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Research Article

Strategic Design of Architecture on the Cloud Service

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Abstract: The architecture of the Cloud Computing can be defined as the components and subcomponents required for the Cloud computing. Usually, the components and subcomponents compromise front-end platforms such as local clients, thin clients, mobile and back-end platforms such as servers, memory. They also include Cloud-based delivery, and networks (like Internet, Intranet, and Intercloud). For 20 years, public Cloud service providers have remained the top three Cloud providers, and characterized by the development of technologies based on software for their own business models and platforms, which have led Information Technology services. As the public Cloud service market develops, its usage spending also increases. And then the increase in spending must be technologically counteracted based on the efficiency of the Cloud. These components are compromised in order to form a Cloud computing architecture. This study aims to derive objective analysis results and implications by proposing the main progress steps so as to analyze the private Cloud service. Its results of our study would make contributions for enterprises to make their policies or decisions before the Cloud Architecture.

Keywords: Bigdata, Cloud, Cloud Service, Architecture Design, Architecture Development

1. Introduction

These days, each public company is scrambling to introduce Cloud services. These Cloud services are key to Bigdata (Park, S. et al., 2015) (Park, S.B. et al., 2015) (Park, S. & Lee, S., 2015) (Lee, J.M. et al., 2015) (Kim, J.K. et al., 2016) (Lee, S.W. & Kim, S.H., 2016) (Lee, S. & Shin, S.Y., 2016) (Nam, M. & S. Lee., 2016) (Kim, S.H. et al., 2017) (Kang, Y.; Kim, S.; Kim, J. and Lee, S. (2017), Artificial Intelligence (AI) (Kim, S. et al., 2018) (Kang J. & Lee, S., 2019) (Kang J. & Lee, S., 2019), and the Internet of Things (IoT) (Huh, S. et al., 2017) (Lee, I. & Lee, K., 2015) (Gubbi, J. et al., 2013) component technologies. However, there is a lack of analysis of Cloud services specialized in private public enterprises. For this reason, in this work, we investigate the trend of private Cloud service providers in Cloud computing platforms. In addition, we also want to analyze the composition and trends of key services and derive implications to present the direction of the enterprise's Cloud strategy. First, we will discuss the Cloud computing service architecture. Cloud services that we will mainly study include AWS, Azure, Google, NBP, and KT. Based on this, the Cloud service providers will then be compared to each other. Finally, we would like to study the case of Cloud service adoption by public enterprises. We will examine the cases of Cloud service introduction in detail in the overseas public sector and the domestic public sector and draw implications.

2. Related Works of Cloud Service

Cloud computing (Figure 1) is Internet-based computing. It is a service that puts programs on a virtualized server on the Internet and brings them to our computer or smartphone whenever we need them. As the word ‘Cloud’ suggests, companies or individuals can use Cloud-covered computing resources (CPUs, memory, disks, etc.) wherever they want to be. To be covered in Clouds means that we can take out and use whatever we want without having to look inside it or not knowing, and we can be guaranteed this wherever the Internet is connected. From a web service operator's perspective, the Cloud has the following advantages: Don't worry about power, location, and scalability when purchasing servers directly. It is possible to use a server that is already prepared somewhere in the data center. In addition, it is possible to focus on the service operation without worrying about setting up the server. In addition, real-time scalability can be supported based on service load, and it can be said to be much more efficient in service operations because it pays as much as it is used.

