MATHSPORT 2019

LESSONS LEARNED IN SCHEDULING THE FINNISH MAJOR ICE HOCKEY LEAGUE

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We have generated the League schedule for the last eleven years

The Popularity of Ice Hockey

1. Canada, Finland
2. Sweden, Russia, Czech Republic, Slovakia
3. Germany, Switzerland
4. USA

World Championships 2019

(Last 8)	Finland vs. Sweden	5 - 4 (ot)
(Semi)	Finland vs. Russia	1 - 0
(Final)	Finland vs. Canada	3 - 1

The problem

- **which teams** play against each other
- on **what day**
- **who** plays **at home**

To 21.03.							
18:30	Pelicans	-	HIFK	6-0	(2-0,2-0,2-0)		5088
18:30	TPS	-	HPK	2-3	(1-1,0-2,1-0)		5124
Pe 22.03.							
18:30	Kärpät	-	Ilves	4-3	(1-3,1-0,1-0,1-0)		5371
18:30	Tappara	-	Lukko	3-2	(1-2,2-0,0-0)		5138
La 23.03.							
17:00	HIFK	-	Pelicans	3-2	(0-1,1-0,2-1)		8200
17:00	HPK	-	TPS	5-3	(2-0,1-1,2-2)		4783
17:00	Ilves	-	Kärpät	0-4	(0-0,0-0,0-4)		6342
17:00	Lukko	-	Tappara	2-3	(0-2,1-1,1-0)		4020
Ma 25.03.							
18:30	Pelicans	-	HIFK	1-2	(0-1,1-0,0-0,0-1)		5371
18:30	TPS	-	HPK	3-2	(0-1,1-0,1-1,1-0)		5145
18:30	Kärpät	-	Ilves	2-1	(0-1,1-0,1-0)		4932

The format

- The League has **15 teams**. The format played in the League is unique.
- The basis of the **regular season** is a **quadruple round robin tournament** (each team plays against each other twice at home and twice away) resulting in 56 games for each team.
- **In addition**, the teams are divided into **five groups of three teams** to get a few more games to play. The teams in the groups are selected based on the traveling time between the teams. These teams **play a double round robin tournament** (once at home and once away) resulting in 4 games for each team totaling 60 games for each team.
- So, the teams play **either four or six games against each other**.
- The total number of games is 420 from the standard 4RR and 30 from the extra 2RR, **totaling 450 games**.

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A relaxed schedule

The schedule of the League is **relaxed**, that is, **each team does not and cannot play in each round**.

- The main reason for this is the **complexity** of the optimization problem, so **it is theoretically not possible to generate a compact schedule**.
- The **venues** of the teams are quite often **in use** for some other events, mostly concerts.
- **Some of the teams also play in** the European Champions Hockey League (**CHL**).
- Other reasons include that a **local football team having scheduled a game** to that day
- or a **world championship event** of some sport being scheduled to the region.

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During these eleven years

the League has continuously looked for improvements:

1) How to make a **more interesting season** for the broadcasting company, sponsors and fans

2) How to **cut down the expenses of the teams**

2005-2006	2006-2007	2007-2008	← Seasons before our contribution		
1 958 843	1 943 312	1 964 626			
2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014
	Away Tours	*January leveling*		*Local rivals*	
1 997 114	2 015 080	2 036 915	2 145 462	2 189 350	2 088 690
2015-2016	2016-2017	2017-2018	2018-2019	← Seasons with 15 teams	
Back-to-back games		*Weekend games*			
1 912 200	1 946 790	1 914 360	1 903 500		

