International Journal of Engineering & Technology, 8 (1.4) (2019) 649-653

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

User Interfaces (UI) of Machine-to-Machine (M2M) Based Mobile Network System for Skilled Construction Workers

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Abstract

The construction industry is more labor-dependent than most other industries. As the competitiveness of construction firms is in part determined by the competence of their workers, most firms endeavor to recruit skilled workers. The South Korean construction industry has declined over the long-term and has had difficulty securing skilled workers, which has increased the number of foreign workers in the country. Accordingly, communication and manpower management related issues have become important, the consequences of which are an increased number of safety-related accidents and quality issues. These problems can be addressed by attracting new proficient labor, improving working conditions, and developing a system to connect existing skilled workers to jobs at construction firms. In this study, a mobile network system was developed to encourage skilled workers to join the construction industry and to be recruited by construction firms.

Keywords: *Construction Skilled Worker, Foreign Worker, Korea Construction Industry, Machine-to-Machine (M2M), Mobile Network System*

1. Introduction

New value is created in modern industries by fusing different industrial fields. The construction industry is creating new value by the fusion of finance, environmental, and high technology, including information technology (IT), bio technology, nano technology, etc. In particular, as the importance of IT has increased globally, the application of IT to the construction industry has also increased [1]. Recently, many industries have begun to use machine-to-machine (M2M) communication networks in various applications, including smart grids, goods tracking services, transportation card payment systems, and smart home services. As these systems provide the latest information to users, they become a source of new value [2]. However, the application of M2M to the construction industry is still in its initial stages. Even so, such advanced technologies are expected to play an essential role in solving various problems of the construction industry.

A large problem in the construction industry is the shortage of skilled construction workers due to the aging of skilled workers, the reticence of young people to obtain jobs in the industry, unstable employment, dangerous working conditions, and limited job market information for skilled construction workers. Consequently, more and more foreign workers have been recruited for domestic construction projects, which has resulted in an increase in safety-related accidents and a degradation in quality degradation as a result of communication problems, a lack of understanding of domestic construction sites, and a general lack of technical skills [3]. The focus of this study is to address the ongoing shortage of skilled construction workers by developing an M2M-based mobile network for skilled construction workers. By providing convenient access to job information, this mobile network will attract young skilled workers into the construction industry and enable construction firms to secure proficient workers.

2. Literature Review and Research Methodology

2.1. Literature Review

Internet of things (IoT) technology connects everyday objects to the Internet. As this technology enables continuous communications in peer-to-machine (P2M), peer-to-peer (P2P), and M2M networks, it has been actively applied in many industries [4]. An IT-based smart grid provides real time interactive communication to enhance efficient energy consumption. These systems are utilized in a variety of applications, including renewable energy, power saving, and electric vehicle charging systems [5]. In addition, the authentication protocols developed for mobile cloud environments have been adopted in many industries [6].

In recent years, M2M networks have been applied in the fields of real-time monitoring, surveillance, and security. Investments in technical development tend to improve the state of the network and reduce transmitted data conflicts by continuously monitoring the activation of machine-type communication (MTC) devices. Mobile M2M communications techniques have been developed to satisfy the demands of users for higher reliability and lower cost mobile networks. In addition, as multiple devices with diverse application can seriously affect the integrity of a mobile network by the simultaneous transmission of small amounts of data, researchers and developers are working to address such problems [7, 8, 9, 10]. Consequently, many M2M-based technologies are being actively applied to advance technology and productivity in various industries. Thus, M2M technology is expected to be useful in solving problems related to the supply and demand of skilled construction workers via the proposed mobile network system.

2.2. Research Methodology

This research was conducted using the four-stage research methodology summarized in Figure 1. In the literature review in Step 1, the significance of this study was clarified. In Step 2, the state of the supply and demand of skilled construction workers was determined and the corresponding impact on the construction industry was analyzed. In Step 3, based on the results of the previous step, the architecture of the skilled construction worker system was formulated, the user interface (UI) of the system was developed, and an entity relationship diagram (ERD) was prepared. In Step 4, the expected benefit of the proposed system on the construction industry was analyzed and a plan for further study was outlined.

