Group 8: A Scheduling Problem

Or how not to spend your last semester at Stern…

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Agenda

- **Our Goal**

- Mathematical formulation of the problem

- The first (unsuccessful) attempts:

  - Week by week

  - An overall approach

- The "American" solution

- Conclusions

- Ways to improve model

Any great love…
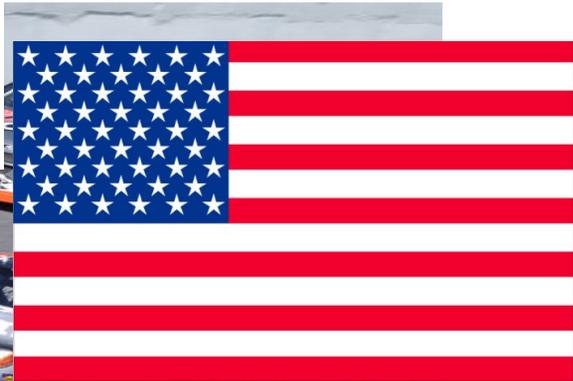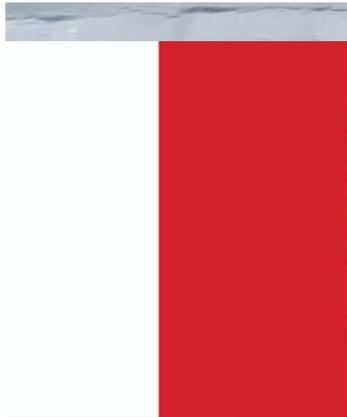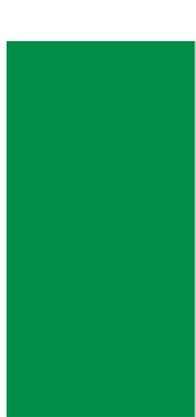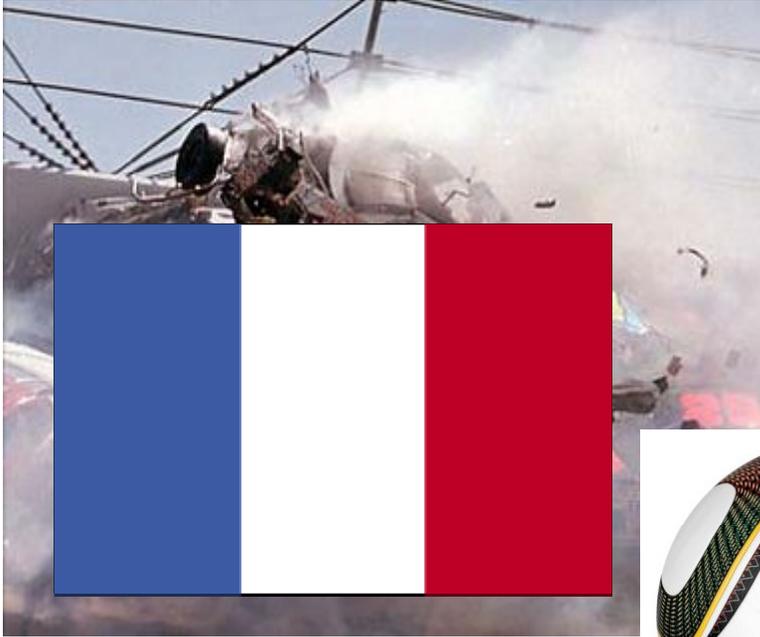
…often hide a great challenge

Main objectives

Develop a game scheduler with the following criteria:

- N teams play each other in a league

- Each team needs to play equally at home and away with appropriate breaks (e.g. two away games in a row are to be avoided)

Using the following simplifying assumption:

- "Mirrored double round robin tournament" (you play opponents in the same order for first and second half of the league)

