

AN ANALYZE OF RESEARCH TRENDS ON THE INTERNET OF THINGS (IoT)

Ahmed Atiyah Itwayya¹,
Mohsin N. Al-Maliki²,
Hasanain A. H. Al-Behadili³,
Ahmed Jabber Roiss⁴

¹Ministry of Electricity - General Company for Southern
Electricity Distribution - Misan Branch.

² Department of Business Administration, University of Misan, Amara, Iraq.

³ Department of Electrical Engineering, University of Misan, Amara, Iraq.

⁴ Ministry of Electricity General Directory of Electricity for south Misan

Email addresses: eng.ahmed.rml@gmail.com (A. A. ITWAYYA1),
muhsen@uomisan.edu.iq (M. N. Al-Maliki2) , dr-hasanain@uomisan.edu.iq
(H. A. H. AL- Behadili3)

Abstract

This study looked at the domestic research trends on the Internet of Things (IoT), which is gaining interest in all fields with the recent development of information and communication technology. They analyzed 101 papers published in academic journals since 2010 with a focus on research topics, research methods, and research fields. Most of the research topics on the Internet of Things were focused on technology and industry, and among them, the proportion of technology was very high. In the technology field, most of the recent technology proposals introducing the technology of the Internet of Things (IoT) have been made. Most of the research methods of the IoT were experimental studies, and a considerable part of the literature review was also occupied. Although the engineering field occupies most of the academic fields that have studied the Internet of Things, there have also been some studies in the social sciences. Considering that the Internet of Things (IoT) has a large ripple effect not only in the industrial field but also socially and culturally, it is necessary to conduct not only technical research but also industrial, service, policy and institutional research through various academic fields and research methods.

Keywords: Internet of Things, Digital Technology, Information and Communication Network, Computer, Communication, Information Delivery.

I. Research purpose

In 1969, the Internet has developed into a universal media that anyone can use thanks to the development of digital technology. In particular, since the World Wide Web (WWW) technology was developed in the 1990s, the Internet has become a means of exchanging information by connecting to computers around the world. The Internet has become a core technology for exchanging information in all fields, such as politics, economy, society, and culture, and is becoming an essential means of daily life. With the development of information and communication network technology, the Internet has developed into a means of connecting

things to things beyond simply connecting computers used by individuals, opening a new era called the 'Internet of Things'.

The Internet of Things means that all things form an intelligent relationship using information and communication technology. In other words, it is a technology and service that is connected through the Internet at anytime, anywhere, and that detects and communicates surrounding situations without human intervention, and cooperates with each other to process and control information appropriately.^{[1][2]} It is a generic term for Internet technology that connects people and things simultaneously and asynchronously in such a way that computer chips are mounted on all objects, and these chips are connected to the Internet to exchange necessary information through mutual communication. When this service is activated due to the connectivity of the Internet of Things and the possibility of expanding information exchange, it is predicted that innovative changes will occur in the entire social system.

Research on the impact of the Internet of Things on the social change system began in early 2000 with the term “ubiquitous computing”. The use of this concept is because it gives the meaning of opening an era where things everywhere are connected to the Internet and exchange information with each other. However, as the development of microcomputers to be mounted on objects was delayed, and the development of networks and devices capable of seamless communication between objects and objects, and between people and objects, the development of networks and devices was delayed, which weakened the interest in research on the Internet of Things. However, since the last years, the development of personal media such as smartphones and SNS, the development of wired and wireless high-speed Internet, and the development of artificial intelligence technology that intelligently processes information, interest and research on the Internet of Things have been activated.

The Internet of Things (IoT) is regarded as the best among the technologies that will change the lives of mankind in the future.^[3] The Internet of Things (IoT) refers to the connection between “things and things”. It is predicted to materialize a hyper-connected society where offline connections are made to become intelligent. In other words, it will play a role as a driving force in the development of a society where everything is connected to the Internet and realizes convenient and efficient services.

The Internet of Things (IoT) is applied to each of the existing industries, causing new changes. At the same time, the Internet of Things itself creates new industries due to its technological characteristics. And this is expected to cause changes in the lives and lifestyles of ordinary people as well as changes in society as a whole. However, recent discussions about this are mainly focused on research, such as introducing the characteristics of the Internet of Things or predicting the impact on society.^{[3][4]} Although the Internet of Things is predicted to have a significant impact on changes in industry and society, research on this is being discussed focusing on the introduction of technology. Therefore, in this study, the current research trends of the Internet of Things are analyzed, and through this, a desirable research direction for the Internet of Things is sought in the future.

II. Characteristics of the Internet of Things and Research Trends

Research on the Internet of Things focuses on introducing related technologies and trends, industrial ripple effects and applications, characteristics and introduction of services, and policy and legal discussions following introducing technologies and services ^{[5][6]}. This is similar to the issues discussed in the process of introducing other new technologies. Because the Internet of Things is a result of the development of digital technology and information and communication technology, the development of these technologies affects related industries and services, and the ripple effect causes socio-cultural changes, and at the same time solves various social and legal and institutional issues it has a linking structure that causes it ^[5].

