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Deployment of Cloud Computing in Logistics Industry

Jae Un Jung*, **Hyun Soo Kim****
BK21Plus Groups, Dong-A University*
Dept. of Management Information Systems, Dong-A University**

물류산업에서의 클라우드 컴퓨팅 활용 방안

정재운*, 김현수**
동아대학교 BK21PLUS총괄사업단*, 동아대학교 경영정보학과**

Abstract Cloud computing(cloud) is a good candidate for complementing weaknesses of logistics information systems(heterogeneous processes not able to be standardized, geographically scattered and seamed connectivity, etc.) and for supporting innovative activities of logistics. In this sense, we aimed to study deployment strategies of clouds specified in the logistics industry. To achieve our research goal, we reviewed up-to-date logistics clouds researches and analysis of clouds; platforms and deployment strategies for logistics. This study contributes to follow-up researches for establishing a development direction of logistics specific clouds and developing more concrete clouds for logistics.

Key Words : Cloud Computing, Deployment, Logistics Specific Cloud, Service Level Agreement, Platform

요 약 클라우드 컴퓨팅(클라우드)은 물류정보시스템이 갖는 취약점(표준화할 수 없는 복잡 다양한 방식, 지리적 산재 및 매끄럽지 못한 연계성 등)의 보완 및 물류의 혁신적 활동을 지원할 수 있는 안성맞춤의 기술로 여겨진다. 이러한 의미에서 본 연구는 물류산업에 특화된 클라우드 활용 방안을 연구하고자 하였다. 이를 위해 물류분야의 클라우드 관련 최신 동향 분석, 물류산업에서 필요로 하는 클라우드와 플랫폼, 도입 방안에 대한 분석을 진행하였다. 본 연구는 후속연구에서 물류분야에 특화된 클라우드의 개발 방향을 설정하고, 보다 구체화된 클라우드를 개발하는 데 시사점을 제공한다.

주제어 : 물류 클라우드, 서비스 수준 합의서, 클라우드 컴퓨팅, 플랫폼, 활용 방안

1. Introduction

In 1961, even before the internet era, John McCarthy anticipated that computer utility could become the basis of a(n) new and important industry and each subscriber might pay only for the capacity s/he actually used but s/he could access to all of a very large system. In addition, he expected that certain subscribers could offer service to other subscribers through the utility[1]. In the context, computer utility means today′s cloud computing. In Parkhill′s 1966 book entitled ′The Challenge of the Computer Utility′, cloud computing

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Corresponding Author: Hyun Soo Kim(Dong-A University)
Email: hskim@dau.ac.kr
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was used as a marketing term[2].

Since then, the concept has evolved through a number of phases which include grid computing, application service provision(ASP), software as a service(SaaS) with advances in wireless and mobile networks, devices, etc[3]. However it has not been long since cloud computing started to gain public concerns. It is just less than a decade. For this reason, potential values of the computing have not been utilized enough into the real world yet, especially into the industrial world.

For these issues, this study stares at cloud computing for logistics. Physical distribution and cloud computing seem to be definitely different in terms of service location(offline vs online), process (physical vs virtual), equipment/facility(onsite vs remote). However, technologies of cloud computing are expected to seamlessly deliver and manage scattered logistics information anywhere anytime for efficient works and services. Also through the convergence of logistics and cloud computing, a(n) new creative or innovative service is expected to emerge even though the service is difficult to be implemented yet.

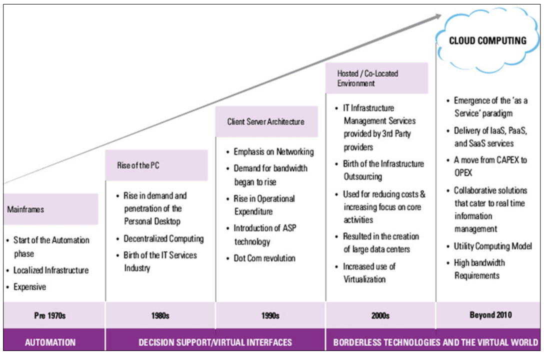
Regarding these aspects, this study aims to explore deployment strategies for logistics cloud computing with state-of-the-art global research projects and literatures.

In section 2, we clarify why cloud computing is suitable for logistics through the comparison of characteristics between cloud computing and logistics industry. In section 3, we present migration criteria for the existing logistics information systems to move into the cloud computing and successful deployment strategies as well as noteworthy cloud services(platform) for logistics.

2. Review

2.1 What is Cloud?

Cloud computing(cloud) is a model for enabling ubiquitous, convenient, and on-demand network access to a shared pool of configurable computing resources(e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction[4]. In short, it is a service that is delivered and consumed on demand at any time, through any access network, using any connected devices[5].



