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A Study to Apply Crowd Sourcing Technology in Intelligent Transportation System (Case Study: Jeju City, South Korea)

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ABSTRACT

The introduction of crowd sourcing techniques requires changes in the existing Intelligent Transportation System (ITS) which is based on in sourcing, providing traffic information generated by detectors through the Variable Message Signs (VMS). High cost and interrupted services are two common problems with ITS. Experts expect crowd sourcing techniques, which are created by Social Networking Service (SNS), will overcome problems of ITS. Crowd sourcing technique was utilized in the Jeju Advanced Traffic Management System (ATMS) project to install ITS on the coastal roads around Jeju city. Installation of the point detectors turned out to be a non-economic method on coastal roads with low traffic volume. However, there existed areas in which traffic information couldn't be generated due to the limited Smartphone users. Cost-effective crowd sourcing techniques indicate the fact that the crowd sourcing technique is more suitable for urban roads with many Smartphone users.

Keywords: *Smartphone, Application, Crowd sourcing, In sourcing, Intelligent Transportation System (ITS)*

1. INTRODUCTION

Smart phones have changed the way we live our lives. These phones are the primary way in which we can communicate. According to the statistics from a Communication Company, referred as 'A' Communication Company in this study, use of smart phones in Korea significantly increased from 800,000 on November, 2008 to 20,000,000 on September 2012. This figure equates to 80% of all Koreans (25,000,000) are active smart phone users [8].

In addition to its use as a cell phone, the primary advantage of a smart phone is as a digital personal assistant. This ranges from looking up information, sending/receiving emails, taking pictures, and writing up the reports.

The biggest advantage of the smart phone is being able to connect to Wi-Fi and 3/4G networks at any location. These advantages have changed the methods used to receive and provide traffic information. The current Intelligent Transportation System (ITS) tracks the existing vehicles passing through the detectors, collects the data, then transmits traffic information through both Variable Message Signs (VMS) and the internet [10].

This form of data collection is limited and cannot provide additional information that could be obtained from a smart phone such as travel speed, time and distances from smart phone applications: all from specific traffic points and areas. Another advantage of using smart phones to obtain traffic data is savings in space and cost, when compared to the installation of the fixed detectors and VMS.

A new methodology to obtain needed services, ideas, or contents is soliciting contributions from a large number of smart phone users, is defined as 'Crowd sourcing'. Crowd sourcing is a new procurement and project management strategy that enables the realization of values associated with an 'Open call' to an unlimited pool of resources, typically through web-based technologies [7]. Crowd sourcing is based on Social Networking Service (SNS), which enables smart phone to create and share information. With the implementation of crowd sourcing in other applications, the current ITS application for tracking traffic data is being reevaluated in the transportation arena. The existing detectors and VMS will not be required in the near future if crowd sourcing is activated as a source of traffic data and analysis.

In this research, the authors studied the following issues: crowd sourcing technique, various traffic applications on smart phones, and limitation comparison of ITS versus crowd sourcing. The authors addressed the crowd sourcing technique in the previous project in Jeju City, Korea and evaluated how to utilize the combination of the existing ITS and crowd sourcing techniques.

2. CROWD SOURCING AND ITS

2.1 Application of crowd sourcing to traffic information

Crowd sourcing is composed of two words 'Crowd' and 'Outsourcing' [5]. Crowd sourcing is the central application as a new management technique of the World Wide Web 2.0,which enables a broad range of applications from various social software mediated platforms for large scale conversation [6][11].The purpose of this new technique is to allow users to interact and

share data using social SNS. It is a highly cost effective method to share and analyze data without involving a team of professional consultants.

The major concept of crowd sourcing is sharing information with the public based on 'Openness' from large groups and people via the internet and SNS. Crowd sourcing and outsourcing are different concepts. Outsourcing is the contracting out of an internal business process to a third-party organization while crowd sourcing is the sharing of information and cooperate with large groups of non-specialists [4].

In traffic analysis, there are numerous applications using crowd sourcing techniques. Smart phone users provide and share traffic information with other users. This information includes road conditions, navigations, road closures, and travel durations using the specific smart phone applications. It provides real time information to other smart phone users via SNS instead of depending on local government agencies charged with providing this information.

