Visualization Analysis and Trends in Indonesian Internet of Things Research Using Bibliometrics

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***Abstract*— The Internet of Things (IoT) has emerged as a critical issue and area of research for a variety of communities, academics, and industries worldwide. Due to the lack of research in IoT and understanding the direction of IoT development in the future. This research presents bibliometric analysis and analysis of science mapping on IoT. Data was taken from the Scopus database based on Indonesian state affiliation from 2012 - 2020. A total of 1415 documents (Conference proceedings, journals, book series, and books) were retrieved, which were then processed online via Scopus Web and by VOSviewer software to perform advanced bibliometric analysis and science mapping analysis. The method is divided into five stages: keyword selection, initial search results, search result refinement, initial compilation, and data analysis. Scopus's list of the most frequently published and indexed articles, the most published papers are in the subject area of Computer Science (29.0%) with 938 documents, Engineering (20.7%) with 668 documents, Physics and Astronomy (9.5%) with 308 documents. The data processed and visualized on this topic offer exploratory information about the current status and trends in the IoT scientific literature and provide insight for established and novice researchers in understanding this research topic.**

Keywords—internet of things, mapping, trend, bibliometric, vosviewer

I. INTRODUCTION

IoT refers to the connecting of commonplace devices in a network that has a massive amount of intelligence. Embedded systems allow every object to be used for interactivity, the Internet of Things has dramatically increased Internet usage, resulting in a network of widely spread gadgets connecting with humans as well as electrical devices that support the web [1]. Next-generation internet technology, dubbed IoT, has risen to prominence. We expect billions of physical objects to be equipped with various sensors and actuators and connected to the Internet through heterogeneous access networks enabled by technologies such as sensing and embedded movement, radio frequency identification (RFID), wireless sensor networks, real-time web services and semantics, and more [2]. The Internet of Things is not a single technology; it is a synthesis of different technologies from numerous Engineering fields that will be used to connect all objects to the Internet for remote sensing and control [3]. Not all activities made by students in aggregate, or all problems they experience during learning are tracked by teachers using this learning management system [4], [5].

Next-generation communication technology relies heavily on the Internet of Things (IoT). Radio frequency identification (RFID) and other hardware and software technologies are employed (RFID) [6], wireless sensor networks (WSN) [7], and cloud computing. The transition from traditional human-to-human communication to interconnectedness between people and things is a significant stage in modern information communication. The Internet of Things, its architecture, and the specific implementation of its operations can be roughly classified into three tiers [8]. The first layer is the perception layer, which is responsible for the collection and integration of input. The second layer is the network layer, which is concerned with the transmission and sharing of information over various types of communication networks. The third layer is the application layer, which is responsible for large-scale data processing, mining, goal determination, and control enablement. By utilizing current technology in a wide range of industries, IoT is able to complete the entire process of intelligent data processing, as shown by the three-tiered architecture. The Internet of Things (IoT) is poised to become an integral part of our everyday lives, both now and in the future, and it provides a wide range of possible applications.

Another research on Internet of Things (IoT) is that conducted by Dwiputra et.all on the parking monitoring system. Motorists will be able to check the availability of parking spaces in a parking lot via their smartphones with the use of IoT [9]. In order to construct this Internet of Things (IoT) parking system, controllers, sensors, servers, and the cloud were all utilized. Each parking space will have sensors and controllers installed on the ceiling to identify the presence of a vehicle. The sensor data is collected by servers and stored in the Cloud [10]. Three sensor circuits and a server were placed in a parking lot and left for a few days to test the system. The tests measure the amount of time it takes for data to travel from the parking lot to the cloud, as well as the success rate of data transmission. Tests conducted on the sensor circuit and Radio Frequency Identification (RFID) show that the parking lot data may be transmitted without any errors. Parking lot information can be updated in less than a minute with this technique.

Many research have been conducted to create IoT for various applications, and it has been deployed in a variety of sectors, including logistics and transportation, the environment, personal and public, energy until biomedical [11]–[13]. Consumers can monitor their energy consumption in real time through the energy domain, which is based on IoT. Among other things, a smart grid may be used in the energy industry. Contingency circumstances may be managed by the deployment of smart loads in a smart grid application based on IoT [14]. A battery monitoring and protection system was established in earlier research [15], and it has two basic components: the local data collecting module and the central module that collects all of the data from the local module [16]. It is possible to connect the central module directly to an HDMI monitor and interact through the user interface.