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Mathematical Formulation

523,827,226,948,913,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000
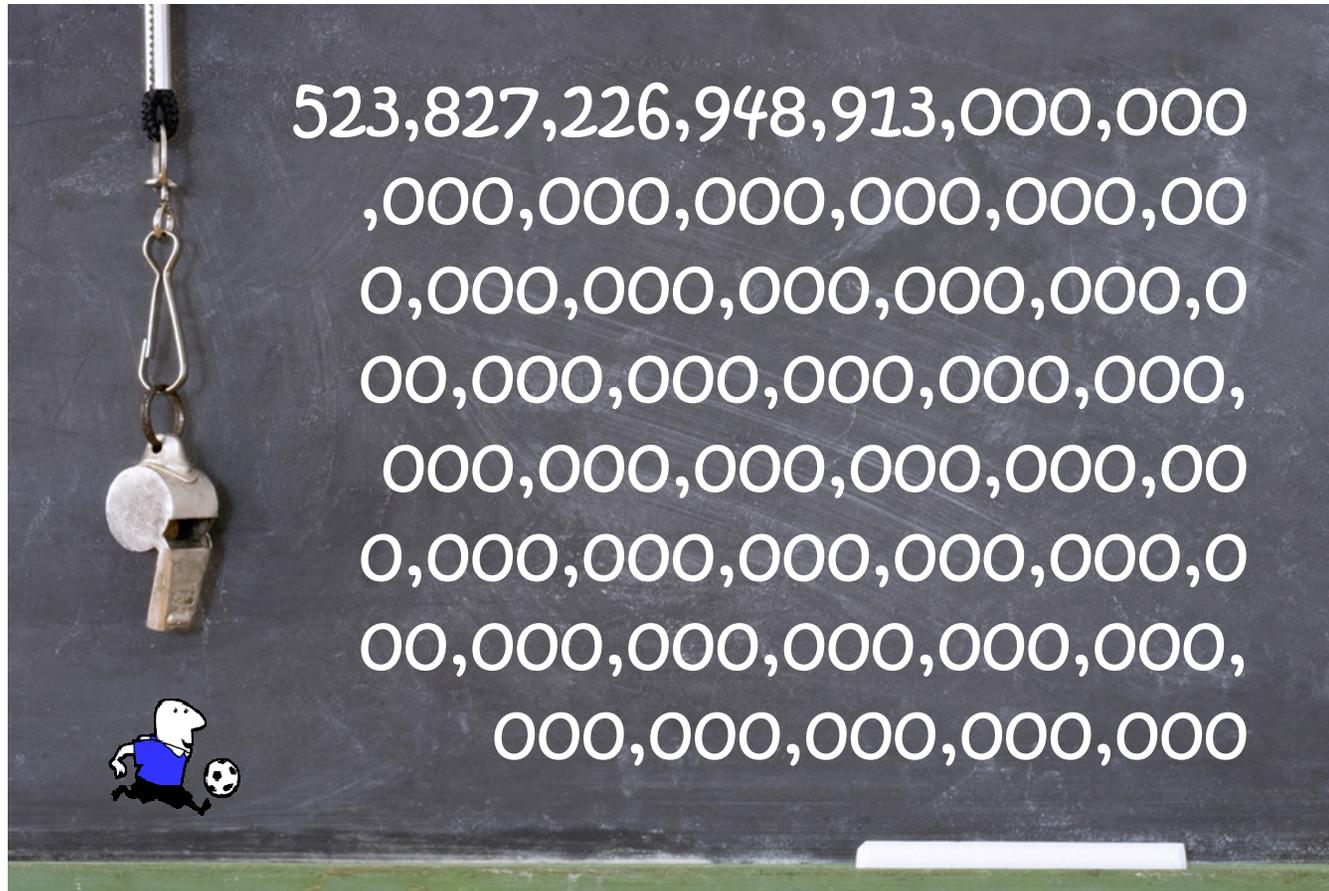
Mathematical Formulation
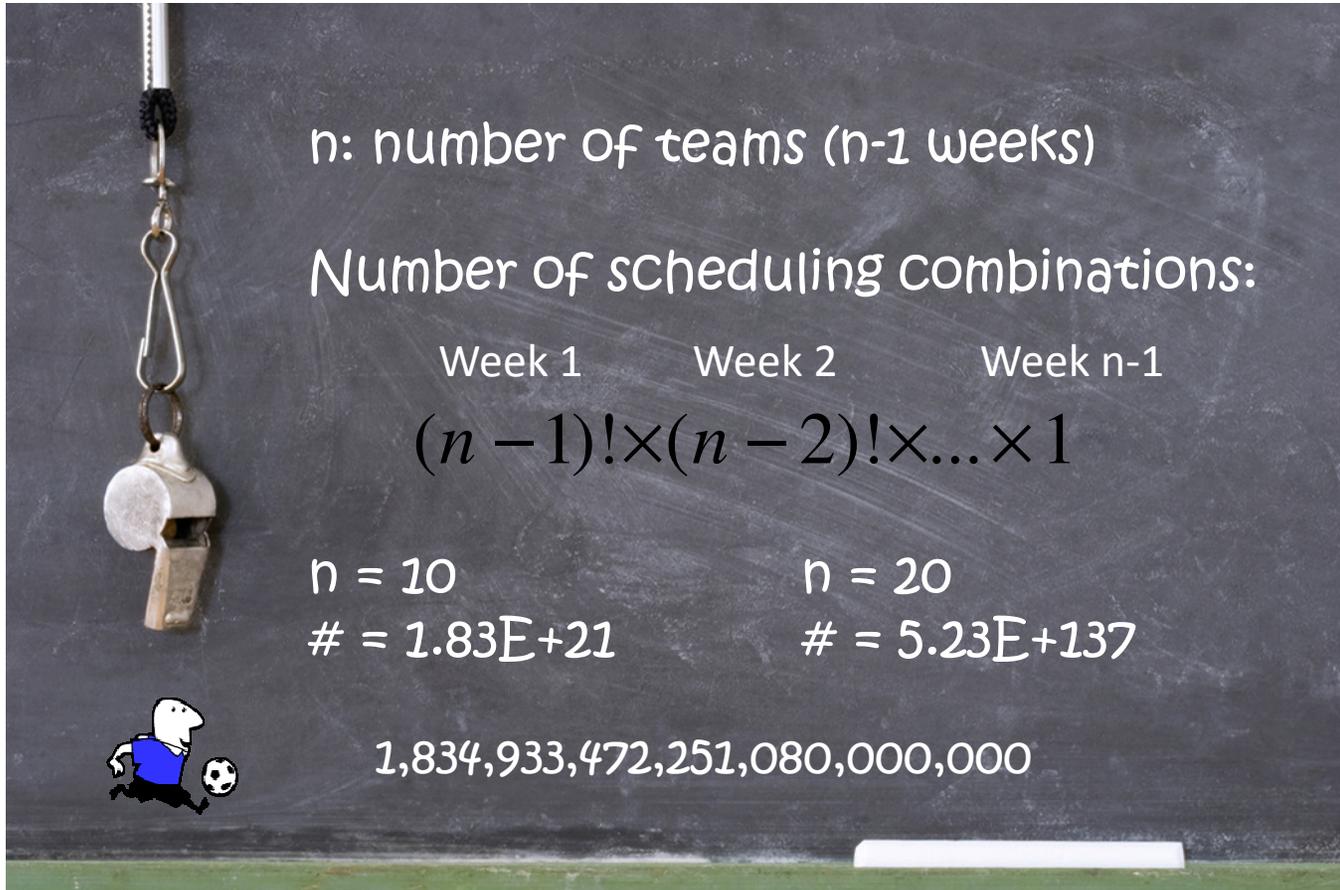
n: number of teams (n-1 weeks)