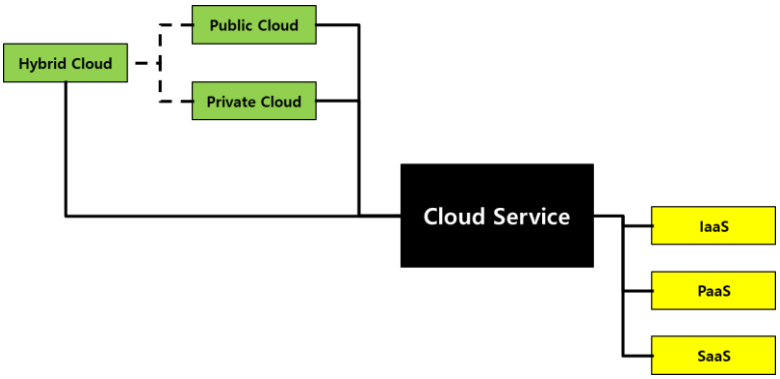

Figure.1 Cloud Services Platform

Cloud computing is divided into public Clouds, private Clouds, and hybrid Clouds depending on the type of service delivery. Each has the following characteristics: With the recent move to adopt the Cloud, more and more workloads are using Cloud for unpredictable traffic, such as events or new services, while leaving key data on-premise (physical servers) rather than moving the entire workload to the Cloud. Public Cloud (open Cloud) is a Cloud service model for anyone with Internet access, not for a particular company or user. The Cloud service provider (CSP) manages hardware and software. Resources such as data, functions, and servers are privileged or isolated for each user in each service, so there is no interference between service users. Occasionally, there are cases that confuse public Clouds with public Clouds introduced by public institutions. The public Cloud that public institutions adopt is the Government Cloud, and the public Cloud that connects to the public Internet network is the Public Cloud. A private Cloud (closed Cloud) is a Cloud that targets only a specific enterprise or a specific user on a limited network, with resources and data stored within the enterprise. Companies also have control of resources. This is extremely secure and has the advantage of being able to customize Cloud capabilities for individual customer situations. Hybrid Clouds have been seen as a combination of public and private Clouds, but the concept has recently become vague, often referring to the combination of Cloud (virtual servers) and on-premises (physical servers). This gives the public Cloud flexibility, affordability, speed, security and reliability of physical servers.

Cloud services can be divided into IaaS, PaaS, SaaS based on service management entities and levels. Infrastructure as a Service (IaaS) is the widest range of Cloud computing services that users can manage. Provides infrastructure-level Cloud computing, enabling users to organize and manage server OS, middleware, runtime, and data and applications directly. The Cloud Service Provider (CSP) builds a data center to virtualize and deliver multiple physical servers, and CSPs are responsible for and manage everything they need to run the server, including network, storage, and power. Typical IaaS offerings include Amazon Web Service (AWS) EC2, Google's Compute Engine (GCE), and Gabia's GCloud. Platform as a Service (Pass) means building a development environment (platform) in advance so that users can develop the services they want on top of a virtualized Cloud in IaaS, and delivering them as services. PaaS provides pre-built operating systems, middleware, runtime, and so on, making it less manageable than IaaS. But PaaS users can save money on managing hardware and software infrastructure because they don't need to worry about anything outside of service, they can focus solely on application development and business, and they don't need to have a separate infrastructure and operate like IaaS. Typical PaaS include Salesforce's Heroku and Redhat's OpenShift. Software as a Service (Sass) is the most complete form of Cloud service. The software is mounted on top of the Cloud infrastructure, providing IT infrastructure resources as well as services such as software and updates and bug improvements. You pay monthly/annual subscription fees and use the provider's software without having to purchase a software license at a separate cost. With SaaS, users can save money on infrastructure deployment, development environment settings, and software development, which can significantly reduce the initial cost of developing their own software. Typical SaaS include Slack, Microsoft 365, Dropbox and Salesforce.

3. Cloud Computing Services Architecture

As Cloud services can be divided into Public Cloud, Private Cloud, and Hybrid Cloud, private Cloud services can be studied separately by AWS, Azure, Google, NBP, and KT. In this section, we study the characteristics of these private Cloud services.

3.1. AWS

Amazon Web Services (AWS) is the world's most comprehensive and widely adopted Cloud platform, providing more than 175 fully functional services in a globally distributed data center. AWS began providing IT infrastructure to businesses in 2006 as a web service, and is now a Cloud computing service provided by Amazon. Currently, AWS operates 76 available territories within 24 geographic regions worldwide, and has announced plans to add three more zones and nine more available territories to Indonesia, Japan and Spain. Through data centers around the world, more than 175 fully functional services are available, and application workloads can be deployed anywhere in the world with a single click. The Korean language website was launched on May 11, 2012, and a Seoul version was added in January 2016. The various services of Amazon Web Services are accessible, available, and managed through REST protocols and SOAP protocols. Costs are determined by actual usage, and some services may be paid in advance. In terms of Service Offering, AWS provides global Cloud-based products, including computing, storage, databases, analytics, networking, mobile, developer tools, management tools, IoT, security, and enterprise applications. In terms of service list, AWS supports a wide range of workloads, including web and mobile applications, game development, data processing and warehousing, storage, and archiving, with a wide range of Cloud services to help organizations move faster, lower IT costs and grow.

