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Adaptation of Hirsh Index (H-Index) Indicator in Sociometric Analyses

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Abstract: There are significant number of metrics developed in sociometry field since it was presented by Jacob L. Moreno in 1932. Each of those metrics are used on different purposes and within correlations to other metrics. At the same time, the scientometrics field which is the field of scientific performance measurement was in the development process as well. Significant number of metrics were developed in the field of scientometrics also which intensively used by authorities and scientists. The most widely used/referred scientometrical metric have been the Hirsch Index (H-Index) indicator which has been developed recently, just in 2005 by Jorge M. Hirsch. In this study H-index is investigated whether it may be a properly indicator in sociometrical analyses as well, or if it may be added as an additional function into already developed indicators. Outcomes show that hirsch index methodology has potential benefits in sociometry field.

Keywords: H-Index, Sociometry, Sociometrical Indicators, Scientometrics, Scientometrical Indicators, H^s-Index

H İndeksi Göstergesinin Sosyometrik Analizlere Uyarlanması

Özet: Jacob L. Moreno'nun 1932 yılında sosyometri bağlamını ilk sunduğu tarihten bu yana sosyometrik incelemeler kapsamında çok sayıda performans göstergesi geliştirilmiştir. Bu göstergelerin her biri farklı bir amaca yönelik ve diğer göstergeler ile beraber kullanılmaktadır. Sosyometri sahasındaki gelişime paralel olarak bilimsel başarımların incelmelerinin yapıldığı bilimmetri sahasında da başarımların incelmeye yönelik çok sayıda gösterge geliştirilmiştir. Daha çok bilimsel ve akademik performans incelemelerinde kullanılan bilimmetri performans göstergeleri günümüzde küresel düzeyde yaygın biçimde kullanılmaktadır. Bu yaygın kullanım içinde bilim insanları ve otoriteler tarafından kabul görmüş ve en çok öne çıkan gösterge ise Jorge E. Hirsch tarafından henüz 2005 yılında geliştirilen Hirsch İndeksi (*H-Index*) göstergesidir. H İndeksi göstergesi sosyometrik analizlerde gerek kendi başına, gerekse de diğer göstergelere eklenilebilecek fonksiyonu ile potansiyeller taşıyan bir göstergedir. Bu çalışma H İndeksi göstergesinin sosyometri sahasında kullanım elverişliliğini tespit etmek amacı ile gerçekleştirilmiştir. Çalışmanın çıktıları H İndeksi göstergesinde kullanılan yöntemin sosyometrik incelemelerde kayda değer kullanım potansiyeline sahip olduğunu ortaya koymaktadır.

Anahtar Kelimeler: H İndeksi, Sosyometri, Sosyometrik Göstergeler, Bilimmetri, Bilimmetrik Göstergeler, H^s İndeksi

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Introduction

Since it was first designed and proposed by Jorge E. Hirsch in 2005, h-index performance indicator perceived by academic world extensively. In such a short time period, it turned out to be the highest referred indicator in scientific societies worldwide.

It was designed by J.E. Hirsch to find a better solution to measure physicists' performance, but it proved to be useful for other fields as well. And thus, he suggested it for other scientific fields as well (Hirsch, 2005).

H-index is a simply accounted performance indicator that demonstrates maturity of a scientist. It is developed on a calculation of researcher's total number of scientific paper and scientific citations received to those papers.

Usage of scientific papers and citations as a performance indicator reaches to first quarter of 20th century. It is known that F. Galton's "English Men of Science" study is the first attempt to measure scholars performance based on their scholarly papers (Galton, 1874). But the first attempt for a more complete known formation of performance evaluation according to scientific papers has been studied by J. M. Cattell in "Statistics of American Psychologists" (Cattell, 1903). It is has been acknowledged that Cattell's study was the first attempt to measure scientists performance in scientific publication outputs (Godin, 2006). But citation component in scholarly performance investigations was a missing item during these studies. Historical background of citations usage in performance evaluations shows the first instance in 1934, in Samuel C. Bradford's "Sources of Information on Specific Subjects" study (Bradford, 1934). Bradford discovered that usage of journals and citation to these journals by researchers has a similar distribution as defined by Pareto principle. As a result, he established "Bradford's Law" which was identifying the distribution of academic references to journals thus helping librarians to develop a better journal collection in their libraries. Later, Vannevar Bush developed a vision of machine-readable records that would demonstrate academic citations distributions of scientists, thus it would be robust way to monitor research capabilities of scientists better (Bush, 1945). After a decade following Bush's finding of machine-readable citations, Eugene Garfield developed use of scholarly citations as a source indicator of scientific impact (Garfield, 1955). Today, his definition of "Impact Factor" is the most referred indicator used for academic performance evaluations. Thus, it can be said that the transformation from focusing on scientific publication only output to scientific impact, which is developed on citation per paper indicators, took a half of century. This approach was used over a half century until H-index was designed in 2005. Then in a sudden time period of few years, individuals started to refer to h-index performance indicator instead of citation per

