A Study on the Structure of Research Domain for Internet of Things Based on Keyword Analysis†

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<Abstract>

Internet of Things (IoT) is considered to be the next wave of Information Technology transformation after the Internet has changed the process of doing business. Since the domain of IoT ranging from the sensor technology to service to the users is wide, the structure of the research domain is not delineated clearly. To do that we suggest to use the Technology Stack Model proposed by Porter et al.(2014) to measure the maturity level of IoT in organizations. Based on the Stack Model, for the general understandings of IoT, we do keyword analyses on the academic papers whose major research issue is IoT. It is found that the current status of IoT application from the perspectives of cloud and big data analytics is not active, meaning that the real value of IoT has not been realized. We also examine the cases which deal with the part of cloud process which is crucial for value accrual. Based on these findings, we suggest the future direction of IoT research. We also propose that IT is to value chain what IoT is to the Stack Model to derive value in organizations.

Key Words: Internet of Things, IoT, Keyword Analysis, Maturity, Research Domain, Value Creation

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Ⅰ. Introduction

Internet of Things is considered to be the next wave of Information Technology transformation after the Internet has changed the process of doing business. By introduction of personal mobile devices to individuals, people are connected to each other and to the Internet services. As pointed out by Porter et al.(2014), IoT changes the "things", not just connecting each other but transmitting data among them. The things can be objects such as humans, animals, and plants, physical devices such as machine, car, and every conceivable ones. Peripheral devices have important implications for the quality life of human beings and competitiveness of industry and organizations. Due to the extension of IP address to 128 bit IPv6, there is an ample address space so that huge number of objects can be addressed. It is expected that the number of "things" connected each other and to the Internet will grow exponentially. For the application, we already noticed the advent of autonomous cars and drones. Since the "things" can be anything ranging from factory machinery, human beings, etc., the application of IoT is limitless. That is why IoT is the main driver of the 4th Industrial Revolution.

Considering the popular and extensive remarks from the mass media and academia on IoT, we believe that it is the time to take a scientific measurement of how much IoT research has contributed to the generation of value to individuals and organizations. However, IoT area is diverse since the research ranges from the core sensing technology, transmitting the sensing data to the gateway using short haul communication protocols, and value adding operation at cloud by integrating external data and information systems.

From the literature review, we have many IoT survey papers, but we did not find any paper which deals with the identification of research domain using the keyword analysis. Since keywords are chosen intentionally by the author, they convey important aspects of each article. Thus, from the keyword analysis, we conjecture that we can find out the research trend of IoT area.

In addition, it is noted that most of the research deals with the technological subjects, especially for sensing devices and networking. However, the physical IoT devices are only useful as long as they are applied to the real situations. Moreover, the characteristics of data captured from sensors are typically big data: variety, volume, and volatile. The big data need to be integrated with other sensor data and the data from the existing systems and analyzed for the application to produce value.

Thus, the objectives of this research are to find 1) the major domains of IoT related research using keyword analysis, 2) the current status of IoT application from the perspectives of cloud and big data analytics. For the second objective, we apply a framework to measure the maturity of IoT application and research. To do that we use the Technology Stack Model proposed by Porter et al.(2014) and modify it to make the model suitable for our analysis. Applying the Stack Model, we examine the cases which deal with the part of cloud process which is crucial for value accrual. We suggest the future direction of IoT research.

In section II, we provide the background literature on IoT, along with the Technology Stack Model for analyzing IoT. In Section III, we explain how we get the sample for the analysis. In fact we use a keyword analysis on the title and keywords databases. In Section IV, we provide the distribution of articles by three disciplines such as Social Science, Fusion, and Engineering, distribution of journals by domains, and keyword distribution for each discipline. In Section V, we look into the abstracts of all the papers in the sample, and analyze the cases from the maturity perspective using the Stack Model. If the papers deal with all or a part of the cloud process mentioned in the Stack Model, we extract the crucial elements of IoT. A conclusion and suggestion to the future research direction are provided in Section VI.