The discussion on IoT technology is centered on the technical elements necessary for the development of the Internet of Things. Broadly speaking, the discussion about the network of the Internet of Things and the platform to connect the network can be said to be key elements. Discussion on the Internet of Things network is focused on the evolutionary direction of wired and wireless communication networks, and in particular, the protocol required to transmit information using the network and the standardization surrounding it are an important agenda. The core technology of IoT platform technology is the development of hardware and devices that transmit and receive information from the Internet of Things, and among them, the development of sensing technology that controls input/output of information by mounting it on a device is a major topic of interest ^{[7][8][9]}.

The industrial ripple effect and application fields of the Internet of Things predict the market of the Internet of Things, and the future growth potential is a major concern. In addition, the movements and trends of related industries, and future activity prospects are also major topics of discussion. The outlook for the IoT market is very positive, and the ripple effect is expected to be very large. Industrial fields to which IoT is or can be applied include agriculture, forestry, fisheries, electricity, gas, water supply, construction, wholesale, retail, food, transport, finance and insurance, real estate and business services, public administration, defense, education and health,etc. it classified as social and other services. In addition, industries directly related to the activation of the Internet of Things can be said to be the information and communication industry and the ICT industry ^{[10][11]}.

As for the characteristics and introduction of IoT services, the main concern is the changes and innovations that can occur when the Internet of Things is applied in each field in the future. The purpose of providing IoT services is the development of individual, industrial, and public sectors, and the main players in these IoT services can be divided into product groups, platform groups, and service groups. In addition, the main service areas of the Internet of Things can be classified into energy, environment, healthcare, lifestyle, security, energy, smart building, smart home, smart production, and transportation ^[13]. These areas are recently pointed out as areas where changes in related services will occur when the Internet of Things is applied or applied. And it is expected that the change will mainly result in service development in an optimistic aspect ^[11].

In the legal and policy-related fields of the Internet of Things, legal issues arising from the introduction of the Internet of Things are the main agenda. The main concern is the discussion of security, personal information protection, and protection of the right to privacy, which can

appear when all objects and objects and objects and humans are connected ^[15]. Furthermore, the problem of the information gap between layers that may appear according to the development of the Internet of Things, and the solution of legal issues surrounding traffic that will appear as a result of the enormous exchange of information are also controversial. In terms of policy, policy issues following the introduction of the Internet of Things (IoT), and foreign policy concerns and solutions to issues are of major interest ^{[15][16]}.

III. Research method

In order to examine the research trends of domestic IoT, this study analyzed related research papers. Among the research papers on the Internet of Things, papers published in academic journals that are more than candidates for registration by the Academic Promotion Foundation and papers published in academic journals published by the academic association, which is a regular academic organization, were targeted for research. The analysis papers were selected by searching for keywords such as 'Internet of Things and 'Intelligence of Things Communication' on KISS and DBPIA, websites that provide information on the original text of the academic thesis, and the homepage of the Academic Promotion Foundation. And the original papers provided by these sites were reviewed and analyzed. The subjects were 101 papers published from 2010 to August 2017, when IoT-related papers were first searched on the academic papers search site.

In order to understand the research trend of domestic IoT, the research year, research topic, research method, and academic field of related papers were analyzed. In the case of the study year, the analysis was based on the year indicated in the academic journal. The research topics were analyzed by classifying them into IoT technology, industry, service, policy and others. Research topics were analyzed through sub-categorization for each field in order to understand research trends in more detail. In the case of technology, it was subdivided into technology standards, technology proposals, technology trends, technology introduction, technology application, and industry into industrial application and convergence, business strategy, industry prospects and ripple effects. The service was analyzed by subdividing it into service strategy and service users, and policy into legislation, policy improvement, and institutional improvement. Research methods were classified into literature review, case analysis, survey, interview, test (model analysis), mathematical prediction and analysis, and others. When two or more research methods were used in one paper, all methodologies used were included and analyzed. The academic field followed the system of the National Research Foundation's academic research field classification table for journals in which IoT papers were published. The classification standard was broadly classified into eight academic fields: humanities, social sciences, natural sciences, engineering, medicine, agriculture, fisheries and marine sciences, arts and sports, and multidisciplinary studies ^[5].

IV. Internet of Things Research Trend Analysis Contents

A. Internet of Things Research Topic:

Research with the term "Internet of Things" has been published in academic journals since 2010. This result is believed to be due to the fact that the term Internet of Things (IoT) has been

used in earnest since 2013. Before the term Internet of Things, the term (Machine to Machine) or IoT communication was used in the world. As a result of categorizing research topics by year, it was found that related research has increased dramatically since 2014. This coincides with the time when discussions on mobile and smart media are active in the world ^[18].

