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Indian Research Output on Cloud Computing Research during the period 2009-2018: A Scientometric Analysis

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Abstract

The present study aims to analyze the Indian research output on cloud computing research during the period of last 10 years i.e. 2009-2018. The data was collected through the Scopus database which is owned by Elsevier. The study examines and analysis many scientometrics parameters like; year-wise distribution of publications; annual growth rate of publications; relative growth rate and doubling time of publications; most productive authors; significant keywords and found that the highest 1797 (23%) of research papers were published in 2018 while the maximum 287.50 annual growth rate was recorded in 2010 and the highest relative growth 1.58 was recorded in the year 2010 forever the highest 2.65 doubling time was recorded in 2018. Chandrasekaran, K. was the most prolific author with a maximum of 39 research papers contributed to cloud computing research in India from 2009-2018. The most significant keyword was 'Cloud Computing' used in 5981 publications from the marked period of study.

Keywords: Cloud Computing, Scientometric, Annual Growth Rate, Relative Growth Rate and Doubling Time, Productive Authors.

1. Introduction

Cloud computing has recently emerged as a buzz word in the distributed computing community. It's a model for enabling convenient, on demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. (Mella, 2009)[1]. "In the modern era, cloud computing technology is changing our world rapidly; it's touching every single part of life like medicinal, water supply, traffic control, power grids etc." (Shukla, 2019)[2] Many believe that Cloud is going to reshape the IT industry as a revolution.

2. Literature Review

Shukla (2019)[3] carried out a scientometric analysis on genetic disorder research during the period 2008-2017 in which a total 3673 records were published. The maximum 504 (13.72%) of research papers were published in the year 2017 and it was observed that the maximum annual growth was 36.27 recorded in 2012 while the most prolific author was Ghosh, K with

66 publications. Forever, the maximum 2585 (70.38%) of records were article type documents.

Shukla et al (2019)[4] investigated a bibliometric analysis in research publications pattern if faculties of library and information science department, Mizoram University, Aizawl during the period 2008-2017. The maximum annual growth 366.67 was found in the year 2010 while the maximum relative growth 1.099 found in 2010 and doubling time 2.806 recorded in 2017. The maximum 119 records were articles type document, followed by conference proceeding with 93 publications during the period of study.

Gaud (2019)[5] conducted a scientometric on robotics research from the marked period 2009-2018. The primary data was downloaded by the Scopus database and found that the maximum 791 (18.29%) of research papers were published in the year 2018. It has been also found that the maximum annual growth was 142.54 recorded in 2010; relative growth was 1.23 in 2010; doubling time was 3.43 in 2018. The average degree of authors collaboration was 0.93 recorded from the marked period of study. Krishna, K M was contributed 51 research results and the maximum 2704 (62.52%) of records were conference paper type document during the period of study.

Verma and Shukla (2019)[6] conducted a scientometric study on information literacy research of selected countries from 2008-2017. The primary data was collected by the Scopus database in which a total 9496 records were found. The highest annual growth 25.68% was recorded in 2010while the highest relative growth 0.795 and doubling time 5.82 was found in the year 2009 and 2017 respectively. The most famous authors was Wolf, M. S. with 65 contributions and the highest 71.59% of records were article type document found during the period of study.

Gaud et al (2018)[7] investigated a bibliometric analysis in the discipline of a faculty member of library and information science department of BBAU, Lucknow from the marked period 1991-2017. The total umbers of 426 publications were found in which the maximum annual growth was 332 recorded in 2007; relative growth was 0.747 and doubling time was 0.928 recorded in 1993. The average degree of collaboration was 0.783 found during the period of study.

3. Objectives of the study

The main objectives of the study are:

- To analysis the year wise distribution of publications.
- To determine the Annual Growth Rate (AGR) of publications.
- To find out the Relative Growth Rate and Doubling Time of Publications.
- To analysis the most Productive Authors Name.
- To identify the Document Wise Publication Distribution.

