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Hackathon

AIMMS Campus

July 11 - 15, 2022

Luis Pinto
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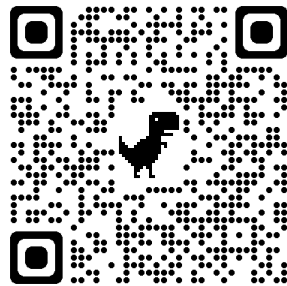luis.pinto@aimms.com | linkedin.com/in/luisfdcp

Luis Pinto

As part of the Customer Success Team, I am involved in Content Creation and User Support roles. Previously I was a partner at a consultancy company using AIMMS to successfully deliver projects to clients. I also started my own company in 2018 in the same area. This brought me a wide range of experiences with different business verticals, planning levels and technologies.

Currently I am based in AIMMS' Haarlem office. MSc degree in Applied Mathematics of Univerisdade Estadual de Campinas – Brazil.

AIMMS User since 2007, AIMMSian since 2021

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Hackathon!

Format

> Tuesday 9:00-10:00

- I will present the problem we will be solving, give some link references and provide you with an overview of what is expected

- The idea is that you can start to think of how to resolve the problem, but no need to code just yet

> Thursday – Whole day

- 9:00–10:00 – Review of the problem / Presentation of the AIMMS Template Project / Introduction of our Consultancy Team

- 10:00–12:30 – Work Session – teams work with consultants to implement improvements to AIMMS template project

- 13:30–15:00 – Work Session – teams work with consultants to implement improvements to AIMMS template project

- 16:00–17:30 – Teams present their solutions / Consultants + AIMMSians decide winner!

Prize!

> For the winning team, we have an AIMMS goodie pack (still a surprise! – but I can say I want it!), trees will be planted in your name, a voucher with 50% discount for next year's AIMMS Campus and a digital certificate "AIMMS Hackathon Champion!" for bragging rights!

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What is provided? What is expected?

> We will provide an AIMMS Project with

- A simple interface

- Input instances – varying from simple to very complex

- A random solution generator – does not optimize anything, but seeks to generate a feasible solution

- A validation process that can provide feedback on quality of solution

> We will evaluate the resulting AIMMS Projects based on

- UX: improving the user experience in our WebUI interface

- Quality of solution: does your approach solve the provided instances?

- Breadth of solution: how many different objectives/constraints were you able to model?

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The problem!

> The problem we select is based on the <u>ITC 2021: International Timetabling Competition on Sports Timetabling</u>.

> We will plan one-on-one matches between sports teams that belong to a single league. We call the complete set of matches a tournament. This tournament follows a double round-robin (2RR). Every team plays against every other team two times: once at home, once away. As a result we have (N - 1) x 2 matches per team, where N is the total number of teams.

> The planning horizon is divided into slots ((N - 1) x 2). We assume that each team plays exactly once per slot. We also assume an even number of teams.

> There are several types of constraints that we briefly present here.

The challenge can be very hard! We do not expect you to implement all constraints. We will have a growing level of difficulties, so don't worry to get them all done!

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Teams	Round	Home	x	Away
Team 0	Round 0	Team 0		Team 1
Team 1	Round 0	Team 2		Team 3
Team 2	Round 1	Team 0		Team 2
Team 3	Round 1	Team 1		Team 3
	Round 2	Team 0		Team 3
	Round 2	Team 1		Team 2
	Round 3	Team 1		Team 0
	Round 3	Team 3		Team 2
	Round 4	Team 2		Team 0
	Round 4	Team 3		Team 1
	Round 5	Team 3		Team 0
	Round 5	Team 2		Team 1

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The problem!

Constraints

> There are both soft and hard constraints. SOFT and HARD tags are included with each one. A PENALTY is also included for each unit of violation. The unit of violation depends on the constraint. A HARD constraint should always be satisfied (although this is sometimes very difficult).

Objective function

> We want to minimize the sum of penalized soft constraints violations.

Structure

> If the timetable instance is "phased", then the first half of slots in the tournament is a complete round-robin and the second half is another complete round-robin. That is, each pair of teams only sees each other once in each half, with their home-away status inverted between halves.

