□ 論 文 □

A Study on the Implementation of ATIS using the Paging Network

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요 약

본 논문에서는 최근 차량의 급격한 증가로 인해 더욱 더 가중되고 있는 도시내 교통혼잡 완화를 위한 하나의 현실적 대안으로서 무선호출망을 이용한 ATIS(첨단 교통정보시스템) 의 구체적 구현방안을 제시하였다. ATIS를 위한 통신매체로서 무선호출망을 사용하는 것은 다음과 같은 잇점을 갖는다. (1) 교통정보의 동시전송 가능 및 이를 통한 무선채널의 경제성 제고, (2) 간단한 망접속 절차 및 송수신의 안정성, (3) 하드웨어 및 통신비용의 저렴. 시스템 구현및 시험을 위해 무선호출망을 이용한 교통정보 전송 프로토콜 및 시험용 전자지도를 개발하였으며, 이의 실용화를 위한 교통정보 서버 및 무선호출망과 연동되는 차량내 교통정보 단말장치를 개발중에 있다. 실현 가능성 시험을 위한 PROTOTYPE 시스템을 개발하였으며, 이를 이용해 시험적인 실제 무선호출망을 통해 가상 교통정보 송수신 시험을 하여 만족할만한 결과를 얻었다. 또한, 향후, 시스템의 지능화를 위해서 교통사건에 의한 교통량변화 모델링을 위한 기본적인 사항들을 연구, 이에 관해 기술하였다. 제안 시스템의 성능 개선 및 지능화, 실제 적용을 위해 계속적인 연구를 진행중에 있으며, 이를 통해 미비점이 좀 더 보완되면 기존 무선통신망을 이용한 ATIS 구현의 좋은 사례가 될 것으로 사료된다.

I. INTRODUCTION

ATIS contributes greatly to the alleviation of traffic congestion and to a decrease in transportation costs. ATIS provides information that a driver needs for effective trip planning and routing. The major purpose of ATIS is to allow drivers to reach a destination in the shortest possible time by providing real-time road traffic information.

Recently, the traffic congestion in Seoul, Korea has become severe due to an increasing number of vehicles beyond road capacity. Thus, demand for accurate and current traffic information has increased rapidly. In response, elementary traffic information services like the traffic broadcasting service and electronic signs along the highway (Variable Message Signs) have been created. However, there is a need for improvement in accuracy, quickness, and range. Therefore we are implementing the traffic information service system that can transfer real-time traffic information through the paging network, which is cost-efficient for data transmission, in an attempt to address the severe traffic conditions in Seoul.

II. THE SYSTEM CONFIGURATION

The proposed system is decomposed into three main stages: traffic information collection, processing/transmission, and display. At first stage, traffic information is acquired through several ways including CCTV cameras, traffic information reporters, and traffic sensors. This information is analyzed and then stored in a database Processing/transmission stage is handled by a traffic information server which provides an interface to the paging network. The paging network also consists of a radio paging terminal (RPT) and many base stations. The display stage is achieved on the terminal installed in a vehicle. The terminal receives and decodes the paged traffic information signals, processes it, and then displays current traffic conditions over a digitized road map on a monitor screen.

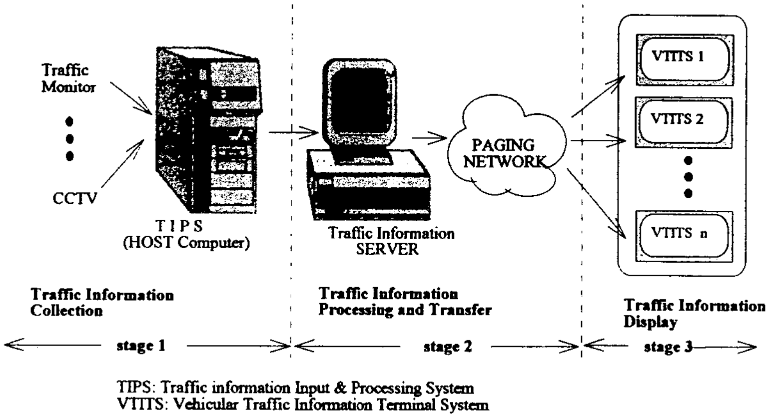


Figure 1. The proposed ATIS configuration

1. Traffic information Input and Processing System

TIPS collects various traffic information (accidents, congestion, regulation, etc.) from many sources, such as reporters, CCTV cameras, designated vehicles, taxis, and buses, through wired and wireless communication facilities. TIPS transmits those traffic information into its database and sends it to the traffic information server for additional processing.

2. Traffic Information Server

The main role of the traffic information server is to analyze the traffic information obtained from TIPS, process it into a suitable format for transmission over the paging network, and then transfer it to an RPT. The traffic information server is made up of a TIPS interface module (TIPSIM), an Operator and Maintenance Module (OAM), a traffic information database (TDB), a traffic information database processing module (TDBPM) and library (TDBLIB), a RPT interface module (RPTIM), and a scheduling module (SCLM). The module descriptions are as follows.

● TIPS interface module (TIPSIM)

TIPSIM is the interface to TIPS. It receives information from TIPS using a pre-defined protocol and stores them in the traffic database through information the TDBPM/LIB modules.

