五、附錄

附錄1.本局發表之論文

Traffic Management System Project of Integrated Freeway and Expressway Networks in Taiwan

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Abstract：The national freeways have been opened to traffic nearly 1,000 kilometers. The 12 west-east expressways have also been opened traffic in succession, and some of them connected with freeway by system interchange. Cope with the integrated highway network of freeway and expressway taking shape and connecting to metropolitan in the west of Taiwan, the Taiwan Area National Freeway Bureau starts to impel the Traffic Information Management, Coordination and Command Center and to upgrade the traffic control system. When the system has been completed, the network will offer a new Intelligent Transportation System service for users.

The principle of TIMCCC is based on concentrating on information and controlling over divisions in order to integrate traffic information and coordinating the operation between different control centers for achieving the efficient network traffic management. The TIMCCC will also include a network traffic simulation facilities and forecast travel time function. The manager shall apply simulation platform to analyze the network performance for different control strategy on special traffic demand of the continuous vacation. With which the users can inquire the travel time of the future between specific locations, and it will be easy for users to decide a better departure time and choose a better route.

The freeway and expressway networks will be divided into three different service levels and to conduct different traffic control strategies. As a result of completion the networks, the route diversion management strategy plays the most important role in the network management. The route diversion strategy will usher the traffic flow to the substitutions, and the overall vehicles will be distributed proportional in the networks to reach equal.

Key words : ITS、TIMCCC, Route Diversion, Integrated Highway Networks

1 INTRODUCTION

1.1 The ITS Technology Applied in Freeway

The TANFB applies ITS technology to manage the National Freeway, including the traffic control system and the electronic toll collection system are stated as follows:

(1) Traffic control system

TANFB started using the first period of traffic control system on National Freeway No. 1 from Keelung to Yangmei in November, 1984. The equipments of the system include vehicle detector, changeable message sign, emergency telephone, close circuit television, central computer, and etc.

Along with other national freeways being opened to traffic, the new traffic control system came along with the new equipments, such as lane control signal, ramp metering control signal, travel time information sign, traffic information browsing service by WWW and phone call, and etc.. It improves the function of traffic management and information service more comprehensive for traveler base on the new ITS technology.

(2) Electronic Toll Collection System

In order to cause the driver to be possible in non-stop and no cash to pass through the toll gate with more effective and secure, the TANFB started to set up the electronic toll collection system (ETC) in Dec. 2004 and the system completed and start to use in Feb. 2006. The ETC system has increased the capacity of toll station, reduced payment time, enhanced the convenience and the security of drivers, and reduced air pollution. By using the ETC, the toll of freeway will be in charge by travel distance, and it will be the more fare for the users. Aside from this, the ETC system will be integrated with the traffic control system, called as ETTM (Electronic Toll and Transportation Management), to lay the foundations of the application in intelligent transportation system.

1.2 Freeway and Expressway Integrated Networks

After the whole National Freeway No.3 has been opened to traffic, the 12 west-east expressways been opened to traffic in succession. The freeway and expressway will be an integrated highway network to connect the each major metropolitan in the western corridor of Taiwan, shown on Figure 1.

In order to integrate future highway network management in Taiwan area, the TANFB has constructed the TIMCCC (Traffic Information Management, Coordination and Command Center) and to upgraded the existence traffic

control system. Resorting to classifying the demand of traffic management, the new traffic management system of freeway and expressway will raise the transportation benefit and safety for whole highway network. When the system has been completed, the network will offer a new ITS (Intelligent Transportation System) service for user.

2 THE CLASSIFICATION OF HIGHWAY NETWORK MANAGEMENT

2.1 Integrated Network Characteristic of Freeway and Expressway

The highway network architecture of western Taiwan is bases on freeway, west-east expressway, and Western Coast Expressway, moreover, the connections of travel demand for each area rely on the highway system of urban expressway, provincial highway, and county highway.

