

Research on the Status Quo and Hot Topics of Internet of Things at Home and Abroad Based on Bibliometrics

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Abstract

This article uses the core collection of web of science (WOS) as the document data source and "internet of things" as the search term to retrieve all core journal articles on the Internet of Things technology from 2008 to 2018. This article adopts bibliometrics and information visualization methods, and uses the analysis function and citespace visualization software that comes with web of science to organize and analyze the time distribution, country / region distribution, institution co-occurrence, and keyword co-occurrence of IoT literature at home and abroad. It reveals the development trend of global Internet of Things research, cooperation between cutting-edge countries, institutions, and changes in hot spots, etc., in order to provide a reference for scholars in this field to understand the status and hot spots of global Internet of Things research.

Keywords

Internet of things; Web of science; Bibliometrics; Citespace.

1. Introduction

The Internet of things refers to a kind of network , which connects any object with the Internet for information exchange and communication according to the specified protocol through information sensing equipment such as RFID, infrared sensor, global positioning system and laser scanner, so as to realize intelligent identification, positioning, tracking, monitoring and management[1]. It is a highly integrated and comprehensive application of the new generation of information technology, which is of great significance to the new round of industrial transformation and the green, intelligent and sustainable development of economic society[2]. Since the concept of Internet of things was put forward in 1999, the Internet of things technology has made great progress, and has been applied to more and more industry fields, such as intelligent transportation, logistics, agriculture, intelligent home and other fields. However, on the whole, the related technologies, standards and services of the global Internet of things are still in the initial stage, and the core technologies, standard systems and industrial systems of the Internet of things are still in the process of continuous development, establishment and improvement.

At present, many scholars at home and abroad have made extensive introductions on the development status, development strategies, key technologies, architecture and application promotion of the Internet of things. The main research focuses on the basic theory and practice of the research of the Internet of things, while there are few literatures on the current research mechanism, research hotspot and research topic of the global Internet of things[3]. Based on this, this paper will use the methods of bibliometrics and information visualization to analyze and discuss the temporal and spatial distribution, organization co-occurrence and keyword distribution of the global Internet of things core journal documents retrieved by web of science, so as to reveal the development status and hot spot

change of the Internet of things research at home and abroad, in order to provide reference for the relevant researchers in this field in China.

2. Data sources and research methods

2.1 Data source

Web of science is a product developed by Thomson Scientific in the United States based on the web environment. It is a large-scale comprehensive, multi-disciplinary, core journal citation index database. The database is updated every week to ensure that the collected literature can include the most important and influential research results in the world[4]. Therefore, this study chooses web of science as the data source, its core collection database as the document data source, and adopts the advanced retrieval method, which combines subject, year and language. By consulting various materials and documents, the English expression "Internet of things" is determined as the subject search term, the year range is 2008-2018, the language is international common language English, click the search, the search time is May 28, 2018, a total of 18138 related articles are retrieved. In addition, click "people R China" in the country column of the search results page to get a total of 4297 Internet of things literature records published in wos in China.

2.2 Research methods

This paper mainly uses bibliometrics and information visualization to study. Bibliometrics is a quantitative analysis method that takes the external characteristics of documents as the research object. With the help of various characteristics of documents, mathematical and statistical methods are used to describe, evaluate and predict the current situation and development trend of science and technology. According to the results of literature retrieval, this study directly uses the "analysis retrieval results" automatically generated by web of science to export the information of sending time, country and organization to excel for collection and mapping, and then obtains the corresponding charts. On this basis, the time distribution, country distribution and organization distribution of related research papers in the field of the global Internet of things are analyzed and discussed.

The information visualization method helps people understand and analyze the data by using the technology and method of graphics and images. The most commonly used information visualization software in the field of literature analysis is CiteSpace, which is a kind of application, which is based on Java environment and specializes in visual analysis of various data, revealing the evolution trend of knowledge and hot front[5]. This research uses the software to analyze the organization co-occurrence and keyword co-occurrence network of the retrieved Internet of things documents, and through the scientific knowledge map, it can show the evolution of the current hot spots in the field of the Internet of things.

3. Research results and analysis

3.1 Time distribution

In order to understand the development of research in the field of Internet of things at home and abroad intuitively from the time of publication, this paper makes a statistical analysis on the number of annual publications on wos since 2008. Using the time distribution data of global and China's Internet of things in wos "analysis and retrieval results" (since 2018 is not over, remove the relevant data), draw a line chart as shown in [Figure 1](#). It can be seen from the figure that from 2008 to 2017, research at home and abroad has been on the rise. From a global perspective, the growth rate of the amount of documents published in the retrieval time span is increasing, among which the largest amount of documents published from 2015 to 2016 was 1776, after which the growth trend slowed down; in 2017, the largest number of documents published in the world was 5741. Compared with the global level, the growth rate of domestic publications is relatively flat, with the largest growth span of 172 from 2010 to 2011 and 957 in 2017.