Number of scheduling combinations:

Week 1	Week 2	Week n-1

$$(n-1)! \times (n-2)! \times ... \times 1$$

n = 10
\# = 1.83E+21

n = 20
\# = 5.23E+137

1,834,933,472,251,080,000,000

Mathematical Formulation
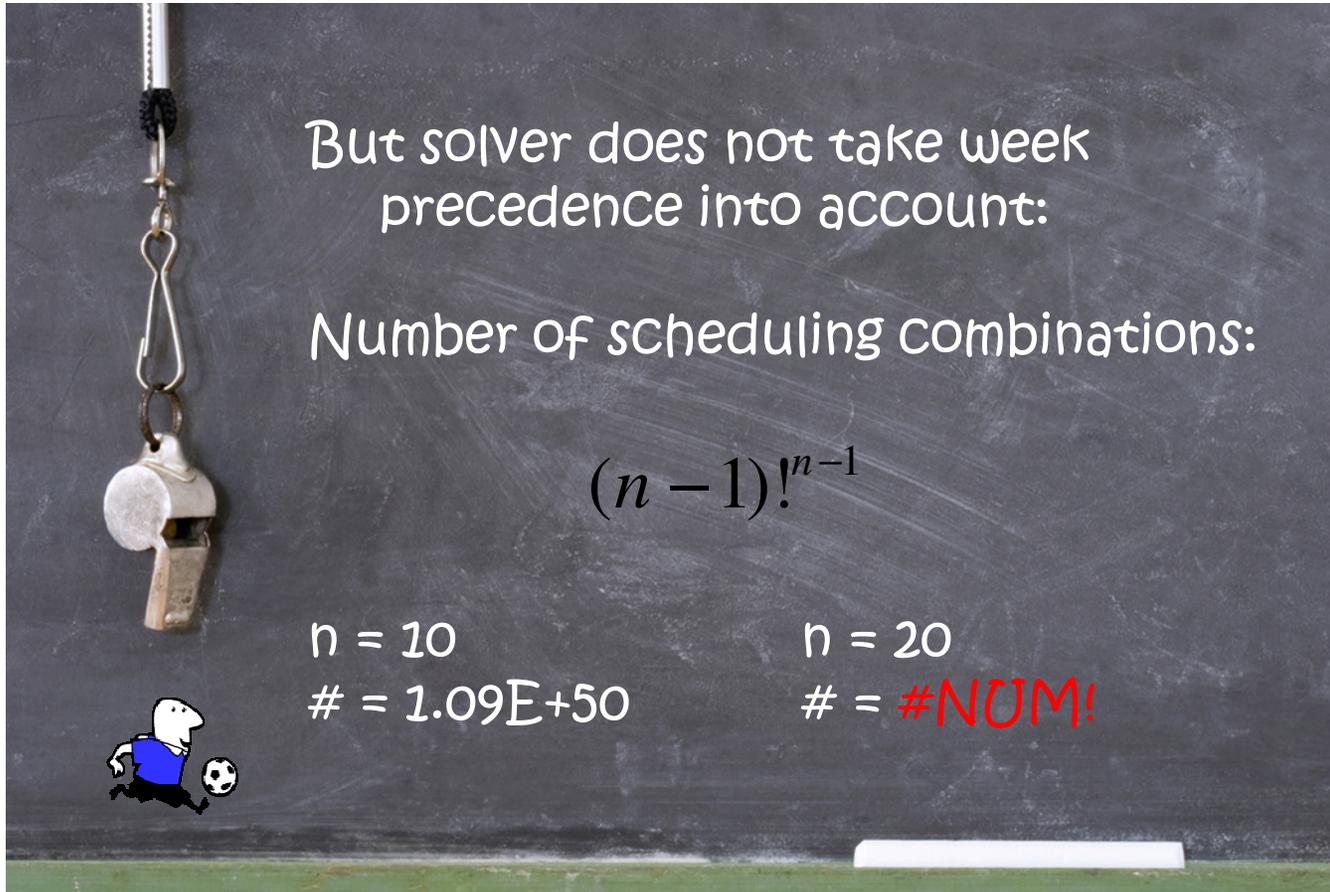
But solver does not take week precedence into account:

Number of scheduling combinations:

$$(n-1)!^{n-1}$$

n = 10
# = 1.09E+50

n = 20
# = #NUM!

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Model approach

- 10 teams
- Simulate week by week
- Penalties for playing again with the same team
- Decision variables are only half of the team

Spreadsheet content:

	A	B	C	D	E	F	G	H	I
1					Only one game against each other - Penalty				
2		Week 1	Week 2		6	7	8	9	10
3	1	10	6		0	0	0	0	0
4	2	7	=IF(COUNTIF($C3:$D3,J$2)>1,COUNTIF($C3:$D3,J$2)-1,0)						0
5	3	9	8		0	0	0	0	0
6	4	6	9		0	0	0	0	0
7	5	8	=IFERROR(-INDEX($B$3:$B$7,MATCH($B8,$C$3:$C$7,FALSE)),100)						0
8	6	-4							
9	7	-2	-5						
10	8	-5	-3						
11	9	-3	-4				0	=SUM(J3:N7)*100	
12	10	-1	-2						
13			=SUMPRODUCT(B3:B12,C3:C12)						
14		0	0						
15		=	=						
16		0	0						
17									
18	Min	6	6						
19	Max	10	10						
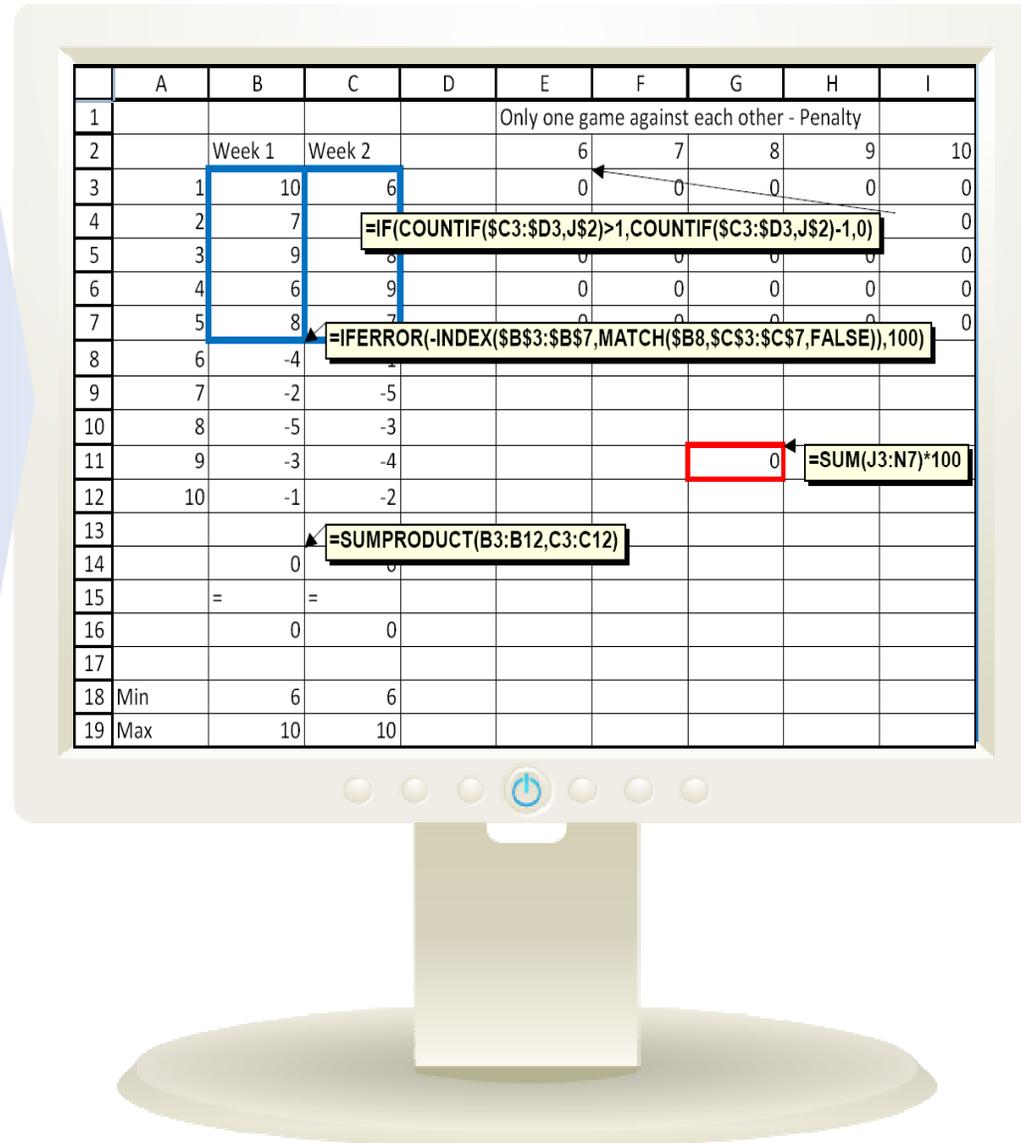
…but fail after only 4 weeks

