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Social Network Based Decision Support System for Smart U-Parking Planning

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Abstract**—**The aim of this study was to build 'Ubi-Net', a decision-making support system for systematic establishment in U-City planning. We have experienced various urban problems caused by high-density development and population concentrations in established urban areas. To address these problems, a U-Service contributes to the alleviation of urban problems by providing real-time information to citizens through network connections and related information. However, technology, devices, and information for consumers are required for systematic U-Service planning in towns and cities where there are many difficulties in this regard, and a lack of reference systems.

Thus, this study suggests methods to support the establishment of sustainable planning by providing comprehensive information including IT technology, devices, news, and social networking services (SNS) to U-City planners through intelligent searches. In this study, we targeted Smart U-Parking Planning to solve parking problems in an 'old' city. Through this study, we sought to contribute to supporting advances in U-Space and the alleviation of urban problems.

Keywords**—**Design and decision support system, smart U-parking planning, social network analysis.

I. Introduction

A U-City is a city that can provide conditions for citizens to obtain and use city information, such as that concerning administration, transportation, welfare, and the environment. Since 2004, Korea has seen the implementation of U-City plans after the establishment of promotion plans. The paradigm of recent U-City plans has changed from technology-oriented plans to space-oriented plans. Accordingly, the plans have changed to U-City plans focused on established urban areas that have various 'city problems', due to the compound and mixed use of land, instead of on new cities with efficiently arranged space plans from the beginning. Also, U-Service, a key element of U-City plans, has changed from an administration-centric city management system establishment service to a citizen-centric service, focused on issues such as life convenience improvement through citizen participation and welfare.

Most established urban areas have a variety of city problems due to structural imbalances, such as high-density development, mixed use of land, and the concentration of population. These city problems manifest in transportation and environment issues, crime, and housing and information imbalances among generations. Although there have been many attempts to solve these problems, numerous difficulties have been encountered in solving such fundamental urban problems, especially with regard to the largely physical methods involved.

Recently, U-City plans have been developed and it is anticipated that help can be provided in solving city problems through U-Services. U-Services contribute to the decision making of users by providing real-time information to them through the establishment of a linked network of relational information, as opposed to the establishment of physical facilities. The beneficial effects of U-Service contribute to cost reduction and efficient use of services and amenities in high-density, established urban areas.

However, there are many difficulties involved in planning U-Services due to the absence of a reference model that could support the decision making of the planner. First, a U-City planner has difficulty designing a U-Space without understanding the underlying IT technology and devices. Second, current U-City plans follow or apply case spaces, or depend on the devices of a specific company. Third, it is necessary to keep up with and understand new technology and devices that are being launched continuously and to provide inclusive information to plan and design a future-oriented U-Space. Finally, there is no room, as yet, for participation in this process by the citizens, the *real* users of U-Space. Solutions to these problems will support the systematic planning of U-Spaces and the implementation of U-Services, as necessary for users, which will improve citizen convenience and participation.

In this study, we aimed to establish a social network analysis (SNA)-based decision making support system named Ubi-Net, which enables the establishment of a systematic U-Service implementation plan and the participation of citizens. Ubi-Net provides IT technology and a device information database (DB) with a real-time update system to support the systematic implementation of a planner. Technology and device information is provided by smart levels to enable efficient and optimized planning within a limited budget. As technology and devices have different service ranges, which can be supported

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in different combinations, the provision of smart levels according to combination will enable the planning of suitable combinations according to budget and purpose. For citizen participation, a relevant DB is established with news and SNS of a U-Service using citizens, which is available to the planner. Also, SNA-based intelligent search is provided for the technology information DB and a citizen participation DB to provide systematic reference for the planner. This study focuses on a parking problem, a typical city problem in established city areas, as an example of how U-Service can help.

II. Existing Study Trends

A. Study of a Smart City

IBM, a leader in the technology associated with smart cities, has promoted a variety of projects and research on smart cities. Reference [1] proposed a decision-making support system that recommends combinations of suitable technologies for a user according to smart levels. As shown in Fig. 1, the decision-making model is promoted in two models, which are a budget-first model and a smart-level-first model. The former supports searches for smart devices and technologies that maximize smart level within a limited budget and the latter supports searches for smart devices and technologies available within an efficient budget with the aim of approaching a smart level set as a target. With the help of these systems, an evaluation model base has been established for smart city strategies to deal with city problems.