On the other hand, AWS computing services provide a container-based application operating environment in a serverless environment and define storage to store and store work results. AWS storage services select and configure storage by usage. AWS' networking services comprise a virtual private network and provide load balancing services for key services. AWS Database Services supports the use and migration of various databases. In addition, AWS' big data analysis service provides an environment where data can be extracted and visualized by organizing a big data environment. AWS Artificial Intelligence Service is creating an environment for artificial intelligence development by providing Amazon Artificial Intelligence Alexa API and voice conversion and facial recognition API. AWS IoT service provides an IoT development platform to implement interfaces with Edge environments. Of course, AWS is providing a development and test environment for mobile app deployment. In addition, AWS management and monitoring services are increasing operational confidence by monitoring resource usage, writing bills based on usage, and measuring and delivering user applications as dashboards. AWS security services provide policies that manage per-organization user-specific privileges, protect users from viruses and external attacks, including firewall services, and automatically back up key data. AWS Developer Tools Services provides Cloud development platform standards to support rapid development and automatically deploy developed sources to distributed applications in batches to improve service quality. Finally, Amazon AWS integrates subscription/authorization/security management centered on AWS organizational services, completes service readiness through a short five-minute service configuration process, and supports use monitoring/billing based on personalized self-service.

3.2. Azure

Microsoft Azure is the world's largest network interconnected Cloud platform with over 160 distributed physical data centers worldwide. It is Microsoft's Cloud computing platform, which began in 2010. Following PaaS in 2011, it launched IaaS services in 2013.

The Azure global infrastructure consists of more than 160 physical data centers, organized by region and connected to one of the largest interconnected networks in the world. Each of these data centers provides high availability and scalability of the Cloud infrastructure with global Azure network connectivity. It can scale to a global scale through 60 Azure regions and 140 countries, the largest number of existing Cloud providers. Azure provides a more comprehensive compliance coverage with more than 70 compliance products, indicating that it was the first major Cloud provider to implement general data protection regulation (GDPR) requirements into contracts. To protect the organization, Azure included security, privacy, and compliance in its development methodology, was recognized as the most reliable Cloud for U.S. government agencies, and obtained FedRAMP High approval, which included 38 Azure services. Azure is free to select the desired tools, applications, and frameworks, such as Jenkins and Chef, to develop and build them in any way they want. As a major open source contributor at GitHub, Microsoft actively supports several open source community projects, including Kubernetes, fluendd, and Helm, and provides integrated multilingual support across products through its independent partnership with Red Hat.

In terms of Service Offering, Azure Cloud Services offers global Cloud-based products, including computing, storage, networking, database, analytics, artificial intelligence, IoT, management tools, mobile, security, developer tools, and enterprise applications. On the list of services, Azure is a broad range of Cloud services that enable organizations to move faster, lower IT costs, and support a wide range of workloads, including web and mobile applications, game development, data processing and warehousing, storage, and archiving.

Azure computing services are services that provide a container-based application operating environment in a serverless environment and define storage to store and store work results. Azure Storage Services can select and

configure storage for each use, expand capacity at any time, and provide backup and recovery services in case of emergency. The Azure networking service configures virtual private networks and provides load balancing services for key services. Azure Database Services supports the use and migration of various SQL and NoSQL databases and provides memory-based distributed caching services. Azure big data analysis service provides an environment where data can be extracted and visualized by organizing big data environments such as data lake. Azure Artificial Intelligence Service is creating an environment for artificial intelligence development by providing voice conversion and photo recognition APIs. It also provides an IoT development platform to implement interfaces with Edge environments.

