Auction-Based Collegiate Athletic Conference Scheduling

An Iterative Market Mechanism for Sports Schedule Formation

Art Steinmetz

2026-02-03

Table of contents

Abstract

This article presents an iterative auction-based model for forming collegiate athletic conference schedules. The mechanism treats away games as differentiated goods, categorized by opponent strength match and travel requirements. Schools bid on game types according to their preferences, and a market-clearing process determines the final schedule. The model enforces hard constraints including exact home/away game requirements and pairwise meeting limits, while prices emerge endogenously to reflect relative scarcity and desirability. Analysis of simulation results reveals how geographic isolation creates systematic disadvantages for remote schools, who must spend more tokens to acquire less desirable schedules. The auction framework provides a transparent, preference-respecting approach to the complex combinatorial problem of conference scheduling.

Introduction

Creating a sports schedule for a collegiate athletic conference is a challenging combinatorial problem. Conference administrators must balance multiple competing objectives: ensuring competitive balance, minimizing travel costs, respecting institutional preferences, and satisfying logistical constraints. Traditional approaches often rely on ad-hoc negotiations or rigid rotation systems that may not adequately reflect school preferences.

This article explores an alternative approach: using an iterative auction mechanism to form conference schedules. In this framework, away games are treated as differentiated goods, and schools express their preferences through bidding behavior. The market mechanism then allocates games in a way that respects both preferences and hard constraints.

The auction-based approach offers several advantages:

1. **Preference revelation**: Schools' bids reveal their true preferences over different types of games
2. **Price discovery**: Equilibrium prices emerge that reflect the relative scarcity of desirable game types
3. **Transparency**: The allocation process is governed by clear rules rather than opaque negotiations
4. **Flexibility**: The mechanism can accommodate heterogeneous preferences across schools

We implement and simulate this mechanism for a 20-school conference where each school plays 12 games per season (6 home, 6 away). The simulation demonstrates how the auction produces feasible schedules while generating meaningful price signals about game type desirability.

Model Description

Agents and Season Parameters

The model considers a set of $N = 20$ schools that form an athletic conference. Each school must play exactly $G = 12$ games per season, split evenly between home and away:

- Home games: $H = 6$
- Away games: $A = 6$

Each school begins the season with a budget of $B_0 = 100$ tokens, used to bid on away games.

School Strengths

Each school i is assigned a discrete strength score $s_i \in \{1, 2, 3\}$:

- $s_i = 1$: Weak
- $s_i = 2$: Moderate
- $s_i = 3$: Strong

The strength match between two schools is defined by the absolute difference in their strength scores:

$$b_{ij} = \begin{cases} 3 \text{ if } & |s_i - s_j| = 0 \quad \text{(evenly matched)} \\ 2 \text{ if } & |s_i - s_j| = 1 \quad \text{(close match)} \\ 1 \text{ if } & |s_i - s_j| = 2 \quad \text{(mismatched)} \end{cases}$$

Schools prefer evenly matched opponents (band 3) over mismatched opponents (band 1).

Geography and Travel

Each school has a geographic location characterized by latitude and longitude coordinates. For each ordered pair of schools (i, j), travel requirements are determined by:

- **Distance**: Haversine distance in miles between school locations
- **Bus travel time**: $T_{ij}^{bus} = \text{distance}_{ij}/60$ hours
- **Travel class** τ_{ij}:
  - B (bus) if $T_{ij}^{bus} \leq 5$ hours
  - P (plane) if $T_{ij}^{bus} > 5$ hours

Travel costs are fixed rates:

Travel Mode	Cost
Home	\$0
Bus	\$1,500
Plane	\$7,500

Plane travel time is treated as constant at 5 hours regardless of distance.

Game Types

Away games are categorized into 6 types based on the combination of strength match and travel class:

$$k = (\text{strength\_match}, \text{travel\_class}) \in \{1, 2, 3\} \times \{B, P\}$$

Each ordered away match (i, j) belongs to exactly one game type determined by b_{ij} and τ_{ij}.