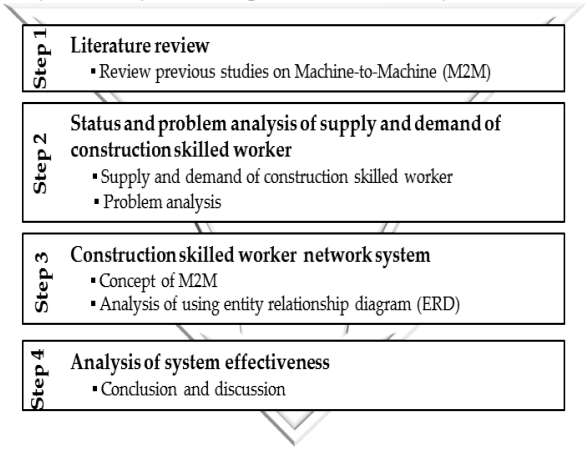

Fig. 1: Research methodology.

3. Problem Summary

3.1. Status of the Problem

From the 1980s to the late 1990s, the domestic construction industry experienced a steep growth in investment in every type of construction. However, such investments plateaued in 1999 due to the International Monetary Fund (IMF) crisis marked. Since the 2000s, improved liquidity and government policies for revitalizing the real estate market led to the growth of the housing construction market. Unfortunately, the global financial crisis of 2008 caused declines in the number of orders placed with domestic construction firms, which has continued until now [11]. The average value of the contracts awarded in the domestic construction industry from 2007 to 2017 are shown in Table 1 [12].

Table 1: Average value of contracts awarded per construction firm versus the year of award.

Year	Amount of contract awarded (million won)	Number of firms	Average amount of contract awarded (million won)
2017	1,603,955	12,028	133.4
2016	1,648,757	11,579	142.4
2015	1,579,836	11,220	140.8
2014	1,074,664	10,972	97.9
2013	913,069	10,921	83.6
2012	1,015,061	11,304	89.8
2011	1,107,010	11,545	95.9
2010	1,032,298	11,956	86.3
2009	1,187,142	12,321	96.4
2008	1,200,851	12,590	95.4
2007	1,279,118	12,842	99.6

This long-term decline of the construction industry has resulted in a continuous decline of new manpower. In 2016, the construction industry faced a shortage of 76,000 skilled workers, and the shortage is estimated to climb to 140,000 domestic workers by 2019 and then grow beyond that [13]. The estimated supply and demand of skilled construction workers by year is shown in Table 2.

Table 2: Estimated supply and demand of skilled construction workers (unit: person)

Year	Occupational Complexity	Manpower Demand (A)	Local Supply (B)	Gap (A-B)
2019	Skilled Worker	734,507	593,711	-140,795
	Laborer	661,707	534,867	-126,841
2018	Skilled Worker	733,093	618,081	-115,012
	Laborer	660,433	556,821	-103,612
2017	Skilled Worker	731,683	636,300	-95,390
	Laborer	659,169	573,234	-85,935
2016	Skilled Worker	730,297	654,078	-76,219
	Laborer	657,914	589,250	-68,665

The main causes of this imbalance include poor working conditions at construction sites, and the reticence of young people to seek jobs at construction sites. At the same time, existing skilled construction workers are aging quickly.

Older construction workers have difficulty finding new jobs due to the challenge of finding job availability information for construction firms; thus, these firms often fail to recruit the required number of proficient workers. The ultimate reason for this situation is that the supply of workers in the construction industry is heavily dependent on human networks. This is also the cause of many other problems, such as the difficulty of training in new technology [14].

3.2. Consequences

As the number of domestic skilled workers decreases, the increasing demand for skilled workers is met by employing foreign workers, which also reduces labor costs. However, this has led to increases in the number of safety-related accidents and quality issues due to communication problems, a lack of understanding of domestic construction sites, and poor working conditions [15]. Since most foreign workers perform simple tasks and receive lower wages than domestic workers, construction firms are prone to employing increasing numbers of foreign workers. The above problems are expected to continue [16].