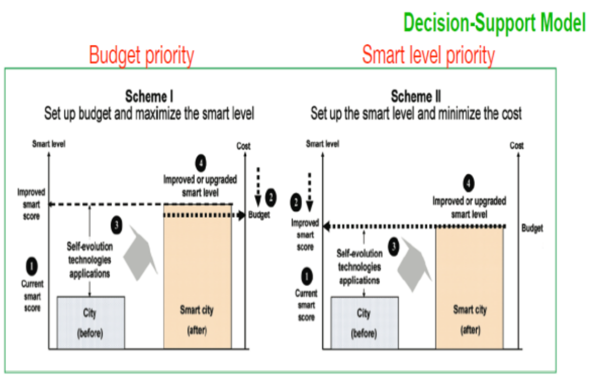

Fig. 1 IBM's a smart city decision-making support system model [1]

Fig. 2 views smart cities by means of a construction of four layers –city objectives, city indicators, city components, and city contents – and has proposed systematic planning according to the construction process of a layer. According to the four processes, a city planner establishes sustainable city objectives. Global traffic indicators show that an evaluation of required travel time on city bus systems is insufficient. Thus, establishment of a bus link system is planned. Next, similar foreign cases are reviewed to implement a link system, a budget for application to the city is obtained, and the policy systems that are required for successful operation of the bus system is reviewed. Also, it is emphasized that the collection and sharing of detailed, incomplete, and vast quantities of information are required for smart city planning through this process. That is, implementation and management of smart city and systematic planning can be accomplished by establishing a reference model for scattered, relevant information and providing it to the planner.

Fig. 2 CISCO's smart city framework layers [2]

Reference [3] studied the development of small- and medium-sized cities, because previous studies on smart cities tended to focus on large cities. According to this study, the strengths and opportunities of a city have to be identified, and comparisons with the major resources of other cities have to be performed clearly, to develop a smart city. For this, the need to develop city indicators for comparison among cities has been proposed and 74 indicators have been developed using statistical data for six characteristics: Smart Living, Smart Environment, Smart Mobility, Smart Governance, Smart People, and Smart Economy. The indicators have been applied to 70 small- and medium-sized cities in the EU to diagnose individual cities.

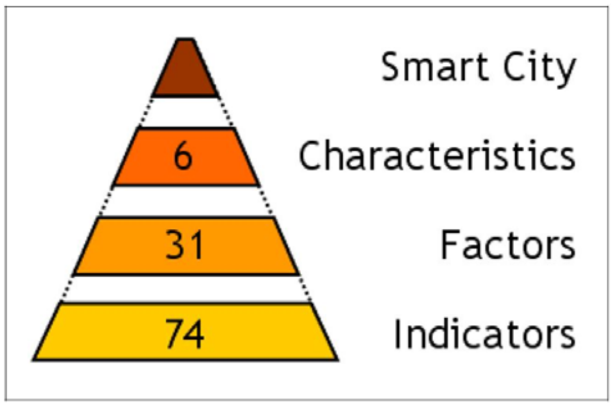

Fig. 3 Structuring the analysis [3]

B. Study on a Decision-Making Support System

[4] The SDS Knowledge Portal provides knowledge on spatial decision making and helps practitioners, researchers, and policy makers find knowledge and information required for solving problems in the process of decision making in real planning. For easy access, it clearly defines terms frequently used in the SDS field, and systematically organizes resources, such as relevant literature, tools, models, data, and cases.

