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Smart Space based on Platform using Big Data for Efficient Decision-making

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Abstract With the rise of the Fourth Industrial Revolution and I-Korea 4.0, both of which pursue strategies for industrial innovation and for the solution to social problems, the real estate industry needs to change in order to make effective use of available space in smart environments. The implementation of smart spaces is a promising solution for this. The smart space is defined as a good use of space, whether it be a home, office, or retail store, within a smart environment. To enhance the use of smart spaces, efficient decision-making and well-timed and accurate interaction are required. This paper proposes a smart space based on platform which takes advantage of emerging technologies for the efficient storage, processing, analysis, and utilization of big data. The platform is composed of six layers - collection, transfer, storage, service, application, and management - and offers three service frameworks: activity-based, market-based, and policy-based. Based on these smart space services, decision-makers, consumers, clients, and social network participants can make better decisions, respond more quickly, exhibit greater innovation, and develop stronger competitive advantages.

Keywords: decision-making, smart space, platform, big data, smart environment

효율적 의사결정을 위한 빅데이터 활용 스마트 스페이스 플랫폼 연구*

이 진 경**

요 약 전 세계 4차 산업혁명의 도래에 맞춰 한국은 적극적으로 국가적 대응계획 I-Korea 4.0을 수립하여 2017년 11월에 발표하였다. 이 계획은 국가성장을 위한 산업혁신과 사회문제 해결을 목표로 하고 있다. 부동산산업도 예외는 아니며 산업혁신을 위해서는 스마트환경에서 주거, 상업, 업무, 복합 등 다양한 가용공간의 효과적 활용이 선행되어야 한다. 이를 위해서는 효율적 의사결정이 필요하고 이는 공간수요자 행태의 실시간 정보와 정확한 예측이 이루어 질 때 가능하다. 이에, 본 연구는 빅데이터 기반 스마트 스페이스 플랫폼을 제안하고 플랫폼의 구조와 서비스를 구체화 시키고자 한다. 스마트 스페이스 플랫폼도 스마트 트래픽, 스마트 시티, 스마트 헬스 등 다양한 스마트환경 적용사례처럼 급속히 발전하고 있는 정보통신기술(ICT)을 이용해 빅데이터의 효율적 저장, 접근, 분석, 활용이 가능하다. 스마트 스페이스 플랫폼의 구조는 6개 레이어 즉, Collection layer, Transfer layer, Storage layer, Service layer, Application layer, Management layer로 구성된다. 이 플랫폼은 의사결정자들이 행위기반(activity-based), 시장기반(market-based), 정책기반(policy-based) 빅데이터를 Searching, Mining, Integrating, Storing, Analyzing, Visualizing 할 수 있는 서비스체계를 가지고 있다.

주제어: 의사결정, 스마트 스페이스, 플랫폼, 빅데이터, 스마트환경

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Ⅰ. Introduction

The Fourth Industrial Revolution has been an important subject of attention for both the public and private sectors. In Korea, for successful paradigm shifts, Korea's Presidential Committee on the Fourth Industrial Revolution introduced the concept of I-Korea 4.0 on November 30, 2017. It embodies the vision of a people-centered Fourth Industrial Revolution, proposes strategies for industrial innovation, and seeks to address social issues. In light of this new direction, a number of industries are expected to make significant changes to their operational philosophy, and the real estate industry is an example of this. For this industry, the effective use of available space within a smart environment needs to be a priority, and smart spaces have been proposed as a way to achieve this. This concept is based on a feasible vision for a variety of spaces, including home, offices, and retail, in a smart environment, such as a smart home, a smart city, smart transportation, smart healthcare, and smart grids. Before establishing smart space, it is important to determine what constitutes a good use of space. For this, efficient decision-making is key, and to achieve this, well-timed and accurate interaction is a basic requirement. Recently, many decision-makers have turned to big data to assist them in their decisions because big data analytics can create new approaches to understanding changes, making business decisions, and providing possible solutions. Beyond its business impact, big data affects governance and management over planning, which involves the process of collecting and organizing outcomes, and an enterprise's utilization (ISACA, 2013).

