

# Real Time Traffic Information Service Using Terrestrial Digital Multimedia Broadcasting System

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**Abstract**—The major contribution of this paper is the implementation of real time traffic and traveler information service through the terrestrial digital multimedia broadcasting (T-DMB) system, which are known to be suitable for the mobile data services as well as audio and video services. The implemented system converts the Korean characteristic traffic information into the transport protocol expert group (TPEG) messages, and provides them to the T-DMB system. By testing the service with the TPEG message decoder implemented in the navigation system on PDA and laptop, it has turned out that it can be used as a highly efficient traffic information service system that could be adopted in Korea as well as in European countries.

**Index Terms**—DAB, T-DMB, TPEG, TTI.

## I. INTRODUCTION

**T**RAFFIC and Travel Information (TTI) service has been more and more important as people spend more time in their car or in public transportations. Therefore, the architecture for TTI service has been upgraded for many years following the development of each new excellent communication and broadcasting system appears [5]–[11].

TTI service dissemination with communication system provides flexible data management capability for each of the users by giving users the information which is more specific to them. But when the same or similar traffic information is delivered to many people, it may cost rather high with frequent use of wireless communication channels [5]–[8]. The broadcasting system based TTI service architecture seems relatively effective to this kind of one-to-many data delivery jobs. However, the data needs to have more generality because it is being delivered to all the users in the service area [9]–[11]. Another cost-effective way to implement the TTI service is using hybrid networks of communication and broadcasting. More efficient TTI data service is possible by balancing push and pull schemes [21], [22].

Recently, Eureka-147 Digital Audio Broadcasting (DAB) standard made a significant step ahead by choosing T-DMB system as one of its multimedia broadcasting functionalities. T-DMB, which is being commercialized in Korea, is a multimedia empowered option of DAB beginning the year 2005 [1]–[4]. Sooner or later, TPEG application service, a well

known TTI service protocol for DVB, DAB and internet, will also begin in Korean T-DMB network.

TPEG is a bearer and language independent TTI service protocol that can be used for many data broadcasting channels or services such as DAB, Data Radio Channel (DARC), Digital Video Broadcasting (DVB), Internet and others [12]–[18].

This paper analyses the result of the trial implementation of TPEG based traffic information service system in Korean T-DMB network. The development includes the TPEG encoder to encode the real time traffic information into the TPEG message sets, the adaptation module for the connection with the governmental traffic information gathering and providing organization of Korea, the stream server to provide the encoded TPEG messages to the T-DMB ensemble multiplexer while being rate-controlled by user specified service data rate. Finally, the software based TPEG decoder on a Windows based PDA and laptop computer which are connected to the T-DMB receiver so that the decoded traffic information data could be used in the navigation tool installed in the PDA and laptop computers. All the computers for receiver test have Geographical Positioning System (GPS) modules for the exact location reference and navigation of the users.

The test was done in the area of Daejeon, which is one of the major cities in Korea, while transmitting the traffic and traveler information through T-DMB test transmitter. The test result shows that the system can be easily used for an efficient traffic information service in Korean mobile multimedia broadcasting environment while satisfying the European TPEG specification. Furthermore, the implemented system itself can be used as a test bed for developing a new TTI services as well as new TPEG applications. The efficient management of the messages in whole process was very important in the real operation of the service and our implementation and test operation experience revealed some technical ideas to give some efficiency to these kinds of services and systems.

The service architecture in this paper and the method to gather the source TTI data are described firstly in Section II. The current applications in TPEG standard are explained in Section III. The specific implementation structure of each module in Korean T-DMB system is described in Sections IV and V. The test and analysis is in Section VI being followed by the conclusion in Section VII.