4. Methodology

The primary data was collected by the Scopus database, which is a product of Elsevier. The study is limited to 10 years i.e. (2009-2018) and it has been shown that a total 7813 research papers were published in cloud computing research which were indexed in the Scopus databases. The following searching string has been used to collect the data i.e. (TITLE-ABS-

KEY("Cloud Computing") AND (LIMIT-TO (PUBYEAR,2018) TO (PUBYEAR,2009)) AND (LIMIT-TO (PUBSTAGE,"final")) AND (LIMIT-TO (AFFILCOUNTRY,"India"))). Only final published research papers was taken for conducting the study and using MS Excel application software for statically calculations.

5. Data Analysis

Year wise distributions of publications

Year wise distributions of research papers were shown in the below table 1. The maximum 1797 (23%) of publications were published in the ending year of the study i.e. 2018, followed by 1602 (20.50%) of articles were published in 2016 while the minimum 16 (0.20%) of records were published in the beginning year i.e. 2009. The overall year wise distributions of publications were shown in table 1.

Table 1: Year Wise Distribution of Publications

Year	No. of Publications	% of Publications
2009	16	0.20
2010	62	0.79
2011	218	2.79
2012	399	5.11
2013	482	6.17
2014	702	8.99
2015	1132	14.49
2016	1602	20.50
2017	1403	17.96
2018	1797	23.00
Total	**7813**	**100.00**

Year Wise Annual Growth of Publications

Year wise annual growth of records in cloud computing was depicts in table 2 in which the highest (287.50) annual growth was recorded in the year 2010, followed by (251.61) in the next year i.e. 2011 and the annual growth has been shown in fluctuating trends during the period of study. The minimum (-12.42) annual growth was recorded in 2017. The similar scientometric study on digital library conducted by (Shukla and Verma, 2019)[8] and found that the fluctuating trend also there in annual growth rate like the particular study. The Annual Growth Rate (AGR) is calculated on the formula given by (Kumar and Kaliyaperumal, 2015)[9]. The whole details of year wise annual growth were shown in table 2.

$$AGR = \frac{EndValue - FirstValue}{FirstValue} \times 100$$

Table 2: Year Wise Annual Growth of Publications

Year	No. of Publications	Annual Growth Rate
2009	16	0
2010	62	287.50
2011	218	251.61
2012	399	83.03
2013	482	20.80
2014	702	45.64
2015	1132	61.25
2016	1602	41.52
2017	1403	-12.42
2018	1797	28.08

Relative Growth Rate and Doubling Time of Publications

The relative growth and doubling time shows in below table 3 in which it has been observed that the relative growth was shown in decreasing trends between (1.58-0.26) while the doubling time has been shown in increasing trend between (0.44-2.65). The whole data of relative growth and doubling time was shown in below table 3. The similar Scientometric study conducted on the cervical cancer by (Ali and Bharati, 2019)[10] in which they were found that the same type of relative growth rate shown in decreasing trend while Dt also same recorded in increasing trend like the particular study. The formula of relative growth rate was given by (Mahapatra in the year 1985)[11] below.

$$\boldsymbol{RGR = \frac{W2-W1}{T2-T1}}$$

Where,
RGR = Growth Rate over the specific period of the interval,
W1 = Loge (natural log of the initial number of contributions)
W2 = Loge (natural log of the final number of contributions)
T1 = the unit of initial time
T2 = the unit of final time

Doubling Time: The formula of corresponding Dt for contributions and pages measurement.

$$\boldsymbol{DoublingTime(Dt) = \frac{0.693}{R}}$$

Table 3: Relative Growth Rate and Doubling Time of Publications

Year	No. of Publications	Cumulative Sum	W1	W2	RGR	Dt
2009	16	16	0	2.77	0	0
2010	62	78	2.77	4.36	1.58	0.44
2011	218	296	4.36	5.69	1.33	0.52

2012	399	695	5.69	6.54	0.85	0.81
2013	482	1177	6.54	7.07	0.53	1.32
2014	702	1879	7.07	7.54	0.47	1.48
2015	1132	3011	7.54	8.01	0.47	1.47
2016	1602	4613	8.01	8.44	0.43	1.62
2017	1403	6016	8.44	8.70	0.27	2.61
2018	1797	7813	8.70	8.96	0.26	2.65

The Productive Authors in Cloud Computing Research

The top 15 most productive authors in cloud computing research during the period 2009-2018 depicts in below table 4. A large number 39 of research papers was contributed by Chandrasekaran, K., followed by Chana, I. with 38 contributions in clouding computing research in India and Sahoo, B. contributed 35 research papers during the period of study. The overall data about top 15 most prolific authors was shown in below table 4.

