Cloud Computing: A Study of Logistics as a Service (LaaS)

Yu-Hsin Hung

***Abstract*—Recently, cloud computing that applies data to generate key information in logistics activities has been an important area for research. In the last five years, the trend of "cloud computing" has emerged and become a core element in logistics management research. The common cloud computing service models are Infrastructure as a Service, Platform as a Service, and Software as a Service. At present, a new term "Logistics as a Service (LaaS)" has been created for this industry. This paper discusses the characteristics and benefits of cloud computing. Furthermore, it proceeds to discuss the various concepts of LaaS. We reviewed the academic literature associated with LaaS to explore the development and research trends. We aim to investigate the methodology as well as future development of LaaS. We surveyed the 117 related publications from 2010 to 2018 and analyzed the time trend and disciplinary distribution of emerging LaaS topics. The findings indicate that intelligence and automation are the core issues that drive the research associated with LaaS. The main research types are system design, systematic analysis, and critical review. "Cloud," "Logistics," "Manufacturing," and "System" are high-frequency keywords for LaaS.**

***Index Terms*—Logistics as a Service (LaaS), cloud computing, logistics management, cloud computing service models.**

I. Introduction

Logistics refers to the process of coordinating and shipping resources from one location to a specified destination. Logistics management includes managing the flow of things from the point of origin to the point of consumption to meet customers' need or corporations' requirement. Logistics involves the implementation of a complex operation and the resources managed include tangible items (i.e., materials, equipment, and liquids) and intangible items (i.e., time). The logistics of tangible items involves materials handling, production, picking and packaging, inventory, transportation, warehousing, and integration of information flow. The recent rise of cloud computing and the current concept of Logistics as a Service (LaaS) have attracted attention from both researchers and service providers. Scholars define LaaS as a logistics network of organizations, people, information, and resources supported by the service-driven cyber-physics system (CPS) [1]. LaaS is employed to meet the enterprise's requirements in the areas of collaboration, visibility, and efficiency within the logistics activities. Intelligent multimodal logistics network plays an important role in LaaS that involves moving a product from the supplier to customer or the provision of an accompanying service in the worldwide logistics. LaaS providers employ professional logistics solutions to inbound/outbound logistics from production facilities to warehouses, retailers, end users, and consumers; in addition, they manage the enterprise's transportation network, which includes truck, rail, air freight, and pipeline. LaaS providers such as Reply Com. are dedicated to enhance the efficiency in the supply chain management and provide a real-time data visualization by leveraging the extensive collaboration among every aspect of the logistics network. The trend in LaaS provides great resources and powerful methodology to support the decision-making process and automation of logistics. Currently, several enterprises utilize LaaS to optimize their logistics process, and the academic research related to LaaS has succeeded. LaaS related studies have increased with research topics ranging from the concept, methodology, system design, and strategy management of LaaS. Thus, providing an overview of this innovative research will benefit the interested people to efficiently understand, investigate, and enhance the functionality of LaaS. Therefore, this study surveyed the academic research output related to LaaS and analyzed publications from the period of 2010 to 2018 via Google Scholar. Indexed publications with keyword "LaaS" in their title, abstract, and content were retrieved and analyzed

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II. Research Background

Cloud computing is a concept that uses diverse services, such as software development platforms, servers, storage, and solutions through the internet. The process of logistics activities has an attribute of complexity and dynamics with an increasing demand for flexible and variable logistics activities. Logistics information technology (IT) systems need to be addressed with other approaches; thus, cloud computing is applied to solve the deficiencies in the traditional logistics IT service, and conduct a new approach, i.e., LaaS. Cloud computing is applied in LaaS for connecting logistics data on the same platform. Additionally, LaaS is used for the development of concepts and prototypes of flexible and modular logistics IT services [2]. Moreover, logistics IT providers play a very important role in providing LaaS related products/service to customers. Fig. 1 shows the current logistics environment.

A. 2018's Top 100 Logistics IT Provider

The rapid proliferation of cloud computing has resulted in rapid growth of digitized logistics service and brought significant attention to research opportunities in the Logistics IT industry. To increase the market share and add value to the

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enterprise, logistics service providers offer customer-driven services in the highly competitive Logistics IT industry. The world-famous logistics research institution Inbound Logistics (IL) proposed a list of the top 100 logistics IT providers in 2018 (see Table I). These providers serve the Fortune 1000 companies, along with the small and medium-scale businesses. The IL editors research the capabilities of these providers based on the submitted questionnaires and other sources, and select 100 technology providers, which offer solutions designed to fulfill the business manager's logistics supply chain challenges [3].