Ⅱ. Background and Literature

1. Technology as leverages for changing business

We have gone through three waves of technology changes last 50 years (Porter et al, 2014). The first wave of technology is achieved through the automated and technology supported work, mostly individual works, a value chain became more efficient and productivity increased. In the second wave of Internet technology enabled coordination and integration in the business process and linked suppliers and customers tightly. In the two waves of technology changes, most of the information in organization was captured by the inside system, not by the things. Thus the role of the things was passive and controlled by the system. In the third wave of technology change, things are equipped with sensors, processors and memories and they are connected to the cloud where the data generated by the things and other sources of data are integrated and analyzed. Analyzed results are used to enhance the things. The things are the real triggers of the change. Penetration of the sensor data deep inside the business sphere will provide opportunities for the fundamental change of doing business.

2. Categorization of IoT

We can trace the route how the data captured from the things are transmitted, processed, integrated, analyzed, and applied back to the things. Based on the implication of Porter et al.(2014), we can categorize the cycle into three levels. The first is a short circuit approach: Environmental data are collected by the things, and processed and analyzed inside the things without connecting outside data or systems. A standalone thermostat is the example. According to a comparative study of three countries such as Korea, Japan, and China's representative mart electronic home appliances, most products do not have self-learning feature. This implies that the IoT system's cloud, especially big database and analytics is not robust. Thus it is important to understand the linkage between the product or sensors and the cloud needs to be systematic for creating value to the users (Jang et al, 2016).

The second level is the closed cloud approach. In this situation, the data generated by the things are connected to the closed cloud where only the historical and related data from the things are stored and analyzed, and the results are sent back to the things.

The third level is the open cloud approach where all the relevant data and systems of an organization as a whole and stakeholders are linked together, and interacting each other. The value accrued and the coordination required will be different for each of the approaches.

It is also indicated in (Kwon, 2015) that most of the research done on technology issues but few discussed on service and business models. Recognizing the phenomena, Kwon (2015) emphasized the role of big data, indicating that the analytical results from the big data provide a crucial additional value to the existing product and services and also it can give a new opportunity for creating higher level services.

3. Literature

A keyword analyses have been used in diverse area. For example, to analyze the complex knowledge domain of big data, a keyword analysis mapped the keywords into the big data processing steps (Namn, 2015). In Law area, a keyword analysis along with other descriptive and social network analysis was used to find the knowledge production structure (Lee, Han, and Kwon, 2015). Joo et al.(2015) analyzed the IoT research trend. They surveyed 101 articles in terms of the publication year, research subjects, research method, and research area. Among the findings, they noticed that most of the papers on research subject come from technology area, followed by the industry application of IoT. But IoT service is very rare, indicating that the application of IoT is not realized as value creating services.

A keyword search on "internet of things" or "web of things" was done on the Web of Science, which is run by Thomson Reuters from 1987 through 2015, resulting in 1,648 articles (Son, 2015). Son (2015) showed that the publication increased rapidly from 2013 and 2014. The ranking of the publications by country was China, US, Spain, UK, and Korea. However, the exploration of research domain by mapping the keywords receiving more than 6 times was not successful due to the lack of data sufficiency.

Kim et al (2015) proposed a categorization scheme for IoT services such as service purpose, service player, and service domain. Using 117 articles, they classified the purpose as the beneficiary of the service, individual, industry, and public. Service players are the providers differentiated as product, platform, and service. They noted that the product providers are dominating, followed by service and platform. It implies that the platform whether it is application development or data integration is the major obstacle for the advanced ecosystem of IoT and for getting the true value out of IoT system. Finally the major domains are grouped into healthcare, lifestyle, smart production, smart home, smart building, energy, security, and transportation. Their findings indicates that the current mode of IoT application is individually oriented healthcare related and wearable devices to measure the bio-data. In addition, the data captured by sensors are simply transmitted to the server or cloud without integration with other sources of data to make the IoT system intelligent.