We looked at research on Internet of Things (IoT) published in Indonesia from 2012 to 2020 using the Scopus database to determine where researchers concentrated their efforts. The Internet of Things has been indexed in Indonesia by Scopus in 1415 scientific publications (IoT). Using VOSviewer and the Scopus visually map, we were able to analyze and visualize the data collected in the study.

II. Research Methods and Data Source

A systematic and clear bibliometric literary review technique that focuses on the limitations of knowledge. The five-stage technique is utilized in this research, as shown in Figure 1.

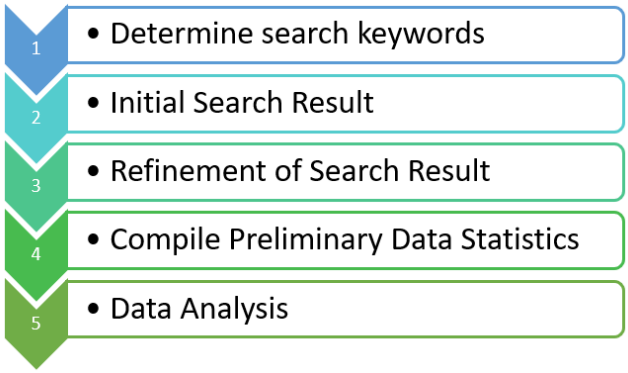

Fig. 1. Bibliographic analysis in five steps

A. Determine search keywords

In November 2021, a Scopus database ran a literary search and turned up 1415 academic papers with the keyword "Internet of Things". We performed the following query command on Scopus TITLE-ABS-KEY (internet AND of AND things) AND (LIMIT-TO (AFFILCOUNTRY, "Indonesia")) AND (EXCLUDE (PUBYEAR, 2022) OR EXCLUDE (PUBYEAR, 2021)).

B. Initial Search Result

This research is limited to 'articles', 'Conference Papers', 'book chapters', 'Reviews', 'Data Papers', and 'Editorials' published between 2012 and 2020 in the state of Indonesia and indexed by Scopus. A total of 1415 items were found during the initial phase of the search process. Using the Research Information Systems (RIS) format, you may store data such article titles, names of authors and members, abstracts, keywords, and citations.

C. Refinement of Search Result

The articles that are relevant are chosen from the Scopus database. The terms 'book chapter', 'Review', 'Conference Paper', 'Data Paper', 'article', and 'Editorial' are included in this data. The file is saved as a RIS file to enable mapping. Vosviewer bibliographic software is used to import RIS data.

D. Compile Preliminary Data Statistics

The data from the Scopus database is used to create a RIS file. The journal article components can still be completed even if the initial stage's data is missing (publication year, volume, number, page, etc). Certain publications' publishing dates and sources were determined through analyzing data.

E. Data Analysis

Vosviewer software is used for bibliometric analysis, which is based on the Scopus database. The Vosviewer program is used to analyze and show the acquired data. This graph shows a breakdown of the network by academic affiliation, researcher type, number of studies, keywords and author cooperation and the most popular studies.

III. Result of This Research and Discussion

A. Most Frequent Institution Affiliation of Internet of Things (IoT) in Indonesia Publication

Comparing the number of documents published in Indonesia for up to ten connections on the Internet of Things (IoT), as shown in Figure 2, the Institut Teknologi Bandung has 170 documents spanning the years 2012 to 2020. The second line in the chart represents Telkom University, which has 162 documents spanning the years 2014 to 2020. The third line in the chart represents Universitas Indonesia, which has 127 documents spanning the years 2014 to 2020.

Next line is Bina Nusantara University with 101 documents, Universitas Gadjah Mada with 60 documents, Institut Teknologi Sepuluh Nopember with 49 documents, Politeknik Elektronika Negeri Surabaya with 46 documents, Brawijaya University with 36 documents, Universitas Sumatera Utara with 32 documents, Universitas Diponegoro with 28 documents,

Fig. 2. Up to ten affiliations' document counts can be compared

B. *The Majority of Authors in Internet of Things Publications In Indonesia Are Single Authors.*

The three authors with the most publications on Internet of Things in Indonesia are Setianingsih, C., and Suryanegara, M., each with 24 documents. And another authors, Sari, R.F. have 23 documents, Adiono, T. with 18 documents, Nashiruddin, M.I. same with Sukaridhoto, S. have 16 documents each. Abdurohman, M. and Murti, M.A. have 14 documents each. Pramukantoro, E.S. and Putrada, A.G. have 13 documents each.

