Design models of PTIS in a telecommunication point of view, and implementation case at Seoul city

(PTIS : Public Transportation Information System)

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ABSTRACT

A transportation problem in Korea is a serious issue that has to be solved urgently in the motor era of 15 million vehicles. Recently ITS has been introduced to improve efficiency of the current roads because an excessive budget and a long term construction are needed to build new roads. Therefore the government enacted the law as of ITS and the ITS architecture.

However, these ITS information services were oriented to mainly vehicles and drivers, not public entities such as bus driver, passengers and so on. Nowadays lots of local autonomous city introduced a public transportation information system (PTIS), and providing useful information for the public. For this PTIS, important design issues are to be focused on detecting and tracking technology of moving bus, and a wireless communication link to transmit the location information. This paper presents design models using several wireless communication methods, and an implementation case using a Wireless packet Data communication Network (WDN) to transmit bus location information at Seoul, Korea.

I. Introduction

Vehicle's mobility steeply falls because of severe traffic jam. Additionally, inefficient mobility of vehicles triggers negative productivity, waste of energy and increase of vehicles' exhaust gas as well as threatens our lives.

The Ministry of Construction and Transportation of Korea enacted the law of Intelligent Transport Systems (Transportation System Efficiency Act, established on Feb 1999). On the basis of the act, lots of local autonomous cities introduced ITS system. However up to now, almost every ITS system was focused on vehicles and drivers, and did not have consideration for the public such as bus passengers, bus drivers and bus companies. Therefore recently lots of local autonomous cities have been coming to introduce a public transportation information system to provide useful information for public travelers.

Buses, namely public transportation unlike owner driven vehicles, are characterized by driving a designated route in a designated schedule mainly for the public, students, housewives and so on. According to recent questionnaire for bus drivers and bus passengers at one of local autonomous cities, it was appeared that bus drivers prefer an interval of time and distance among the preceding bus, my bus and bus running behind while bus passengers are curious about their waiting time. To provide the appropriate information for the driver and passengers, PTIS system was developed not only to collect necessary data from moving bus, but also to provide value added information after processing the data.

This PTIS comprises an in vehicle terminal, bus station display, communication link and central system. In a telecommunication point of view, it is composed of location detecting system, path tracking system, and wireless communication link to transmit the location information.

This paper presents a description of PTIS design technique, an introduction of detection of bus location, wireless communication network, and implementation case of PTIS at Seoul city, Korea including the applied wireless packet data communication network.

II. A classified wireless communication method for PTIS

1. Detection and Tracking of Bus Location

Detection method of bus location on moving is consisted of coordinates detection using GPS(Global Positioning System), and Spot detection as a small cell area detection.

1) Coordinates detection method

Calculate the latitude and longitude of the bus using GPS signal including accurate time.

2) Spot detection method

- Beacon : 223,987.5Khz~224,137.5Khz (6ch, 25Khz/ch), 4.8kbps, 5~50m cell area
- DSRC (Dedicated Short Range Communication) : 5.790GHz~5.811GHz (2ch, 10MHz/ch), 1024Kbps, about 100m cell area
- Wireless LAN : Commercial 801.11 b/g/a, about several 100m cell area application

3) A basis of system design

Bus onboard terminal continuously tracks the detected location coordinates to calculate the travel time between links of the road network and average travel time, which is to be memorized in a data base(DB).

Practically, even though the coordinates method using GPS has a very high accuracy, sometimes we meet malfunction in an underground parking lot, among high rise building and under an overpass because of attenuation of GPS signal. On the other hand, spot detection method has very coarse accuracy with deviation of several 10 m, however, this spot method can't catch an unexpected situation (such as accidents, sudden traffic jam and so on) during driving between two cells and also it is difficult to calculate in the real time a characteristic of traffic flow continuously. In order to overcome the spot cell problem, one should install lots of antenna for spot detection system.

Recently, the GPS became a commonly used tool for detection and tracking of location. And Galileo project will improve the accuracy in the near future.

2. Wide range Communication Link to transmit Location Information

Communication network is the most important factor to transmit location information of moving vehicles. Because the communication network needs a wide communication cell area, it is difficult for a private company or a local autonomous city to install the network anew. Therefore, several cities decided to lease the existing private owned communication network at large communication expenses.