Azure management and monitoring services monitor resource usage, create bills based on usage, and instrument user applications and provide them as dashboards. Development and test environment for mobile app construction is also provided. Azure Security Services manages user-specific permissions by organization through AD, protects users from viruses and external attacks, including firewall services, and provides security monitoring assessments through security centers. Azure Developer Tools Services provide Cloud development platform standards to support rapid development and automatically deploy developed sources to distributed applications in batches to improve service quality. Azure Enterprise App Integration Services provide services that enable seamless integration of on-premise and Cloud-based applications, data, and processes across the enterprise. Finally, Azure service provides work processes that enhance user's ease of use, such as Tour Guide, automatic setting of subscription information, single contract operation with Discount, service cost calculation, and TCO simulation during the subscription, usage, monitoring, and subscription billing phases.

3.3. Google

GCP is the world's largest network interconnected Cloud platform with more than 160 distributed physical data centers worldwide. Google App Engine, released in 2008, is the first service to be the origin of the current GCP. When the developed application program code is uploaded, it is PaaS, where the code begins to run in its own container-based execution environment. It is based on an infrastructure that supports services provided by Google such as YouTube and Gmail. Google Cloud covers 61 areas and more than 130 access points distributed in over 35 countries worldwide, and every Google infrastructure, from redundant Cloud revisions to high bandwidth connectivity over subsea cables, is designed to enable users to deliver services anywhere in the world.

The services provided by GCP are based on the idea of providing components necessary for application development and execution as abstract API services. In particular, it is highly scalable and relatively easy to create applications that are used on a global scale because the services provided by GCP are based on the infrastructure and software environment Google uses internally. GCP provides global Cloud-based products, including computing, storage, networking, big data, developer tools, artificial intelligence, management tools, and enterprise applications. GCP maintains agility with the highest level of security and a flexible platform, supports innovation with AI and data analytics, and supports web and mobile application development using fully integrated open-source software. GCP computing services can select resources for virtualized computing, use serverless application platforms, and support GPU servers for research. GCP Storage Services can select and configure storage for each use, expand capacity at any time, and provide BigQuery data transfer services for big data processing. GCP networking services construct virtual private networks and provide load balancing services for CDN services and key application services for global content transfer rates. GCP Database Services supports various SQL and NoSQL databases and provides global distributed storage services for data stability. GCP big data analysis service provides an environment where data can be extracted and visualized by establishing a data lake environment through the composition of big data platforms. GCP artificial intelligence service provides a machine learning engine and an artificial intelligence development environment by providing text and voice conversion, image recognition, and video analysis APIs. GCP IoT service provides IoT development platform to implement interface with Edge environment. The GCP API management service provides developers with secure and fast access to the tools and information needed to explore the API and test and use the application.

GCP security, identity, and access manage user-specific privileges by organization, protect users from viruses and external attacks, including firewall services, and provide security monitoring assessments through security centers. The GCP Developer Tools service provides Cloud development platform standards to support rapid development and automatically distribute developed sources to distributed applications to improve service quality. GCP service provides work processes that enhance users' ease of use, such as Tour Guide, automatic setting of subscription information, single contract operation with Discount, service cost calculation, and TCO simulation at the subscription, usage, monitoring, and subscription billing stage.

3.4. NBP

NBP is a Cloud platform that provides reliable service by connecting physical data centers distributed in six global global revolutions with dedicated lines. Beginning in 2017, the company began its Cloud business for IT business success by incorporating Cloud technologies and service experiences provided to Naver and Line services such as Compute, Storage, Networking, Database, Security, Global, Management, etc. NBP Cloud has built and operated revisions at six rezones and 11 major global hubs, and all NBP infrastructures continue to expand global rezones to enable users to deliver services anywhere in the world, with dedicated lines between global data centers for optimal speed.

NBP services provide global solutions, including enterprise applications, through computing, storage, networking, big data, developer tools, artificial intelligence, management tools, and marketplace. NBP provides NBP services based on its fast and reliable experience in IT infrastructure operations for Naver and many other services. NBP computing services provide resource choice for virtualized computing and support GPU servers for research. Storage services select and configure storage for each use and provide backup services for data protection. NBP networking services construct virtual private networks and provide load balancing services for CDN services and key application services for global content transfer rates. The NBP database service supports various SQL and NoSQL databases. Analysis and big data services provide a big data analysis environment by constructing a big data cluster. NBP artificial intelligence services provide text and voice translation and facial recognition APIs, and provide an AI development environment.

