# Design of LBSs Using DGPS and Digital Mobile Broadcasting System

Seong-Geun Kwon* *Regular Member*

ABSTRACT

In this paper, new LBS (location based service) are proposed using conventional DMB (digital multimedia/mobile broadcasting) system. LBS applications are proposed that can be suitable for the subway and ground transportation based on S-DMB (satellite-DMB) and T-DMB (terrestrial-DMB) respectively. In the shaded area such as subway, the broadcasting signal transmitted from the satellite of S-DMB system should be retransmitted by the earth repeater called the gap filler and each gap filler has its own identification value called the gap filler ID which introduces the area in which the gap filler was installed. Therefore, the LBS can be implemented by using the gap filler ID of S-DMB on the subway in which the GPS (global positioning system) can't be received. Unlike the LBS on the subway, the combination of T-DMB and DGPS (differential GPS) will be introduced as a way for ground transportation. Generally, DGPS has been designed to compensate the position value calculated from the GPS signal so that positioning error of about 1 meter can be obtained by using DGPS information. T-DMB system transmitting DGPS signal will be expected to be commercial in Korea and, if using DGPS information transmitted through T-DMB network, LBS with more precise positioning than GPS alone can be implemented in the ground vehicles.

**Key Words :** LBS; DGPS; T-DMB; S-DMB; Gap filler

## Ⅰ. Introduction

Mobile Broadcasting began to be taken an interest around the world about 10 years ago and DMB as the world's first mobile broadcasting system was commercially launched in Korea. DMB can serve AV services with CD and VCD-quality during fast movement and can be classified into S-DMB and T-DMB according to the transmission scheme.

The broadcasting signal of S-DMB is emitted from the ground station to the broadcasting satellite and retransmitted to the earth through the S-band (24 GHz) and Ku-band (12-14 GHz) [1,2]. In most open spaces, S-DMB signals can be received directly from the broadcasting satellite but must be received by the repeater called gap filler in the shaded area such as indoor areas, underground spaces, and high-rise buildings [3,4]. In Korea, S-DMB services can be watched anywhere even in the subway because gap fillers have already been installed at all of the metropolitan subway. T-DMB is a terrestrial mobile broadcasting system in VHF band based on European DAB (digital audio broadcasting) standard [5,6]. DGPS signal is some sort of compensation information to improve the accuracy of the position value calculated from the GPS signal and it was confirmed by the project of MLTM (Ministry of Land, Transport and Maritime Affairs) of Korea that DGPS signal transported through T-DMB network in real time can be applied in the field of more precise positioning than conventional GPS [7].

Generally, LBS is supported only in the region that the signal of GPS satellite can be reached so that it is impossible to carry out the LBS-based applications in the shaded area such as subway. Also because position error by GPS is generally about 50 meter, accurate LBS can't be implemented through only the GPS system. Therefore, in this paper, new system architecture of LBS and positioning is proposed based on the gap filler of S-DMB and DGPS transmitted from T-DMB, respectively. In the retransmission case by the gap filler of S-DMB, gap filler ID is generally added into the pilot channel of the S-DMB transmission frames so that the position of the handset could be estimated by analyzing the gap filler ID in the received signal at the handset. Thus LBSs in the subway are proposed in this paper by utilizing the gap filler ID in

*경일대학교 전자공학과 (sgkwon@kiu.ac.kr)
접수일자 : 2013년 5월 2일, 수정완료일자 : 2013년 6월 14일, 최종게재확정일자 : 2013년 6월 20일

the S-DMB handset without a separate GPS module.

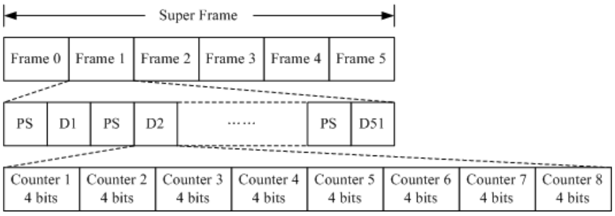



Figure 1. Structure of frame and superframe of S-DMB.

