Proposals for Improving Korean CALS System using Semantic Technologies

Dongjin Choi[1], Pankoo Kim[1*], Myoungbae Seo[2], and Namgon Kim[2]
[1]Chosun University, Gwangju, Republic of Korea
dongjin.choi84@gmail.com, pkkim@chosun.ac.kr
[2]Korea Institute of Constrction Technology, Goyang-Si, Gyeonggi-Do, Republic of Korea
{smb, ngkim}@kict.re.kr

Abstract

Continuous Acquisition and Life-cycle Support (CALS) System has been running by the Ministry of Land, Transport and Marine Affairs (MLTM) in Republic of Korea, in order to manage huge amount of construction businesses effectively based on the Project Management Information System (PMIS) concept. In Europe, Japan, and other developed countries, including the United States had already been applied this PMIS into the construction industry for maintaining diverse construction businesses much earlier than South Korea did. The project for preparing construction CALS system had been started since 1998, and currently there are many kinds of system such as Construction business information system, Construction business management system, Facility maintenance system, Land acquisition compensation system, Construction approval system, Construction CALS portal system, and more which are operating in on-line. However, these systems are operated by their own purpose independently, so it is not easy to analyse data which might be related to among the systems. In particularly, there are hundreds of thousands of meaningful data around the system which can provide helpful information for users who are looking for new business partners or lands, organizations. Most of the tasks for the construction business has done by human hands so far. Only resulting data is transformed into digital values in order to give a service to construction institutes for maintaining or construction companies for searching the projects, and so on. This paper provides few proposals for improving Korean Construction CALS systems by using semantic technologies such as an ontology theory, Internet of Things (IoT), and semantic web technology in order to deal with huge amount of data in CALS systems.

Keywords: CALS system, Semantic Technologies, Internet of Things (IoT)

1 Introduction

Web-based Project Management Information System (PMIS) has been considered as an important system in construction business for managing construction projects in Republic of Korea. Because, this system is able to support coordination and collaboration among participants in construction businesses via the internet based on Information Technologies (IT) [5]. People who work in construction business is no longer have to manage their projects by their hands. It is able to report or supervise the construction projects by using the construction PMIS. Due to the efficiency of PMIS, Europe, Japan, and other developed countires, including the United States, had already been applied the PMIS into the construction industry for maintaining diverse kind of construction projects much earlier than South Korea did. The Korean government made a plan to build PMIS for construction industry (named CALS system) since

IT CoNvergence PRActice (INPRA), volume: 2, number: 4 (December), pp. 44-54
*Corresponding author: Department of Computer Engineering, Chosun University, 309, Pilmun-daero, Donggu, Gwangju, Republic of Korea, Tel: +82-62-230-7636

1998, and there are currently many kinds of system such as, Construction business information system, Construction business management system, Facility maintenance system, Land acquisition compensation system, Construction approval system, Construction CALS portal system, and more in order to deal with different kinds of needs from construction participants [4] as shown in Figure 1. Although, these CALS systems built for supporting the construction participants needs, it is not easy to please all their needs, due to the fact that these systems are operated by their own purpose independently. Therefore, the huge amount of meaningful data around the systems needs to be managed semantically.