At present, the world attaches great importance to the development of Internet of things technology. Whether it is the "smart earth" plan of the United States, the 14 point action plan of the European Union, or the "u-japan" plan of Japan, the "it839" and "u-korea" strategies of South Korea, Internet of things is regarded as an important strategic goal of the current development. During the "12th Five Year Plan" and "13th five year plan", China successively issued the "China Internet of things white paper (2011)" and "13th five year plan" of the Internet of things and other policy documents to support and encourage the development of China's Internet of things. The state's attention is the main reason for the growing research of Internet of things at home and abroad. It is expected that in the next few years, research in the field of Internet of things will continue to rise.

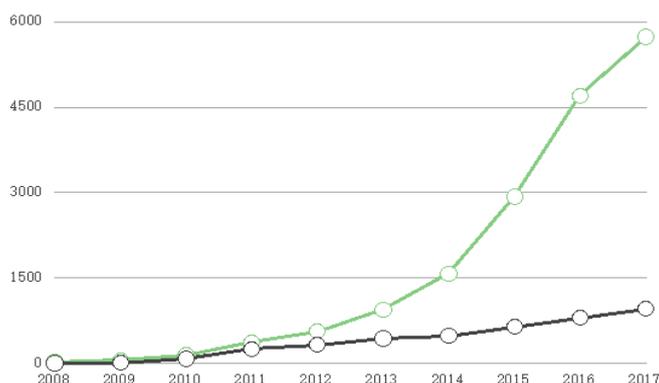


Figure 1. Time distribution of WOS publications in the field of Internet of Things (Green polyline represents global data and black polyline represents domestic data)

3.2 Country distribution

By analyzing the distribution of countries / regions in the field of Internet of things, we can reveal the active countries and regions in this field. The distribution of countries and regions with more than 300 publications in the world is shown in Figure 2. China's mainland is far ahead in the amount of publications, 4297, accounting for 23.7% of the global total, which is significantly higher than other countries and regions, showing that China's research scale in the field of the Internet of things has ranked first in the world. The second is the United States, with 2758 publications, accounting for 15.2% of the global total, which shows that the United States has a strong research strength in this field. In terms of citation reports, the total cited frequency of 4297 papers in China is 15298, with an average of 3.54 for each article; while that of 2758 papers in the United States is 15619, with an average of 5.63 for each article. The comparison shows that there is a certain distance between the recognition of Chinese scholars' research results and the quality of papers and the United States, which needs to be further improved.

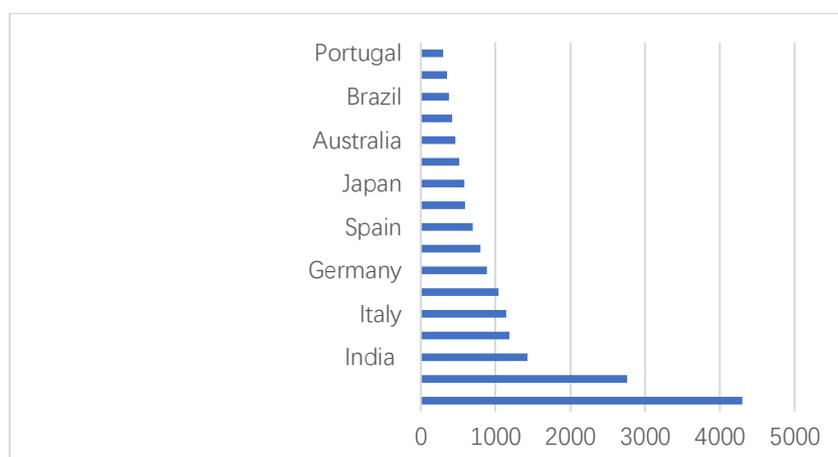


Figure 2. Distribution of countries / regions in internet of things research

The leading number of WOS publications reflects China's advantageous position in the field of Internet of Things. As early as 1999 when the concept of the Internet of Things was put forward, China started the technical research on the core sensor network of the Internet of Things. After nearly 20 years of construction and development, China has become one of the world's leading countries in the field of sensor network standards, R & D level is at the forefront of the world [6]. China's wireless communication network and broadband coverage are high, which can realize the complete industrial chain of the Internet of Things, which provides solid infrastructure support for the development of the Internet of Things. The process of the integration of industry, university and research in the field of Internet of Things in China; the promulgation of a series of incentive measures by the national government and the release of special funds have created a good policy environment for the development of China's Internet of Things. China's activity in the field of Internet of Things research is bound to be inseparable from these factors.