DGPS being operated by the MLTM of Korea has been designed for the safety of the ship sailing the coastal waters and its signal is transmitted by the radio beacon in the form of RTCM (Radio Technical Commission for Maritime Service) SC (Special Committee)-104 in the frequency band of 280-319kHz. DGPS services are working 24-hour from a base station and its signal can be measured within the radius of 100-180km with positional accuracy of about 1m. Despite these advantages of DGPS service, its application areas are limited due to the expensive dedicated DGPS handset and the special transmission medium. So MLTM has built the DGPS system through T-DMB to widespread DGPS because T-DMB is a popular mobile broadcasting media with more than 40 million handsets in commercial. As a second offer in this paper, a positioning architecture is proposed using DGPS signal transmitted through T-DMB network to obtain more precise accuracy in the ground vehicle.

To implement the LBS service using S-DMB and T-DMB system based on the proposed algorithm, the experiments are conducted by modifying the firmware of the DMB chip and UI (user interface) of the handset in the commercial DMB handset. From the simulation results, it was confirmed that efficient LBS and more precise positioning could be implemented by utilizing an S-DMB and T-DMB module respectively.

This paper is organized as follows. Section II presents the overview of mobile broadcasting system such as S-DMB and T-DMB. Section III describes the proposed LBS model and precise positioning for ground and underground vehicles. Finally, the experimental results and conclusions are in Section IV and Section V, respectively.

# Ⅱ. S-DMB and T-DMB System

The proposed architecture of LBS and positioning is based on the S-DMB and T-DMB transmission system, respectively. In this chapter, the features of S-DMB and T-DMB which have been utilized in the proposed system are introduced as follows.

## 1. S-DMB

The role of pilot channel in S-DMB is to transmit the unique word distinguishing S-DMB transmission signal, configuration information of CDM channel, and receiver starting information. Pilot signal is transmitted in the CDM (Code Division Multiplexing) channel spread by Walsh code W0. The structure of pilot signal in the frame and superframe is shown in Fig. 1 [3,4]. One period of pilot signal is called a frame and a superframe is composed of 6 frames. PS and D is pilot symbol and data respectively, with each of the 4-byte length. D3(23)-D22(26), D27(47)-D46(50), and D51 represent the pilot information, RS (Reed-Solomon) code, and additional information.

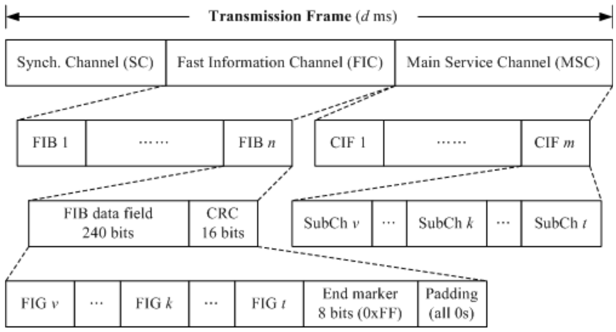



Figure 2. Transmission frame of T-DMB.

D51 in the pilot signal can be used as an extension area to carry the additional information, for example, the transmission path of the received signal can be included in D51. Typically, D51 is filled with dummy values if S-DMB signal is received directly from the satellite but the gap filler ID with 2 byte length is usually included in D51 in the case of indirect receiving by the gap filler.

## 2. T-DMB

The transmission frame of T-DMB signal is composed of SC (synchronization channel), FIC (fast information channel), and MSC (main service channel) and transmitted repeatedly with d ms period as shown in Fig. 2. SC and MSC has the role of acquiring transmission signal in the T-DMB handset and transferring broadcast content such as audio, video, and data. FIC is originally designed for fast delivery of T-DMB data and composed of MCI (multiplex configuration information), SI (service information), and FIDC (fast information data channel) where MCI represents the configuration information of broadcasting channels and FIDC is a way of rapid transmission of data service. There are data transmission protocols in T-DMB system adequate for transmitting DGPS signal such as TPEG (Transport Protocol Expert Group), FIC, MOT (multimedia object transfer), and TDC (transparent data channel) [5,6].