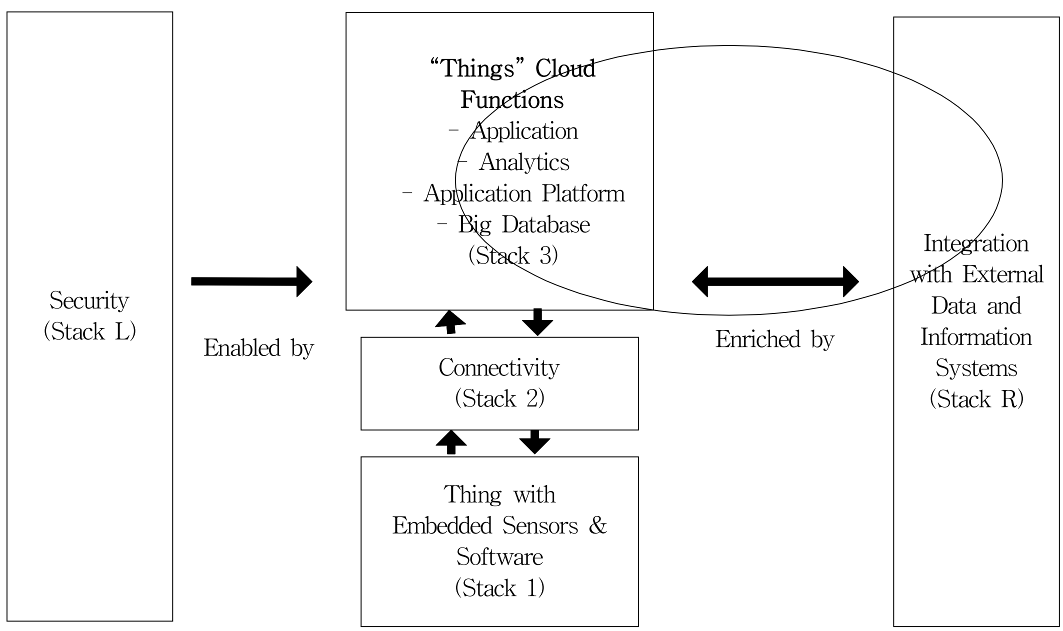
IoT application domains are grouped into transportation and logistics, healthcare, smart environment of home, office, and plant, and personal and social domains, along with the sub domains for each group of domain (Atzori, et al., 2010).

Defining the IoT as the intersection of physical and digital entities, Miorandi et al (2012) presented the challenges of technology, applications, and research on IoT. They identified the leading application areas such as environmental monitoring, smart cities, smart business, and inventory and production management, Regarding business applications, in turn they suggested the RFID technology based inventory and production control system, and identification technology at retail stores for limiting thefts and counterfeits, and bio-sensor technologies to guarantee the quality of the products. Their applications are based on the simple monitoring and identification, not on the cloud and big data analytics, making the IoT approach a closed cloud.

4. Framework of IoT research

Like a value chain model which a business process is analyzed as a chain of specific activities where strategies can be applied to enhance value to customer (Porter and Miller, 1985), Porter et al.(2014) proposed the IoT Technology Stack Model. The Stack Model is important in the following points: it is comprehensive and systematic. From the original Stack Model, I modified it into a simplified model for the purpose of this research as in <Figure 1>.. We focus on the circled area, an intersected area of cloud functions and integration with other product cloud data and information systems. Importance of cloud in IoT is that cloud technologies complement a number of restrictions of IoT and offer various advantages such as scalability, interoperability, reliability, efficiency, availability, security, ease of access, ease of use, and reduced cost of deployment (Choi et al.,, 2015).

For the convenience of the readers, a brief explanation for each cloud in Stack 3 in <Figure 1> is provided here as follows: 1) Big database cloud is the place where a diverse set of IoT and other types of data are merged together, 2) Application Platform Cloud (PaaS) is a platform where a set of standardized development tools like APIs to database access and system build-up is provided, and 3) Analytics cloud builds rules, logics, patterns from diverse analytic techniques. Analytics ranges from descriptive, diagnostic, forecasting, or prescriptive levels, 4) Applications are based on the cloud data and analytics, applications on cloud are used to monitor, control, optimization, and manage things, 5) As an enabler of IoT, for Security and integrity (Stack L) of IoT, and to make IoT legally binding, a set of security measures such as privacy control, access control, encryption, etc. need to be provided seamlessly. Secure measures enable the applicability of IoT, and 6) A real convergence of IoT is realized by the integration of external data and enterprise information systems (Stack R), so that the value out of IoT is limited not to the "things", but to the whole organization. We will use this framework in Section V to survey the papers to see the maturity level of IoT application.



<Figure 1> IoT Stack Model: Modified from Porter & Heppelmann(2014)

Ⅲ. Data

We utilize peer reviewed academic papers. We first use keyword search to filter an appropriate set of samples for IoT. Our assumption is that the keywords filtered and sorted indicate the inherent characteristics of related papers without looking into the details of papers.

