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ORIGINAL ARTICLE

Citations and Publications on Network Security Research during 2013-2022: A Scientometric Study

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ABSTRACT

Background: This report covers network security research papers from 2013 to 2022 using the Scopus interdisciplinary online database. The study's goal is to examine the year-by-year growth of publications, relative growth rate and doubling time, top ten authors' contributions, authorship patterns, degrees of collaboration, collaborative coefficient, collaborative index, co-author index, document types, time series analysis, contributions of top ten journals, institutions, countries, languages, and highly cited papers in network security research publications.

Aim: This study studies or evaluates Network security research trends from 2013 to 2022 to discuss the possibility of employing data from the Scopus database. Between 2013 and 2022, there was an annual rise in Network security research articles of 84,739 research publications, 7,93,177 citations, 60372 cited publications, and 24367 uncited publications.

Objectives: To perform a bibliometric analysis of the Citations and Publications on Network Security Research between 2013-2022. The authors' study purpose is to look at how scientometric Network security research is evolving and to detect any trends in that development. It also intends to discover prior trends in Network security research publications published in scientometrics based on the sample data.

Material: This study confirmed that the relative growth rate is decreasing trend. At the same time doubling time was found that 0.83 in the year 2014 and 4.89 in the year 2022 and it is confirmed that doubling time is an increasing trend. The subject a maximum of 69062 (81.34%) research publications are contributed by Computer Science, the authorship pattern, 5964 research publications are contributed by single authors, and the average degree of collaboration is 0.92. The collaboration coefficient of the average is 0.62. The collaboration Index average is 3.29. The Modified collaboration coefficient of the average is 3.29.

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Result: The document types a maximum of 50492 (59.59%) research publications are contributed by conference paper, during the journal of the maximum of 5521 (33.63%) research publications are contributed by the lecture notes in computer science including subseries lecture notes in artificial intelligence and lecture notes in bioinformatics. The Institute a maximum of 1553 (17.93%) contributions are Chinese Academy of Sciences, the country, a maximum of 5521 (33.63%) research publications are contributed by the China.

Conclusion: Network security consists of the provisions established in an underlying computer network infrastructure, rules set by the network administrator to safeguard the network and network-accessible resources from unauthorized access, and the effectiveness (or lack thereof) of these measures when combined.

Keywords:

• Scientometrics • RGR • RCI • Degree of collaboration • Collaborative co-efficient • Collaborative index • Modified collaborative co-efficient • time series • Co-authorship index

INTRODUCTION

Every firm or organization that handles a substantial volume of data has some level of protection against a variety of cyber threats. This is a comprehensive term that encompasses software and hardware solutions, as well as policies, guidelines, and configurations for network usage, accessibility, and overall threat protection. The most basic example of network security is password protection that the network user chooses. Network security has recently emerged as a significant topic in cyber security, with many firms seeking applications from individuals with expertise in this field. Network security solutions defend a variety of computer system vulnerabilities, including users, location, data, devices and applications. Network security refers to any activity taken to ensure the integrity and usefulness of your data and network. In other words, network security is an activity designed to protect the integrity of your network and data. Network security is the practice of safeguarding a computer network from unauthorized access, misuse, or attacks. It entails using tools, methods, and policies to guarantee that data transmitted across a network is safe and secure, protecting sensitive information from hackers and other dangers.

Network security employs multiple levels of protection, both at the network's edges and within it. Each layer has rules and controls in place to limit who has access to network resources. People who have been granted access can use the network safely, but those who attempt to harm it through assaults or other threats are prevented from doing so.The basic premise of network security is to safeguard large amounts of stored data and networks in layers that assure the establishment of rules and regulations that must be acknowledged prior to executing any activity on the data. These levels are: Physical Network Security: This is the most basic level of security, which includes preventing unauthorized persons from gaining control of the network's secrecy. Technical network security is primarily concerned with protecting data stored in the network or data in transit via the network. This kind serves two uses. One is guarded against unauthorized access, while the other is guarded against malevolent activity. Administrative Network Security: This level of network security protects user behavior, such as how permissions are issued and how the authorization process works. This also ensures that the network has the necessary sophistication to protect itself against all attacks. This level also highlights important infrastructural changes.[1]

SCIENTOMETRIC STUDY

Scientometric is a study to measure the performance of researchers as well as the research publications. The research activities contain major changes over the last few decades and emerged as established research in the discipline of "Library and Information Science". The study of scientific literature has a long history dating back to the early decades of the past century. However, despite the number of research literature in this area, it was not until 1969, that the term bibliometrics first appeared in print (Pritchard 1969)[2] Definition of bibliometric was 'application of mathematical and statistical methods to books and other media of communication',

particularly in North America, the term was quickly adopted and used (Wilson, 1999)[3]. At the same time, Nalimov and Mulchenko (1969)[4] coined the term scientometrics to refer to 'the application of quantitative methods which are dealing with the analysis of science viewed as an information process. In contrast, this term was widely used in Europe (Wolfram, 2003)[5]. Initially, therefore, scientometrics was restricted to the measurement of science communication, whereas bibliometrics was designed to deal with more general information processes, Andres A (2009)[6].

