Internet of Things: Reflected on Web of Science

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Abstract— The Internet of Things (IoT) usually refers to a world- wide network of interconnected heterogeneous objects such as sensors, actuators, smart–devices or objects or components or products, RFID, embedded computers, etc. uniquely addressable, based on standard communication protocols. The explosive research growth of the IoT is changing our world and allowing people to innovate concept. The present study aims to analysis at mapping the global research efforts related to Internet of Things using scientometric techniques. Scientometric is a series of analyses used for evaluating or quantifying literature and information. It is a scientific method widely used in many fields.

Index Terms— Internet of Things, IOT, Research Productivity, Web of Knowledge, Web of Sciences, Scientometric Analysis

I. INTRODUCTION

Internet of Things (IoT) is a new paradigm that refers to a world-wide network of interconnected physical things using standardized communication protocols to provide human useful services such as personal health care and green energy monitoring [1]. The IOT is enabled by the latest developments in wireless technologies, smart sensors, communication technologies and Internet.

The Internet of Things brings together two key concepts: Internet-connected devices everywhere in any time and any place and ubiquitous computing, where "the most profound technologies are those that disappear" in such a way that these devices made themselves indistinguishable from explicit technology that the humans use in their lives [2]. IoT aims at increasing the ubiquity of the Internet by integrating every object for interaction via embedded systems and leads to the highly distributed network of devices communicating with human beings as well as other devices [3]. The present study is to identify the state of Internet of Things research internationally and plot trends over time, to identify the institutions which undertake IOT research and to pinpoint the scientific specialties which are emphasized in the field. The results of the investigation could possibly constitute benchmarks for monitoring the evolution of the research in this field and the impact of the outbreak on research efforts internationally.

II. OBJECTIVES

The main objectives of this study are to study the performance of global research on IoT during 2004–2015, based on publications output, as indexed in Web of Science database. In particular, the study focuses on the following objectives:

- To study the year wise growth of research output
- To study the distribution by type and language of documents and sources;
- To study the country wise distribution pattern of the global research output ;
- To study the contribution, global share, and citation impact of top 10 most productive countries;
- To study the distribution of global research output by broad subject areas;
- To study the publication productivity and citation impact of most productive top 10 authors;
- To study the most productive journals; and to study highly cited papers between 2000- 2015.

III. METHODS

A. Data source

Web of Science™ (Web of Knowledge) is an online subscription-based scientific citation indexing service maintained by Thomson Reuters (New York, USA). It provides citation search, giving access to multiple databases that reference cross-disciplinary research and allowing for an in-depth exploration of specialized subfields [13]. We sought articles from Web of Science/ Knowledge Citation Database. Two citation indexes, namely Science Citation Index Expanded and Social Sciences Citation Index®, were included. The keyword "Internet of Things" was used to identify papers for the purposes of this review. In order to include all published items, we used the Basic Search method to search Web of Science. This review is concerned with four types of papers on Internet of Things: articles, reviews, editorial materials, and news items. T. The retrieved papers were assessed using the following criteria: (1) publication year, (2) document type, (3) language(s), (4) countries/territories, (5) institution(s), (6) author(s), (7) research field, (8) journal of publication, and (9) number of citations. The search was done on July 20, 2016.

B. Data analysis

The analyses were performed using the analysis functions in Web of Science and the statistics functions in Origin Pro 7.5. The results of the analyses are displayed in the figures and tables.

