



Gujarat University

School of Emerging Science and Technology

Data Science (Sem-6)



**Topic : Scheduling Cricket Tournament for ODI World Cup
Using Mixed Integer Linear Programming (MILP)**

Mentor : Dr. Ankush Suthar and Prof. Gautam Chauhan

Members :

Dhruv Dangi - DS(6)

Enrollment No. – 202222600035

Krishna Nakrani – DS(23)

Enrollment No. – 202222600009

❖ Abstract

Scheduling a cricket tournament efficiently while minimizing travel distance is a complex optimization problem. This project formulates a **Mixed Integer Linear Programming (MILP)** model to schedule a round-robin cricket tournament, ensuring fairness in match distribution, venue allocation, and rest periods. The model considers multiple constraints, including a minimum **4-day gap between consecutive matches for teams**, **3-day gap between matches at the same venue**, and an **equal number of matches per venue**. Additionally, it ensures teams play only **once per venue** and restricts consecutive-day matches. The objective function minimizes the total travel distance across all teams, reducing logistical burdens. The **PuLP** library in Python is used for optimization, and the final schedule is presented using the **tabulate** library. The proposed model provides an efficient, balanced, and travel-optimized schedule, ensuring smooth tournament operations.

❖ Introduction

Sports tournament scheduling is a complex optimization problem that involves balancing multiple constraints, such as **match frequency, venue availability, rest periods, and travel distances**. Traditional scheduling methods often lead to inefficiencies, including **increased travel costs, uneven match distribution, and inadequate rest periods for teams**. To address these challenges, this study formulates the tournament scheduling problem as a **Mixed Integer Linear Programming (MILP) model** and implements an optimization-based solution using **PuLP in Python**.

The primary objective is to **minimize the total travel distance** while ensuring **fairness in match frequency, venue distribution, and rest periods**. The model is designed for a **10-team, 9-venue round-robin tournament over 45 days**, incorporating constraints such as **single-match-per-day venue restrictions, minimum rest periods between matches, and equal venue allocation**. The optimization model defines decision variables to determine match scheduling while optimizing travel logistics using a **precomputed distance matrix**.

The methodology follows four key steps:

- 1. Data Collection** – Gathering details on teams, venues, and inter-venue distances.
- 2. Mathematical Modeling** – Formulating the MILP model with objective functions and constraints.

3. **Implementation using PuLP** – Solving the model programmatically.
4. **Validation and Analysis** – Evaluating the generated schedule for fairness and efficiency.

This study contributes to **sports analytics and operations research** by demonstrating how **mathematical optimization techniques** can improve **tournament scheduling**. The findings provide insights into reducing **travel fatigue, ensuring fair competition, and optimizing logistics**, with potential applications across various sports tournament formats.

❖ Literature Review

1. MILP in Sports Scheduling

MILP models have been extensively utilized in tournament scheduling due to their ability to handle multiple objectives and constraints. Costa et al. (2010) developed a MILP model to optimize round-robin tournament scheduling, incorporating travel distance constraints and rest periods. Similarly, Ribeiro & Urrutia (2004) proposed a MILP-based approach for scheduling football tournaments while minimizing team travel and ensuring a balanced distribution of home and away matches.

In the cricket domain, Wright (2014) explored MILP formulations to minimize travel distances and maintain fairness in scheduling. The author emphasized the importance of integrating venue constraints to ensure equitable distribution of matches across different stadiums. These works provide a foundation for optimizing ICC One-Day tournaments using MILP models.

2. Travel Distance Minimization

Travel distance is a significant consideration in tournament scheduling, particularly for large-scale international tournaments. Schaefer (2009) introduced a MILP-based approach to minimize total travel distances for teams while ensuring that they play at different venues. The Traveling Tournament Problem (TTP), a variant of the traveling salesman problem, has been applied to sports scheduling to determine optimal venue assignments based on minimal travel costs.

3. Scheduling Constraints and Venue Fairness

Ensuring fairness in tournament scheduling is crucial for competitive balance. Murray (2017) proposed a MILP framework that enforces constraints on venue assignments, ensuring that no team plays consecutive matches at the same location.

❖ Methodology

1. Data Collection

- **Teams:** A list of 10 participating teams.
- **Venues:** A list of 9 available stadiums where matches will be played.
- **venue Distances:** A dictionary containing the distances (in km) between venues to minimize travel.