As a result of analyzing the research topics by dividing them into five categories: technology, policy, industry, service, and others, 57 of 101 papers were technology-related research. This is because IoT-related technologies are continuously developing and are being partially applied to actual industrial fields, so research that introduces technological features is active. After technology, research on industry was actively conducted, and research related to service or policy had a remarkably small number of research papers, indicating that it has not received much attention at this time.

(Table 1) Internet of Things Research Trend Analysis Unit

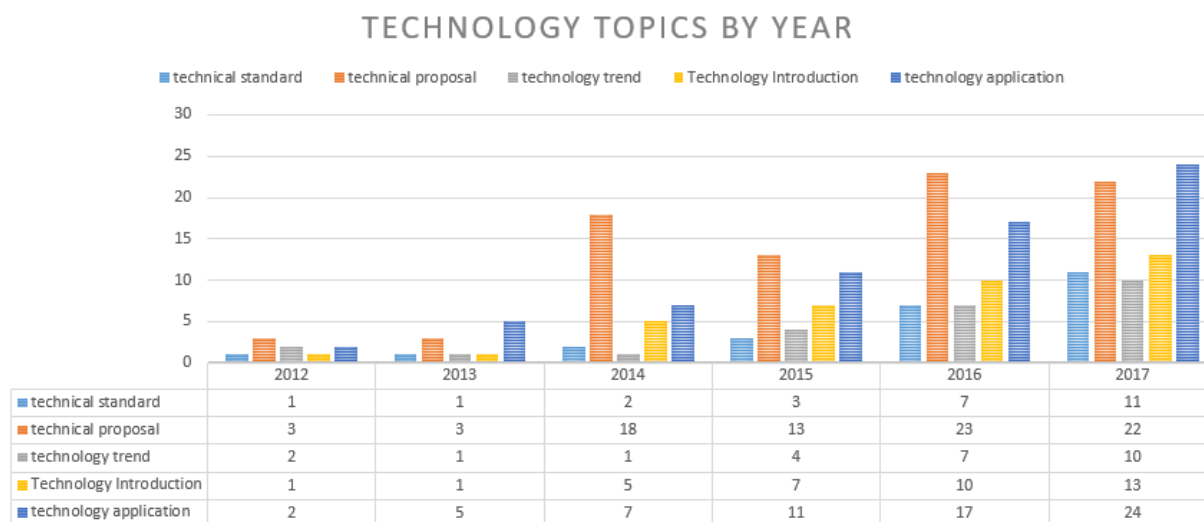
Analysis Target	Unit of analysis	Standard
Research topic	Technology, industry, service, policy, etc.	Key research areas on the Internet of Things in the dissertation
Research method	Literature review, case analysis, survey, interview (including in-depth interview), Test (model proposal), mathematical prediction and analysis, etc.	Internet of Things Research Methodology Adopted by the Paper (Multiple Choice)
Field of study	Humanities, Social Sciences, Natural Sciences, Engineering, Medicine, Agriculture, Fisheries and Oceanography, Arts and Physical Education, Complex Studies	The National Research Foundation's major classification of academic journals in which IoT papers are published

1. Research topics related to technology

Research topics related to technology were subdivided into technology standards, technology proposals, technology trends, technology characteristics (introduction), and technology applications. In the technology field research, the number of papers related to technology proposals was remarkably high with 33 papers. This seems to be because the standard technology for connecting and exchanging information between devices, which is the core technology of the Internet of Things, has not been developed. The ultimate form of the Internet of Things is the connection of everything around the user. That is, all things are connected regardless of devices such as smartphones, TVs, washing machines, and air conditioners. However, each device has a different service platform according to the size of the device or the purpose of the service provided, so there is a limit in compatibility. In order to overcome and improve these issues, and to efficiently connect various different devices, research on technology proposals is being actively conducted. And these technical proposals focus on organically connecting different types of devices based on existing technology rather than proposing new technology development ^[12].

In addition, among the research on technology proposals and technology introduction, studies on sensors occupy a large proportion ^[19]. Sensing technology is a major technology of the Internet of Things that attaches electronic tags to necessary objects or places to acquire surrounding context information and delivers information in real time ^{[20][17]}. In order for the

Internet of Things to be possible, each device must be able to collect information on its own. And the sensor attached to the device acts as a human sense organ and collects information. Sensors are the field with the highest potential for research in the future in that intelligent devices are sensory organs that acquire information.



(Figure 3) Technology Topics by Year

In addition to sensing technology, some studies on IoT security technology are also being conducted [16]. Internet of Things security technology is a broad technology that is applied to all major technology fields such as sensing, network infrastructure, and interfaces, and a large amount of data generated through the Internet of Things. Multiple connections in the Internet of Things require various security technologies suitable for each field. The security technology of the Internet of Things includes various parts such as protocols and networks, but the development of technology related to user information protection and privacy protection is of utmost importance. Therefore, more active research is needed in the future [11].

