Restructuring the BCS:
How to Mathematically Solve One of Sports Biggest Controversies

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Introduction

The National Collegiate Athletic Association (NCAA) Division I-A colleges are considered the most competitive places to play an amateur sport while receiving a college education. These schools spend millions of dollars and man hours on perfecting their teams and attracting the best high school graduates in every sport with the intention of winning a National Championship.

One of the most controversial topics in today's sports world is the Bowl Championship Series. Also known as the BCS, it serves as college football's only real form of a playoff system. It has been in operation since 1998 when it replaced the Bowl Alliance System. The goal of the BCS is to narrow all 120 NCAA Division I-A football schools down to the top two who go on to compete in the BCS National Championship Game. It also selects 8 other teams to play in 4 other prestigious games, known as BCS bowl games. These bowls are named the Rose, Sugar, Orange, and Fiesta Bowl. Of the 10 teams selected, 6 are automatic bids given the the conference champions of the ACC, Big East, Big Ten, Big 12, Pac 12, and SEC while the other four are at-large bids.

In this paper we look to understand the current BCS system and its flaws and using that knowledge, in conjunction with methods we learned in Operations Research, develop our own ranking and playoff system to more fairly select a true national champion for college football. To solve the playoff system, we look to create a 12-team tournament in which each of the 12 teams can be crowned the champion by winning all of their tournament games. As for the ranking problem, we will look to create a new computer algorithm that ranks teams by using a random walk to represent voter behavior. It will not have bias such as conference affiliation, and opinion polls will play a minimal part in the system. Finally, our playoff system will input the top 12 teams from this new ranking system to create a bracket that schedules games as fair as possible. By doing this, we hope to eliminate some of the flaws and controversies surrounding the BCS and crown a true National Champion.

Current Method

The current BCS system first ranks all the teams using a combination of polls and computer selection methods. It gives equal weight to the AP Media Poll, the USA Today Coaches' Poll, and an average of 6 BCS computer ranking systems. The team with the highest average of the three gets ranked first in the BCS standings.

The AP poll is made up of credible and knowledgable sports writers who rank their 25 top teams. Teams receive points for each vote and then ranked based on the total points accumulated. The USA Coaches' Poll works in a similar way but consists of votes from 59 Division 1-A football coaches. Finally, there are 6 computer systems created by professionals that mathematically compute rankings. The exact formulas used are unknown but some of the factors they consider are strength of schedule, win-loss record, and margin of victory.

The ranking at the end of the regular season then determines who plays in each game. The top two teams automatically play for the Championship Game. After that, the automatic qualifiers (conference champions) have contracts to play in specific bowl games **(see Appendix A)**. Then, the other four bids are filled from a pool of the remaining teams who have at least 9 wins and are in the top 14 of the final ranking. The teams that get chosen at this point are determined by each bowls individual committee. After all teams have been matched up and play, a final year end ranking comes out with the National Champion ranked 1st followed by everyone else.

Criticism and Flaws

The BCS has been under fire many times. Congress has already looked into holding hearings to determine the legality of the BCS under the terms of the Sherman Anti-Trust Act, which is in place to limit monopolies and agreements which unreasonably restrain competition. It is criticized mainly for its inequality to teams trying to reach a BCS bowl game as well as the unexplained distribution of revenues to college conferences and teams participating in these games. Also, it does little to pick a true champion for college football.

The main flaw we see in the BCS is the unchecked mathematical algorithms used by the 6 BCS computer ranking systems. Only those in charge of running them know what the formulas are and even then may not understand exactly what is going on. While some of the constraints are known (such as win-loss record, strength of schedule), it is speculated that monetary profits, and other unfair factors are also worked in. Obtaining a fair ranking system is a difficult mathematical problem, and it becomes increasingly more difficult when these formulas can't even be checked out.

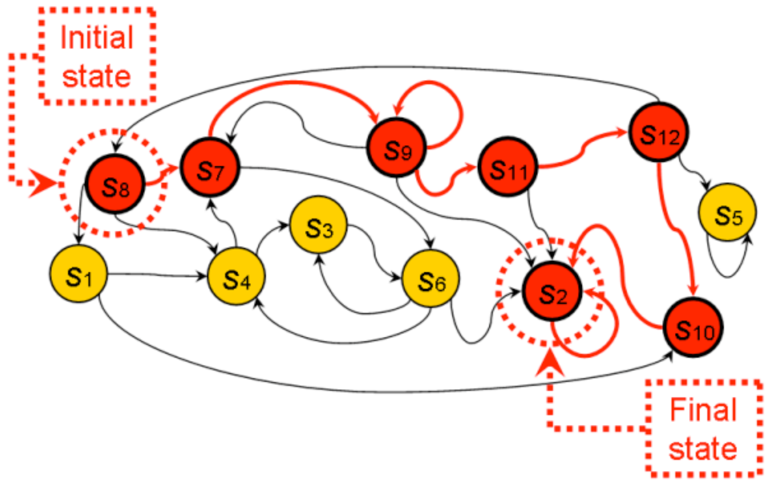
The BCS also relies on a series of Borda counts to rank teams. Both the AP and Coaches' poll use a truncated ballot of 25 teams. This is flawed because the opinion polls are biased and there is not always a consensus on the proper rankings. Coaches and sports writers are able to perform tactical voting and/or lobby for votes to influence their position. Coaches are known to rank teams within their own conference higher (to raise strength of schedule) as well leave other teams out to hurt their BCS chances. In total, these opinion polls contribute to 2/3rd of the final ranking.