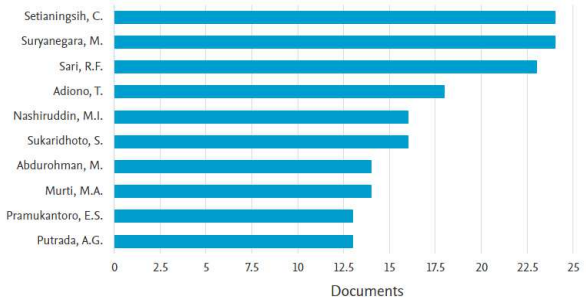

Fig. 3. Up to ten authors' document counts can be compared

Setianingsih, Casi from Telkom University who also collaborated with several other researchers, such as Suryanegara, Muhammad from Universitas Indonesia. This demonstrates the existence of interdisciplinary research collaboration.

C. *The Highest Frequency of Internet of Things Publication in Indonesia by Subject Area*

In Indonesia, 938 academic documents are available in the Computer Science field (29.0 percent). Then, Engineering field which contains 668 academic papers (20.7 percent). There are 308 academic documents in the Physics and Astronomy sector, followed by the Decision Sciences sector with 292 academic documents (9.0 percent), then Energy sectors with 186 academic documents (5.8 percent), Materials Science with 139 academic documents (4.3 percent), Social Sciences with 138 academic documents (4.3 percent), and Environmental Science with 84 academic documents.

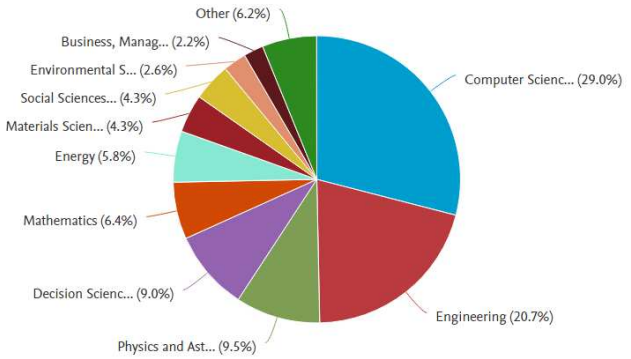

Fig. 4. Publication of Internet of Things Documents in Indonesia by Subject Area

Computer Science field, Engineering field, and Physics and Astronomy field are the fields with the most IoT publications in Indonesia. Computer Science students can learn about the Internet of Things (IoT) formally.

D. *The Most Common Type of Internet of Things Document Publication in Indonesia*

The Internet of Things is the subject of a wide range of academic papers in Indonesia, including six distinct categories. Fig. 5 shows that the majority of academic publications on the Internet of Things in Indonesia are conference papers, with 1128 academic documents, followed by articles with 271 academic documents, book chapters with 8 documents, reviews with 5 documents, data papers with 2 documents, and editorials with 1.

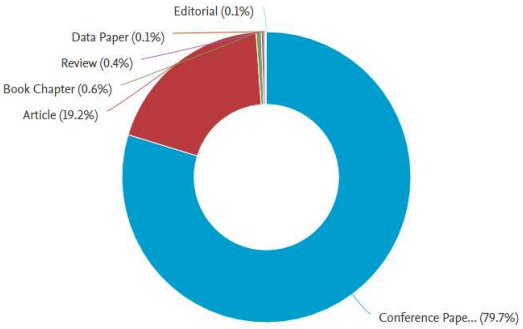

Fig. 5. Chart of Indonesian Internet of Things (IoT) Publication Figure

There are six main publication types: Conference Paper, articles Book Chapter, Review, Data Paper, and Editorial. This does not exclude future scientific and literary advances from leading to an increase in the number of additional document kinds as well.

E. *Internet of Things in Indonesia Publications Document Per Year Based on Source*

It is estimated that the five most important documents published each year in this country come from international publications. In Indonesia, "Journal Of Physics Conference Series" with 124 documents from 2017 until 2020 in orange line color, then "IOP Conference Series Materials Science And Engineering" with 107 documents at 2014 until 2020 in purple line color, then "IOP Conference Series Earth And Environmental Science" with 37 documents from 2016 until 2020 in blue line color, "Telkomnika Telecommunication Comp" with 32 documents from 2015 until 2020 in green line color, "Telkomnika Telecommunication Comp" Fig. 6 illustrates this point.

