

Revealing the best doubles teams and players in tennis history

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Abstract

The aim of this study was to identify the best male doubles teams and the best male doubles individual players in the Open Era of tennis. The obtained data were recorded from the official ATP website and include 58,365 male doubles teams (10,717 individual male doubles players) who played 128,195 matches, in the period from 1968 to the end of 2014. The problem of ranking doubles teams and individual doubles players who were active in different time periods was solved using social network analysis. Firstly, we represented male doubles teams and the matches played between them as a network of directed contacts. Secondly, network analytic methods, the PageRank algorithm in particular, were applied to the complex network system of male doubles tennis matches. The results revealed the Bryan brothers as clearly the best doubles team, and Todd Woodbridge was recognised as the best individual doubles player, in the observed period. The findings of the study establish the PageRanking procedure as an alternative tennis ranking technique to the accepted ATP ranking system.

Key words: tennis, doubles team, PageRank, network analysis.

1. Introduction

In this paper we deal with the problem of finding the best doubles team and the best individual doubles player in the history of tennis. Being the best in the world in any sport brings many benefits as well as obligations and high pressures, and tennis is no exception. The number one spot in the tennis rankings is very desirable among tennis players as it can bring with it a great deal of prestige and celebrity (Dingle *et al.*, 2013).

In his autobiography, Pete Sampras (Sampras, 2008, p.84) quoted a famous quip by Peter Fleming. Fleming was McEnroe's long time tennis doubles partner and when asked to name the best doubles team of all time he answered: "The best doubles team in the world is John McEnroe and anyone". Bob and Mike Bryan (the famous Bryan brothers) obviously did not agree with Fleming's statement. On World Tennis Day, March 3rd 2014, the Bryan brothers won an exhibition tennis match against John and Patrick McEnroe. The Bryans are indeed twenty years younger than the McEnroes and there should not have been any question about the match's outcome but it was the serious approach to the match which was very interesting. The Bryans led 7-0 before they relinquished their first

game to the veterans (only one first-to-nine set was played in the match). And this is not a characteristic of an exhibition match at all. Tensions during the match and interviews before and after the match (e.g. McEnroe, 2013; Garber, 2013) suggest that being considered the best doubles team and/or best individual doubles player is an important goal for tennis players.

The solution to the proposed problem is not straightforward. The ranking system used in professional men's tennis is well established and has generally been acknowledged by players and interested public from its initial stage in the 1970s. The ATP ranking of a male tennis (doubles) player (or a male tennis doubles team) is calculated over the immediate previous 52 weeks. However, with this kind of method it is impossible to compare the results of players who were active in different periods. In Figure 1, the distribution of matches played by eight doubles teams who won the highest number of Grand Slam titles between the years 1968 and 2014 (both years included) is displayed. The activity of doubles teams in different periods can be noticed. Our aim is to provide a method to compare the performance of, for instance, the Bryan brothers with the doubles team of Hewitt and McMillan who finished their tennis careers more than ten years before the Bryan brothers even started theirs. A very robust technique that can cope with this kind of problem is social network analysis.