Preference Specification

Schools express preferences over game types through disutilities $v_{i,k} \leq 0$. More negative values indicate less desirable game types. Disutility captures:

- Strength band preference (evenly matched preferred)
- Travel time burden
- Travel cost burden

To convert disutilities to willingness-to-pay (value):

$$\text{value}_{i,k} = v_{i,k} - \min_k v_{i,k}$$

This ensures the most-preferred game type has the highest value and the least-preferred has value zero.

Feasibility Constraints

The final schedule must satisfy:

(a) Total games per school:

$$\sum_{j \neq i} x_{ij} + \sum_{j \neq i} x_{ji} = G \quad \forall i$$

(b) Exact home/away split:

$$\sum_{j \neq i} x_{ji} = H \quad \forall i \quad \text{(home games)}$$

$$\sum_{j \neq i} x_{ij} = A \quad \forall i \quad \text{(away games)}$$

(c) Pairwise meeting cap:

$$x_{ij} + x_{ji} \leq 1 \quad \forall i < j$$

(d) Binary decision variables:

$$x_{ij} \in \{0, 1\}$$

Iterative Auction Process

The auction proceeds iteratively:

1. **Demand determination**: Each school determines integer demand for each game type given current prices and remaining budget
2. **Clearing problem**: An LP solver finds the value-maximizing allocation respecting feasibility and demand constraints
3. **Price update**: Prices increase for game types with excess demand

4. **Budget update**: Schools pay for allocated games at current prices
5. **Schedule update**: Cumulative schedule matrix is updated

The process terminates when all schools have complete schedules or a maximum iteration limit is reached.

Auction Simulation

Section 1: Initialize Season Parameters

This section establishes the fundamental parameters that govern the auction simulation, including the number of schools, games per season, and budget allocations.

The conference consists of 20 schools, each playing 12 games with an even split between home and away. Each school starts with 100 tokens to bid on away games.

Section 2: Create Schools and Geographic Locations

Schools are created with randomly assigned strength scores and geographic locations within a region approximating the eastern United States.

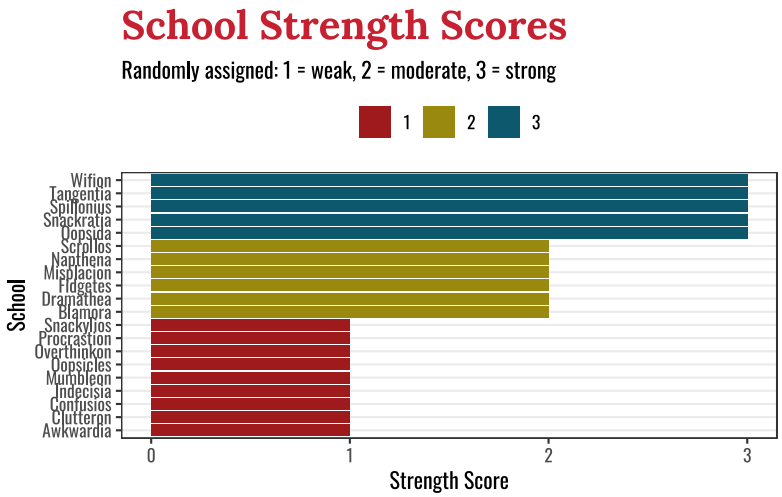

Figure 1: Distribution of school strength scores

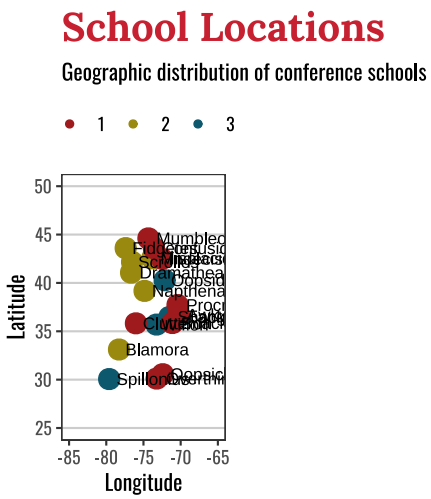

Figure 2: Geographic distribution of conference schools

Figure 1 shows the distribution of strength scores across schools. Figure 2 displays the geographic spread of schools across the conference region.