Finally, the selection system for bowl games does not always select the highest ranked teams, rather individual BCS bowl committees select teams from a pool of teams that meet certain criteria. Obviously, the selection for the at-large bids are not always fair. An example illustrating this can be seen by looking at what happened this season! Virginia Tech, ranked 11th in the final BCS rankings, and Michigan, ranked 13th, are both playing in a BCS bowl game. Arkansas, 6th, Boise State, 7th, Kansas State, 8th, and South Carolina, 9th, all missed out on a bid to play in a BCS bowl. There is no reason that these lower ranked teams should be selected above the higher ranked teams.

These flaws provide a clear reason for controversy as they allow for bias and what should be non-factors to affect the overall system. Bottom line, the BCS is an unfair system and continues to be a topic of discussion among fans, players, coaches, administrators, and broadcasters.

Introduction to Random Walks

The ranking algorithm used follows the basis of a Markov chain. A Markov chain is a collection of random states having the property that, given the present, the future is conditionally dependent on the past. An example of a Markov chain that we used to construct our BCS ranking system was that of a random walk. A random walk is a mathematical formalization of a trajectory that consists of taking successive steps. It looks at the path a particle travels on, in which each state traveled is of a fixed length and has a unique probability of being traveled upon. The figure below gives an example of the random walk through different transition states.



When applying the random walk to the current BCS system, each transition state represents the specific team that the voter gives their vote too. The link between each state/team denotes the probability the voter switches its allegiance from one team to the other. For example, as the voter walks from state/team j to state/team i, it implies that the voter has switched from team j to team i ($i \neq j$), where the probability of switching teams is the link between both teams/states. As seen a little later, our algorithm uses this type of ranking system, but with a unique definition for the probabilities.

Our Algorithm

In order to rank teams, we cannot simply take into account schedule. There are 120 teams in Division I-A football, and since each team only plays about 12 games per season, there is not enough interplay among teams. We cannot compare these teams fairly by simply taking the best records. Some teams play more difficult teams, and their wins should count for more than a team whose wins come against easy opponents. We can take Google's PageRank system as an example of how to do something similar-rank web pages. A web page is like a team, and page B linking to page A is like team A beating team B and getting that team's vote. A web page's link should be worth more if that web page has a higher rank. This is just like how beating a team with a higher rank should be worth more. In PageRank, the rank of page A is equal to the rank of all pages linking to it divided by the number of outgoing links those pages have:

$$PR(u) = \sum_{B(v)} \frac{PR(v)}{L(v)}\ , B(v) = \left\{ v \middle| v \ links \ to \ u \right\}$$

Our algorithm will also take into account the rank of opponents. However, we want to also consider the margin of victory in games. So, we will alter our algorithm to differ from PageRank. We will treat each team as a node on a graph. Directed edges between two nodes will represent a game played between those two teams. Consider team i playing team j, with team I scoring 14 points and team j scoring 7 points. There will be a directed edge from node i to node j with a weight of j's score percentage (j's score divided by the total score). This weight will be significant later in our transition matrix. Here is what our graph will look like:

$$\frac{S_i}{S_T}$$

$$S_i = Score \ of \ \ team \ i, \quad S_T = Total \ score$$

We will now have a graph consisting of 120 nodes with directed edges between them. Each node will have degree about 14, with about 12 outgoing and about 12 incoming. With our graph complete, we will now imagine a random walker, walking around our graph. Because each team has common opponents with other teams, our graph is connected. To model a random walk around our graph, we can think of each node as a state. This is like a voter, where state i represents the voter supporting team i. Following the random walking method, we will create a transition matrix, P, to represent the probability of a random walker moving from state i to state j. First, however, we have to define the probability of moving from state i to state j. Like PageRank, we will divide the weight of the edges (which in the case of PageRank were all 1) by the sum of the weights of outgoing edges. So, our probability of moving from state j to i is:

$$P_{ij} = \frac{\text{weight of arrow from j} \rightarrow \text{i}}{\sum\limits_{B(k)} \text{weight of arrow from j} \rightarrow \text{k}}$$