[Fig. 1] Evolution of Cloud Computing
Source: KPMG, G. Joshi(2012), edited.

[Fig. 1] shows evolutionary phases of cloud computing in terms of computation and service characteristics, from mainframes of 1960s up to now via the phases of PC and ASP[6].

On the other hand, cloud models are fundamentally composed of five essential characteristics(on-demand self-service, broad network access, resource pooling, rapid elasticity, measured service), three service models(software as a service-SaaS, platform as a service-PaaS, infrastructure as a service-IaaS) and four deployment models(private cloud, community cloud, public cloud, hybrid cloud)[4]. Also as cloud computing matures, various things like process and communication are introduced as a service(XaaS)[7]. In this sense, many things of logistics need to be researched as a cloud service.

2.2 Overlap between Clouds & Logistics

Logistics is a representative SMEs(small and medium enterprises) dominated industry[8]. Therefore, it is difficult for most of logistics companies to consider the whole of information flows and to invest/manage their information assets[9]. In addition, a logistics product is a set of processes to get X from A to B but the processes are very difficult to be standardized because they include lots of dynamic and non-determined factors. Under these situations, cloud gives an obvious hint to provide complex services to very diversified logistics customers and to simplify cooperation, execution and management to specialized logistics companies[10]. It means that cloud can help logistics companies to devote almost all of their ability and capability to their professional activities(logistics businesses) as it wraps and hides complicated issues on logistics information delivery, management and utilization in cloud technologies. By extension, cloud models, especially SaaS model can be a future ERP for an advanced supply chain including logistics without major headaches(e.g. maintenance, upgrade) and costs[11].

2.3 Global Movements for Logistics Clouds

Related to activities for logistics cloud computing, in Korea, ASP and web-based SaaS models are utilized for collaborative logistics. In particular, the Korean government encourages and forces ports and logistics companies to use EDI(electronic data interchange) systems for seamless logistics information delivery to another player[9]. However logistic information still experiences difficulties between heterogeneous platforms of logistics information systems. Recently, the Act on Development of Cloud Computing and Protection of Service Consumers to activate the cloud industry for B2B, B2C, B2G just passed Korea Cabinet meeting in October, 2013[12,13]. The government anticipates commercial cloud booming through the law.

In Germany, a project for smart port logistics of the Hamburg port - a representative advanced port - is underway with the private cloud model connected with intermodal traffic management and M2M(machine to machine) communication[14].

In Europe, LOGICAL(Transnational LOGistics' Improvement through Cloud computing and innovAtive cooperative business modeLs) which is a joint R&D project funded by EU is under research on cloud computing for logistics with 14 partners(including port, airport, logistics company, university, research center) in the east and central European countries(Czech Republic, England, Germany, Hungary, Italy, Poland, Slovenia)[15]. From the case, we referred to conceptual architecture and platform of logistics clouds in section 3.3.

3. Strategies for Logistics Clouds

3.1 Criteria of Migration to the Cloud

Expected benefits of cloud computing are the same with the standard cloud benefits whether cloud computing is applied to any activity[2]. If it is true, we can refer to the existing references for logistics clouds.

According to [16, 17], benefits and risks of clouds are as shown in <Table 1>.

〈Table 1〉 Benefits and Risks of Cloud Computing

	Benefits	Risks
User	optimized and rapid provision, application anywhere with any device, pay-per-use pricing, low migration cost, backup(storage) of important data, etc.	responsibility ambiguity on incidents by non-contractual services, loss of governance and trust, service provider lock-in, access of non-secure cloud service user, data loss and leakage, etc.
Provider	cost saving, highly scalable/flexible infrastructure, efficient/flexible resource/security management, business agility with rapid service deployment, acceleration of service innovation, capability aggregation, effective/efficient update, etc.	responsibility ambiguity on dissension between data ownership and access control, protection inconsistency by decentralized architecture, service unavailability, business discontinuity, supplier lock-in, shared environment, license risks, evolutional risks, etc.