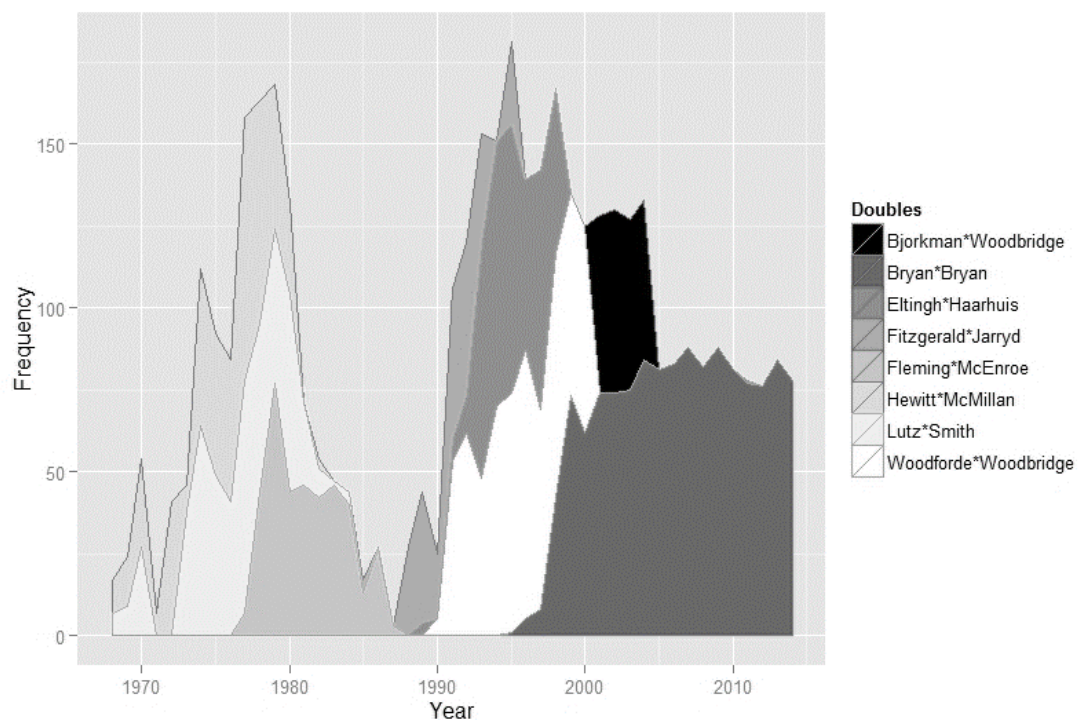


Figure 1. Distribution of matches played by the 8 best doubles teams of all time according to Grand Slam titles.

A very broad and generally recognised definition of a social network is that it consists of a set of people (also called actors) and the interactions (relations) between them (Wasserman and Faust, 1994). A strategy for investigating social structures through the use of social network and graph theories is called social network analysis (Otte and Rousseau, 2002). In the world of sport we can find many cases that can be a subject of

interest for social network analysis (Wasche *et al.*, 2012). The most straightforward network relation in sport is arguably between team players on the pitch exchanging passes in ball games. However, matches between individual players or teams can also be considered as a network relation. The use of social network analysis can provide a more global view of the studied problem as it simultaneously analyses and shows the complete list of interactions between the actors.

Indeed, in recent years, there has been an increase in the number of sports studies that use the tools of complex social network analysis. A social network approach has been applied in studies of quantitative analysis in sport, such as football (soccer) (Onody and de Castro, 2004; Hughes and Franks, 2005; Yamamoto and Yokoyama, 2011; Cotta *et al.*, 2013), basketball (Skinner, 2010), baseball (Saavedra *et al.*, 2009; Sire and Redner, 2009) and tennis (Radicchi, 2011; Breznik and Batagelj, 2012). Some studies have been applied to ranking individuals and/or teams based on their performance (Mukherjee, 2013; Motegi and Masuda, 2012; Radicchi, 2011; Breznik, 2013).

The number of titles won in the strongest tennis tournaments, called Grand Slams, is traditionally used by fans to rank tennis players over a longer period of time. However, doubles teams and individual doubles players achieve their Grand Slam titles against different opponents, e.g. against opponents of different strengths. This article applies network analytic methods to directly compare the strength of doubles teams and the strength of individual doubles players. It provides an alternative approach to ranking tennis doubles teams and individual tennis doubles players over the desired period of time.

In the first part of the paper we follow Radicchi's idea (Radicchi, 2011) by applying the PageRank algorithm to rank male tennis doubles teams. The use of the algorithm is further justified as PageRanking has been found in the past to be an even better predictor than the official ranking system in tennis (Dingle *et al.*, 2013). In order to use the PageRank algorithm, all matches between male doubles teams in the observed period are considered as a network of contacts. Consequently, weighted directed links between two opponent teams are constructed according to the number of matches played. In the second part of the paper, we additionally provide the partitioning of a network of doubles teams to a network of individual doubles tennis players.

2. Methods

2.1. Database

The data used in the study include information on 128,195 tennis matches played among 58,365 male doubles teams from 1968 to the end of 2014, and were obtained from the open source online tennis database (<http://www.atpworldtour.com/>). We can find 10,717 professional male tennis players, who played at least one doubles match in the observed interval. We restricted our analysis only to matches played in Grand Slams and ATP World Tour tournaments and therefore Futures tournament type were excluded from the study. For the years available, we recorded the ATP year-end best doubles team and best individual doubles player of the year.

2.2. Network representation – doubles teams

We represented doubles teams and matches played between them as a network of contacts. Each match can be understood as a contact between two opponents (in this case two doubles teams). Therefore, for each match we established a link between two doubles teams that played that match. The network of contacts obtained in this way could be classified as a large social network. As reported by Albert and Barabasi (2002), these kinds of networks have topological complex features that are consistent with the majority of networked social systems. In Figure 2 we displayed the degree distribution of all contacts (all matches played) on a log-log scale. The distribution roughly follows a straight line which indicates a power law degree distribution (Clauset *et al.*, 2009). This type of social network, also called a scale-free network, is very frequent in social systems and contains some common patterns. The degree distribution is asymmetrically right-skewed, i.e. the majority of vertices possess low degrees. In the case of tennis doubles matches, 25,003 doubles teams (or 42.84% of all doubles teams) played only one match. Moreover, from the property of power law distribution, we can calculate that approximately 85% of all matches are linked with the players in the top half of the degree distribution. Conversely, 50% of matches are linked to the 5.5% of players with the most contacts. Figure 2 reveals that one doubles team possesses more than 1,000 contacts, i.e. they played more than 1,000 matches together. We can find a small group of doubles teams who played between 500 and 1,000 matches.