The applications based on crowd sourcing techniques for traffic congestion are implemented with 'Location-Based-Service (LBS)' which is calculating traffic speed using Global Positioning System (GPS) in the Smartphone and SNS platform. This LBS is similar to popular applications such as Yelp or Foursquare which are used to find restaurants a based on the LBS and GPS. The SNS platform attracts voluntary participation from drivers and share traffic information. It also provides convenient service such as navigation. Crowd sourcing, like other popular applications, only works with voluntary participation. Typical traffic applications used in crowd sourcing are:

- **Google maps:** Google maps is utilized to acquire traffic information that provides traffic condition and forecasting.
- **Trapster:** Another example of a crowd sourcing traffic application is Trapster. This application shares information with users for speed cameras and police locations.
- **Hopstop:** Hopstop is another application which shares the public transport route and station information.
- **Taxi Magic:** This applications shares with users for call-taxi information.

These applications used crowd sourcing to easily and effectively provide the critical traffic information to users. The snap shot of the popular application is shown in Figure 1.

Fig 1: Snap Shot Examples of Trapster

2.2 Problems of the existing ITS

ITS was traditionally built using in sourcing' and 'outsourcing' of techniques. In sourcing is to provide comprehensive organization in the services and functions of businesses and organizations. However, outsourcing is the contracting out of an internal business process to a third-party organization. In the early stages of ITS by using in sourcing approach, it was built to focus on the government agencies and transportation research center within the limited time and budget. The internal information of the constructed system is also limited to provide the users only through a small number of media such as VMS or internet. Therefore, these restrictive information elicited a lot of questions about the effectiveness of ITS, data collection and provision. Point detection methods such as CCTV or VMS were not used on the road where the detectors were not installed. In other words, the point detectors were installed in traffic congestion areas but the spatial limits of information were exposed.

To solve information limitation issues, the government agencies contracted with the third parties to purchase traffic information and provided it to users. Recently, the city provides the section information instead of the position information using the Automatic Vehicle Identification or Dedicated Short Range Communication. However, there was still information limitation to collect traffic information and it was not enough to provide information to users. Information providing system is also limited service. VMS, which is typical information providing system used to detect the vehicles, which have only passed through VMS. The information limitation issues were overcome by using navigation service and digital multimedia broadcasting; however, this created another issue that the users were forced to purchase navigation to get information.

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The introduction of crowd sourcing technique is expected to alter the existing ITS. Crowd sourcing technique would change the way to collect and share information data. This technique could extend the acquisition range of using Smartphone applications and the phone user participation to get a broader range of traffic information. The issues are to re-define the function and role of ITS how to fit it into the crowd sourcing technique. To analyze this technique, crowd sourcing technique was applied in the Jeju Advanced Traffic Management System project.

3. APPLICATION OF CROWD SOURCING AND INTERSOURCING

3.1 Advanced Traffic Management System (ATMS) Project in Jeju City, South Korea

Jeju ATMS project was established the ITS in South Korea known as VMS and CCTV for one year from April, 2010 to April, 2011 [2]. ITS was installed in high populated and traffic congested areas due to significantly increased travelers and city expansion. Based on these reasons, the ATMS project promoted traffic management effectiveness. The schematic map of Jeju city ATMS project boundary is shown in Figure 2.

Fig 2: Jeju City and Jeju Beltway from Jeju ATMS Project

The annual average daily traffic in the roadways and local streets in Jeju City is approximately 7,000-10,000 vehicle/hour obtained from the traffic information management center in Jeju City. Due to less daily traffic volumes compared to other cities in Korea, it was not effective to install traffic detectors in the area [3]. Accuracy shall be accomplished with traffic volume of at least 500 vehicle/hour/lane during off-peak hour and over 1,000 vehicle/hour/lane during peak hour [9].

3.2 Application of Crowd sourcing for Jeju ATMS Project, South Korea

Traffic information based on crowd sourcing technique was provided by 'A' Communication company. This communication company created the traffic information application for the smart phones and provided the services to the phone users.

Traffic information for this study was provided by the communication company who was under contract with the City of Jeju. This study installed speed detectors in areas where they were not present for better traffic data acquisition. Figure 3 shows the data acquisition range between 'Before data acquisition and 'After data acquisition.

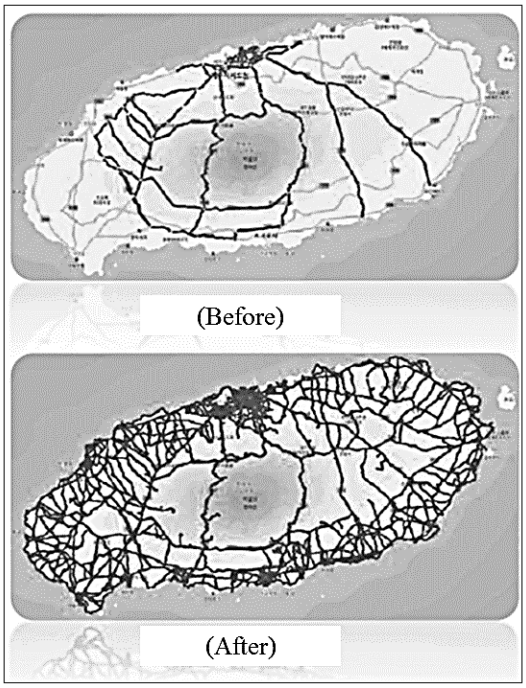

Fig 3: Data Acquisition Range between 'Before' and 'After'