IV. FINDINGS

A. Growth of Literature: Yearwise Research Output

A total of 1598 papers on Internet of things, published between 2000 and 2015 were retrieved from Web of Science. From 2002 to 2008, the publication rate remained low, at about two articles per year. From 2009 to 2010, the publication rate increased to 14 and 37 respectively. This was followed by several publication peaks in 2011, 2012, 2013, 2014 and 2015. The number of publications has been steadily increasing since 2011, when 70 papers were published, which was followed by a significant increase to 707 (44.243%) in 2015 indicated that this field has been attracting more attention.
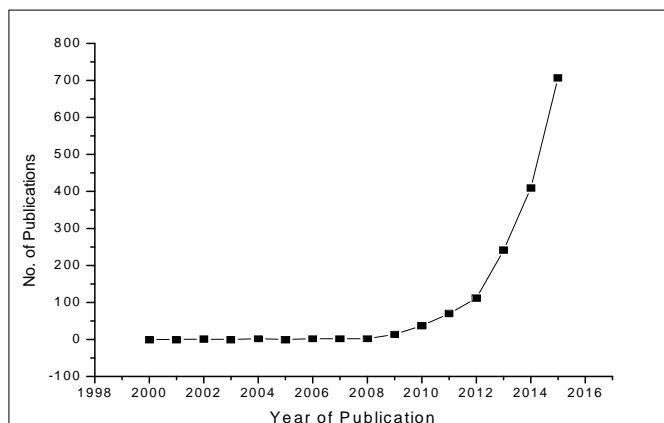

Figure1. Number of Publications on internet of things in WOS 2000 - 2015

TABLE I. YEAR-WISE RESEARCH OUTPUT

Year	Publications	%
2004	2	0.13
2006	2	0.13
2007	2	0.13
2008	2	0.13
2009	14	0.88
2010	37	2.32
2011	70	4.38
2012	111	6.95
2013	241	15.08
2014	409	25.59
2015	707	44.24

B. Types and language –wise output

The analysis of document types showed that original research articles (n = 1420, 88.861 %) were the most common type of papers about Internet of Things indexed in the Web of Science between 2000 and 2015. Other document types included editorial materials (n = 103, 6.446 %), reviews (n = 43, 2.691 %). proceeding papers (n= 36,2.253%), news items (n = 15, 0.939 %),meeting abstracts(n=7, 0.438), book review (n=6, 0.375)and The analysis indicated that 98.561 % of the literature in this field was in English(n= 1575). The remaining publications were in Spanish (n = 7, 0.438 %), German (n = 5, 0.313 %), and other languages.

TABLE II. TYPES OF PUBLICATIONS

Document Types	Records	% of 1598
Article	1420	88.861
Editorial material	103	6.446
Review	43	2.691
Proceedings paper	40	2.503
News item	15	0.939
Meeting abstract	7	0.438
Book review	6	0.375
Correction	3	0.188

TABLE III. LANGUAGE-WISE OUTPUT

Languages	Records	% of 1598
English	1575	98.561
Spanish	7	0.438
German	5	0.313
Portuguese	4	0.25
Chinese	3	0.188
French	2	0.125

C. Country/territory wise output on Internet of Things

Analysis of the contributions of different countries/territories to Internet of Things research was based on journal articles, in which addresses and affiliations of at least one author were provided. The China has the highest scientific output worldwide with 456 papers (32.11%), followed by USA (252 papers; 17.75%) Spain (139 papers;9.79%), South Korea (112;7.89) and England (110papers; 7.75%)., India with 27 papers (1.90 %), ranked 16th Place. 63 records (3.942%) do not contain data in the field being analyzed

TABLE IV. TOP 10 COUNTRY-WISE SHARE OF PUBLICATION

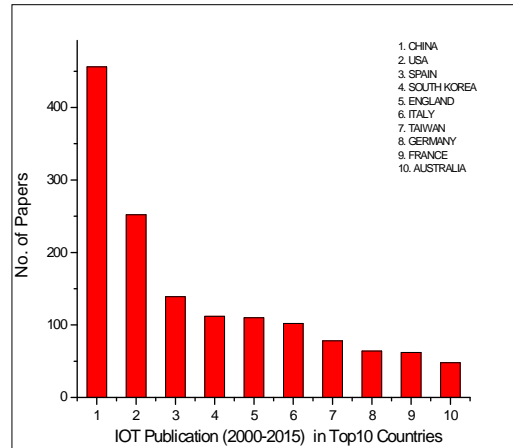| Countries/Territories	Papers	% of 1598
CHINA	493	30.851
USA	302	18.899
SPAIN	148	9.262
ENGLAND	130	8.135
SOUTH KOREA	118	7.384
ITALY	115	7.196
TAIWAN	82	5.131
FRANCE	69	4.318
GERMANY	67	4.193
AUSTRALIA	51	3.191