For the investigation, we used the Korean Citation Index (KCI) Search Engine, to filter out the academic articles whose major themes are “Internet of Things”. Note that KCI search engine provides searching areas like title, author, institute, publisher, journal, keyword, and abstract. Among the seven areas, we chose title and keyword for the search: The title is the most important and condensed identifier of an article. If the keyword is shown in the title, the relevancy of the keyword will be high. Keywords are intentionally chosen by the authors and journal editorial boards require authors to provide a certain number of keywords. Keywords are important part of the bibliographic data to convey the semantics of an article. The relevance of the search result from the set of keywords will be lower than that from the title. But we include the keywords for the search to make the sample data set more comprehensive. The two search conditions were connected with conjunction “OR”.

On these two areas, we performed searching using “IoT” since the term is used extensively by default. We limit the searching to Social Science, Fusion, and Engineering, since other areas such as Humanity, Natural Science, Agro-Oceanic Science, and Art and Physical Science have published insignificant number of articles. The keyword search was done on February 24, 2017. After the exclusion of articles which did not provide keywords at all, the total number of articles searched by the term resulted in 511 articles. From the 511 articles, all the keywords are extracted. The set of the extracted keywords is the sample, along with the articles themselves. By the simple sorting operation, the total number of keywords from each of Social Science, Fusion, Engineering reached at 234, 328, and 1495, respectively, excluding the term IoT, Internet of Things, and Internet of Products.

Ⅵ. Keyword Analysis

In this section we use the sample derived from the keyword search on title and keyword database to understand the key aspects of IoT research domain articles.

1. Distribution of articles by the discipline

Since 2010 when the term IoT newly appeared in a Social Science journal, we notice a rapid growth in terms of the number of publications. Compared with the Social Science, the publication from Fusion Science and Engineering is increasing dramatically. In Social Science, most of the articles deals with the introduction to IoT or conceptual issues of IoT. The scope of Fusion area is not limited to management, expanding to the issues of in-depth scientific and technology. In the Engineering area, journals on Electronics and Communications are most active since there are big opportunity to enhance the capability of sensors in terms of cost, performance, low power, and endurability of the devices. In addition, the reliable connectivity among sensors and to the gateway needs much research.

It is conjectured that the number of authors will increase because IoT requires cooperative research to cover the diversity of coverage and to acquire the real value out of IoT as time goes by.

In <Table 1>, the set of three areas as a whole shows a positive relationship between the year and the average number of authors per article. The average number increase from 1.95 in 2014, 2.16 in 2015, and 2.62 in 2016. However, it does not hold for each of the areas. In contrast with the areas of Fusion and Engineering, the number of articles in Social Science decreases in 2016 and does not reflect the general popularity of IoT.

<Table 1> Distribution of Articles and Authors

Category		2016	2015	2014	Total
Number of Articles (A)	Social Science	20	24	9	53
	Fusion	46	26	8	80
	Engineering	173	127	46	378
	Total	239	177	63	511
Number of Authors (B)	Social	37	36	17	90
	Fusion Science	97	63	14	174
	Engineering	496	284	92	944
	Total	626	383	123	1208
Average Number of Authors (B/A)	Social Science	1.85	1.5	1.89	1.70
	Fusion Science	2.11	2.42	1.75	2.18
	Engineering	2.87	2.24	2.00	2.50
	Total	2.62	2.16	1.95	2.36

2. Distribution of articles by the journal domain

For the recognition of diverse domain of research on IoT, we provide the distribution of academic journals which published IoT related articles in <Table 2>. As expected, the number and the range of the distribution is quite large.

In the Social Science, Law journals contributed the most, followed by management area journals. The reason for the high contribution of Law journals can be explained as the privacy and personal information including health related are critical in IoT. In the Fusion area, journals related with Interdisciplinary journals produced most articles, followed by Science and Technology journals. Fusion area journals encompasses a wider area of IoT subjects than that in Social Science area. In Engineering area, Electronics & Communications and Computer Science journals dominate the research. It can be explained by the fact that there are many important issues such as embedded technology, sensors and telecommunication protocols, and so on.