● Operation and maintenance module (OAM)

OAM operates and manages the overall

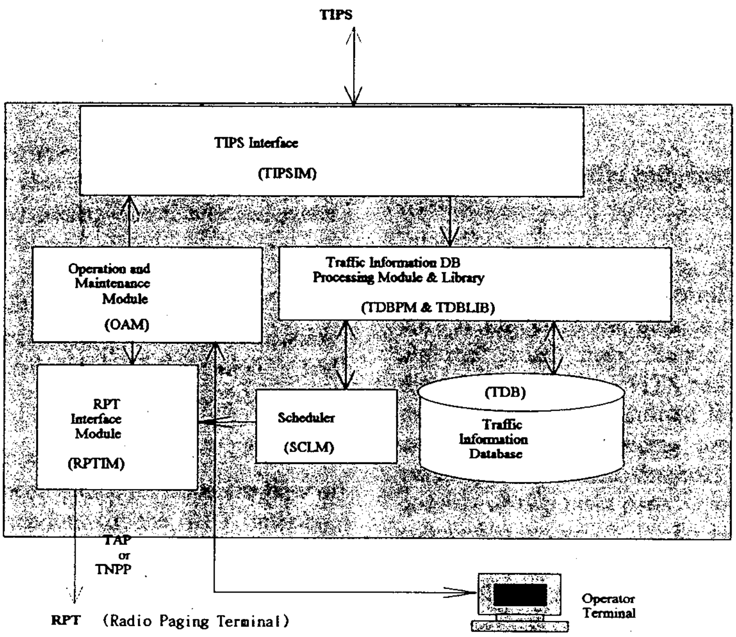


Figure 2. The Traffic Information Server subsystem

system through menu-driven operator commands.

- Traffic information database (TDB)
  TDB stores and maintains the traffic information.

- Traffic information DB processing module (TDBPM)
  TDBPM handles the interaction with the database. It also maintains the integrity of the database by erasing obsolete or redundant data.

- Traffic DB library (TDBLIB)
  TDBLIB performs relevant database functions, including initialization and termination.

- Scheduler module (SCLM)
  SCLM schedules and regulates the flow of traffic information to the RPT interface module.

- RPT interface module (RPTIM)
  RPTIM sends the traffic information to an RPT for paging. TAP (Telocator Alphanumeric Protocol) and TNPP (Telocator Network Paging Protocol) are supported. [8,9]

3. Paging network

The paging network consists of a radio paging terminal (RPT) and paging transmitters located in base stations. The information from the server is translated into POCSAG format, which is the protocol used for paging transmission. This data is transmitted from the base stations to VTITS via air.

4. Vehicular Traffic Information Terminal System

VTITS, a terminal system in the vehicle, decodes paged traffic information from the air.

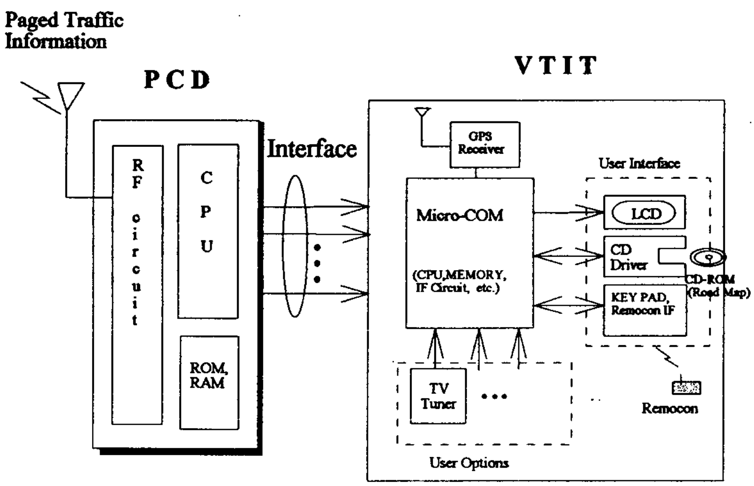


Figure 3. The configuration of VTITS

It processes the data in relation to the digitized road map (stored locally) and displays the result. VTITS can also guide the driver by finding the current location, tracing car movement, or finding probable optimal paths to a specified destination.. VTITS consists of two main parts: a paging network connection device (PCD) for handling paging signal reception, and a vehicular traffic information terminal (VTIT) which handles the processing and display.

The PCD receives the paged traffic information signal, decodes it into the original format, and stores it for later retrieval. The VTIT obtains necessary traffic information through PCD-VTIT interface and generates the current traffic conditions on a digitized road map. The result is displayed on a monitor screen. VTIT also provides user facility functions with the help of auxiliary devices like a GPS receiver and CD-ROM. These functions include car-navigation and location retrieval (of hotels, public offices, etc.). The VTIT can also receive non-traffic related information (as a normal paging receiver) like weather forecasting information and stock price information and display them on the monitor screen. In addition, the VTITS can also function as a TV or a CD player as user options.

[2,3,5]

III. TRANSMISSION OVER THE PAGING NETWORK

Providing traffic information corresponding to individual users'needs may be possible by utilizing bi-directional communication media such as roadside beacons, cellular telephone networks, etc. By using these media ,detailed traffic information can be provided individually on demand. However, sending common information like traffic information in main streets individually through these media causes waste of radio resources and may compel higher service cost to users. It may also brings higher cost of a data receiver and a processor installed in a vehicle. Moreover, in case of road congestion cased by a traffic accident, drivers may rush to call the system to know what situation they are. And so the call may exceed capacity of a network or an information providing system.