The freeway in the western corridor consists of National Freeway No.1 and No.3 of north-south direction, No.2, No.4, No.8 of east-west direction as well as the under constructing National Freeway No.6. The main axle of eastern corridor is the National Freeway No.5.

The 12 west-east expressway of total 361.46 Km in length starts from Keelung -Taipei living circle of northern side to Kaohsiung-Pingtung living circle of southern side to connect by National Freeway No.1, No.3, Western Coast Expressway, important provincial highway, and county highway which constitutes north to south express transportation network in western corridor. Each living circle has its expressway at least to turnover freeway rapidly, to achieve the region balanced development, conduct traffic flow. How of freeway, and expand goal of its range of service. The maps of highway network for northern, central, and southern area are shown on Figure 2, Figure 3, and Figure 4.

2.2 The Classification of Highway Network Traffic Management

To coordinate the integrated traffic control system demand and consider the schedule of each freeway and expressway section opening to traffic, the freeway and expressway networks will be divided into three different service levels. The central principles are shown as below:

(1) The First Level Highway Network

The first level highway network is considering to keep traffic flow fluently in mainline and to balance traffic of the National Freeway No.1 and No.3. The management of the first level highway network has the same function of national freeway which may regard as extending of freeway. It includes national freeway and the west-east expressway connecting with National Freeway No.1 and No.3 directly.

(2) The Second Level Highway Network

The function of the second level highway network is to guide the traffic flow to Western Coast Expressway when the mainline of National Freeway No.1 and No.3 have traffic jam. The network includes the west-east expressway which connecting with Western Cost Expressway and National Freeway No.1 or No.3 directly and the Western Coast Expressway for better alignment.

(3) The Third Level Highway Network

There are not satisfy the characteristics of the first and the second level highway are attributed to the third level highway network. Under the limitation of resources, the most important goal of management is to collect the traffic information of alternative routes. The content of information should be correct and acceptable as the principle.

2.3 The Impetus Plan for Intellectualizing Traffic Control

According to the classification of highway network and traffic management analysis, the original northern, central, and southern traffic control centers can not satisfy for future requirement. By establishing the national traffic management center, national traffic control system will be operated under TIMCCC. For TIMCCC establishment and expressway management brought into traffic control center, the future traffic management and control construction architecture for western highway network is shown on Figure 5.

3 TRAFFIC CONTROL STRATEGY OF HIGHWAY NETWORK

3.1 Management of Various Network Levels

(1) The First Level Network Management

The goal of constructing the integrated traffic control and management facilities is to maintain the transportation smooth and provide the optimized driving environment. Besides the ramp metering control, lane control, speed limit control, and warning control implemented in each road section, the highway network control is for the larger traffic demand of National Freeway No.1 and No.3. Other freeway and expressway system act the role of auxiliary coordination to offer the requirement of route diversion for National Freeway No.1 or No.3. The traffic control strategy includes monitoring, event management, traveler information service, and management of constructing section, as shown in Table 1.

(2) The Second Level Network Management

In addition to ramp metering control, for the consideration of controls facilities resources and budget, the traffic control strategies of the second level highway network are to offer the information requirement and instruction to implement route guidance strategy in National Freeway No.1 and No.3.

(3) The Third Level Network Management

The traffic control strategies of the third level highway network are to offer information, notify the urgent event, and rescue essentially.

Table 1 Traffic Control Strategies for Management Requirements

Management Requirement	Traffic Control Strategies	
For Network Management	Route Diversion	Route Guidance Control Strategy
		Metropolitan Network Management Strategy
		Route Guidance Information Service Strategy
		Network Information Service Strategy
For Event Management	Tunnel Control Strategy	
	Weather Management Strategy	
	Metropolitan Recurring Congestion Management Strategy (for Mainline Congestion/for Exit Congestion of Ramp)	
	Ramp Control Strategy	
	Highway Detection and Surveillance Strategy	
	Dynamic Road Shoulder Using Strategy	
For Mainline Traffic Smooth	Intersection Control Strategy	
For Traveler Information Service	Advanced Traveler Information Service System	