Figure 2 . IOT Publication (2000-2015) in Top10 Countries

D. Authors of papers about IOT published between 2000 and 2015

Overall, 4357 authors wrote the 1598 papers retrieved, giving an average of 2.73 authors per publication. Xu LD published 30 papers 1.87 %) which was much higher than any other author The 10 most published authors wrote 122 papers and were cited 1358 times. Average Citations per item is 11.13. The H-index was 21

TABLE V. TOP 10 PRODUCTIVE AUTHORS

Authors	Address	Papers	% of 1598	No. of Citations
XU LD	Old Dominion Univ, Dept Informat Technol & Decis Sci, Norfolk, VA 23529 USA	30	24.59	779
JARA AJ	Univ Appl Sci Western Switzerland HES SO, Inst Informat Syst IIG, Sierre, Switzerland	21	17.21	197
SKARMETA AF	Univ Murcia, Fac Comp Sci, Dept Informat & Commun Engn, E-30100 Murcia, Spain	19	15.57	113
ZHANG Y	Fudan Univ, Software Sch, Shanghai 200433, Peoples R China	12	9.84	57
YANG LT	St Francis Xavier Univ, Dept Comp Sci, Antigonish, NS B2G 2W5, Canada	12	9.84	80
LIU Y	Beijing Univ Posts & Telecommun, State Key Lab Networking & Switching Technol, Beijing 100876, Peoples R China	12	9.84	38
ZHANG L	Xidian Univ, Natl Sch Software, Xian 710071, Peoples R China	11	9.02	192
ZHENG LR	Fudan Univ, Sch Informat Sci & Engn, Shanghai 200433, Peoples R China.	10	8.19	95
ZHANG DQ	Telecom SudParis, Inst Mines Telecom, Comp Sci, Essonne, Ile De France, France	10	8.19	70

E. Research field of papers

Papers about Internet of Things indexed in the Web of Science were distributed over 72 research fields. The largest number of papers belonged to the Computer Science field (848 papers; 53.06 %), followed by 648 papers (40.55 %) in the field of Telecommunications, 561 papers (35.1 %) in the field of Engineering, and 154 papers (9.63 %) in the field of Instrumentation. Less than 300 papers belonged to other research areas.
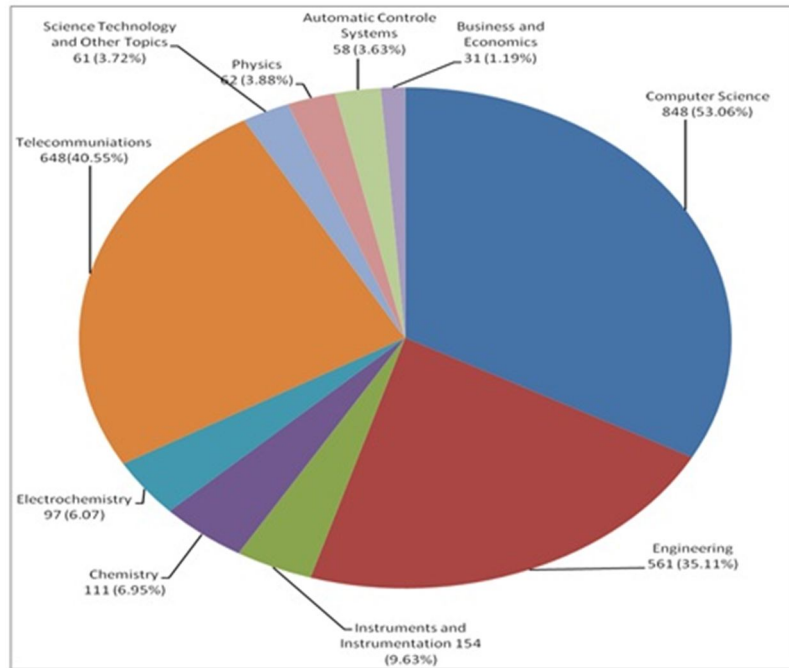
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Figure 3. Top 10 Research Fields of papers about Internet of Things, Published between 2000-2015

F. Most productive Journals

Our analysis showed that the 1598 retrieved papers were published in 417 journals. Among the journals publishing papers about Internet of Things between 2000 and 2015 that were indexed in the Web of Science, International Journal of Distributed Sensor Networks Journals had the highest numbers 97(6.70 %), followed by Sensors, which published 90 (5.63 %) and IEEE Internet of Things Journal publishes 59 (3.69%) Papers.