Table 4: Top 15 Most Productive Authors in Cloud Computing Research

S. N.	Authors Name	No. of Publications
1	Chandrasekaran, K.	39
2	Chana, I.	38
3	Sahoo, B.	35
4	Buyya, R.	30
5	Singh, S.	28
6	Sood, S.K.	28
7	Gupta, B.B.	26
8	Sarddar, D.	26
9	Jana, P.K.	25
10	Misra, S.	25
11	Pattnaik, P.K.	25
12	Balamurugan, B.	24
13	Varalakshmi, P.	24
14	Aramudhan, M.	23
15	Vidyarthi, D.P.	23

Subject Area Wise Distribution of Publications

The subject area wise distribution of publications illustrates in below table 5. The maximum 6215 publications were came in the subject field of Computer Science, followed by Engineering subject with 3009 publications and the field of mathematics subject 1240 publications. The overall data of top 15 subject area wise distribution of publications has been shown in table 5.

Table 5: Top 15 Subject Area Wise Distribution of Publications

S. N.	Subject Area	No. of Publications
1	Computer Science	6215
2	Engineering	3009
3	Mathematics	1240
4	Decision Sciences	736
5	Medicine	359
6	Physics and Astronomy	357
7	Social Sciences	255
8	Energy	227
9	Business, Management and Accounting	222
10	Biochemistry, Genetics and Molecular Biology	166
11	Pharmacology, Toxicology and Pharmaceutics	159
12	Multidisciplinary	153
13	Materials Science	152
14	Environmental Science	133
15	Chemical Engineering	103

Type of Publication in Cloud Computing Research

The different types of publications in cloud computing research revels in below table 6. The highest 4849 (62.06%) of records were conference papers type documents, followed by Article type documents with 2540 (32.51%) of records and 293 (3.75%) of research papers were Book chapter type documents. Review type document 82 (1.05%); Book type document 29 (0.37%); Editorial type documents 15 (0.19%); Erratum and Short survey type document 2 (0.03%) each; Letter type document 1 (0.01%).

Table 6: Type of Publication in Cloud Computing Research

S. N.	Type of Publications	No. of Publications	% of Publications
1	Conference Paper	4849	62.06
2	Article	2540	32.51
3	Book Chapter	293	3.75
4	Review	82	1.05
5	Book	29	0.37
6	Editorial	15	0.19
7	Erratum	2	0.03
8	Short Survey	2	0.03
9	Letter	1	0.01

Top 10 Source Title in Cloud Computing Research

The top 10 source title in cloud computing research depicts in below table 7 in which the highest 371 publication's source title is 'International Journal of Applied Engineering Research', followed by 'Advances in Intelligent Systems and Computing' source title with 362 publications and 'ACM International Conference Proceeding Series' source title with 176

publications. The overall data of top 10 source title in clouding computing research has been shown in below table 7.

Table 7: Top 10 Source Title in Cloud Computing Research

S. N.	Source Title	No. of Publications
1	International Journal of Applied Engineering Research	371
2	Advances in Intelligent Systems And Computing	362
3	ACM International Conference Proceeding Series	176
4	Communications in Computer and Information Science	152
5	Proceedings of The 8th International Conference Confluence 2018 on Cloud Computing Data Science and Engineering Confluence 2018	150
6	Procedia Computer Science	133
7	Proceedings of The 7th International Conference Confluence 2017 on Cloud Computing Data Science and Engineering	127
8	Journal of Advanced Research in Dynamical and Control Systems	120
9	International Journal of Pharmacy And Technology	107
10	Indian Journal of Science and Technology	106
11	International Journal of Control Theory and Applications	92
12	Smart Innovation Systems and Technologies	78
13	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics	75
14	Journal of Theoretical and Applied Information Technology	70
15	International Journal of Engineering and Technology	64