With our matrix values added, we now have to find a ranking. To do this, we will multiply our transition matrix by a ranking vector, π:

$$\pi = \begin{matrix} \pi_1 \\ \vdots \\ \pi_n \end{matrix}, \quad \pi_i = \text{rank of team i}$$

By multiplying π by P, we can obtain a new ranking vector. We will want to continue this multiplication until our ranking vector reaches a steady state solution. In order to get this ranking vector, we will take the eigenvalues of P, the largest of which should be 1. The eigenvector corresponding to eigenvalue 1 is our initial ranking vector. Each iteration, we continue the multiplication:

$$\pi = \pi * P$$

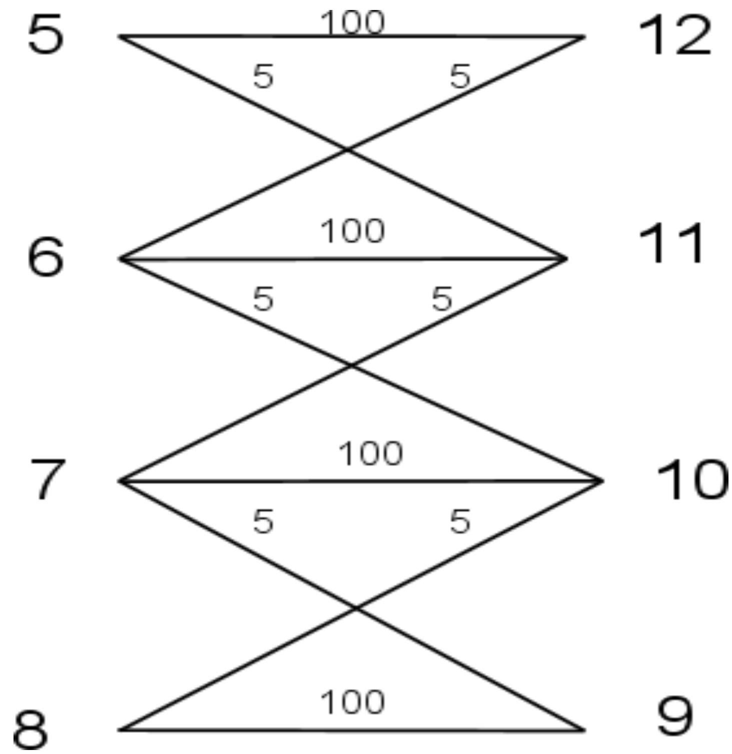
We will reach the steady state after only a few iterations, giving us our final ranking vector. The entries in the vector can now be sorted so that the team with the highest value is ranked 1st and so on, giving us our rankings.

Explanation of Scheduling Method

Scheduling the tournament games is another issue that is separate from ranking them. The current system allows only eight teams to compete for the national championship, and the teams chosen to play in the final game are decided not by their performance through the championship series, but by a number of polls and formulas that do not take previous on-field competition into account. Our championship series will be a 12-team bracket formulated to maximize competition and fairness. While fairness can be an ambiguous term, there are a set of beliefs that tournament brackets operate on which we will enforce using a weighted bipartite matching graph.

Assuming the teams have already been ranked, the top four ranked teams will receive a bye in the first round. This leaves the remaining eight teams to be put on a bracket in a way that is most fair. General championship brackets operate in a way that rewards the highest ranked team by allowing them to play the lowest ranked team, second highest plays the second-to-last lowest, etc. Our bracket will operate under that rule, as well as the condition that two teams from the same conference cannot play each other in the first round.

Since only the teams ranked 5-12 will be scheduled initially, the fifth team becomes the highest ranked team that needs to be considered. Because of this, it is only fair that it plays the lowest i.e. twelfth ranked team. Now if Team 5 and Team 12 are in the same conference, the next lowest team to consider allowing Team 5 to play would be Team 11. The following bipartite graph illustrates the matching problem and can be solved using a variety of algorithms.



The way in which fairness F will be calculated is by summing the weights of the bipartite edges. By maximizing F, it is ensured that the most fair decisions are made.

Our constraints are as follows:

For each team $x_{i,j}$ with rank i, conference number j

maximize $\sum_x F_x$ such that

for opponent $y_{l,k}$:

$k \neq j$ and $i < l \ \forall \ i,l$

Using these constraints to solve the bipartite matching problem will guarantee the first round is as fair as possible. Once Round 1 has been determined and played, a new system exists. Teams ranked 1-4 will now enter the system, and will be matched up against four of the bottom 12 ranked teams (the winners of the first round).