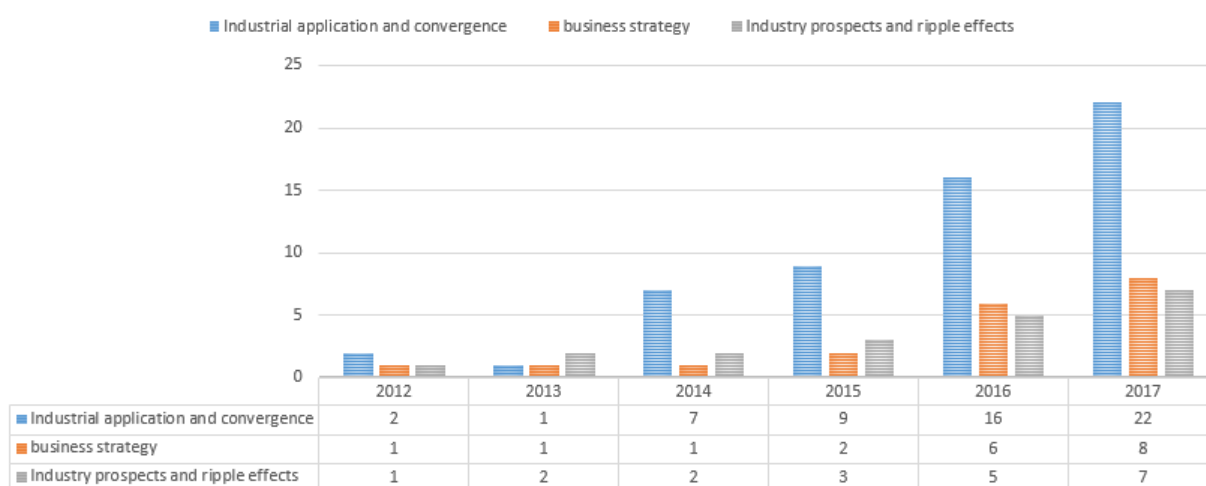
2. Research topics related to industry

There were 28 research topics related to the Internet of Things (IoT) related industry, and among them, 22 studies on industrial application and convergence accounted for the majority. Studies on industrial application and convergence are studies that show how the Internet of Things can be applied to everyday industrial fields. Industrial fields to which IoT is applied are healthcare [18], security devices, monitoring system and environmental monitoring network [10] It is being carried out across a variety of fields. These results show that IoT research is currently being conducted in a limited field. However, as time goes by, it is expected that application methods will be studied in all industries beyond IT [4].

Currently, studies related to IoT industrial application and convergence are mainly at the level of proposing IoT technology in the relevant industrial field rather than the actual case of industry or business point of view. In order for the Internet of Things to take root in society, it is necessary to derive many application ideas in the industrial field. Lin, C. C., Deng, D. J., & Lu, L. Y. (2017)., who studied the industrial outlook and ripple effect of the Internet of Things,

suggest three things for industrial revitalization using the Internet of Things, which provides implications for future research. *First*, an ecosystem environment in which large and small businesses can co-exist must be established. In order to develop and spread new services through the convergence of IoT technology and other industrial fields, the interest and participation of many people, including the government, companies, and citizens, who make up the ecosystem is important. *Second*, the development of IoT core technologies and the discovery of service models that constitute the industrial base should be activated. In order for the Internet of Things to make people's lives richer and more convenient, it is necessary to develop user-centered services from a long-term perspective. *Lastly*, since the most worrying part about the use of new services according to technological evolution is the leakage of private information, the related industry can only be activated when trust is secured through technology and preparation in this field. Therefore, future research in the industrial field needs to be conducted in consideration of these factors, rather than simply focusing on the industrial application of the Internet of Things ^[17].

INDUSTRY THEME BY YEAR



(Figure 4) Industry themes by year

3. Service-related research topic

There are studies on the service strategy and service users in the research on the IoT service. However, the research on the IoT service was only 7 out of 101 studies, so the proportion of research was insignificant. In particular, there was a drift tree related to the service status in the initial classification, but there was no study on it. This phenomenon seems to be due to the fact that the domestic IoT is in its infancy and the atmosphere for research on the service status is not ripe yet. Therefore, it was confirmed that this field is a subject for further research in the future.