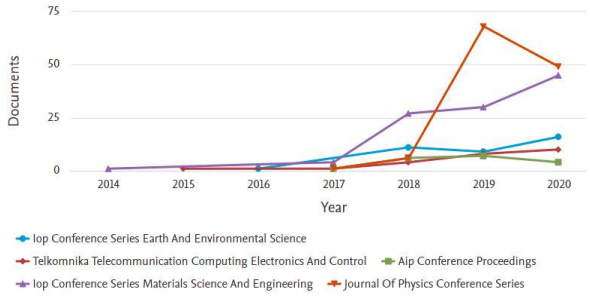

Fig. 6. Indonesian Internet of Things Documentation Per Year

In Indonesia, researchers in the field of Internet of Things prefer to publish their findings in Proceedings, as evidenced by the Journal of Physics Conference Series. According to the experts, the number of pages compared to publications may be limited.

F. Internet of Things Documents Per Year in Indonesia Publication Rate

A rise in the number of Internet of Things in Indonesia articles produced annually between 2012 until 2020 may be seen. In 2012, just two papers were released; by 2016, that number had risen to 26 papers published. The number of citations will continue to rise until 2020, when there will be 507 papers. From chart we can see the documents has increase until 2020.

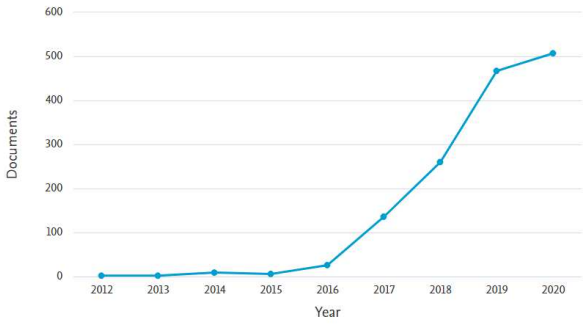

Fig. 7. Annual Graph of Indonesian Literature Documentation on the IoT

G. The most popular Internet of Things publications in Indonesia

When it comes to the Internet of Things (IoT) in Indonesia, Neural Computing and Applications will publish the most cited international paper in the country in 2020 [17]–[21]. The top three articles from each year are shown in the following table:

TABLE I. FROM THE HIGHEST TO THE LOWEST RANKED PUBLICATIONS IN THE INDONESIAN IOT FIELD, BELOW ARE THE TOP THREE

No.	IoT in Indonesia Documents Scopus Publication				
	Document Title	*Authors*	*Year*	*Source*	*Cited by*
1.	"Hybrid optimization with cryptography encryption for medical image security in Internet of Things"	Elhoseny, M., Shankar, K., Lakshmanaprabu, S.K., Maseleno, A., Arunkumar, N.	2020	Neural Computing and Applications 32(15), pp. 10979-10993	88
2.	"A Data-Oriented M2M Messaging Mechanism for Industrial IoT Applications"	Meng, Z., Wu, Z., Muvianto, C., Gray, J.	2017	IEEE Internet of Things Journal 4(1),7801816, pp. 236-246	73
3.	"Optimization of Random Access Channel in NB-IoT"	Harwahyu, R., Cheng, R.-G., Wei, C.-H., Sari, R.F.	2018	IEEE Internet of Things Journal 5(1),8239592, pp. 391-402	57

H. Indonesian Internet of Things (IoT) publications

E-learning in health science's keyword network mapping was performed using VOSViewer software. Title and abstract fields are the ones we'll be using for this study. The calculation is carried out using binary counting. Two repetitions are the minimum number of keyword-related documents. Sixty-nine out of 24454 terms pass the litmus test. For example, the term "10" must be used at least ten times. Each word will be assigned a relevancy score. There are 691 terms to choose from, as shown in Figure 8 below:

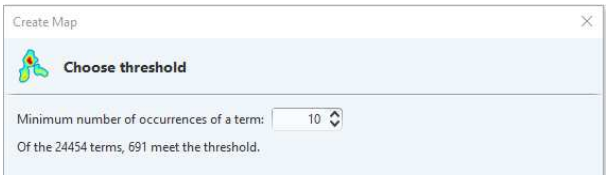

Fig. 8. Choose threshold the Indonesian Internet of Things Publication

After that step, we must choose number of terms to be selected. From 691 terms found, the default option is to select is 60% most relevant. So, we can get 415 terms selected. It was default from this Vosviewer software. But we still can change it if want another number of this terms.