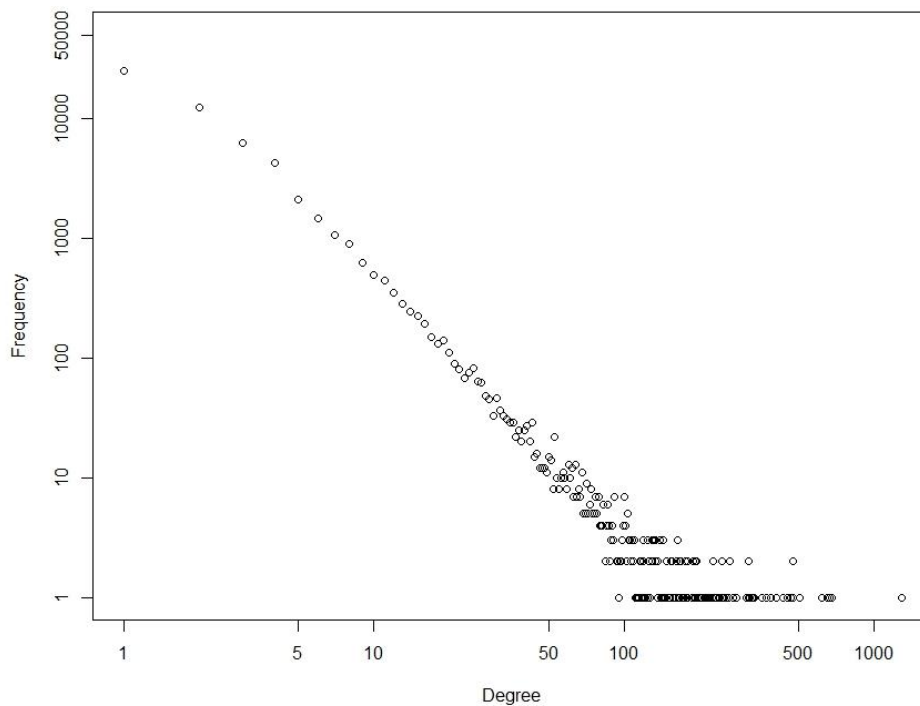


Figure 2. Distribution of all matches played between male doubles teams on a log-log scale.

Contacts between opponents can also be understood as directed links, i.e. a directed connection from doubles team j to doubles team i implies that team i has won a match against doubles team j . Numerous matches can be played between a pair of doubles teams,

therefore a weighted representation of directed contacts is established by assigning a weight w_{ji} which equals the number of times doubles team i won against doubles team j . In Figure 3 we displayed the subgraph of the directed contact network of doubles teams. It includes only male doubles teams that won at least three Grand Slam titles between 1968 and 2014. The widths of the contacts are proportional to the weights on directed links (i.e. the number of wins by the doubles team at the terminal part of a directed link over the doubles team at the initial part of a directed link). For example, the strongest directed link in Figure 3 connects Knowles and Nestor with the Bryan brothers (and points from Knowles and Nestor to the Bryan brothers). It implies that among the doubles teams in Figure 3 the Bryan brothers achieved the highest number of wins over the doubles team Knowles and Nestor.

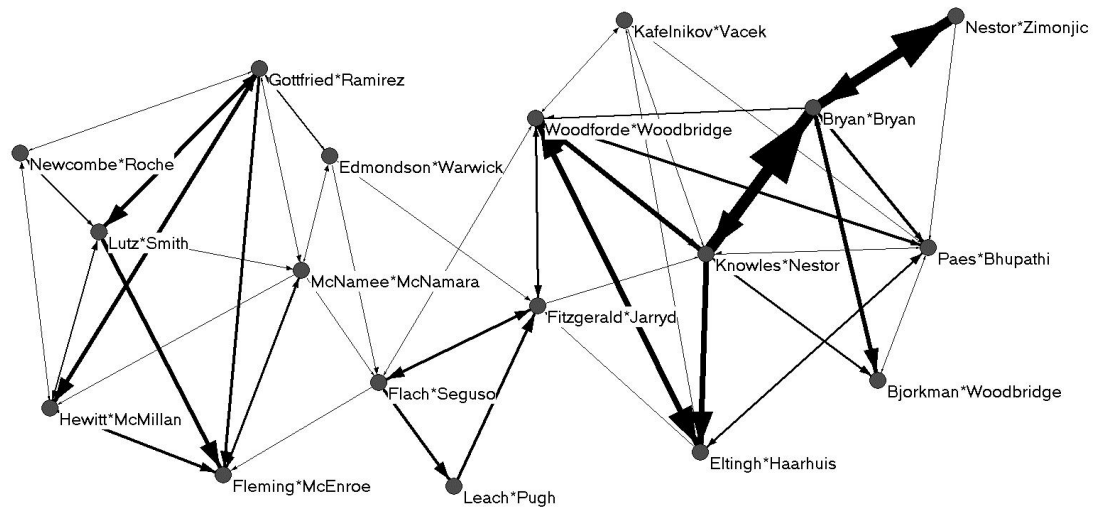


Figure 3. The subgraph of the directed contact network with only the best male doubles teams included.