	B	C	D	E	F	G	H	I	J	K	L	M
1								Only one game against each other - Penalty				
2		Week 1	Week 2	Week 3	Week 4	Week 5		6	7	8	9	10
3	1	6	10	10	7	7		0	1	0	0	1
4	2	10	8	7	6	9		=IF(COUNTIF($C3:$G3,I$2)>1,COUNTIF($C3:$G3,I$2)-1,0)				
5	3	8	7	6	9	10						
6	4	9	9	8	8	6		0	0	1	1	0
7	5	7			10			0	0	0	0	0
8	6	-1	=IFERROR(-INDEX($B$3:$B$7,MATCH($B8,$C$3:$C$7,FALSE)),100)									
9	7	-5	-3	-2	-1	-1						
10	8	-3	-2	-4	-4	-5						
11	9	-4	-4	-5	-3	-2			400			
12	10	-2	-1	-1	-5	-3						
13			=SUMPRODUCT(B3:B12,C3:C12)									
14	Sumproduct	0				0		=SUM(I3:M7)*100+C14+D14+E14+F14+G14				
15		=	=	=	=	=						
16		0	0	0	0	0						
17												
18	Min	6										
19	Max	10										
20												
21			=C3+C4+C5+C6+C7									
22	Subsum	40			40	40						
23		=	=	=	=	=						
24		40	40	40	40	40						

WRONG WAY

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We create a "slightly" more complicated approach…

Model approach

- 10 teams

- Simulate all 10 weeks

- Penalties for:

  - Playing again with the same team (season)