Though cloud has lots of potentials for logistics, it does not mean that all applications are suitable for external cloud[18]. [10] presented that the best to start for selecting logistics processes to move to the cloud can be processes related to customer acquisition and transport co-ordination. In the same reference, criteria to implement cloud models for logistics were introduced as follows:

- Integration(coupling) with other applications
- Integration with existing data structures
- User interaction
- Possibility of process monitoring
- Possibility of verification and validation
- Security and data protection
- Cost and efficiency

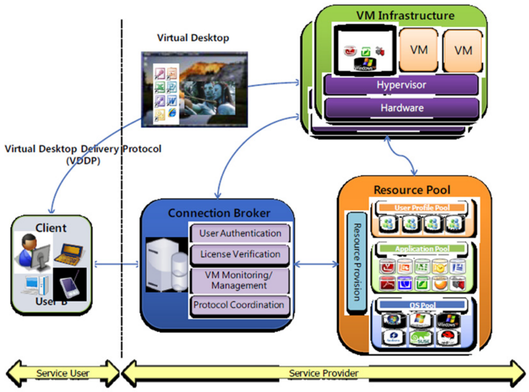
On the other hand, when the existing processes move to the clouds, issues on seamless and smooth data flow and connectivity need to be considered for advanced logistics productivity. As mentioned earlier, it is because logistics players basically want to share their data between them in each internal supply chain under the conditions that 60% of companies data are on PC, laptop, and other mobile devices like smartphones[19]. Furthermore, as time goes on, more dynamic and complicated activities require to extend collaborative areas with heterogeneous applications, devices, O/S, etc.

3.2 Clouds for Advanced Logistics

3.2.1 For Slim Information Assets

For specialized logistics services, logistics companies need to concentrate their capability and assets in their professional scope. In this sense, desktop as a service(DaaS) is meaningful to logistics industry as well as other industries.

Fig.[2] shows a conceptual architecture of DaaS that presents interactions between client, virtual desktop, virtual machine infrastructure, resource pool(O/S, application, user profile) and connection broker by virtual desktop delivery protocol(VDDP)[20].

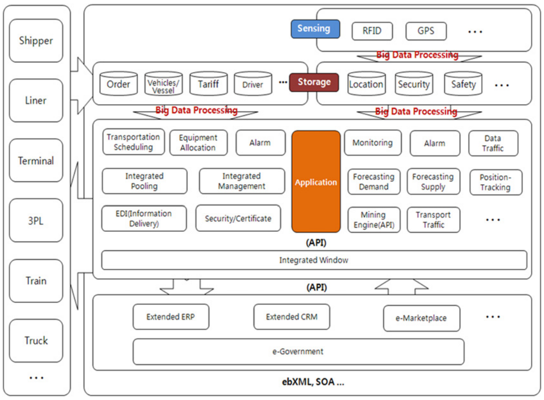


[Fig. 2] Architecture of DaaS
Source: International Telecommunication Union(2012b), p.18, Figure I.1.

Through the service, small and medium sized logistics companies can keep the up-to-date office IT assets with thin clients that have access to DaaS in their slim room. At the same time, they can expect to overcome spatial constraints immovable.

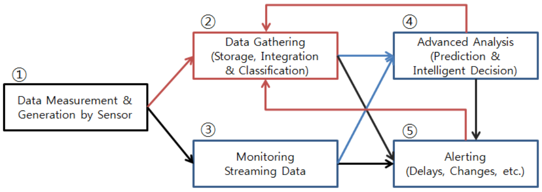
3.2.2 For Logistics Specific Clouds

To define logistics specific clouds, units of workloads and processes were modularized in terms of information utilization. [Fig. 3] was derived through the analysis of an intermodal transportation company in Korea.



[Fig. 3] Modularized Logistics Processes and Workloads

The modules requires to be departmentalized again by each transport mode and agent's role. And then, each service will be classified into cloud categories for efficient work processing.



[Fig. 4] Strategic Map for Utilizing Logistics Clouds

In terms of information utilization, the logistics clouds in [Fig. 3] can be more diversified and extended at lower complexity with the following fundamentals as shown in [Fig. 4].

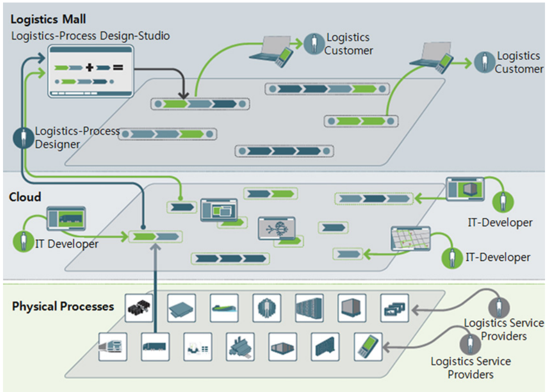
Basically, there are three types of logistics clouds in [Fig. 3] that are on sensing(and network) related to logistics data measurement and generation through sensors like RFID, NFC, GPS on fixed and moving things(① of [Fig. 4]); on storage infrastructure related to hard disk, DBMS, data warehouse, etc.(② of [Fig. 4]); and on enterprise applications(S/W) related to tracking/tracing, planning, risk management, etc.(③, ④, ⑤ of [Fig. 4]).

