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)

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

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

- **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:**

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

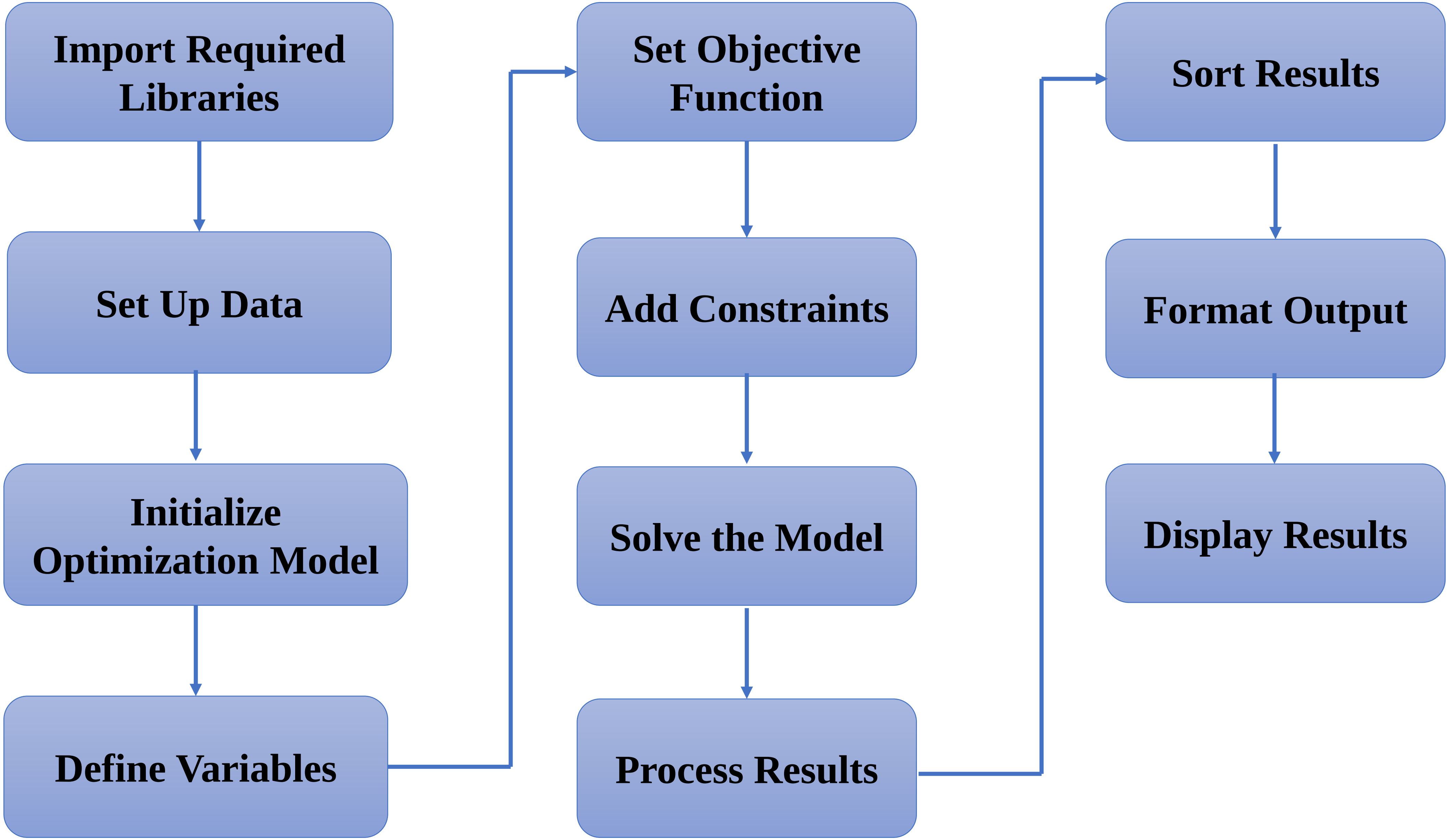
7. **Each team plays at most once per venue:**