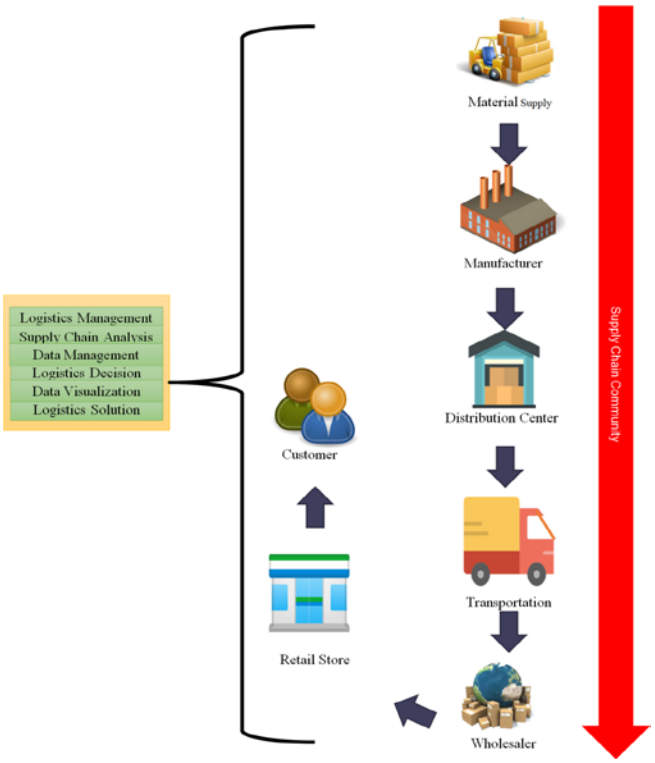

Fig. 1. The current logistics environment.

A. The Current LaaS Marketplace

Because of the progressing development in the internet of things, the commerce capabilities of new cloud computing platforms are expanding. The logistics industries require real-time collaboration, flexible delivery, intelligent analytics, and automation. Bayer pointed that the new logistics marketplace will be handling logistics for transactions concluded over the Internet [4]. In the LaaS marketplace, the service provider aims to convey the product from the vendor to the customer swiftly, efficiently, and economically. The global contractually committed service providers have been formed that causes the broad range of logistics services and expertize of internationally experienced companies (see Fig. 2). The marketplace includes various functions, such as real-time goods tracking, distribution automation, and online monitoring systems. In contrast to traditional logistics solutions, where the intelligence and commerce are initiated and controlled by the shipper, the LaaS marketplace platforms allow for bidirectional commerce. Modern LaaS marketplace needs advanced data analysis tools, which will enrich it with an intelligent analytical solution for statistics, transaction data, demand, and supply chain.

TABLE I: 2018'S TOP 100 LOGISTICS IT PROVIDERS

No.	Name	No.	Name
1	360data	51	Logistical Labs
2	3Gtms	52	Macola Software
3	3PL Central	53	Macro Point
4	A3 Freight Payment	54	made4net
5	Acuitive Solutions	55	Magaya Corporation
6	Agistix	56	Magic Logic Optimization
7	Amber Road	57	Manhattan Associates
8	ASC Software	58	McLeod Software
9	BluJay Solutions	59	Mercury Gate International
10	Bringg	60	Modus Link
11	C3 Solutions	61	Navegate
12	Cadre Technologies	62	Next Generation Logistics
13	Camelot 3PL Software	63	NGC Software
14	Cargo Smart	64	Nulogx
15	Carrier Logistics	65	Vision Global Technology Solutions
16	Cass Information Systems	66	Omnitracs
17	CDM Software Solutions	67	Optricity
18	Cheetah Software Systems	68	Optym
19	Clear Track	69	Oracle
20	Cloud Logistics	70	Paragon Software Systems
21	CT Logistics	71	Path Guide Technologies
22	CTSI-Global	72	People Net
23	Cypress Inland (Yard View)	73	PINC
24	Data2Logistics	74	Precision Software
25	Datex	75	project44
26	Demanad Management	76	Questa Web
27	Deposco	77	Quintiq
28	Descartes Systems Group	78	RateLinx
29	Elemica	79	REZ-1
30	enVista	80	Shippers Edge TMS
31	Epicor	81	SMC³
32	Fascor	82	Softeon
33	Fortigo	83	Sphere WMS
34	Freight Management	84	SPS Commerce
35	Freightgate	85	Suntek Systems
36	GT Nexus	86	Supply Vision
37	GTG Technology Group	87	Snapfulfil
38	HighJump	88	Systems Logic
39	Highway 905	89	TECSYS
40	Info-X Software Technology	90	TMW Systems
41	Infor	91	TOPS Software
42	Integration Point	92	Trans-iTechnologies
43	ITOrizon	93	Transporeon
44	JDA Software	94	Transport Gistics
45	JTS	95	U.S. Bank
46	Kuebix	96	Ultra Ship TMS
47	LLamasoft	97	URoute
48	LOG-NET	98	Veraction
49	Logility	99	Visual Compliance
50	LogiNext	100	WIN(Web Integrated Network)