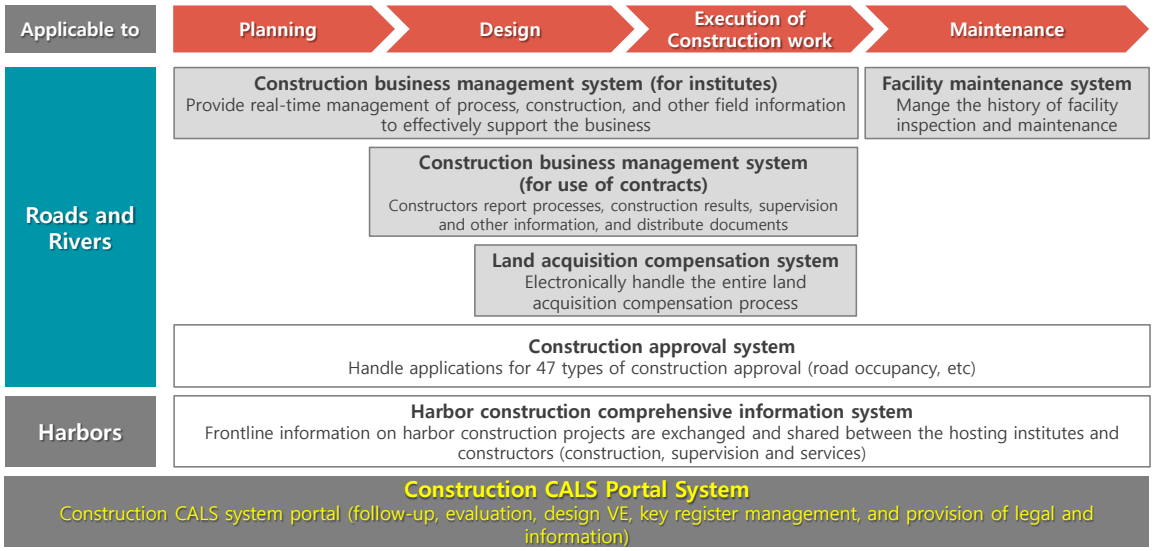

Figure 1: Key types of Korean construction CALS systems

Moreover, the most of tasks for the facility maintenances such as road and bridge has done by human hands so far. It is almost impossible to maintain entire facilities by human efforts because of the amount of facilities, location and time limits, and other issues. Therefore, many studies [8, 3] have been considered Ubiquitous Sensor Network (USN) technologies for sustainability systems in the construction industry. The USN technology is one of the most hot-issued technologies these days in order to support environmental monitoring, warfare, child education, surveillance, micro-surgery, and agriculture [6]. This USN technology has been applied to various field such as maintenance of a construction monitoring system [8], bridge health monitoring system [2], and water level monitoring system [3]. These studies have proved that the USN technology can support remote monitoring system for the construction facilities.

Even though, Korean construction CALS system have been developed and upgraded for many years, there is a weakness to overcome by using currently hot-issued information technologies. This paper propose ideas to enhance performances of Korean construction CALS systems especially for construction business management system, facility maintenance system, and construction technical information system based on ontology, Internet of Things, Semantic technology for Big data, respectively. We believe that the proposed ideas can improve effectiveness of construction business processes and make participants easy to use Korean construction CALS systems for their needs.

The rest of this paper is organized as follows. Section 2 describes related works (Ontology technology, Internet of Things, and Semantic technology for Big data) which we applied for the Korean construction CALS systems. Section 3 explains the proposed ideas for improving Korean construction CALS systems especially for construction business management system, facility maintenance system, and construction technical information system based on three kinds of semantic technologies. Finally,

we conclude this paper in Section 4 with suggestions for future works.

2 Related Works

2.1 Ontology

Ontology is a formal naming and definition of the entities that really fundamentally exist for a particular domain in computer science and information science [9]. In other words, ontology can be defined as a specification of a shared conceptualization [10]. The ontology is a description of the concepts and relationships which can exist among concepts in a particular domain. The ontology has been considered as a key point of the Semantic Web which is aimed to convert current web into structured web documents, in order to let machine understand data on the web. The ontology can be described by Resource Description Framework (RDF) which is a general specification method to decompose any types of knowledge into small pieces such as a class, property, and instance. For example, a general knowledge 'Apple is a fruit' can be described by the RDF logic as shown in Figure 2.

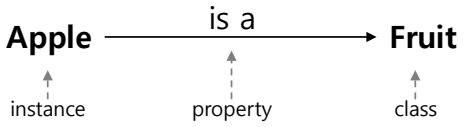

Figure 2: An example for a general knowledge 'Apple is a fruit'

A class can be a any types of general entities, such as 'animal', 'fruit', 'vehicle', and more. An instance will represent for specific entities which has to be a part of given class that really exist in real world, such as 'jaguar', 'apple', 'Porsche', and etc. A property is a term for indicating specific features or criterion for the given class or instance, in order to distinguish their own identity. Also, the property can be a relationship among classes and instances to build machine readable real world knowledge. The most important thing of class and instance is that not only subclass must inherit the properties of its upper class but also, the instance have to inherit the properties of its parent class.