paper measure extensively. Since 2005, h-index have been one of the hottest indicator which have been discussed in scientometrics field. There are dozens of h-index derivative indicators but none of them has succeeded in terms of usage by scientist. The used version is the initial formation still.

On the other hand, development of sociometrical evaluations has realized in the first half of 20th century. As the founder of sociometry, Jacob L. Moreno defines sociometry in his monograph of “Who Shall Survive” (Moreno, 1934) which he investigates measurability of relations between individuals, societies, and objects within scope of sociology field. His “Who Shall Survive” monograph was an achievement of 14-year study between 1920 & 1934.

Sociometry field have been shaped in between 1934 and 1973. The first definition of sociometry was by Moreno in 1934. Moreno defined sociometry field as investigation of measurability of relations between individuals, societies, and objects within scope of sociology field. (Moreno, 1934).

Later in 1954, Moreno defined institutional development phases of sociometry field which as Hot period (1923-1937), Cold period (1937-1950) and Perceptual period as post-1950. (Moreno, 1954), it may be said that theoretical development of sociometry has been developed until 50s. But after 50s, implementation phase of sociometry is taking place. Plenty of institutes are established between 1945 and 1950 to develop sociometrical researches in the fields such as the Research Center for Group Dynamics (RCGD) at MIT (RCGD, n.d.), the Tavistock Institute (TIHR, n.d.), Harvard Department of Social Relations (Harvard Department of Social Relations, n.d.) and the Institute for Human Relations under Yale University (HRAF, n.d.). Many of these institutes are continuing their activities still. In addition, it has been observed that starting from 1970s, sociometry have started to be used more as applied technical information in more fields such as social psychology, small groups sociology, network analyses, etc. (Erdogan, 2014).

The social atom, which developed by Moreno, was one of significant base to develop those indicators on. In the social atom, Moreno displays the person with all other persons in relation to himself as well as his relations to them. Thus, the display is a visualization of person’s environment in connections to other persons. Each connection has its own qualification that may be one of below connection contexts;

- attraction unreciprocated
- reciprocated attraction
- rejection unreciprocated
- reciprocated rejection
- attraction – rejection

Thus the person is monitored within his/her social environment with relations' contexts (Moreno, 1934) (Zeleny, 1949).

Starting from early periods of development of sociometry field, plenty of indicators have been developed based on Moreno's social atom. Those indicators have been used in many ways usefully, such as (Zeleny, 1941 and Zeleny, 1947), (Jennings, 1943), and (Tryon, 1950).

The aim of this study is to evaluate if H-index indicator, which is used in scientometrical studies, may contribute sociometrical analyses with an additional value, especially in social network analyzes which turn out to be significantly important for sociological research in recent years.

Definition and Value of H-Index

H-index indicator is defined as defined as the number of papers with citation number $>h$, as a useful index to characterize the scientific output of a researcher (Hirsch, 2005).