LITERATURE REVIEW

Cabanillas-Lazo, *et al.* (2024)[7] were carried out a bibliometric study on Effect of Bariatric Surgery on Gut Microbiota, 595 numbers of data extracted from Scopus for the period 2016 to 2022. A total of 518 published papers were included in the analysis. Carel Le Roux was the author with the highest scientific production; however, Edi Prifti had the highest impact. French National Institute of Health and Medical Research *(Institut national de la santé et de la recherche médicale)* was the institution with the highest number of published articles. Six of the 10 institutions with the highest production were in France, yet the United States had the highest volume of scientific production in this research topic. Most papers were published in first quartile journals. Articles with international collaboration had the highest impact. There is a sustained increase in the number of publications since 2019.

Chang Y. *et al.* (2023)[8] were carried out a bibliometric study on Global research tendency and connection between colorectal cancer and gut flora for the time 2001 to 2021. A total of 2,707 publications were obtained, with a rapid increase in the number of publications since 2015. The United States and China are the main contributors in this field and have established a network of partnerships in several countries. 414 academic journals have published articles on this topic. The author with the highest number of publications is Jun Yu from the Chinese University of Hong Kong. In addition to "intestinal flora" and "colorectal cancer," high frequency terms in the keyword co-occurrence network analysis included inflammatory bowel disease, *Fusobacterium nucleatum*, inflammation, long-chain fatty acids, ulcerative colitis, bile acids, and resistant starch. Analysis of keyword trends using burst testing revealed that biomarkers, abnormal crypt foci, bifidobacteria, β-glucuronidase, short-chain fatty acids, bile acids, and DNA methylation are at the forefront of research in this area.

Kaidi Nie. *et al*. (2024)[9] were conducted a study on "Bibliometric and visual analysis of intestinal flora and immunity. This study analyzed 16,611 publications, including 10,865 articles and 5746 reviews, and found a continuous increase in publications related to gut micro biota and immunity since 2013. We identified 62,872 authors contributing to this field from 2144 journals and 9965 organizations/institutions in 145 countries/ regions. The top publisher with the highest output is University of California System with 525 papers. Among these journals, the top 3 most prolific journals are Frontiers in Immunology, Frontiers in Microbiology, and PLOS ONE. The literature with the highest citation frequency is published in Science and has been cited 3006 times by Patrick M. Smith and others.

Lu Zhang *et al*. (2022)[10] were conducted "a bibliometric study of global trends in diabetes and gut flora research from 2011 to 2021. We searched the Web of Science Core Collection database for articles on diabetes and gut flora related research from 2011-2021 on July 2, 2022. The literature data were analyzed for country, institution, author, steward, journal, and highly cited literature using Citespace.5.8.R3 and Vosviewer 1.6.17. Finally 4834 articles that met the requirements were included. The overall trend of articles published in the last 11 years is increasing, and the trend of articles published after 2019 is increasing significantly. In total, 109 countries, 4820 institutions, and 23365 authors were involved in the field of research. The highest number of publications was 1262 articles from the United States, the institution with the most publications was the University of Copenhagen with 134 articles, and the author with the most publications was PATRICE D CANI with 52 articles.

Keya Ghosh *et al.* (2024)[11] examine the present study of scientometric analysis of "Intestinal flora" research from 2000 to 2023. A scientometic analysis. The year-wise growth of "Intestinal flora research publications

during the 24-year study period between 2000 and 2023 with the top in the year 2023 with 1412 (20.425%) research publications. A maximum document type of 5296 (76.61%) research publications are contributed by Article. A maximum number of articles are published in English 4991 (72.19%). Highest cited article Sex and virulence in Escherichia coli: An evolutionary perspective is published in Molecular Microbiology with citations 1573. The Maximum of 119 research publications are contributed by the Frontiers in microbiology and citations is 1115. A maximum of 30 research publications are contributed by Tab B and Zhang, X. Collaborator country a maximum of 4773 research publications are collaborated by the China and citations is 51487 (34.82%) The average degree of collaboration is 0.95. Authorship pattern single authorship modes with 343(4.96%) publications.

Ravichandran S *et al.* (2022)[12] examine the present study of scientometric analysis of Leukemia research output 2011-2020 from an Indian perspective. The year-wise growth of leukemia research publications during the 10-year study period between 2011 and 2020 with 5,474 research publications and 86,869 citations. A maximum of 692 (12.64%) research publications are contributed in the year 2020. and the CAGR is 5.37. Authorship pattern more than five authorship modes with 1,910 (34.89%) publications, the average degree of collaboration is 0.97. The average collaborative coefficient value is 0.76, the average collaboration index value is 4.30, and the average value is 4.3. A maximum of 128 (17.16%) research publications are contributed by Malhotra, P. India. a maximum of 3837 (70.09%) research publications are contributed by Article. The Maximum of 266 (24.14%) research publications are contributed by the Indian Journal of Hematology and Blood Transfusion. Collaborator country a maximum of 462 (37.90%) research publications are collaborated by the United States of America. The highly cited paper of 18098 citations is received by Ferlay, J (2015) Cancer incidence and mortality worldwide.

OBJECTIVES THE STUDY

The main objective of this study was to use Scientometrics to analyze the Network Security research output covered in the Scopus database during 2013–2022.