2.3. Network representation – individual doubles players

A network of directed contacts between doubles teams allows us to create a network of directed contacts between individual doubles players. Let us consider first that there exists a directed link in a network of doubles teams pointing from doubles team j (players C and D) to doubles team i (players A and B) (Figure 4A). First we split the players in doubles teams i and j and obtain four nodes representing individual doubles players A , B , C and D . The directed link in a network of doubles teams from team j to team i is replaced by four directed links. Two of them point from player C to players A and B and the other two point from player D to players A and B (Figure 4B). In this way we obtain a network of individual doubles players and contacts between them. The directed contacts in the network point from both players in the doubles team that lost the match to both players in the doubles team that won the match. Finally, we can weight a network of contacts between individual doubles players in a similar way as we weighted the network of contacts between doubles teams.

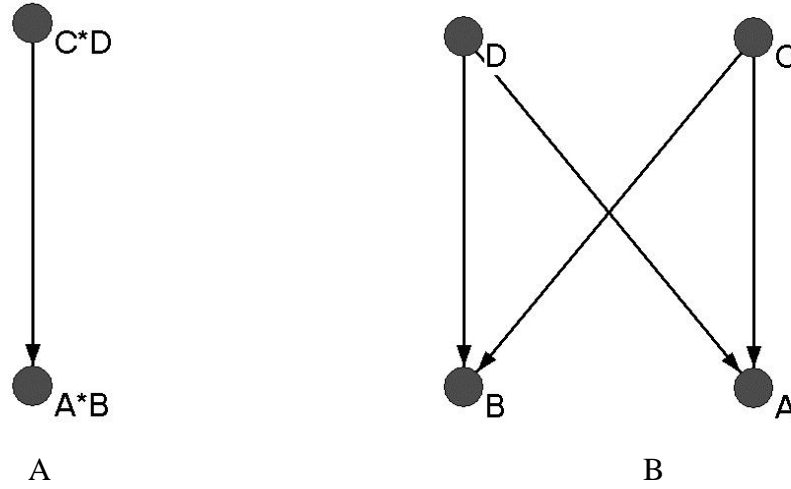


Figure 4. A network representation of a match won by team A*B against team C*D displayed with A) a doubles team network of contacts, and B) a network of individual doubles players.

2.4. Ranking measure

Representations of networks, a directed network of doubles teams and a directed network of individual doubles players, can be used to rank doubles teams and players, respectively. Similarly to Radicchi (2011), we can imagine that each doubles team (individual doubles player) in the network carries *tennis prestige* or *tennis strength* that flows in the graph along its weighted links. For each match played, prestige flows from the team (player) that lost a match to the team (player) that won a match. It is reasonable to assume that wins against better players should carry more weight than wins against less successful players. According to the PageRank algorithm (Brin *et al.*, 1999), the strength PR of each team (player) t_i (for $i=1, \dots, N$) in a network can be mathematically calculated solving the following system of equations

$$PR_{t_i} = \frac{1-d}{N} + d \sum_{t_j \in M(t_i)} \frac{PR_{t_j}}{L_{t_j}}$$

where the $M(t_i)$ denotes a set of all nodes (nodes represent teams or players) incidence with the terminal node being t_i , and L_{t_j} being an out-strength of the node t_j (the sum of the weight of all links with t_j as the initial node). The additional constraint that $\sum_{i \in (1, \dots, N)} PR_{p_i} = 1$, e.g. the sum of the strength of all teams (players) equals a value of 1, ensures that PageRank remains the probability distribution. Parameter $d \in [0,1]$ (known as the *damping factor*) ensures the convergence of the process. It is also a control parameter which accounts for the importance of the various terms contributing to the score of the nodes. We set the dumping factor to 0.85 which, according to Chen *et al.* (2007), provides a higher value of PageRank score and is generally assumed to be the best choice.

The implementation of the PageRank algorithm and supplementary calculations in the statistical program R (R Development Core Team, 2015) were made using the package

igraph (Csardi and Nepusz, 2006). For the analyses and visualisation of networks the Pajek program (Batagelj and Mrvar, 1996-2015) was used.