3.3 Institutional (extended) distribution

By analyzing the distribution of the WOS issuing organizations (extended) in the field of the Internet of Things, we can reveal the information of the leading research institutions (extended) in the world in this field. The top 20 institutions in the world for the number of posts are shown in [Table 1](#). The institutions listed in the table are composed of 6 research institutes (research centers), 13 universities and one enterprise. Among them, the Chinese Academy of Sciences posted the most papers, with 301 papers, accounting for 1.7% of the total; followed by Beijing University of Posts and Telecommunications, with 267 papers. This shows that Chinese scholars, represented by scholars from the Chinese Academy of Sciences and Beijing University of Posts and Telecommunications, rank high in their research strengths in this field, and have made outstanding contributions to China's number one in the world. In addition, three Chinese universities including Tsinghua University, Beijing Jiaotong University and Shanghai Jiaotong University are among them. [Table 1](#) has a key reveal that IBM is the only company on the list, indicating that it attaches importance to the research in the field of Internet of Things and has obtained rich research results. In contrast, the main strength of China's research in the field of the Internet of Things is still concentrated in universities, and enterprises have participated in research and achieved very few research results.

Table 1. Distribution of global IoT research and publication institutions (extended)

Number	Institutions (extended)	Amount
1	Chinese Academy of Sciences	301
2	Beijing University of Posts and Telecommunications	267
3	National Centre for scientific research (CNRS)	227
4	University Of California	204
5	University Of Georgia	147
6	Tsinghua University	140
7	University of Paris Sacré	140
8	University of Coimbra	126
9	Indian Institute of Technology	122
10	European Microelectronics Research Center	116
11	French National Institute of Information and Automation	116
12	Georgia Institute of Technology	113
13	University of London	108
14	Korea Institute of electronic communication	107

15	Royal Institute of Technology	107
16	Beijing Jiaotong University	101
17	Florida State University	100
18	Korea Institute of advanced science and technology	99
19	Shanghai Jiaotong University	97
20	International Business Machines (IBM)	95

This paper focuses on the analysis of the distribution of research institutions of the Internet of things, inter agency cooperation and research topics of major institutions. The 4297 pieces of data of domestic Internet of things research institutions retrieved by wos are imported into CiteSpace for visual analysis, and the scientific knowledge map as shown in [Figure 3](#) is obtained. The text on the node represents the name of the institution, and the size of the node and the text represents the total number of times that the representative institution cooperates with all other research institutions. It can be seen from the figure that the nodes and characters of CAS and Beijing University of Posts and telecommunications are large, indicating that they have more cooperation with other research institutions. The comparison of the quantity of papers released shows that cooperation with other institutions has a positive effect on promoting the research results of this institution. In September 2009, Wuxi City and Beijing University of Posts and Telecommunications signed a cooperation agreement on sensor network technology research and industrial development. The agreement states that Wuxi City will cooperate with Beijing University of Posts and telecommunications in the construction of Research Institute, mainly focusing on sensor network, involving optical communication, wireless communication, computer control, multimedia, network, software, electronics, automation and other technical fields. In addition, relevant applied technology research, transformation of scientific research achievements and industrialization promotion are also included in the agenda [7]. The cooperation with Wuxi City has greatly promoted the research of Beijing University of Posts and telecommunications in the field of Internet of things. In addition, Beiyou has a series of measures to promote the research on the construction of the Internet of things: setting up special research projects on the Internet of things, encouraging teachers to actively participate in the research on the construction of the Internet of things, and building a demonstration area of the Internet of things in the campus. It has reference and demonstration significance for other domestic universities to promote the development of Internet of things research.



Figure 3. Scientific knowledge map of domestic Internet of things research institutions

The connection between the nodes in Figure 3 represents the cooperative relationship between the two research institutions, and the thickness of the connection represents the number of research cooperation between the two end institutions of the connection. It can be seen from the figure that almost every two nodes have a connection, which indicates that there is a good cooperative relationship between the research institutions in China. In order to understand the research topics of cooperation among research institutions, we use CiteSpace software to cluster Fig. 3, and get the cluster analysis map as shown in Fig. 4. #0, #1, etc. represent the cluster number, followed by the cluster name represents the research topic, and the orange polygon represents a cluster set. It can be seen from Figure 3 that the research topics of the research institutes in the field of Internet of Things in China can be basically divided into eight categories: #0 modern manufacturing, #1 active learning approach, #2 mapping system, #3 regional geological survey, #4 machine-to-machine communication, #5 intrusion detection model, #6 smart community, #7 context-based ontology matching.