2. Mathematical Modeling

The optimization problem is formulated as a **Mixed Integer Linear Programming (MILP) Model** using **PuLP**, with the following components:

- **Decision Variable**

Let $x_{t1,t2,v,d}$ be a binary variable such that:

$$x_{t1,t2,v,d} = \begin{cases} 1 & \text{if match between team } t1 \text{ and team } t2 \text{ is scheduled at venue } v \text{ on day } d \\ 0 & \text{otherwise} \end{cases}$$

- **Objective Function**

Minimize:

Total travel distance of teams throughout the tournament.

Mathematically:

$$\min \left(\sum_{t1,t2,v1,v2,d} distance(v1, v2) + x_{t1,t2,v2,d} \right)$$

where $distance(v1, v2)$ represents the travel distance between two venues.

- **Constraints**

1. **Each match occurs exactly once.**

$$\sum_{v,d} x_{t1,t2,v,d} = 1, \forall (t1, t2) \in teams$$

2. **Each venue hosts exactly 5 matches to ensure fairness.**

$$\sum_{t1,t2,d} x_{t1,t2,v,d} = 5, \forall v \in venues$$

3. Each team plays exactly 9 matches:

$$\sum_{t1,t2,v,d} x_{t1,t2,v,d} = 9, \forall t \in teams$$

4. Minimum 4-day gap between a team's matches:

$$\sum_{t1,t2,v} (x_{t1,t2,v,d} + x_{t1,t2,v,d+1} + x_{t1,t2,v,d+2} + x_{t1,t2,v,d+3}) \leq 1, \forall t \in teams,$$
$$\forall d \in days[: -3]$$

5. Minimum 3-day gap between venue usages:

$$\sum_{t1,t2} (x_{t1,t2,v,d} + x_{t1,t2,v,d+1} + x_{t1,t2,v,d+2}) \leq 1, \forall v \in venues,$$
$$\forall d \in days[: -2]$$

6. At most one match per day:

$$\sum_{t1,t2,v} x_{t1,t2,v,d} \leq 1, \forall d \in days$$

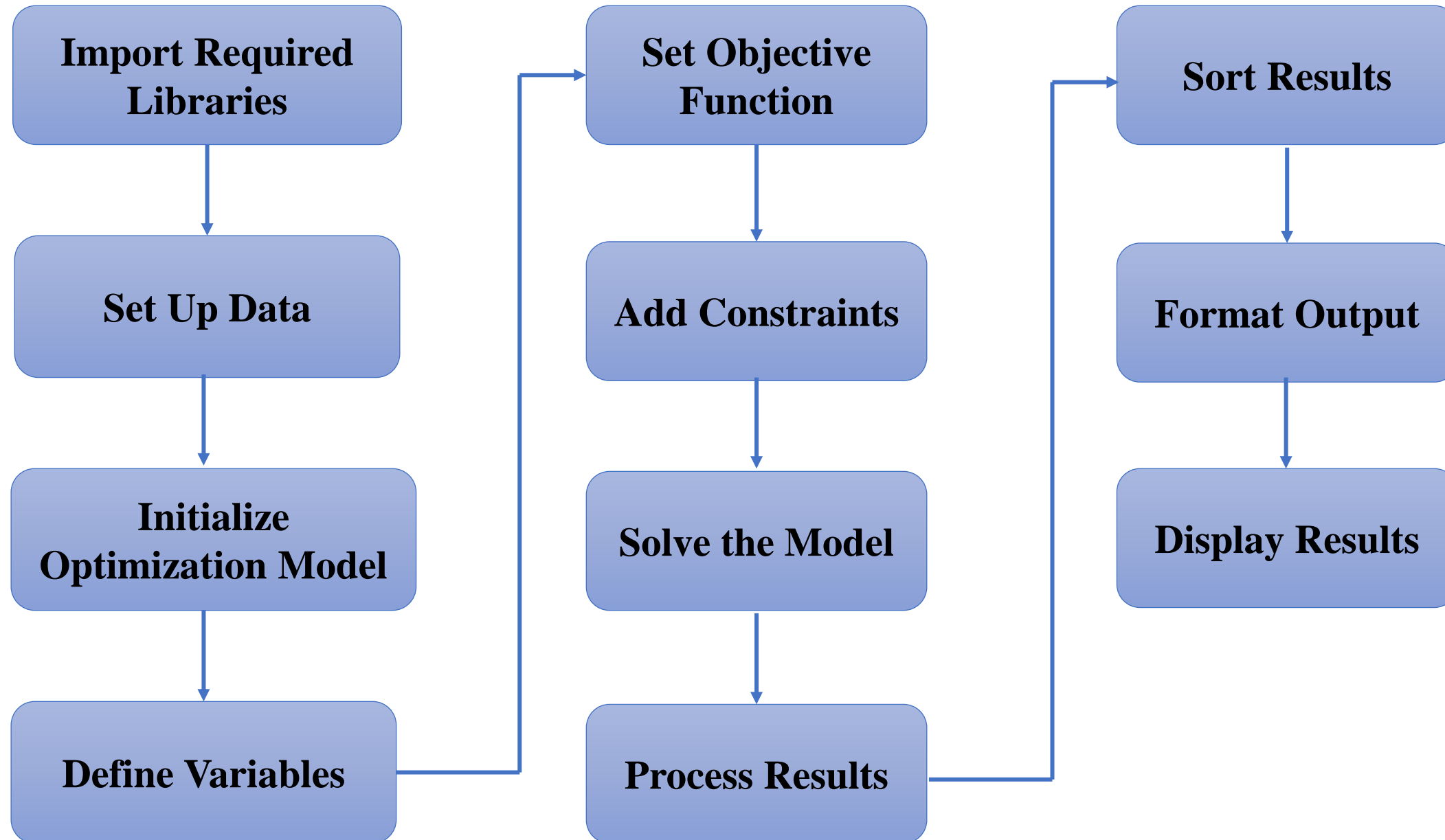
7. Each team plays at most once per venue:

$$\sum_{t1,t2,d} x_{t1,t2,v,d} \leq 1, \forall t \in teams, \forall v \in venues$$

8. No consecutive day matches for teams:

$$\sum_{t1,t2,v} (x_{t1,t2,v,d} + x_{t1,t2,v,d+1}) \leq 1, \forall t \in teams, \forall d \in days[: -1]$$

3. Implementation using PuLP



4. Validation and Analysis

- 1. Launch the application
- 2. View Initial Schedule

Match Schedule Finder

Match Schedule Finder

Search:

Date	Match	Venue
01-Mar-2025	England vs South Africa	Ahmedabad
02-Mar-2025	India vs New Zealand	Mumbai
03-Mar-2025	Sri Lanka vs Afghanistan	Pune
04-Mar-2025	Pakistan vs Netherlands	Jaipur
05-Mar-2025	Australia vs England	Delhi
06-Mar-2025	Bangladesh vs South Africa	Lucknow
07-Mar-2025	India vs Afghanistan	Jaipur
08-Mar-2025	Sri Lanka vs Netherlands	Ahmedabad
09-Mar-2025	Australia vs New Zealand	Pune
10-Mar-2025	Pakistan vs Bangladesh	Mumbai
11-Mar-2025	India vs South Africa	Chennai
12-Mar-2025	England vs Netherlands	Hyderabad
13-Mar-2025	Afghanistan vs New Zealand	Lucknow
14-Mar-2025	Australia vs Bangladesh	Jaipur
15-Mar-2025	Pakistan vs Sri Lanka	Chennai
16-Mar-2025	India vs Netherlands	Pune
17-Mar-2025	Afghanistan vs South Africa	Bengaluru
18-Mar-2025	Bangladesh vs New Zealand	Delhi

Teams:

Afghanistan
Australia
Bangladesh
England
India
Netherlands
New Zealand
Pakistan
South Africa
Sri Lanka

Venues:

Ahmedabad
Mumbai
Pune
Jaipur
Delhi
Lucknow
Chennai
Hyderabad
Bengaluru

Calculate Distance

Clear

Matches Found: 45

3. Select Filtering Method

I. Type in Search Box

Match Schedule Finder

Match Schedule Finder

Search:

Date	Match	Venue
02-Mar-2025	India vs New Zealand	Mumbai
07-Mar-2025	India vs Afghanistan	Jaipur
11-Mar-2025	India vs South Africa	Chennai
16-Mar-2025	India vs Netherlands	Pune
22-Mar-2025	India vs Bangladesh	Hyderabad
29-Mar-2025	India vs Sri Lanka	Lucknow
02-Apr-2025	Australia vs India	Ahmedabad
09-Apr-2025	Pakistan vs India	Delhi
14-Apr-2025	England vs India	Bengaluru

Teams:

Afghanistan
Australia
Bangladesh
England
India
Netherlands
New Zealand
Pakistan
South Africa
Sri Lanka

Venues:

Ahmedabad
Mumbai
Pune
Jaipur
Delhi
Lucknow
Chennai
Hyderabad
Bengaluru

Calculate Distance

Clear

Matches Found: 9

II. Select Team from List box

Match Schedule Finder

Match Schedule Finder

Search:

Date	Match	Venue
02-Mar-2025	India vs New Zealand	Mumbai
07-Mar-2025	India vs Afghanistan	Jaipur
11-Mar-2025	India vs South Africa	Chennai
16-Mar-2025	India vs Netherlands	Pune
22-Mar-2025	India vs Bangladesh	Hyderabad
29-Mar-2025	India vs Sri Lanka	Lucknow
02-Apr-2025	Australia vs India	Ahmedabad
09-Apr-2025	Pakistan vs India	Delhi
14-Apr-2025	England vs India	Bengaluru

Teams:

Afghanistan
Australia
Bangladesh
England
India
Netherlands
New Zealand
Pakistan
South Africa
Sri Lanka

Venues:

Ahmedabad
Mumbai
Pune
Jaipur
Delhi
Lucknow
Chennai
Hyderabad
Bengaluru

Calculate Distance

Clear

Matches Found: 9

III. Select Venue from List box

Match Schedule Finder

Match Schedule Finder

Search:

Date	Match	Venue
01-Mar-2025	England vs South Africa	Ahmedabad
08-Mar-2025	Sri Lanka vs Netherlands	Ahmedabad
30-Mar-2025	Bangladesh vs Afghanistan	Ahmedabad
02-Apr-2025	Australia vs India	Ahmedabad
13-Apr-2025	Pakistan vs New Zealand	Ahmedabad

Teams:

Afghanistan
Australia
Bangladesh
England
India
Netherlands
New Zealand
Pakistan
South Africa
Sri Lanka

Venues:

Ahmedabad
Mumbai
Pune
Jaipur
Delhi
Lucknow
Chennai
Hyderabad
Bengaluru

Calculate Distance

Clear

Matches Found: 5

4. View Match Details

- Double-click a match in the table

Match Schedule Finder

Search:

Date
02-Mar-2025
07-Mar-2025
11-Mar-2025
16-Mar-2025
22-Mar-2025
29-Mar-2025
02-Apr-2025
09-Apr-2025
14-Apr-2025

Match Details

i

Date: 02-Mar-2025

Match: India vs New Zealand

Venue: Mumbai

--- Team 1: India ---

Captain: Rohit Sharma

Coach: Rahul Dravid

Recent Performance: India boasts a formidable batting lineup and aims to secure another ICC trophy since their 2013 Champions Trophy win.

Key Players: Virat Kohli, Jasprit Bumrah

World Ranking: 2

--- Team 2: New Zealand ---

Captain: Mitchell Santner

Coach: Gary Stead

Recent Performance: Entering the tournament with high confidence from recent successes, including winning a tri-nation series in Pakistan.

Key Players: Kane Williamson, Trent Boult

World Ranking: 1

--- Venue: Mumbai ---

Location: Wankhede Stadium, Mumbai, India

Capacity: 33000

Pitch Type: Offers bounce and pace, aiding fast bowlers

Weather Forecast: Hazy sun and hot, 35°C

Historical Matches: Venue for the 2011 ICC Cricket World Cup Final

Facilities: Parking, Food Stalls

OK

Venue
Mumbai
Jaipur
Chennai
Pune
Hyderabad
Lucknow
Ahmedabad
Delhi
Bengaluru

Teams:

Afghanistan

Australia

Bangladesh

England

India

Netherlands

New Zealand

Pakistan

South Africa

Sri Lanka

Venues:

Ahmedabad

Mumbai

Pune

Jaipur

Delhi

Lucknow

Chennai

Hyderabad

Bengaluru

Calculate Distance

Clear

Matches Found: 9

5. Calculate Team Travel Distance

- Select a team
- Click “Calculate Distance” button

The screenshot shows a web application titled "Match Schedule Finder". At the top, there is a search bar with the text "Search: India". Below the search bar is a table with three columns: "Date", "Match", and "Venue". The table lists 9 matches for the team "India".

Date	Match	Venue
02-Mar-2025	India vs New Zealand	Mumbai
07-Mar-2025	India vs Afghanistan	Jaipur
11-Mar-2025	India vs South Africa	Chennai
16-Mar-2025	India vs Netherlands	Pune
22-Mar-2025	India vs Bangladesh	Hyderabad
29-Mar-2025		Lucknow
02-Apr-2025		Ahmedabad
09-Apr-2025		Delhi
14-Apr-2025		Bengaluru

On the right side of the application, there are two lists: "Teams:" and "Venues:". The "Teams:" list includes Afghanistan, Australia, Bangladesh, England, India (highlighted), Netherlands, New Zealand, Pakistan, South Africa, and Sri Lanka. The "Venues:" list includes Ahmedabad, Mumbai, Pune, Jaipur, Delhi, Lucknow, Chennai, Hyderabad, and Bengaluru. At the bottom right, there is a "Calculate Distance" button.