3.3 Results and limitations of crowd sourcing

In order to get better quality of crowd sourcing data, more data is required which in turn requires more user participation. The research assumed that the vehicle speed data through the crowd sourcing would be more accurate than through speed detector.

To evaluate the accuracy of the data, the authors analyzed one month of collected data from 8:00 to 9:00. Table 1 and Figures 4 and 5 show the speed comparison between crowd sourcing and speed detector. The accuracy was calculated with the mean absolute percentage error. The urban area was limited from Chung-An Rd to Kwang-Yan Intersection and the rural area was limited from 516 Rd to Jeju University Intersection. As a results of this analysis, the accuracy of urban area was 96.9%; however, the rural area was 78.9% in Table 1.

Table 1: Speed Comparison between via Crowd sourcing technique and via Speed Detector

Limitation	Speed from Crowd sourcing (STDV)	Speed from Detector (STDV)	Accuracy[a]
Urban (Chung-An Rd[b])	38.6km/hr (3.076)	39.3 km/hr (3.229)	96.9%
Rural (516 Rd[c])	57.2 km/hr (10.147)	59.5 km/hr (4.111)	78.9%

a Accuracy (%)=100-MAPE (Mean Absolute Percentage Error)
b Chung-An Rd: A-Ra Apartment to Kwang-yang Intersection
c 516 Rd: Don-Naeko Park to Jeju University Intersection

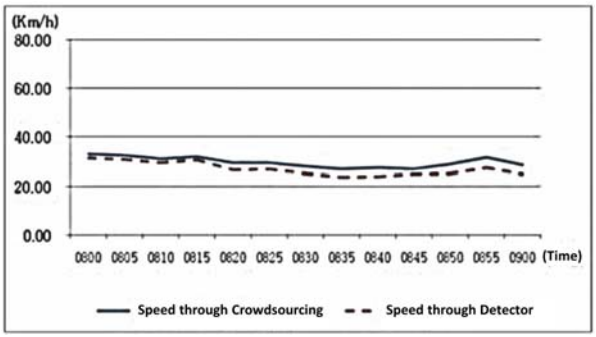

Fig 4: Speed Comparison in Urban

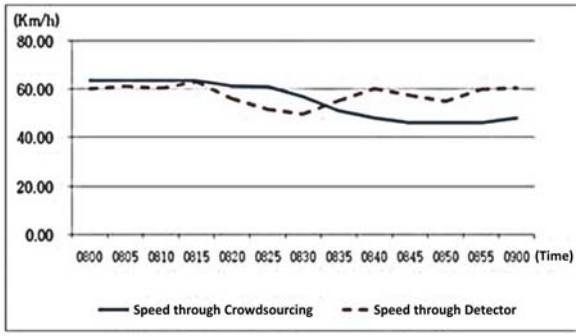

Fig 5: Speed Comparison in Rural

The results in rural area were not accurate in Table 1. Also, the speed in rural area had a greater standard deviation. The traffic information collection via crowd sourcing technique was limited to the number of phone users. The more traffic detected, the better traffic information resulted. In other words, the accuracy of the traffic data was up to the frequency of traffic information collection.

Crowd sourcing technique in rural areas is not cost effective due to the limited traffic volumes. Table 2 shows that the frequency of data collection through Bus Information System (BIS) and the given data from the communication company. The frequency in the urban area for the peak hour is absolutely higher.

Table 2: Frequency of data collection through Bus Information System and given data from the communication company

Time	Urban		Rural	
	BIS	'A' Comm.	BIS	'A' Comm.
0800-08:05	15	25	5	0
08:05-0810	16	18	5	4
08:10-08:15	17	32	4	3
08:15-08:20	15	15	3	4
…	…	…	…	…
08:40-08:45	15	7	6	1
08:45-08:50	16	20	4	8
08:50-08:55	16	23	4	2
08:55-09:00	15	35	5	0
5 mins Avg/STDV	15.2/ 1.2	28.4/ 10.7	5.2/ 1.7	2.4/ 5.2
1 hour Avg/STDV	178.3/1.8	310.2/ 12.8	60.8/ 1.9	39.2/ 11.2

The traffic information through crowd sourcing technique wasn't useful in rural areas where the critical number of users are existing in lieu of urban areas. However, if there was a way to have the number of users in rural areas, this crowd sourcing technique would be cost effective and provide the higher quality of traffic information to users.