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

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

3. Select Filtering Method

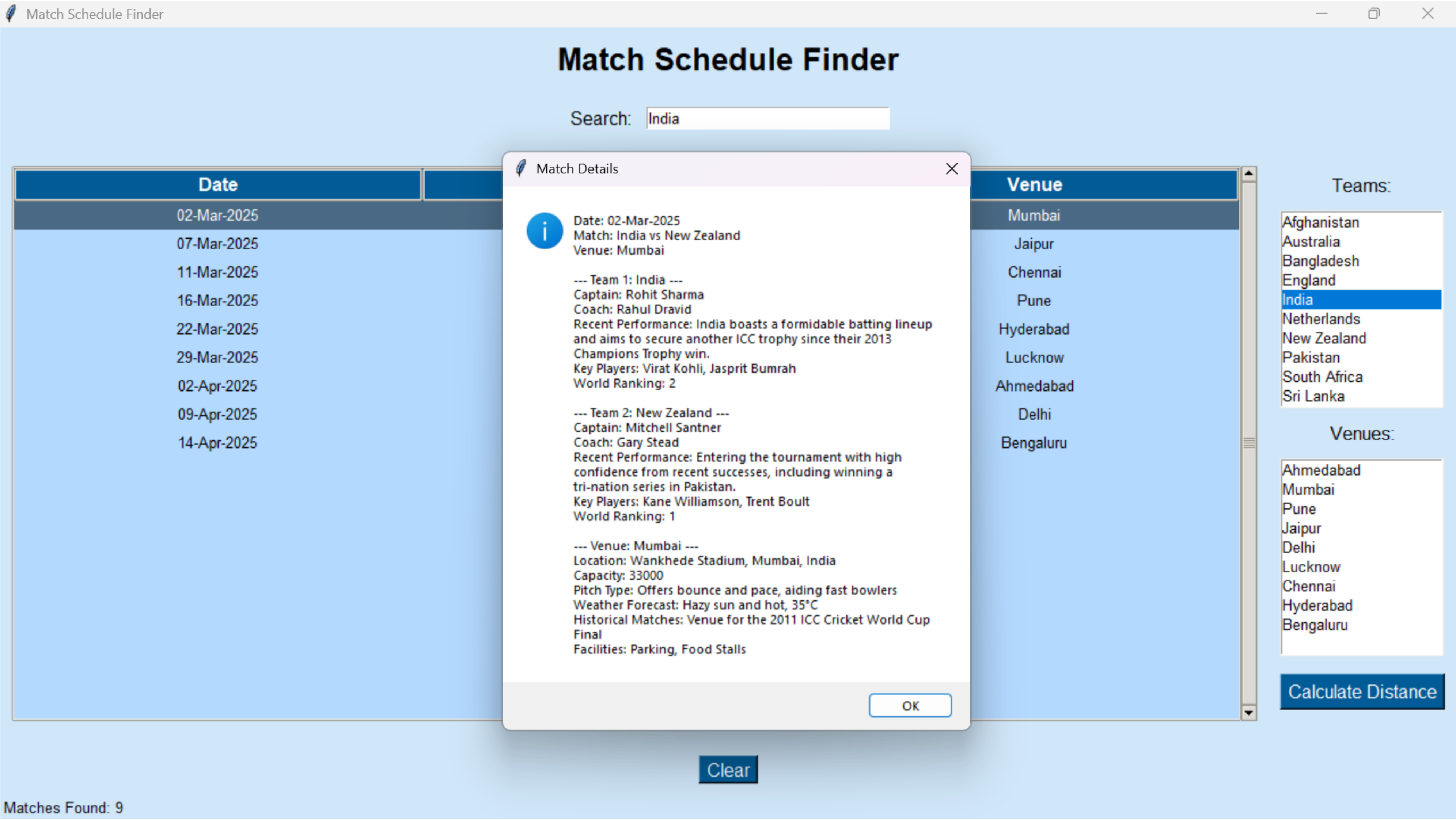
I. Type in Search Box