3. Results

We ran the PageRanking procedure on both networks - the directed network of doubles teams and the directed network of individual doubles players. In Table 1 we listed the top 30 male tennis doubles teams according to tennis doubles matches played between 1968 and 2014. Doubles teams are ranked according to calculated PageRank scores (denoted by PageRank). Additionally, for each doubles pair we provided the number of matches played (Match), the percentage of matches won (Percent), and the number of Grand Slam titles (GS) between 1968 and 2014. We observed that the Bryan brothers (from the USA) occupy the top spot followed by Mark Woodforde and Todd Woodbridge (the 'Woodies') from Australia. Mark Knowles (the Bahamas) and Daniel Nestor (Canada) are followed by a famous doubles team from the USA, Peter Fleming and John McEnroe, in third and fourth spots respectively. The Dutch players, Jacco Eltingh and Paul Haarhuis, occupy the fifth position. We calculated the correlation between the PageRank and the percentage of matches won. The Spearman rank correlation coefficient confirmed a statistically significant positive correlation between the PageRank and the Percent for the top 100 doubles teams ($\rho=0.67$; $p<0.01$). The highest number of Grand Slam wins (16 up to the end of 2014) was achieved by the Bryan brothers. Mark Woodforde and Todd Woodbridge won 11 Grand Slam titles, Peter Fleming and John McEnroe are in third place in this ranking with 7 Grand Slam wins. Todd Woodbridge and Daniel Nestor are the only players who won three or more Grand Slam titles with more than one tennis partner. Todd Woodbridge achieved this feat with Mark Woodforde (11 Grand Slam titles) and, later on, with his Swedish doubles partner Jonas Bjorkman (5). Daniel Nestor's doubles partners were Mark Knowles (3) and Nenad Zimonjić (3) from Serbia.

Table 1. Top 30 male doubles teams in the history of tennis (the use of italics indicates that both players were active at the end of 2014).

Rank	Team	Country	PageRank	Matches	Percent	GS
1	<i>Bryan*Bryan</i>	<i>USA</i>	<i>0.009414</i>	<i>1176</i>	<i>76.79</i>	<i>16</i>
2	Woodforde*Woodbridge	Australia	0.005748	654	78.90	11
3	Knowles*Nestor	Bahamas*Canada	0.004719	663	72.70	3
4	Fleming*McEnroe	USA	0.003650	388	88.92	7
5	Eltingh*Haarhuis	Netherlands	0.003276	433	77.83	5
6	Newcombe*Roche	Australia*USA	0.003138	209	74.16	7
7	Hewitt*McMillan	South Africa	0.003120	465	81.51	4
8	Fitzgerald*Jarryd	USA*Sweden	0.003013	242	72.73	4
9	Lutz*Smith	USA	0.003010	504	72.63	5
10	<i>Paes*Bhupathi</i>	<i>India</i>	<i>0.002865</i>	<i>407</i>	<i>74.12</i>	<i>3</i>
11	Gottfried*Ramirez	USA*Mexico	0.002793	474	75.97	3
12	<i>Nestor*Zimonjic</i>	<i>Canada*Srbia</i>	<i>0.002717</i>	<i>309</i>	<i>73.35</i>	<i>3</i>
13	Bjorkman*Woodbridge	Sweden*Australia	0.002498	211	75.21	5
14	Okker*Riessen	Netherlands*USA	0.002141	356	76.92	1
15	Black*Ulyett	Zimbabwe	0.002089	314	65.00	2
16	Flach*Seguso	USA	0.002059	453	72.85	3
17	Leach*Pugh	USA	0.001967	251	71.58	3
18	Edberg*Jarryd	Sweden	0.001860	162	75.71	4
19	<i>Matkowski*Fyrstenberg</i>	<i>Poland</i>	<i>0.001805</i>	<i>682</i>	<i>59.24</i>	-
20	Casal*Sanchez	Spain	0.001796	622	68.54	2
21	McNamee*McNamara	Australia	0.001670	203	63.71	4
22	Novak*Rikl	Czech Republic	0.001654	332	64.01	-
23	Emerson*Laver	Australia	0.001648	219	76.58	3
24	Ferreira*Leach	South Africa*Australia	0.001548	228	63.67	-
25	Connell*Galbraith	Canada*USA	0.001500	213	65.38	-
26	Curren*Denton	South Africa*USA	0.001444	330	66.39	1
27	Case*Masters	Australia	0.001404	370	63.91	2
28	Gullikson*Gullikson	USA	0.001379	386	56.79	-
29	Alexander*Dent	USA	0.001375	474	63.71	1
30	Bjorkman*Mirnyi	Sweden*Belarus	0.001371	191	73.33	2

In Table 2 we rank the top 30 individual male doubles players between 1968 and 2014 according to the PageRank scores. The top spot is reserved for Todd Woodbridge, who is closely followed by the Bryan brothers. Each of these three players won the highest number of Grand Slam titles, 16 each in total, up to the end of 2014. Mark Woodforde, in 6th place, is the only other player with more than 10 Grand Slam titles. John McEnroe is in 7th place according to the PageRank score. However, he is the player with the highest percentage of wins as he won an impressive 83.41% of all his doubles matches. He is, in that category, more than 6% clear of the other players. The USA can be considered the country with the best tennis doubles players as 11 players in Table 2 are from that country. Other players are more equally distributed by country of origin, three players each are from Australia and the Netherlands, and two players each are from the Czech Republic, India and Sweden. Other countries are represented only by a single player.