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Capacity Constraints

\<CA1 teams="0" max="0" mode="H" slots="0" type="HARD"/\>

Each team from **teams** plays at most **max** home/away games (**mode** = "H" or "A") during time slots in **slots**. Penalty is number of games over max.

Ex.: Team 0 cannot play at home on time slot 0.

Round	Home	x	Away
Round 0	Team 0		Team 1

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Capacity Constraints

<CA2 teams1="0" min="0" max="1" mode1="HA" mode2="GLOBAL" teams2="1;2" slots ="0;1;2"

type="SOFT"/>

Each team in **teams1** plays at most **max** home/away/any games (mode1 = "H", "A" or "HA"), against

teams in **teams2** during time slots in **slots**. **Mode2** will always be "GLOBAL".

Penalty is number of games over max.

Ex.: Team 0 plays at most one game against teams 1 and 2 during the first three time slots.

Teams	Min	Max	Mode	Against	Slots
Team 0	0	1	Home or Away	Team 1, 2	Rounds 0, 1, 2

Round	Home	x	Away
Round 0	Team 0		Team 1
Round 1	Team 0		Team 2
Round 2	Team 0		Team 3

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Capacity Constraints

<CA3 teams1="0" max="2" mode1="HA" teams2="1;2;3" intp="3" mode2="SLOTS" type="SOFT"/>

Each team in **teams1** plays at most **max** home/away/any games (**mode1** = "H", "A" or "HA") against teams in **teams2** in each sequence of **intp** time slots. **mode2** = "SLOTS" always.

Penalty is number of games over max in any sequence of **intp**.

Ex.: Team 0 plays at most two consecutive games against teams 1, 2, and 3.

Round	Home	x	Away
Round 0	Team 0		Team 5
Round 1	Team 0		Team 1
Round 2	Team 0		Team 2
Round 3	Team 0		Team 3
Round 4	Team 0		Team 4

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Capacity Constraints

<CA4 teams1="0;1" max="3" mode1="H" teams2="2,3" mode2="GLOBAL" slots ="0;1" type="HARD"/>

Teams in **teams1** play at most **max** home/away/any games (**mode1** = "H", "A" or "HA") against teams in **teams2** during time slots in **slots** (when **mode2** = "GLOBAL") or during each individual time slot in **slots** (**mode2** = "EVERY").

Penalty is number of games over max.

Ex.: Teams 0 and 1 together play at most three home games against teams 2 and 3 during the first two time slots.

Round	Home	x	Away
Round 0	Team 0		Team 2
Round 0	Team 1		Team 3
Round 1	Team 0		Team 3
Round 1	Team 1		Team 2

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Game Constraints

`<GA1 min="0" max="0" meetings="0,1;1,2;" slots="3" type="HARD"/>`

At least **min** and at most **max** games from meetings = $\{(i_1, j_1), (i_2, j_2), \ldots\}$ take place during time slots in **slots**.

Penalty is number of games under min or over max.

Ex.: Game (0,1) and (1,2) cannot take place during time slot 3.

Round	Home	x	Away
Round 3	Team 0		Team 5
Round 3	Team 1		Team 2

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Break Constraints

`<BR1 teams="0" intp="0" mode2="HA" slots="1" type="HARD"/>`

Each team in **teams** has at most **intp** home/away/any breaks (**mode2** = "H", "A" or "HA") during time slots in **slots**.

Penalty is the number of breaks over the limit. We say that a team has a break if it has two consecutive home games, or two consecutive away games.

Ex.: Team 0 cannot have a break on time slot 1 (they cannot repeat the home or away of slot 0).

Round	Home	x	Away
Round 0	Team 0		Team 5
Round 1	Team 0		Team 2

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Break and Fairness Constraints

<BR2 homeMode="HA" teams="0;1" mode2="LEQ" intp="2" slots="0;1;2;3" type="HARD"/>

The sum over all breaks (**homeMode** = "HA", the only mode we consider) in **teams** is no more than (**mode2** = "LEQ", the only mode we consider) **intp** during time slots in **slots**.

Penalty is the number of breaks over the limit.

Ex.: Team 0 and 1 together do not have more than two breaks during the first four time slots.