A modal dialog box titled "Total Distance" is displayed in the center of the screen. It contains an information icon and the text: "The total distance for the selected team's path is 8664 Kms." There is an "OK" button at the bottom right of the modal.

At the bottom of the application, there is a "Clear" button and a status bar that says "Matches Found: 9".

5. Points Table

1. Display First Match

Match Schedule and Points Table

Match Schedule and Points Table

Match 1: England vs South Africa at Ahmedabad on 01-Mar-2025

Who won? (Choose from A, B, or T):

A	B	Status
England	South Africa	

2. Enter Winner and Submit

- Type "A", "B", or "T" in winner_entry
- Press Enter or click Submit button

Match Schedule and Points Table

Match Schedule and Points Table

Match 2: India vs New Zealand at Mumbai on 02-Mar-2025

Who won? (Choose from A, B, or T):

A	B	Status
England	South Africa	
India	New Zealand	

3. Display points table

Match Schedule and Points Table

Match Schedule and Points Table

Final Points Table

Who won? (Choose from A, B, or T):

A	B	Status
New Zealand	13	SemiFinals
Netherlands	12	SemiFinals
Pakistan	11	SemiFinals
Bangladesh	10	SemiFinals
Australia	9	
England	9	
South Africa	9	
Sri Lanka	8	
India	6	
Afghanistan	3	

4. Press Enter for Semifinals
5. Submit Semifinal Winner
 - Enter "A", "B", or "T" and press Enter
6. Display Final Points Table

Match Schedule and Points Table

Final Points Table

Who won? (Choose from A, B, or T):

A	B	Status
New Zealand	15	Finals
Bangladesh	12	Finals
Netherlands	12	
Pakistan	11	

7. Press Enter for Finals
8. Submit Final Winner
 - Enter "A", "B", or "T" and press Enter
9. Display champion

Match Schedule and Points Table

Champion: New Zealand

Who won? (Choose from A, B, or T):

A	B	Status
New Zealand	Champion	

❖ **Observation**

- **Optimized Travel Distance** : The **MILP model successfully minimizes total travel distance** for all teams by strategically assigning venues. This leads to reduced logistical costs and less travel fatigue for players.
- **Fair Match Distribution** : Each team plays exactly **nine matches**, ensuring that all teams have an equal number of games. The allocation of venues is also **balanced**, preventing any team from having an unfair home advantage.

- **Adequate Rest Periods** : The model enforces a **minimum 4-day gap** between consecutive matches for each team, reducing the risk of player fatigue and injuries. Additionally, no team plays on consecutive days, ensuring fairness.
- **Even Venue Utilization** : Each of the **nine venues hosts exactly five matches**, ensuring that no venue is overutilized or underutilized. This helps in maintaining pitch quality and operational efficiency.
- **No Scheduling Conflicts** : The constraints prevent any **overlapping matches** or double bookings at venues. The **single-match-per-day rule** ensures that only one match is played at a given venue each day, making scheduling practical for broadcasters and organizers.

❖ **Challenges and Limitations**

Complexity of Constraints:

Ensuring all constraints are met, especially the ones related to the minimum gap between matches for teams and venues, can make the problem complex.

Scalability:

As the number of teams, venues, and days increases, the size of the problem grows exponentially. This can result in longer computation times and increased memory usage.

Distance Optimization:

The model aims to minimize total travel distance, but this may conflict with other constraints (like the minimum gap between matches).

Match Scheduling:

Ensuring each match occurs only once and each team plays exactly 9 matches can be challenging when combined with venue constraints.

Real-World Factors:

The model does not consider real-world factors such as weather conditions, venue availability, or logistical challenges that might impact the schedule.

❖ Conclusion

This project developed an **optimized scheduling model** for a **10-team cricket tournament** using **Mixed Integer Linear Programming (MILP)** to minimize **travel distances** while ensuring **fair match distribution and adherence to key constraints**. The model ensured that **each team played exactly nine matches**, with **each venue hosting five matches**, while maintaining a **minimum 4-day rest period** and avoiding **consecutive matches for teams and most venues**. The final schedule was structured and presented in a clear format.

Future enhancements could include **real-time adjustments for unforeseen changes**, **additional constraints for team preferences**, and **further refinement of travel logistics**.

This project demonstrates the **practical application of mathematical optimization in sports scheduling**, contributing to a **well-structured, fair, and efficient tournament format**.

References

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