Figure 4. Cluster analysis of the co-occurrence network of domestic IoT research institutions 1

In order to better understand the co-occurrence of a research institution and other institutions and their co-occurrence research topics, the clustering format was changed to timeline based on Fig. 4 to obtain the cluster analysis map shown in Fig. 5. In the figure, the horizontal line and its left end "number" represent a clustering theme in Figure 4. The nodes and text on the horizontal line indicate the organization that it represents, and the node and text size indicate the organization it represents and other research organizations. The total number of co-occurrences. The connection indicates that there is a cooperative relationship between the two ends of the node on the same topic. Huazhong Univ Sci & technol scholars have rich and extensive research in the field of Internet of Things, and co-occurrence with other institutions on each research topic, so this article analyzes this issue with Huazhong University of Science and Technology. Huazhong University of Science and Technology scholars' main research topics are 4 machine-to-machine communication; secondly, they have studied #0 modern manufacturing with Tsinghua University and Northwest University; and they have studied #1 active learning approach with Wuhan University and Beijing Inst Technol; Cooperated with St Francis Xavier Univ, Univ British Columbia and other institutions to study the #2 mapping system; studied #3 regional geological survey with China Univ Geosci and other institutions ; and the subject of co-occurrence research with Jilin University and Shenzhen University is #4 machine-to-machine communication; the subject of research with Univ Sci & Technol Beijing and other institutions is 5 intrusion detection model; the subject of research with Zhejiang University and other research

institutions is 6 smart community; and cooperation with research institutions such as Beihang Univ Investigated #7 context-based ontology matching.

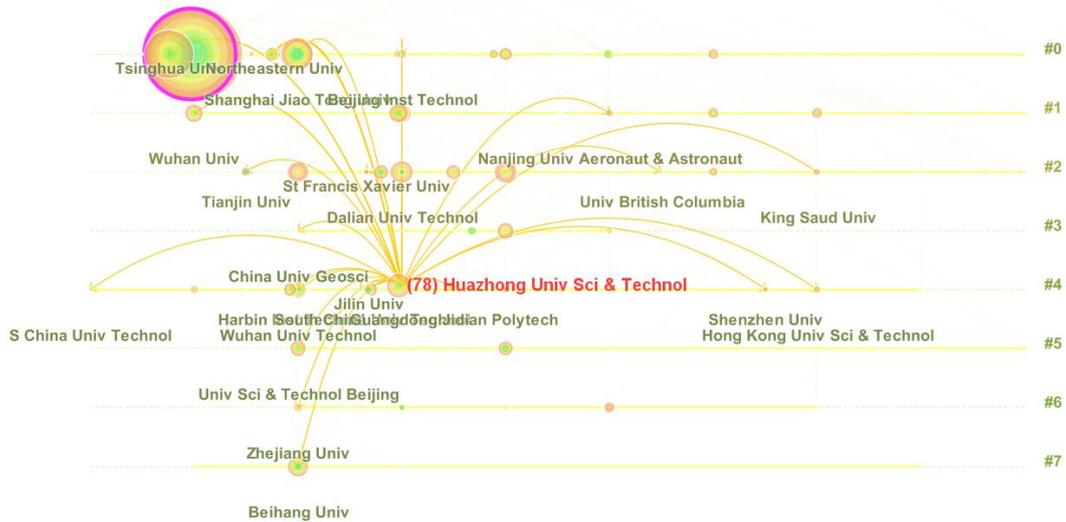


Figure 5. Cluster analysis of the co-occurrence network of domestic IoT research institutions 2

3.4 Keyword co-occurrence analysis

Keywords are the refined expressions of academic research topics. The information they contain includes the title, abstract, etc. of a document, and is a highly concentrated form of a document. Research and analysis of keywords that appear frequently in the literature can reveal research hotspots and trends in this field. Import 18139 global Internet of Things documents retrieved by web of science to citespace, click the keyword option for visual analysis, and get the keyword list and the keyword co-occurrence network map shown in Figure 6.



