A study on IOT Applications and technologies in Logistics

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Abstract. One of the most trending state-of-the-art technologies due to broadening usages of logistics is Internet of Things (IOT) applications which has been enabled by new expandable platforms which are occupied in many applications like transportation, smart city, smart home and etc. To broaden this field of study there is need to classify and group all documents to find useful patterns and speed up and accurate future studies in order to achieve to greatest results. In this paper, some analysis to fulfil the pattern of studies and determine latest IOT applications in logistics is done. Results demonstrate that new inclines in IOT applications with logistics are embedded in airports and railways and some technologies like WSN, RFID and GIS are top of useful devices in this direction.

Keywords: IoT, logistic, bibliometric, internet of things

1 Introduction

Bibliometrics evaluates the impact of research outputs using quantitative measures. Bibliometrics complements qualitative indexes of research impact such as peer review, funding received. Together they assess the quality and impact of research.

Bibliometrics is used to process needed research outputs impact pieces of evidence when applying for jobs, research funding, find new and extruding areas of research, identify potential research colleagues and specify journals in which is appropriate to publish.

One of the total state-of-the-art technology due to broadening usages of logistics is IoT applications which have been enabled by new expandable platforms which are engaged in many fields such as transportation and smart city. Basically, IoT is an embedded devices platform are connected to the internet, hence they collect and exchange data with each other through a network. It makes interaction, collaboration and, learning among devices possible just like humans do.

The IoT facilitates the improvement of numerous industry-oriented and user-specific IoT applications. IoT applications enable two paired device and human-device interactions in a reliable and robust manner, while devices and networks provide connectivity. IoT applications on devices need to ensure that data have been received and acted upon properly with appropriate timing. For instance, transportation and logistics applications

monitor the transported goods' status. During transportation, the conservation status (e.g., temperature, humidity) is always under monitoring to avoid spoilage when the connection is out of range [9].

IoT applications are expected to provide some objects with connectivity and intelligence. It is widely being deployed, in various fields, namely: smart home applications, health care, smart cities, agriculture, automation. One of the most related them in below will is revealed.

Through Industrial Automation, speeding developments are happening, as well as the quality of products, which are the critical components for a greater Return on Investment. Today with IoT technologies, one could re-design products and other processes to get better performance in both cost and customer satisfaction. So, IoT all in this field includes the following domains, such as the smart grid, factory digitalization, self-checkouts and inventory management, operation management and predictive maintenance, packaging optimization, logistics, and supply chain optimization

IoT develops, makes difference, and keeps going. The IoT has combined hardware and software to make the world smarter. It has been growing at an exponential pace and offers some opportunities for infrastructure and business.

With all subsequent studies, the question of this paper that has not been answered yet is an accurate bibliometric study to find fields of progress in this area and justify answers by some analytics, then knowing which IoT technologies have been embedded yet and which of them are more useful and at last, a roadmap of these findings to lead researchers to better academic studies and developing new IoT approaches and methods.

The rest of this paper starts with reviewing some of the works that have been done in this field of study in section.2, then the method of search in order to conduct the study will be determined in section.3, after those some analytics on the results will be done in section.4, results of these analytics will be survived in section.5 and at last conclusion and final scientific findings will be discussed in section.6.

2 Literature Review

Recently, with becoming IoT and its applications a hot topic, some studies in the format of bibliometric and scientometric have been conducted. In [14], Python modules called ScientoPy were developed to execute quantitative analysis that brings insight into research trends by a lead author’s country affiliation inquiry, most published authors, top research applications, communication protocols, software processing, and operating systems. Another research in this area by [10], provided an overview of the key concepts related to IoT services development. Several research challenges have been identified, which are expected to become major research trends in the next years. In another study with a more bibliometric approach, [11] introduced a research theme five-cluster overview through IoT that shows the IoT increasing importance, but on the other hand, the studies that acknowledge the IoT applications for organizations and supply chains, and the wider socio-organizational context that needs to be considered.

It also highlights the need for alternative theories to be used in order to study IoT-related phenomena.

In terms of IoT applications, due to supply chain management,[3] found out that most studies have focused on conceptualizing the impact of IoT with limited analytical models and empirical studies, and also most studies have focused on the delivery supply chain process and the food and manufacturing supply chains. Another application of IoT s economics that is reviewed by [13], biggest producers of greenhouse gas emissions, including Brazil and Russia, still lack studies in the area. In addition, a disconnection between important industry initiatives and academic research seems to exist that shows it can be useful for all institutions and researchers to figure out potential research gaps and to focus on future investments.