The biggest advantage of using ontology is that as log as we have well structured ontology, it can be easily expanded by adding new classes or instances at their position as same as in the real world. Moreover, it is easy to infer the characteristics of unknown instances or classes with only a few information. Because of this advantage, many studies have been dealing with the ontology for knowledge expansion, relation discovering among concepts [11], automatic ontology construction [1], and more. According to the research [11], [1] by Dr. Hwang, proposed a method to enrich WordNet which is the most popular knowledge base around world, in order to reduce a semantic gap between concept pairs of WordNet and those of real world. These researches have proved that enriched knowledge base which is one of the ontology can be successfully applied to solve Word Sense Disambiguation (WSD) problems.

The current Korean construction CALS systema is not managed their data semantically. Even though, there is a high possibility that data in these systems is likely to be related each other, many of meaningful data has been spread all over the systems with a simple relationship for responding queries from system users. Therefore, we propose an idea to apply one of the important factor for semantic technology which is the ontology to manage various construction projects semantically, especially for Korean construction business management system.

2.2 Internet of Things

The Internet of Things (IoT) is the interconnection among embedded computing devices such as biochip, built-in sensors, smart devices, and more within the existing Internet infrastructure. IoT is aimed to provide advanced connectivity of devices, systems, and services that goes beyond Machine-to-Machine (M2M) communications. Eventually, the IoT will consist of a very large number of embedded smart devices that being connected to the Internet in the future. According to Gartner[1], they estimated that there will be nearly 26 billion devices on the IoT by 2020 and IDC[2] declared that the market scale for the IoT will be reached to approximately 8.9 trillion US dollars by 2020 because of dramatic increase of demands from customers and companies. The IoT will be converged with various industries such as, healthcare, energy, retail, public safety, transportation, and construction, in order to offer intelligent services to people as shown in Figure 3.

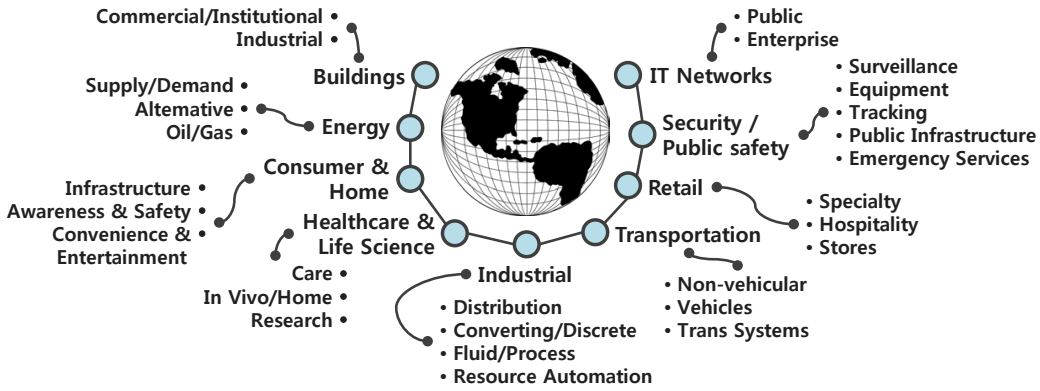

Figure 3: The blue print for the Internet of Things (IoT)

The IoT requires three kinds of important technologies, in order to actualize the IoT concept in to the real world [7]. The first necessary technology is sensing and identification. Sensing and identification is one of the core technologies for retrieving information from the target areas by using an embedded sensor chip. This sensor will be distributed various areas for detecting certain events. The information collected from the sensors has to be accurate, reliable, and secured from attackers. The second important technology is wireless network technology. Every sensor in IoT has to be connected to the network in order to send a detected information to the server and receive a task from administrators. The network infrastructure in IoT has to be stable in anywhere in anytime for remote services to human. The last important technology is middleware which is a software layer between the technological and the application levels. Because of middleware's major role in simplifying the development of new services, the middleware is gaining more importance in these days. This middleware has to satisfy the following requirements. Services composition is a common layer on top of a Service Oriented Architecture (SOA) based middleware architecture. It has to provide the ability to configure the services provided by the networked objects to make a specific application. Service management is a layer to provide main functions which are available for each object for management in the IoT. The objects in IoT have to be access to the different devices with a common network policy.