This study focuses on the role of big data as the first step in the establishment of smart space. A key contribution of this study is to propose a smart space based on platform that utilizes big data compared with smart cities and smart homes. Smart cities apply information and communication technology (ICT) to solve issues arising from urbanization (Avelar, et al., 2015; Felipe, et al., 2011; Kim, 2017). Smart homes embrace home automation and distribute commands and information via wireless networks to electrical appliances, information gadgets, and other internet-based applications via a ubiquitous home network (Rita, et al., 2016). Of course, the smart space depends on the physical infrastructure of smart cities and smart homes and also uses technologies for big data, but this paper gives shape to the structure of smart space as a platform and discusses the services provided by this platform.

This paper is organized as follows. Section 2 reviews big data and smart environments to understand basic conditions for smart space. Section 3 presents research methodology for platform development and platform benefit review. Section 4 defines the smart space proposed by this paper and describes structure and functions as a platform and its services, and discusses efficiency of smart space platform and effectiveness with decision-making. Section 5 concludes the article.

Ⅱ. Big data and smart environments

1. Big data

Big data has attracted attention from both academic researchers and business analysts. This paper focuses on definition of big data, its aspects, government's strategy for big data, high-impact application area using big data. Firstly, big data is defined as huge or complex sets of data which can reach sizes in the exabytes or more and that exceed the technical storage, processing, managing, interpreting, and visualizing capabilities of traditional systems (Tiwari, et al., 2018). The data can be anything, such as images and video, online purchase records, and geolocation information from mobile phones, and come from many different sources. For example, in 60 seconds, more than 98,000 tweets are sent, 695,000 status updates are posted on Facebook, 685,445 Google searches are launched, and 1820 TB of data is created (Raguseo, 2018).

Secondly, big data can be approached from the perspective of the 6 Vs: volume, variety, velocity, value, veracity, and visualization. Volume represents the size of a dataset, which is typically multiple terabytes or petabytes. Variety refers to the composition of the dataset and to the structural heterogeneity of the data, i.e., whether it is structured, semi-structured, or unstructured. Velocity indicates the dynamic nature of big data, including the speed of collection, storage, and analysis. Value refers to the fact that the analysis of big data can enable a firm to maximize the value of its business by supporting decision-making in close to real time. Veracity is the reliability of the dataset in terms of the credibility and accuracy of the data and results derived from it. Visualization refers to the presentation of the data, information, concepts, strategies, metaphors, and compounds (Rogge, et al., 2017; Chang, et al., 2014; Seo, et al., 2015).

Thirdly, the strategy for most governments with regards to big data is focused on promoting open data and collecting public and private data(Jeon, et al., 2017; Kim, et al. 2017). The central governments of the USA, the EU, and the UK all run big data websites. However, they face representative problems such as protecting personal information and acquiring licenses for data reuse. Thus, significant efforts have been made to improve policies and systems and to encourage technical development because efficient data usage is of great importance for the future of a state. The USA's decision-making organization is the Office of Science and Technology Policy, the EU's is the European Commission, and the UK's is the Cabinet Office(Park, et al., 2015). Korea's decision-maker is the Presidential Committee on the Fourth Industrial Revolution, the exclusive organization is the Ministry of Science and ICT, and twenty central departments have participated in nurturing industrial big data centers.