Recently, manufacturers and buyers as well as logistics companies are attracted to logistics information services based on tracking data of freight location and status for security, quality management, client satisfaction, etc. By popular demand, application services for transport management, supply chain visibility, warehousing (e.g. inventory, space) optimization, etc. with tracking data are provisioned by cloud service providers(CSP) like BT(British Telecom)[21], Cloud Logistics[22], KL-Net[23], T-Systems[24].

On the other hand, each logistic cloud seems to be separated but each cloud requires to be coupled or federated strategically for efficient or intelligent job processing. For example, if data of goods or logistics equipment/facilities can be traced in real time, and can be stored safely(IaaS), more exact/efficient decisions and responses to dynamic situations(for contracting, planning, monitoring, etc.) are possible by proper applications(SaaS). However, under the current situation, this is an old dream because consignors(shippers), logistics service providers, logistics application(S/W) providers, etc. are separated with heterogeneous ownership, devices, platform, O/S, etc.

Therefore, we need to turn to the logistics clouds on the open and scalable platforms that anyone can access to get what s/he wants with any device anytime anywhere.

So far, we discussed clouds for logistics as a service but there is another issue for logistics as a *product*. The latter means electronic or virtual marketplace for trading logistics orders(transportation, warehousing, etc.) and logistics clouds(supporting logistics works) [8,25].



[Fig. 5] Overview of Logistics Marketplace Source: Fraunhofer(2011), edited.

[Fig. 5] shows an overview of logistics marketplace on cloud computing designed by [26]. For more efficient utilization of logistics clouds, such marketplaces for logistics are also required to be on open or sharable platforms.

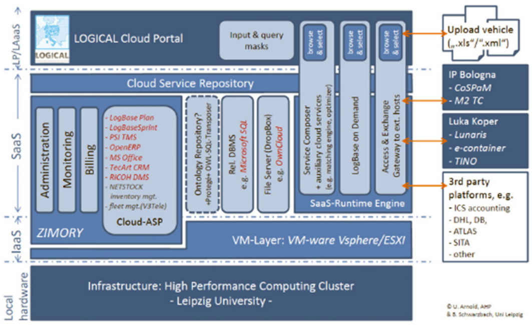
3.3 Platform for Logistics Clouds

Even though lots of C/S(client/server) based logistics information systems were transformed to web and mobile applications(SaaS), the systems are still facing problems on how to control logistics data/information of freewheeling forms[9].

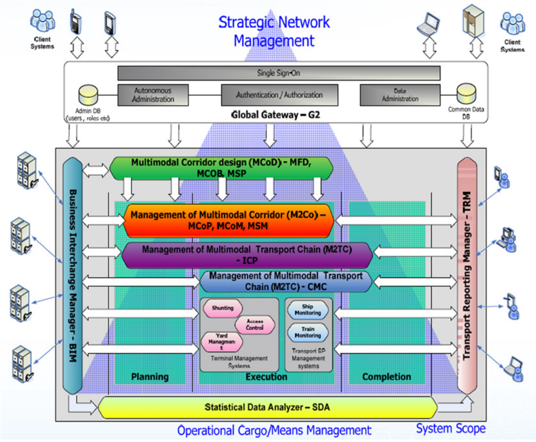
According to interviews with industrial workers in charge of logistics, most of them do not care about operating system, established location, version, etc. of their logistics information systems. i.e. they have only to do their tasks within the given time through the given systems. It implies that they may persist their existing working systems.

In terms of user satisfaction, cloud-based open platforms as aforementioned, give significant insight into facilitating logistics information flow or reducing information transactions by collaboration(federation) between heterogeneous systems[19].

[Fig. 6] shows a conceptual architecture of logistics clouds based on the Leipzig Hub of Germany, designed by [27]. And [Fig. 7] shows a conceptual platform of logistics clouds based on Interporto Bologna Logistic Hub in Italy, designed by [28]. Both of them cover the world-wide intermodal transportation.



[Fig. 6] Architecture for Logistics Clouds
Source: U. Arnald et al.(2013). p.1060, Fig.2.



[Fig. 7] Platform for Logistics Clouds
Source: A. Aulicino & G. Dall'Asta(2012). p.18.

3.4 Deployment Strategies

Through the [29], three main drivers to utilize cloud computing: more flexibility, cost savings, and better scalability of their IT were surveyed as more important factors than complexity reduction, more(core) business focus, collaboration, etc.