- To identify and analyze the growth rate of world research in Network Security research output publications.
- To analyze the author's, relative growth rate and doubling time research output publications.
- To analyze the subject and authorship pattern of research output publications.
- To identify the degree of collaboration and collaborative index (CC,CI, MCC).
- To analyze the co-authorship index and time series research output publications.
- To know the global research output of document-wise distribution of publications.
- To assess the institution-wise and journals research concentration.
- To examine the country-wise distribution of publications.
- To analyze the Funding Agencies supported Network Security research.
- To analyze highly cited papers of research publications.

METHODOLOGY

The study retrieved and downloaded 10 years of publications data on the global output in Network Securityresearch output from the Scopus database covering the period of 2013-2022. The present study aims toanalyze the research output of Researchers in the field of Network SecurityResearch Output. The growth rates of output in terms of research productivity wereanalyzedduring the study period. The authorship pattern and author productivity are examined to identify the pattern of research contribution in the field of Network SecurityResearch Output. The data have been extracted and tabulated in the form of tables and figures and it is also analytical in nature strengthening the empirical validity due to the application of suitable statistical tools. The data was collected on 15.12.2022 and the Micro Soft excel format was downloaded.

DATA ANALYSIS AND INTERPRETATIONS

Year-wise growth of Network Security research publications

Table 1: Year-wise growth of Network Security research publications

S. no	Year	Publications	%	Citations	%	Cited	%	Uncited	%	CPP	RCI
1	2013	3650	4.31	50121	6.32	2823	4.68	827	3.39	13.73	1.47
2	2014	4826	5.70	61829	7.80	3789	6.28	1037	4.26	12.81	1.37
3	2015	5991	7.07	81603	10.29	4893	8.10	1098	4.51	13.62	1.46
4	2016	6576	7.76	89419	11.27	5539	9.17	1037	4.26	13.60	1.45
5	2017	8432	9.95	122526	15.45	7086	11.74	1346	5.52	14.53	1.55
6	2018	10160	11.99	132738	16.73	8396	13.91	1764	7.24	13.06	1.40
7	2019	11282	13.31	116215	14.65	9113	15.09	2169	8.90	10.30	1.10
8	2020	10673	12.60	83560	10.53	8071	13.37	2602	10.68	7.83	0.84
9	2021	11907	14.05	43025	5.42	7156	11.85	4751	19.50	3.61	0.39
10	2022	11242	13.27	12141	1.53	3506	5.81	7736	31.75	1.08	0.12
	Total	84739	100.00	793177	100.00	60372	100.00	24367	100.00		

Table 1 shows theyear-wise growth of Network Security research publications during the 10-year study period between 2013 and 2022 with 84739 research publications and 793177 citations. From the study, it is identified that a maximum of 11907 (14.05%) research publications are contributed in the year 2021, followed by 11282 (13.31%) publications in the year 2019, and 11242 (13.27) publications in the year 2022. The average research publication per year is 8473.9

During the 10 - year study it is identified that a total number of 84739 publications received 793177 citations. Out of that maximum of 132738 (16.73%) citations received 10160 publications in the year 2018. Followed by 122526 (15.45%) citations received 8432 publications in the year 2017. From the study, out of 84739 publications, 60372 (100%) research publications are cited publications, and uncited 24367 (100%) research publications. The maximum citation per paper is 14.53 in the year 2017, followed by CPP is 13.73 in the year 2013, and by CPP is 13.62 in the year 2015. The maximum RCIis 1.55 in the year 2017 and the minimum RCI is 0.12 in the year 2022.

Top 10 Authors 'contributions to network Security research publications

Table 2: Top 10 Author's contributions to network security research publications

Authors		Publications	%	Citations	%	H- Index	CPP	RCI
Das, A.K.	China	157	13.62	7075	20.04	51	45.06	1.47
Choo, K.K.R.	United States	151	13.10	4982	14.11	41	32.99	1.08
Conti, M.	India	131	11.36	3500	9.91	26	26.72	0.87
Guizani, M.	United Kingdom	128	11.10	3527	9.99	31	27.55	0.90
Kumar, N.	Germany	128	11.10	5425	15.36	43	42.38	1.38
Gupta, B.B.	South Korea	105	9.11	2758	7.81	28	26.27	0.86
Susilo, W.	Australia	94	8.15	1227	3.48	16	13.05	0.43
Kumari, S.	France	88	7.63	3378	9.57	33	38.39	1.25
Rodrigues, J.J.P.C.	Canada	87	7.55	2708	7.67	29	31.13	1.02
Obaidat, M.S.	Italy	84	7.29	728	2.06	15	8.67	0.28
Total		1153	100.00	35308	100.00			

Table 2 identified the top 10-author contributions for the research publications on Network Security research from the Scopus database. From the study, it is identified that amaximum of 157 (13.62%) research publications are contributed by Das, A.K. The China, followed by Choo, K.K.R. United States with 151(13.0%) research publications, Conti, M., Indiawith 131 (11.36%) research publications. The highest citations of were 7075 (20.04%) Das, A.K. In the Chinaand the lowest number of citations is 728(2.06%) Obaidat, M.S. Italy.The highest CPP is 45.06, the H-index is 51 and RCI is 1.47. The lowest CPP is 8.67, the H-index is 15 and RCI is 0.28.From this study, it is identified that 1153 (100%) research publications are contributed by the top 10 authors from 10 different countries.