II. Select Team from List box

III. Select Venue from List box

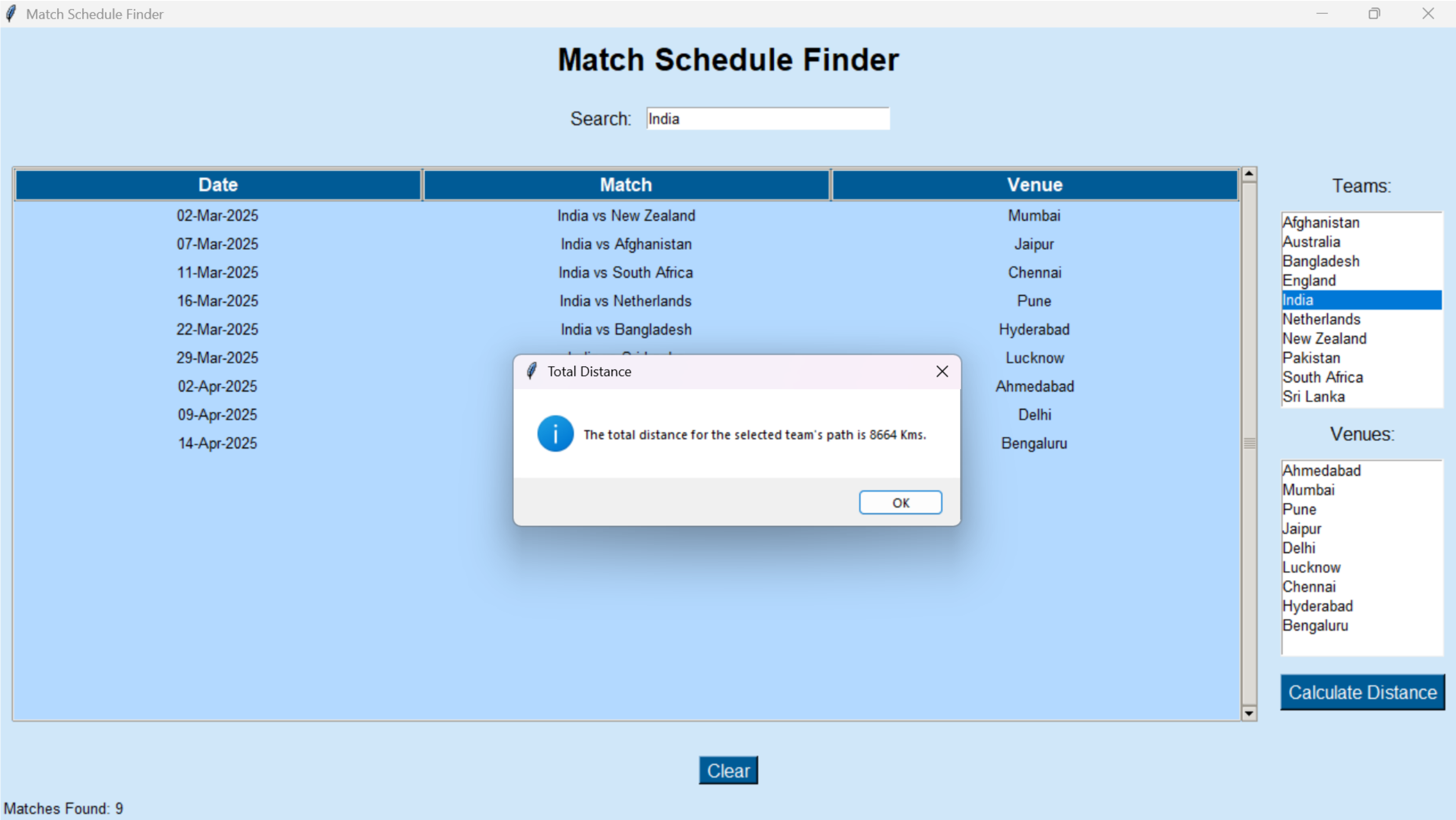
4. View Match Details

- Double-click a match in the table