# Ⅲ. The Proposed LBS Model

In this paper, new system architecture of LBS and precise positioning for ground and underground transportation are proposed based on the gap filler of S-DMB and DGPS transmitted through T-DMB, respectively. In particular LBS are possible to be implemented by the gap filler of S-DMB without a separate GPS module. Each LBS system and positioning according to the type of transportation will be examined.

## 1. LBS for a subway based on S-DMB

The implementation of LBS for underground vehicle such as subway that can't take advantage of the GPS is proposed based on the gap-filler ID of S-DMB. The gap fillers are installed at all subway stations of the metropolitan area in Korea so that S-DMB services are available at all subway lines. Thus in the case of an S-DMB signal received through the gap-filler, the location of a handset can be obtained easily only if possible to distinguish which the gap filler is delivering the S-DMB signal to the handset. Therefore, if the information about the point in which the gap filler is installed and the gap filler ID are recorded as database (DB) in the specific memory of S-DMB handset, the location of the handset can be identified by analyzing the DB [8-10]. In this paper, implementation of the LBS application for subway without a separate GPS module is proposed through the gap filler related DB. The method of location registration [8], destination arrival notification [9], and local information notification [10] are proposed as applicable in the subway.

### 1.1 Location Registration

The gap filler ID is the unique value assigned to the specific gap filler and the installed regions, and if needed to register the name of the region and nearby attractions, they can be added into the gap filler related DB of S-DMB handset [8]. For example, if the user is around the SamSeong Station of Subway Line 2 and wants to register Coex as a nearby attraction, the name and nearby information can be registered into the gap filler related DB based on gap filler ID as shown in Table 1.

Table 1. Structure of gap filler related DB including local information.

| Gap filler ID | 0x0100 | 0x0101 | 0x0102 | 0x0103 |
|---|---|---|---|---|
| Station Name | GangNam | YeokSam | SeolLeung | SamSeong |
| Local Name | SEC | Finance Center | Posco Center | Coex |

### 1.2 Destination Arrival Notification

If passenger of public transport watching S-DMB contents can enter the destination to get off into the handset, the remaining distance and time to the destination can be calculated in the handset by counting the number of gap fillers between the current position and the destination based on the gap filler related DB registered in the previous section. In this paper, destination arrival notification using gap filler related DB is presented [9]. For example, if the current and destination Subway Stations are SamSeong and SaDang, respectively, the remaining time can be calculated by the number of gap fillers by referring to the gap filler related DB stored in the handset as shown in Table 2. Thus, destination information such as distance, number of stations, and remaining time can be provided to the handset users by the proposed method. By doing this, the remaining arrival time can be calculated by using the internal software timer of the handset.

Table 2. Database of destination arrival notification.

| Current Position | | Destination | | Gap filler | Remaining time to destination |
|---|---|---|---|---|---|
| Name | Gap filler ID | Name | Gap filler ID | | |
| SaDang | 0x00FC | SamSeong | 0x0103 | 7 | 20 min |

### 1.3 Local Information Notification

We explained the method of registering the local attractive information with the gap filler ID into the related DB in the previous section. If you get to the region that you've previously registered, the relevant information registered in the DB will be useful. Thus in this paper, using the gap filler related DB, the notification method of local information such as violation enforcement cameras and tourist attractions which users have registered is proposed [10]. If the terminal user enters the name of the local area being managed by the gap filler related DB, it is possible to implement the handset device to indicate local information which is already registered to the users. What we have introduced as LBS for subway can be represented as flow diagrams in Fig. 3.