Figure 6. Co-occurrence network map of global IoT literature keywords

Organize the keyword list and merge words with similar meanings, such as "architecture" and "framework"; acronyms and full names, such as "Internet of things" and "iot" "Internet of things (iot)" merge. The top 40 keywords of the frequency after the rearrangement are intercepted to obtain the hot word list shown in Table 2. Table 2 shows that from 2008 to 2018, the keywords that appear more frequently in the global Internet of Things literature are Internet of science, wireless sensor network, internet, system, security, cloud computing, big data, smart city, RFID, design, privacy, architecture, model, protocol, algorithm, etc.

Table 2. Glossary of hot topics in global IoT research

Number	Keyword	First year	Time	Number	Keyword	First year	Time
1	Internet of Things	2008	5987	11	design	2010	430
2	wireless sensor network	2009	1219	12	management	2010	428
3	system	2008	1011	13	challenge	2012	418
4	internet	2010	909	14	privacy	2009	406
5	security	2009	898	15	architecture	2010	378
6	cloud computing	2010	660	16	model	2012	318
7	big data	2013	539	17	protocol	2012	286
8	sensor	2009	513	18	authentication	2013	271
9	smart city	2012	510	19	service	2010	267
10	RFID	2008	509	20	algorithm	2011	256
11	design	2010	430	31	cyber-physical system	2015	128
12	management	2010	428	32	industry 4.0	2016	122
13	challenge	2012	418	33	machine learning	2016	118
14	privacy	2009	406	34	5g	2016	96
15	architecture	2010	378	35	middleware	2010	79
16	model	2012	318	36	device	2017	77
17	protocol	2012	286	37	interoperability	2014	47
18	authentication	2013	271	38	access control	2013	42
19	service	2010	267	39	integration	2013	40
20	algorithm	2011	256	40	supply chain	2011	34

Cluster analysis of the 40 hot words in Table 2 can be roughly divided into four parts: the theoretical research part of the Internet of Things, the technical research part, the Internet of Things application part, and the Internet of Things security part. The theoretical research part of the Internet of Things includes keywords such as system, challenge, architecture, protocol, scheme, m2m, ontology, interoperability, etc.; the technical research part includes wireless sensor network, cloud computing, big data, sensor, RFID, model, optimization, ZigBee, Cyber-physical system, 5g and other hot words; the Internet of Things application part includes smart city, smart home, smart grid, supply chain and other keywords; the Internet of Things security part mainly includes hot words such as security, protocol, authentication, access control.

As can be seen from the table, from 2008 to 2009, domestic and foreign IoT research was mainly focused on extensive research on IoT theory, key technologies, and security; after 2010, more attention was paid to IoT applications and IoT technology updates. And other specific issues. On the whole, it shows the gradual and in-depth study of Internet of Things technology research.

4. Conclusion

Using the method of bibliometrics, based on the analysis function of web of science and CiteSpace, 18139 research literatures of Internet of things in wos core database are analyzed in terms of time distribution, country / region distribution, organization co-occurrence and key words co-occurrence, and the following conclusions are obtained:

First, the statistical research on Internet of things at home and abroad has been on the rise from 2008 to 2018. At present, all countries are interested in encouraging the development of the Internet of things. It is expected that in the next few years, relevant research in the field of the Internet of things will still increase. China ranks first among the countries that study the Internet of things in the world in terms of the amount of papers issued by wos, which shows that China has obvious advantages in the field of research, but the citation rate of papers is not high, and the recognition of research results and the quality of papers need to be further improved.

Secondly, there are many research institutions from Internet of things in China, and the research results are rich. China holds five seats in the top 20 research institutions of the global Internet of things, and the Chinese Academy of Sciences and Beijing University of Posts and Telecommunications rank first and second respectively. In the analysis of the co-occurrence of domestic institutions, it is found that there are good cooperative relations between domestic institutions and foreign institutions, mainly focusing on the eight themes of modern manufacturing industry, active learning, laser mapping system, regional geological survey, machine to machine communication, intrusion detection model, intelligent community, environment-based ontology matching.

Third, the research on the technology of the global Internet of things is gradually and continuously deepened in the retrieval time span. The overall research focuses on four parts: the theoretical part is mainly the Internet of things system, architecture, network data exchange rules, etc.; the technical part is mainly wireless sensor network, cloud computing, big data, RFID, etc.; the application part is mainly smart city, smart home, supply chain, etc.; the security part is mainly confidentiality rules, identity verification, access control, etc. At present, the technology and application of the Internet of things at home and abroad are still in the primary stage. In the future, the research in this field should pay more attention to the research and development of key technologies, the expansion of application fields, the determination of international standards, as well as the integration, security and other issues with cloud computing, big data, artificial intelligence and other information technologies.

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