## II. TPEG AND TPEG APPLICATIONS [12]–[17]

TPEG is a bearer and language independent TTI service protocol which has unidirectional and byte oriented asynchronous framing structure. TPEG frames are transmitted through the Transparent Data Channel (TDC) of DAB/T-DMB signal. TPEG currently has two popular applications. One is for the information of road traffic status message (RTM; Road Traffic

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Message) application and the other is for the Public Transport Information (PTI) message application.

TPEG-RTM application describes the traffic events in the road networks. In order to get this traffic information, we implemented an adaptation module, which maintains the connection with one of the governmental traffic information gathering and providing organizations and saves the information to XML database.

Since there are many different structural and environmental situations between the traffic information in Korea and other countries as well as the countries in Europe, there may be some different understanding of several parameters and also, there may be some different way of using the values of the parameters in the TPEG message set. In this system, we tried to transmit link speed information, which is very popular and so is necessary in Korean navigation systems, through TPEG-RTM to show the specific traffic conditions of the specific links to users. In order to provide the real time link speed information source to the TPEG encoder, we connected the system to one of the governmental traffic information gathering and providing organization of Korea. For the linkage with the road links in the digital maps, we used the description field of the message.

For the transmission of PTI application service, there needed to be a database containing public transportation schedules, which can be combined with real time transportation information later in the service provider. Although it does not cover all the public transportation databases, we gathered some of the time tables of the public transportation networks around Daejeon area and implemented a public transportation information database in the PTI message author.

The basic forms of SNI (Service and Network Information) information structure are implemented for the test stream. For the locations of each RTM and PTI event, TPEG-Loc (TPEG Location Referencing) is used with WGS84 specification. This location information is very useful to show the specific location of the accident or event in the digital map in the navigation system side.

### III. SERVICE ARCHITECTURE AND PREPARATION OF THE DATA

The efficiency of the traffic information mostly depends on its timely display or alert at the user terminal. The information comes late to the user only occupies the valuable transmission capacity of the network. Therefore, the usability of the information becomes high when it comes beforehand enough the user comes near to the point or use the information.

Fig. 1 shows the concept of T-DMB based TTI service architecture used in this paper. The TTI server plays a major role in the processing and encoding of incoming traffic information data and providing the real time TPEG message to the T-DMB transmission system as well as the management of the TTI database.

The information used in this implementation comes from one of the governmental traffic information providers under police department and FM traffic information broadcasters. They gather accident and event information in most of the major highways and in the roads of the several big cities in Korea. In Korea, including several Asian countries, the most important information to describe the traffic status of a certain

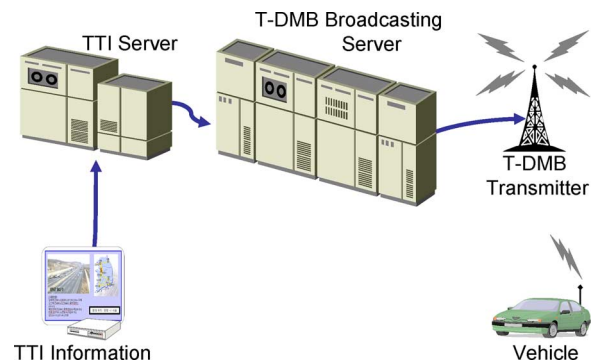


Fig. 1. T-DMB based TTI Service Architecture. TTI Server plays a major role in this architecture. It mediates the data between the information server and the T-DMB broadcasting server.

road is to give people the average vehicle speed information in that road at that time so that the users who receive these information can avoid the roads with heavy traffic. Therefore, they make every effort to gather those kinds of information by setting up many kinds of sensors and cameras on the roads. They are gathering the speed and location information from the probe cars which report their speed periodically to the center or utilizing the information from the voluntary reporters who are in the place and giving some urgent information about the place to the nearest police department. They give an ID to each of the roads called links, which are the roads between nodes (crossroads).

Although accuracy and timing issues should be considered in other researches, governmental traffic information provider processes all of these data and gives the traffic information every five minutes from their TCP/IP output port. We used these data for real time transmission of traffic information by filtering out unnecessary information, converting them into TPEG messages and providing them into the T-DMB transmission channel.