After these three kinds of important technologies are satisfied, the IoT make possible to offer a huge number of applications which available to the various domains and the environments, in order to improve

[1]Gartner is an American information technology research and advisory firm providing technology related insight.
[2]International Data Corporation (IDC) is an American market research, analysis and advisory firm, specialized in information technology and telecommunications.

the quality of human lives. The IoT technology is not only able to applied to transportation and logistics area but also healthcare, smart environment, social, and more.

We will propose ideas to apply these helpful technologies into Korean construct CALS systems in Section 3, in order to overcome weakness of current systems and offer better services to users of construction institutes, organizations, and others.

3 Proposals for Improving Korean Construction CALS systems

This section provides three kinds of proposal for improving current Korean construction CALS systems especially for the construction business management system, facility maintenance system, and construction technical information system for roads and buildings based on ontology, Internet of Things, Semantic technology for Big data, respectively, in the following subsection.

3.1 A proposal for Improving the Construction Business Management System

The construction business management system is one of Korean construction CALS systems for sharing information and reporting tasks during the entire of construction businesses procedure (planing, Designing, Execution of construction work, and Maintenance) in on-line. It aims to provide construction business management efficiently by reporting their tasks and offering statistics of current construction business achievement. This system has been run for supporting construction institutes to supervise various construction businesses remotely, in order to minimize business risks and costs and improve integrities among construction participants.

The current construction business management system has been merged with Contractor Integrated Technical Information Service system and Port Construction Project Management System. Therefore, the present system has to dealing with many kinds of official tasks and demands from construction participants. The problem is that the system menu is so much complicated for users as shown in Figure 4. In order to satisfy requests from construction officers, general users, and system administrators, the system menu designed to provide various categories as much as possible. Due to this multiplicity, it increases complexity of menu therefore it requires extra education to get used to use this system. Even though, the sub menus are not very closely related to their parent menu, they located in the wrong hierarchy. We believe that this system menu can be managed semantically by using ontology.

The current system menu provides construction information to users by using the tree-based hierarchy. This is the out-of-data method to represent an information on web-based system. The system menus need to be re-organized based on their semantic relationship. So, it is able to prevent extra education for system usage and time costs for finding menus. Therefore, it is possible to provide easier services to anyone who wants to use construction business management system.

Ontology is one of the solutions for representing semantic relationships among related system menus and re-organizing the current menu. We designed the construction task ontology as shown in Figure 5. According to the following figure, construction business can be defined as a parent class that has subclasses as ‘Construction Officer’, ‘Participation’, and ‘System Administrator’ which are the real system users. An ongoing work and task of a construction officer and participation during an construction project can be defined as a property of the given ontology.

The most important thing of ontology technology is that every subclass inherits all the properties of the parent class. For example, the properties of parent class ‘Monitoring’, ‘Authority’, ‘Registration’, ‘Change’, ‘Document’, ‘Periodical Report’, ‘Regular Report’ will be inherited to its subclasses. The one of the properties of parent class ‘Regular Report’ can have sub-properties which are the ‘Weekly Report’ and ‘Monthly Report’. Each of these ‘Regular Report’ has instances as ‘Report’, ‘Consturction