Relative Growth Rate of Publications

The relative growth of publications was analyzed by using the two parameters namely relative growth rate and doubling time originated by **Mahapatra (1985**)[13]. RGR is a measure to study the increases in the number of articles over a period of time. It is calculated as

$$R(a) = \frac{(W2 - W1)}{(T2 - T1)}$$

Whereas

R (a) = RGR = the mean relative growth rate over the specific period of interval

W_1 = the logarithm of the beginning number of publications/pages

W_2= the logarithm of the ending number of publications/pages after a specific period of interval

$T_2 - T_1$ = the unit difference between the beginning time and the ending time.

Doubling Time

The doubling time is the time taken for the doubling of the number of records actually published within a stipulated period. The doubling time is calculated from the relative growth rate and the natural logarithm number is used, the difference has a value of 0.693. Thus the corresponding doubling time can be calculated by the following formula,

$$Dt = \frac{0.693}{R(a)}$$

Relative growth rate and doubling time of network security research publications

Table 3: Relative growth rate and doubling time of network security research publications

Year	Publications	Cumulative	W1	W2	RGR	Dt
2013	3650	3650		8.20		
2014	4826	8476	8.20	9.04	0.84	0.83
2015	5991	14467	9.04	9.58	0.53	1.30
2016	6576	21043	9.58	9.95	0.37	1.86
2017	8432	29475	9.95	10.29	0.34	2.07
2018	10160	39635	10.29	10.59	0.30	2.35
2019	11282	50917	10.59	10.84	0.25	2.78
2020	10673	61590	10.84	11.03	0.19	3.66
2021	11907	73497	11.03	11.20	0.18	3.94
2022	11242	84739	11.20	11.35	0.14	4.89
Total	84739					

The relative growth rate and the doubling time (Dt) were calculated and the results are presented in table 3. From the study, it is identified that the relative growth rate is 0.84 in the year 2014 and 0.14 in the year 2022. This study confirmed that the relative growth rate is decreasing trend. At the same time doubling time was found that 0.83 in the year 2014 and 4.89 in the year 2022 and it is confirmed that doubling time is an increasing trend.

Subject wise of network security research publications

Table 4: Subject wise of network security research publications

Subject area	No. of articles	%
Agricultural and Biological Sciences	681	0.80
Arts and Humanities	164	0.19
Biochemistry, Genetics and Molecular Biology	1442	1.70
Business, Management and Accounting	1621	1.91
Chemical Engineering	571	0.67
Chemistry	1290	1.52
Computer Science	69062	81.34
Decision Sciences	9249	10.89
Dentistry	4	0.00
Earth and Planetary Sciences	818	0.96
Total	84902	100.00

Table 4 identified the top ten subject contributions for the research publications of Network Securityresearch from the Scopus database. From the study it is identified that a maximum of 69062(81.34%) research publications are contributed by Computer Science, followed byDecision Sciences with 9249(10.89%) research publications, Business, Management and Accountingwith 1621(1.91%) research publications. The lowest subject is Dentistrywith 4(0.00%). Research publications.

Authorship pattern in network security research publications

table 5: Authorship pattern in network security research publications

	Authorship pattern						
Years	**1**	**2**	**3**	**4**	**5**	**>5**	**total**
2013	467	900	1039	702	304	238	3650
2014	519	1300	1276	945	457	329	4826
2015	520	1560	1625	1235	602	449	5991
2016	519	1660	1792	1311	708	586	6576
2017	609	2033	2209	1735	974	872	8432
2018	611	2441	2602	2055	1267	1184	10160
2019	616	2378	2957	2309	1527	1495	11282
2020	692	2205	2474	2170	1516	1616	10673
2021	831	2437	2622	2422	1643	1952	11907
2022	580	2079	2353	2209	1709	2312	11242
Total	5964	18993	20949	17093	10707	11033	84739

Table 5 identified theyear-wise authorship pattern in the field of Network Securityresearch during the 10-year study period. From the study, it is identified that, out of 84739 research publications, 5964 research publications are contributed by single authors,and the remaining 78775 research publications are multi-author contributions. Of the multi-

author publications, a maximum of 18993 research publications are contributed by two authors, followed by 20949 publications contributed by three authors and17093 publications are four authors. And 10707 publications are contributed by five authors. During the 10- year study period more than five authors contributed to11033 publications.

Degree of collaboration in network security research publications

Table 6: Degree of collaboration in network security research publications

Years	Single author publications	Multi authors publications	Total author publications	Degree of collaborations DC = Nm/(Ns+Nm)
2013	467	3183	3650	0.87
2014	519	4307	4826	0.89
2015	520	5471	5991	0.91
2016	519	6057	6576	0.92
2017	609	7823	8432	0.93
2018	611	9549	10160	0.94
2019	616	10666	11282	0.95
2020	692	9981	10673	0.94
2021	831	11076	11907	0.93
2022	580	10662	11242	0.95
Total	5964	78775	84739	0.92

The degree of collaboration is the relationship between single author and multi-author contributions. The degree of collaboration is calculated by the **Subramanian (1983)**[14] formula and used by **Ravichandran (2021)**[15] **Sivasamy (2020).**[16]

$$DC = \frac{Nm}{(Nm + Ns)}$$

Where DC = Degree of Collaboration

N_m = Number of Multi- authored publications

N_s = Number of single-authored publications

In the present study, Nm = 78775, Ns= 5964

So that the degree of collaboration is =78775/ (78775+5964) = 0.92

Table 6 shows the degree of collaboration in Network Securityresearch publications for the 10-year studies period. From this study, it is identified that the degree of collaboration is between 0.87 in the year 2013 and 0.95 in the year 2022. The average degree of collaboration is 0.92. From this study, it is identified that the majority of Network Securityresearch publications are contributed by collaborative authors.