To attract more domestic skilled construction workers into construction, reasonable wages must be available, along with job training and career planning. At the same time, it is necessary to provide existing skilled workers with accessible job information.

4. Mobile Network System

4.1. M2M System Concept

M2M is commonly employed to intelligently collect and process information received from things, and thereby provides a new and efficient service. As an intelligent service using various cognitive functions of things and the convenience of mobile technology, M2M is actively used in an ever expanding variety of applications. The concept of a typical M2M system is shown in Fig. 2.

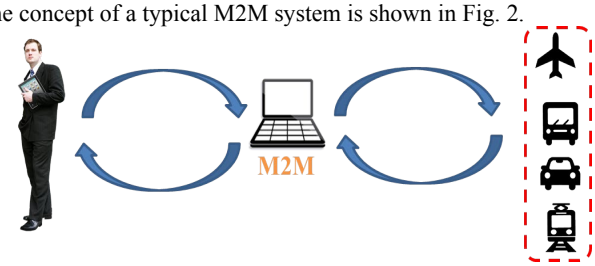

Fig. 2: Typical M2M system.

In 2009, the size of the M2M market reached about $29.5 Billion US dollars, including the service and chip/module markets. By 2013, the market size had grown to $48.5 Billion US dollars. The sales of M2M cellular modules has grown by over 28% every year and the unit price of modules has increased by 12–14% [17]. Many advanced countries consider IoT to be a core strategic tech-

nology for enabling inter-industry convergence, green policies, and data. Thus, IoT-related technologies have been widely promoted and have received increasing amounts of investment.

4.2. Case Study

To correct the imbalance between the supply and demand of skilled construction workers in the domestic construction industry, the Korea Land Corporation (LH) and the Construction Workers Mutual Aid Association jointly provide the construction dream net (http://www.cid.or.kr) service [18]. The web pages of this service are shown in Fig. 3.

Fig. 3: Construction dream net main screen.

The construction dream net service is a job portal site managed by the Construction Workers Mutual Aid Association, and provides useful job information to both skilled construction workers looking for jobs and construction firms that require skilled workers. On the site, information is classified under the categories of job seeker and employer, and there are seven different classes of occupations. Each employer provides information related to the posted job, including the type of work being offered, and the desired, age, gender, expertise, and skill of applicants. Job seekers provide similar types of information. If the information provided by a job seeker matches that of an employer, they are connected by the staff of the Construction Workers Mutual Aid Association. However, this service cannot provide real-time correspondence between an employer and a job seeker. In addition, as recruitment is mediated by the staff of the Construction Workers Mutual Aid Association, additional manpower is required. The system proposed in this paper is designed to address these problems in the existing system.

4.3. System Design

In the proposed system, when a job seeker or employer enters their information, it is stored in a network server so that it can be provided to both sides in real time via the real-time matching function. The structure of the proposed system is shown in Fig. 4 [19, 20].

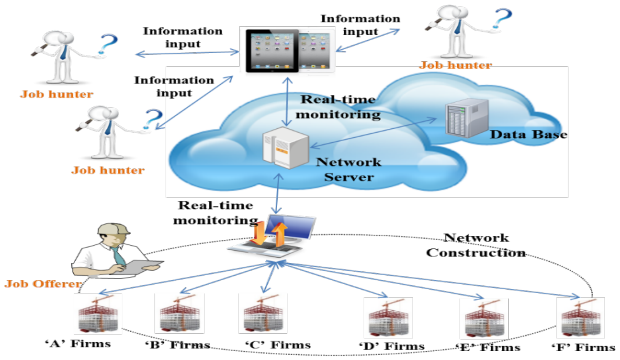

Fig. 4: Structure of the proposed system.

4.4. System Entity Relationship Diagram

As shown in Fig. 5, the system provides several screens for inputting detailed information by either job seekers or employers, including the location of the job site and information related to the user, job seeker, employer, and career. The provided details are then analyzed to match suitable workers with firms.