Section 3: Define Game Types and Preferences

Schools have preferences over different types of away games. Game types are defined by the combination of opponent strength match and travel requirements.

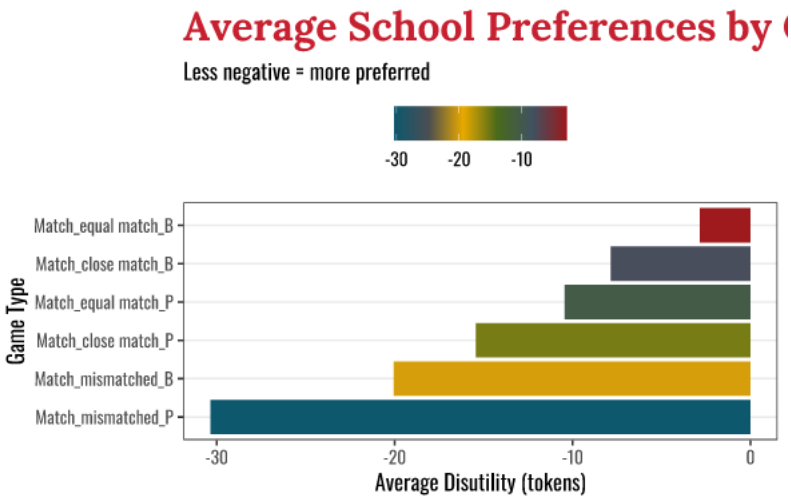

Figure 3: Average school preferences by game type

Schools strongly prefer evenly matched bus games (low disutility) and dislike mismatched plane games (high disutility).

Section 4: Create School Pairs with Travel Information

This section computes the travel requirements between all pairs of schools, determining which games require plane travel versus bus travel.