3.2 The Route Diversion Management Strategy

As a result of completion the network, the route diversion management strategy plays the most important role in the freeway and expressway networks. The purpose of the strategy is to guide the traffic flow to the substitutions, and the overall vehicles will be distributed proportional in the network. In view of the first level highway in the network, there are four parts to be constructed, including Route Guidance Control Strategy, Metropolitan Network Management Strategy, Route Guidance Information Service Strategy, and Network Information Service Strategy.

(1) Route Guidance Control Strategy

When there is an accident or serious congestion occurs in either National Freeway No.1 or No.3, as the original route and the alternative route differ greatly in travel time, the Route Guidance Control Strategy should be activated. The scope of route guidance is the west -east expressway adjacent to each other and the information will be offered in front of the decision point. By using the west -east connection road to link back to National Freeway No.1 or National Freeway No.3 to the destination, the traveler could avoid the congestion or incident, and utilize each road in the network effectively.

By using Route Guidance Sign which is an entire page of changeable sign, the information of the accidental location and route guiding is announced by letters as the principal, and an route layout also is shown in left side as the subsidiary, which as shown on Figure 6.

(2) Metropolitan Network Management Strategy

Generally there will be several exits of highway to get to the metropolitan, and the destination will be differing from each traveler. It is difficult to offer the best path to traveler for route guidance. Thus, in order to serving the trips in living circle, the graph information will be offered and the traveler will get the traffic condition in downstream as a reference for exit choice.

With the same Route Guidance Sign for Route Guidance Control Strategy, the congestion information will be offered in the metropolitan network as a drawing map by using different color to distinguish the Level of Service (LOS) in each segment of network. When the segment is blocked by red, it means the LOS is getting to E or F, and the delay is hard to bear for driver. The information could let the traveler who familiar with the network forming a concept of the crowded condition for downstream segment and judging the proper path to enter in the metropolitan by himself. The message is shown as on Figure 7.

(3) Route Guidance Information Service Strategy

Taking the Sijhih-Wugu Section Viaduct of National Freeway No.1 for example, it is the main alternative route of National Freeway No.1 in Taipei metropolitan area. The Route Guidance Information Service Strategy is to offer the travel time and the traveler could choose a better path by his own. The travel time information service will be announced for user's reference sustained. The "Route Travel Time Comparing Sign" will be set up in the upstream of the path decision point for the path, which is shown on Figure 8. The sign shows the different travel time between the mainline and the viaduct as a reference for traveler for choosing the proper path.

(4) Network Information Service Comparing Strategy

National Freeway No.1 and No.3 converged on Hsinchu System Interchange and the Changhua System Interchange as a decision point of route choice.

Because the network information providing in front of the Hsinchu System Interchange is much more complicated, the Network Information Service Strategy will use two changeable message signs abreast display brief and clear traffic information of National Freeway No.1 and National Freeway No.3 individually. These two signs are used to provide complete information of National Freeway No.1 and National Freeway No.3 to the traveler, as a reference for choosing their travel path when passing by Hsinchu System Interchange, which is shown on Figure 9.

4 TIMCCC SYSTEM ENGINEERING

4.1 TIMCCC System Architecture

TIMCCC is composed of six subsystems. There are Data Collection and Management Subsystem (DC&M), Traffic Monitoring and Control Subsystem (TM&C), Emergency Response and Coordination Subsystem (ERC), Multi-Media Dissemination Subsystem (MMD), Traffic Information

Dissemination Subsystem (TID) and Advanced Traffic Management Laboratory (ATML). The entire architecture is shown on Figure 10.
Data will be exchanged between TIMCCC and external systems, except ETC system, by using XML data exchange technology over HTTP. Among others ETC traffic volume of each lane in every toll station will be transmitted to the nearby traffic management center first and then transferred to TIMCCC through internal computer network by leased line. Data exchanged structure between TIMCCC and external systems is shown on Figure 11.