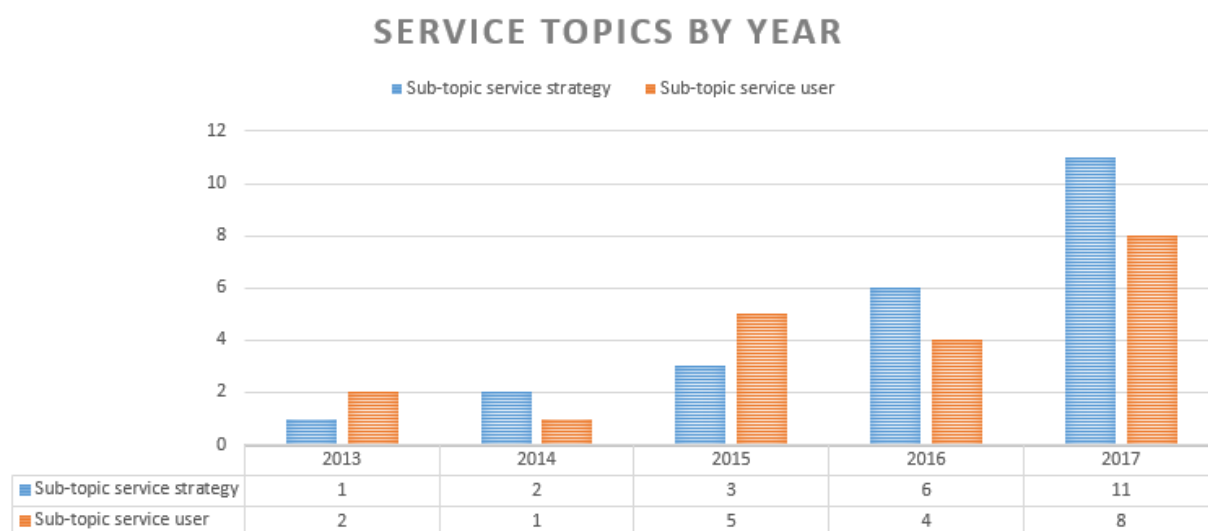
With full-scale IoT services appearing in TV commercials, it is clear that interest in IoT services is growing. However, research on the Internet of Things is still technology-oriented, and studies on service and user convenience are lacking. As a direct study on service and user convenience, there was a study by ^{[22][23]}. There is a study on the search for factors that influence

when consumers choose M2M housekeeping technology ^[13], a case analysis on the interaction between the Internet of Things and users ^[24], the Internet of Things. In addition, a study ^{[1][4]} on the effect of advertisements implemented with technology.

On the other hand, as a study on IoT service strategy, Singh, M., & Kumar, S. (2017) conducted a study on the classification system and utilization of IoT service as a basic study for activating the IoT service market. The classification and utilization of the service system can be said to be a basic study to explore how the Internet of Things, which is being applied in various fields, can be applied from the user's point of view. Therefore, at this point in time when interest in the Internet of Things is growing and services are being activated, it is necessary to conduct extensive research on the current status and strategies of IoT services at home and abroad, as well as the interests between service providers and users.

4. Research topics related to policy

Although the Internet of Things (IoT) is still developing at a rapid pace in terms of technology, it has not yet reached a sufficiently mature state in terms of industry. This situation means that there is no discussion on the clear legal position, definition, and technical regulation of the Internet of Things. This is because there are no legal or policy issues raised in the course of application or service in the industrial field of IoT. For this reason, the government is also announcing policies to revitalize the industry rather than enacting laws or preparing regulations on the Internet of Things ^{[1][9]}.



(Figure 5) Service topics by year

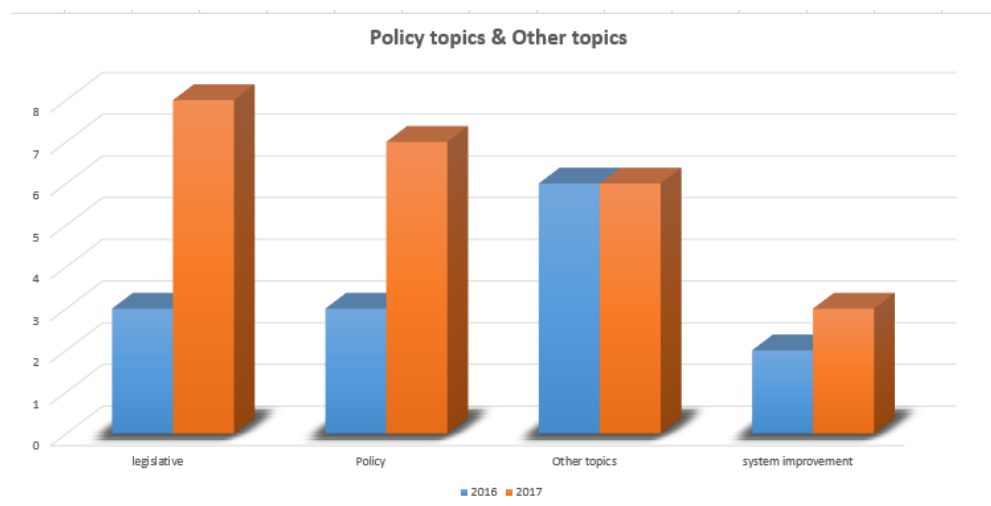
All studies on the policies of the Internet of Things are about security and information protection. Since the Internet of Things (IoT) is a structure in which the devices surrounding us are connected to the Internet, there is a high possibility that all information can be leaked through any device around us. For this reason, it can be said that policy studies are mainly concerned with information security. As the Internet of Things develops, human life becomes easier, but as much information is accumulated in the Internet world, the importance of

information protection cannot but be emphasized. However, it is also necessary to consider that excessive regulation in the name of security and information protection acts as a stumbling block for an industry that is in the midst of growth. Nevertheless, at the time when the IoT service starts, it is necessary to have more active legal and institutional discussions for users to safely use the Internet of Things and to provide reliable IoT services. The Internet of Things (IoT) is not limited to a specific industry and has characteristics that change our lives.