The way in which these teams will be charged against eachother is similar to the method of the first round. The only difference is, inter-conference play is no longer required; i.e. teams from the same conference are permitted to play against each other. With this constraint removed, the only other rule that must be followed is to consistently maximize fairness. After the first round there will be a set of four teams remaining with ranks, w,x,y,z such that $w<x<y<z$. Maximizing fairness simply means Teams {1,2,3,4} will play Teams {w,x,y,z} respectively. After these match-ups are determined, the tournament will proceed as mapped, and the Championship College Football team will be determined.

The final aspect to this championship bracket is the location of the games played. Initially, it was thought to be a constraint, since it is unfair for one team to travel a significantly greater distance than its opponent. However, since the tournament games will be played starting January of the new year, it is unrealistic for competitions to be held in most of the northern states. For this reason, we are choosing to use the existing bowl game locations for our tournament.

Ranking Results

Our final rankings for the 2011 season are (Compare to actual rankings, Appendix B):

1. Louisiana State University
2. University of Alabama
3. Oklahoma State
4. Boise State
5. University of Houston
6. University of Wisconsin
7. Stanford University
8. University of Oregon
9. University of Michigan

10. University of Southern Mississippi
11. Oklahoma University
12. Virginia Tech
13. University of South Carolina
14. University of Georgia
15. Texas Christian University
16. Michigan State University
17. University of Arkansas
18. University of Nebraska
19. Kansas State University
20. Northern Illinois University
21. University of Notre Dame
22. Florida State University
23. Baylor University
24. West Virginia University
25. Ohio University

Scheduling Results

Once the final rankings were determined, the next step was to run them through the scheduling algorithm. This part was surprisingly efficient because for the final ranks, no two teams from the same conference were set to play each other in the first round. The first round bracket was determined as follows:

These four games and the four games of the second round will be played at fields rotating between the 20 most southern Division 1-A home fields, with the only parameter being that a team cannot play on its' home field if it makes it to the tournament. The third round games will be played at the locations of the four current BCS Bowl games. The games will be played in Pasadena, California (current location of the Rose Bowl), New Orleans, Louisiana (current location of the Sugar Bowl), Glendale, Arizona (current location of the Fiesta Bowl), and finally Miami Gardens, Florida (current location of the Orange Bowl). The championship game will be played in a neutral southern city at the city's NFL Stadium.

Issues With Our Method

While our method seems to outperform the current system it still has some of its own problems. One of the biggest changes we made was eliminating automatic bids to the 6 BCS conference champions. However, in our system 4 out of the 6 conference champions still qualify. Clemson (ACC champion, #15) and West Virginia (Big East champion, #23) are in fact the only 2 teams of the 10 playing in bowl games this year not to qualify in our system. Clemson goes unranked and West Virginia comes in at #24. Instead, non-BCS schools such as Houston and Boise St. (who most agree should have been selected) replace them. The reason this can be seen as an issue is because it fails to acknowledge conference champions which in turn make conference champion games less valuable.

Another issue can be seen in our playoff scheduling method. While it strives to fairly match teams up, our system has conditions under which it fails. These rare cases would occur when 3 teams from the same conference are all ranked between #5 and #12. This scenario is highly unlikely though because teams from the same conference play each other during the regular season which affects the chances of each other making the top 12.

From the BCS standpoint, our system is flawed due to monetary reasons. Small market teams from non-BCS conferences regularly make it into the playoffs instead of conference champions. Much of the BCS is driven by money, sponsorships, tv time, and large audiences. The BCS conferences are given large sums of money as part of their contracts which also include more bonuses should multiple teams qualify. In essence, the main issue with our method is that it disrupts the financial foundation the BCS is built on.

Appendix A

BCS Bowl game conference contracts:

- Rose Bowl – Big Ten champion vs. Pac-12 champion
- Fiesta Bowl – Big 12 champion vs. at large
- Orange Bowl – ACC champion vs. at large
- Sugar Bowl – SEC champion vs. at large

*The Big East champion fills one of the remaining spots

Appendix B

BCS Standings

RK	TEAM	RECORD
1	LSU	13-0
2	Alabama	11-1
3	Oklahoma State	11-1
4	Stanford	11-1
5	Oregon	11-2
6	Arkansas	10-2
7	Boise State	11-1
8	Kansas State	10-2
9	South Carolina	10-2
10	Wisconsin	11-2
11	Virginia Tech	11-2
12	Baylor	9-3
13	Michigan	10-2
14	Oklahoma	9-3
15	Clemson	10-3
16	Georgia	10-3

17	Michigan State	10-3
18	TCU	10-2
19	Houston	12-1
20	Nebraska	9-3
21	Southern Miss	11-2
22	Penn State	9-3
23	West Virginia	9-3
24	Texas	7-5
25	Auburn	7-5