4.2 Functions of TIMCCC Subsystems

(1) Data Collection and Management Subsystem (DC&M)
The goal of Data Collection and Management subsystem is to collect related data for the requirement of other subsystem. All collected data will be transformed into the unified format before saved into database. The collected data, including ETC data, traffic data of vehicle detectors and weather information, will be used by Advanced Traffic Management Laboratory, Traffic Monitoring and Control subsystem and other related subsystems.
(2) Traffic Monitoring and Control Subsystem (TM&C)
The collected traffic data from all traffic management centers will be processed by Traffic Monitoring and Control subsystem. To visualize the collected real-time traffic data, the system generates the dynamic overview of traffic conditions and projects it on the display wall. By using the monitored traffic data, the system will automatically generate traffic control strategies including strategies for multi-areas which controlled by different traffic management centers. The system may maximize the benefits of traffic control devices.
(3) Emergency Response and Coordination Subsystem (ERC)
The main function of Emergency Response and Coordination subsystem is to provide communication network service and traffic information for Emergency Response and Coordination Center. The goal of ERC subsystem is to be a user platform with convenient coordination and integrated information, which may increase efficiency of coordination.
(4) Multi-Media Dissemination Subsystem (MMD)
The aim of Multi-Media Dissemination subsystem is to broadcast traffic information to media companies. During interviews, media workers can get the real-time traffic information, record streaming video signal of CCTV or capture operation GUI of TM&C subsystem provided by Multimedia Monitor and Display Software of MMD subsystem. Information can be also projected on the TV wall.
(5) Traffic Information Dissemination Subsystem (TID)
The goal of Traffic Information Dissemination subsystem is to integrate the information dissemination of TIMCCC. The integrated traffic information is also broadcasted to the user who is traveling or before departure. Travelers can use a computer, mobile phone or PDA to get real-time video of CCTV, congestion information, mean speed, events, traffic control strategies, and travel time information by internet or interactive voice response system. Travelers could change traveling schedule according to collecting integrated traffic information by using this convenient service. Value-added information service providers can also get well-formatted traffic information by using XML technology.
The value-added traffic information service of vehicle navigation systems is expected to grow dramatically while the integration of highway network traffic information is completed.
(6) Advanced Traffic Management Laboratory (ATML)
Traffic simulation and travel time forecast are the main development tasks in the Advanced Traffic Management Laboratory. In order to make the forecast function of Traffic Monitoring and Control subsystem works effectively, one traffic simulation system, covering the whole network, will be installed in the laboratory. Researchers will study the travel time changing, Original-Destination database generation or traffic control strategies after assigning simulated events into the system.
TIMCCC will integrate the traffic information from each control center and as a result, will accumulate massive historical data, including historical travel time by time interval, OD Matrix by time interval and so on. To consider the needs of road users, the following two kinds of travel time forecast willl be generated by using the historical data.

(A) Inquiry of Travel Time Forecast of Current Date
A diagram of travel time forecast of future hours will be browsed on the Internet. The user shall decide the departure time useing the forecast reveal time.
(B) Inquiry of Travel Time Forecast of the Future Date
After the project is completed, travel time forecast of future days will also be forecasted by broadcasting the massive collected data. In the future, users can inquire the travel time forecast between specific locations. It is expected that the system will help road users to decide a better departure time and choose a better route or adjust one's trip destination.