Therefore, the Internet of Things (IoT) is not limited to laws and policies related to the Internet or communication, such as the Telecommunications Business Act, but is also related to laws and policies related to all environments surrounding humans. This suggests that the discussion of law and institutional improvement on the Internet of Things is not independent but should be done together with other fields. In addition, it can be seen that it is necessary to prepare systems and policy measures that take into account the ripple effect in the fields related to our lives from the stage of the technology introduction process ^{[8][4]}.

5. Other research topics

Subjects other than technology, policy, industry, and service were classified as other and as a result of analysis, 4 papers were classified. In the study by ^{[20][21]}, who proposed a model that enables a comprehensive understanding of services by reflecting the relationships among components within IoT / IoE services, not only the relationships between people but also the relationships between people and things in IoT services. We judged that the relationship is important and proposed a stakeholder object map (SNT MAP) reflecting this. Meanwhile, Vashi, S., Ram, J., Modi, J., Verma, S., & Prakash, C. (2017, February) conducted a study on UX (User experience) design in the Internet of Things based on a user-centered design paradigm. I thought that the layout of the existing social commerce app was similar to the data-based layout in the interface of IoT devices, and analyzed the layout using the data-based app as a model to organize the structure of the UX design.



(Figure 6) Policy topics & Other topics

Dorri, A., Kanhere, S. S., & Jurdak, R. (2016) analyzed the IoT platform as a technology and the platform in the major fields of global companies. In addition, he performed quantitative information analysis centered on literature so far and dynamic analysis of keyword mapping

centered on keywords for future promising area detection. Vashi, S., Ram, J., Modi, J., Verma, S., & Prakash, C. (2017, February) looked at humans connected to the Internet of Things from a philosophical point of view. He established an ontological foundation that can minimize the harmful effects such as human exclusion, identification of humans and machines, and transparent exposure of privacy that the network of the Internet of Things will cause sought based on the 'mutual world of flesh'.

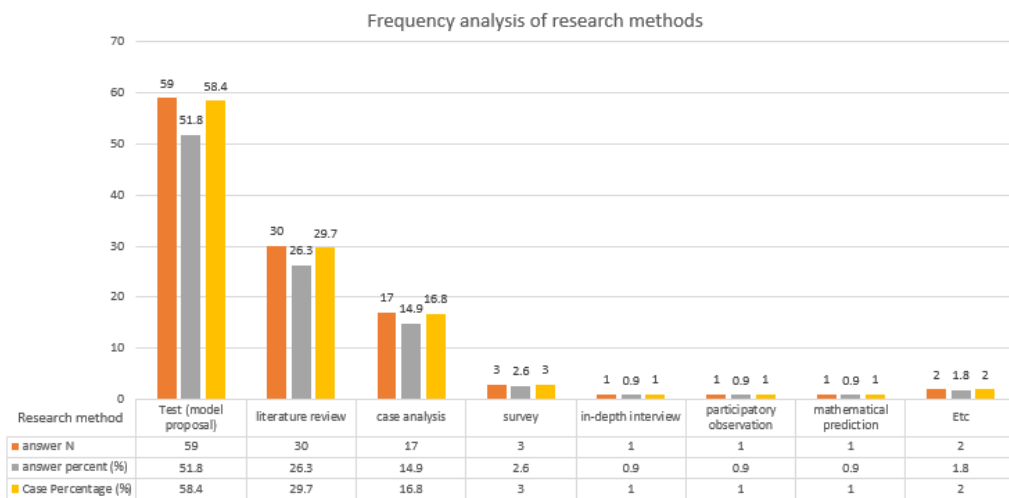
B. Internet of Things Research Methods:

1. Use of research methods

In order to analyze which research methods were mainly used for IoT research, the research methods used in the papers were reviewed. As a result of the study, the test (model proposal) method was found to be the most used. This result is because the technical proposals that appeared the most in the topic analysis are mainly made through tests (model proposals). The test (model proposal) is centered on the process of executing and evaluating an IoT system, system component, or software program. Besides the test (model proposal) method, there were relatively many studies on literature review and case analysis. In the case of literature review, technology trends on the Internet of Things are considered through domestic and foreign references, and case analysis focuses on research that suggests application cases of the Internet of Things. Other studies, such as surveys, in-depth interviews, and participatory observations, were rarely used as there were only one or two studies [18][20].