3 Research methodology

In order to comprehend great researches and results in IoT applications in logistics, the Web of Science is used to search engines for articles to find the most authentic ones. So, the proposed method searched for titles, abstracts, and keywords that the term "Internet of things" AND "Logistics" appearing. As a result, there have been 249 research outputs from 2004 which is the start of trending of IoT technology up to now. that 4 of them are highly cited in this field which are leading other articles to the future of IoT researches.

After analyzing these results by VOS viewer, we accessed new and more comprehensive keywords. According to Table.1, these are: "internet of things", "IoT", "internet", "logistics", "RFID", "industry 4.0", "big data", and "cloud computing". So, then we combined all searches with the format of "Internet of things" + all keywords above to gather a true list about the intersection of IoT and logistics.

Table 1. Initial keywords list for search

Selected	Keyword	Occurrences	Total link strength
☑	internet of things	174	1203
☑	iot	109	729
☑	internet	75	651
☑	logistics	61	514
☑	things	51	433
☑	internet of things (iot)	48	351
☑	rfid	37	259
☑	management	34	329
☑	model	29	301
☑	industry 4.0	29	229
☑	technology	23	235
☑	security	23	194
☑	big data	23	186
☑	supply chain	23	179
☑	cloud computing	23	158
☑	systems	18	212
☑	design	18	167

As a result, our study attained to 3434 results from 2004 which is the start of trending of IOT technology combined with logistics up to know that 154 of them are highly cited in this field which are leading other articles to the future of IOT researches. There are

about 3119 articles and 84 proceeding papers (conference papers) and also 239 reviews which have the most shares among all types of papers in this field according to Fig.1.

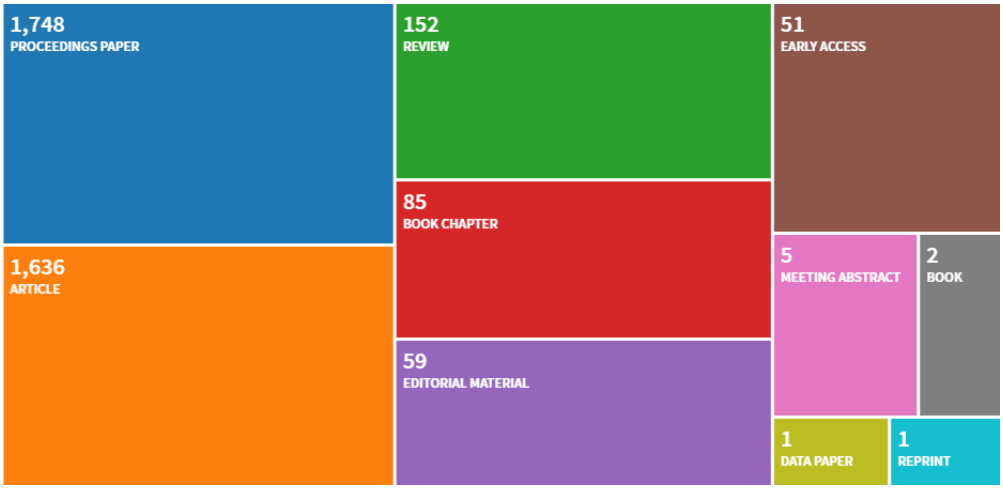


Fig. 1. Types of papers

Another information about our final dataset of search results is explained below:

- Total citation of papers in our dataset is 34823.
- Without self-citations (papers in our dataset cite each other) the total citation will be 32609 that shows papers mentioned in our dataset have a lot of impact on other fields of IoT or logistics and are influential papers.

4 Data analytics

4.1 Discuss on years of research

It's essential to find the trend of academic works in every field grouped by years. According to Fig.3 First pioneer publications in this field were ([5], [9)] that brought up the idea of the usage of IoT in many applications like logistics. Some analytics about years of publication are mentioned below:

- Total Publications by Year: Every year has some publications that important thing about this is the total number of publications per year which is shown in Fig.2 that most active years are 2019 with 1332 and 2018 with 936 articles that make sense and it can be predicted that in 2020 this record will break.

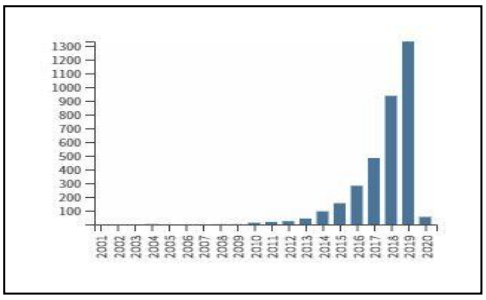


Fig. 2. Total Publications by Year

- Sum of Times Cited by Year: Another statistic about years is sum of cites per year that every year differs a lot in this metric with years before (Displayed in Fig.3).