Reference [5] developed a variety of design elements by using AutoCAD and arranged facilities to enable the drawing preparer to easily find the design for a facility and prepare design drawings for village developments. Reference [6] studied menus and analysis processes for each detailed item so that detailed analysis could be performed for the elements (topography, geology, vegetation, population, land price, traffic volume) necessary for city railroad construction by developing a decision-making support system for selecting the optimum line in city railroad planning. Reference [7] developed a system for reducing disaster recovery time from a typhoon in Taiwan through a study on a decision-making support system. Various DBs, such as basic DBs for administrative areas, rivers, public facilities and traffic, real-time rainfall monitoring, and rainfall prediction, and flood possibility DBs have been established to support decision making, all of which can reduce recovery work time.

As shown in previous studies, many indexes have been developed to establish design or decision support systems, and much information is needed to find optimum solutions for each circumstance.

C. Trend in Smart U-Parking Service

TABLE I
CHANGES IN INFORMATION DELIVERY SYSTEM IN SMART U-PARKING SERVICES

1st Stage (1999-2003)	2nd Stage (2006~2011)	3rd Stage (2012~2014)
·One-way provision of information ·Provision of static information	·Sharing of parking space ·Two-way provision of information ·Provision of static and dynamic information	·Sharing of parking lot information ·Sharing of vacancy information ·Sharing of privately owned parking space ·Development of participation-type business model ·Contents enrichment

In total, 17 services at home and abroad were analyzed to find trends in U-Parking services. In the initial stage of a U-Parking service, it is limited to a one-way service that informs users of the location of a parking area and vacant spaces using VMS. In the second stage, parking spaces around the destination are shared and the service provider provides real-time information on vacant spaces to users with an App and the web. In the third stage, contents are enriched by developing a user-participating business model, such as the sharing of parking area information, vacant spaces, and privately owned parking spaces. The most important issue in relation to U-Parking service changes is that contents have been enriched and user-participation business models have been developed by establishing a voluntary participation space for users. That is, crowd sourcing has to be activated for enhancements such as service improvement and idea digging by establishing a participation space for users for the collection and provision of detailed information.

III. UBI-NET FOR DECISION-MAKING SUPPORT

A. Concept of Ubi-Net

The main purpose of Ubi-Net is to provide a reference model for decision making to U-City planners. SNA-based intelligent search is provided for obtaining inclusive information from DBs of components for U-City planning. The information DBs consist of technologies, devices, companies, experts, cases, and SNS and this information includes a variety of formats, such as raw data in non-processed format and organized knowledge, such as past cases.

Technology and device information supports U-City planning at an optimum smart level, considering the budget. Existing U-City plans have been implemented without the planner's understanding of technologies and devices and tend to follow certain case spaces or depend on certain companies. As the characteristics of the planned place have not been truly reflected because of this, U-spaces that do not correspond to the intent of a planner have been planned, budgets have been wasted, and there has been difficulty in providing a U-Service that can be fully experienced by citizens. The smart level indicates the range of available services, according to the combination of technologies and devices, and it supports planning suitable for the planner’s purpose within a limited budget.

Also, the provision of information on companies, experts, and cases to planners constitutes a reference model for the improvement of U-Space. It is possible to plan U-Space and U-Service by examining cases similar to the target site. The key point of U-City planning is to provide necessary information to users anytime, anywhere. This is macroscopic, and the required information varies according to the size and age of the city, such as a new city, an established city, a rural city, and a metropolitan area. Also, the necessary information differs among residential, commercial, and industrial areas. That is, it is necessary to clearly understand and analyze the target site for efficient planning of U-Space and U-Service. Ubi-Net is a decision support system for planners that provide an intelligent reference establishment of, and search for, U-City planning components.

B. Ubi-Net Process

Ubi-Net can be divided into a data input module, a database module for storing and indexing, and a search module that provides suitably visualized results for a query. The database of the DB module enables the storage of information in a variety of formats. This is because there are not only data suitable for table format, such as technology and device information, but also those that include their own information such as total service and items linked with technology and device DBs. Also, there are items expressed in stepwise figures, such as smart levels, and those that should contain descriptive text, such as news and SNS. It is important to establish a method for storing these atypical data and those in a variety of formats in one place, and efficiently managing increasing data in the future.