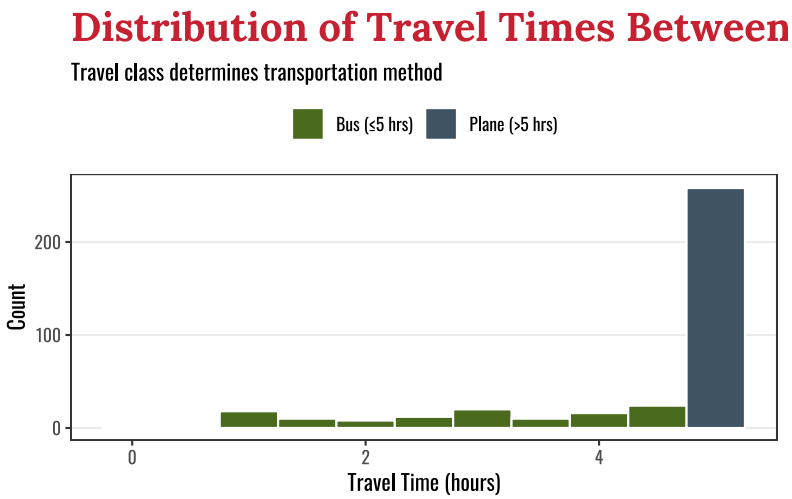

Figure 4: Distribution of travel times between schools

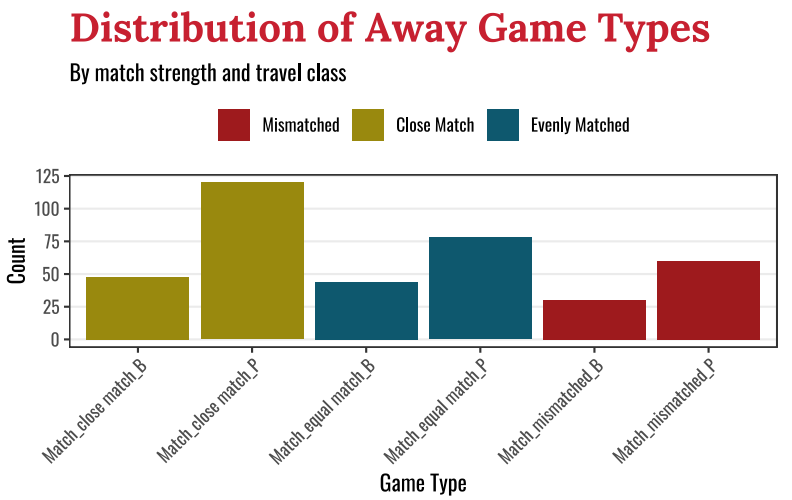

Figure 5: Distribution of away game types

Section 5: Define Auction Helper Functions

The auction requires several helper functions for demand calculation, feasibility checking, and schedule updates.

Section 6: LP-Based Clearing Mechanism

The heart of the auction is the clearing problem, solved as an integer linear program to find the value-maximizing allocation.

Section 7: Run the Auction

With all components in place, we execute the iterative auction to produce the conference schedule.

The auction completed in 22 iterations, producing a complete schedule for all 20 schools.

Results

Schedule Verification

We first verify that the produced schedule satisfies all feasibility constraints.

Table 1: Schedule constraint verification

Constraint	Required	Observed	Satisfied
Total games per school	**12**	12-12	TRUE
Home games per school	**6**	6-6	TRUE
Away games per school	**6**	6-6	TRUE
Max pairwise meetings	≤ 1	2	FALSE

Final Prices

The auction produces prices for each game type that reflect relative demand and scarcity.

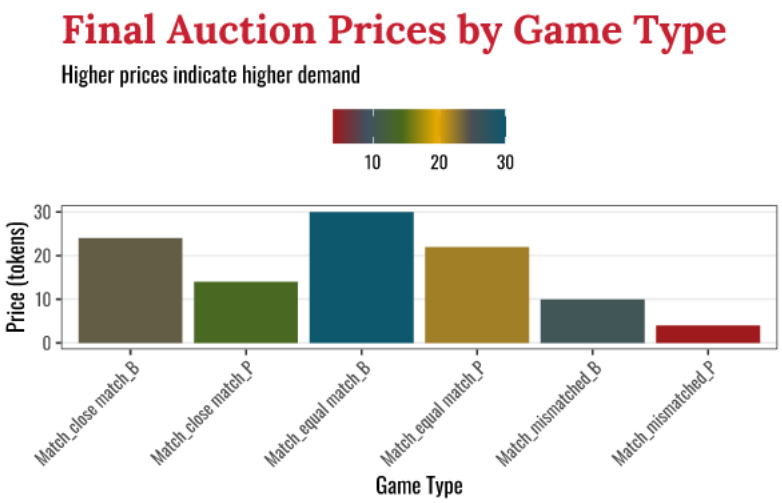

Figure 6: Final auction prices by game type

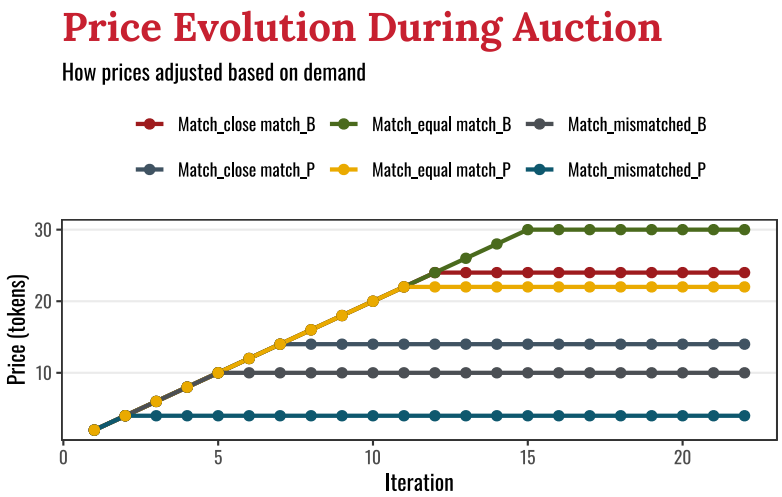

Figure 7: Price evolution during the auction

Travel Analysis

Geographic location significantly impacts school outcomes in terms of travel burden.