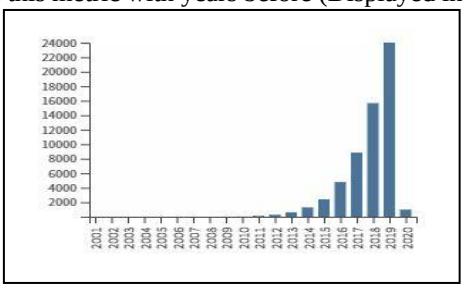


Fig. 3. Sum of Times Cited by Year

4.2 Discuss on keywords of this field

The most important part in bibliometric studies is keywords survey including occurrences of key words and their relation with each other. Results of Figure. Shows that most frequent keywords in our research are “Internet”, “Internet of things”,” IOT”,” Things”,” Security”,” Fog Computing” and “Cloud computing”. (Displayed in Table.2)

Table 2. Final keywords list

Selected	Keyword	Occurrences	Total link strength
☑	internet of things	921	6811
☑	internet	635	5506
☑	big data	533	4373
☑	cloud computing	430	3369
☑	iot	366	2726
☑	internet of things (iot)	362	2614
☑	things	359	3219
☑	security	243	2216
☑	cloud	229	1836
☑	fog computing	228	1598
☑	system	199	1712
☑	management	195	1904
☑	challenges	183	1922
☑	framework	175	1771
☑	architecture	168	1693
☑	model	164	1454
☑	design	160	1503

Our results indicating that both occurrences and relations have the same patterns that can be seen in Figure. Due to Fig.4, some keywords like “System”, “Security” and “Networks”,” Cyber-physical systems” and “Big data” have been under study for a long time.

In addition, some keywords like “Edge”, “Blockchain”, “SVM” and “Energy management” are lately trending keywords of edge technologies in this area.

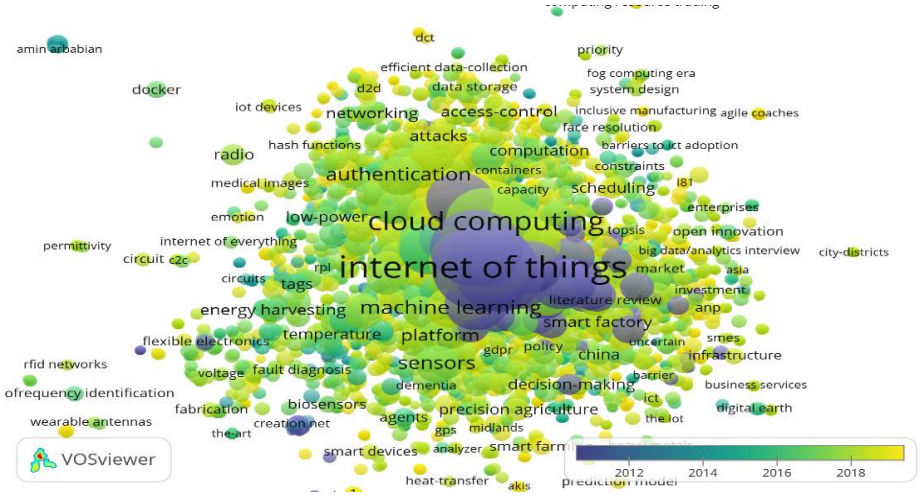
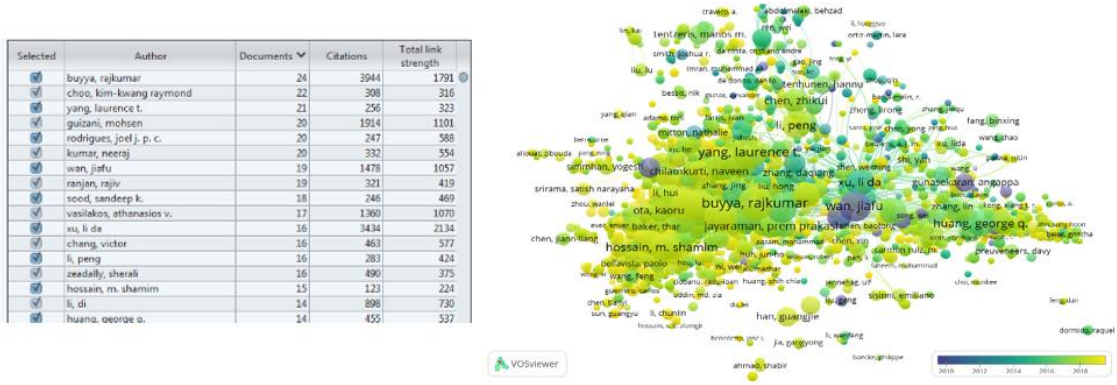


Fig. 4. Keyword’s occurrence graph

4.3 Discuss on authors in this field

Great authors in field of IOT are divided by two aspects: Number of documents and number of citations.