Our approach to resolve these problems is utilizing a one-way communication means like paging network. The paging network is economical in the installation cost of the network and transmission cost because it has a broadcasting capability and its radio coverage is wider then that of other media. It also guarantees a certain data transmission under a wireless environments because it has been stabilized over many years. And it also has advances in transmission speed by using high-speed paging protocol like FLEX protocol of Motorola Inc. which supports 6,400 bps . Therefore, Using a paging network as a communication means for ATIS can be very effective. This chapter describes the transmission format and procedure for the traffic information data. It also describes the theoretical consideration and the advantage of the paging transmission, and the strategy of service usage control.

1. POCSAG format structure in paging transmission

In present, all the paging data are normally transmitted as POCSAG format which is defined as radio paging data format No.1 by CCIR. The outline structure of POCSAG format is indicated in figure 4. POCSAG code consists of preamble (576 bits, for bit synchronization) and a number of batches. Each batch contains a synchronization codeword(32bits) and 8 codeword frames. Each codeword frame consists of address codeword(32 bits). In general, address codeword contains CAP code which is a pager identification number. [10] However, in case of traffic message transmission, it is also used for data area by setting a flag bit(first bit) into 1. A data codeword has 20 bits data area except for overhead bits which is used for error checking. And so one codeword can contain 20/7 characters.

2. Traffic Messaging Format (TMF) cell

This paper deals with only the following types of traffic information: congestion, accidents, road maintenance, and regulations. Those information are made in ASCII character format in the interest of data stability and ease of error detection. Redundancy checks can be made. The traffic message format only contains characters that are not used in the TAP protocol as control characters (TNPP provides data transparency).

For effective transmission, there are two formats corresponding to two distinct cases: a traffic event confined to a single section, or a traffic event spanning multiple contiguous sections. The multiple section format is similar to the single section except its location data field which encompasses extra node id's, and a terminating character. (See Figure 5.)

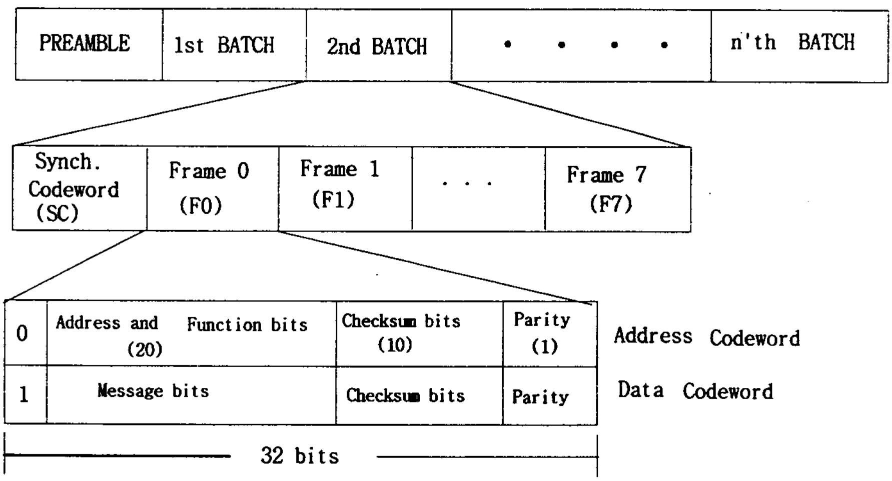


Figure 4. The structure of POCSAG format

SYN (0x16) (1 byte)	EVENT Type (1 byte)	LOCATION	
		S_NODE id (n bytes)	E_NODE id (n bytes)

(a) The TMF cell format for traffic events in a single section

SYN (0x16) (1 byte)	EVENT Type (1 byte)	LOCATION			@ (0x40) (1 byte)
		S_NODE id (n bytes)	I_NODE id(s) (n x m bytes)	E_NODE id (n bytes)	

(b) The TMF cell format for traffic events spanning multiple sections

Figure 5. The structure of TMF cell and TMF block format

A summary of characters used in the preceding format figures is as follows

SYN (ASCII 0x16) : signals the start of a traffic event cell.

EVENT Type : data field identifying type of traffic event. A traffic congestion event has many event types corresponding to different degrees of severity

LOCATION : S_NODE id, I_NODE id(s), E_NODE id - data field representing the road section to which the traffic event applies. S_NODE id is a number representing the starting point of the event, E_NODE id represents the ending point of the event, while I_NODE id(s) represents any nodes in between them. Each NODE id is a predetermined n bytes and is unique.

@ (ASCII 0x40) : signals the end of a location field when indeterminate.

3. The transmission procedure

Traffic information service can be achieved only by sending current data periodically. The paging network is suitably adopted for this purpose, because it is basically a one-way communication method. The data layer for transmitting traffic information is illustrated in Figure 6.

A TMF message block consists of all TMF cells applicable to a fixed period of time. The TMF block format is indicated in Figure 7.