Traveler information including location based information relatively does not needs timing requirement as tight as traffic information. Therefore, we implemented the management module for this information in the authoring server of the system. Time tables of the public transportation for Public Transport Information (PTI) application service of TPEG are managed like that.

### IV. TTI DATA SERVER FOR T-DMB SYSTEM

A more detailed internal processing structure of TTI server in the Fig. 1 is shown in Fig. 2. Adapter manages TCP/IP connection with the traffic information provider, filtering out the unnecessary frames from the incoming data and stores them in the database. The authoring server has TPEG encoder which converts the TTI data read from the database into binary TPEG messages. The authoring server also has general management user interface which can handle database and overall functionality of the TTI data server. The stream server on the right side works as connection with T-DMB data server or ensemble multiplexer. It reads the binary TPEG data file and provide the data stream to the T-DMB system with user specified data rate. Detailed functions of each module are described in each section of the followings

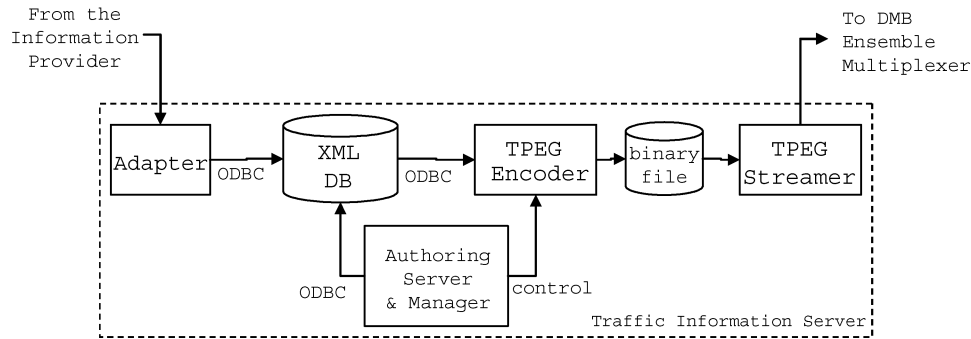


Fig. 2. The TTI Server Architecture for T-DMB. Inside the TTI server, adapter, authoring server, TPEG encoder and streamer provides the data to the T-DMB ensemble multiplexer by manipulating the database.

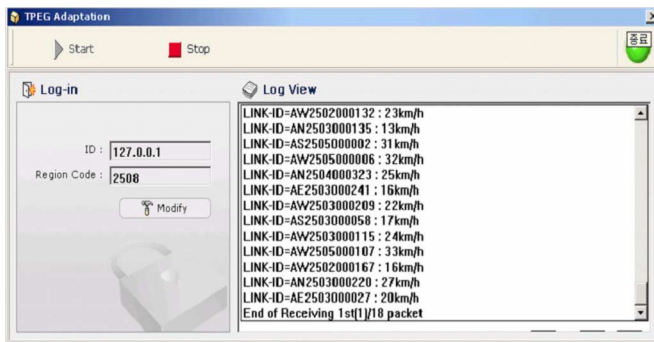


Fig. 3. The user interface of the adapter in TTI Server. It shows the status of the network address of the data server and the specific region code which can be modified by the user and log view window shows the average vehicle speed of the specific link ID.

### A. Adapter

For the connection with traffic information provider and TTI server and efficient management of the connection, there needs to be a stable module to do that kind of works which are independent to the status of the other modules.

Fig. 3 shows the user interface of the adapter module. The adapter module also has the functions which monitors the incoming data from the traffic information server and filters out when it detects unnecessary data for TPEG message application and stores the data into the database. The structure of the database is very similar to the TPEG message structure. It has many tables which are related to RTM, PTI, SNI (Service and Network Information) and LOC message and named according to the name of the components. For example, the average vehicle speed information is managed and stored in the forms of “network performance” table, the name of which is the same as the name of the component description.