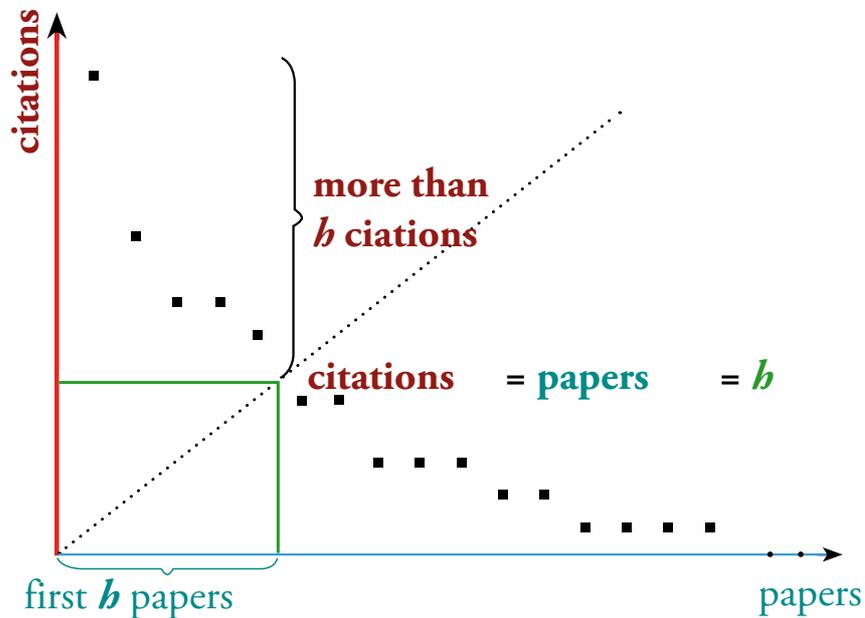
In addition to Hirsch's definition, Glänzel indicates that the advantage of the h-index is that it combines an assessment of both quantity (number of papers) and quality (impact, or citations to these papers) (Glänzel, 2006).

The calculation is defined by Ann-Will Harzing simply as below (Harzing, 2008): A scientist has index h if h of his/her N_p papers have at least h citations each, and the other $(N_p - h)$ papers have no more than h citations each.

To simplify with an example; if the person's h-index value is 10, it means that 10 paper authored by the person have 10 or more citation. Higher value is perceived as higher performance and lower value is perceived as lower performance.

H-index calculation is defined with graphical demonstration as well. Since it is calculated on papers and citations, citation count is positioned on vertical axis which angle side is 0 citation. Papers are placed on horizontal axis, but this time highest cited to lowest where it starts from angle. Citation count of each paper is positioned on chart with a dot in accordance to axis values. Then an angle bisector is positioned in chart. The nearest citation and paper count position on bisector value is matched to H-index value. Thus, crossed value is defined as first h papers have equivalent or more than h citation (See Figure 1).

Figure 1 – H-Index with Graphical Demonstration



H-index is accepted as the most appropriate scientific performance indicator for combination of scientific production and impact together. It may be used in different levels; countries, organization or individual. But it is used for individual performance measures mostly. It may be limited to subject area, time periods, individual's statutes, and many other factors. Thus, many limitations or normalizations are possible to implement.

As previously mentioned h-index is used to find out the entity's scientific competence in the field, or in another word; scientific maturity level. Thus, this performance value is an indicator of entity, which is a node in networked environments. Contribution of better node value to network analyses will add more contribution to analyses certainly.

H-index indicator has been criticized intensively followed up by plenty alternate indicators. But none of these alternates have taken h-index place in use. This is because of h-index counting flexibility as of limitations and normalizations (Kelly and Jennions 2006, Bornmann and Daniel 2007, Costas and Bordons 2007, Hirsch 2007, Sekercioglu 2008, Bartneck and Kokkelmans 2011).

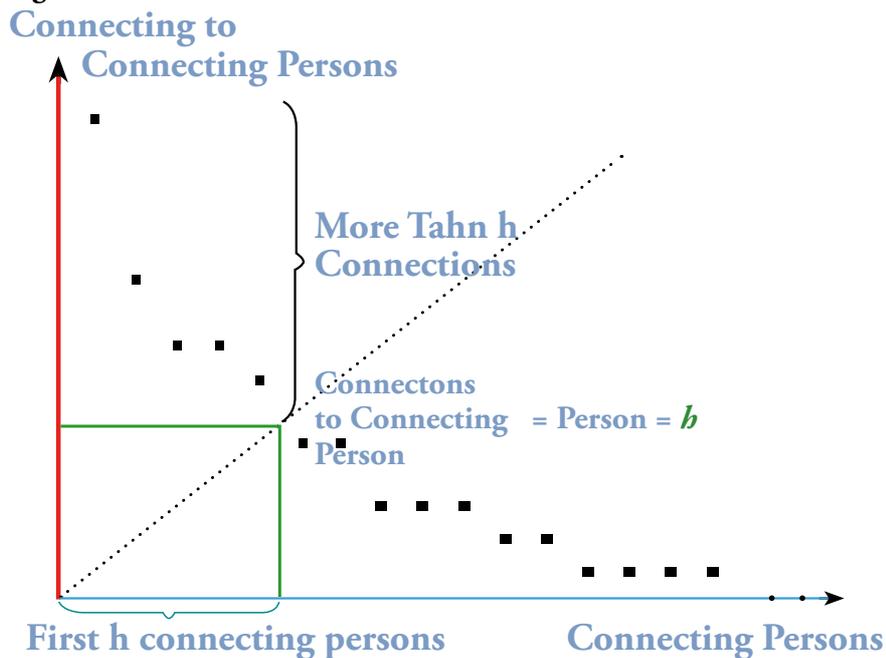
However, Hirsch himself is emphasizing below that H-index should not be taken as single indicator as researcher only performance indicator (Hirsch, 2005):

