scheduling process by teams, stadium operators, TV stations and municipal authorities (police, security measures). Stadiums are also being used increasingly for competing events other than sports. In addition, team sports are being ever more professionally marketed in order to make them more attractive to paying spectators, both in the stadium and those watching on TV, where possible keeping the thrills coming right through to the end of the season. A sports league can help make this happen by following a pro-active approach to the scheduling of the match calendar – by, for example, scheduling top teams toward the end of the season or by scheduling particularly interesting matches on days with anticipated high viewership. It has become increasingly more difficult and laborious to plan tournaments that can meet all these different demands. Now, more than ever, these needs can only be met with the help of professional software planning systems employing complex mathematical methodologies. Such planning systems must operate flexibly in fulfilling a variety of both *hard* and *soft conditions*. Among the hard conditions are: number of round-robins, choice of game modes, specifying fix matches, scheduling of home- or away-games on certain match days, complementarities, scheduling no-break-rounds at either the beginning or end of a tournament and other conditions that determine the break structure. Often, for example, the number of breaks needs to be minimized. Among the soft conditions are: team requests relating to home- or away-games, relaxed complementarities, the possible need for a variety of fix matches and other issues.

Your Software Solution from Virtual-Optima

Virtual-Optima offers unique and easy-to-use software employing complex mathematical models that can provide league operators with the means for developing their own complex scheduling plans, explore variations and then chose the one best suited to their needs. When necessary, the software can be adjusted to fit league requirements and practices. In addition to supplying software, Virtual-Optima also offers to generate the schedules for the leagues directly.

Our software is both efficient and easy to use and includes all the common variables useful in preparing a full season's match schedule:

- Calendaring of match days, including the option of spreading matches over several days.
- Uniform kick-off times that can subsequently be changed for each matchup.
- Input of no-break rounds.
- Setting fix matches.
- Exclusion of certain matchups in specific rounds.
- Configuration of numerous variations per schedule.
- Setting of individual rounds with subsequent recalculation.
- Input of a dummy team, given an uneven number of teams.
- Input of sub-groupings.
- Other options for making subsequent adjustments, such as changing match dates.
- Input of complementarities (soft und hard).
- Definition of a variety of break-structures.

- Establishing home- and away-games for each team and round.
- Setting of game modes, as previously noted.

Once a schedule has been generated, the results are saved directly into pdf, MS-Word, Excel and text files. These files contain:

- The schedule itself (complete with individual cover-sheets, logos und titles)
- Information regarding compliance with soft conditions, specific club preferences and non-compulsory complementary match-ups.
- Home/away structure individualized for each team and round.
- Total number of breaks.
- Schedule matrix.
- All match-ups individually broken down by opponent and round.

Licensing and Service

Our software (or its use) can be leased to create a single season of schedules or a license can be purchased at a reduced price for multiple year periods.

Along with tournament schedules adapted to individual league/association needs, we also offer our customers the following additional services:

- Customer service by phone or email.
- User manual in multiple languages.
- Software support, servicing and updating in terms of our service agreement.
- Analysis and use of our high-performance solver via Internet.

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