The NBP management and monitoring service monitors resource usage, prepares bills based on network usage, and instruments users' applications and provides them as dashboards. NBP application management services provide developers with secure and fast access to the tools and information needed to explore APIs and test and use applications. NBP security, identity, and access manage user-specific permissions by organization, protect users from viruses and external attacks, including firewall services, analyze vulnerabilities, and provide a security monitoring environment. The NBP Developer Tools service provides an automated build and deployment environment and provides a history-specific management of the source through source management tools. Naver offers a variety of Cloud products to configure the IT environment needed for its business, including compute, storage, networking, database, management, security, global revision services, and Naver's open API.

3.5. KT

KT is a Cloud platform that provides reliable service by connecting physical data centers distributed in six global global revolutions with dedicated lines. KT G-Cloud is strengthening user data protection by providing security Cloud services exclusively for public institutions based on know-how of KT Cloud, the largest service in Korea, and enhancing service reliability through information protection authentication.

KT provides computing, storage, networking, DB, security, artificial intelligence, IoT, and management tools, has built G-Cloud exclusively for public and financial institutions, and offers global solutions, including enterprise applications, through Marketplace. Based on the know-how of KT Cloud, Korea's largest service, it provides security Cloud services exclusively for public institutions, and provides reliable services through the formation of independent dedicated Cloud centers and information protection certification. KT Computing Service enables resource selection for virtualized computing and supports GPU servers for research, while storage services select and configure storage for each use and provide backup services for data protection.

KT Storage Service selects and configures storage for each purpose of use. Networking services provide dedicated line services and provide DNS load balancing services to ensure the speed of web services. KT Database Service has a wide range of choices as it supports various SQL and NoSQL databases. KT's analysis and big data service will provide a big data analysis environment by constructing a big data distributed cluster. Artificial intelligence service is constructing development environment by providing voice recognition, artificial intelligence secretary, translation and video analysis API. KT IoT service can configure IoT development and deployment platform. Management and monitoring services support resource monitoring, distribution management, and help-desk services to back up data and systems. KT Enterprise Services can provide a Cloud environment exclusively for companies by strengthening the security environment by establishing a dedicated network of companies, and provides VDI services and Cloud marketplace services. It is going to carry out fast content transfer through global content web caching linkage service through KT CDN service. Through security services, KT provides firewall services and monitoring and control services that can prevent external attacks. KT's public/financial services are serviced as a dedicated Cloud platform with a security environment for public and financial institutions through the establishment of G-Cloud. KT Cloud Services provides a variety of Cloud products to configure IT environments needed for businesses such as compute, storage, networking, database, management, security, IoT, and artificial intelligence.

4. Private Cloud Services Adoption Cases

4.1. Private Cloud Services Adoption Cases (International)

The U.S. CIA establishes and operates private Cloud services. The 2013 US Central Intelligence Agency case shows that the pursuit of service efficiency from a business perspective leads to the development of Cloud technology, and that the philosophical perspective of service providers has significant implications for technology and business ecosystems. The CIA establishes and operates an independent AWS private Cloud inside the building. The factor AWS was selected for is that Cloud systems that can be easily deployed are advantageous. In addition, for AWS, software excellence has surpassed hardware. The AWS ecosystem, which attracts developers, offers a variety of services. This is sufficient to provide services differently from other Cloud providers offering 3rd-Party solutions, and the open AWS ecosystem offers users tremendous benefits. This makes it easy for users to implement applications. When a rich ecosystem is established, it reduces the time to market products, gives flexibility in choosing suppliers and application architectures, and has the advantage of lowering costs through competition from suppliers.