Collaborative of Co-efficient (CC)

The pattern of co-authorship collaboration among the authors can be measured with the following formula suggested by **Ajiferuke,** *et al***. (1988)**[17]

$$CC = 1 - \left[\sum_{j=0}^{k} \left(\frac{1}{j} \right) \times Fj / N \right]$$

Whereas,

Fj = Number of publications with j author papers

N = Total number of research publications and

k = the greatest number of authors/papers in the given field

Collaboration Index (CI)

The simple indicator is presently employed in the publications to the collaboration index among the co-authors, which is to be understood nearly as the mean number of authors per paper are suggested by **Ajiferuke,** *et al***.(1988)**[17]

$$CI = \frac{\sum_{j=1}^{k} jfj}{N}$$ **Here**

J - The number of co-authored papers appearing in a discipline

N - The total number of publications in the field over the same time period of interval and

k - The highest number of authors per paper in a same-time field.

Modified Collaboration Coefficient

The modified collaboration coefficient (MCC) counted by the formula which is suggested by **Savanur and Srikanth, (2010)**[18]

Which is given below:

$$MCC = \frac{N}{N-1}\left[1 - \frac{\sum_{j=1}^{k} jfj}{N}\right]$$

Where,

j = the number authors in an article i.e. 1, 2, 3.....

Fj = the number of j-authored articles

N = the total number of articles published in a year, and

A = the total number of authors per article

Collaboration index and collaborative co-efficient of network security research

Table 7: Collaboration index and collaborative co-efficient of network security research

	Authorship pattern									
Years	**1**	**2**	**3**	**4**	**5**	**5**	**CC**	**CI**	**MCC**	**total**
2013	467	900	1039	702	304	238	0.58	2.99	2.99	3650
2014	519	1300	1276	945	457	329	0.59	3.04	3.04	4826
2015	520	1560	1625	1235	602	449	0.61	3.12	3.12	5991
2016	519	1660	1792	1311	708	586	0.61	3.18	3.18	6576
2017	609	2033	2209	1735	974	872	0.62	3.26	3.26	8432
2018	611	2441	2602	2055	1267	1184	0.64	3.32	3.32	10160
2019	616	2378	2957	2309	1527	1495	0.65	3.42	3.42	11282
2020	692	2205	2474	2170	1516	1616	0.65	3.45	3.45	10673
2021	831	2437	2622	2422	1643	1952	0.64	3.46	3.46	11907
2022	580	2079	2353	2209	1709	2312	0.67	3.62	3.62	11242
Total	5964	18993	20949	17093	10707	11033				84739

It is observed from table 7, the collaborative coefficient is calculated and presented during the 10- year study period for Network Securityresearch publications. It is observed from the table 7 highest collaboration co-efficient is 0.67 in the year 2022 and lowest CC is 0.58 in the year 2013, and the average CC is 0.62. The collaboration index observed in table 7themaximum collaboration Index is 3.62 in the year 2022, a minimum of 2.99 in the year 2013, and an average CI is 3.29. The Modified collaboration coefficient observed in table 7is a maximum of is 3.62 in the year 2022, a minimum of 2.99 in the year 2013, andan average MCC is 3.29.

Co-Authorship Index

Co-authorship Index (CAI) is obtained by calculating proportionately the publications by single, two, and multi-authored papers **Garg & Padhi, (1999)**.[19]

$$CAI = \frac{N_{ij} / N_{io}}{N_{0j} / N_{\infty}} X\ 100$$

Where,

Nij = Number of papers having authors in block i

Nio = Total output of block i

Noj = Number of papers having j authors for all blocks.

Noo = Total number of papers for all authors and all blocks

CAI=100 indicates that a country's co-authorship effort for a particular type of authorship correspondents to the world average.

CAI>100 reflects a higher than average co-authorship effort and

CAI<100 shows lower than average Co-authorship effort for a given type of authorship pattern.

For calculating the co-authorship index for authors, years have been replaced with block years. For this study, the authors have been classified into two blocks (i.e. 2008-2014 and 2015-2021) Vs**.** Single, Two, Three authors, and More than three authors.

Co-Authorship index (CAI) in network security research publications

Table 8: Co-Authorship Index (CAI) in Network Security Research Publications

5 year Block	Single author	CAI	Two authors	CAI	Three authors	CAI	More than three authors	CAI	Total
2013-2017	2634	126.97	7453	112.82	7941	108.98	11447	84.75	29475
2018-2022	3330	85.61	11540	93.17	13008	95.21	27386	108.14	55264
Total	5964		18993		20949		38833		84739

Table 8 shows that Co-Authorship Index values are calculated by block year period for Network Securityresearch publications for the selected 10- year study period. From the study, it is identified that CAI for single, two, and three authorship contributions are decreasing trend from 1st block year to 2nd block year. At the same time, CAI is increasing trend for more than three authors from 1st block year (84.75) to 2nd year block year (108.14).