User can set the IP address of the data server and the specific region code, which are assigned to each of the information providers and adaptation modules. The log view window shows the status and the data being received by the data server. At the time of the first connection, the user should pass the authentication process by putting in the specific region code and password.

### B. TPEG Authoring Server

As described in the Fig. 2, the TPEG authoring server and manager works as a user interface to control and monitor all

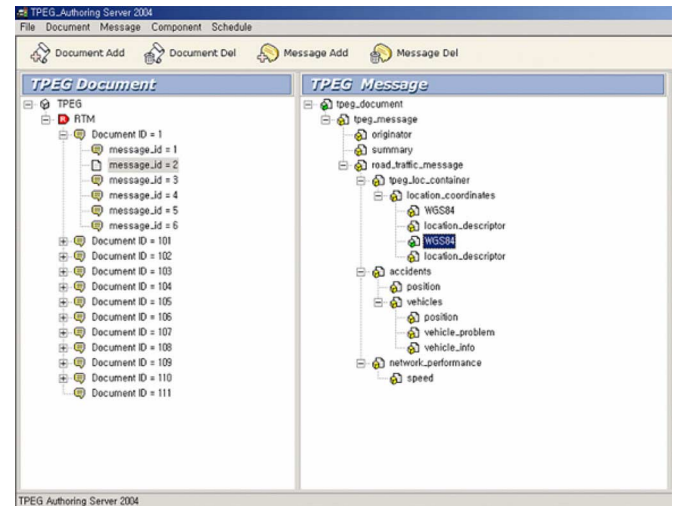


Fig. 4. The tree structured TPEG authoring server. Each of the message are managed by the basic structure called “document”. In this case for the TPEG RTM message, each document has several messages (left window) and each of the components are shown in the right window.

the functionality of the system. It enables the user to access the database and modify, delete and sometimes, manually add new urgent messages. Fig. 4 shows the user interface of the TPEG authoring server, in which all the TPEG messages are handled with tree structures. The TPEG authoring server has TPEG encoder inside the module. The encoder reads the traffic information data from the database and encodes them into the TPEG binary message container according to the specification and stores the messages as a binary file. The reason why we use the binary file is to let the binary file to work as a temporary data file which can be used as a kind of buffer when the streamer controls the data rate to provide the data stream into the T-DMB transmission system.

The authoring server can be combined with the author for traveler information such as location based databases, including time tables of public transportations for the TPEG-PTI application service.

For the internet service or data exchange of TTI data with other data service providers, the authoring server can manage and provide the data with TPEG ML codes. This is very useful when the server wants to provide the data to the other service area or it wants to get the TTI data from the other information server.



Fig. 5. Stream server user interface. It includes the start and stop button for the beginning of the streaming with the specified stream rate and configuration button for the connection with the ensemble multiplex or data server. It also has several connection status monitoring displays.

### C. TTI Stream Server for T-DMB System

Fig. 5 shows the user interface of the stream server. As in the Fig. 2, the stream server works as the mediator between TTI data encoding module and T-DMB transmission system. It reads the binary file which is stored by the TPEG encoder and provides the data to the data server or ensemble multiplexer of the T-DMB transmission system. As the user interface says, the service data rate can be controlled in the streamer and it should be notified to the T-DMB ensemble multiplexer before the connection to be used in the multiplexing with other T-DMB A/V, audio and data services. Its fine control of the data rate is done by using the temporary binary file between the TPEG encoder and streamer. While controlling the data rate, the status of the underflow and overflow can be detected to notify status signals to every system as well as to the users.

As the average vehicle speed information of all the road links in the forms of RTM message occupies most of the data in the TPEG messages (actually, the information is being transmitted most often in the experiment, see Table I), the number of transmission times of the other messages is controlled based on the number of times of the transmission of the average vehicle speed information message. The numbers in the setting in the Fig. 5 indicate the relative frequency to this RTM messages.