The TMF message block is sent (by TAP or TNPP) to a radio paging terminal (RPT)

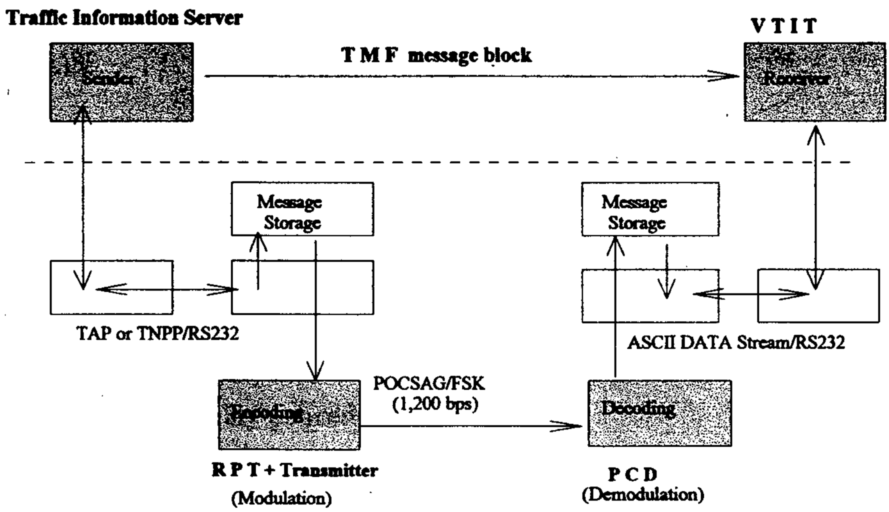
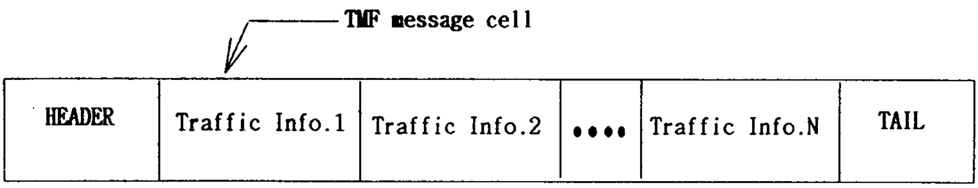


Figure 6. The data layer for transmitting traffic information



HEADER - represents the start of the TMF block and is a stream of a specially designated character
TAIL - represents the end of the TMF block and is a stream of a specially designated character

Figure 7. The format of a TMF message block

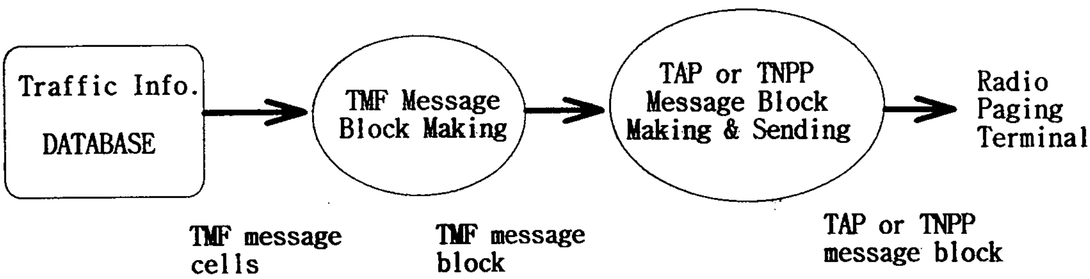


Figure 8. The transmission procedure of traffic information

where it is encoded in POCSAG for air transmission, as FSK analog paging signals, and sent to paging transmitters in base stations. The conceptual procedure is presented in Figure 8.

4. The reception and display procedures

The air transmission of a TMF block is received by VTITS. It is processed and displayed on the VTIT monitor screen. At this time, the traffic information DB in VTIT is updated with the latest information. Two message buffers are used to allow reception of the next message block while processing the current block. The detailed procedure follows. (see also Figure 9.)

- paged traffic data received and decoded.
- extraction and analysis of cells in traffic information block.
- storage of cells in the traffic information database.
- process traffic information stored in DB to display traffic conditions on terminal screen

5. The estimation of the transmission capacity

This section describes the theoretical estimation about the transmission capacity of traffic data through paging network

□ Prerequisites for calculation and test
- transmission speed: 1,200 bps
- size of one TAP message block: 150 bytes
- batching efficiency: 0.85
- RPT interface protocol: TAP
- number of batches in one POCSAG scheme: 40 batches

□ Theoretical calculation of transmission capacity
- the number of TAP blocks that can send in 40 batches
  [40 batch × 16 codeword × (20/7)] /150 bytes = 12
- the time required to send pure data in 40 Batch and POCSAG efficiency

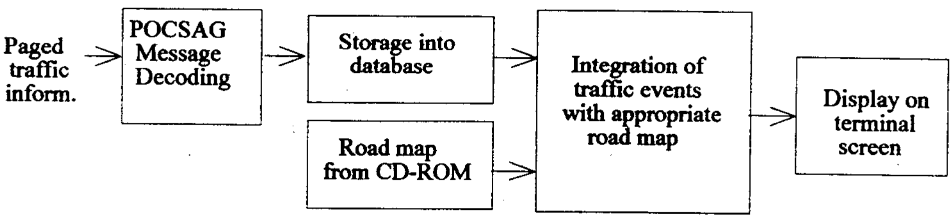


Figure 9. The reception and display procedure of traffic information

- (data bits) = (TAP block size) × (number of TAP block) × 7 bits × batching efficiency = 10,710 bits
- (transmission time of pure traffic data) = 10,710/1,200 = 8.925 sec
- (POCSAG efficiency) = (pure data transmission time)/(transmitter control time delay + batch transmission time) = 0.464

  - the number of traffic events during N minutes, when we assume average length of a traffic event is about 15 bytes. (V means transmission speed)

$$(N \times 60 \times V \times 0.464)/(15X7) = 3.9771 \times V \times N$$

if N = 5, V = 1,200
then the number of traffic events
= 1,590 events

Through above analysis, we can estimate that it theoretically takes about 5 minutes to transfer 1,500 traffic events data as a TMF format over the paging network.