Obviously a single number can never give more than a rough approximation to an individual's multifaceted profile, and many other factors should be considered in combination in evaluating an individual. This and the fact that there can always be exceptions to rules should be kept in mind especially in life-changing decision such as the granting or denying of tenure.

H-Index Proposal for Sociometrical Research: *How to Count*

The counting of H-index in sociometrical research is identical to scientometrical calculation. The only change is data types that are entity's connections instead of papers, and connections to the connecting entity instead of citations to the paper. These data types are seen as the most proper matching items for social power measure in context of maturity performance analyses in social networks. To simulate h-index in sociometrical measures, Figure 1 that is showing H-index as in scientometrical context may be redesigned as below;

Figure 2. H-index Calculation in Sociometrical Research



Then, annotation from Harzing (Harzing 2008) may be transformed simply as below: "A person has index h if h of his/her N_{cp}^1 connected people have at least h connections each, and the other $(N_{cp}-h)$ connected people have no more than h connections each."

Adaptation of h index counting is done for sociometrical analyses with this identical way that has a complete applicability.

¹ N_{cp} stands for "Number of connecting persons."

Any sorts of normalizations or limitations are applicable to this identical measurement as well which lets flexibility of analyses in different aspects.

H-Index Proposal for Sociometrical Research: *Potential Usage*

As indicated above “Social Atom” idea defined by Moreno (Moreno, 1934), is the first known attempt to measure performance of person’s social connectivity level. However, it has been developed based on connections to the node (persons), but without an indication of strength of each connecting node. In another word, social atom is measuring performance with first layer connections to node only without measuring strength of connecting nodes. Many other researchers have discussed this. Many complementary or alternate social network-analyzing approaches have been offered since Moreno’s social atom definition (Homans, 1950; Homans, 1961; Gitlin, 1978; Lewin, 1964; Mullins, 1973; Granovetter, 1973, Hanneman and Riddle, 2005; and so on).

With implementation of h-index in sociometrical analyses, almost all proposed alternates or complementary functions may be taken one layer further by measuring social strength of connecting node to the atom with a combined measurement to indicate social maturity performance. Thus, it may serve best to reflect power of each node to the connected central node.

It may be implemented to many different entities such as a person, governmental organization, an NGO, a company, etc. But such an indicator will be used substantially for personal evaluations within his or her social connections in real life or virtual media. It may be developed limited to age group, social status, gender, connection types, etc. within normalized measures. In today’s world, online social network platforms such as tweeter, facebook, Linkedin, provide great opportunities to measure social power of individuals, a government, an NGO, and so on.

H-index indicator has a significant flexibility in terms of customization according to any normalization or limitations such as age, commercial sector, status, gender, and so on. Taking these factors in account, H-index may be customized to a narrowed or a broader universe.

H-Index Proposal for Sociometrical Research: *Data Sources*

Since any entity within a connected environment is eligible to be measured with proposed h-index indicator, any adequate data source accompanied to entity’s connected environment can be used. This may be:

- Connected people data in a Facebook or linkedin account of a person
- Connected organization data in an institutional information repository of an organization

- Followers' data in any sort of a Tweeter account (Person, Company, NGO, etc.)
- State register data of a person's family, and so on...