In the T-DMB transmitter, the incoming TPEG messages are transmitted through the Transparent Data Channel (TDC) of DAB/T-DMB ensemble structure using stream mode. And the channel can be extracted in the DAB/T-DMB receiver and decoded in the TPEG decoder finally.

## V. T-DMB RECEIVER AND TPEG DECODER

If the T-DMB signal is received by the receiver and the FIC (Fast Information Channel) of the DAB/T-DMB ensemble says that it contains the TPEG application service in the TDC (Transparent Data Channel) stream, the data stream is provided to the

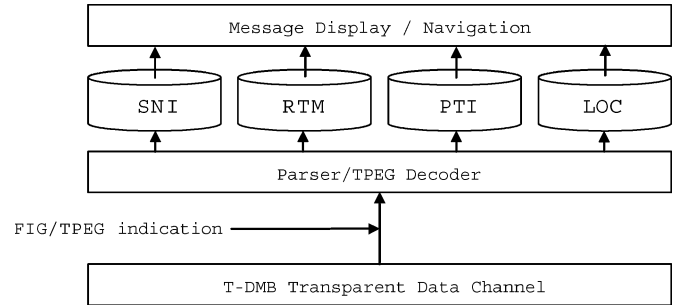


Fig. 6. The TPEG message decoding structure. If the data service component type of the FIG indicates that the TDC contains the TPEG message, the TPEG decoder automatically parses each of the message and list up them for the application module to use in the navigation and display.

TPEG decoder. Fig. 6 shows the decoding structure of the received TPEG stream. The data received through the T-DMB signal is decoded from the T-DMB receiver and is parsed and decoded before they are used in the navigation application.

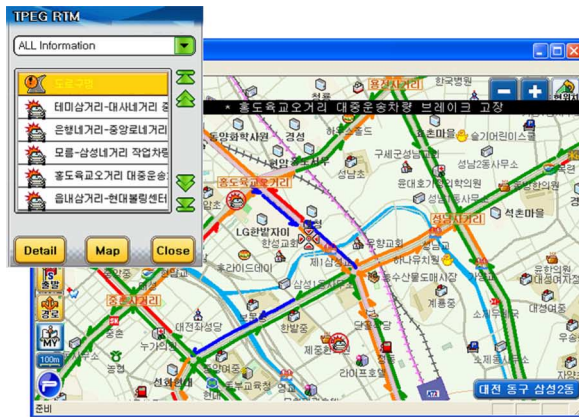
In the implementation of the receiver, general DAB/T-DMB data receiver with USB interface is used for the T-DMB signal reception. By using this receiver, all the data in the T-DMB signal can be extracted and provided to the PDA or laptop PC, which has navigation application with digital maps and GPS connection capability as well as TPEG decoding module.

Fig. 7 shows the example of the navigation application with TPEG message from the TPEG receiver and the digital map installed in the receiver. Fig. 7(a) shows the simple RTM message decoded by the TPEG decoder in the laptop navigation tool. The decoded event contents are displayed with appropriate icons in time order on the left side of the display. TPEG message service combined with navigation tools is shown in the background of the message window. If the RTM messages in the textual list have the specific location information in their LOC part, the icon will appear in the map of the navigator to show if the event will give any influence to the users' navigation way to the destination. Fig. 7(b) shows the same application in PDA type navigation.

Sometimes, the automatic re-routing is necessary when the event seriously blocks or hinders the pre-searched navigation routes. In this case link speed information for each link received and stored at the receiver is useful in re-searching the route. The information also can be used to notify the users the severity of the traffic condition of each links with several pre-defined colors.