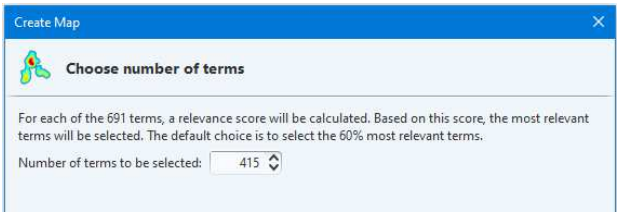

Fig. 9. Choose number of terms the Indonesian Internet of Things Publication

After we choose our terms before, then the next step we can verify selected terms to create Network Map.

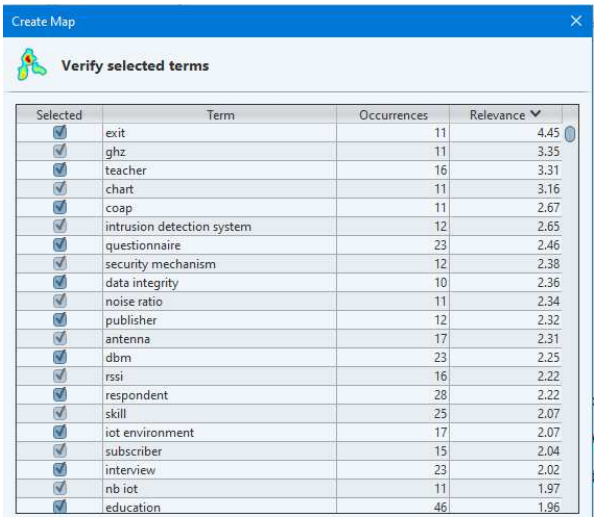

Fig. 10. The Indonesian Internet of Things Publication has a few terms that need to be verified.