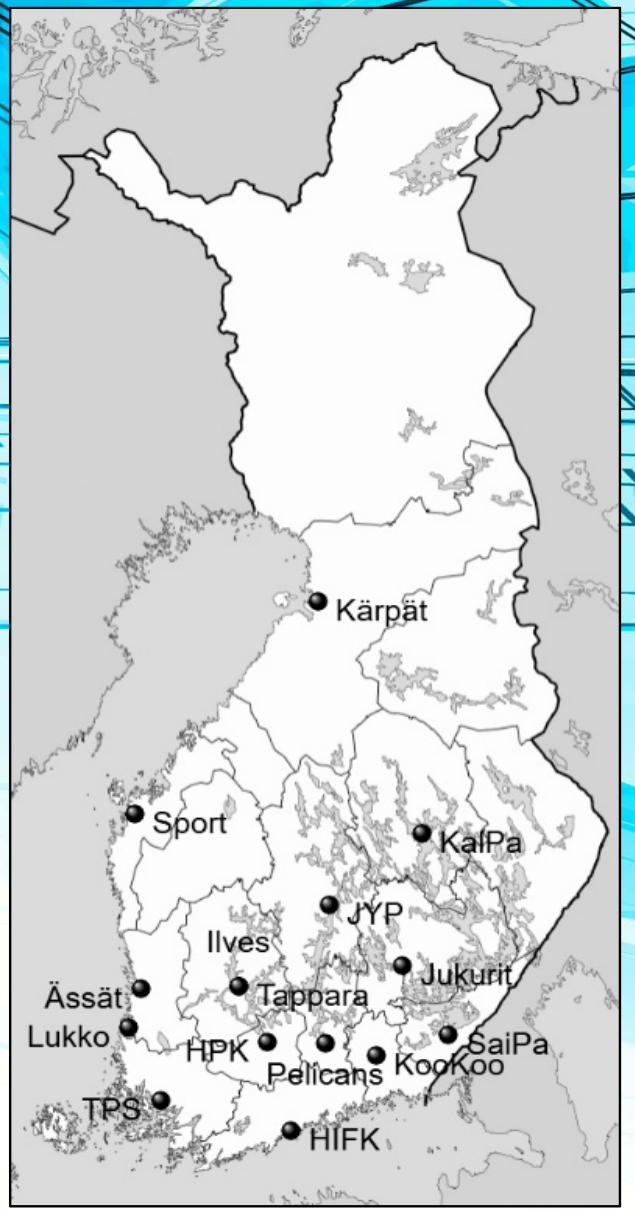
New TV/Net contract

Table 4: The number of spectators in the League in the last thirteen seasons, and the timing of the League format innovations

Away tours

Western teams Sport, Ässät, Lukko and TPS would like to meet **eastern teams** KalPa, Jukurit, SaiPa and KooKoo **in two consecutive rounds**, and vice versa. Furthermore, the **northern team** Kärpät basically wishes to meet whatever southern teams in two consecutive rounds.

This has a serious drawback. **We cannot schedule an away tour to Friday and Saturday** since that would imply two weekend home games in a row for another team.



January leveling

“Dry January” and “Depressing November” are clearly the most unprofitable months. The former refers to the Finnish habit of having an alcohol free January and the latter to the dark and rainy weather in November. We tried to tackle this by introducing the January leveling games and the back-to-back games in November.

January leveling adds two extra games for each team. In January, in the middle of the season, **the last team on the current standings selects an opponent against which it plays once at home and once away on two consecutive days on Friday and on Saturday.** The opponent selects the day for its home game. **Then, the second last team** (or the third last if the second last was selected by the last team) selects its opponent from the rest of the teams **and so on**. The teams can choose to select their opponents either by maximizing the winning possibilities or by maximizing the ticket sales.

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Local rivals

Some teams play against certain other teams more than four times. The local rivals play in the same group. The defined local rivals play as many games as possible in the first two rounds.

Furthermore, the **number of Friday and Saturday games between some local rivals is maximized.**

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Back-to-back games

"Dry January" and **"Depressing November"** are clearly the most unprofitable months. The former refers to the Finnish habit of having an alcohol free January and the latter to the dark and rainy weather in November. We tried to tackle this by introducing the January leveling games and the back-to-back games in November.