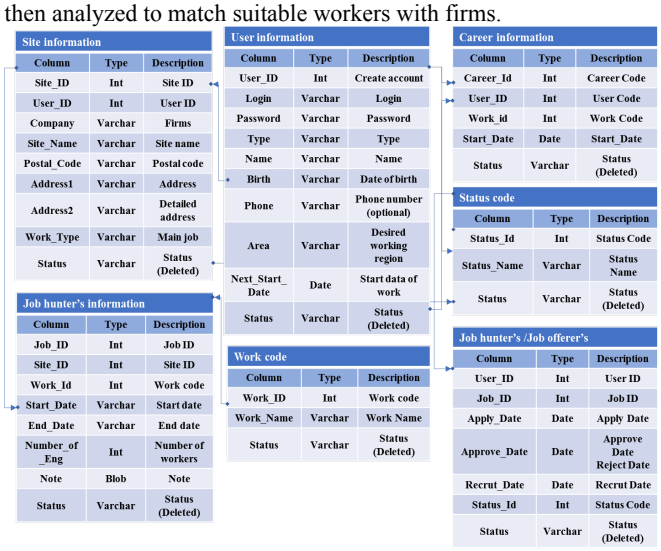

Fig. 5: ERD analysis of the system.

4.5. System Development

4.5.1 Main Screen for Job Seekers

Each job seeker inputs their personal information (e.g., academic, career, qualifications, job type of interest, etc.) using the mobile application shown in Fig. 6. The information provided by a job seekers is registered in real time and stored in the network server.

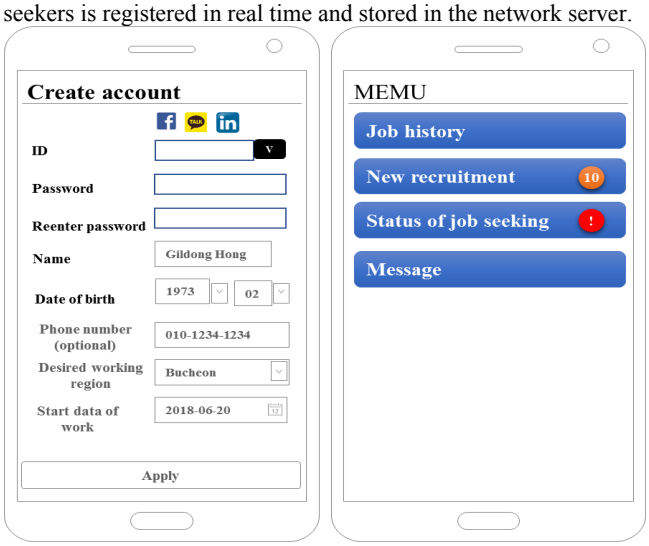

Fig. 6: Main screen for job seekers.

4.5.2 Main Screen for Employers

Each employer provides details pertaining to the workers wanted in a construction site (e.g., academic, career, qualifications, required strengths, etc.) using the mobile application, as shown in Fig. 7. This information is registered in real time and stored on the network server.

Fig. 7: Main screen for employers.

4.5.3 Matching Information

After the necessary data has been provided by both job seekers and employers and stored in the network server, the data is analyzed and sent (if appropriate) to the mobile applications of each matching job seeker and employer in real time. Job seekers can then select positions at suitable firms, as illustrated in Fig. 8.

Fig. 8: Matching information screen.

The advantages in the proposed mobile network system will be described from four perspectives.

First, the perspective of the job seeker.

The system saves the time required for monitoring which companies are currently hiring as information can be automatically provided to both parties if a suitable match is identified. This allows a human network to be built for sharing relevant information between members.

Second, the perspective of the employer.

The system allows employers to locate sufficient job seekers for each construction site and to efficiently manage information related to hiring activities.

Third, the system perspective.

This system allows the supply and demand of construction workers to be monitored in real time and analyzed based on the types of workers in demand. The results of such analyses can then be utilized as a basis for industry development.