2. Research method by research topic

The trend of applying research methodologies to the Internet of Things is closely related to the research topic. As previously analyzed, since the research of the Internet of Things is mainly focused on the technical field, the test method used for technical analysis took up a high proportion. Of the total 59 pilot studies, 45 were in technology-themed studies and 14 were in industry-themed studies. The characteristic of the research method by subject is that, in the case of literature review, it is widely used in all research subjects [17]. This is because literature review has versatility that can be used in research on any subject. In addition, case analysis was used in various topics. This is the result of research in all fields in the process of introducing domestic and overseas cases of the Internet of Things. For in-depth research on each topic in the future, it is necessary to activate the use of research methods such as surveys and in-depth interviews [16].



(Figure 7) Frequency analysis of research methods

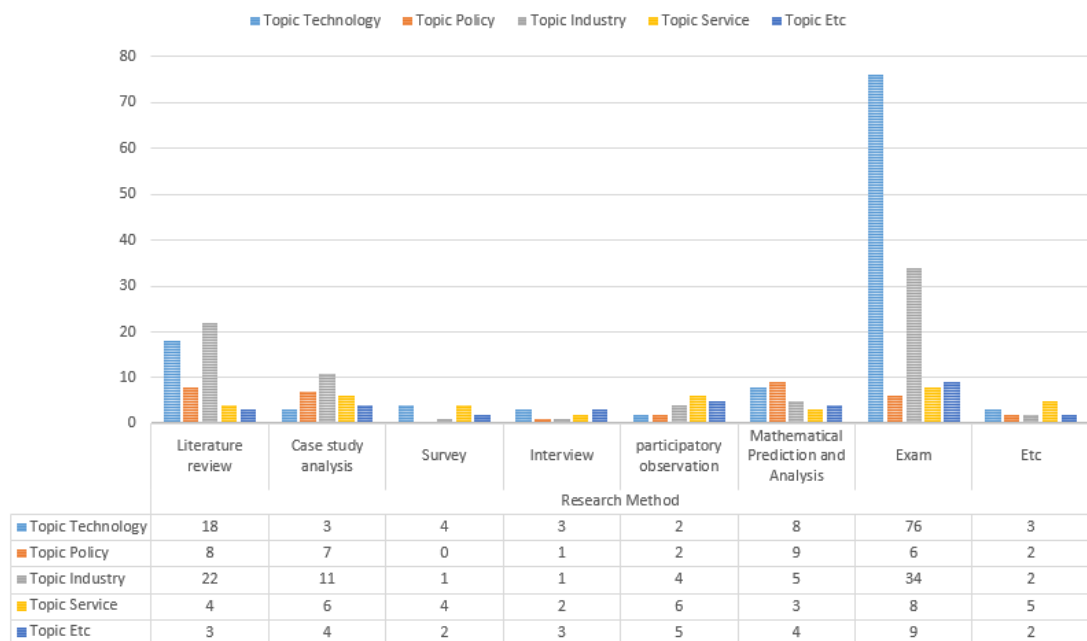
3. Internet of Things Research Academic Field

In this study, we analyzed which academic fields are being conducted in IoT research. The humanities, social sciences, natural sciences, engineering, medicine, agriculture, water and marine sciences, arts and physical education, and complex studies were classified and analyzed, but in reality, they were limited to six fields, including engineering.

Engineering is the most active field of IoT research. 76 out of 101 studies were conducted in the engineering field, and most of the research was conducted in the engineering field. This seems to be because research on technology is mainly conducted in the engineering field. In other words, it can be seen that the field of study of IoT is also closely related to the research subject.