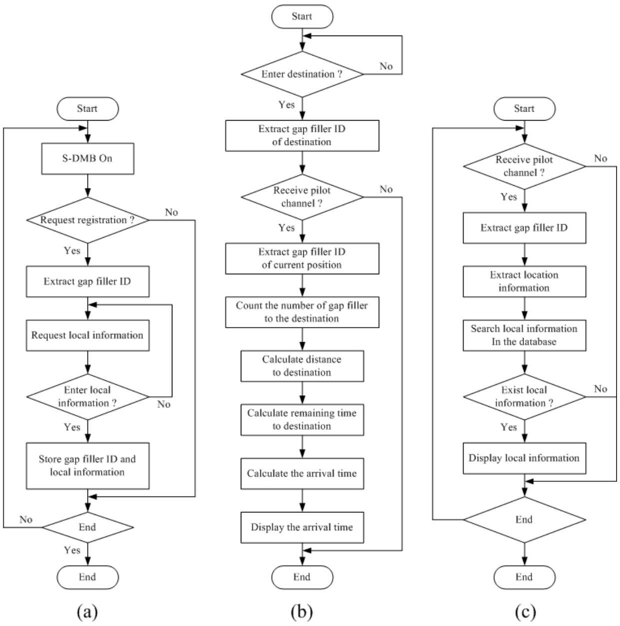



Figure 3. The flow diagram of the proposed (a) location registration, (b) destination arrival notification, and (c) information notification.

## 2. LBS for ground vehicles based on T-DMB

In this paper, in order to implement the LBS with a higher accuracy for ground vehicles that can receive GPS signals, DGPS transmitted through T-DMB is utilized. DGPS transmission through the conventional NTRIP (networked transport of RTCM via internet protocol) has some limit that available only to certain users to access internet service and a drawback of the relatively low positioning precision [7]. In order to improve the positioning accuracy of conventional NTRIP method, the DGPS information obtained from the reference stations will be reprocessed by using virtual stations in T-DMB transmission system. The position of a virtual station could be calculated by interpolating that of adjacent reference stations so that many points of true location will be provided in the T-DMB transmission more than the conventional NTRIP method using only several reference stations. Therefore, the positioning accuracy based on T-DMB could be greatly enhanced more than the conventional NTRIP method.

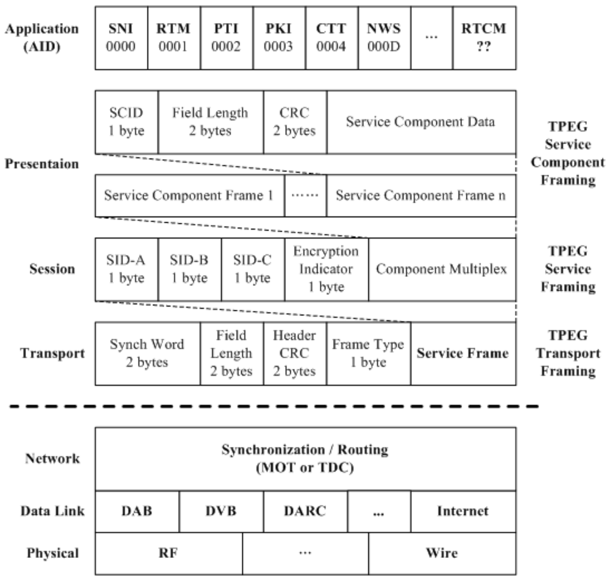



Figure 4. The syntax of TPEG protocol to deliver DGPS.