Time Series Analysis

Time series analysis reveals the estimated growth values are identified based on previous data. A straight–line equation is adapted to measure the future values based on previous data. Time series analysis used by **Jeyshankar and Ramesh babu (2013)**[20]**Ravichandran (2020)**[21]

Time series analysis of network security research publications

Table 9: Time series analysis of network security research publications

Year	Count (Y)	X	X2	XY
2013	3650	-5	25	-18250
2014	4826	-4	16	-19304
2015	5991	-3	9	-17973
2016	6576	-2	4	-13152
2017	8432	-1	1	-8432
2018	10160	1	1	10160
2019	11282	2	4	22564
2020	10673	3	9	32019
2021	11907	4	16	47628
2022	11242	5	25	56210
Total	84739		110	91470

Table 9 shows that the time series analysis formula has been predicted for Network Security research publications for the years 2025 and 2030.

The straight Line Equation is

$Y = a + bx$

Here,

$\sum Y = 84739$, $\sum X^2 = 110$, $\sum XY = 91470$

$a = \sum Y/N = 84739/10 = 8473.9 = 8473$

$b = \sum XY/\sum X^2 = 91470/110 = 831.54 = 831$

Estimated publications in the year 2025 are when X=2025-2015=10

$Y = a + bx$

= 8473+ (831*10) = 8473+8310 = 16783

Estimated literature in 2030 is when X=2030-2015=15

Y = a + bx

= 8473 + (831*15) = 8473+12465 = 20938

The estimated growth based on a time series analysis statistical application will be expected in the Network Securityresearch publications in the year 2025 is around equal to 16783 and the year 2030 is around equal to 20938. So that time serious analysis confirmed that the publications on Network Securityresearch are increasing trend.

Document types of network security research publications

Table 10: Document type of network security research publications

Document type	No. of articles	%	Cumulative	%
Conference Paper	50492	59.59	50492	4.41
Article	30545	36.05	81037	7.08
Book Chapter	1737	2.05	82774	7.23
Review	1210	1.43	83984	7.34
Conference Review	336	0.40	84320	7.37
Book	217	0.26	84537	7.39
Editorial	58	0.07	84595	7.39
Short Survey	43	0.05	84638	7.39
Retracted	36	0.04	84674	7.40
Data Paper	15	0.02	84689	7.40
Erratum	14	0.02	84703	7.40
Letter	13	0.02	84716	7.40
Note	11	0.01	84727	7.40
Undefined	12	0.01	84739	7.40
Total	84739	100.00	1144625	100.00

Document types identified during the 10-year study period on Network Securityresearch publications are shownin table 10. From the study, it is identified that a maximum of 50492(59.59%) research publications are contributed by Conference Paper, followed by 30545(36.05%) research publications areArticle and third placed in the book chapter with 1737(2.05%) research publications. The lowest document type of Note 11(0.01%) research publications. This study confirmed that more than 96% of research publications are contributed by Conference Paperand articles. Remaining nearby 4% of research publications are identified in the other form documents.

Journal's contributions to network security research publications

Table 11: Journal's contributions to network security research publications

S.No	Journal	No. of articles	%	Citations	%	H-Index	CPP	RCI
1	Lecture Notes in Computer Science Including Subseries, Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	5521	33.63	34844	32.69	65	6.31	0.97
2	ACM International Conference Proceeding Series	2163	13.17	8123	7.62	33	3.76	0.58
3	IEEE Access	2058	12.54	43212	40.54	81	21.00	3.23
4	Advances in Intelligent Systems and Computing	1500	9.14	4315	4.05	21	2.88	0.44
5	Communications in Computer and Information Science	1297	7.90	3072	2.88	20	2.37	0.36
6	Security and Communication Networks	821	5.00	7784	7.30	41	9.48	1.46
7	Lecture Notes in Electrical Engineering	798	4.86	1128	1.06	12	1.41	0.22
8	Journal of Physics Conference Series	793	4.83	980	0.92	13	1.24	0.19
9	Proceedings of SPIE the International Society for Optical Engineering	767	4.67	1400	1.31	14	1.83	0.28
10	Lecture Notes of the Institute for Computer Sciences Social Informatics and Telecommunications Engineering Lnicst	700	4.26	1726	1.62	14	2.47	0.38
	Total	16418	100.00	106584	100.00			

Table 11 shows the top 10 journals' contributions in the field of Network Security research. From the study, it is identified that the maximum of 5521(33.63%) research publications are contributed by the Lecture Notes in Computer Science Including Subseries, Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics, followed by ACM International Conference Proceeding Series with 2163 (13.17%) research publications, third-placed in the IEEE Access with 2058(12.54%) research publications. During 10 the year study period the highest citations were 43212(40.54%) from the Journal of IEEE Access, the CPP is 21.00, the H-Index is 81 and RCI is 3.23. The Lowest citations of 980(0.09) Journal of Physics Conference Series, the CPP is 1.41, the H-Index is 13 and the RCI is 0.19During the 10 year study period top 10 journals are contributed by 16418(100%) research publications.

