Standard Architecture of China Intelligent Bus Systems

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Abstract. This paper summarizes the ITS standards of China, and designs the standard architecture of intelligent bus system, including the technical specifications on devices, communication protocols, data resource, and application software being implemented. The development efforts will update the intelligent bus system architecture to ensure interoperability among devices, protocols, databases, and application systems; and it will increase reusability of the devices and systems of intelligent bus system; and integrate the operations among bus companies, bus industry, and management agencies.

1. Background
China has significantly increased its urbanization from 20% to 57% in the last 30 years resulted from the economic development in the last several decades, and also the number of vehicles and private cars ownership, which lead to the growing urban traffic congestion and environmental pollution issues.

Starting from the end of 2012, the State Council of China has issued the Transit Priority Policies. To support this national policy, it is very important to establish the needed system standardization to improve the QoS of bus system through the intelligent bus systems. There are several successful examples on how the Advanced Public Transportation System (APTS) standardization can improve the operations around the world. In 1992, APTA established Transit Communications Interface Profile (TCIP). The EU standards organization is also promoting the integrated Fare Management Standards under ISO-TC204-WG8. To further standardize the data communication and data interface, APTA has launched TCIP 3.0 to cover 9 additional public transport business areas, including the Common Public Transportation, Control Center, Fare Collection, Incident Management, On board, Passenger Information, Scheduling and Run cutting, Spatial Representation, Transit Signal Priority.

In China, although the public transit system got rapid development, but there are lack of technical standards on intelligent bus system. This paper summarizes the ITS standards of China, and designs the standard architecture of intelligent bus system, including the technical specifications on devices, communication protocols, data resource, and application software being implemented.

2. Framework of Intelligent Bus System
China intelligent bus system framework is developed to deliver different users’ demands. These include the daily bus operation, routine management, and automatic service quality assessment. As shown in Figure 1, the architecture include the five layers, including the sensing layer, communication protocol layer, data layer, application layer, and the user layer.

✦ The sensing layer is mainly focus on using all kinds of sensors to detect or monitor the status of the passengers, buses, bus-stops and bus-lanes and so on, is the foundation of the intelligent system.
✦ The protocol layer is mainly focus on data communication and transferring between sensing
layer and data layer, in accordance with the requirements of the protocol accepted by the system.

- The data layer is composed of data management, data resource include metadata, data exchange and databases, data management mainly focused on data quality audit and data modelling.

- The application layer is about different user’s application; mainly include traveller information system for travellers, intelligent dispatching and enterprise resources management for bus companies, quality of service supervising and development evaluation for different level management agencies, and data opened for other user’s application such as research agencies or researchers.

- The user layer mainly includes interactions among the passengers, bus companies, management agencies and other research agency or personal researchers.

![Figure 1. Framework of Intelligent Bus System of China](image)

### 3. Standard Architecture of Intelligent Bus System

#### 3.1. Standard Architecture Design

The Architecture is developed as based on the function demand analysis and technical framework design of the intelligent bus system in China. Figure 2 illustrates the Standard architecture and related data flow to support the data collection, data management, data analysis, and data distribution of the intelligent bus system. The system architecture is further divided into three sub-architecture layers; including operation and monitoring standard-sub-architecture, data resource standard-sub-architecture, and management and service standard-sub-architecture, respectively.

![Figure 2. Standard Architecture of Intelligent Bus System](image)
3.2. Data Collection-Operation Monitoring Standard-Sub-Architecture
The Data Collection-Operation Monitoring Standard-Sub-Architecture is focused mainly on sensing and data acquisition by all kinds of sensors to monitoring the status of the passengers, buses, bus-stops and bus-lanes dynamically. This serves as the foundation of the intelligent bus system. Among them, the integrated OBU is the core of this sub-architecture, with this device, the sensing and information transmission network. Figure 3 describes the various service established between vehicles, passengers, traffic (include signal priority), control centre, bus operation environment (bus station and bus lane).

Figure 3. Standard-Sub-Architecture on Operation Monitoring and Data Collection

3.3. Data Management-Data Resource Standard-Sub-Architecture
The data management sub-architecture is focused mainly on data source and data management According to the description of the sub-architecture on data resource. These include the detailed specification on metadata, data exchange between different-level platforms and data quality verification. Figure 4 describes the interactions among the database specification, and the needed data exchange and interface between operating entity levels.
3.4. Data Application- Management and Service Sub-Architecture

According to different users of the intelligent bus system, the data application sub-architecture is focused on data application, it consists of three specifications, which are specifications on intelligent dispatching and operation for bus companies, on intelligent supervising and management for all DOT agencies, on intelligent traveller information service system for passengers separately.

3.4.1. Specification on Intelligent Dispatching and Operation for Bus Companies. The specification aims to improve the efficiency for bus companies, focused on the dynamic optimizing allocation of the related resources of bus system such as buses and drivers, considering the real-time traffic situation and spatial-temporal regulation of passengers.

3.4.2. Specification on Intelligent Supervising and Management for DOT agencies. The specification has made requirements for the three levels of management agencies separately from comprehensive...
monitoring, performance evaluation and decision support and optimization, especially, there are much more requirements to the city level compared with other two levels.

Figure 6. Specification on Intelligent Supervising and Management for DOT agencies

3.4.3. Specification on Intelligent Traveller Information Service System for Passengers. The specification is focused on providing the needed traveller information service to achieve real-time, online information delivery to maximize the usability and usefulness of the urban public transit systems. This standard proposed requirements in terms of different stages of travel like the stage of before traveling, bus-stop waiting, inter-bus traveling and transferring.

Figure 7. Specification on Intelligent Traveller Information Service System for Passengers

4. Conclusions
This paper summarizes the ITS standards of China, and designs the standard architecture of intelligent bus system, including the technical specifications on devices, communication protocols, data resource, and application software being implemented. Based on the APTS pilot project, 10 national technical specifications already developed and formalized into China National Standards, on different devices,
protocols, data resource, and application software being implemented to guide ITS APTS demonstration projects currently ongoing in China.

Continuous improvements in the intelligent bus system are also needed to keep up with the rapid information technology development. Further improvement are also needed to address the multimodal system integration, data mining across operating agencies, and distributed, cloud-based data service that can fully take advantage of the available public and private partnerships.

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