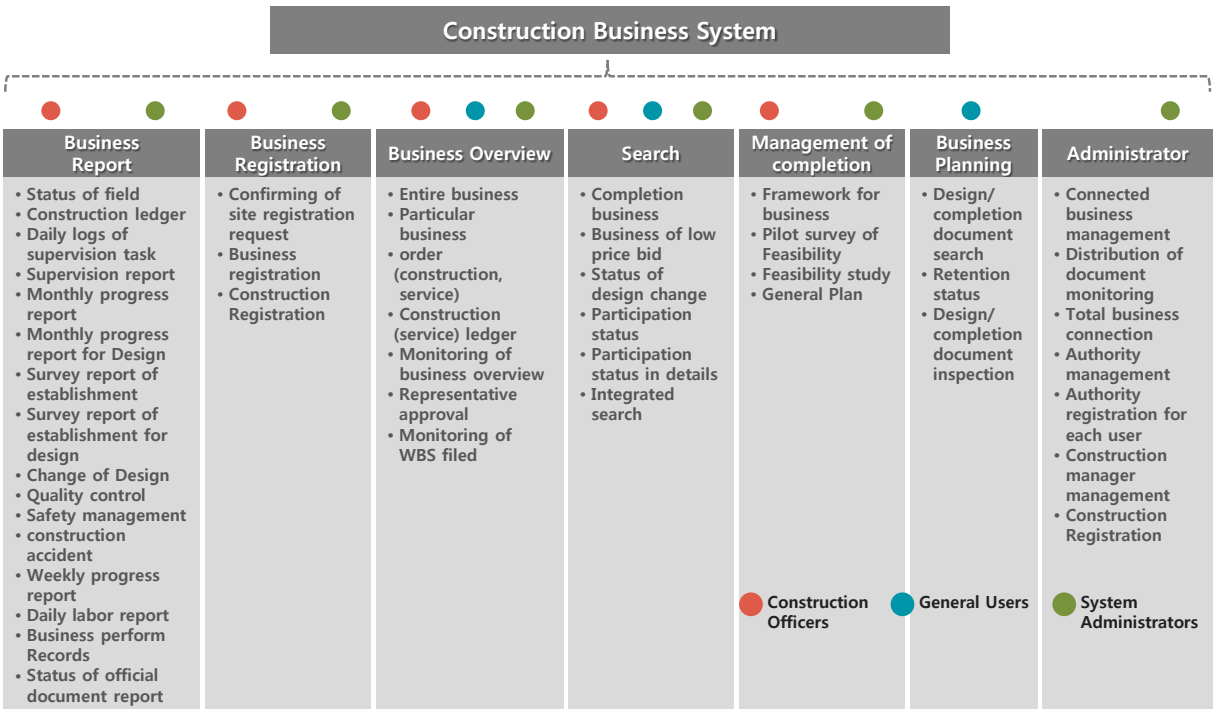

Figure 4: The construction business management system menu and user authorities

Ledger', and 'Daily logs'. These instances indicate the actual documents of official reports during the construction project.

If we apply construction task ontology into construction business management system, it will be possible to improve performances of paperwork and reduce time costs to get used to familiar with the system usage. Moreover, it will also be able to manage many kinds of data in the system semantically.

Figure 5: A Design of the construction task ontology

3.2 A proposal for Improving the Facility Maintenance System

The facility maintenance system in Korean CALS system has been running for maintaining 25 facilities(roads, buildings, bridges, tunnels, and more) effectively by web-based system. This system is merged with other maintenance systems which are the bridge management system (BMS) and the road fine system, in order to monitor the entire construction facilities around South Korea.

The current facility maintenance process has been done by human effort. The most of the maintenance tasks, such as supervising the facilities to decide whether it requires a maintenance or not, are depending on human hands so far. The person who associated with the facility maintenance task has to visit the place where the facility is located, and check a crack, water leak, and damages by the naked eyes. For this reason, it is not able to manage entire construction facilities effectively and it might result in huge disasters or accidents which can be avoidable if we find the problems in the facilities in advance. We need to overcome the traditional facility maintenance task by using the IoT technology, in order to monitor the construction facilities remotely, even though the facilities are located in a place where human is not easy to go, regularly.

In this section, we propose a method to improve the traditional facility maintenance task by using the IoT technology as shown in Figure 6.

A car black box or video event data recorder (VEDR) is a device to record information related to vehicle accidents or crashes. This device will be triggered by electronic sensors which are able to detect current location with the global positioning system (GPS), current speed with an acceleration sensor, video, and event collected by a gravity sensor which can detect an impact. This device will record current location, video, speed, and degree of impact information, if an impact is applied to a vehicle at least a certain degree.

According to Korean Consumer Agency (KCS) and IRS global[3], distribution rate of car black box on last October in South Korea was 25 to 30 percent and the market size was expected to increase by 10 times among three years. Especially, the most of taxies in Korea must have the VEDR device by the law.