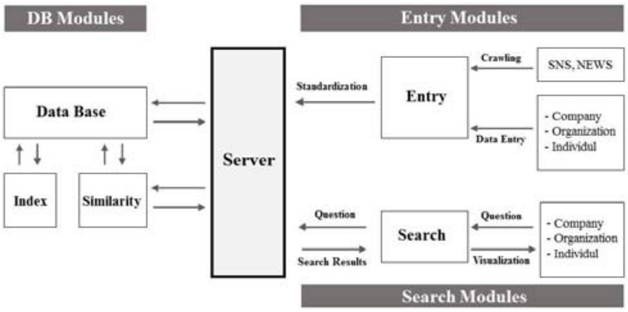

Fig. 4 Three Modules in Ubi-Net Process

As shown in Fig. 4, SNS and news are collected by crawling in the data input module. For the news and SNS- related DB, data are classified according to types, and similarity is calculated through co-word analysis to give priority. For technology and device information, the technology information DB was collected from the list information system managed by the Public Procurement Service. For consistent management in the future, an update system using the Public Procurement Service DB and a voluntary input system for companies are to be established for the purpose of autonomous DB collection.

The search module visualizes and provides relevant information according to the query word. Industry trends and demand are identified through key word analysis for news and SNS. If technology and device information are searched, the corresponding company and device are visualized according to interconnections. Also, if a certain service is searched, relevant services are provided together to help identify the service structure of the corresponding field.

C. Ubi-Net Algorithm

The core algorithm of Ubi-Net seeks to provide a practically satisfactory solution instead of the optimum solution for planning within a limited time. A heuristic method is a simple decision-making process that indicates a method to solve or find a problem on the basis of experience. U-Service has different applicable technologies according to the purpose, budget, and service of the plan. However, planning applicable technologies suitable for the characteristics of all the planning components are not possible, and a heuristic method has been used to help find interests closest to the plan and to establish a satisfactory plan.

When information of an applicable technology is entered, the importance indicator (G) of the technology for a smart level is determined. This indicator can be updated by an expert. Also, service information using the technology can be reviewed and scored by planners and citizens, and scores of a single technology (S) and a technical score (F) of filtered services can be obtained according to the recorded data. These data continue to be managed by managers and users and these figures can be used for Ubi-Net planning, enabling system planning close to the information desired by users. As shown in the figure, the applicable technology recommendation algorithm is performed by outputting the user-entered data to the recommended applicable technologies.

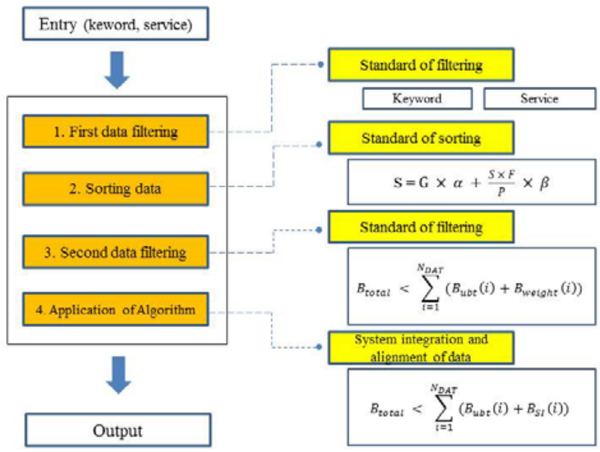

Fig. 5 Ubi-Net Applicable Technology Planning Algorithm Structure

This algorithm performs first data filtering on the basis of an integrated service after input data are entered by the user and the filtered data are sorted in the order of priority according to the sorting criteria (S). The sorted data are second filtered according to the budget, locations are calculated for intelligent facilities where each technology has been applied, and recommended applicable technologies are generated and output.

IV. Key Components of Ubi-Net

A. Technology and Device DB

As mentioned above, the technology and device DB were established using the List Information System of the Public Procurement Service [8]. The device information of the agency has a four-step classification system and is provided through OpenAPI; it is classified in detail into 56 large classifications, 346 medium classifications, 1,678 small classifications, and 11,886 minute classifications. The item information contained in the classification system is a vast-scale DB with about 100 million items, and the classification system for parking-related information has 7 large classifications, 11 medium classifications, 16 small classifications, 20 minute classifications, and 9,250 items within it. Parking-related technology and device information were established using OpenAPI and each individual item provides detailed properties, such as item name, unit, product life, model name, manufacturer, and detailed product descriptions.