In 2013, the U.S. state government adopted a private Cloud within its California-owned data center, aiming to standardize and open up all government agencies' IT services and reduce increasing IT costs. The state government saved 65% of ICT budget by utilizing the Cloud that is borrowed through the Internet rather than directly building information and communication technology (ICT) resources such as servers and software (SW). New technologies, a scalable and scalable service model, can be adopted more quickly to support all public sectors, schools, cities, counties, or state agencies in California with the same quality, security, and innovation.

In 2019, the U.S. Department of Defense chose a single company to build a private Cloud with the aim of integrating defense information with the government's cost-cutting policy, and a huge Cloud system market will be opened with the Pentagon and private companies. The U.S. government spends the most on Cloud costs in the defense sector, followed by health and space development. Consequently, IT cost reduction is one of the challenges facing. The Department of Defense envisioned a huge Cloud system that could store and analyze all information to build a system for quick decision making, and published its proposal request in March 2018. It is intended to provide U.S. defense and mission partners with enterprise-class commercial Cloud services covering IaaS and PaaS, and includes the U.S. Department of Defense, Intelligence, Coast Guard, and the media, including the Army, Navy, Marine Corps, and Air Force.

4.2. Private Cloud Services Adoption Cases (Domestic)

In 2011, the National Information Resources Agency is gradually implementing G-Cloud construction projects for each government center in accordance with the government's plan to develop Cloud computing services, which is expected to present the basic direction of the public Cloud market and form a Cloud ecosystem. According to the comprehensive plan to revitalize Cloud computing at the pan-government level in December 2009, the G-Cloud construction project was started in 2011 and is being carried out step by step. With the vision of "realizing the world's best Cloud computing service leading the world's No. 1 e-government service," the National Intelligence Service set a goal of transitioning 60% of e-government work to the Cloud, introducing 50% open software, and reducing IT operating budget by 40%. In order for our companies to keep up with the pace of innovation and further lead, we need a large market and a rich software development ecosystem. Cloud platforms and development environments are being transformed faster by open-source projects. It can only be sustainable if it can form an ecosystem for Cloud development. Many Cloud platforms are based on open-source software, so they are being introduced in the private sector, and more and more people are available for technical support in Korea. In addition, government-led Cloud platforms, such as pasta (PaaS-TA), are rapidly embracing innovations made in the market. If a large procurement market is established, the workforce can be assembled, and the driving force can create jobs that can build up technology and cultivate manpower in more domestic companies.

In 2019, the Korea Information Society Agency (NIA) establishes a Cloud platform inside the NIA and uses private Cloud KT and NHN Cloud services as the first innovative case for government and public institutions. It is planning to establish an on-site Cloud inside NIA and establish an integrated operation management system through a public private partnership (PPP) method that encourages technology-investment by private businesses. PPP is a method in which businesses invest and establish Cloud platforms inside NIA and pay monthly fees. Four types of external services to be relocated in 2020 and one type of business system to be relocated in 2021 are subject to PPP application. The NIA Cloud transformation work will be carried out by InfraNix, a mid-sized software service (SaaS) company in South Korea, and the Cloud infrastructure will use KT Cloud and NHN Toast Cloud. The remaining systems will be transferred to KT's Cheonan Cloud Center and NHN Pangyo Cloud Center. This project is a precedent for innovation in expanding private Cloud services in the public sector.

5. Conclusions

Private Cloud service platforms AWS, Azure, GCP, NBP, KT Cloud service content and technology analysis and public institution introduction cases were analyzed to derive implications for considerations in the form of deployment. The top three global operators, Amazon, Microsoft and Google, have been operating their businesses based on software-based services. Their characteristics are that ICT technology in all areas has developed in an effort to improve the services of their main businesses, which has led to the start of Cloud subscription services and continuous development. The core of the development of Cloud services can be characterized by open source platforms, open source development ecosystems, server and container virtualization, and what they have in common is the evolution of technology based on the software ecosystem. Amazon AWS has remained at the top of the list for 20 years with innovative technologies and pricing policies, and has developed core technologies through the efficiency of its development service platform. MS Azure is fiercely competing with AWS in the global market for technology and service coverage and quality based on software-owned technologies and capital. Google GCP Services has the highest growth rate in 2020. It is securing its status as the top three major operators as it secures market competitiveness by securing service competitiveness based on Google's application development capabilities. Naver's NBP ranks No. 1 in Korea by adding loyalty to domestic users by securing infrastructure and technology personnel formed based on domestic portal development and operation capabilities, but it will gradually become a key point to secure service competitiveness due to technology gaps with global competitors. KT Cloud Service is inherently developing its business based on hardware hosting based on its experience with KT Data Center and its operations. However, application development service-based development technology, which is at the core of competitiveness, will be vulnerable and lose its place in service competitiveness. Recruitment of 100% public Cloud is also a very serious issue to consider. In all industries as well as manufacturing, staying with technology users means industrial subordination, and if we are not competitive with technology through openness, we have to have nothing and hand over industrial sovereignty.