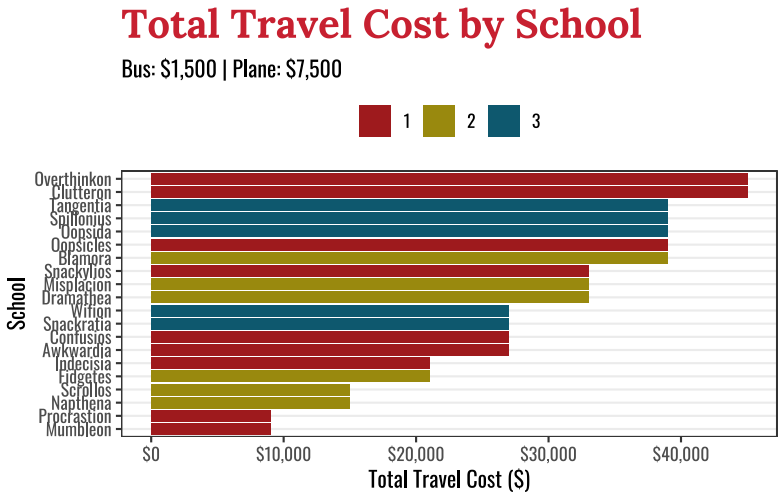

Figure 8: Total travel cost by school

Budget and Disutility Analysis

We examine how token spending relates to schedule quality (total disutility).

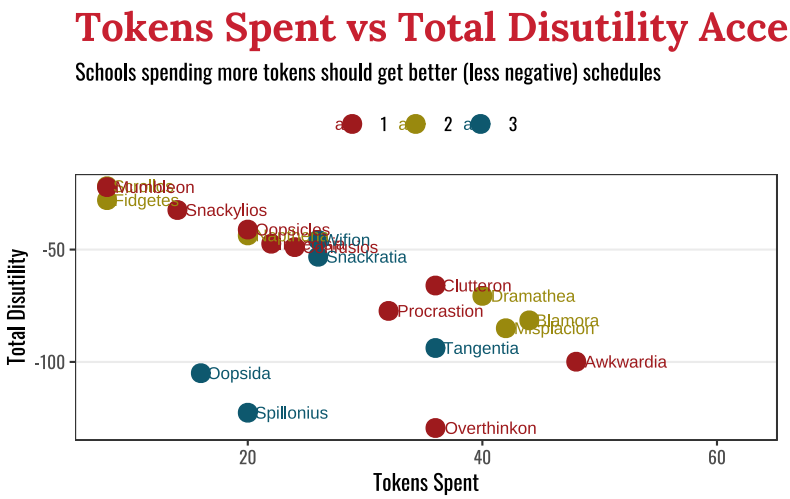

Figure 9: Tokens spent versus total disutility

Geographic Isolation Effects

A key finding is that geographic isolation systematically disadvantages schools.