Fig. 2. The LaaS marketplace.

III. The Related Research

The papers from Google Scholar were used to analyze the comprehensive profile of LaaS. We used the Bibliometrics methodology to analyze the time trend, authors' network analysis, and the citation patterns. The papers from 2010 to 2013 were retrieved using Publish or Perish (PoP) software, and the result was transformed into a Web of Science format. From the processed results, the authors' network analysis was obtained using CiteSpace. This study used keywords of "LaaS" and obtained 117 academic-related publications as outputs. The concept of LaaS was proposed recently; hence, the small number of research related to the logistics industry is presented. Table II shows the result of the analysis using the Bibliometric research methodology. Table III demonstrates the LaaS related research and the current citation status.

TABLE II: The Metrics of LaaS Publication

Metrics	
Publication Years	2010-2018
Citations	912
Cites/year	114
Cites/paper	7.79
Cites/author	395.83
h-index	13
g-index	28

TABLE III: The Main LaaS Research List

Cites	Authors	Title	Year
140	F. Tao, Y. Cheng, L. Zhang, A.Y.C. Nee [5]	Advanced manufacturing systems: socialization characteristics and trends	2017
117	L. Ren, L. Zhang, F. Tao, C. Zhao, X. Chai et. al [6]	Cloud manufacturing: from concept to practice	2015
111	L. Ren, L. Zhang, L. Wang, F. Tao et. al [7]	Cloud manufacturing: key characteristics and applications	2017
60	J. R. Huscroft, B. T. Hazen, D. J. Hall et. al [8]	Reverse logistics: past research, current management issues, and future directions	2013
46	W. Huber [9]	Industry 4.0 in automobile production	2016
43	C. Yu, X. Xu, Y. Lu [10]	Computer-integrated manufacturing, cyber-physical systems and cloud manufacturing–concepts and relationships	2015
42	K. Nowicka [11]	Smart city logistics on cloud computing model	2014
33	G .Prockl, A. Pflaum, H. Kotzab [12]	3PL factories or lernstatts? Value-creation models for 3PL service providers	2012
33	D. Collado-Ruiz, H. Ostad-Ahmad-Ghorabi [13]	Fuon theory: Standardizing functional units for product design	2010
29	M. Klumpp, U. Clausen, M. ten Hompel [14]	Logistics research and the logistics world of 2050	2013
22	Z. Chu [15]	Logistics and economic growth: a panel data approach	2012
22	L. Ren, L. Zhang, C. Zhao, X. Chai [16]	Cloud manufacturing platform: operating paradigm, functional requirements, and architecture design	2013
13	J.A. Vohr [17]	Haiti disaster relief: logistics is the operation	2011
13	T. Tolio, A. Bernard, M .Colledani, S. Kara, G. Seliger et. al [18]	Design, management and control of demanufacturing and remanufacturing systems	2017
13	V.V. Sople [19]	Supply Chain Management: Text and Cases	2012
10	Y. Wang, S. Ma, L. Ren [20]	A security framework for cloud manufacturing	2014

This study analyzed the authors' network in the 117 publications from 2010 to 2018. Ren collaborated with other researchers and proposed four cloud computing-related papers with high citation, and mentioned LaaS in these papers [16]. Fig. 3 demonstrates one academic network, which included Lin, Shlov, Smirnov, and Sandkuh [21]. Fig. 4 shows another academic network, which included Klumpp and Clausen. The research type of LaaS research includes system design (33.33%), systematic analysis (26.67%), critical review (20.00%), case study (6.67%), concept introduction (6.67%), and data analysis (6.67%). Table IV summarizes the types and the keywords of the LaaS related research.