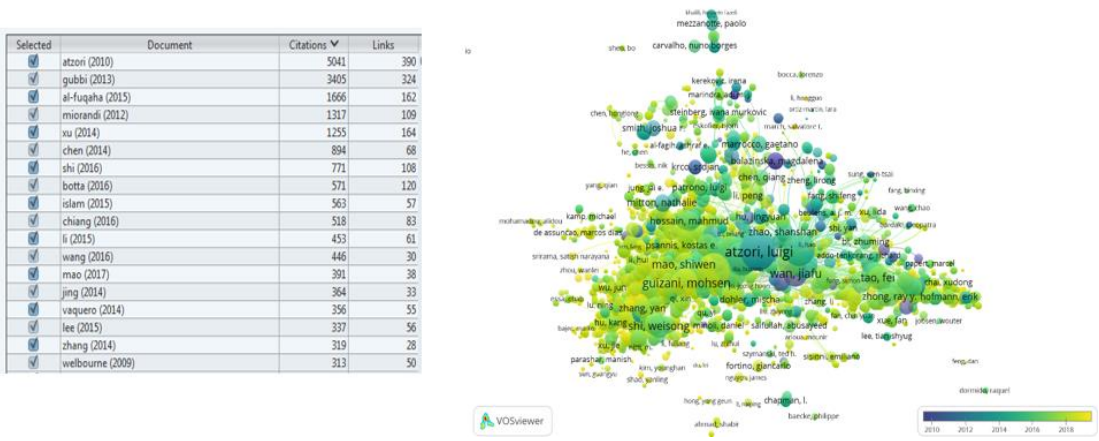
1. Number of documents: According to Fig.5 Rajkumar Buyya with 24 publications, Choo Kim-Kwang with 22 and Laurence Yang with 21 are top listed in numbers of documents in this area.



Selected	Author	Documents	Citations	Total link strength
☑	buyya, rajkumar	24	3944	1791
☑	choo, kim-kwang raymond	22	308	316
☑	yang, laurence t.	21	256	323
☑	guizani, mohsen	20	1914	1101
☑	rodrigues, joel j. p. c.	20	247	588
☑	kumar, neeraj	20	332	554
☑	wan, jiafu	19	1478	1057
☑	ranjan, rajiv	19	321	419
☑	sood, sandeep k.	18	246	469
☑	vasilakos, athanasios v.	17	1360	1070
☑	xu, li da	16	3434	2134
☑	chang, victor	16	463	577
☑	li, peng	16	283	424
☑	zeadally, sherali	16	490	375
☑	hossain, m. shamim	15	123	224
☑	li, di	14	898	730
☑	huang, george q.	14	455	537

Fig. 5. Number of documents list and graph

2. Number of citations: As shown in Fig.6, from this point of view, Luigi Atzori with 5073 citations and Antonio Iera with 5049 and Giacomo Morabito with 5041 citations are the best in citations. Also, there are new successful authors like Mohsen Guizani and Amir taherkordi in the plot.



Selected	Document	Citations	Links
☑	atzori (2010)	5041	390
☑	gubbi (2013)	3405	324
☑	al-fuqaha (2015)	1666	162
☑	miorandi (2012)	1317	109
☑	xu (2014)	1255	164
☑	chen (2014)	894	68
☑	shi (2016)	771	108
☑	botta (2016)	571	120
☑	islam (2015)	563	57
☑	chiang (2016)	518	83
☑	li (2015)	453	61
☑	wang (2016)	446	30
☑	mao (2017)	391	38
☑	jing (2014)	364	33
☑	vaquero (2014)	356	55
☑	lee (2015)	337	56
☑	zhang (2014)	319	28
☑	welbourne (2009)	313	50

Fig. 6. Number of citations list and graph

4.4 Discuss on countries

One of the subjects which have been always on the edge is countries with most documents and most citations that are somehow the same as each other in this field. Due to

Fig.7, it can understand that there are 14 groups or clusters that have been working with each other in the meantime. Foremost, due to Table.3, China with 1000 documents and 16760 citations, USA with 580 documents and 19396 citations, and Italy with 183 documents and 9717 citations are academic leaders of this field having the most documents and highest citations by their publication.