3.4 The use of Bus Information System (BIS) and the Crowd sourcing Supplement

To overcome the problem of the variation in the number of acquisition, BIS information was utilized by applying the crowd sourcing technique.

Accuracy of traffic information data for this project was jeopardized due to the longer interval time between stations and traffic congestions in the project site.

For this research, the traffic speed through crowd sourcing technique and the generalized bus speed were used to calculate the fusion speed using Equation 1. Then the fusion speed was processed with the different weights

to compare with the speed throughout the ITS detector. Figure 6 shows the fusion data process for this project.

$$\text{Fusion Speed} = \sum_{i=1}^{n} (Vi \times wi) / \sum_{i=1}^{n} wi \qquad (1)$$

Vi Speed in Collected Data i
wi Weight in Collected Data i

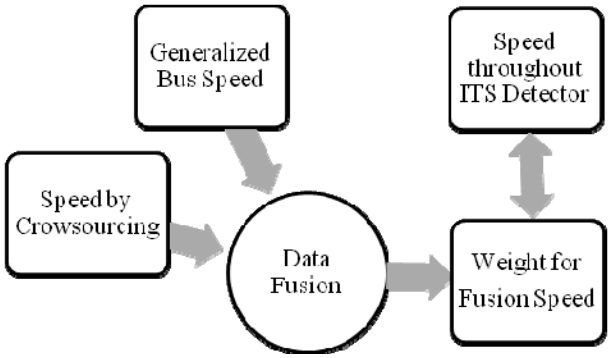

Fig 6: Fusion Process to Estimate

To measure the traffic speed, the project sites were divided into 3 sections from 8:00 to 9:00 on January 9-13, 2012 and the results were compared between fusion speed and detected speed in Table 3.

The accuracies in the sections were 96.2%, 94.7% and 96.1% which are close to the actual speed. In rural area, there was not enough traffic volumes to get good quality of traffic speed data. The limited information could be used. Thus, the fusion speed, which is mixed with detected speed information and BIS information, was effective to provide the traffic data to users. Through this study, the results found that two different data collection techniques had shortcomings but could complement each other to collect better and more traffic information data. This complement was defined as Intersourcing in this research.

Table 3: Fusion Speed and ITS Detector in Rural area

Project Limits	Fusion Speed (STDEV)	Detected Speed (STDEV)	Accuracy
Kyorae-Sungpan	59.4 km/hr (1.256)	58.4 km/hr (3.141)	96.2%
Sungpan-Ipsuk	62.4 km/hr (2.382)	66.1 km/hr (5.958)	94.7%
Ipsuk-Doneko Park	61.9 km/hr (4.112)	66.1 km/hr (5.958)	96.1%

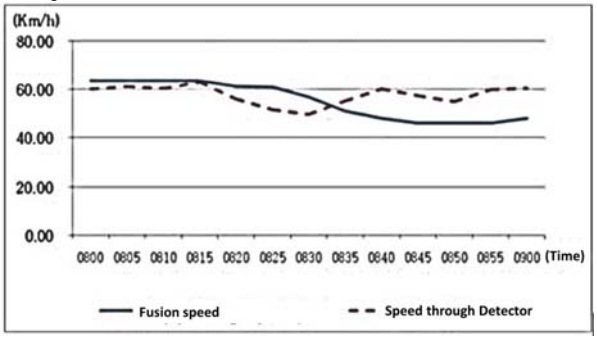

Fig 7: Comparison between Fusion Speed and ITS Speed Detector in Rural Area

4. CONCLUSION

ITS technique should change the way we build and maintain the data through crowd sourcing. Crowd sourcing issues are mostly concentrated around problems with data quality, accuracy and data aggregation [1]. Crowd sourcing is currently utilizing a way to collect various traffic information, so that it can provide effectively to users. Before crowd sourcing, the detector used to gather information using in sourcing or it purchased information from the private companies, which were outsourcing to improve information quality. However, it is difficult to detect all the cars on all the roads and provide accurate information to users

In order to develop crowd sourcing, studies should focus on how to complement the existing ITS systems. Its role is to separate the specific delimiter according to the traffic volume due to more users in high traffic volume. Crowd sourcing is suited for the heavy downtown traffic but should not be used for the light rural area traffic. ITS by itself is not cost effective in heavy traffic areas. Although ITS is more effective in light rural areas, there is a necessity to have ITS provide public information service to the traveling public.

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