6. The advantage of the paging transmission and the strategy of service usage control

One of the main advantages in traffic information service using a paging network is the economical usage of the frequency resources, because it is possible in the paging network to transmit traffic information(all the congestion information in urban main streets) to many corresponding users simultaneously through one frequency channel. In addition, even a fast transmission of a number of data is possible in paging network in near future, because its transmission speed is remarkably increased up to 6,400 bps(FLEX protocol) which is above five times of current speed.

For example, if the volume of traffic message is 5 minutes quantity(all the traffic information at main roads in a city are contained) and it is sended to 100,000 users at a point-to-point transmission, it takes about 8.5 hours (5 × 100,000) to transmit and it is obviously impractical in the transmission of dynamic traffic messages.

In data transmission using paging method, we can avoid the uneconomical transmission like that and it takes only 5 minutes to transmit in the above example case, because it is possible in paging transmission to simulcast the information to all users by using the same CAP code.

In normal paging service like a numeric paging, a CAP code(7 digits) is endowed to each user and is transmitted through the address area of POCSAG paging format. the pager of a subscriber gets his message, only in case that his pager decodes the CAP code and it is consistent with his CAP code. But, in the transmission of traffic information common to each subscriber, the common CAP code specially designed for transmitting only traffic messages must be used, because by doing so, we can avoid the unnecessary waste of the frequency bandwidth due to a repetitive transmission of the common information.

But, in this case the specific procedure for

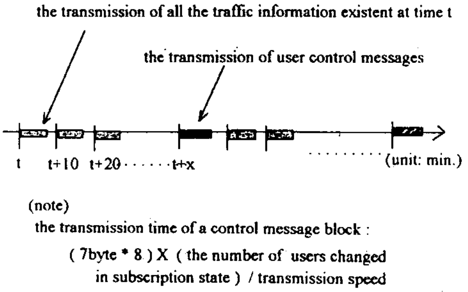


Figure 10. The transmission strategy of traffic information and user control messages (example)

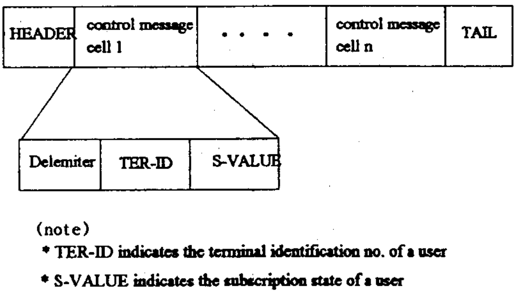


Figure 11. The structure of a control message block (example)

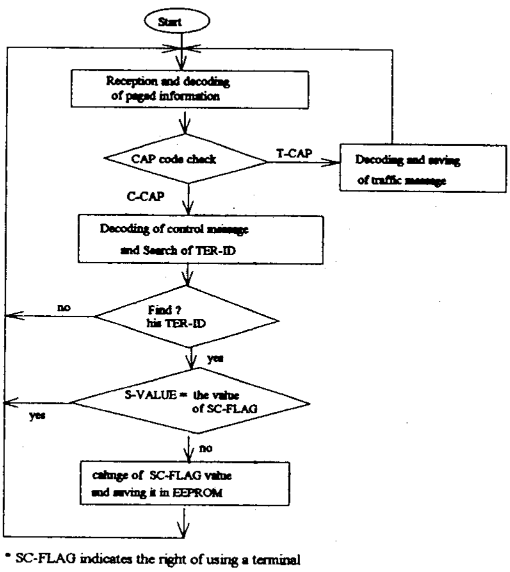


Figure 12. The processing procedure of user control message (example)

controlling the usage of unauthorized users is necessary. And so we study the control strategy of service users. As one approach about this, we differentiate traffic information from control messages by using two common CAP code, respectively T-CAP(for traffic information and C-CAP(for control messages). Traffic information server checks the subscription state of subscribers(service registration, cancellation) and process it into control message block and send it to RPT with C-CAP periodically.

As the result of analyzing the control message which is received and decoded through the air interface, a traffic information terminal controls the output of the traffic information on a monitor. In this scheme, two common CAP-codes(T-CAP,C-CAP) are transmitted through the address area and actual control messages (user-ids and service states, etc.) are transmitted not through the address area but through the data area of POCSAG paging format. By doing so, we can achieve the simulcast transmission of traffic information to many users and control the traffic information usage of a unauthorized user at the same time. (See Figures 10,11,12)

IV. THE DEVELOPMENT OF PROTO TYPE SYSTEM AND TRNANSMISSION TEST

The prototype system of the proposed system which we are implementing was developed for investigating the technical feasibility of ATIS implementation using paging network as a initial system model. This chapter describes the configuration and screen display example of the prototype system. It also describes a transmission test of virtual traffic information on the prototype system through the tentative paging network.

1. The prototype configuration

The prototype consists of four parts: virtual TIPS which virtual traffic information is inputted on the road map screen by manual and is processed for sending it to simple TIS,

simple TIS which process traffic information for transmitting over paging network, paging network which wireless data broadcasting is done, virtual VTITS which receives traffic information through paging network and displays it on the road map screen of notebook computer , and execute simple navigating functions.

2. The implementation of digital road map

We implemented a digital road map that includes all main roads of Seoul that are more than 4-lanes for the prototype system. a digital road map is the most fundamental element of a in-vehicle navigation system. In performing the function of a in-vehicle navigation system, the digital road may plays an essential role in giving a display of the vehicle location, quick map display function, location retrieval. [6,7] Our map includes diverse information such as spatial data, geographical data, topological connections, and it was designed to be decomposed into basic elements (i.e. points, lines, and areas) and have a vector-data layer structure for allowing the fast overlaying between map information and traffic information.. The map is scaled at 1:10,000. The Tokyo reference point TM coordination system is used.