Table 2. Top 30 individual male doubles players in the history of tennis (the use of italics indicates that a player was active at the end of 2014).

Rank	Team	Country	PageRank	Matches	Percent	GS
1	Woodbridge, Todd	Australia	0.006124	1042	75.56	16
2	<i>Bryan, Mike</i>	<i>USA</i>	<i>0.006004</i>	<i>1203</i>	<i>76.81</i>	<i>16</i>
3	<i>Bryan, Bob</i>	<i>USA</i>	<i>0.005938</i>	<i>1187</i>	<i>76.60</i>	<i>16</i>
4	<i>Nestor, Daniel</i>	<i>Canada</i>	<i>0.005811</i>	<i>1381</i>	<i>71.42</i>	<i>8</i>
5	Bjorkman, Jonas	Sweden	0.005161	1019	69.98	9
6	Woodforde, Mark	Australia	0.005063	895	72.18	12
7	McEnroe, John	USA	0.004332	635	83.41	9
8	Knowles, Mark	Bahamas	0.004934	1125	66.38	3
9	<i>Paes, Leander</i>	<i>India</i>	<i>0.004616</i>	<i>1086</i>	<i>66.48</i>	<i>8</i>
10	Newcombe, John	Australia	0.004503	448	73.29	11
11	Jarryd, Anders	Sweden	0.004478	846	70.28	8
12	Leach, Rick	USA	0.004421	1038	62.27	5
13	<i>Bhupathi, Mahesh</i>	<i>India</i>	<i>0.004336</i>	<i>1038</i>	<i>66.17</i>	<i>4</i>
14	Haarhuis, Paul	Netherlands	0.004318	846	70.99	6
15	McMillan, Frew	South Africa	0.004286	855	71.86	4
16	Okker, Tom	Netherlands	0.004152	816	75.91	2
17	Gottfried, Brian	USA	0.004145	848	69.18	3
18	<i>Mirnyi, Max</i>	<i>Belarus</i>	<i>0.004102</i>	<i>993</i>	<i>65.14</i>	<i>6</i>
19	Fleming, Peter	USA	0.004008	686	74.13	7
20	Ramirez, Raul	Mexico	0.003992	756	73.03	3
21	Smith, Stan	USA	0.003914	777	72.11	5
22	Riessen, Marty	USA	0.003911	719	72.93	2
23	Stewart, Sherwood	USA	0.003894	1105	66.17	3
24	Fitzgerald, John	USA	0.003783	837	63.32	7
25	<i>Zimonjic, Nenad</i>	<i>Serbia</i>	<i>0.003703</i>	<i>952</i>	<i>65.12</i>	<i>3</i>
26	Lutz, Robert	USA	0.003621	724	69.05	5
27	Eltingh, Jacco	Netherlands	0.003581	536	71.03	6
28	Smid, Tomas	Czech Republic	0.003541	976	66.19	2
29	Suk, Cyril	Czech Republic	0.003493	1255	55.25	1
30	Ulyyett, Kevin	Zimbabwe	0.003413	994	63.26	2

Table 3 shows the list of the best doubles teams and the best individual doubles players of the year according to the PageRank score and the ATP year-end classification. With the PageRank algorithm we can identify the best doubles team and the best individual doubles player even for those years before the ATP ranking system was established. Some long periods of dominance are reported in both categories. Among doubles teams, the top spot was occupied for three or more years by: *Okker and Riessen* (1971-1973), *Woodbridge and Woodforde* (1995-1997), and the *Bryan brothers* (2010-2014). In the individual doubles player category, the PageRank algorithm has detected the dominance of *Ramirez, Raul* (1974-1976), *Todd Woodbridge* (1995-1997) and *Mike Bryan* (2011-2014). Although in many cases the best doubles teams and best individual doubles players are the same in both lists (PageRank and ATP year-end) we can discern some differences. The most significant one concerns John McEnroe. He was recognised as the best

individual doubles player by the ATP in the period 1979-1983. However, the PageRank score puts him in first place only in 1979 and 1981.

Table 3. Best doubles teams and best individual doubles players of the year.