Table 3. List of countries

Selected	Country	Documents	Citations	Total link strength
☑	usa	580	19396	5474
☑	peoples r china	1000	16760	5500
☑	italy	183	9717	2008
☑	australia	195	6706	2105
☑	england	256	6503	2076
☑	south korea	246	3338	1603
☑	qatar	25	2409	549
☑	canada	146	2281	1196
☑	india	205	2185	1731
☑	spain	184	2182	1156
☑	germany	112	1976	819
☑	sweden	73	1950	818
☑	saudi arabia	111	1857	973
☑	france	83	1418	582
☑	taiwan	129	1214	672
☑	greece	53	1048	398
☑	malaysia	46	1037	632

According to Fig.7, there are some expert countries like USA, China, England and India which have been working on this area more than others and also newly added countries such as Iraq, Pakistan and Vietnam.

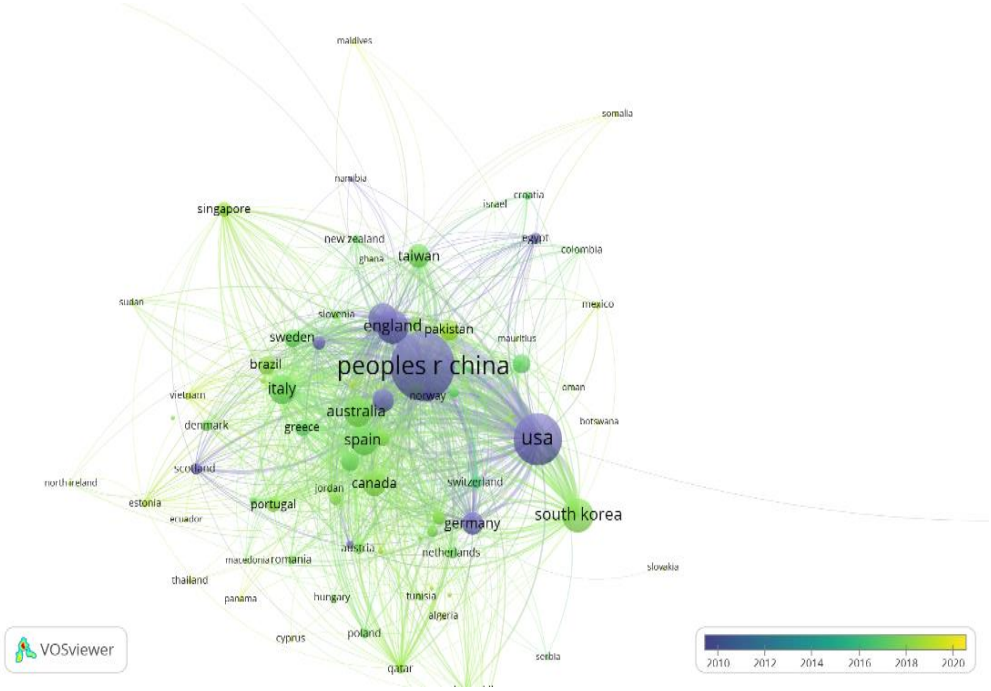


Fig. 7. Graph of countries

4.5 Discuss on Most important documents

Finally, have to classify all documents by their citation which is the best metric for evaluating the importance of an article. In order to group them, Fig.8 will help us to find out which articles have most citation. Note that most of them are not lately released. So, with attention to Table.4, and also Web of Science introduces us three articles:[2],[5] and [1] as hot papers meaning they are on top of the list of noticeable articles to read and cite them in IoT applications field.

Table 4. Important documents list

Selected	Document	Citations	Links
☑	atzori (2010)	5041	390
☑	gubbi (2013)	3405	324
☑	al-fuqaha (2015)	1666	162
☑	miorandi (2012)	1317	109
☑	xu (2014)	1255	164
☑	chen (2014)	894	68
☑	shi (2016)	771	108
☑	botta (2016)	571	120
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☑	jing (2014)	364	33
☑	vaquero (2014)	356	55
☑	lee (2015)	337	56
☑	zhang (2014)	319	28
☑	welbourne (2009)	313	50

Hence, a substantial question will be asked “What are hot papers or some papers that are being cited which are Recently published?”. To answer that from Fig.8 it can find out that [7],[12],[15] and [4] are the most newly noteworthy articles.