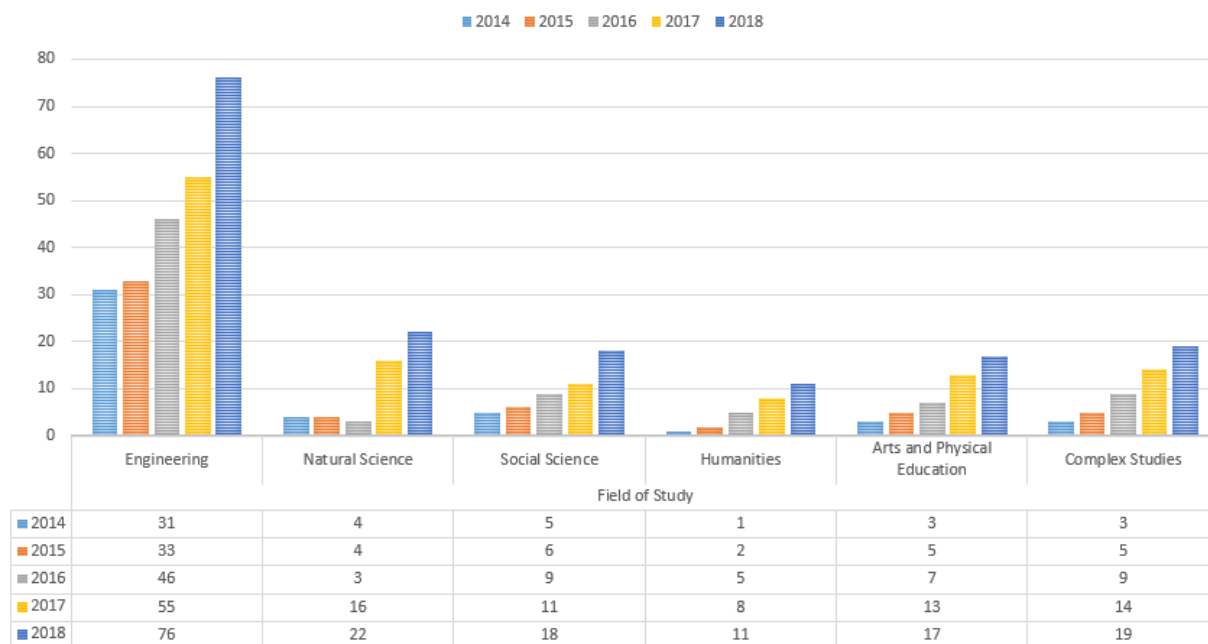
After engineering, research in the social sciences was found to be the most active. This is because studies on the social effects of IoT are mainly conducted in the social field. Following the social sciences, a lot of research on the Internet of Things has been conducted in complex studies. However, although the Internet of Things is basically based on ICT technology, it reflects the fact that some research related to the convergence of the Internet of Things is being conducted in that the field of application is infinite [19][24]. There was a total of 5 studies in the field of arts and sports, and they were related to IoT design such as user environment.

RESEARCH METHOD BY TOPIC



(Figure 8) Research method by topic

ACADEMIC FIELDS BY YEAR



(Figure 9) Academic Fields by Year

Considering that IoT is a service based on ICT technology and a growing industry, it is inevitable that research so far is centered on engineering. However, future research will have to be more diversified and more extensive across all disciplines. As the age of the Internet of Things matures, the Internet of Things becomes a part of it across all fields [21]. Considering that there may come a world where all companies and all disciplines have nothing to say without talking about the Internet of Things, it is necessary to diversify the fields of study that interest them in the future.

V. Suggestions for future IoT research

The Internet of Things (IoT) is a technology that automatically controls computers through mutual connection while extending the use of computers that people have used so far to objects. If the Internet of Things (IoT) spreads due to these characteristics of IoT technology, it is predicted that a full-fledged smart society will emerge. In other words, the operating system and logic of the current social formation will change to a new paradigm, and human efforts and resource investment will appear with incomparable effects. In other words, human effort and resource investment will be halved, while social utility will more than double compared to input. In particular, it is expected that a big bang will occur in the industrial field using the Internet of Things, creating new industries and jobs [22].

With the development of the Internet of Things, its ripple effects are expected to appear in various fields of society. Therefore, it is necessary to expand the field of research on the Internet of Things in the future to various fields rather than being limited to the technical aspect. In particular, it is necessary to conduct more active research on how IoT can be applied to the

industrial field and how related industries can be vitalized. Research on the impact of the Internet of Things on humans and society also needs to be revitalized. Along with research on various services that can be implemented through the IoT, it is necessary to promote research that considers the effects these services will have on society and its members ^[14]. This is because no matter how excellent a technology is, it is difficult to spread if society and its members do not adopt it. In particular, it is necessary to actively conduct research on prevention of side effects that may occur due to service activation. In addition, as IoT is already being applied in various fields of our society, research on policies and systems for effective introduction is also needed. should proceed together.

Research methods for the Internet of Things also need to be diversified. In the current technology field, research on model prediction or simulation is at the center, so research is mainly conducted on the aspect of model proposal, and literature review and case studies are also conducted. Although partially conducted, studies such as surveys, in-depth interviews, participatory observations, and mathematical prediction and analysis need to be activated for research on socio-cultural ripple effects and effects on users. In the case of research methods, there is a possibility that the research topic will be naturally resolved if the research topic is diversified, but it should also be considered that the content and subject of the related research can be changed through the improvement of the research method. It should be developed into a study that verifies the social acceptability of technology through observation, participation, etc. ^[23].

The field of research on the Internet of Things also needs to be diversified. As mentioned earlier, the impact of the Internet of Things affects all areas of society and humans, so an engineering approach is important, but research in basic fields such as natural sciences, social sciences, and humanities It also needs to be actively pursued. In addition, the development of art and physical education, the combination with the Internet of Things, and cooperation between various convergence phenomena and the Internet of Things can be said to be important research tasks. In addition, approaches and research in law are needed for social acceptance of IoT. A new level of academic approach should be sought so that IoT can be positioned as a research that drives the development of our society and improves the quality of life of members of society through various analysis methods in various academic fields.

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