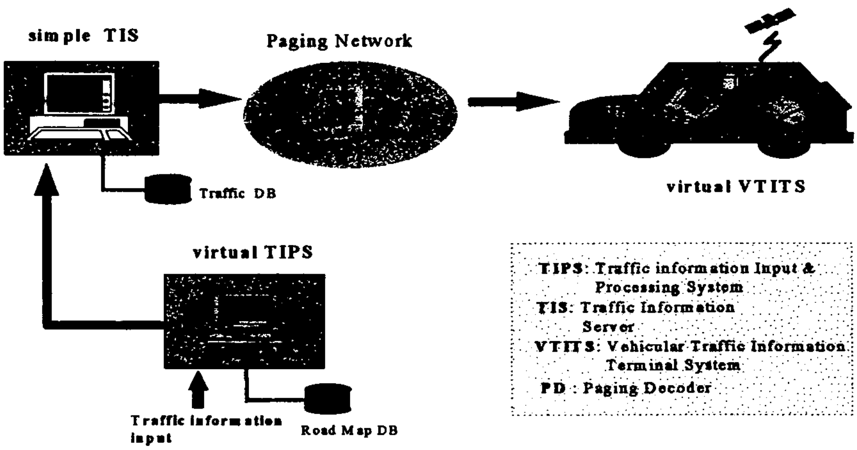


Figure 13. The configuration of prototype

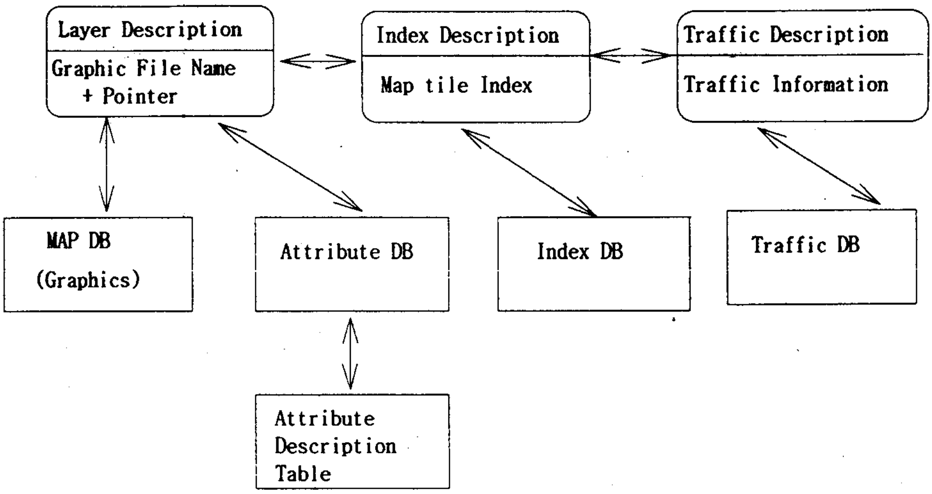


Figure 14. The overall configuration of map database

3. The transmission test of virtual traffic data

We tested the transmission and reception of 1,500 virtual traffic events in our prototype system through our tentative paging traffic network under prerequisites indicated in the previous chapter. As a result of our experimental test, we got that it takes about 8 minutes to service 1,500 traffic events through paging network. It is thought that the gap time between the theoretical estimation value and the experimental value is due to time delay in TAP protocol, processing time in traffic server and VTITS Therefore, we conclude that it is possible to update about 1,500 traffic information on the main road of capital area per 10 minutes under current paging network. It is also thought that the period of updating traffic data will be decrease due to a advances in the transmission speed of the paging system.

4. The display example of virtual VTITS

This section describes the main functions of virtual VTITS by way of display example illustrated in Figures 15, 16, 17, 18.

V. TRAFFIC FLOW MODELING AND SIMULATION

We study traffic modeling techniques to add up the forecasting capability of the traffic congestion to our future system. We expect our system become to provide near future traffic information as well as current traffic information over the paging network in future through this research. This chapter describes basic ideas of traffic simulation model and test result using SES/MB framework for forecasting of future traffic changes by traffic events.