H-Index Proposal for Sociometrical Research: *Sample Case Study*

For the sample case study, LinkedIn online professional network platform was selected. LinkedIn platform is providing extensive network connections of a person with adequate shared information, which is matching to evaluate proposed h-index performance indicator.

Necessary data have been provided from 6 sample persons within same company with different managerial titles. Persons' titles and details with hierarchical rank are as below:

Person 1: Director (Governmental and Corporate Sales)

Gender: Male

Age: 39

Business Experience Years: 20+

Years in the company: 20+

Person 2: Group Executive (Corporate Sales)

Gender: Male

Age: 28

Business Experience Years: 7

Years in the company: 2

Person 3: Academic Sales Executive

Gender: Male

Age: 34

Business Experience Years: 12

Years in the company: 4

Person 4: Sales Support Executive

Gender: Female

Age: 32

Business Experience Years: 10

Years in the company: 2

Person 5: Financial Services Executive

Gender: Female

Age: 36

Business Experience Years: 15

Years in the company: 15

Person 6: Sales Representative

Gender: Male

Age: 23

Business Experience Years: 2

Years in the company: 2

Results of proposed h-index indicator derived from provided data have been measured as below for each person;

H-index for Person 1: **257**

H-index for Person 2: **127**

H-index for Person 3: **154**

H-index for Person 4: **117**

H-index for Person 5: **83**

H-index for Person 6: **58**

Table 1 shows details for sample of 2 persons² data and determined H-index value (See Table 1).

Above results are showing correlation between hierarchal position of the person in the company and measured h-index performance. The shift between person 2 and person 3 can be explained as an indicator of closeness of competition in the business environment.

The same level of correlation is seen between business experience years and measured h-index value. The only underperforming person compared to others is Person 5. This should be regarded as low performance in social relation generation.

Age data is expected to be in correlation with H-index typically. But it is not as strong as expected in above sample. 3 out of 6 persons are matching to measure H-index ranking as of age rank.

“Years in the company” data does not show any correlation to measured H-index.

Conclusion

Hereby I would like to name sociometry adapted H-index indicator as H S-index.

The definition of h S-index is below;

Hs-index is an indicator which demonstrate maturity level of a person's social connectivity by measuring total number of connected people in the context of total connection they have generated each.

² Person 5 and Person 6.

More indicators may be adapted to sociometrical analyses, which have been developed in scientometrics. But in fact, as usage eligibility and validity of measurements have been confirmed with this study, the h-index has the most significant potentials in sociometrical research, especially in social network analyses.

However H-index has many constraints in scientometrical evaluation, almost none of those constraints are an issue in sociometrical analyses. Thus, it makes h-index a better indicator in sociometry. Some of important constraints are below (Kelly and Jennions, 2006; Bornmann and Daniel, 2007; Costas and Bordons, 2007; Hirsch, 2005; Hirsch, 2007; Sekercioglu, 2008; Bartneck and Kokkelmans, 2011; Wendl 2007; Zhang, 2009; Bartneck and Kokkelmans 2011; Ferrara and Romero 2013; Ruane and Tol, 2008):

- H-index does not account for the number of authors of a paper.
- This is not an issue for adopted H^S -index because a connection is made up of a single entity.
- “The h-index does not account for the typical number of citations in different fields.”
- H^S -index can be measured simply specialized to a field, a business area, an age period, and so on.
- *The h-index discards the information contained in author placement in the authors’ list, which in some scientific fields is significant.*
- This is not a case in sociometrical analyses since a connection is made up of single entity.
- *The h-index is bounded by the total number of publications. This means that scientists with a short career are at an inherent disadvantage, regardless of the importance of their discoveries* (Hirsch, 2005).
- This is not an issue, since h^S -index may be run on any age groups.
- The h-index does not consider the context of citations.
- This can be an issue in sociometry as well. But h-index is possible to be measured limited or classified to any combination of connections sorts.
- *The h-index does not account for confounding factors such as “gratuitous authorship”, the so-called Matthew effect* (Merton, 1968; Merton 1988).
- Again this is not an issue in sociometrical analyses, since a connection is made up of a single entity.
- *The h-index is a natural number which reduces its discriminatory power.*
- This is valid in case if value range of source data is small. Average number of papers and citations per person is not high enough in all scientific fields, such as mathematics, architecture or law. When h-index is measured for scientist in these fields, scores are resulting in a

very small value ranges. Thus, it is not helping to differentiate successful performances. But this is not the case for h^S -index in sociometrical analyses. In most of the cases, number of connections to the persons has adequate value ranges. Because of this, above criticism is not valid for H^S -index.