Year	PageRank doubles team	ATP year-end doubles team	PageRank doubles individual	ATP year-end doubles individual
1968	Rosewall*Stolle	-	Newcombe, John	-
1969	Newcombe*Roche	-	Newcombe, John	-
1970	Nastase*Tiriatic	-	Tiriatic, Ion	-
1971	Okker*Riessen	-	Riessen, Marty	-
1972	Okker*Riessen	-	Nastase, Ilie	-
1973	Okker*Riessen	-	Okker, Tom	-
1974	Lutz*Smith	-	Ramirez, Raul	-
1975	Gottfried*Ramirez	-	Ramirez, Raul	-
1976	Gottfried*Ramirez	-	Ramirez, Raul	Ramirez, Raul
1977	Hewitt*McMillan	-	McMillan, Frew	McMillan, Frew
1978	Hewitt*McMillan	-	McMillan, Frew	McMillan, Frew
1979	Fleming*McEnroe	-	McEnroe, John	McEnroe, John
1980	Lutz*Smith	-	Smith, Stan	McEnroe, John
1981	Fleming*McEnroe	-	McEnroe, John	McEnroe, John
1982	Stewart*Taygan	-	Taygan, Ferdi	McEnroe, John
1983	Jarryd*Simonsson	Fleming*McEnroe	Smid, Tomas	McEnroe, John
1984	Edmondson*Stewart	Edmondson*Sherwood	Smid, Tomas	Smid, Tomas
1985	Flach*Seguso	Flach*Seguso	Seguso, Robert	Seguso, Robert
1986	Edberg*Jarryd	Gildemeister*Gomez	Forget, Guy	Gomez, Andres
1987	Mecir Sr.*Smid	Casal*Sanchez	Smid, Tomas	Seguso, Robert
1988	Leach*Pugh	Leach*Pugh	Leach, Rick	Jarryd, Anders
1989	Aldrich*Visser	Leach*Pugh	Aldrich, Pieter	Jarryd, Anders
1990	Aldrich*Visser	Aldrich*Visser	Forget, Guy	Aldrich/Visser
1991	Flach*Seguso	Fitzgerald*Jarryd	Fitzgerald, John	Fitzgerald, John
1992	Woodbridge*Woodforde	Woodbridge*Woodforde	Woodbridge, Todd	Woodforde, Mark
1993	Eltingh*Haarhuis	Connel*Galbraith	Eltingh, Jacco	Connel, Grant
1994	Eltingh*Haarhuis	Eltingh*Haarhuis	Bjorkman, Jonas	Haarhuis, Paul
1995	Woodbridge*Woodforde	Woodbridge*Woodforde	Woodbridge, Todd	Woodbridge, Todd
1996	Woodbridge*Woodforde	Woodbridge*Woodforde	Woodbridge/Woodforde	Woodbridge/Woodforde
1997	Woodbridge*Woodforde	Woodbridge*Woodforde	Woodbridge, Todd	Woodbridge, Todd
1998	Bhupathi*Paes	Eltingh*Haarhuis	Bhupathi, Mahesh	Eltingh, Jacco
1999	Woodbridge*Woodforde	Bhupathi*Paes	Woodbridge, Todd	Paes, Leander
2000	Woodbridge*Woodforde	Woodbridge*Woodforde	Woodbridge, Todd	Woodforde, Mark
2001	Johnson*Palmer	Bjorkman*Woodbridge	Johnson, Donald	Bjorkman, Jonas
2002	Knowles*Nestor	Knowles*Nestor	Knowles, Mark	Knowles, Mark
2003	Arthurs*Hanley	Bryan*Bryan	Mirnyi, Max	Mirnyi, Max
2004	Bryan*Bryan	Knowles*Nestor	Bryan/Bryan	Knowles/Nestor
2005	Bryan*Bryan	Bryan*Bryan	Bryan Bob	Bryan Bob
2006	Bjorkman*Mirnyi	Bryan*Bryan	Bjorkman, Jonas	Bryan/Bryan
2007	Bryan*Bryan	Bryan*Bryan	Bryan/Bryan	Bryan/Bryan
2008	Bryan*Bryan	Nestor*Zimonjic	Bryan Mike	Zimonjic, Nenad
2009	Nestor*Zimonjic	Bryan*Bryan	Zimonjic, Nenad	Bryan/Bryan
2010	Bryan*Bryan	Bryan*Bryan	Bryan Bob	Bryan/Bryan
2011	Bryan*Bryan	Bryan*Bryan	Bryan/Bryan	Bryan/Bryan
2012	Bryan*Bryan	Bryan*Bryan	Bryan Mike	Bryan Mike
2013	Bryan*Bryan	Bryan*Bryan	Bryan/Bryan	Bryan/Bryan
2014	Bryan*Bryan	Bryan*Bryan	Bryan/Bryan	Bryan/Bryan

4. Discussion

The results of the study indisputably revealed the Bryan brothers as the best doubles team in the Open Era of tennis. They are classified clearly in first place by the PageRanking procedure. By the end of the year 2014 they had won 16 Grand Slam doubles titles, which is 5 more than any other doubles team. The Bryan brothers hold the record of being in the number one spot on the ATP year-end ranking list 8 times. Their annual domination was confirmed by the PageRank calculations but with a slightly different sequence of years. The percentage of all matches won by the end of 2014 by the Bryan brothers is

praiseworthy but not extraordinary as in the case of the doubles team of Fleming and McEnroe. One reason for such a discrepancy between the results of the PageRank algorithm and the percentage of matches won lies in the strength of opponents faced by each doubles team. The PageRank algorithm recognised the Bryan brothers' opponents as being much stronger in comparison to those of Fleming and McEnroe. In addition, as reported by Radicchi (2011), the PageRank score is strongly correlated with the number of matches won and therefore doubles teams with a higher number of matches played are favoured.