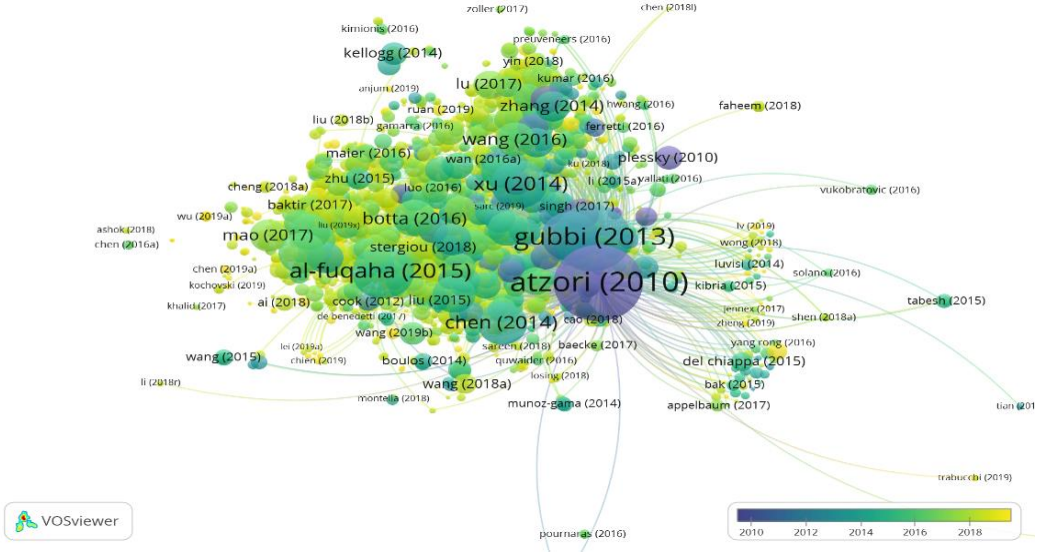

Fig. 8. Important documents graph

5 Results

In this section, we will use bibliometric analysis and some keywords related to logistics that is useful to find all IOT technologies have been utilized in logistics. According to Figure.4 all useful keywords in this direction in sort of importance are 12 keywords explaining all subjects and academic studies in this field including: “Internet of things”,” IoT”, “airport”,” technology”,” inventory”,” loading unloading”,” Logistic”,” port”,” TECH”,” rail”,” road” and “transportation”.

In the following, foregoing keywords will combine to determine IOT technologies in logistics. Hence, double words searching method is used to fulfil the main purpose of study. The output of searches are many articles and other kind of papers. These results will be used to find keywords that describes the technologies that have intersection with different types of logistics with purpose of answering the paper question. All results are shown in appendix A. In the next step, some patterns and connections between these technologies should be extracted.

There is not a lot of connection between our results per search, because of length of words. Totally:

1. As can be seen, “airport” + “internet of things” has the most technologies which means most of utilization of IOT has been in airport area and its facilities and after that, “Logistic” + “Internet of things” gives us the most technologies as might have guessed. So, some analytics on this will be conducted and as shown in Table.5 and Fig.9, there are some significant keywords known as airport IOT technologies introduced here. Most important ones are “radio frequency machines”, “Cloud computing”, “Distributed computer systems” and some new technologies here are “Citizen science”, “Distributed data stream”. Continuously, for all searches, these analytics will be survived and all results are in Appendix A (Table A).