1) Several wireless communication industries in Korea [1]

- Wireless Packet Data Network : 898~900Mhz, 938~940MHz(60ch, 12.5kHz/ch, 9.6kbps)
- Digital Cellular Network : 824~849MHz, 869~894MHz, 1750~1780MHz, 1840~1870MHz (14.4k~ 144kbps)
- TRS (Trunk Radio System) : 805~821, 851~866MHz (18 kbps)

2) A basis of System Design

Additional data communication service of digital cellular networks, which was for originally voice transmission, is used for transmission of bus location data. As a result it takes approximately 10 seconds for a call set up time at cellular base station, and 1.5 seconds for location data transmission. Moreover, when there are lots of buses, namely subscribers, the ordinary subscriber for voice communication will experience a severe communication traffic jam.

Alternatively, Wireless packet Data Network (WDN) having very fast set up time was originally dedicated to digital data communication and has been commonly used for a collection and providing of traffic information.

From a ITS service point of view, the digital cellular network and TRS network can be applied to medium sized cities, which have less severe traffic condition and 500 or fewer buses. However, it is necessary for large cities, which have more than 1000 buses, to have an appropriate communication network as follows.

- Real time communication due to very short call set up time
- Bulky message, short and burst type message can be linked

- Less effect during a specific period such as rush hour time, incidents and so on

Giving consideration to the above points, the WDN was decided to apply to Seoul BMS (Bus Management System) system.

3. Various models of Bus Information and Management System

As stated above, in order to meet client's distinctive needs, a number of communication network systems have been developed in Korea; each design is customized to installation budgets of base station, communication expenses, system reliabilities, and so.

1) PTIS model I

Model I has the GPS based location detection and WDN communication link at Seoul City, Ul san metropolitan city, Su won city, An yang city, and for the capital area BIS system, which is the largest system. However the WDN system is restricted within several city areas.

2) PTIS model II

Model II is a supplements model with Wireless Mesh LAN, DSRC or Beacons especially inside of central area of downtown. In case the networks are installed privately by the local autonomous city, the Wireless Mesh LAN is used to spot detection and communication to central system without communication expenses. Especially this Mesh has mobile routing characteristics at mobile terminal, so that PTIS model II can make an ad hoc network easily without wired connection. In case Wireless Mesh LAN system is applied, the PTIS model II can offer high speed services, such as multimedia data and so on. However services of these systems are restricted within the model II system area. In case the buses go through the outer area of the area, PTIS services could not be used.

3) PTIS model III

Model II has GPS based location detection, Wireless LAN and the existing digital cellular networks instead of WDN. This model is appropriate where the city is small scale and has no current WDN network, such as Won ju city. The PTIS services provide the public with public transport information in the downtown of Won ju city as well as the outer track of the city, that is, Wireless LAN system in the downtown without extra communication expense and digital cellular network in the outer area with relatively less expense.

In this paper, the implementation case of PTIS model I for the BMS(Bus and Management System) application is presented.

III. Implementation of PTIS mode I [2]

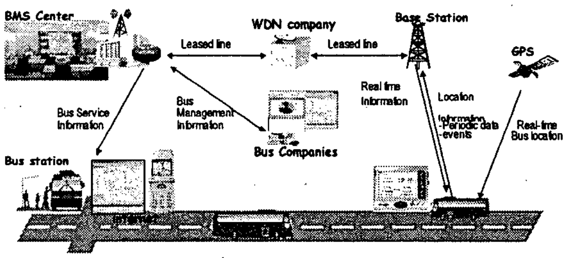
1. Introduction

From this chapter, the name of PTIS model I for Seoul city is replaced by BMS as a proper noun. The architecture of this BMS system is conformed to the third level architecture (namely subsystem) of the Korean ITS architecture, CBIS BIS and CBIS BOMS of APTS.

Seoul, a host city for the 2002 FIFA World Cup, is the capital city of Korea with 10.3 million people, 3million vehicles including 7,600 buses on 420 routes in 605 square meters. Traffic condition in Seoul faces various challenges nowadays. Vehicle's mobility steeply falls because of severe traffic jam. Additionally, inefficient mobility of vehicles triggers negative productivity, waste of energy and increase of vehicles' exhaust gas.