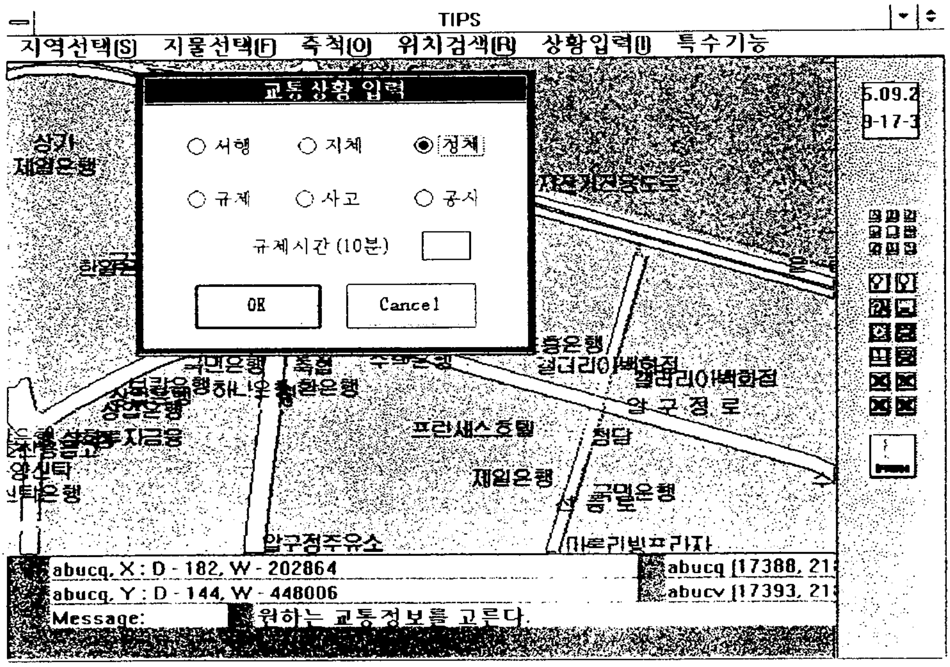


Figure 15. The display example of virtual TIPS

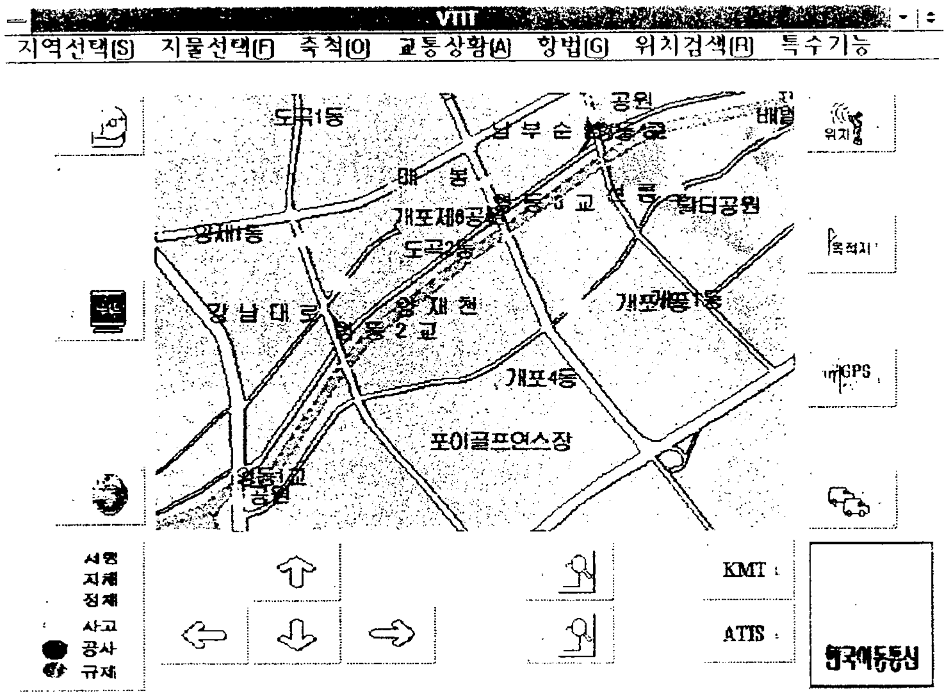


Figure 16. The display example of the traffic information in the virtual VTITS.

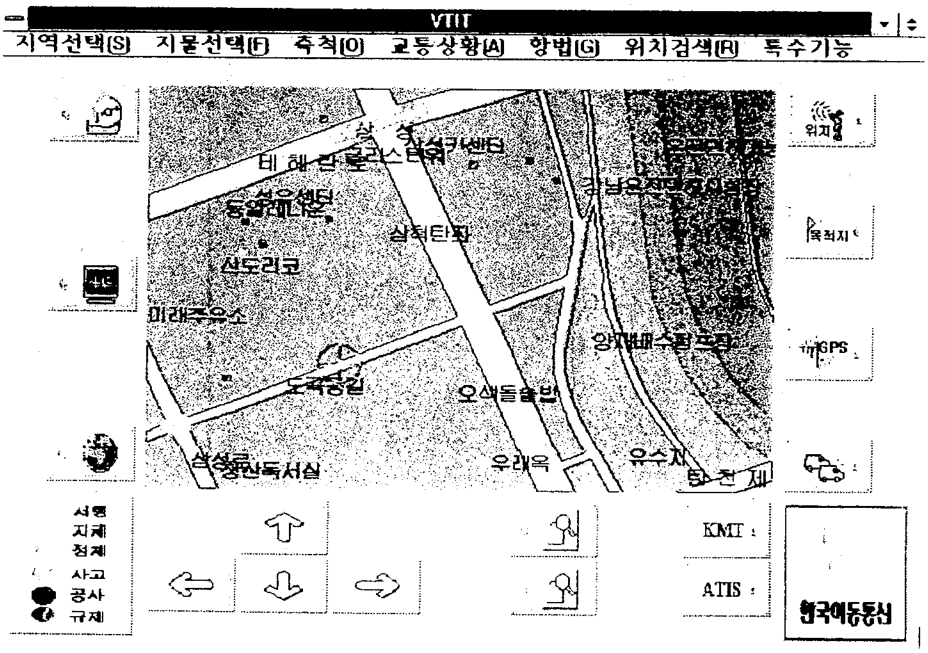


Figure 17. The display example of a current vehicle position in the virtual VTITS