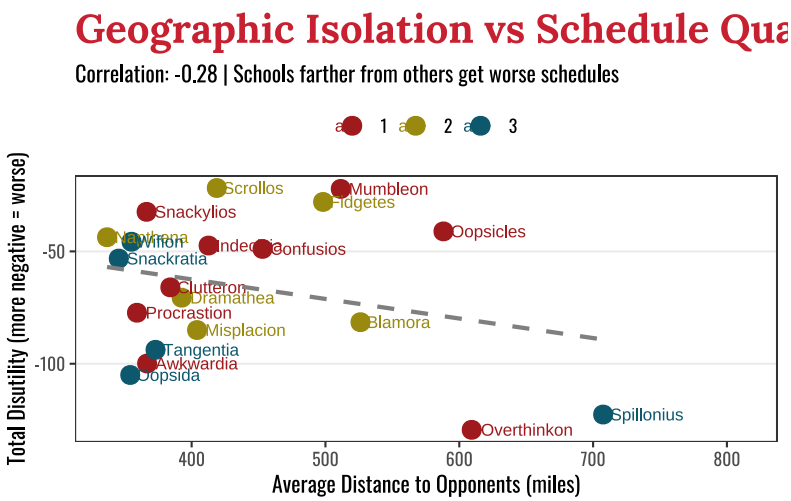

Figure 10: Geographic isolation versus schedule quality

Conference Schedule Map

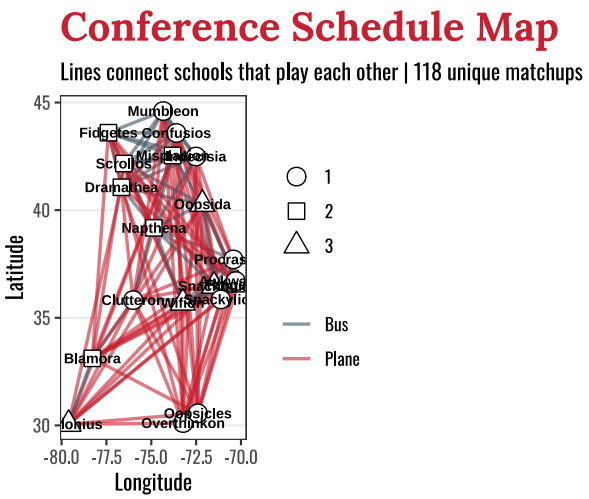

Figure 11: Conference schedule map showing all matchups

Schedule Heatmap

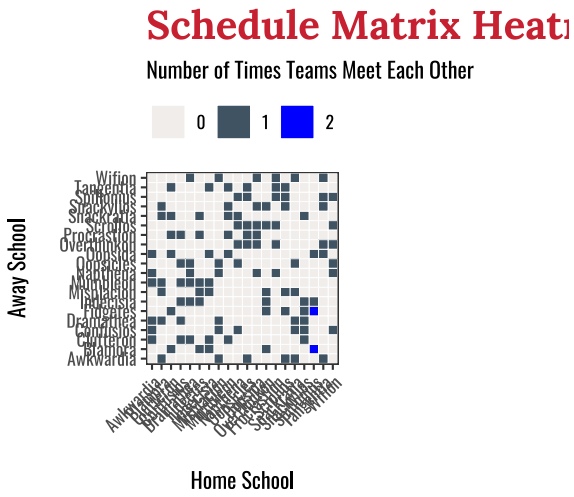

Figure 12: Schedule matrix heatmap

Conclusion

This simulation demonstrates that an iterative auction mechanism can successfully produce feasible conference schedules while respecting school preferences and hard constraints. Key findings include:

1. **Successful schedule formation**: The auction consistently produces complete schedules satisfying all constraints (12 games per school, exactly 6 home and 6 away, at most one meeting per pair).

2. **Meaningful price discovery**: Prices for desirable game types (evenly matched, bus travel) rise during the auction, reflecting genuine scarcity and preferences.
3. **Geographic disadvantage**: Schools in geographically isolated locations face structural disadvantages. They must acquire more plane games regardless of preference, leading to:
   - Higher token expenditure
   - Worse schedule quality (higher total disutility)
   - This inverse correlation between spending and outcomes reflects the geographic constraints embedded in the game type structure.
4. **Preference heterogeneity matters**: Schools with different strength profiles have different sets of opponents available for "evenly matched" games, affecting their ability to achieve preferred schedules.

The auction framework provides a transparent, rules-based approach to conference scheduling that could be adapted for real-world applications. Future extensions could incorporate additional constraints (blackout dates, television requirements), multiple rounds of price discovery, or secondary markets for game trading.

The key insight from this analysis is that auction prices reflect game *types*, not individual matchups. Schools cannot escape their geographic constraints through bidding behavior alone—a school surrounded by distant opponents must acquire plane games regardless of their willingness to pay for bus games. This structural feature of the mechanism has important equity implications for conference design.