Finally, the big data era has quietly descended on many organizations, from governments to companies. According to research by Chen, Chiang, and Storey(2012), this paper is to introduce five high-impact application areas for the use of big data. The first area is e-commerce and market intelligence. Various analytical techniques have been developed for product recommendation systems, such as association rule mining, database segmentation and clustering, anomaly detection, and graph mining. The second area is e-government. Government and political processes have become more transparent, participatory, online, and multimedia-rich. As such, selected opinion mining, social network analysis, and social media analytical techniques can be used to support online political participation, e-democracy, political blogs and forums analysis, e-government service delivery, and process transparency and accountability. For e-government applications, semantic information directories and ontological development can be used to better serve target citizen groups, as seen in Politics 2.0 in the U.S. In addition to this, big data supports the efficient management of government. For example, Singapore operates a traffic prediction system called TPT based on big data analysis that goes beyond the existing real-time traffic information. DC Water, which manages the water and sewage system in Washington D.C. in the U.S., introduced a big data system for the effective management of sewage and the collection system (Chun & Lee, 2014). The third area is science and technology. Many science and technology fields from astrophysics and oceanography to genomics and environmental research have reaped the benefits of high-throughput sensors and instruments. Scientific and technological means of managing, analyzing, visualizing, and extracting useful information from large, diverse, distributed, and heterogeneous datasets accelerate the progress of scientific discovery and innovation. The fourth area is smart health and wellbeing. This area can implement association rule mining and clustering, health social media monitoring and analysis, health text analytics, health ontologies, patient network analysis, and adverse drug side-effect analysis. However, it has to contend with the complex issue of preserving privacy. The final area is security and public safety. Intelligence, security, and public safety agencies gather large amounts of data from multiple sources, from criminal records and terrorist incidents to cybersecurity threats and multilingual open-source intelligence. Researchers in computational science, information systems, social sciences, engineering, medicine, and many other fields have been called upon to help enhance the ability to combat violence, terrorism, cybercrime, and other cybersecurity concerns.

2. Smart environments

Recently, Information and Communication Technology (ICT) and Internet of Things (IoT) provide smart environments. Several applications of smart environments are now commonplace, including smart homes, smart healthcare, smart grids, smart transportation, and smart cities (Hashem, et al., 2016).

Smart homes are centered around home automation, such as distributing commands and information via wireless networks to electrical appliances, information gadgets, and other internet-based applications via a ubiquitous home network that can control security, lighting, ventilation, and temperature, thus saving electricity, protecting occupants from intruders, and managing energy use. Various computational methods have been proposed for the development of sophisticated control systems for smart home environments. Smart air-conditioners, security devices, mobile phone, and home theaters have been used to put smart homes into practice, and artificial intelligence (AI) technology supports multi-agent systems and automation control (Rita, et al, 2016).

Smart healthcare relies on cost-effective and sustainable healthcare information systems which can collect, process, and transform healthcare data into information, knowledge, and action (Demirkan, 2013). For example, a smart hospital system is able to collect in real time both the environmental conditions and a patient's physiological parameters via smart architecture for the automatic monitoring and tracking of patients, personnel, and biomedical devices within hospitals and nursing institutes. Sensed data is delivered to a control center where an advanced monitoring application makes them easily accessible for both local and remote users (Mainetti, et al., 2015).

A smart grid refers to an advanced communication and information infrastructure that enables the optimization of energy production, transmission, distribution, and storage. Other benefits involve system management automation, educated planning, lower costs and effort, and the improvement in electricity system reliability. The key drivers for the development of a smart grid are recent technology breakthroughs in energy storage, electric vehicles and operation and the efficiency improvements required to ensure network resilience and the security of supply. For smart grids, big data analytics can investigate the very large volumes of data produced by various components within the smart grid and transform the data into meaningful inputs such as patterns of operation, alarm trends, fault detection, and control commands (IEEE Smart Grid Working Group, 2017).

Smart transportation refers to efficiently managed routes. The patterns obtained from the large amounts of traffic data can minimize traffic congestion by providing alternative routes, reduce the number of accidents by analyzing the location and frequency of previous accidents, and optimize freight movements. The data collected from transport systems allows for the consolidation of shipments, the optimization of shipping movements, a reduction in the environmental impact, and an increase in safety (Hashem, et al., 2016).