<Table 2> Distribution of articles by journal domain

Social Science		Fusion Science		Engineering	
Discipline	Articles	Discipline	Articles	Discipline	Articles
Management	15	Interdisciplinary area	49	Electronics & Communications	115
Law	21	Science & Technology Studies (Others)	16	Computer Science	114
Trade	6	Science & Technology	5	ICT Theory and Applications	44
Social Science	3	Technology Policy	5	General Engineering	42
Mass Media	2	Information Service	3	Electrical Engineering	8
Geography	2	Library Information Science	2	Embedded Systems	12
Others	17	Science of Emotion & Sensibility	2	Aerospace Engineering	9
				Industrial Engineering	5
				Software Engineering	5
				Others	24
Total	56	Total	82	Total	378

3. Distribution of keywords for each area of research disciplines

We categorize the keywords derived for each of the three disciplines in <Table 3> through <Table 5>. Since the naming of keywords is done by the authors, a specific keyword may be represented in many different ways.

In that case, we group the keywords with similar meaning into a new keyword concept. For each keyword, we provide the frequency, along with the location of Stack in the simplified Stack Model of <Figure 1>. The assignment of Stack to each keyword is based on the author's judgment, considering the characteristics of keywors and Stack. As a reference, there are three vertical stacks, from Stack 1 through Stack 3, and two horizontal stacks, Stack L for the Stack of security, and Stack R, for the Stack of integration with other data and information systems in <Figure 1>.

From a total of 234 keywords in the Social Science articles, the following major keywords are summarized. As is indicated in <Table 3>, personal information protection issues are the most frequently appearing keywords. It reflects that the domain of IoT research is narrow, limited to the application for individual usages.

<Table 3> Keyword distribution in Social Science discipline

Subjects	Frequency	Keywords included	Stack
Personal information	22	Personal information protection, privacy	L
Sensor	10	Device, Wearable device	1
Cyber security	9	Data security, information security, internet security	L
Big Data	6		3
Hyper Connected Society	8	Digital Ecosystem	3
Supply Chain	5		3
M2M	5		1
Business Model	3		3
Value	3		3

<Table 4> Keyword distribution in Fusion discipline

Subjects	Frequency	Related keywords included	Stack
Convergence	14	IoT Convergence, Convergence Technology	3
Sensor	14	Wearable device, sensor data, sensor network	1
Communication protocol	10	Beacon, BLE, Bluetooth, Zigbee	2
Security Management	6	Security framework, security mechanism, security provisioning, safety	L
IoT Service	6		3
Arduino	6		1
Service	6	Service brokering platform, service certification, service composition, service quality	3
Cryptography	4	authentication	L
Big data	3		3
Cloud	3		3
Information Security	5		L
Privacy	3		L
Smart Grid	3		3
Ontology	3		3
U-health	2		3

<Table 5> Keyword distribution in Engineering discipline

Keywords	Frequency	Stack	Keywords	Frequency	Stack
Sensor, Device, RFID, LED	91	1	Security, Encryption, Information Security, Authentication, Privacy	72	L
M2M	27	1	Arduino, Raspberry	21	1
Gateway	16	2	Health	15	3
Big Data	15	3	Cloud	13	3
CoAP	12	2	Platform	12	3
Service	19	3	Energy	11	3
Bluetooth	9	2	Power Management	9	3
Home	14	3	Middleware	8	3
BLE	7	2	Heterogeneity	27	3
smart factory	5	3	Ontology	5	3

Keywords related with business settings such as big data, supply chain, business models are not dealt with in depth, but dealt with conceptually. Also note that the keywords representing the Stack L and Stack 1 are listed in the top, which indirectly proves that the research on Stack 3 is not active. Ideally IoT should go along with “Big Data”. That is why authors choose “Big Data” as keyword for convenience reasons without any significant implication of the term in the research.

On the other hand, a total of 328 keywords are identified from the articles of Fusion area. Subjects with high frequency are shown in <Table 4>. Compared with the keywords from Social Science area, the spectrum is quite wide from technology to service. As is noted, “Convergence” is the major keyword since in this area, authors try to present new applications such as game and diet augmented by the IoT sensors for enhanced functionality. But the application is limited to closed cloud approach.

From the 378 articles on Engineering, a set of 1495 keywords are extracted. As expected, technology oriented terms such as “Sensor”, “Security”, and “Arduino” are the major keywords <Table 5>. Many papers discuss specific technology for the sensing device, application of connectivity protocol to devices, network security, designing prototype and demonstrating systems using open platform system “Arduino” or “Raspberry”. Issues such as “Big Data”, “Service“, and ”Cloud“ are conceptually dealt with, not in depth. Also note that technical issues for the application of IoT on ”Home“, ”Factory“, ”Energy Saving“ are included, but the cloud based analytics and integration with other data sources and information systems are not discussed.