TABLE IV: The Keyword and Research Type of the Main LaaS Research

Ref.	Type	Keywords
[5]	Systematic analysis	Advanced manufacturing system (AMS), Socialization, Service Resource sharing Value creation, User participation, Cloud manufacturing
[6]	System Design	cloud manufacturing, cloud computing, service-oriented business model, cloud platform, architecture, MfgCloud, public cloud, enterprise information systems
[7]	Critical review	cloud manufacturing, cloud computing, Internet of Things, cloud business model, private cloud
[8]	Systematic analysis	Content analysis, reverse logistics, Delphi method
[10]	Critical review	Cloud manufacturing, Cyber-Physical Systems, computer integrated manufacturing, Industry 4.0, Internet of Things
[11]	Systematic analysis	Logistics, cloud computing
[12]	System Design	Distribution management, logistics management, Service factory, Lernstatt, contract logistics, business model, logistics service providers
[13]	System Design	Life cycle assessment, Ecodesign, functional unit, product development, product family, FuonsDesign domains
[14]	Critical review	Logistics trends, logistics research, excellence cluster, ExcellenceCluster LogistikRuhr
[15]	Data Analysis	NA
[16]	System Design	NA
[17]	Case Study	NA
[18]	System Design	Sustainable development, system, circular Economy
[19]	Concept introduction	NA
[20]	Systematic analysis	NA

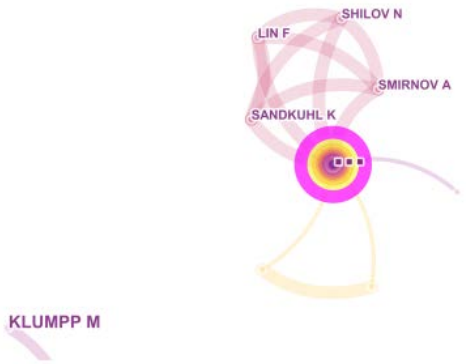

Fig. 3. The authors' network.

Fig. 4. The other authors' network.

IV. Time Trend of Publications

Fig. 5 shows the time trend in LaaS. 48 LaaS academic outputs were found from 2010 to 2012. The number increased to 90 in 2013. However, in the year of 2014, the number of LaaS publications went down to 22 and stayed relatively stable from 2015 to 2018. This may be because LaaS as a technology has gained a broader research coverage that focuses on cloud computing applications. Cloud computing has developed a diverse type of service model. Vazquez-Martinez formulated the CloudChain model for digital products based on supply chain principles [22]. Li et al. (2018) proposed a prototype for demonstrating the e commerce logistics and pointed that the importance of integration of diverse logistics systems to attain intelligent infrastructure.

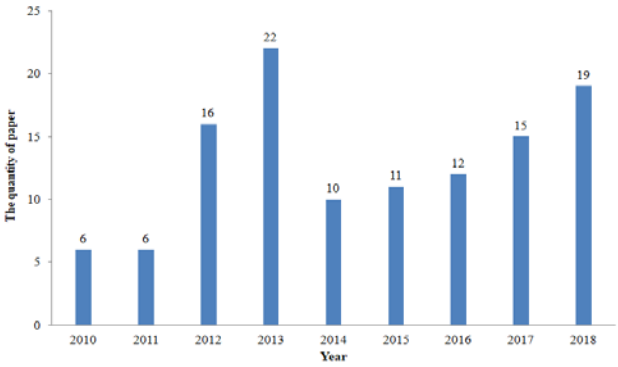

Fig. 5. The time trend of LaaS research from 2010 to 2018.

V. Future Research Prospect

The top four keywords of LaaS research are "Cloud," "Logistics," "Manufacturing," and "System" (see Fig. 6). According to the profile indicated in the previous analysis, LaaS is strongly related to cloud computing, manufacturing, and system. The future research will be based on these research topics. The cloud computing-related issues include data collection, integration, storage, analysis, machine learning, security, and infrastructure. The manufacturing related issues include an intelligent system, predictive maintenance, preventive analytics, automation, and real-time processing. The system related issues include mobile application, visualization, business intelligence, and customer-driven solution.

Fig. 6. The visualization of major keywords in LaaS literature.

VI. Conclusion

This paper reports results from the 117 published academic papers associated with LaaS. We used descriptive statistics, PoP, and CiteSpace to analyze the publications from 2010 to 2018 in Google Scholar. The time trend, research types, high-frequency keywords, and topic evolutions of these academic outputs have been reported. The concept of LaaS has been proposed recently, but the findings showed that literature on LaaS has a high number of citations. The concepts of cloud computing, manufacturing, and system are essential in LaaS.

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