The BMS system, PTIS model I, was introduced, as one of public transport activation strategies, to solve the above traffic problem. An objective is a maximum use of buses through a scheduled time of bus service, and to collect real time traffic statistics for the future transportation strategy.

The BMS system comprises central system, called BMS center, local equipment including in vehicle units with a total of 7,600 buses on 420 routes and wireless packet data communication network between buses and central system as follows.

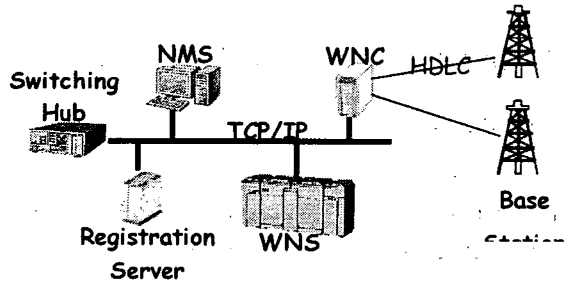


<figure 1. Configuration of Seoul BMS>

2. Wireless Packet Data Network of BMS system [3]

RD_LAP(Radio Data Link Access protocol), dedicated to wireless data communication, was presented in 1995 considering requirements of exclusive use of data communication. This system was introduced in 1996 to Korea for the application of dealing stocks, a telemetry and remote control of roadside ramps and so on. Nowadays it has been used for the purpose of Intelligent Transportation

System and Bus Information/Management System.



<figure 2. Configuration of the WDN>

This WDN(Wireless packet Data Network) using RD_LAP protocol has a different characteristics as compared to the current digital cellular networks evolved from wireless voice communication, not exclusive use of data communication.

1) Configuration of the WDN

- WNS (Wireless Network Switch)
: Process subscriber's data
- WNC (Wireless Network Controller)
: Control base stations
- Registration Server
: Management of subscriber's location
- NMS (Network Monitoring System)

Each sever system inside central office of the WDN communicates with one another using TCP/IP while HDLC (High level Data Link Communication) protocol is used between the central system (namely WNC, Wireless network Controller) and base stations.

2) Air Interface Characteristics of the WDN

The WDN at 900MHz is divided into an upstream and a downstream with 45Mhz band gap, in which the base station (Full Duplex) manages communications between the network and all the mobiles (Half Duplex), namely in vehicle units on buses, within their area. Regarding the power output, the base station has 3 Watt eirp, and the local system 1 Watt eirp.

Large cell mean long path link delay and lots of shadow. Therefore, considering frequency reuse distance and frequency directive characteristics, the cell plan was redesigned with 3 sectors per base station inside of the central area of Seoul city, so that the communication performance between the buses and BMS central system could reach up to 99%. Major characteristics of frequency are as follows,

Item	Remarks
Frequency band	Outbound 938~940 (MHz), Inbound : 898~900 (MHz)
Channel, Bandwidth	60 channels, 12.5 KHz per channel
Rate, Modulation	9600 [bps], 4 Level FSK, 3/4 Trellis coding
RF output (eirp.)	Outbound 3 Watt (Full Duplex) , Inbound 1 Watt (Half Duplex)

<Table 1. Technical specification of Wireless packet Data Network>

3) Functional Characteristics of the WDN

This WDN using RD_LAP protocol was designed for an exclusive use of data communication by nature, which has a different characteristics compare to the current digital cellular networks evolved from wireless voice communication. Thus WDN was applied to the ITS application due to the advantage of a real time response, a simultaneous subscriber connectivity, a data communication performance and so on. On the ITS point of view, the WDN has important characteristics as follows,

- Unnecessary of call set up time
- A total of 20,000 subscribers per one base station (2,000 subscriber per channel)
- Fixed communication expenses regardless of the quantity of communication data

3. Central system of Seoul BMS [4]

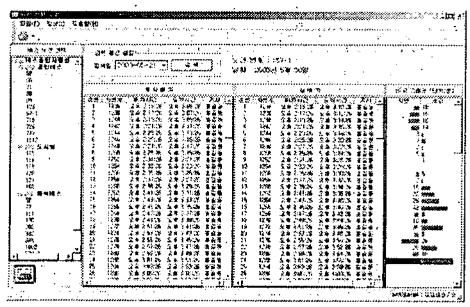
1) Data Collection Subsystem

Location information by GPS is processed to a periodic data and an event data, which are transmitted to central system via wireless packet data communication.