Top 10 Institution contributions to network security research publications

Table 12: Top 10 Institution's contributions to network security research publications

institutions	Publications	%	Citations	%	H-Index	CPP	RCI
Chinese Academy of Sciences	1553	17.93	18211	19.64	59	11.73	1.10
Beijing University of Posts and Telecommunications	1071	12.36	9312	10.05	43	8.69	0.81
Ministry of Education China	990	11.43	11858	12.79	53	11.98	1.12
Xidian University	917	10.59	13160	14.20	57	14.35	1.34
Institute of Information Engineering	850	9.81	7525	8.12	39	8.85	0.83
University of Chinese Academy of Sciences	776	8.96	5271	5.69	31	6.79	0.63
Tsinghua University	713	8.23	11242	12.13	48	15.77	1.47

University of Electronic Science and Technology of China	622	7.18	7641	8.24	42	12.28	1.15
National University of Defense Technology China	610	7.04	3531	3.81	29	5.79	0.54
CNRS Centre National de la Recherche Scientifique	560	6.47	4950	5.34	31	8.84	0.83
Total	8662	100.00	92701	100.00			

During the 10-year study period, the top 10 institutions' contributions are identified in table 12, from the study the maximum of 1553 (17.93%) contributions are Chinese Academy of Sciences, followed by Beijing University of Posts and Telecommunications with 1071(12.36%) research publications, Ministry of Education China contributed with 990(11.43%) research publications.The highest citations were 18211(19.64%) from the Chinese Academy of Sciences, and the CPP is 11.73, the H-Index is 59, and RCI is 1.10. The lowest citations of 3531(3.81%) National University of Defense Technology China, and the CPP is 5.79, H-Index is 29 and RCI is 0.54. During 10 the year study period Top 10 institutions are contributed by 8662 (100%) research publications.

Top 14 Countries' contributions to network security research publications

Table 13: Country-wise contributions to network security research publications

Country	No of articles	%	Citations	%	H- Index	CPP	RCI
China	23141	32.24	295880	23.72	189	12.79	0.74
United States	15869	22.11	230882	18.51	163	14.55	0.84
India	13005	18.12	97227	7.79	103	7.48	0.43
United Kingdom	4160	5.80	65295	5.23	106	15.70	0.90
Germany	3225	4.49	34587	2.77	72	10.72	0.62
South Korea	2671	3.72	372121	29.83	77	139.32	8.01
Australia	2604	3.63	51091	4.10	97	19.62	1.13
France	2429	3.38	25840	2.07	67	10.64	0.61
Canada	2416	3.37	44795	3.59	93	18.54	1.07
Italy	2252	3.14	29845	2.39	69	13.25	0.76
Total	71772	100.00	1247563	100.00			

Table 13 shows the top 10 countries' research publications for Network Securityresearch during the study period from 2013-2022. From this study, it is identified that a maximum of 23141 (32.24%) research publications are contributed by the China, followed by United Stateswith 15869 (22.11%) research publications, and third place is the Indiawith 13005(18.12%) research publications. During ten year study period the highest number of citations was 295880 (23.72%) in the China, the CPP is 12.79, the H-index is 189 and RCI is 0.74. The lowest citations ofwere25840 (2.07%) in France. The CPP is 10.64, the H-index is 67 and RCI is 0.61. The top 10 countries contributed 71772(100%) research publications.

Top 10: Funding agency's contributions to network security research publications

Table 14: Top 10 Funding agency's contributions to network security research publications

Funding agency	Publications	%
National Natural Science Foundation of China	8873	44.11
National Science Foundation	3548	17.64
National Key Research and Development Program of China	1699	8.45
Horizon 2020 Framework Programme	1404	6.98
Fundamental Research Funds for the Central Universities	1288	6.40
European Commission	786	3.91
National Research Foundation of Korea	777	3.86

Japan Society for the Promotion of Science	616	3.06
Engineering and Physical Sciences Research Council	615	3.06
Natural Sciences and Engineering Research Council of Canada	509	2.53
Total	20115	100.00

Table 14 shows the top 10 funding agencies' research publications for Network Security research during the study period from 2013-2022. From this study, it is identified that a maximum of 8873(44.11%) research publications are contributed by the National Natural Science Foundation of China, followed by National Science Foundation with 3548 (17.64%) research publications, and third place is the National Key Research and Development Program of China with 1699 (8.45%) research publications. The top 10 funding agencies contributed 20115(100%) research publications.

Top 10: Keyword contributions to network security research publications

Table 15: Top 10 Keyword contributions to network security research publications

Keyword	No. of articles	%
Network Security	82363	54.08
Cryptography	10190	6.69
Internet of Things	9425	6.19
Computer Crime	8866	5.82
Security	8801	5.78
Authentication	8550	5.61
Intrusion Detection	7838	5.15
Denial-of-service Attack	6491	4.26
Cloud Computing	5336	3.50
Security Systems	4449	2.92
Total	152309	100.00

Table 15 shows the top 10 funding agencies' research publications for Network Security research during the study period from 2013-2022. From this study, it is identified that a maximum of 82363 (54.08%) research publications are contributed by the Network Security, followed by Cryptographywith 10190 (60.69%) research publications, and third place is the Internet of Things with 9425 (6.19%) research publications. The top 10 funding agencies contributed 152309(100%) research publications.