  - All teams play during game day

  - Not playing home/away between 4-5 times

  - Playing home/away consecutively

  - being Brazil…

- Decision variables for only half of the teams
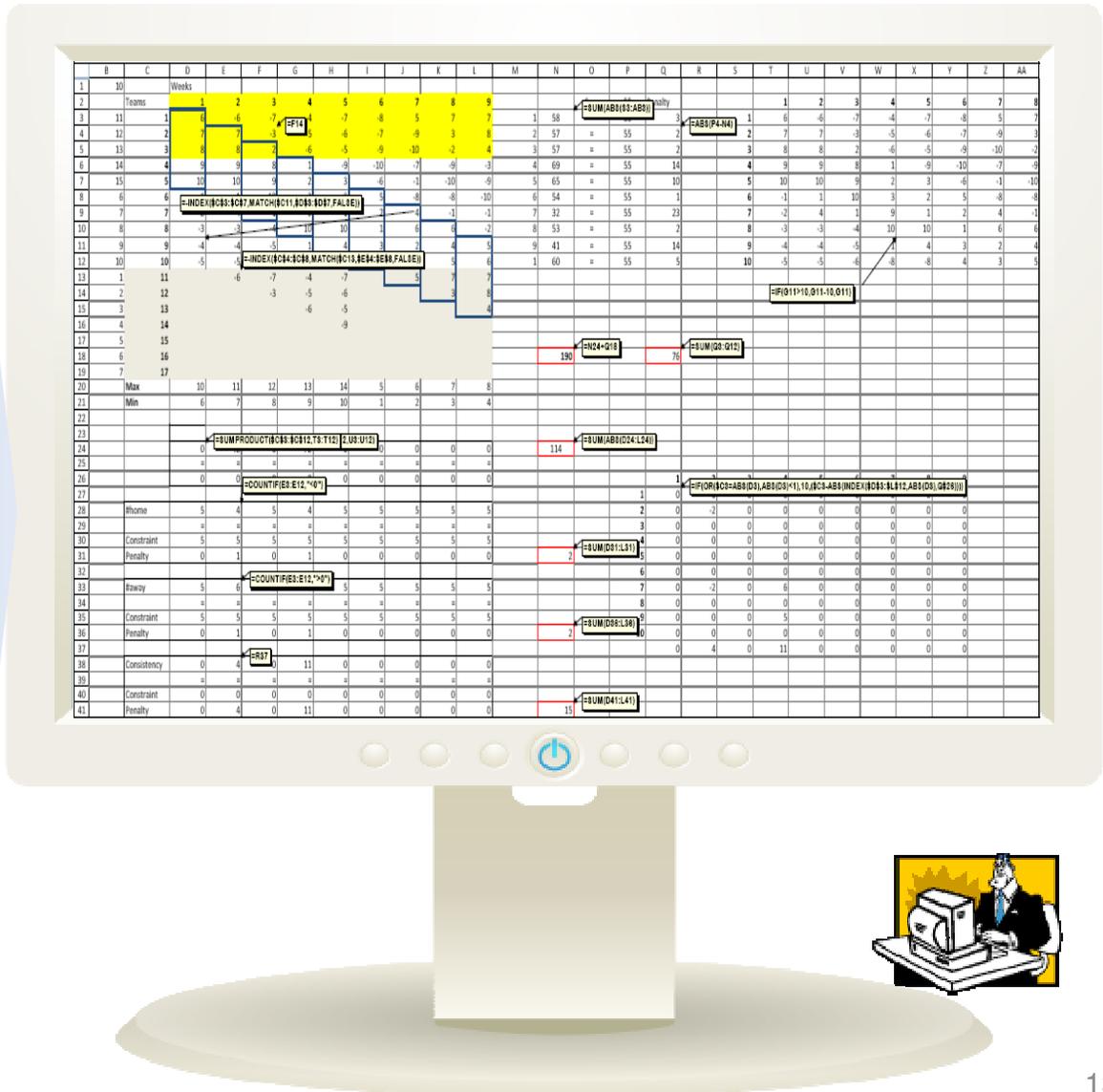
…but solver reacted unexpectedly…