Smart cities have been developed by governments to adopt technologically-based approaches and to handle the negative effects of urbanization via interconnected cities. Because many cities face uncontrolled growth, traffic congestion, crime, and complex waste resource management, they have started to compete with each other to attract the best professionals by providing them an attractive environment within which to live and work (Avelar, et al., 2015). A smart city thus invests in human and social capital and promotes the wise management of natural resources through participatory governance. It can be distinguished from other similar ideas such as digital or intelligent cities in that it focuses on factors such as human capital and education as drivers of urban growth, rather than focusing solely on the role of ICT infrastructure (Lee, et al., 2013).

Ⅲ. Research Methodology

1. Platform development

In smart environment, a platform development primarily needs technical function design, definition of status and attributes of dataset, and application of analytic techniques. This paper firstly designs technical function of the platform based on smart city and smart transportation studies. Because both of city and space have spatial characteristics and similar location systems. Secondly, the paper considers status and attributes of data through computational social science studies combining social science, computer science, and network science. Finally, analytic techniques related directly with service frame use recent application of advanced analytics.

2. Platform benefits review

To review benefits of proposed smart space platform, this paper first focuses on efficiency of platform structure, and then indicates matching between purpose of decision-maker and service using the platform to make efficient decision for a good use of space. Because this paper is a conceptual cornerstone for a smart space platform, it could not evaluate a validity and usefulness as a model.

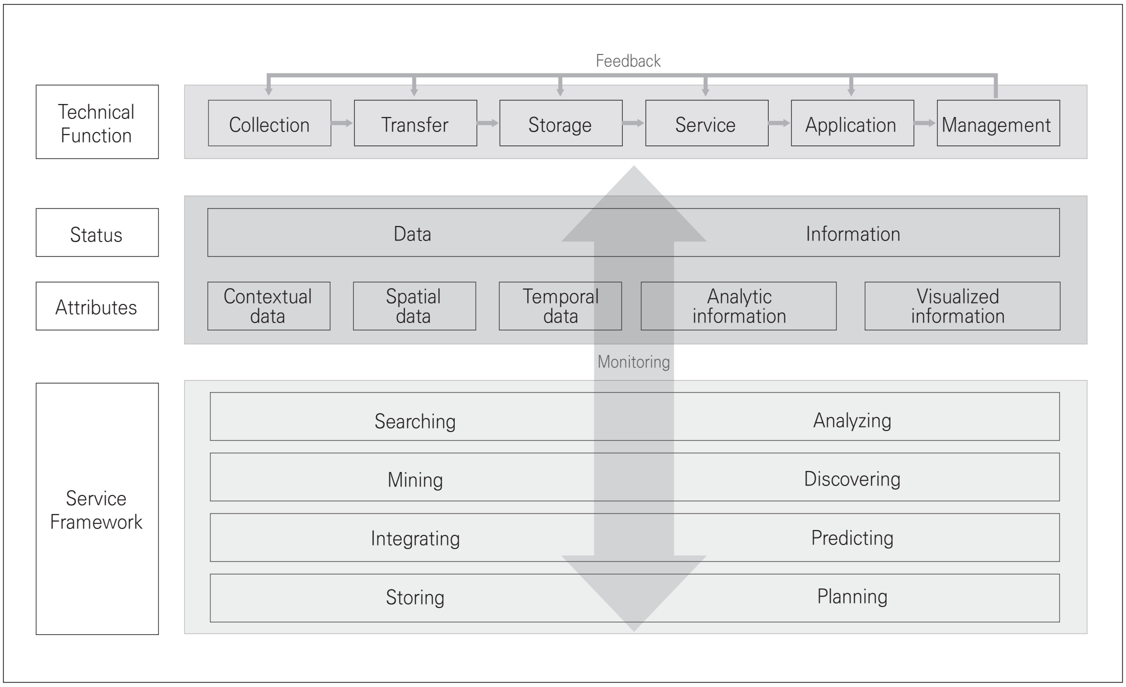
Ⅳ. Smart space and Effectiveness with decision-making

1. Smart space based on platform

1) Structure of smart space platform

In this paper, a smart space is defined as a good use of space, whether it be a home, office, or retail store, within a smart environment. To enhance the use of smart spaces, efficient decision-making and well-timed and accurate interaction are required. To achieve this, this paper proposes a smart space as a platform which takes advantage of emerging technologies for the efficient storage, processing, analysis, and utilization of big data.