According to the PageRanking procedure, Todd Woodbridge is interestingly considered to be the best male doubles player in the Open Era of tennis. At the end of 2014 he shared the highest number of Grand Slam titles (16 titles in total) with both of the Bryan brothers. Todd Woodbridge's advantage, according to the PageRank score, is not nearly as impressive as that of the Bryan brothers in the doubles team category. The percentage of matches won by an individual doubles player proved again to be in a significant but not perfect correlation with the PageRanking procedure. That said, special focus falls on John McEnroe. He won the highest percentage of matches in both categories, in the doubles team category and among individual doubles players. From that perspective it makes it easier to understand his conflict with the Bryan brothers, which was mentioned at the beginning of this article. John McEnroe is also indisputably considered to be the best singles tennis player among the best doubles players. He won 7 Grand Slam titles in singles competition and was placed 3rd on the list of the best singles players in the history of tennis (Radicchi, 2011). John Newcombe won 5 Grand Slam titles in the singles category. Stan Smith is the only other player among the top 30 individual male doubles players with at least 2 singles Grand Slam titles.

However, the question raised in the introductory part, with the argument between McEnroe and the Bryans, is more profound. It is a fact that the best male tennis players in the singles category nowadays very rarely play doubles matches. Exceptions are Davis Cup matches and the Olympic games. There is a limitation in both types of tournament – players in a doubles team in the Davis Cup and at the Olympic games must represent the same country. In addition, in the Open Era of tennis this sport has only been on the Olympic games' schedule since 1988. The list of Olympic winners in the tennis doubles team category discloses some great tennis players that were never considered as regular doubles players, let alone doubles specialists. Such players are: Roger Federer with Stan Wawrinka (they won gold in Beijing, 2008), Fernando Gonzales with Nicolas Massu (gold in Athens, 2004) and Boris Becker with Michael Stich (gold in Barcelona, 1992). However, it is not the place to speculate here what would happen if the best singles players played in the doubles team competition more often. The matches in the doubles team category are well documented and we firmly believe that the algorithm used on the dataset gave us a reliable result.

On the country level, the USA demonstrated their dominance in the male doubles category. They stand out with an amazing 9 of the 30 best doubles teams and even 11 of the 30 best individual doubles players. Australia is the second most successful country. It is represented by 3 individual doubles players in the top 10, Todd Woodbridge (in 1st place), Mark Woodforde (6th) and John Newcombe (10th). The Netherlands is the next important country in the men's doubles tennis competition, represented by the doubles

pair Jacco Eltingh and Paul Haarhuis in 5th place. Both of them, together with Tom Okker, can be found on the list of the top 30 best individual doubles players.

The results of this study further establish the PageRanking procedure as an alternative tennis ranking technique to the accepted ATP ranking system. However, applying this kind of algorithm, authors of previous studies argued that still active players are disadvantaged as they have not yet played all of the matches in their careers (Radicchi, 2011; Breznik, 2013; Murkherjee, 2013). This is in compliance with the outcome that only 4 of the top 30 best doubles teams were still active at the end of 2014. The term 'active as a team' is meant in the sense that both players in a team were still active but not necessarily playing together. In the case of individual doubles players, the situation was slightly better as 7 of the 30 best players were still active at the end of 2014. We strongly believe that the Bryan brothers have a realistic chance of overcoming Todd Woodbridge at the top of the all-time best individual doubles players ranking.

5. Conclusion

In this paper we applied network analytic methods to a complex network system, i.e. matches played between doubles teams on the ATP tour. The actual ATP ranking method is generally recognised and accepted but it is unable to evaluate results over different periods of activity. On the other hand, the PageRanking procedure uses all available information and proved to be an effective algorithm to identify the best doubles teams and the best individual doubles players in the Open Era of tennis. In addition, we annually compared obtained results with the official ATP rankings at the end of each year. The results confirmed that the procedure was reliable. In many cases the best doubles team and/or individual doubles player of the PageRank procedure were identical with the ATP year-end classification. The Bryan brothers were recognised as clearly the best doubles team and Todd Woodbridge as the best individual doubles player in the observed period.

Social network analysis is becoming a very popular statistical method. However, we believe that it is still not sufficiently exploited in the field of sport. Moreover, the network analytic approach applied in this study offers several ideas and challenges for future analyses. A very straightforward extension of this research could deal with female and mixed doubles teams and/or individual doubles players, and compare those results to this study. It would be interesting to examine the selection of tennis partners in doubles teams. Some players are more steadfast and loyal to their doubles partner. On the other hand, some players more rapidly switch to another doubles partner. Dealing with network dynamics, the data offers an opportunity to study temporal networks, i.e. network behaviour over time.

6. References

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