V. Is IoT ApplicatioValue-Oriented?

From the major list of keywords in <Table 3>~<Table 5>, we can understand the major themes of IoT research on three academic areas such as Social Science, Interdisciplinary, and Engineering.

Due to the decline in the number from Social Science in <Table 2> which includes journals dealing with applications of IoT, we conjectured that the life cycle of IoT research is in matured stage. In addition, big data and cloud are the most associated terminologies with IoT, but the tables from 3 to 5 do not convey these popularity. Actually we expected keywords of "service", "value", "cloud", "analytics", "big data" with high frequencies. However, in reality, it turned out not to be true. Moreover, it is difficult to find the current state of research on IoT application since the research domain of IoT application is quite wide, and the keywords provided by authors are conceptual.

Similar concern raised by Kwon (2015) is that most of the research done on technology issues, but few discussed on service and business models. Kwon (2015) emphasizes the role of big data, indicating that the analytical results from the big data provides a crucial additional value to the existing product and services and also it can give a new opportunity for creating higher level services. Shim (2015) also mentions the importance of value network and the identification of effective business models which provide additional values to customers. Once a value network is established, a product can be value added in one case; while a totally different service may be derived from the same product, making the participants' stakes become bigger. Drones, Google's Nest thermostat, Apple's Health App, and GE's Industrial Internet are given as representative cases.

Regarding the value from the cloud database, Kim, W.(2016) noted that the current IoT applications depend on heavily on the vertical combination of sensors and devices networks, making the creation of IoT services expensive. He suggests an open market for IoT data sharing so that the application developers from diverse industries can access the data and integrate them with their own data so that the value from IoT can be enhanced. A platform is necessary for the echo-system suitable for easy utilization of resources among the IoT service providers, resource owners, and developers.

For the right direction of IoT development, Kim G.(2016) recommended the focus on the H/W development in the near future and S/W side such as big data analysis after that.

Since the data does not support the value orientedness of IoT and the related problems raised by the authors mentioed in the above, we review the abstracts of the whole set of 511 papers to see the level of IoT application, especially the extent of cloud utilization.

As a reference, from the total 511 articles, we found only 15 articles dealing with cases of cloud based IoT. Based on the modified Porter et al's Stack Model, we examine the level of the clouds and integration with other data sources and information systems for those 15 IoT cases in <Table 6>, using the types of cloud shown in the circled area in <Figure 1> of Section II. Thus, <Table 6> does not show the Stack 2 of Connectivity and Stack L of Security. The "things" mentioned in those articles ranges from casino chips, companion animals, bookcase, and so on.

<Table 6> IoT Application Cases Viewed from the Cloud of Stack Model

"Things"	Big Database Cloud	Analytics Cloud	Application	Integration*	Source
Slot Machine, Chips, Tables	Chip movement, Situational information of table	-	Casino management system	Corporate ERP and CRM	Lee et al. (2015)
Cow	-	-	Monitoring system	-	Kim et al. (2014)
Cattle	Cattle bio data & movement data &	Forecast analytics	Control of meat quality and Disease forecasting	-	Kim et al. (2016)
Waste Recycling Bin	Types and amount of waste deposited	Descriptive statistics	User refund & waste bin management	-	Nam et al. (2016)
Jewelry Short-circuit actuator	Environmental data such as temperature, humidity, and illumination intensity	-	-	-	Yoon et al. (2015)
Person	Individual person's bio-data, emotional data, and weather condition	Case based reasoning	Diet recommendation system	Ontology from external systems	Joh (2014)
Fermented food	Fermentation data	Optimization and forecast	Determination of the optimum fermentation conditions & optimum completion time	-	Kim et al. (2017)
Train cars & freights	Train device status & freight information	-	Safety due to device malfunction & in-transit freight information management	-	Won et al. (2015)
Indoor living room	Levels of carbon dioxide, particulate matter and VOCs(Volatile Organic Compounds)	-	Indoor air quality monitoring system	-	Kim et al. (2016)
Companion animals	Data such as walking distance and intensity of exercise of companion	Optimized feeding, customized	Customized companion animal care systems	Feed, pharmaceutical, and	Kim, S. (2016)