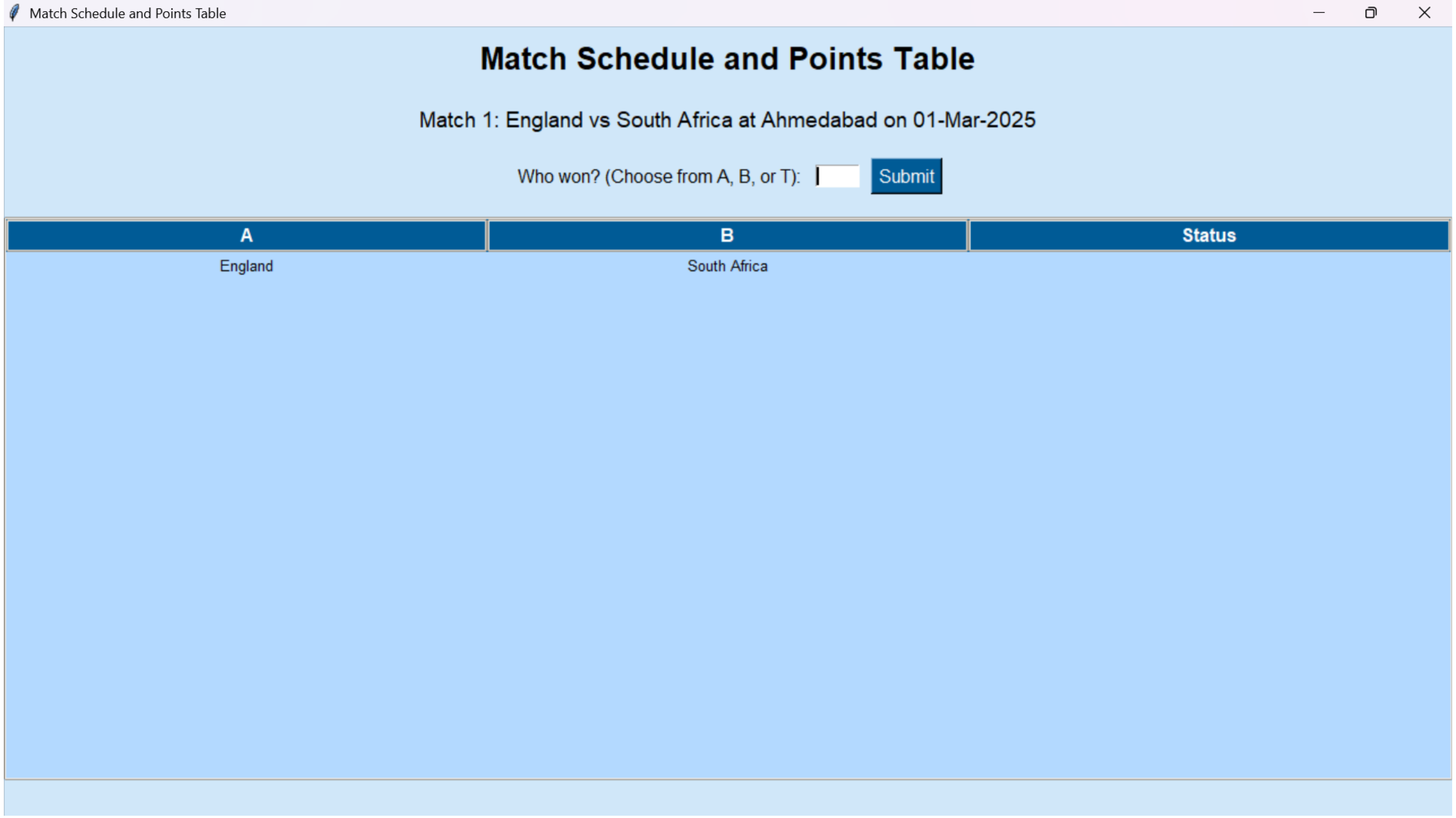
5. Calculate Team Travel Distance

- Select a team
- Click “Calculate Distance” button



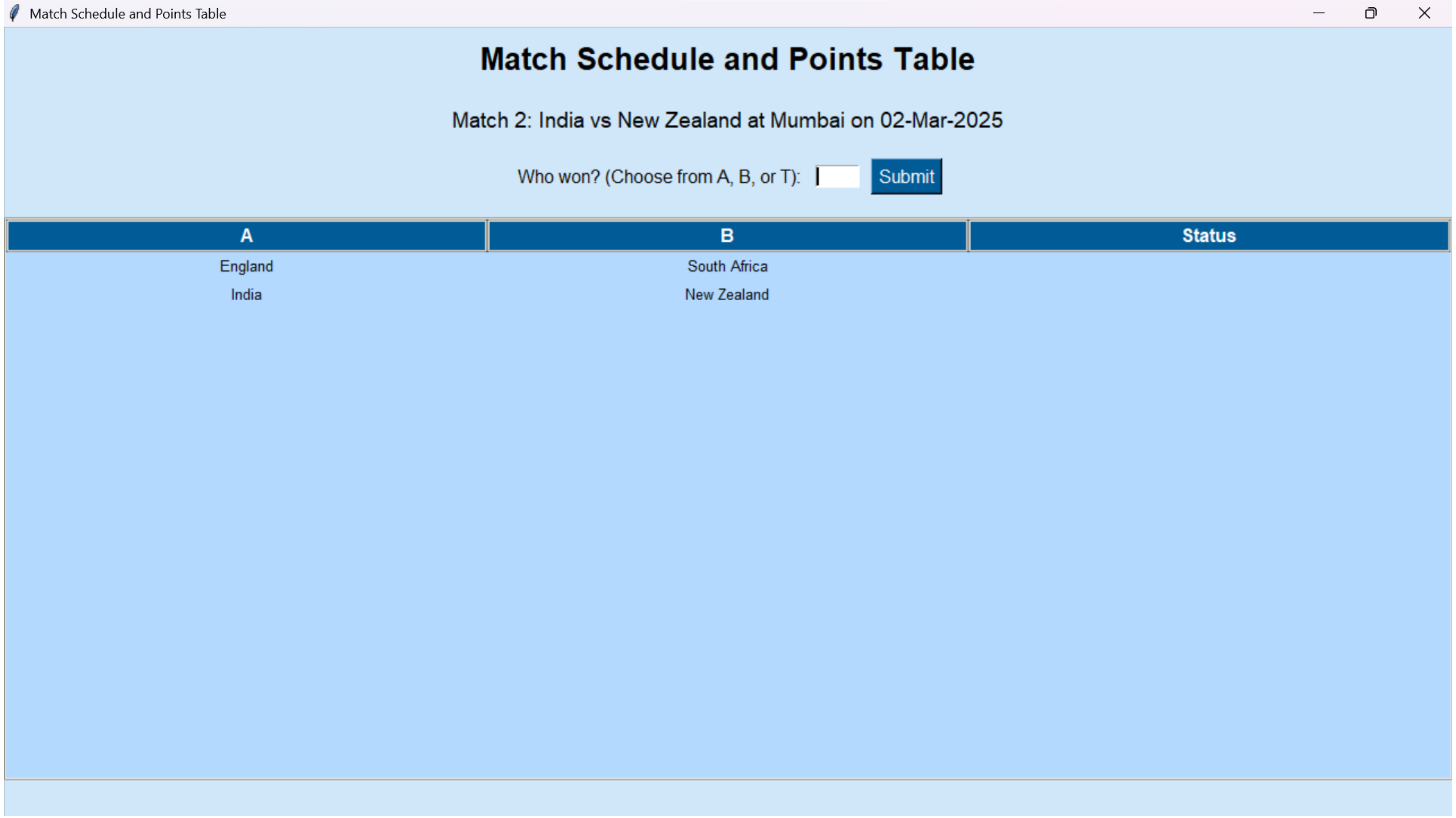
5. Points Table

1. Display First Match