5 CONCLUSION

In accordance with the future integrated highway network management of Taiwan area, the TANFB is impelling the Integrated Freeway and Expressway Network Traffic Management System. The system will use the ITS technology to upgrade and expand the existing traffic control system to cover the whole highway network. The different control centers will be integrated to establish information centralism in TIMCCC. Other than that, we also induct ITS technology comprehensive.
To coordinate the integrated traffic control system demand and consider the schedule of each freeway and expressway section opening to traffic, the freeway and expressway network will be divided into three different service levels with different traffic control strategies. And the route diversion management strategy plays one of the most important role in the first level highway network management. There are four categories to be constructed, including Route Guidance Control Strategy, Metropolitan

Network Management Strategy, Route Guidance Information Service Strategy, and Network Information Service Strategy. The four strategies willl guide the traffic flow to the substitutions, and the overall vehicles will be distributed proportional in the network to reach equal.

After the new system established completely, the huge traffic information database will be collected. The database will be applied to analyze the network performance for the different control strategies by using simulation platform. Base on the performance analysis, we can draw up the new better control strategies for different traffic demand of weekday, weekend, and the continuous vacation.

Fig. 1 Integrated Freeway Networks

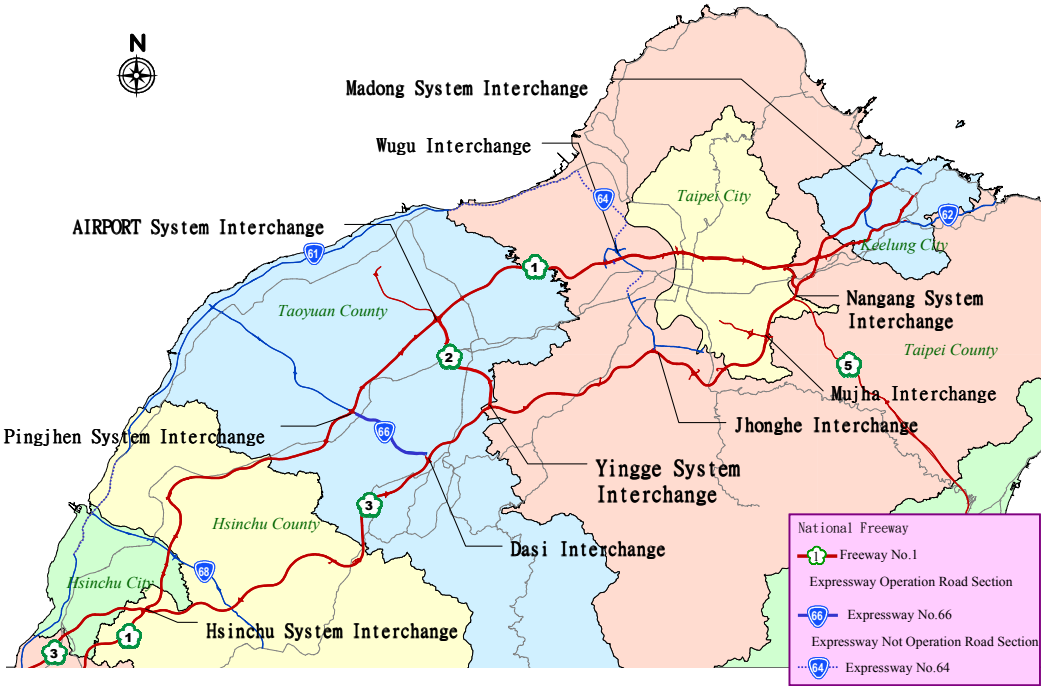

Fig. 2 Network of Expressway in Northern Area

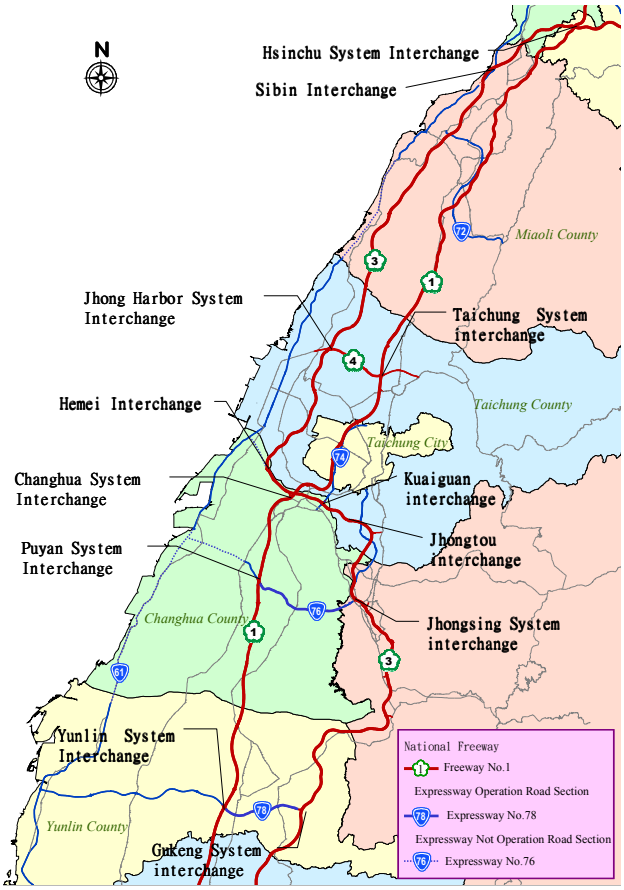

Fig. 3 Network of West-East Expressway in Central Area

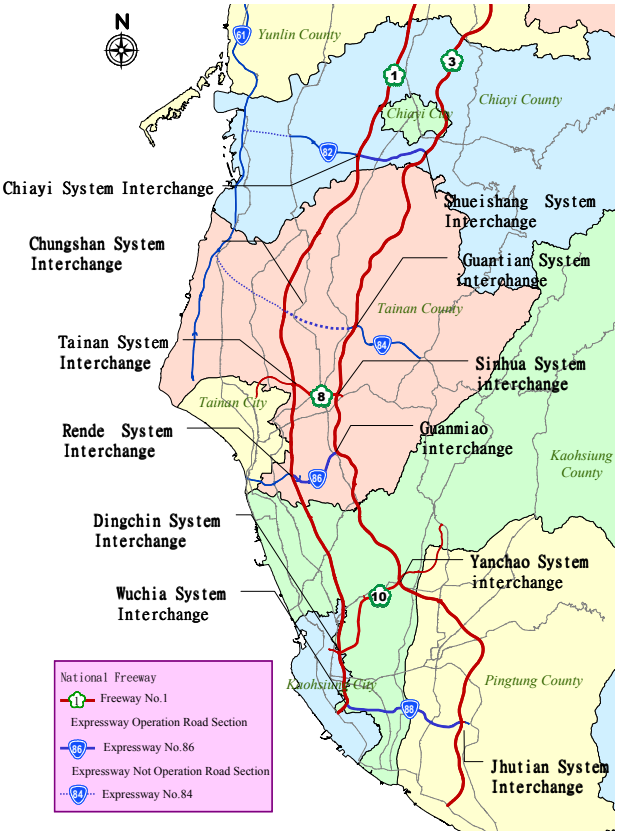

Fig. 4 Network of West-East Expressway in Southern Area

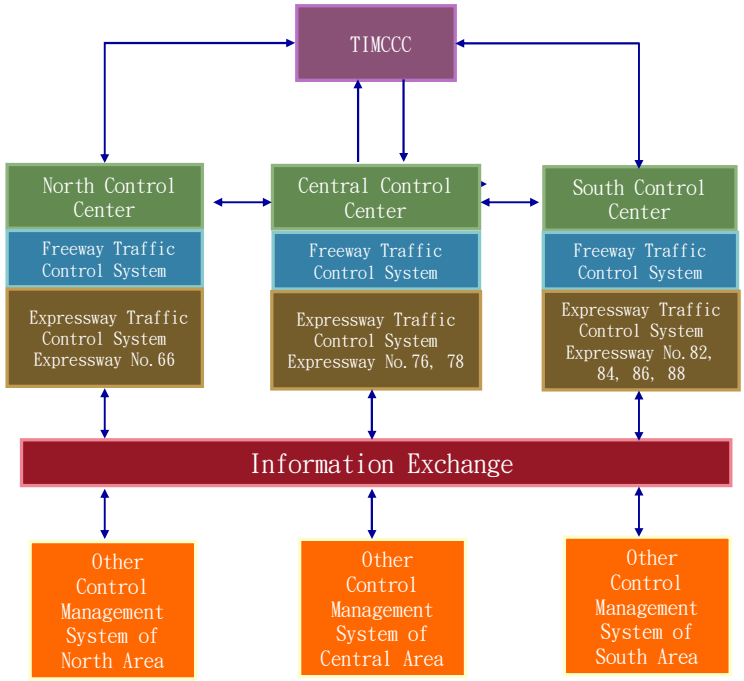

Fig. 5 The Integrated Freeway and Expressway System Construction Architecture

Figure 6 Route Guidance Sign

Figure 7 The Information for Metropolitan Network Management Strategy

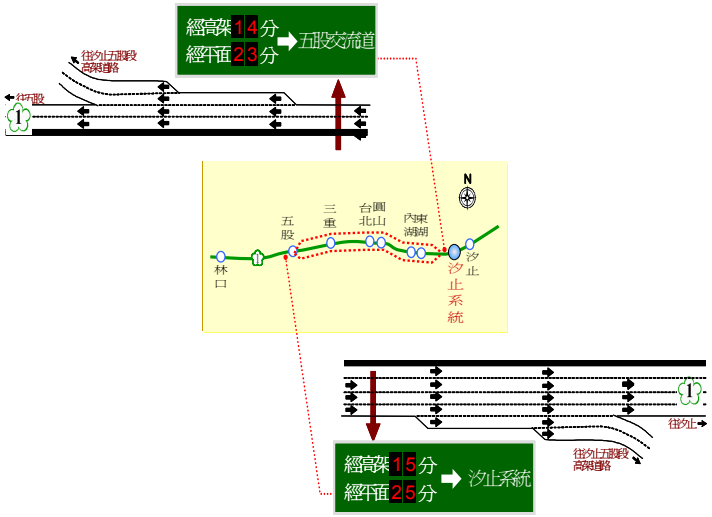

Figure 8 Route Travel Time Comparing Sign

Figure 9 The Arrangement of Changeable Message Sign for Network Information Service