A voluntary input system for companies is targeted as a technology and device DB update method. There is difficulty involved in any single operator collecting and managing new technical and device information in the future. To deal with this, an environment for voluntary input by companies and information collection by an operator is to be established and a voluntary data collection system is to be made through a two-way system whereby both the operator and companies can enter information.

B. Smart Level of Technology and Device

A U-Service consists of a combination of sub-services. To plan a U-Parking service, the subject of this study, a combination of sub-services, such as parking controls, parking guides, parking operations, and fee payment is required. A sub-service also consists of a combination of a variety of devices and technologies. As a smart level of a U-Service is determined by the combination of sub-services, and each unit of service consists of a combination of devices and technologies, the final smart level to be accomplished is the result of an appropriate combination of these components. As shown in Fig. 6, the U-Parking Service consists of sub-services such as parking control, parking guides, and parking operations. Planning by purpose, budget, and services is supported according to the smart level of the technical combination of sub-services.

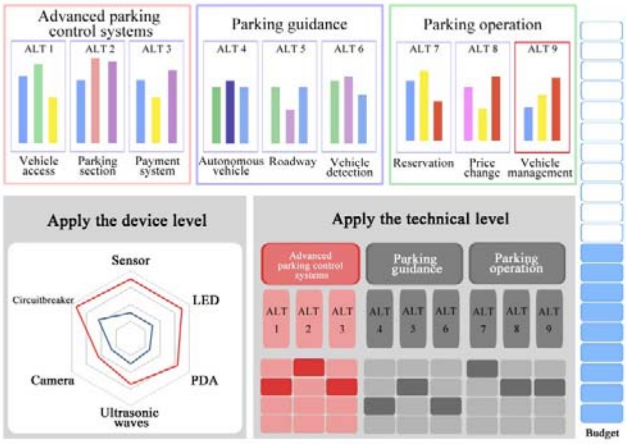

Fig. 6 Unit service planning example which considers budget

C. SNA-Based Intelligent Search

According to [9], graph theory-based social network analysis is a theoretical and statistical method for studying social structure using social relationship among actors, and uses the form of social relationships or social connection patterns as the analysis target. This can be said to be a theory that shifts the focus from the individual properties of a person to the relationships of a person. Also, the behavior and selection of a person vary according to the position at which the person is placed in a network.

U-City planners have difficulty in the design of a U-Space without an understanding of underlying IT and devices, and it is essential to understand and keep abreast of the new technologies and devices that are continually being launched. Also, there has been some difficulty in providing usable U-Services, which has been due to the lack of a participation space for citizens, who are the real users of the service.

This study supports SNA-based intelligent search using a technical information DB and news and SNS DBs. Before establishing a network, it is essential to arrange data according to similarity in order to use the DBs of different forms, such as table data and text information. If a planner searches for a U-Service to be designed, highly relevant technical information and news and SNS information are provided together. This will provide planners with insight with regard to technical understanding and trends in the corresponding services and required information for citizens.

V. Conclusion

We sought to establish Ubi-Net, a decision support system that provides SNA-based intelligent searches of technology and device DBs and news and SNS DBs, which provide important information for U-City planners. The key objective in establishing Ubi-Net is to support sustainable planning and improvement by providing inclusive information on U-Space components.

To provide comprehensive information, it is proposed that the technical DB is established using the List Information System of the Public Procurement Service and that news and SNS DBs are established to identify technical trends and user demand. Also, applicable technologies for U-Services vary according to the planning purpose, budget, and services. An algorithm has been proposed that recommends applicable technologies using a heuristic method that finds or solves problems on the basis of experience. Smart levels are proposed through optimum combinations of technologies to support practical planning suitable for the purpose and budget of the planner.

This study describes the establishment stage of Ubi-Net and aims for verification through application in a test bed and later in full system implementation. It will contribute to the systematic establishment of U-City plans and U-Space improvements.

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