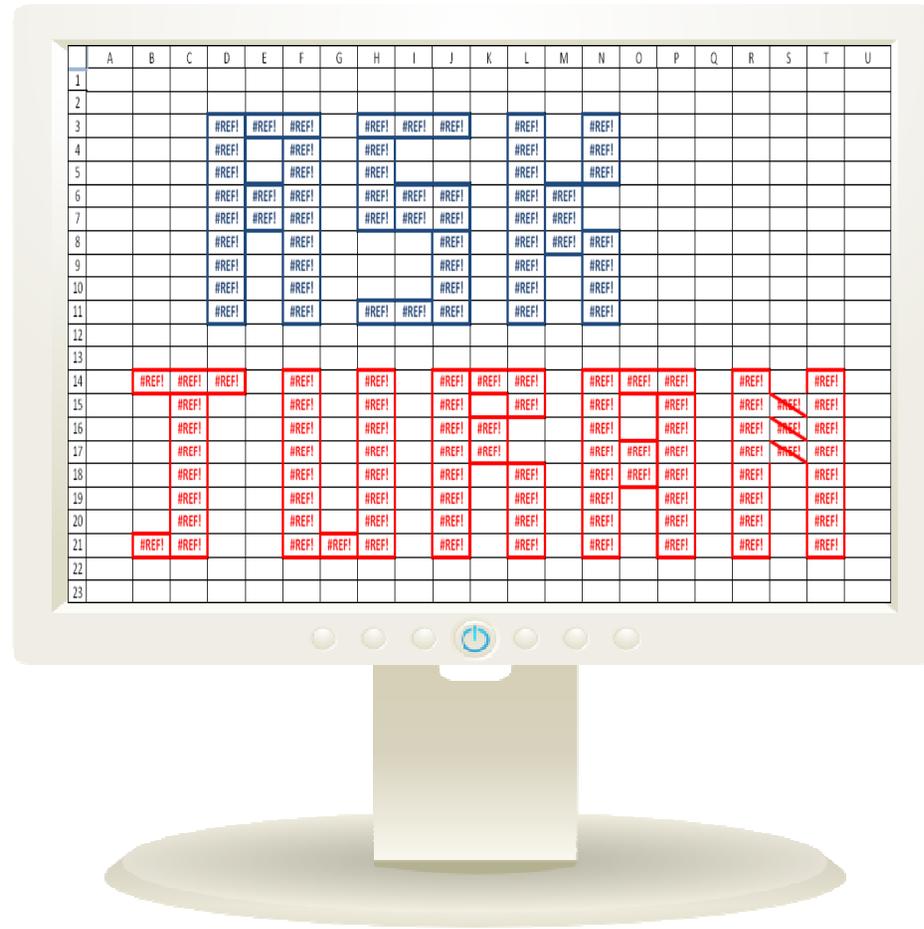
…and our team took it in different ways…
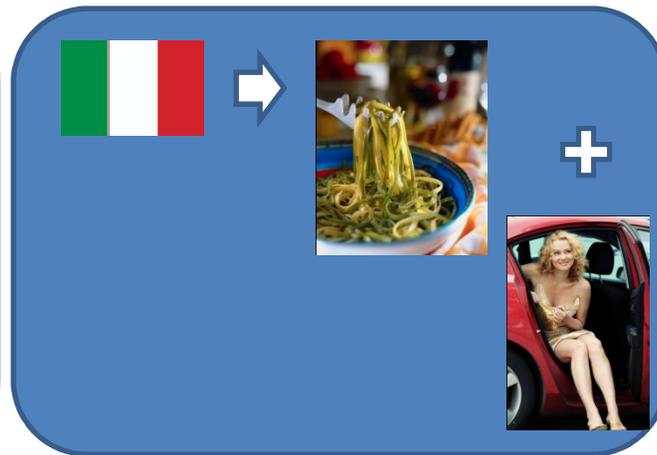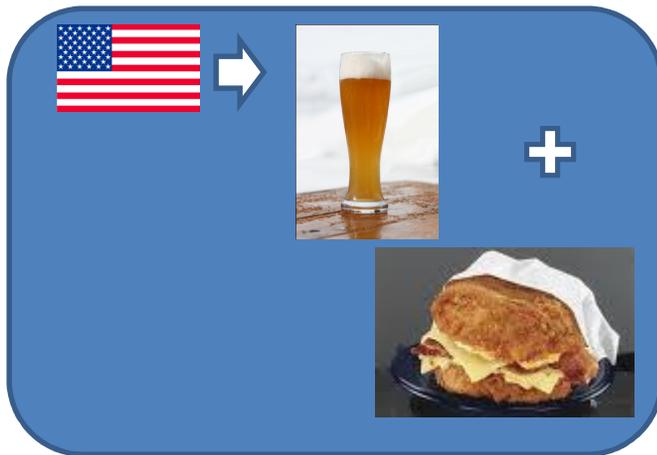
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But then we got the final idea….