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References

A. Park, S.; Hwang, J.S. and Lee, S. (2015). A Study on the Link Server Development Using B-Tree Structure in the Bigdata Environment, Journal of Internet Computing and Services, 16(1), 75-82.
B. Park, S.B.; Lee, S.; Chae, S.W. and Zo, H. (2015). An Empirical Study of the Factors Influencing the Task Performances of SaaS Users, Asia Pacific Journal of Information Systems, 25(2), 265-288.
C. Park, S. and Lee, S. (2015). Big Data-oriented Analysis on Issues of the Hyper-connected Society, The E-Business Studies, 16(5), 3 – 18.
D. Lee, J.M.; Park, S.B. and Lee, S. (2015). Are Negative Online Consumer Reviews Always Bad? A Two-Sided Message Perspective, Asia Pacific Journal of Information Systems, 25(4), 784-804.
E. Kim, J.K.; Lee, S.W. and Choi, D.O. (2016). Relevance Analysis Online Advertisement and e-Commerce Sales, Journal of the Korea Entertainment Industry Association, 10(2), 27-35.
F. Lee, S.W. and Kim, S.H. (2016). Finding Industries for Bigdata Usage on the Basis of AHP, Journal of Digital Convergence, 14(7), 21-27.
G. Lee, S. and Shin, S.Y. (2016). Design of Health Warning Model on the Basis of CRM by use of Health Big Data, Journal of the Korea Institute of Information and Communication Engineering, 20(4), 1460-1465.
H. Nam, M. and S. Lee. (2016). Bigdata as a Solution to Shrinking the Shadow Economy, The E-Business Studies, 17(5), 107-116.
I. Kim, S.H.; Chang, S. and Lee, S.W. (2017). Consumer Trend Platform Development for Combination Analysis of Structured and Unstructured Big Data, Journal of Digital Convergence, 15(6), 133-143.
J. Kang, Y.; Kim, S.; Kim, J. and Lee, S. (2017). Examining the Impact of Weather Factors on Yield Industry Vitalization on Bigdata Foundation Technique, Journal of the Korea Entertainment Industry Association, 11(4), 329-340.
K. Kim, S.; Hwang, H.; Lee, J.; Choi, J.; Kang, J. and Lee, S. (2018). Design of Prevention Method Against Infectious Diseases based on Mobile Bigdata and Rule to Select Subjects Using Artificial Intelligence Concept, International Journal of Engineering and Technology, 7(3), 174-178.
L. Kang J. and Lee, S. (2019). Algorithm Design to Judge Fake News based on Bigdata and Artificial Intelligence, International Journal of Internet, Broadcasting and Communication, 11(2), 50-58.

M. Kang J. and Lee, S. (2019). Strategy Design to Protect Personal Information on Fake News based on Bigdata and Artificial Intelligence, International Journal of Internet, Broadcasting and Communication, 11(2), 59-66.
N. Huh, S.; Cho, S. & Kim, S. (2017). Managing IoT devices using blockchain platform. In 2017 19th international conference on advanced communication technology (ICACT), IEEE, 464-467.
O. Lee, I. & Lee, K. (2015). The Internet of Things (IoT): Applications, investments, and challenges for enterprises. Business Horizons, 58(4), 431-440.
P. Gubbi, J.; Buyya, R.; Marusic, S. & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. Future generation computer systems, 29(7), 1645-1660.