## VI. TEST AND ANALYSIS

We have tested the implemented system with the receiver and navigator like in the Fig. 7 in the out-door reception field of Daejeon by transmitting the TPEG message contained T-DMB signal with 40 W power transmitter covering the test field. The traffic information server receives the traffic information data from the traffic information provider with adaptation module. The traffic information server then makes the TPEG frames with the received data stream and let the streamer provide the stream into the T-DMB/DAB ensemble multiplexer.



(a)



(b)

Fig. 7. Simple TPEG message and navigation example. As well as the TPEG RTM and PTI messages, the average vehicle speed is used for displaying the status of the traffic in each link by varying the colors just beside each road links. (a) Laptop computer; (b) PDA.

In the coverage of 7 km, and with 64 to 96 kbps of TPEG encoded TTI service data rate in about 1.5 Mbps of T-DMB ensemble, both the T-DMB based TTI service provider and the TPEG message based navigation system worked well in most of the area.

Regarding the traffic information gathered and provided by the information provider is accurate enough, the time delay from the information source to the display of the final TTI service decoder is very important for the real time traffic status information. That is, although a message is correct at the time of its generation, untimely message will cause wrong decision in the re-routing process at the navigation system and thus wasting the valuable transmission channel capacity for the messages which are useless or sometimes giving adverse effect. Traffic information centers in Korea provide their newly updated traffic status information in every 5 minutes. This is due not only that they regard the traffic status is stationary during the time interval of 5 minutes, but also to the maximum performance of the information gathering system including relatively old devices is providing data in every 5 minutes. This means that even though the traffic sensors are reporting every time to the center, the center

TABLE I  
COMPONENTS DELIVERED THROUGH TTI CHANNEL OF T-DMB SYSTEM

Message	Average size per message (bytes)	Percentage
Average vehicle speed (Network Performance)	60	99.58
RTM events	81	0.12
PTI events	79	0.30

processes these data and provides the resultant data in every 5 minutes. Following this information provision interval, most of the navigation tools which receive this data are programmed to update their traffic information in every 5 minutes at minimum. This helps the navigation tools to minimize the access frequency to traffic data, which, in most cases, are not changing for more than 5 minutes. The average delay of the implemented system is turned out to be a little less than 3 minute including the radio frequency propagation delay between transmitting and receiving antennas. As the traffic information gathering and providing cycles in Korean traffic information providers are averaged to 5 minutes, the implemented system is thought to be working well enough for Korean TTI service and for navigation tools which receive and uses for this data for their navigation.

However, because the overall delay depends on the amount of data and the amount of the data depends on the numbers of road links in the specified area, the delay can be increased in other countries in which they have more road links. To analyse the amount of data transmitted through the air in the implementation of this paper, we examined the sizes of each message in the binary TPEG data stream.

Table I shows the sizes of the TTI message components being transmitted through T-DMB system. Although average link speed is delivered through the network performance in the form of RTM message, we separated them from the general RTM event messages. In order to make the average vehicle speed information on every road links to be real time enough, over 99 percent of the messages are occupied by average vehicle speed information, while RTM and PTI messages occupy 0.12 percent and 0.3 percent respectively. The amount of the data which occupies the total TTI data channel can be controlled by the management function in the authoring server and stream server.

For the examination of the amount of the transmitted data, which are mostly average link speed, the number of road links is necessary. Recently, the number of Korean standard road links is announced to be more than twenty thousand. Taking the number into consideration, we analysed the average time spent during the transmission of the whole message.