T-DMB network has been built nationwide infrastructure and more than 42 million T-DMB handsets has been distributed in Korea, especially GPS module is usually mounted on the TDMB handset of smartphone type. So there is no extra cost to build the transmission system of DGPS information and GPS module in the T-DMB handset. The candidate of T-DMB protocol to transmit the DGPS information can be FIDC and TPEC, where TPEG is based on the MOT or TDC. The syntax of the T-DMB protocol is as follows. TPEG has been designed to transfer the traffic information such as RTM (road traffic message), PTI (public transport information), PKI (parking information), and CTT (congestion and travel time information) and can be used to deliver RTCM type of DGPS information by only defining the AID (application ID) about RTCM in the application layer as shown Fig. 4. FIDC is used for fast transmitting T-DMB data service so that it is adequate to deliver the DGPS information only if defining data type of RTCM as was done in the case of TPEG. So broadcasters must select TPEG or FIDC protocol to deliver DGPS data according to the circumstances of each broadcaster and if TPEG has been selected, MOT or TDC should be chosen additionally as the DAB protocol to transport TPEG stream. Therefore, the LBSs and precise positioning could be implemented by the proposed methods for the underground vehicles such subway and the ground vehicles by utilizing the gap filler ID of S-DMB and DGPS of T-DMB, respectively.

## Ⅳ. Experimental Results

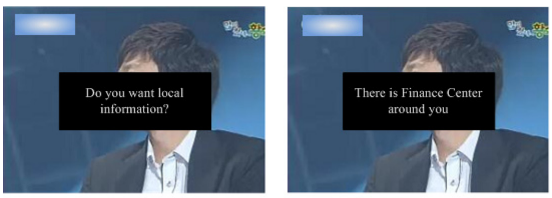
In this paper, new system architecture of LBS and precise positioning for underground and ground vehicle are proposed based on the gap filler of S-DMB and DGPS transmitted from T-DMB respectively. This chapter describes how the proposed LBS show the verification results. LBS scenarios for subway such as location registration, destination arrival notification, and local information have been verified using gap filler ID of S-DMB without a separate GPS module. For ground transportation, the validation for positioning precision using DGPS information transmitted through T-DMB network was conducted in comparison with the conventional GPS and NTRIP.


(a) (b)

Figure 5. The implementation of the proposed location registration.


(a) (b)

Figure 6. The implementation of the proposed destination arrival notification.




(a) (b)

Figure 7. The implementation of the proposed local information notification.

### 1. LBS for a subway based on S-DMB

In general, gap filler ID is not transferred to the AP (application processor) in the commercial S-DMB receiver module. So, in this experiment, the software in the S-DMB receiver module was modified to transfer gap filler ID to the AP and the related software in the AP was modified to create and manage the gap filler related DB. Comparisons with existing GPS systems and Cell types are considered to be meaningless because of their poor performance in underground and wide cell spacing of the cell type system, respectively.

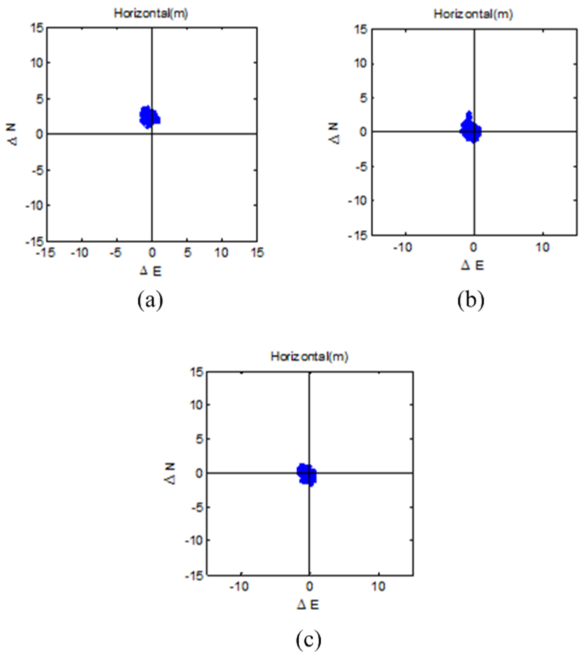



Figure 8. The positioning error of (a) GPS alone, (b) DGPS through NTRIP, and (c) DGPS through T-DMB network.