TABLE VI. THE TOP 10 JOURNALS THAT PUBLISHED PAPERS ON INTERNET OF THINGS

Source Titles	Records	% of 1598
International journal of distributed sensor networks	97	6.07
Sensors	90	5.632
IEEE internet of things journal	59	3.692
IEEE sensors journal	38	2.378
Ad hoc networks	36	2.253
China communications	35	2.19
IEEE communications magazine	34	2.128
Wireless personal communications	33	2.065
IEEE transactions on industrial informatics	29	1.815
Personal and ubiquitous computing	27	1.69

G. Number of citations in papers about Internet of Things published between 2000 and 2015

A total of 1598 papers on Internet of Things were cited 10,877 times in the Web of Science between 2000 and 2015. Until 2003, papers about Internet of Things were not cited From 2004 to 2009 rarely cited. Since 2010, citations have consistently increased; papers about Internet of Things were cited 59 times. Other peaks occurred in 2011(204), 2012(490), 2013(1173), and 2014(2280). The number of citations per year reached its maximum in 2015 (3939 citations).
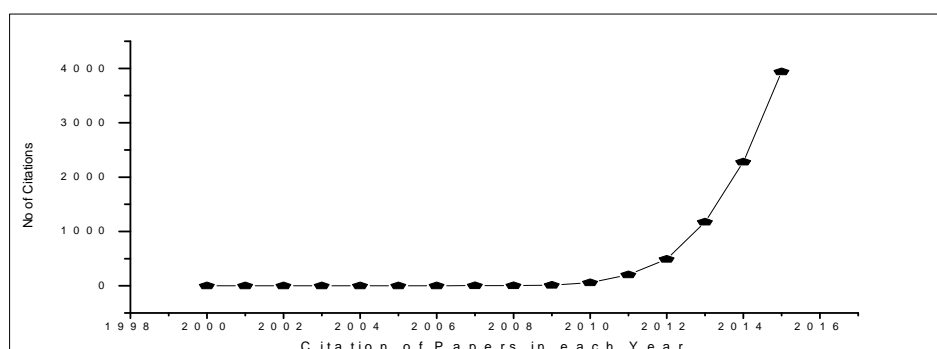
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Figure 4. Citation of papers on Internet of Things

V. Conclusion

The objective of the present study was to perform a bibliometric analysis of all Internet of Things related publications indexed in the Web of Science. Bibliometrics is a series of analyses used for evaluating or quantifying literature and information. It is a scientific method widely used in many fields. Web of Science Core collection Index papers were analyzed for various factors. This analysis determined the current state of research and trends in studies about Internet of Things between 2000 and 2015. The number of papers has exponentially been increasing over the 15 year study period, especially since 2010. Publication peaks were noted, in 2013, 2014, and 2015. Almost all (98.5 %) of the literature in the field was in English. For better international communication, English is the first language of choice for many authors. It was found that the China has the highest scientific output worldwide, publishing 456 papers about Internet of Things shows the growth of development of technology and also because of more number of research institutions with highest funding in the field of Internet of Things research shows the China's determination of adequate research budgets for scientific investigations There is obviously a long way to go for other countries to catch up.

The analysis of journals in which papers about Internet of things were published could help scholars select the appropriate journal for paper submission, thereby increasing the chance of acceptance. The analysis of the authors who published the most papers about Internet of Things could, to some degree, help encourage global cooperation and teamwork in the field of Internet of Things research. It can help researchers make the best use of available resources to increase efficiency and accelerate progress. The average number of citations is very high indicating that people are paying more attention to Internet of Things. Our review had several limitations.

Our search of the Web of Science database from 2000 to 2015 is quite sensitive and papers published elsewhere were excluded, so it is likely that some true "classic" articles were missed. A notable attribute of this study is that this field attracts more researchers.

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