〈Fig. 1〉 summarizes the technical function and usages of a smart space platform. The smart space platform is divided into six layers of technical function: collection, transfer, storage, service, application, and management. The collection layer accumulates data from various sources such as smartphones, computers, sensors, cameras, global positioning systems, social networking sites, commercial transactions, and games (Hashem et al., 2016). The transfer layer controls the regulation of the transferring protocol, enabling data transfer



〈Fig. 1〉 Structure of a smart space platform
〈그림 1〉 스마트 스페이스 플랫폼 구조

within heterogeneous networks. The storage layer applies the distributed storage framework to integrate, store, process, and back up the data. The service layer provides a function for exchanging, searching, and analyzing mass data based on parallel computing technology to support the application layer. The application layer supports visualized display and traces based on GIS to fulfill multiple requirements for different applications. The management layer controls the registration center for terminal registration management, service management, authority safety management, and storage distribution management (Xu, et al., 2016). The management layer performs interface control with different providers, monitors user requirements, improves relevant services, and builds service containers equipped with various service pools such as cities, the environment, transportation, economics, energy, safety, and real estate.

The datasets in the collection, transfer, and storage layers can be separated into contextual data, which means chatting online, buying products in a store, and performing actions in an online game, spatial data, which is the consumption of a product at a physical location, the use of software at home, and banking transactions in neighborhoods within the city, and temporal data, which is the things happening now or in the past, or at many points in time over a specified period, extending into the future (Chang, et al., 2013). In the three layers, users can search, mine, integrate, and store relevant data in different settings. The service and application layers represent the technical environment that enables the analysis and visualization of information. Big data analytics can be defined as the application of advanced analytic techniques on big datasets as a new form of business intelligence practice. It refers to the process of analyzing huge amounts of data of various types to draw conclusions by uncovering hidden patterns and correlations, trends, and other valuable information and knowledge, thus increasing operational efficiency, offering greater benefits to the business, and exploring new markets and opportunities (Tiwari, et al., 2018).

2) Efficiency of smart space platform

A technical function of smart space platform is designed for various sensors and devices in IoT and ICT environments. So it is able to manage big data system in smart networks realtime-based from collection input-source to application of output-information. Also, it equips cloud computing system to perform complex large scale computing tasks for processing big data sets. to achieve these efficiency gains, the platform confronts with challenge of sustainable resources and self-sustainable platform, improvement and adaptability challenge for emerging communication and cloud computing technologies, interoperability challenge between multi smart applications, and timely investment of all kinds of participators.

The platform handles various data attributes such as contextual data, spatial data, temporal

〈Table 1〉 Efficiency of smart space platform
〈표 1〉 스마트 스페이스 플랫폼의 유용성

Structure	Efficiency gains	Challenges
Technical function	• platform for various sensors and devices in IoT and ICT • big data system in smart networks • cloud computing to perform complex large scale computing tasks	• sustainable resources and self-sustainable platform • adaptability for emerging communication and cloud computing technologies • interoperability between multi smart applications • timely investment
Dataset	• handling various data attributes • access to open public data • using analytic and visualized information	• protecting security, privacy and confidentiality • legal and policy
Service framework	• big data analytics • services each level to achieve discovering, predicting, planning • tailored services for decision-maker, consumer, client, social network participant etc.	• collaboration among developer, user, government • managing complexity of services

data, accesses to open public data, and uses analytic and visualized information. These various dataset compose accurate analysis results. However, using various data sources has conditions precedent such as protecting security, privacy and confidentiality, legal, and policy, which are intrinsic problems of big data.