The American way…

…with a little bit of (hard) (manual) work…

Phase 1 → Phase 2 → Phase 3

... "Yes, we can!!"

Model approach

- Little constrain
- A lot of penalties
- Run solver and... "pray"
- Take a bear (or two) and start to solve the remaining discrepancy manually
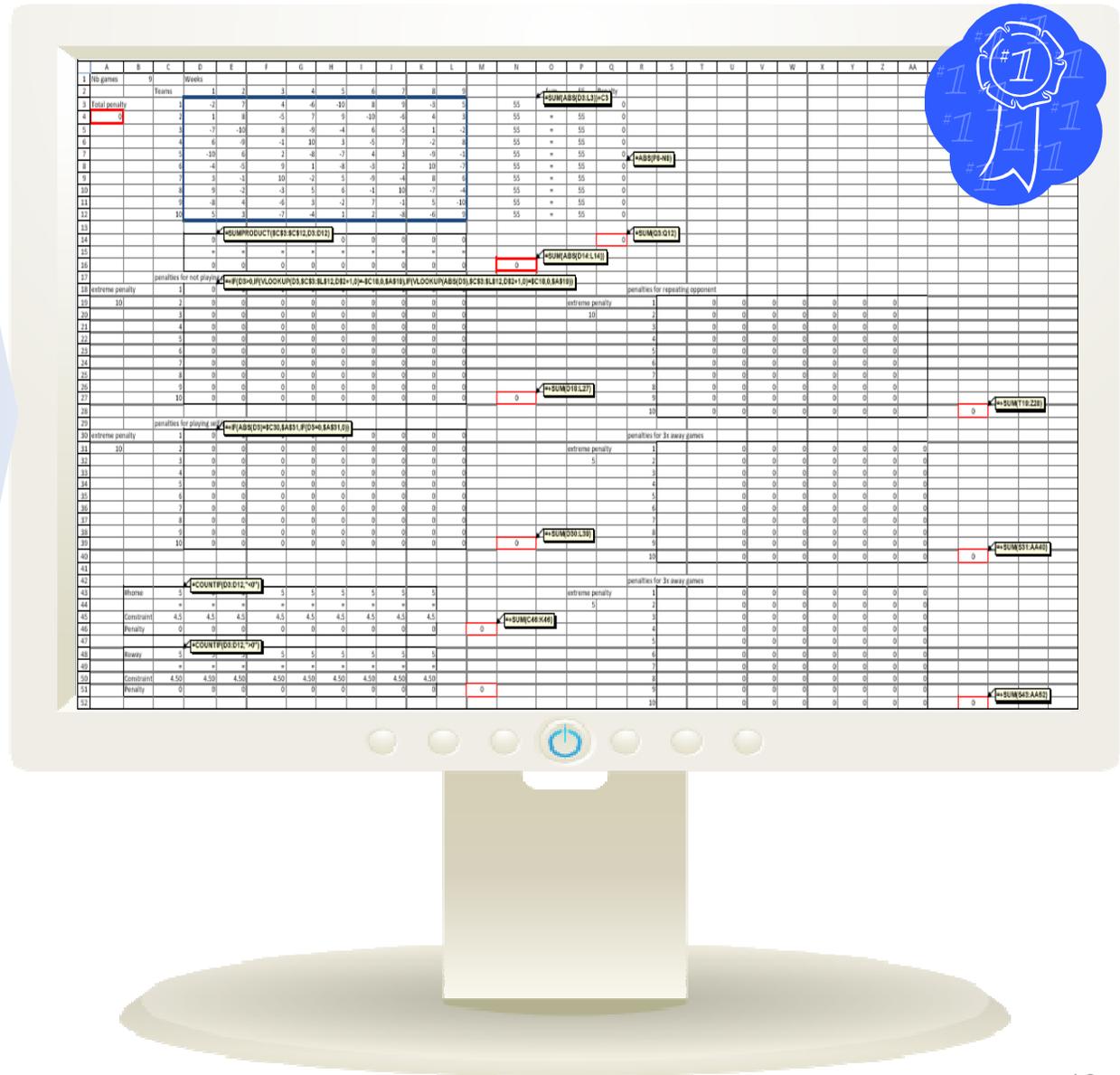
"...and Yes, we did!!"

Teams	Weeks								
	1	2	3	4	5	6	7	8	9
1	@ 2	vs 7	vs 4	@ 6	@ 10	vs 8	vs 9	@ 3	vs 5
2	vs 1	vs 8	@ 5	vs 7	vs 9	@ 10	@ 6	vs 4	vs 3
3	@ 7	@ 10	vs 8	@ 9	@ 4	vs 6	@ 5	vs 1	@ 2
4	vs 6	@ 9	@ 1	vs 10	vs 3	@ 5	vs 7	@ 2	vs 8
5	@ 10	vs 6	vs 2	@ 8	@ 7	vs 4	vs 3	@ 9	@ 1
6	@ 4	@ 5	vs 9	vs 1	@ 8	@ 3	vs 2	vs 10	@ 7
7	vs 3	@ 1	vs 10	@ 2	vs 5	@ 9	@ 4	vs 8	vs 6
8	vs 9	@ 2	@ 3	vs 5	vs 6	@ 1	vs 10	@ 7	@ 4
9	@ 8	vs 4	@ 6	vs 3	@ 2	vs 7	@ 1	vs 5	@ 10
10	vs 5	vs 3	@ 7	@ 4	vs 1	vs 2	@ 8	@ 6	vs 9

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Conclusions

Our learning…

1. Solver sometimes, is not a solution finder, but a "solution facilitator"

2. This problem is much more complex than initially thought, so next time we will check online before finding out that there is tons of literature about this topic

3. There is always the "lifetime guarantee"!!

…will follow us in our future

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- **Ways to improve model**

And if you are not bored yet…

Ideas for improving the model:

Find a working solution!
Add a Brazilian to the team!
Add constraints:
- Minimize breaks
- Don't play strong opponents too often in a row
- Don't play in stadiums that are not available that day
- Hire Juran as a consultant!

Our Questions…

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Your Questions