Round	Home	x	Away
Round 0	Team 0		Team 5
Round 0	Team 1		Team 6
Round 1	Team 0		Team 6
Round 1	Team 5		Team 1
Round 2	Team 7		Team 0
Round 2	Team 2		Team 1
Round 3	Team 3		Team 0
Round 3	Team 1		Team 4

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Fairness Constraints

`<FA2 teams="0;1;2" mode="H" intp="1" slots="0;1;2;3" type="HARD"/>`

Each pair of teams in **teams** has a difference in played home games (**mode** = "H", the only mode we consider) that is not larger than **intp** after each time slot in **slots**.

Penalty is the largest difference between home games over the limit.

Ex.: the difference in home games played between teams 0, 1 and 2 is not larger than 1 during the first four time slots.

Round	Home	x	Away
Round 0	Team 0		Team 5
Round 0	Team 1		Team 2
Round 1	Team 6		Team 0
Round 1	Team 2		Team 1
Round 2	Team 1		Team 0
Round 2	Team 2		Team 4
Round 3	Team 2		Team 0
Round 3	Team 1		Team 4

	# Home games
Team 0	1
Team 1	3
Team 2	3

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Separation Constraints

<SE1 teams="0;1" min="5" mode1="SLOTS" type="HARD"/>

Each pair of teams in **teams** has at least **min** time slots (**mode1** = "SLOTS", the only mode we consider) between two consecutive mutual games.

Ex.: there are at least 5 time slots between the mutual games of team 0 and 1 (that is matches 0-1 and 1-0).

Penalty is the number of slots less then the minimum limit.

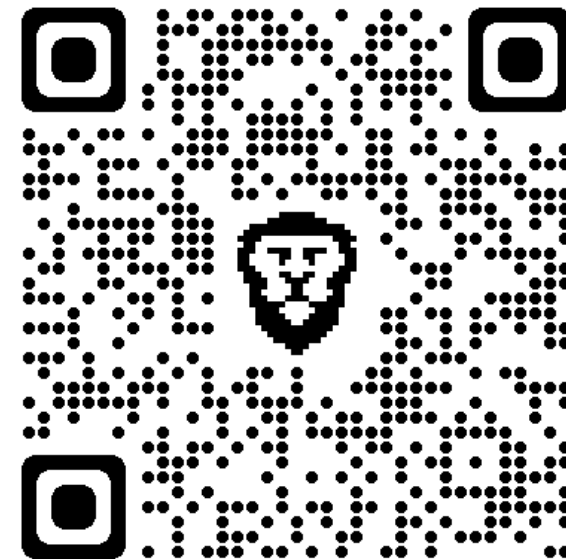| Round	Home	x	Away
Round 0	Team 0		Team 1
Round 1	Team 6		Team 0
Round 1	Team 2		Team 1
Round 2	Team 1		Team 4
Round 2	Team 0		Team 4
Round 3	Team 1		Team 0

Remember!

> You will be provided with an AIMMS kick starter project that already imports data and validates results.

> You can focus on how to create a nice solution – from an optimization and visual point of view.

> You do not need to implement all constraints – we have instances with 0, 1, 2… constraints.

> We have great AIMMS partners and AIMMSians to help you out.