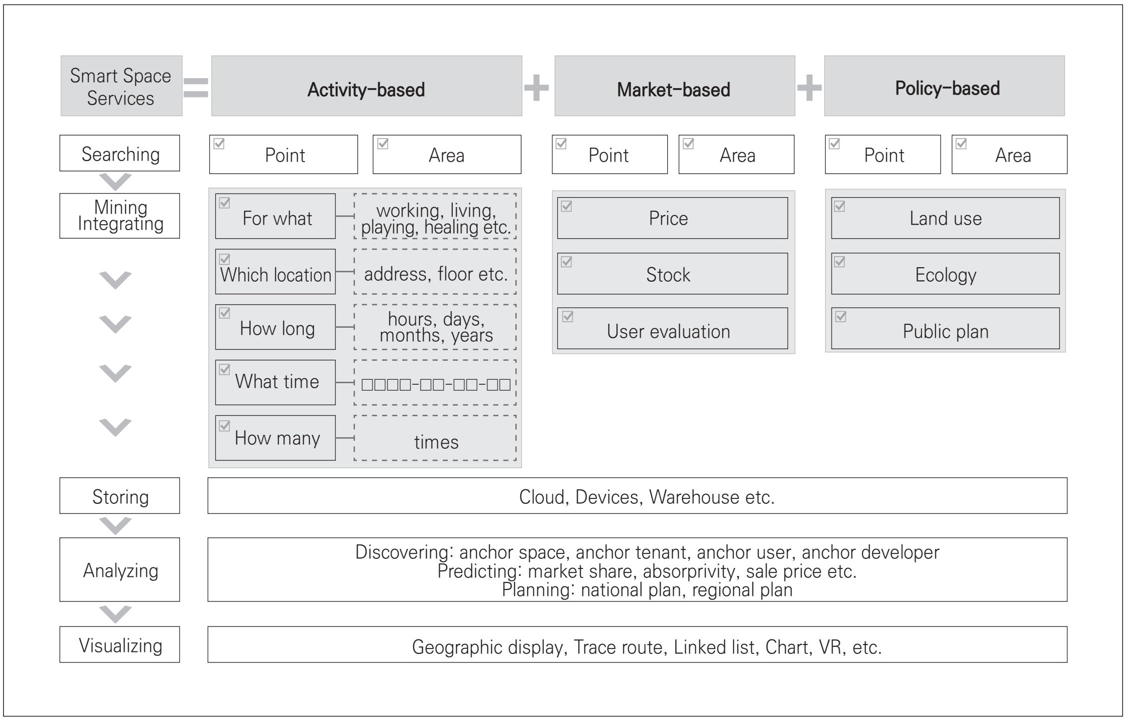
Service framework of the platform focuses on purposes of decision-maker which are discovering targets, predicting market factors, and planning policy via big data analytics. Efficient usage of services from platform expands when developer, use, and government collaborate, and when complexity of service manage.

2. Services using a smart space platform

1) Services

The services provided by a smart space platform can be classified as activity-based, market-based, or policy-based. The activity-based framework manages large volumes of data from multiple sources, such as sensor-captured radio frequency identification (RFID) data, mobile device records, locations based on coordinate geometry, and the internet. The market-based framework controls online analytical processing (OLAP) using public open sources, business reports, and consumer evaluation records. It is useful to illustrate price, supply, and demand information. The policy-based framework interlinks system screening regulations, policies, and plans from the public sector, such as land use and environmental conditions. Using the services provided by smart spaces, decision-makers, consumers, clients, and social network participants are able to make better decisions, act more rapidly, achieve greater innovation, and maintain stronger competitive advantages through analysis, discovery, prediction, and planning. In particular, big data analytics in supply chain management has been the subject of around 100 studies published between 2010 and 2016; a review of these finds that one of the main goals of big data analytics is to make full use of the data to improve productivity by providing the right information for the right user at the right time. As such, big data analytics has applications in a number of different industries, including finance, healthcare, and manufacturing (Tiwari, et al., 2018). A solid platform supports successful big data analytics. The platform has to provide searching, mining, integrating, storing, analyzing, and visualizing services that suit the various needs of the users. A smart space platform has spatial data as well as general big data as geographic characteristics. The spatial data is represented by various large-scale datasets such as 2D/3D numerical maps, topographical maps, satellite images, aerial photographs, and digital elevation models (DEMs) (Moon, et al., 2016).