We schedule so-called back-to-back games where seven **pairs of teams play against each other on consecutive rounds on Friday and on Saturday**. These match-up games have been highly welcomed by the fans and by the media. However, they have one drawback. The **gap between the teams' other confrontations** may be quite long. We tackle this by matching as many teams within the same group as possible (see Section 2).

Weekend games

The schedule **maximizes the number of games on Fridays and on Saturdays**.
This is a somewhat complicated task.

Due to the travel distances between some venues, **certain combinations** of a home team playing the next day an away game against some opponents **are not allowed.** Similarly, certain combinations of a home team playing on the previous day away against some opponents are not allowed.

The number of forbidden pairs is as high as **52**.

In case of existing traveling error in the final schedule, the teams can agree to move the Friday game to Thursday.

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Extremely challenging

Ten most important ones

1) The team **cannot play at home** on certain days (as explained earlier) + **two teams share a venue**

2) As many **Friday and Saturday games** as possible

3) Some teams prefer their home games to be played on **working days** to maximize the number of business spectators

4) The **number of breaks** (two consecutive home or away games) should be minimized

5) The further located a team is from the other teams the more **away tours** (two away games on consecutive days) the team should be assigned

6) The interest of media and fans must be increased by introducing **special interest games**, e.g. local rival games and back-to-back games

7) Two games between the same opponents should **not** be played **on close days**, and the games should be played on different venues.

8) For each team and at any point in the tournament, the **difference between home and away games played** should be at most three.

9) **The difference in the number of games played** between different teams should be at most two at any point in the tournament.

10) As many **full rounds** as possible

Some indicators of the schedules generated for the last two seasons

#Rounds	#Full rounds	#B1	#B3	#F2 errors	#F3 errors
84	36 (43%)	261 (58%)	67	1	2
94	30 (32%)	288 (64%)	61	6	1
#Home game restrictions	#3-breaks at home	#3-breaks away	#Away tours	#Restr. travel combinations	#Traveling errors
54	11	11	29	52	11
66	8	22	30	52	11

Table 3: The indicators of the schedules generated for the 2017-2018 and 2018-2019 seasons

The schedules were generated using the PEAST algorithm.

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Practical lessons learned 1/3

- Eleven years ago, we thought that to generate good-quality League schedules, **the most important thing is** to build the best possible (academic) **optimization algorithm** for the problem. However, we were very **wrong**.
- An essential part of the problem is the process of **consulting** with the various League parties.
- During the first four years, we tried to find out and resolve all the restrictions, requirements and requests the teams had. But we did not get all the data we needed. The team CEOs were used to getting unsatisfactory schedules, which they then tried to modify for **their** special purposes. The teams were allowed to make changes to the generated schedule. **They kept on acting the same way**.
- The next two years we tried to solve this by interviewing several team CEOs to get a better picture of their requirements and requests. We also tried to **make them understand** that we are seeking for the best possible schedule for all the teams, not just for their team.