	animals	information provision based on life cycle, recommendation of medical treatment.		health care data and information systems	
Surveillance devices	-	Predictive capability	CPTED(Crime Prevention Through Environmental Design) system	-	Kim et al. (2016)
Bookcase (color sensor & color actuator)	-	-	Contextual design	Integration with other systems such as SNS	Kang (2015)
Portable air quality measurement system of indoor	Fine-dust density,	Presentation of descriptive and dashboard information	Monitoring and recommending precautious warning system for fine-dust level	Integration with regional fine-dust level data	Lee et al. (2016)
Refeer container sensor and actuator* (Stand alone system)	Temperature, status, and location data	-	Monitoring the remote container	-	Moon et al. (2015)
Greenhouse sensors	Temperature, humidity, bright intensity, acidity level, wind velocity, etc.	Predictive analysis and optimum growth condition recommendation	Plant growth management system	Integration with plantation data and knowledge base	Lee et al. (2014)

*: Integration with external data & information systems.
-: Indicates the appropriate information is not provided in the article.

From the <Table 6>, the following facts are derived: 1) 12 out of 15 cases are from Fusion area, and the remainder from Engineering. 2) Cloud for "application platform", where tools for application development are provided in terms of API and programming modules, does not exist in the IoT cases extracted from the three areas of disciplines. 3) Even though the papers mention the cases which deal with a part of the cloud services, most of them are conceptual, or normative. In addition, research reflects prototypes for device and system design. 4) Integration with enterprise information systems is rare: Treating the IoT system as a closed loop system, from capturing the surrounding data from a "thing", connecting to cloud DB, analytics cloud for the analysis of the incoming data along with the historical data, and providing the result to the user or sending back to the product, without integrating other information systems. In summary, IoT research needs to be augmented so that IoT should be part of the platform to give values to the whole organization in the future.

Ⅵ. Conclusion and Future Research

In this paper we showed that a keyword analysis can be applied to trace the major domains of IoT related research. The results indicate that the predominant keywords are Personal information protection in Social Science, Convergence in Fusion, and Sensor and security in Engineering. In addition we also proposed a framework which can be used to measure the maturity level of IoT application. However, the current status of IoT application from the perspectives of cloud and big data analytics is not active, meaning that the real value of IoT has not been realized.

For the research method, a robust method or a technique for grouping similar keywords into a concept needs to be employed in the future research. In addition, the sample may not represent the real population. As a future research direction, a comparison between Korea and International countries by incorporating the keywords from the SSCI and SCI journals will reveal the comparative status for applying IoT for value creation.

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요약

키워드 분석 기반 사물인터넷 연구 도메인 구조 분석†

남수현*

사물인터넷은 인터넷이 비즈니스 프로세스를 근본적으로 변화시킨 이후의 기술로 간주되고 있다. 그러나 사물인터넷의 영역이 하드웨어적인 센서 기술로부터 애플리케이션을 통한 서비스까지 광범위하여 아직까지 연구도메인에 대한 구조가 명확하지 않다. 본 연구에서는 기업에 가치를 제공하기 위해서 사물인터넷의 성숙도를 측정하기 위하여 Porter 등 (2014)이 제안한 기술스택 모델을 적용할 것을 제안한다. 스택모델을 이용하여 사회과학, 복합학, 공학 분야에서 발간되는 논문을 대상으로, "사물인터넷 (IoT)"을 키워드로 포함하고 있는 논문의 저자들이 제공한 키워드 분석을 실시하여 사물인터넷 연구의 일반적인 동향을 살펴본다. 결과에 의하면, 클라우드와 빅데이터 분석 기반의 IoT 활용은 활발하지 못하고 결과적으로 IoT로부터의 가치가 충분히 실현되지 못하는 것으로 나타났다. 또한 가치 도출에 중요한 클라우드 프로세스를 적용하는 연구 논문 사례를 발췌하여 사물인터넷의 응용 수준을 측정하였다. 본 연구에서 IT의 가치사슬모형 적용과 유사하게, IoT의 가치를 높이기 위해 스택모델 적용을 제안한 것도 의미가 있다 할 수 있다.

핵심주제어: 사물인터넷, 키워드 분석, 성숙도, 연구 도메인, 가치 생성

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