Highly cited paper network security research publications

Table 16: Highly cited paper network security research publications

S. no	Titles	Citations	Document Type
1	Carlini, N., and Wagner, D. *et al.* (2017) Towards Evaluating the Robustness of Neural Networks, Proceedings - IEEE Symposium on Security and Privacy, article no: 7958570, 39-57.	3024	Conference Paper
2	Islam, S.M.R., *et al.* (2015) The internet of things for health care: A comprehensive survey, IEEE Access, 3, article: 7113786, 678-708.	1759	Article
3	Papernot, N., *et al.* (2017) Practical black-box attacks against machine learning, ASIA CCS 2017 - Proceedings of the 2017 ACM Asia Conference on Computer and Communications Security, 506-519.	1421	Conference Paper

S. no	Titles	Citations	Document Type
4	Pasqualetti, F., *et al.* (2013) Attack detection and identification in cyber-physical systems, IEEE Transactions on Automatic Control, 58(11):2715-2729.	1352	Article
5	Khan, M.A., and Salah, K. (2018) IoT security: Review, blockchain solutions, and open challenges, Future Generation Computer Systems, 82, 395-411.	1308	Article
6	Zuboff, S. (2015) Big other: Surveillance capitalism and the prospects of an information civilization, Journal of Information Technology, 30(1):75-89.	1084	Article
7	Kolias, C., *et al.* (2017) DDoS in the IoT: Mirai and other botnets, Computer, 50(7):80-84.	1066	Article
8	Luu, L., Chu, *et al.* (2016) Making smart contracts smarter, Proceedings of the ACM Conference on Computer and Communications Security, 24-28-October-2016, 254-269.	1021	Conference Paper
9	Antonakakis, M., *et al.* (2017) Understanding the mirai botnet, Proceedings of the 26th USENIX Security Symposium, 1093-1110.	1013	Conference Paper
10	Shokri, R., ans Shmatikov, V. (2015) Privacy-preserving deep learning, Proceedings of the ACM Conference on Computer and Communications Security, 2015-October, 1310-1321.	957	Conference Paper

Table 16 the highly cited papers in Network Security research publications during the selected 10-year study period. From the study, it is identified that a maximum of 3024 citations are received for the publication of Carlini, N., and Wagner, D. *et al.* (2017) Towards Evaluating the Robustness of Neural Networks, Proceedings - IEEE Symposium on Security and Privacy, article no: 7958570, 39-57. Followed by 1759 citations by Islam, S.M.R., *et al.* (2015) The internet of things for health care: A comprehensive survey, IEEE Access, 3, article: 7113786, 678-708, and 1421Papernot, N., *et al.* (2017) Practical black-box attacks against machine learning, ASIA CCS 2017 - Proceedings of the 2017 ACM Asia Conference on Computer and Communications Security, 506-519. The top 10 highly cited publications are covered by 05 articles and 05 conference papers.

MAJOR FINDING

- During the 10-year study period year-wise growth of Network Security research publications between 2013 and 2022 with 84739 research publications and 793177 citations. A maximum of 1907(14.05%) research publications are contributed in the year 2021.
- During the authorship a maximum of 157 (13.62%) research publications are contributed by Das, A.K. The China. The relative growth rate is 0.84 in the year 2014 and 0.14 in the year 2022. This study confirmed that the relative growth rate is decreasing trend. At the same time doubling time was found that 0.83 in the year 2014 and 4.89 in the year 2022 and it is confirmed that doubling time is an increasing trend.
- During the subject a maximum of 69062 (81.34%) research publications are contributed by Computer Science, Tthe authorship pattern, 5964 research publications are contributed by single authors, and the average degree of collaboration is 0.92. The collaboration coefficient of the average is 0.62. The collaboration Index average is 3.29. The Modified collaboration coefficient of the average is 3.29.
- During the study period CAI for single, two, and three authorship contributions are decreasing trend from 1st block year to 2nd block year. At the same time, CAI is increasing trend for more than three authors from 1st block year (84.75) to 2nd year block year (108.14).
- The time series analysis statistical application will be expected in the Network security research publications in the year 2025 is around equal to 16783 and the year 2030 is around equal to 20938. So that time serious analysis confirmed that the publications on Network security research are increasing trend.
- The document types a maximum of 50492 (59.59%) research publications

are contributed by conference paper,the journal of the maximum of 5521 (33.63%) research publications are contributed by the Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence and Lecture Notes In Bioinformatics.

- During the Institute a maximum of 1553 (17.93%) contributions are Chinese Academy of Sciences, the country, a maximum of 5521 (33.63%) research publications are contributed by the China, and the funding agency is a maximum of 8873 (44.11%) research publications contributed by the National Natural Science Foundation of China.
- During the maximum of 3024 citations are received for the publication of Carlini, N., and Wagner, D. *et al.* (2017) Towards Evaluating the Robustness of Neural Networks, Proceedings - IEEE Symposium on Security and Privacy, article no: 7958570, 39-57.

CONCLUSION

As the internet grows in popularity, network security becomes increasingly critical. The security threats and internet protocol should be examined to identify the necessary security technologies. Security technology is largely software-based, but it also includes numerous physical components. The Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics contributes the most research publications (5521, 33.63%) to the journal. The Institute receives a maximum of 1553 (17.93%) contributions. The Chinese Academy of Sciences, the country, contributes a maximum of 5521 (33.63%) research papers. In addition network Security consists of the provisions made in an underlying computer network infrastructure, policies adopted by the network administrator to protect the network and the network-accessible resources from unauthorized access and the effectiveness (or lack) of these measures combined together.

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