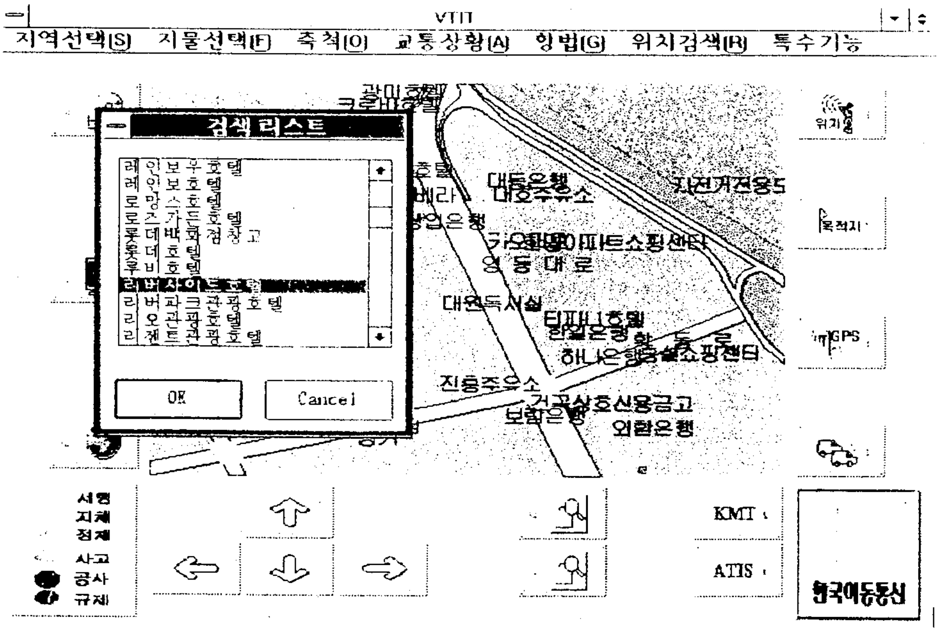


Figure 18. The display example of location retrieval

1. Traffic flow modeling

Traffic flow simulation models can be classified as being either microscopic or macroscopic models. In microscopic simulation models the individual vehicle is studied, and the attention is focused on their performance in the context of the whole traffic network system.

The macroscopic approach can be used to simulate the large network or complex system. It uses simplified models of roads and intersections [12]. The discrete event modeling technique can be basically employed to describe macroscopic models. To do this, we have employed the System Entity Structure / Model Base (SES/MB) framework that integrates the dynamic-based formalism of simulation with the symbolic formalism of AI[11]. The SES/MB framework support to hierarchical, modular discrete event modeling and simulation environment. The SES/MB framework was proposed by Zeigler as a step toward marrying the dynamic-based formalism of simulation with the symbolic formalism of AI[11]. It consists of two components: a system entity structure (SES) and a model base (MB). The system entity structure, declarative in character, represents the knowledge of decomposition, component taxonomies, coupling specification, and constraints [12]. The model base contains models that are procedural in character, expressed in DEVS (Discrete Event System Specification) formalism. The traffic network model basically consists of nodes and links. A node is either an intersection (CROSS) or an external sink (TRANSD) or source (GENR); a link (ROAD) is a uni-directional pathway for vehicle between nodes.

2. Simulation test

As an example of traffic modeling and simulation, also consider the traffic network shown in Figure 19 with the supposition of a road construction and a political demonstration, which are scheduled on road 4c and cross G at 5 and 8 time unit later, respectively. (see Figure 19). The simulation results of such situation are demonstrated in Figure 20, in which the traffic congestion on each road is dynamically changed according to the congestion propagation due to traffic incidences.

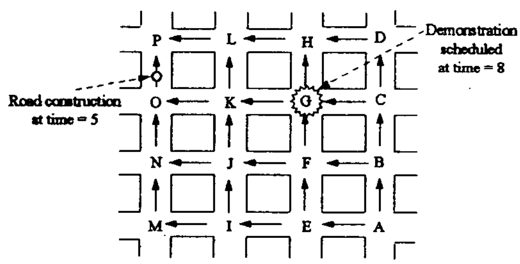


Figure 19. Simulation example of Traffic Network

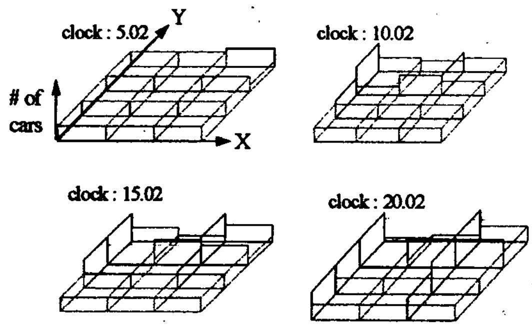


Figure 20. Simulation result: Space-congestion Representation (partially shown)

VI. CONCLUSION

Advanced Traffic Information System has become a realistic alternative to address the severe traffic congestion in the Seoul, Korea, which has about two million cars exceeding the capacity of the roads. We have proposed technical issues for implementing ATIS using the paging network, which is economical in transmission cost and has a simple air interface protocol. We developed prototype ATIS and the feasibility test of the system using paging network protocol is successfully conducted by use of prototype system. For adding the forecasting capability in future system, the discrete event modeling and simulation approach using the SES/MB framework was applied to analyze and predict the traffic changes in simple traffic network.

KMT-ATIS, which we are developing, attempts to fill a void by providing a real-time traffic information, route guidance, some other information useful to drivers on a low-cost hardware and wireless telecommunication network. It is hoped that this research will allow the general public to begin viewing real time reliable information as a tangible reality.

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