2. Enter Winner and Submit

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



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): Submit

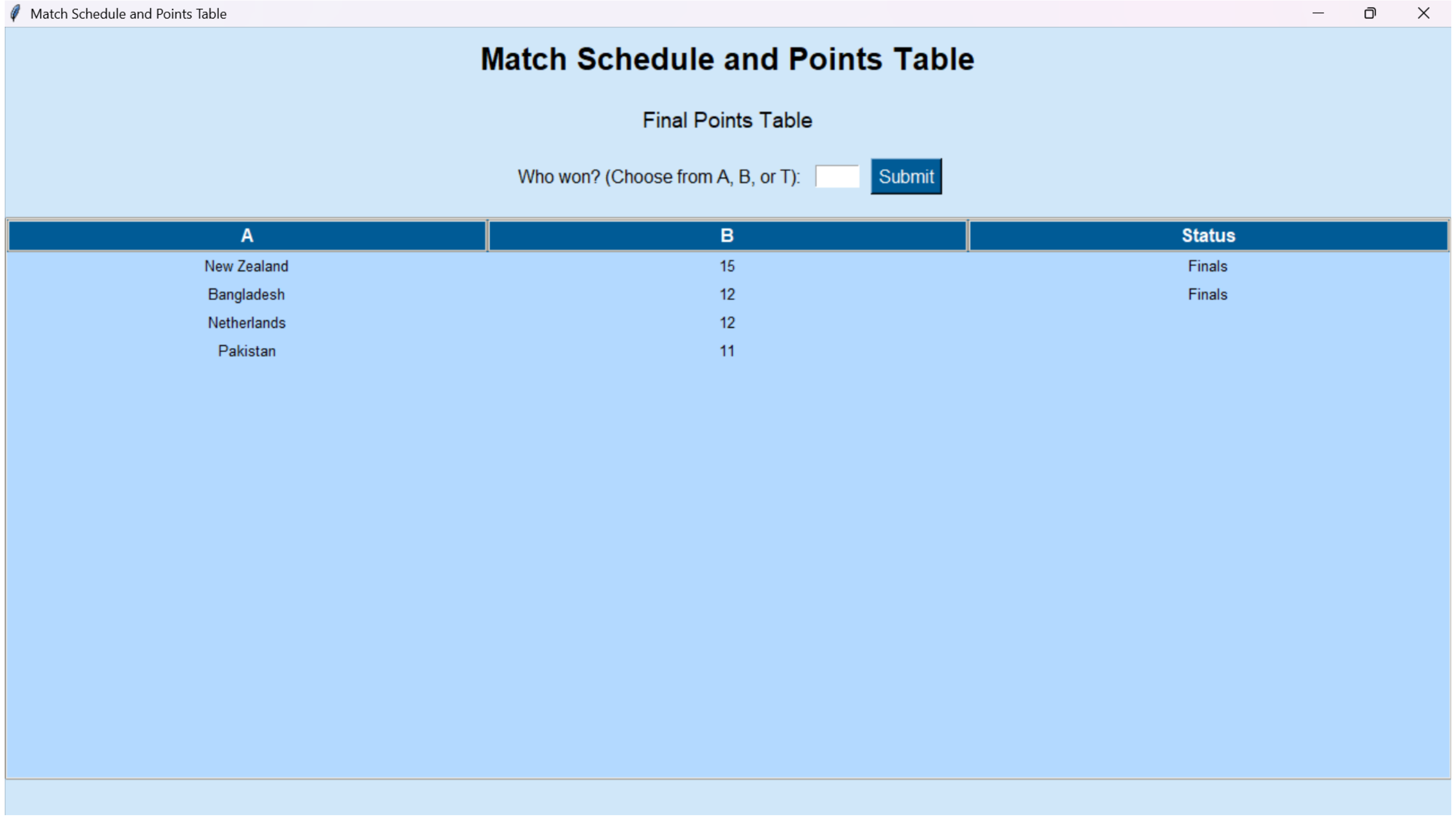
A	B	Status
New Zealand	13	SemiFinals
Netherlands	12	SemiFinals
Pakistan	11	SemiFinals
Bangladesh	10	SemiFinals
Australia	9	
England	9	
South Africa	9	
Sri Lanka	8	
India	6	
Afghanistan	3	