In other word, more than 2.4 million digital devices are recording roads and many kinds of facilities, consistently. The most important thing of the current VEDR devices is that they have an ability to connect network by using wireless Internet protocol or Bluetooth. Because of the networking ability, it is possible to send a retrieved message from the VEDR to anywhere. This issue can bring huge changes in the current traditional facility maintenance system. We not only are able to monitor the facilities with 2.4 millions of digital eyes remotely, but also can discover cracks on the roads more easily than before. If the central analysis system (CAS) receive an event which might have possible information for cracks on the road, the system will be distinguish the precise crack by using images with information from diverse sensors. After detecting a road which needs a maintenance by the system, human will finally confirm that the system results are correct or not.

We believe that this proposal can be developed within a few year and it can be applied to the current facility maintenance system.

3.3 A proposal for Improving the Construction Technical Information System

This section is dealing with a method for improving the construction technical information system in Korean CALS system by using the semantic technology. The construction technical information system provides many kinds of construction business related contents through web-based portal system. This system especially aims to support global competitiveness of Korean construction industries. There

[3]IRS global is a Koran market research, analysis and advisory firm, specialized in information technology, vehicle, and energy. http://www.irsglobal.com/

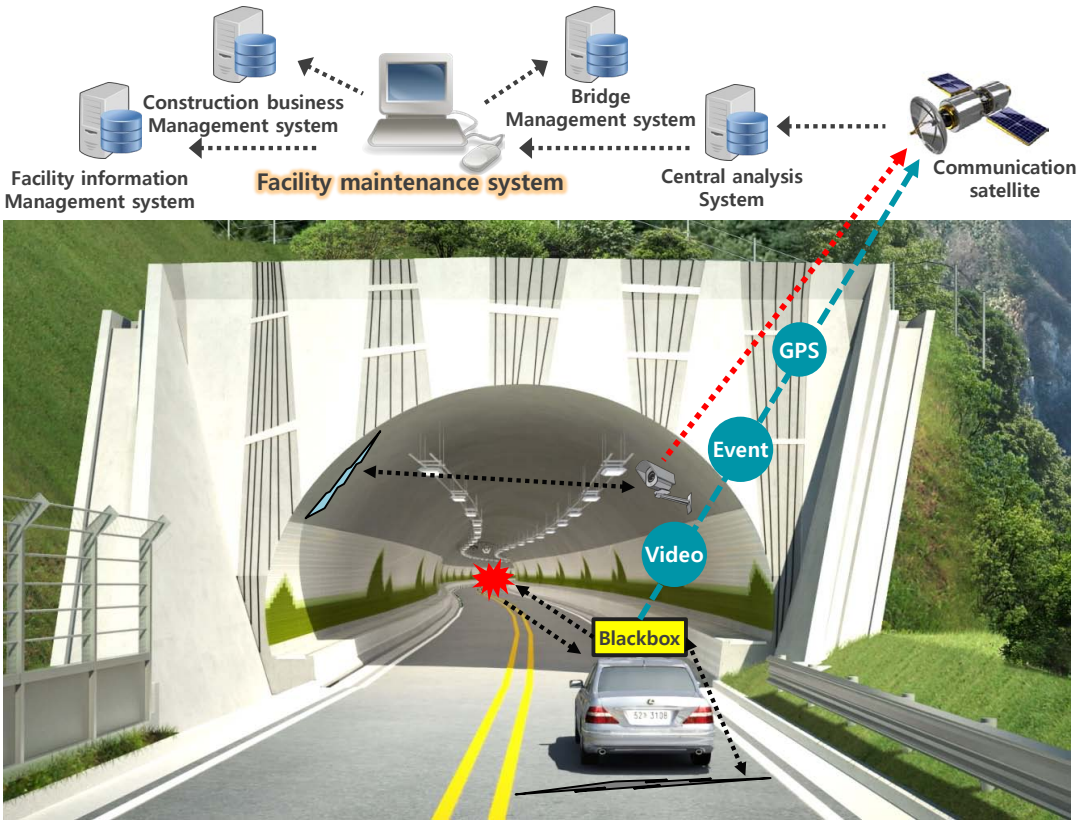

Figure 6: A proposal for maintaining construction facilities in Korea by using the VEDR

are four kinds of categories which are International construction technology, Korean construction technology, Research and development, and Information plaza. The international construction technology category provides construction business related official documents and processes in overseas. It also provides diverse technical reports and survey researches. The Korean construction technology category has contents for construction standards, on-going project information, and more. The research and development category has research papers, patent, trends, and reports. The information plaza offers educational videos, construction policies, and communities.