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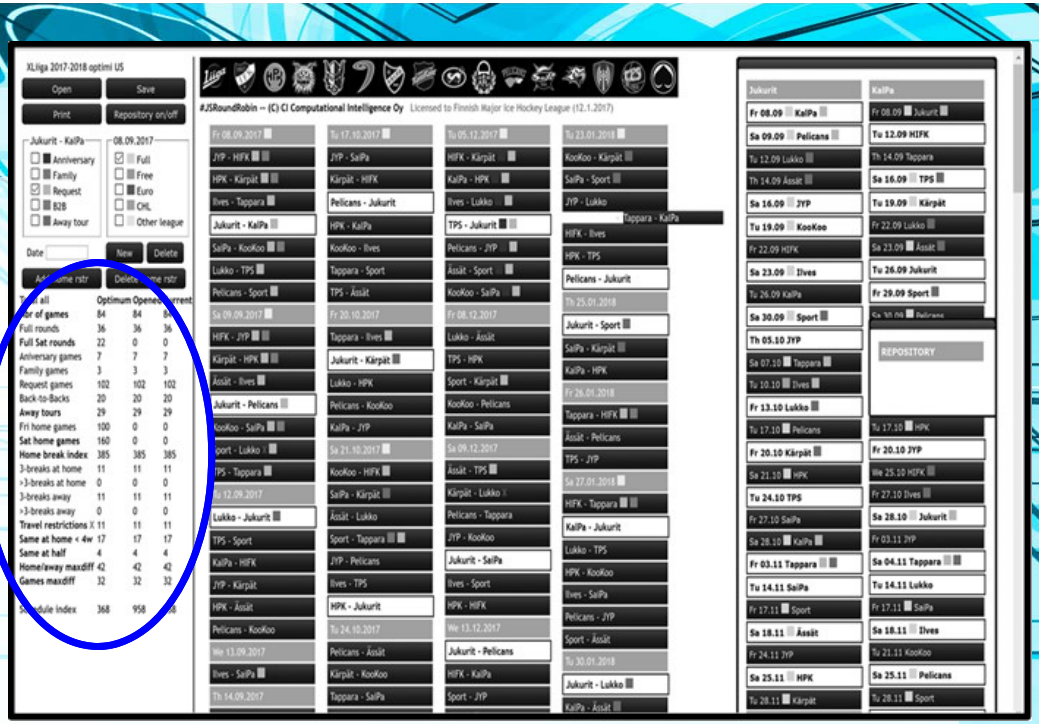
Practical lessons learned 2/3

The solution was to introduce a software called **JSRoundRobin**, which allows the competition manager to move games manually. He starts with the generated optimized schedule. The profound idea is that each time he tries to move a game from its current round to a new round, he can **immediately see the consequences of that move**:



1) whether the move is feasible or not
2) how the global fitness value of the schedule changes
3) how the fitness value of each team changes
4) how the number of violations of each constraint changes
5) how the requests of each team are fulfilled

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Practical lessons learned 3/3

→ **the process now goes as follows:**

1) We first **brainstorm** the possible improvements to the format **with the League's competition manager**.
2) Then, **the format gets approval** by the team CEOs and the main broadcasting company.
3) Next, the competition manager tries to **gather all the** restrictions, requirements and requests from the teams and from the broadcasting company
4) Then the competition manager together with us decide **the priorities** of the gathered constraints
5) Next, we generate some **test schedules** to check whether it is possible to handle the given framework
6) We run **the PEAST algorithm** several days to find the best possible schedule
7) The competition manager sends the optimized schedule to the **team managers**
8) He uses the **JSRoundRobin** software to consider whether it is possible to move requested games to the new rounds. Most often this is not possible.

Some academic lessons learned

- As stated before, to generate good-quality League schedules, **the most important thing is NOT** to build the best possible (academic) **optimization algorithm.**
- During the eleven years, we have used the **PEAST algorithm** to schedule the League. The evolution of the algorithm is closely related to our research in **workforce optimization.**
- The acronym PEAST stems from the methods used: **Population, Ejection, Annealing, Shuffling and Tabu**.
- To cut down the huge search space of quadruple round robin, we schedule **two double round robins**. This requires some extra work between the RRs.
- **Random initial solutions** yield superior or at least as good results compared to sophisticated initial solutions.
- We call the final generated schedule as the **candidate for practical optimum**. The **final practical optimum** is the one generated by the competition manager after he has considered the moves requested by the team CEOs using the JSRoundRobin software.

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Some sports related issues

- Regarding away tours, the probability for the team **to win its second away game** has been **30% smaller** than to win any away game.
- The probability of a team **to win a Saturday home game** is more than **20% higher** compared to any other weekday.
- The probability of a **top-three-team** to win a Saturday home game is almost **30% higher** compared to any other weekday.
- It should be noted here, that we have found **no evidence** that the **carry-over effect** has influence on the final standings.
- The team's rank group (best six, preliminary playoffs, eleven or worse) **after 30 rounds** almost certainly **implies** its rank group after the regular season, i.e. **60 rounds**.

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Thank you for your interest