Fig. 8 shows the time spent to deliver the whole Korean link speed according to the sub-channel data rate of DAB/T-DMB system (data rates are considered before convolutional coding) information regarding the number of the links is 20,000 which is that of the map data used in the implementation. The number is for the general map data used in Korea, so it may be changed according to the resolution of the road links in the digital map

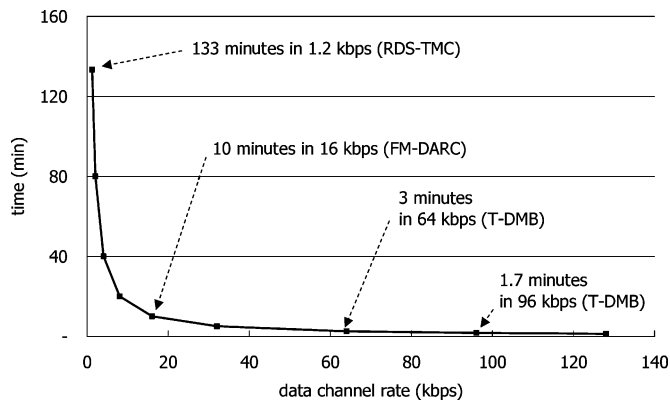


Fig. 8. Transmission time for the whole link speed information according to various TTI channel data rates in one T-DMB ensemble.

used in the service. If we use the service data rate from 64 to 96 kbps, the time for the delivery of whole link speed information is from 1.7 to 3 minutes. Currently both of values are less than 5 minutes as indicated in the figure. The figure also shows the estimated time for the delivery of the same amount of data when we used RDS-TMC [9] and DARC [10].

As well as the other data broadcasting services, the TTI services will be delivering more graphical and rich-media information about the traffic condition. Therefore, we will need to assign more capacity to those kinds of services. Compared to the recommended general data rate of around 10 kbps [1], we used relatively higher data rate in this implementation because of the real time link speed information (which is one of the popular indication method for the real time traffic status) and other experimental data delivery. However, it is certain that if we transmit richer media service like slow rate CCTV pictures through the TPEG message, the necessary data capacity will increase rapidly. Therefore, if the requirement of the TTI service includes more and more multimedia contents, the necessary data rate will grow much more in the future and thus, more efficient management of the multimedia traffic information service will be needed.

In case of link speed information delivery as in this paper, the ideas of efficiency and minimization of the data rate can exist in many parts. When applying the received traffic information for navigation, it is important to set an optimal expired time of each message. Considering the importance of the road links, the data service provider as well as the author should give a proper time to stay in the receiver for each message. Otherwise, with high data rate, the memory in the receiver will be full with the unused messages. In the same way, it is also important that the service provider and message authoring server should have a kind of filtering out functionality for the relatively unnecessary information. With this filtering out function, the data rate will be decreased dramatically. This functionality can be anywhere in the message generation or encoding modules.

The test result of the implementation in this paper also shows that as well as RTM and PTI services, the other TPEG applications such as PKI (Parking Information) and CTT (Congestion and Travel Time) are also possible as long as they have the same

TPEG frame structure. Furthermore, the implemented system can be used as a platform for the new TTI applications of the TPEG.

## VII. CONCLUSION

This paper introduces the result of the trial implementation of TPEG based TTI service in Korean T-DMB network. We developed TPEG authoring server, adaptation module and stream server to automatically encode TPEG messages from the data coming from the traffic information provider and to provide the encoded TPEG messages to the T-DMB ensemble multiplexer with the user specified data rate. We also implemented software TPEG decoder in a PDA and laptop computer which is connected to the T-DMB data receiver to verify that the transmitted traffic information could be successfully used in the navigation system moving in the service area.

The test result in the city of Daejeon in Korea shows that the system is well suited as a real time TTI service of the city and it also showed that the system can be used for the development of richer media TTI services for the preference of the users in the future. The analysis of the result also revealed that the timing is important to the real time traffic information service. Therefore, even if the implemented system in this paper currently satisfies the real time condition under Korean traffic information gathering system and amount of road links, several considerations should be made to be used in the other countries. As the TTI service needs richer media contents in the future, the more efficient management of the TTI data service is also needed for the delivery of traffic information through the limited capacity.

Although the environment in many aspects will be different in other countries, the implementation reveals that there needs to be an analysis of the cost-effectiveness compared to the communication networks and also to hybrid networks of communication and broadcasting network.

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