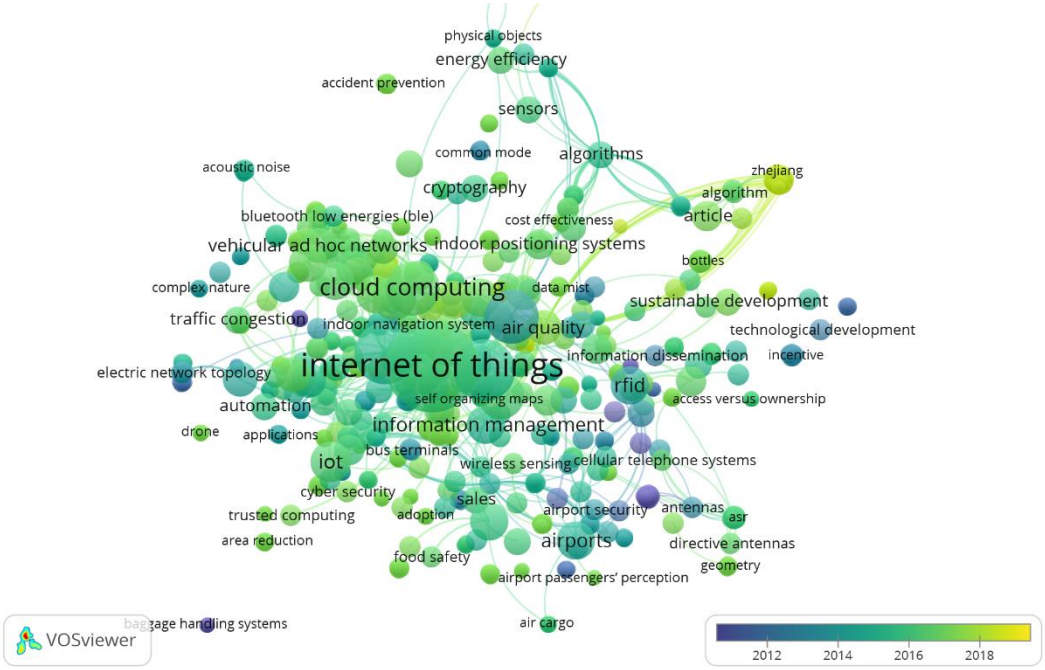

Fig. 9. "airport" + "internet of things" keywords graph

Table 5. "airport" + "internet of things" keywords list

Selected	Keyword	Occurrences	Total link strength
☑	internet of things	35	516
☑	internet	16	268
☑	internet of things (iot)	16	226
☑	radio frequency identification (rfid)	12	222
☑	cloud computing	12	179
☑	big data	10	151
☑	surveys	9	143
☑	internet of thing (iot)	8	122
☑	artificial intelligence	7	126
☑	iot	7	82
☑	mobile telecommunication systems	6	123
☑	distributed computer systems	6	117
☑	vehicles	6	110
☑	digital storage	6	102
☑	information management	6	101
☑	airports	6	96
☑	supply chains	6	89

2. The most frequent technology that appears in 6 searches is the Wireless sensor network (WSN) defining a group of spatially dispersed and specified sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind, etc. The next

technology that includes 5 searches is Radio-frequency identification (RFID) which is a form of wireless connection that utilizes the use of electromagnetic or electrostatic coupling in the radio frequency portion of the electromagnetic spectrum to uniquely identify an object. After that is Geographic Information System (GIS) with 3 appearance which is an arrangement designed to receive, store, manipulate, analyze, control, and present structured and unstructured data. All mentioned, are devices that make IoT cycle possible.

3. From all keywords that are generated from the search results, it might have understood that most applications of IoT in logistics are in fields of:

    a. Traffic control": using devices to intelligently managing traffic by optimizing times of traffic lights or warning officers to reduce the risk of accidents and mass of cars. Managing parking lots and monitoring systems in format of internet network is also be done to optimize this process.
    b. Automation": in this area using smart sensors and remote-controlled devices, speed of work and reliability will rise, and also the quality of products will get better under certain infrastructures like smart inventory control, decision support system, barcodes, smart maintenance, building smart expert systems, using NFCs, smart online fault detection systems, etc.
    c. Transportation": Managing Vehicles and containers with intelligent scheduling and timetabling is the true form of the familiar form of logistics that doesn't need any modeling or optimization using old methods. In fact, instead of them, sensors will gather a large amount of data every moment and will help this process more accurate and with less estimation or risks.

In the next step, all analytics discussed earlier to get used to drawing a roadmap that is a great assistant to follow this field and help to concentrate more effectively on important points (Figure.10). In this figure, it's obvious although three important major fields and four significant time intervals have been in this area, IoT applications have been more utilized in some specific areas and three unequal time phases.