Top 10 Significant Keywords and Affiliation in Cloud Computing Research

The top 10 significant keywords and affiliation in cloud computing research reveled in below table 8. The 'Cloud Computing' keywords used in 5981 publications, followed by 'Digital Storage' with 1091 publications and 'Distributed Computer Systems' keyword used in 1000 publications while the most productive affiliation was 'Vellore Institute of Technology' with 358 contributions, followed by 'Anna University' with 313 contributions and 'Sthyabama Institute of Science and Technology' was contributed 216 publications during the period of study. The overall data of top 10 keywords and affiliation has been shown in below table 8.

Table 8: Top 10 Significant Keywords and Affiliation in Cloud Computing Research

S. N.	Significant Keywords	No. of Publications	Affiliation Name	No. of Publications
1	Cloud Computing	5981	Vellore Institute of Technology	358
2	Digital Storage	1091	Anna University	313
3	Distributed Computer Systems	1000	Amity University, Noida	216
4	Cryptography	789	Sathyabama Institute of Science and Technology	147
5	Network Security	652	KoneruLakshmaiah Education	129

			Foundation	
6	Scheduling	551	Thapar Institute of Engineering & Technology	126
7	Cloud Environments	541	IBM, India	104
8	Big Data	534	National Institute of Technology Karnataka	101
9	Resource Allocation	529	SASTRA Deemed University	98
10	Security	509	Bharathiar University	96
11	Quality of Service	487	National Institute of Technology Kurukshetra	79
12	Cloud Service Providers	480	Indian Institute of Technology Roorkee	78
13	Virtual Machine	447	Guru Nanak Dev University	77
14	Virtualization	438	Kalinga Institute of Industrial Technology, Bhubaneswar	77
15	Data Privacy	431	Panjab University	74

6. Major Findings

- The highest1797 (23%) of research paper published in 2018, it's a last year of the study, while the minimum 16 (0.20%) of research papers were published in the starting year of the study i.e. 2009.
- The maximum 287.50 annual growth rate was found in 2010 while the minimum -12.42 annual growth rate was found in 2017.
- The maximum 1.58 relative growth rate was found in 2010, while the minimum 0.26 was recorded in the last year of the study i.e. 2018.
- The maximum 2.65 of doubling time was found in 2018 while the minimum 0.44 was found in 2010.
- The maximum 39 contributions were contributed by Chandrasekaran, K., followed by 38 contributions by Chana, I. in cloud computing research.
- Computer science was the most famous subject field in cloud computing research while the maximum 4849 (62.06%) of records were conference papers type documents during the period of study.
- International Journal of Applied Engineering Research was the most famous source title, while cloud computing keyword was used maximum time in the publications.
- Vellore Institute of Technology was the most prolific affiliation with 358 publications in cloud computing research in India.

7. Conclusion

This paper deals with various scientometric parameters and mesuresed productivity of cloud computing research in India. Cloud computing is very useful for the entire field like- Library sector, Database, Medical, Huge data storage etc. "Cloud Computing, the long-held dream of computing as a utility, has the potential to transform a large part of the IT industry, making software even more attractive as a service and shaping the way IT hardware is designed and purchased. Developers with innovative ideas for new Internet services no longer require the large capital outlays in hardware to deploy their service or the human expense to operate it. They need not be concerned about over provisioning for a service whose popularity does not

meet their predictions, thus wasting costly resources, or under provisioning for one that becomes wildly popular, thus missing potential customers and revenue. Moreover, companies with large batch-oriented tasks can get results as quickly as their programs can scale, since using 1000 servers for one hour costs no more than using one server for 1000 hours. This elasticity of resources, without paying a premium for large scale, is unprecedented in the history of IT." (Fox et al., 2009)[12].

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