The most important drawback of the current system is that all of search results are based on the keyword matching. If the user queries are not exactly matched with the titles of documents in this system, it is not able to find the documents that users want to refer. Moreover, it requires construction background knowledges, in order to find the precise category which might have contents user needs. For example, there are 33,266 different kind of construction reports including supervision, regular, and survey report. If the user give a query with incorrect words, there is not other way to find a correct content.

Even though, many studies have been researched for enhancing performance of information retrieval by using the semantic technology, the information retrieval technique in the current system is out of date.

Therefore, we propose a method to avoid unnecessary results which might not be related to user's needs by using semantic technologies such as ontology, natural language processing techniques as shown in Figure 7. We need to reduce non-relevant results of user queries as much as we can.

The most of the contents in the current construction technical information system are based on the text or pdf files. Only simple annotations are given for distinguishing these contents, the most of annotations are titles. Titles of given documents are not always represent the major point of the documents. The

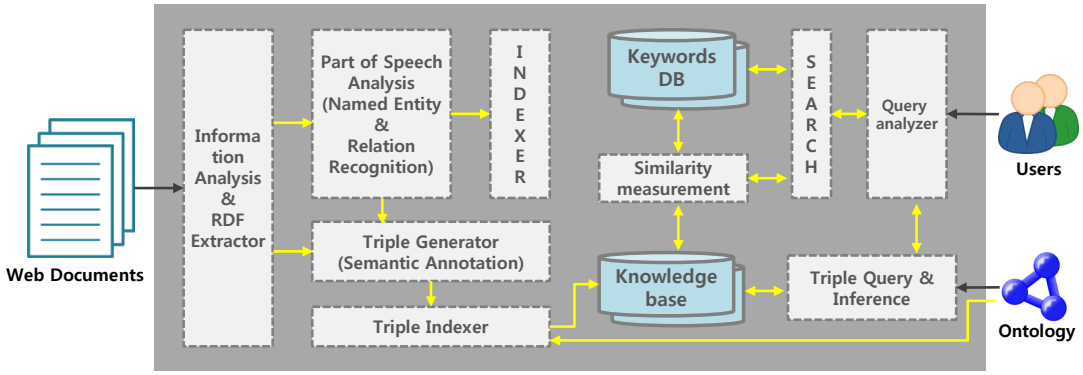

Figure 7: A proposal for improving information retrieval results in the current information system

information retrieval result can be improved if we prepare semantically related annotations in advance. However, it is almost impossible to annotate the entire contents in the system by human hands. It requires and automatic method but it has to be based on the semantic technology.

As shown in the Figure 7, every web document can be analysed by using Part of Speech (POS) tagger and knowledges represented by triples which can be converted into the resource description framework (RDF) from the documents. Queries of users have to be analysed semantically, in order to find the user needs. After that, we can compare results between user queries and knowledges triples from the given documents by using a semantic similarity measurement.

If we build the system based on the proposed method, we are no longer have to struggle to find a content from huge amount of data in the current system.

4 Conclusion and Future Study

The Korean Continuous Acquisition and Life-cycle Support (CALS) system is a system to support project management, facility maintenance, land acquisition compensation during the entire construction business period (starting from planning, designing, execution of construction work, and maintenance). The Korean CALS system has been developed by the Korean government since 1998, and there are many kinds of systems (Construction business information system, construction business management system, facility maintenance system, land acquisition compensation system, construction approval system, and construction CALS portal system) have been running on the web-based.

These system is aimed to provide convenience of construction business management, information disclosure and share, effectively report current construction project, and more. However, the current system has been out of date and many of valuable information has not been managed semantically so far. Therefore, this paper proposed methods for improving the construction business management system, facility maintenance system, and construction technical information system. The construction business management system can be improved if we build a construction business ontology and apply to the system menu to guide user to find information. It also be able to manage huge amount of data semantically. The facility maintenance system needs to build remotely monitoring system using the car black box or VEDR base on the IoT technology due to the high distribution rate of the VEDR and its network ability. We also proposed a method to improve the construction technical information system by using the natural language processing technique, in order to understand user demands and provide correct answers for their needs.