However, in terms of cost, clouds do not always present identifiable, immediate or on-going cost savings[30]. For instance, a car is cheaper to lease if you're going to keep it for two years, but if you're going to keep the auto for 10 years, then it makes sense to buy it[31].

For the reason, logistics companies need to consider a trade-off between performance and cost of clouds. Related to the issue, [32] experimented with scenarios of cloud computing configuration based on SOA(service-oriented architecture). In the experiment, computing performance increased proportionally to configuration environment (composed instance number and size) but improved efficiency of each configuration performance and cost was not linear and exponential. In short, a strategic trade-off(sensitivity) analysis between cost and configuration(clouds composition) are required for logistics cloud challengers.

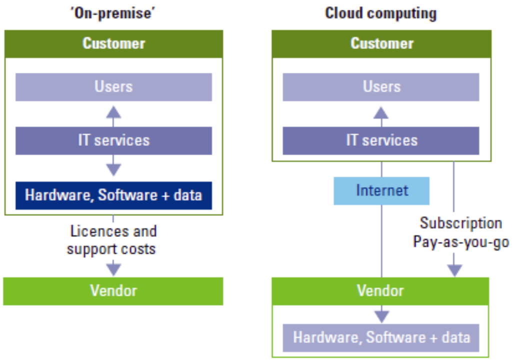
On the other hand, logistics service providers should utilize heterogeneous applications simultaneously in their workplace whether the applications are on clouds or not, whether they are separated or not. Under such conditions, logistics challengers need to consider a strategic deployment model if they want to adopt proper clouds for their dynamic characteristics.

Related to the issue, experimental case studies were conducted in the research of [33]. In the experiment, they considered cloud data center on the federated network. The result shows that the average turn around(time) of federated clouds was faster than twice. Also as shown in [Fig. 8], in terms of makespan, public deployment model was faster than private model alone. Through the results, we can know that cloud benefits can be different by combination strategy of deployment models.

Strategy	Makespan (s)	Cloud cost (U$)
Private only	127155.77	0.00
Public 10%	115902.34	32.60
Public 20%	106222.71	60.00
Public 30%	98195.57	83.30
Public 40%	91088.37	103.30
Public 50%	85136.78	120.00
Public 60%	79776.93	134.60
Public 70%	75195.84	147.00
Public 80%	70967.24	160.00
Public 90%	67238.07	171.00
Public 100%	64192.89	180.00

[Fig. 8] Cost and Performance by Deployment Strategy
Source: R. N. Calheiros et al.(2011), p. 46, Table III.

However, whichever deployment model is selected, moving into the cloud does not necessarily change the implementation process itself[31]. Even though IT service processes or mechanisms are changed, there is no difference between before and after cloud deployment in terms of users(logistics companies). Cloud users have only to change their payment method, then cloud providers will do the rest as shown in [Fig. 9].



[Fig. 9] Before and After Cloud Deployment
Source: M. Chung and J. Hermans (2010), p.12.

Lastly, lots of logistics companies worries about information security because it is closely connected to business knowhow, benefits, etc. Therefore cloud computing researchers pay the greatest attentions to cloud security[34]. In addition, the security problem can be solved by obvious SLA(service level agreement) which is the contractual basis between the cloud service providers and users. SLA contains details of shared information and service level guarantees are offered by cloud service providers[5].

4. Conclusion

Cloud already became one of the trendy terms in the field of IT but it is also true that its potential values are still behind the cloud in the real world. For this reason, this study showed a new approach to the cloud with an overview of up-to-date clouds specified in logistics industry. Second, the study introduced noteworthy clouds for logistics industry. Third, it presented critical strategies for clouds to migrate to logistics industry when the existing logistics information systems move to the cloud systems.

For future research, we will design a logistics cloud model and simulate the model in terms of workload, cost and agility. It will make another contribution for follow-up researches as it provisions the basis of developing new logistics clouds.

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Jung, Jae Un

- Feb. 2008: Dong-A University, M.S. in MIS
- Aug. 2010: Dong-A University, Ph.D. in MIS
- Oct. 2013~: Dong-A University, BK21Plus Groups, Research Professor
- Research Area: Logistics Information System, System Dynamics, etc.
- E-Mail : ace@goodplayer.kr

Kim, Hyun Soo

- Feb. 1987: KAIST, M.S. in Management Science
- Feb. 1992: KAIST, Ph.D. in Management Science
- Mar. 1992 ~: Dong-A University, Dept. of MIS, Professor
- Research Area: Logistics Information System, Intelligent Information System, etc.
- E-Mail : hskim@dau.ac.kr