Fourth, the institutional perspective.

The basic data about the skilled construction workers enrolled in this system can be used to develop education and training programs, in the development of government policies, or to revise existing laws.

4.6. Limitations and Future Research

The purpose of this study was to develop a system to match skilled workers with open jobs at suitable construction firms in the domestic construction industry by providing information related to open job opportunities in real time. To achieve this, the current state of the domestic construction industry was analyzed, and it was found that the demand for skilled workers was urgent. The main reason for the imbalance between workers and jobs was the decrease of new skilled workers entering the construction industry due to the poor and dangerous working conditions at construction sites and the unstable nature of many positions. Thus, the percentage of aging workers in the industry continues to grow.

Consequently, increasing numbers of foreign workers are finding employment in construction. However, the resulting communication problems, lack of understanding of the domestic construction industry, and low skill level have increased the number of safety-related accidents and degraded construction quality. To address these problems, appropriate legal measures must be instituted, employers must change their perception, and the safety of construction sites should be improved. In addition, steps should be taken to simplify the process of connecting job seekers and potential employers.

In this study, a mobile network system was proposed for skilled construction workers that could provide information in real-time. However, the proposed system would only provide the information in the system to both parties when it identified a match between a job seekers and employer. In the future, additional studies will be used to create a database of skilled construction workers.

5. Conclusions

In comparison to other industries, the construction industry is directly affected by environmental factors, has a longer project duration, invests a larger amount of money, and depends heavily on a skilled labor force. As the competitiveness of construction firms is determined by the competence of workers, most construction firms adopt several approaches to recruit skilled workers. The South Korean construction industry has undergone a long period of decline and there are now difficulties in securing young skilled workers. Consequently, this has resulted in an increase in the number of older workers, an imbalance between the supply and demand of workers, and the adoption of new technology through-

out the industry. A primary cause of this imbalance is that, at present, information related to job openings is exchanged via human networks. Along with legal and systematic changes in the industry, a real-time information service for job seekers and employers is required in order to increase the number of young skilled workers entering the field.

This study proposed an M2M-based mobile network system, which has already been widely adopted in other industries, for skilled construction workers. To create new values and provide valuable information to customers, the M2M technology is being applied to develop various techniques such as smart grid, goods tracking service, transportation card payment system, and smart home services. As of 2013, the market size of M2M was as large as 48.5 billion US dollars. The sales of M2M cellular modules increase by over 28% every year and the unit price of the modules tends to increase by 12–14%. Many advanced countries have attempted to activate this market. The existing system used by skilled construction workers to find work is only focused on connecting job seekers and employers by providing necessary information.

A comparison between the existing and proposed systems is shown in Table 3.

Table 3: Comparison between the existing and proposed systems.

Existing System	Construction dream net	Construction skilled worker network system
Applicable system	Construction site	Construction site
Real time monitoring	Moderate	High
System accessibility	Moderate	High
System convenience	High	High
System utilization as an actual tool	Provides information for job seekers and employers	Real-time information is provided to both parties, and data management is also possible.

In a mobile network system for skilled construction workers, when a job seeker or employer enters relevant information, it is stored in the network server and could be provided to both sides in real time through the real-time matching function. The mobile network system for skilled construction workers consists of screens for inputting detailed information that either a job seeker or employer has in mind. Input information includes site information, user information, job hunter information, job employer information and career information. Such details are analyzed to match adequate workers with firms.

In that system, information was processed by staff members, there was no provision to provide new information, and the data analysis capabilities were lacking. Accordingly, the productivity of the system was low, and it was not cost effective. In contrast, the proposed system provided information in real-time based on data provided by job seekers and employers. In addition, new information could be provided easily. The advantages of the proposed mobile network system were discussed from four perspectives (job seeker, employer, system, and institutional). It is anticipated that the system developed in this study will be used to address the imbalance between the supply and demand of skilled construction workers.

Acknowledgement

This research was supported by Basic Science Research Program through Korea Institute of Construction Technology Education (KICTE)

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