Even though these proposals only dealing with blueprint, we believe that our proposed method can be applied to other business project management systems and it will provide much convenient service to

human in the near future.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No. 2013R1A1A2A10011667).

References

[1] "ar drone 2.0". `http://ardrone2.parrot.com/`.

[2] A. Balasubramanian, B. Levine, and A. Venkataramani. Dtn routing as a resource allocation problem. In *Proc. of the 2007 conference on Applications, technologies, architectures, and protocols for computer communications (SIGCOMM'07), Kyoto, Japan*, pages 373–384. ACM, August 2007.

[3] J. Burgess, B. Gallagher, D. Jensen, and B. N. Levine. "maxprop: Routing for vehicle-based disruption-tolerant networks". In *Proc. of the 25th IEEE International Conference on Computer Communications (INFOCOM'06), Barcelona, Spain*, pages 1–11. IEEE, April 2006.

[4] S. Burleigh, A. Hooke, L. Torqerson, K. Fall, V. Cerf, B. Durst, K. Scott, and H. Weiss. Delay-tolerant networking: An approach to interplanetary internet. *IEEE Communications Magazine*, 41(6):128–136, June 2003.

[5] S. Lee and J. H. Yu. "assessment of asp-pmis quality in korea". *Construction Engineering and Project Management*, 1(3):9–17, December 2011.

[6] A. Lindgren, A. Doria, and O. Schelén. Probabilistic routing inintermittently connected networks. 7(3):19–20, July 2003.

[7] F. Segor, A. Bürkle, T. Partmann, and R. Schönbein. "mobile ground control station for local surveillance". In *Proc. of the 2010 Fifth International Conference on Systems (ICONS'10), Menuires, France*, pages 152–157. IEEE, April 2010.

[8] T. Spyropoulos, K. Psounis, and C. S. Raghavendra. Spray and wait: An efficient routing scheme for intermittently connected mobile networks. In *Proc. of the 2005 ACM SIGCOMM workshop on Delay-tolerant networking (WDTN'05), Philadelphia, USA*, pages 252–259. ACM, August 2005.

[9] N. Uchida, N. Kawamura, and Y. Shibata. Delay tolerant networks on vehicle-to-vehicle cognitive wireless communication with satellite system for disaster information system in a coastal city. 1(1):53–66, 2013.

[10] N. Uchida, N. Kawamura, and Y. Shibata. "evaluation of cognitive wireless based delay tolerant network for disaster information system in a rural area". In *Proc. of the 7th International Conference on Complex, Intelligent, and Software Intensive Systems (CISIS'13), Taichung, Taiwan*, pages 1–7. IEEE, July 2013.

[11] N. Uchida, N. Kawamura, and N. S. Yoshitaka Shibata. "proposal of data triage methods for disaster information network system based on delay tolerant networking". In *Proc. of the 8th International Conference on Broadband and Wireless Computing, Communication and Applications (BWCCA'13), Compiegne, France*, pages 15–21. IEEE, October 2013.

Author Biography

Dongjin Choi is a Ph.D student in the Department of Computer Engineering at Chosun University in Republic of Korea. His research interests include Semantic technology, text mining, and natural language processing. Contact him at 8109 IT Building Chosun University, 375 Seoseok-dong Dong-gu Gwangju, 501-759, Korea.

Pankoo Kim received the B.S. degree in computer engineering at Chosun University, the M.S. and the Ph.D. degree in computer engineering at Seoul National University in Republic of Korea. He is a professor in the Department of Computer Engineering at Chosun University. His research focuses on Semantic Web Technologies, Ontology, Multimedia, Natural Language Processing, and Data Mining (Corresponding author).

Myoungbae Seo finished his Master degree in computer engineering at Chosun University in Republic of Korea. He has been a researcher in Korea Institute of Construction Technology since 2003. His research interests include Construction Information Management, Building Information Modeling, Asset Management, 3D Printing and Image Processing.

Namgon Kim finished his Master degree in Computer engineering at Kongju University in Republic of Korea. He has been a researcher in Korea Institute of Construction Technology since 1991. His research interests include Construction Information Management, Building Information Modeling