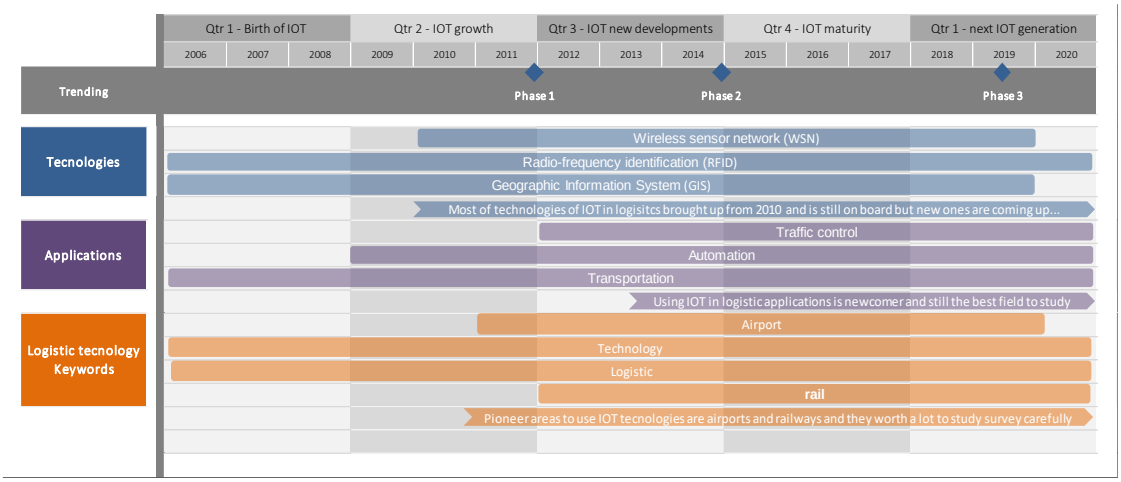

Fig. 10. IOT technologies and applications roadmap

6 Conclusion

In conclusion, from all analytics in intersection of internet of things and logistics area grouping by years, authors, documents, countries and keywords, to wrap up these points in summary, there are some points:

1. Some countries like USA, China, India and England have always been pioneers in this field.
2. Citation in this area doesn't have anything to do with history of that article because of state-of-the-art instinct of this technology. So, most cited articles are for not many years away.
3. Most used keywords of this field are "System", "Security" and "Networks"," Cyber-physical systems" and "Big data".
4. New hot keywords to use for this field are "Edge", "Blockchain", "SVM" and "Energy management".
5. At last, it's a great environment to fulfil or interests in internet of things because of its available infrastructure.
6. Airports and railways are always best places to facilitate with IOT devices and testing experiments in this field and three sections are the antecessors of developing IOT application with logistics approaches which many of technologies have been coming out from these processes including traffic control, automation and transportation.
7. IOT research in logistics contains four stages of progress and with passing every period, more technologies will come out and in future this trend will continue.

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8 Appendix A

In the following, search results of final keywords extracted from paper analytics which explains IOT technologies will be noted.

Table 6. A.1. technology search results part 1

airport + internet of things	airport + internet of things2	airport + technology	inventory .Internet of things	"loading unloading" + "Internet of things"	Logistic + "Internet of things"
RFID	intelligent system	object detection	RFID	Vehicle scheduling	RFID
intelligent buildings	efficiency	air navigation	scheduling	simultaneous control	mobile devices
energy saving	vehicular cloud	cooling	contex awareness	decision support system	service oriented architecture
energy conservation	security	traffic control	retail store	expert system	wsn
mobile device	ads-b	safety	automatic identification	emission	information exchange
mobile phone	optimization	gis	track and trace	RFID	energy conservation
retail store	vehicle to vehicle communication	simulation	robotic	real time information	temperature and humidities
integration	access control	temperature	inbound logistic	information sharing	information sharing
customer experience	fog	drainage	mobile phone		bar code
DATA MANAGEMENT	face recognition	engines	NFC		food saftey
fingerprint recognition	face identification	noise pollution			cellular telephones
enabling technologies	enviromental monitoring system	fire			near field communication
antennas	baggage handeling	water (waste-surface)			wireless sensor node
wsn	mobile application	groundwater pollution			mobile phone
cyber-physical system	decision support system	accident			mobile application
contex awareness	operational monitoring				expert system
data fusion	sales				waste management
	bsc				GIS
	health information				Traffic control
	lightening quality				fault detection
	air condition				virtual reality
	thermal comfort				data mining
					process control
					maintenance
					image processing
					traceability systems
					radio waves
					container

Table 7. A.2. technology search results part 2

Logistic + technology	port + IOT	rail + iot	road + iot	road + tech	transportation + iot
image processing	smart phone	electric fault current	traffic light	temperature	internet of vehicle
signal processing	mobile internet	failur analysis	vehicle to vehicle		wsn
intelligent system	GIS	fault detection	ITS		embeded sys
maintenance	robotic	high speed	Routing		decision support sys
assessment method	WSN	contorel	WSN		inventory control
		delay	accident preventin		smart parking
		automation	mobile devices		
		intelligent system	navigation		
		monitoring	traffic monitorog		
		multimodal transportation	traffic control		
		data acquisition	parking		
		embeded sys	time delay		
		cyber physical sys			
		reliability			
		rfid			
		smart sensor			
		vehicular sensor network			
		wireless			
		WSN			
		signal processing			
		condition monitoring			