- *The h-index can be manipulated through self-citations*

Self-citations is not a case in social network connections. In most of the case, the person is not able to manipulate connections from him/herself.

None of above criticisms has a potential to create any shortage in h^S -index usage for sociometrical analyses. Thus, h^S -index is proving to be a more proper indicator in sociometry then scientometrical evaluations.

On the other hand, when placing h^S -index within Moreno's social atom concept, the most important missing point would be absence of connection contexts in h^S -index. The same argument has been in place for scientometrical limitations of h-index as well. The solution for absence of connection contexts in h^S -index is in line with h-index; h^S -index is possible to be measured limited or classified to any sort or combination of connection contexts, such as h^S -index in reciprocated attraction connections.

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Appendix | Ek**Table 1. Sample for 2 Person's Case Study Data and Determined H-index Value**

Person 5: Financial Services Executive H-index: 127			Person 5: Sales Representative H-index: 83		
Connecting Person	Total Connections to Connecting Person	H-index	Connecting Person	Total Connections to Connecting Person	H-index
Connection 1	500		Connection 1	500	
Connection 2	500		Connection 2	500	
Connection 3	500		Connection 3	500	
Connection 4	500		Connection 4	500	
Connection 5	500		Connection 5	500	
Connection 6	500		Connection 6	500	
Connection 7	500		Connection 7	500	
Connection 8	500		Connection 8	500	
Connection 9	500		Connection 9	500	
Connection 10	500		Connection 10	500	
Connection 11	500		Connection 11	454	
Connection 12	500		Connection 12	445	
Connection 13	500		Connection 13	434	
Connection 14	500		Connection 14	411	
Connection 15	500		Connection 15	358	
Connection 16	500		Connection 16	350	
Connection 17	500		Connection 17	342	
Connection 18	500		Connection 18	342	
Connection 19	500		Connection 19	319	
Connection 20	500		Connection 20	305	
Connection 21	500		Connection 21	303	
Connection 22	500		Connection 22	288	
Connection 23	500		Connection 23	285	
Connection 24	500		Connection 24	268	
Connection 25	490		Connection 25	260	
Connection 26	467		Connection 26	250	
Connection 27	454		Connection 27	249	
Connection 28	413		Connection 28	247	
Connection 29	411		Connection 29	237	
Connection 30	392		Connection 30	235	
Connection 31	392		Connection 31	233	
Connection 32	384		Connection 32	228	
Connection 33	378		Connection 33	220	
Connection 34	376		Connection 34	216	
Connection 35	376		Connection 35	203	
Connection 36	375		Connection 36	203	
Connection 37	371		Connection 37	191	

Connection 38	371	
Connection 39	368	
Connection 40	353	
Connection 41	350	
Connection 42	339	
Connection 43	338	
Connection 44	332	
Connection 45	316	
Connection 46	316	
Connection 47	311	
Connection 48	310	
Connection 49	295	
Connection 50	292	
Connection 51	291	
Connection 52	275	
Connection 53	268	
Connection 54	260	
Connection 55	259	
Connection 56	257	
Connection 57	247	
Connection 58	237	
Connection 59	235	
Connection 60	233	
Connection 61	233	
Connection 62	231	
Connection 63	227	
Connection 64	225	
Connection 65	216	
Connection 66	197	
Connection 67	174	
Connection 68	164	
Connection 69	153	
Connection 70	150	
Connection 71	148	
Connection 72	143	
Connection 73	137	
Connection 74	131	
Connection 75	127	
Connection 76	120	
Connection 77	119	
Connection 78	117	
Connection 79	105	
Connection 80	104	

Connection 38	174	
Connection 39	160	
Connection 40	158	
Connection 41	157	
Connection 42	154	
Connection 43	144	
Connection 44	136	
Connection 45	128	
Connection 46	120	
Connection 47	117	
Connection 48	103	
Connection 49	103	
Connection 50	91	
Connection 51	86	
Connection 52	80	
Connection 53	78	
Connection 54	71	
Connection 55	70	
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