Software codes to create the gap filler related DB are designed in the following manner. First, gap filler ID and metro station names are written in the form of a linked list. That is, the gap filler ID and address pointer storing metro station names are set as the first data of each node and first link in the linked list, respectively, and the number of links in each node is increased whenever local information around the metro station is registered in the handset. The size of the DB for the Metropolitan Subway used in this experiment is about several kilo-bytes and, even when considering a National Subway system of Korea, memory with only hundreds of kilo-bytes is sufficient. Generally, memory with several mega-bytes in the handset is usually provided to the user area so that a separate memory and server system is not needed to implement the proposed algorithm. This experiment was conducted at the Seoul Subway Line 2, and experimental results for the location registration, destination arrival notification, and local information notification are shown in Fig. 5, Fig. 6, and Fig. 7. The software for each of the proposed LBS scenarios has been implemented by configuring each UI (user interface) if a DMB key is pressed while watching S-DMB broadcasting. When the DMB key is pressed, location registration is organized by asking the user about whether to register local information as shown in Fig. 5. Remaining arrival time is shown in Fig. 6 (b) when the destination information was entered as shown in Fig. 6 (a). If local information registered exists in the gap filler related DB, notifying the user of the local information is shown in Fig. 7.

### 2. LBS for ground vehicles based on T-DMB

The verification of positioning accuracy using DGPS information transmitted through T-DMB was conducted in the field test comparison to the conventional GPS alone and DGPS through NTRIP. The positioning error between true value and positioning value using each positioning method was represented in Fig. 8. From the results shown in the Fig. 8, though the positioning error of GPS alone and DGPS through NTRIP is about 2.7m and 0.9m respectively, that of DGPS through TDMB is about 0.75m. Therefore if the DGPS information received through T-DMB network in real time will be used to estimate the position, the postion can be measure d more accurate than the conventional GPS alone and DGPS through NTRIP. So positioning using DGPS through T-DMB can be utilized in the LBS application fields that require high-precision positioning. We confirmed from these experiment that LBS scenarios such as location registration, destination arrival notification, and local information notification are adequate for subway only using gap filler ID of S-DMB system without a separate GPS module and high-precision positioning could be possible to be applied in the LBS application fields if using DGPS information transported through T-DMB real time.

## Ⅴ. Conclusions

The implementation of LBS only using existing mobile broadcasting system without having to add separate hardware components were proposed in this paper LBS scenarios such as location registration, destination arrival notification, and local information notification are proposed for the underground transportation such as subway by using gap filler ID of S-DMB system without GPS module. Gap filler ID which is a unique value identifying installation area will be added to the pilot data of an S-DMB signal transmitted by the gap filler. Therefore it was confirmed that using gap filler ID various LBSs could be implemented in the S-DMB terminal without a separate GPS receiver module. High-precision positioning for the ground vehicle was introduced by utilizing DGPS information transported through T-DMB real-time. The DGPS information obtained from the reference stations could be reprocessed to extract the location of virtual positions called virtual station for more accuracy in T-DMB transmission system. The position of a virtual station could be calculated by interpolating that of adjacent reference stations so that many positions with virtual station will be provided in the T-DMB transmission more than the conventional NTRIP method. Therefore, the positioning accuracy based on TDMB could be greatly enhanced more than conventional NTRIP method.

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## 저자

**권 성 근**(Seong Geun Kwon)

・1996년 2월 : 경북대학교 전자공학과(공학사)
・1998년 2월 : 경북대학교 대학원 전자공학과(공학석사)
・2002년 8월 : 경북대학교 대학원 전자공학과(공학박사)
・2002년 11월~2011년 2월 : 삼성전자 책임연구원
・2011년 3월~현재 : 경일대학교 전자공학과 조교수
<관심분야> : 멀티미디어, 모바일 방송, 워터마킹