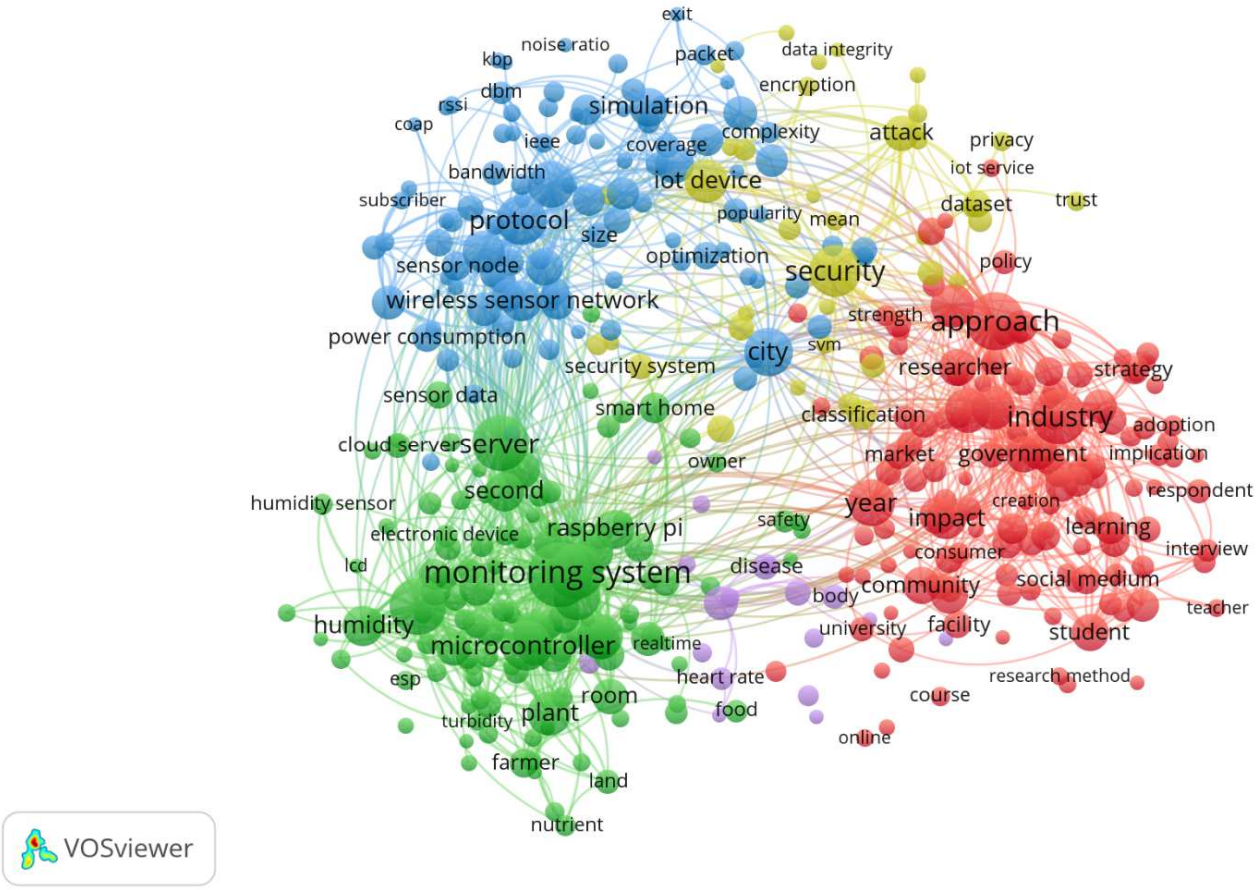

Fig. 11. Indonesian IoT (Internet of Things) Map

There are five sets cluster color of keyword-based study themes depicted in figure 9.

1. Cluster 1 (132 items) with the red color. This cluster have the word network like Approach, industry, year, impact, strategy, community, student, and others.
2. Cluster 2 (125 items) with the green color. This cluster have the word network like monitoring system, microcontroller, raspberry pi, server, smart home, and others.
3. Cluster 3 (102 items) with the blue color. This cluster have the word network like Protocol, iot device, city, optimization, wireless sensor network, simulation, and others.
4. Cluster 4 (38 items) with the yellow color. This cluster have the word network like Security, attack, iot device, trust, privacy, classification, and others.
5. Cluster 5 (18 items) with the purple color. This cluster have the word network like patient, degree, accident, body temperature, treatment, and others.

I. This Research is a Collaboration of Authors

A trend of collaborative research may be seen in figure 10 of the Internet of Things (IoT) in Indonesia article. There are 3633 writers in the Author Network of Collaboration, 78 meet the thresholds.

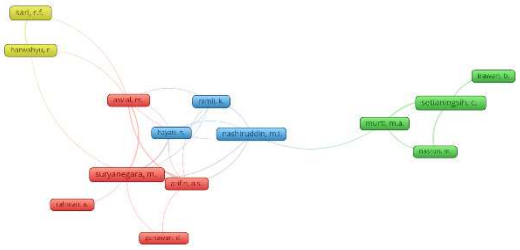

Fig. 12. Network for Author Collaboration

As shown in Figure 10, Suryanegara has 24 documents and links to other authors in the blue and yellow colors, respectively. Suryanegara have 23 Total link strengths (TLS). Suryanegara interconnected with Hayati, N who have 7 documents with TLS is 10. Then interconnected with Harwahyu, R who have 11 documents with TLS is 11. They are interconnected with the green cluster from Nashiruddin, M.I and Murti, M.A. All of this have TLS is 73.

IV. Conclusion

Using data from the Scopus-indexed international Internet of Things (IoT) in Indonesia papers, this paper reveals patterns and trends. Institut Teknologi Bandung has 170 documents from 2012 to 2020 with the most Internet of Things (IoT) linkages. The second line in the chart represents Telkom University, which has 162 documents spanning the years 2014 to 2020. The third line in the chart represents Universitas Indonesia, which has 127 documents spanning the years 2014 to 2020. With 1415 academic publications, Computer Science Engineering, and Physics and Astronomy sector.

According to the contribution to knowledge, this study offers a categorization of the convergence axis in Internet of Things (IoT) in Indonesia may have to wait several years to find the important themes. So, new topics may be studied or researched in order to increase understanding in this area. It is imperative that researchers in Indonesia examine the impact and contribution of the Internet of Things (IoT) as soon as possible by combining information from Scopus and other indexes.

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