In case of a periodic data, information including current location and average vehicle speed is transmitted at 20 second intervals.

Occasionally when the bus arrives at or leaves the bus station, and there might be abnormal situations such as accidents, malfunction of the bus, the driver will send an event data to the central system with ease operation of in vehicle unit

2) Data Processing Subsystem

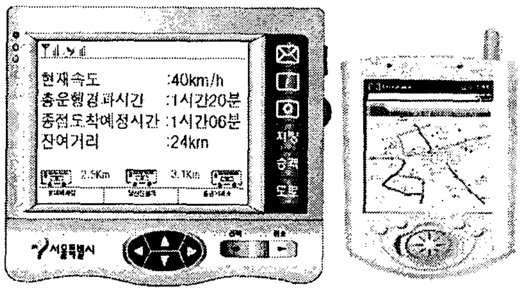


<figure 3. UI design for dispatch management>

Several sever system process the collected data to make estimated arrival time to a bus station as well as the interval among the preceding bus and the one running behind in terms of time and distance. Utilizing those data, abundant statistical analysis enables the manager of BMS center to carry out trend analysis in order to plan services more effectively for the future.

3) Offering Information Subsystem

All bus drivers can keep a regular dispatch interval and driving on schedule owing to the location information. Passengers can get various information through Internet, cellular phone and PDA as well as a message sign board at the bus station. And the information via Internet is presented in a variety formats depending on a user's preferences or requirements.

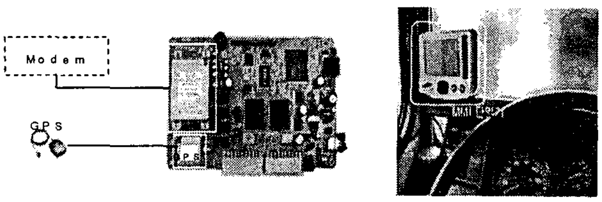


<figure 4. Drivers terminal and PDA>

4. Local equipment of Seoul BMS

1) In vehicle Terminal

The terminal comprises main controller, MMI (5" LCD), GPS receiver, WDN modem and antennas (GPS and WDN). Dipole antenna with 1W.eirp fixed on the roof of a bus can improve sensitivity of received RF signal. Bus drivers can receive useful information on driving situation such as bunching of buses, and take remedial action to ensure optimum route operation. In addition, user friendly menu driven MMI ensures ease of system operation.



<figure 5. In-vehicle Unit>

2) Bus station terminal

Bus station terminal, to be implemented in the near future, has two design types, LED display type on the pole and LCD (20") type attached at the shelter depending on the environment space condition and passengers density of the bus station. The high visibility displays with receiving real time data from central system give not only accurate routes, but also arrival time information for a number of approaching buses.

<figure 6. Bus Station Terminal>

5. Conclusions

For the purpose of ITS services, WDN system and digital cellular network has been applied in spite of lower data speed, several 10 bps to 144kbps. In an expense and performance point of view, several supplements such as wireless LAN, RF Beacon are mingled with a broad area communication network.

Recently, next generation communication network with higher data speed such as Wi Bro(Wireless Broadband Network, 1Mbps at 2.3Ghz), Wireless LAN(802.11 b/g/a), HSDPA(High Speed Downlink Packet Access, 14Mbps, based on the asynchronous IMT 2000) are to be presented in Korea, which has been attempting to be integrated to ITS. Given the availability of high speed communication network in the future, users will be able to be on the move and on line at the same time. Consequently, lots of services like multimedia can be offered with less expense.

Moreover these PTIS models are to be linked to urban traffic control system to give bus priority at key intersections in road networks.

This kind of various attempts will become established in the near future as a standard of ITS communication network.

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