https://tinyurl.com/aimmshackathon2022

https://github.com/aimms/aimmscampushackathon2022

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Quick sample! Input

```xml
<?xml version="1.0" encoding="UTF-8" standalone="no"?>
<Instance>
  <MetaData>
    <InstanceName>Test Instance 1</InstanceName>
    <DataType>A</DataType>
    <Contributor>ITC2021</Contributor>
    <Date year="2020" month="10"/>
  </MetaData>
  <Structure>
    <Format leagueIds="0">
      <numberRoundRobin>2</numberRoundRobin>
      <compactness>C</compactness>
      <gameMode>P</gameMode>
    </Format>
  </Structure>
  <ObjectiveFunction>
    <Objective>SC</Objective>
  </ObjectiveFunction>
  <Resources>
    <Leagues>
      <league id="0" name="League 0"/>
    </Leagues>
    <Teams>
      <team id="0" league="0" name="Team 0"/>
      <team id="1" league="0" name="Team 1"/>
      <team id="2" league="0" name="Team 2"/>
      <team id="3" league="0" name="Team 3"/>
      <team id="4" league="0" name="Team 4"/>
      <team id="5" league="0" name="Team 5"/>
    </Teams>
```

```xml
    <Slots>
      <slot id="0" name="Slot 0"/>
      <slot id="1" name="Slot 1"/>
      <slot id="2" name="Slot 2"/>
      <slot id="3" name="Slot 3"/>
      <slot id="4" name="Slot 4"/>
      <slot id="5" name="Slot 5"/>
      <slot id="6" name="Slot 6"/>
      <slot id="7" name="Slot 7"/>
      <slot id="8" name="Slot 8"/>
      <slot id="9" name="Slot 9"/>
    </Slots>
  </Resources>
  <Constraints>
    <BasicConstraints/>
    <CapacityConstraints>
      <CA1 max="1" min="0" mode="H" penalty="1" slots="9;6;7" teams="0" type="HARD"/>
      <CA1 max="0" min="0" mode="H" penalty="1" slots="6" teams="4" type="HARD"/>
      <CA1 max="0" min="0" mode="A" penalty="1" slots="7" teams="4" type="HARD"/>
      <CA1 max="0" min="0" mode="A" penalty="1" slots="3" teams="5" type="HARD"/>
      <CA1 max="1" min="0" mode="H" penalty="1" slots="9;2;1" teams="1" type="HARD"/>
      <CA1 max="1" min="0" mode="H" penalty="1" slots="2;4;5" teams="1" type="HARD"/>
      <CA1 max="1" min="0" mode="A" penalty="1" slots="2;6;8" teams="1" type="HARD"/>
      <CA1 max="2" min="0" mode="A" penalty="1" slots="6;8;1;0" teams="2" type="HARD"/>
      <CA1 max="0" min="0" mode="H" penalty="1" slots="4" teams="5" type="HARD"/>
```

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Quick sample! Output!

```xml
<?xml version="1.0"?>
<Solution>
    <MetaData>
        <InstanceName>ITC2021_Test1.xml</InstanceName>
        <SolutionName>Test</SolutionName>
        <ObjectiveValue infeasibility="0.0" objective="0.0" />
    </MetaData>
    <Games>
        <ScheduledMatch home="0" away="1" slot="5" />
        <ScheduledMatch home="0" away="2" slot="2" />
        <ScheduledMatch home="0" away="3" slot="1" />
        <ScheduledMatch home="0" away="4" slot="3" />
        <ScheduledMatch home="0" away="5" slot="9" />
        <ScheduledMatch home="1" away="0" slot="0" />
        <ScheduledMatch home="1" away="2" slot="8" />
        <ScheduledMatch home="1" away="3" slot="8" />
        <ScheduledMatch home="1" away="4" slot="7" />
        <ScheduledMatch home="1" away="5" slot="6" />
        <ScheduledMatch home="2" away="0" slot="6" />
        <ScheduledMatch home="2" away="1" slot="3" />
        <ScheduledMatch home="2" away="3" slot="4" />
        <ScheduledMatch home="2" away="4" slot="5" />
        <ScheduledMatch home="2" away="5" slot="0" />
        <ScheduledMatch home="3" away="0" slot="7" />
        <ScheduledMatch home="3" away="1" slot="3" />
        <ScheduledMatch home="3" away="2" slot="9" />
        <ScheduledMatch home="3" away="4" slot="0" />
        <ScheduledMatch home="3" away="5" slot="2" />
        <ScheduledMatch home="4" away="0" slot="9" />
        <ScheduledMatch home="4" away="1" slot="2" />
        <ScheduledMatch home="4" away="2" slot="1" />
        <ScheduledMatch home="4" away="3" slot="6" />
        <ScheduledMatch home="4" away="5" slot="4" />
        <ScheduledMatch home="5" away="0" slot="4" />
        <ScheduledMatch home="5" away="1" slot="1" />
        <ScheduledMatch home="5" away="2" slot="7" />
```

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Thank you for joining the challenge!

Special thanks to

Organizers of ITC2021
Franco Peschiera and baobab
AIMMSians that helped prepare this
Our partners that will join us!