All kind services provide selecting option location of one point or area to users (see Fig. 2). Users can search real-time location information, existing spatial data, and access information (e.g., IP, port etc.) for data interfaces, and also create new spatial datasets for administrative districts or influence radius area. Users can select ‘for what’, ‘which location’, ‘how



〈Fig. 2〉 Smart space platform services
〈그림 2〉 스마트 스페이스 플랫폼의 다양한 서비스

long', 'what time', 'how many' for mining and integrating in the activity-based service framework, 'price', 'stock', and 'user evaluation' in the market-based framework, and 'land use', 'ecology', and 'public plan' in the policy-based framework. The users can then store that information in the cloud, their devices, or in a warehouse. They are able to analyze the big datasets to discover anchor spaces, anchor tenants, anchor users, and anchor developers, to predict market share, absorptivity, and sale price, and to devise national and regional plans.

The smart space platform supports the visualization of analytic information such as geographic displays, trace routes, linked lists, charts, and VR. As reported by Seo and Kim (2015), visualization methods can be divided by six categories: data visualization (e.g., tables, line charts, pie charts, bar charts, histograms, scatter plots, bubble charts, area charts), information visualization (e.g., data maps, tree maps, clustering, semantic networks, time lines, diagrams, and tag clouds), concept visualization (e.g., mind maps, layer charts, concentric circles, decision trees, and PERT charts), strategic visualization (e.g., organizational charts, strategy maps, failure trees, and portfolio diagrams), metaphor visualization (e.g., metro maps, story templates, funnels, and trees) and compound visualization (e.g., cartoons, rich

〈Table 2〉 Effectiveness with decision-making
〈표 2〉 의사결정 정보의 효과성

Services	Activity-based		Market-based		Policy-based	
	well timed	accurate interaction	well timed	accurate interaction	well timed	accurate interaction
Searching	●	●	●	●	▲	▲
Mining	●	●	●	●	▲	▲
Storing	●	●	●	●	▲	▲
Analyzing	●	●	●	●	◑	◑
Visualizing	●	●	●	●	◑	◑

●: If decision-makers can achieve fully their purpose each services, there is best achievement.
▲: If decision-makers can achieve partially their purpose each services, there is second best
◑: If access to services is restricted to special users such as policy makers, there is only special user.

pictures, knowledge maps, and learning maps). Visualization technology has developed rapidly and can now illuminate big data analytics. Smart spaces and big data have become accepted as the key factors in the innovation of future business models.

2) Effectiveness with decision-making

For decision-making, the smart space platform provides searching service, mining service, integrating service, storing service, analyzing service, and visualizing service on three points of view as activity-based, market-based, policy-based. Decision-makers can achieve their purpose when they access timely, and interact accurately each services. 〈Table 2〉 shows effectiveness with decision-making. Because they can access real-time spatial information, and create new decision-making information, activity-based and market-based services achieve well timed and accurate interaction conditions. On the other hand, because policy-based big data is consisted of public open data source, there are time lag and access constraint for searching and mining. Also, only decision makers of public sector can achieve to analyze and visualize timely and accurately until now.

Ⅴ. Conclusions

The use of smart spaces based on big data is an opportunity to innovate the real estate industry. However, to build a smart space platform, some challenges first need to be overcome. First, big data has a number of inherent problems, such as privacy leaks, the lack of global legal interoperability, and confusion of the ownership of data. As individual needs for privacy vary, policymakers need to modify legislation and regulations to keep up-to-date with changes in technology. The lack of global legal interoperability comes from the development of separate legal and regulatory frameworks within each country. Personal data ownership includes property rights and the establishment of usage rights, which is not easily extended to data (ISACA, 2013).

The second challenge is technically generating the ability to effectively mine different sources and to integrate various datasets.

The final challenge is the big data governance process. Proper governance is required to achieve the realization of benefits realization, the reduction of risk, and the optimization of resources.

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