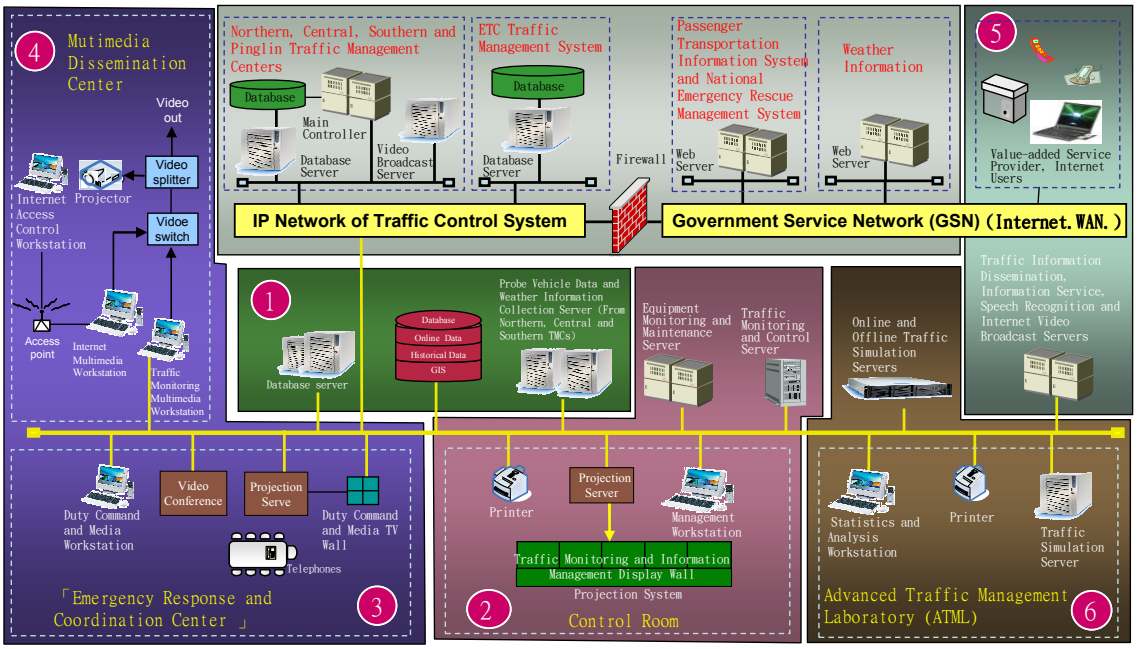

Figure 10 TIMCCC System Architecture

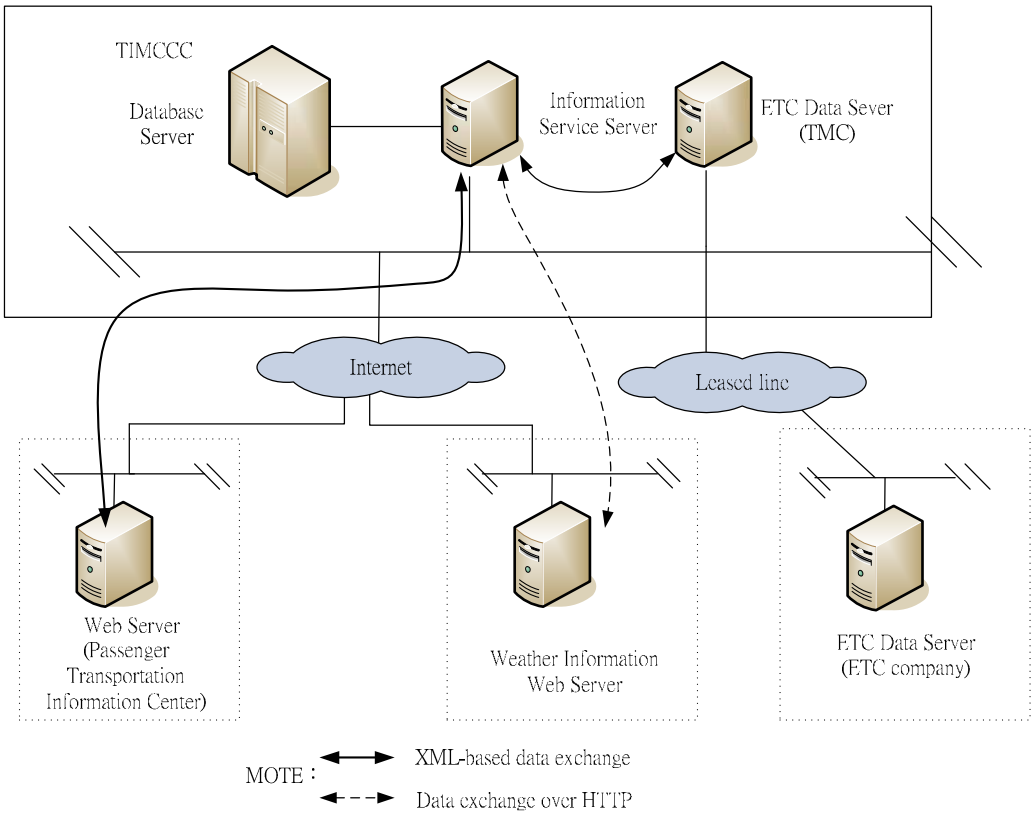

Figure 11 Data Exchanged Structure between TIMCCC and External Systems