4. Press Enter for Semifinals

5. Submit Semifinal Winner

- Enter "A", "B", or "T" and press Enter

6. Display Final Points Table

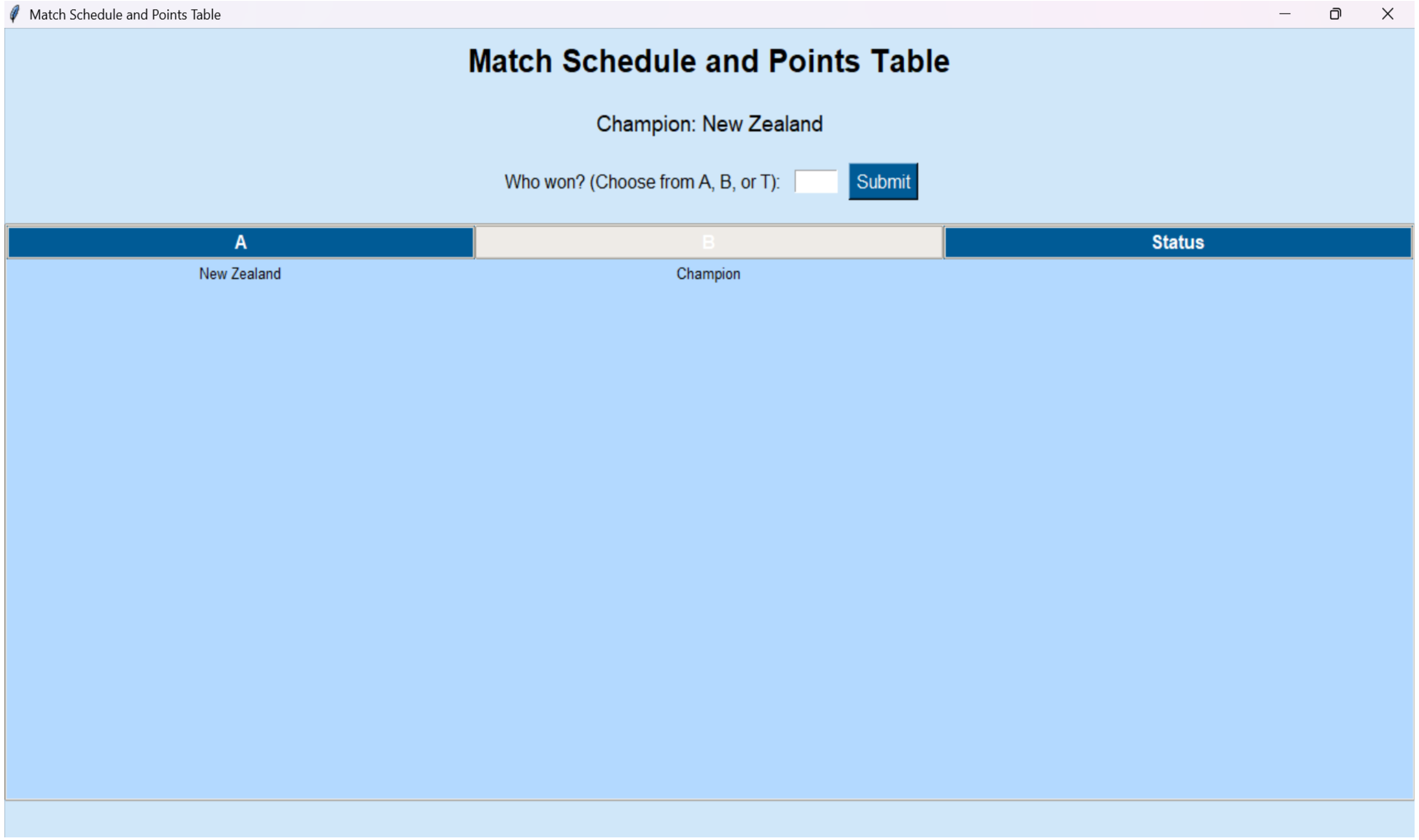


7. Press Enter for Finals

8. Submit Final Winner

- Enter "A", "B", or "T" and press Enter

9. Display 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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2. Ribeiro, C., & Urrutia, S. (2004). Scheduling football tournaments using MILP. *Journal of Scheduling*, 7(5), 383-399.
3. Wright, M. (2014). Cricket scheduling: Optimization models for fairness and efficiency. *European Journal of Operational Research*, 235(2), 635-648.
4. Schaefer, C. (2009). Minimizing travel distance in sports scheduling. *Computational Optimization and Applications*, 44(4), 321-341.
5. Murray, R. (2017). A MILP framework for equitable sports scheduling. *Annals of Operations Research*, 254(1), 89-106.