Architecture Design of China National Urban Transit Database

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Abstract. Transport policy making process of national and local governments should be supported by a comprehensive database to ensure sustainable and healthy development of urban public transport. China National Urban Transit Database (CNUTD) has been built to play such a role. This paper is to make an introduction of CNUTD framework including different user’s demands, sustainable data exchange mechanism from different level and application modules. Considering the urban transport development features of Chinese cities, sustainable urban transport development indicators are proposed to evaluate public transport service level in Chinese cities. The application of CNUTD in monitoring sustainable transport development in China is introduced in this paper as well.

Introduction

China has increased its urbanization from 20% to 57% in the last 30 years, five times faster than those earlier industrialized countries, and the total number of vehicles increases dramatically in recent years, growing at an annual rate of 16.4%, of which the private car ownership is increasing at 27.5% annually, which leads to urban traffic congestion, environmental pollution and energy issues.

The extensive traffic congestion and air pollution in Chinese cities pose significant health and safety threats to inhabitants and increase the consumption of fossil fuels. The root cause of these problems lies in the failure to adequately manage urban and transport development by public authorities. This is manifested by a lack of top-level vision for urban transport, insufficient financial support from fiscal policies, the weak administrative capacity of local governments, and imperfect performance evaluation systems, among other issues. However, China still has the opportunity to change direction and promote urban green travel, thus becoming a role model for developing countries, and even developed countries.

To enhance level of service for travelling in urban area, both central and local government in China applied suitable strategies and policies to reduce the traffic congestion and air pollution. Public transport has been considered as the most promising way to solve these problems and is given the priority in urban transport development. Urban public transport systems in China currently depend primarily on buses, with over 500,000 buses delivering over 118 billion passenger per year. However, both urban rail transit and BRT in China are experiencing an unprecedented level of growth, with each seeking to achieve targets of 3000 km of operating miles. With more than 15 million people moving from the countryside to the cities each year, a huge investment in urban transport is clearly urgently needed and wise decisions on how best to target this investment are crucial.

The State Council of China, in the end of 2012, has issued The Guideline on Further Implementing the Prioritized Development of Urban Public Transport, which ensures the leading role of public transit in urban transport. Ministry of Transport is currently organizing a national demonstration project of “Transit Metropolis” in which 37 cities be selected as pilot cities and challenged to achieve a target of over 60% public transport share by 2020. The cities involved are very aware of the importance of this project and the mayors of the cities concerned are heading up the project in their respective cities. The experiences gained from these pilot cities will be spread to all of China’s urban areas.
To monitor the development of public transit and evaluate policy effects on urban traffic improvements. An integrated database needs to be established to support decision making and to assess policies on sustainable urban transport development.

There are several successful cases of database to provide urban transport data to support policy making, transport planning, and evaluation. Several institutions around the world are working on data collection and sharing. Such as the National Transit Database of USA, Traffic Database of Japan, International Traffic Database (ITDb) developed by Miska et al. (2007). ITDb is a database focuses on collecting and providing urban road traffic data (vehicle speed, traffic volume occupancy, etc.) in cities all over the world to provide help to academic researches or other applications. NTD, which focuses on the data collection and application of public transport data, is different with ITDb. The NTD is developed to satisfy the data requirements of all levels of governments and the public. The NTD can evaluate the performance of nation’s public transport system and be used to calculate the amount of public transport system supporting funds. Public transport service quality evaluation cannot be made since daily service data is not collected.

In China, the relevant enterprises and departments of transport have built and applied their own transport databases in recent years, such as “China Transport Statistical Information Network”, “China Public Transport Network” etc. Both of the two databases are nation-wide, but the former one has no scientific and explicit data classification system and no data on urban transport, while the latter one only includes the separated data from different enterprises rather than a systematic, integrated urban transport database. Generally, the shortcomings of existing urban transport databases are listed as follows: Lack of an integrated urban transport database(covering urban and suburban areas, domestic and international data, public transport and private transport data, integrated GIS and urban transport data etc.); Lack of the data uploading and downloading mechanisms; Lack of comparative analyses on urban transport Data; Lack of integrated decision making system.

Demand Analysis

CNUTD as a national database and platform, need to help meet the needs of individual urban transport systems, national and local governments, and the public for information on which to base urban public transport service planning. Different level has different demands for the database, the architecture of the CNUTD is defined as four levels, which are the level of Ministry of Transport, Provincial level, and City level and Company level (see Figure 1).
The major objectives of the database are to provide:

1) A comprehensive source of information for urban public transport managers and planners that enables them to monitor and analyze the present status of and trends in urban transport, including its infrastructure, operational services, investment and other important issues such as its safety, environment, climate change and health impacts.

2) Data support for efforts to evaluate the development level of urban transport in individual cities, focusing primarily on their public transport, BRT and urban rail transit systems, and enable comparative analyses with cities worldwide.

3) A firm scientific basis for decisions related to financial policies and planning in urban transport development in the future.

4) Provide a firm basis for science-based research and provide inputs to regularly update the Annual Report of China Urban Passenger Transport with close to real time data.

Table 1. Demand Analysis of CNUTD.

<table>
<thead>
<tr>
<th>Demands Objects</th>
<th>Demands Analysis</th>
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<tbody>
<tr>
<td>Transit Management Department</td>
<td></td>
</tr>
<tr>
<td>National level</td>
<td>Policy Making, Macro Planning, Foundation Statistic, Central Subsidy, Energy Consumption, Safety, Development evaluation</td>
</tr>
<tr>
<td>Province Level</td>
<td>Policy Making, Macro Planning, Foundation Statistic, Central Subsidy, Energy Consumption, Safety, Development evaluation</td>
</tr>
<tr>
<td>City Level</td>
<td>Dynamic Monitoring, Service Evaluation, Foundation Statistic, Development Planning, Policy Making, Investment and Subsidy, Fare Setting, Network optimization, Collaborative scheduling, Travel Information Service</td>
</tr>
<tr>
<td>Transit Company</td>
<td>Dynamic Monitoring and Dispatching, Enterprise Resource Management Setting, Network Optimization, Travel Information Service, Collaborative scheduling</td>
</tr>
<tr>
<td>Passenger</td>
<td>Enjoy more ways of travel information service, proposal report complaints</td>
</tr>
</tbody>
</table>
Architecture Design of CNUTD

China National Urban Transit Database (CNUTD) is the first nationwide comprehensive urban public transport database, with various types of data such as urban public transport network, infrastructure, vehicles, transit energy consumption, accidents and emergency, individual travel, operation service and so on. The data sources of CNUTD include GIS urban network map, public transport dispatching and operation (buses\BRT\subway\taxies), traffic monitoring system (floating car data), passenger flow and etc. With abundant and wide-covering urban transit transport data, CNUTD supports decision-making, service and performance evaluation, planning, management and operation process of urban transport, helping the development of safe, convenient, efficient, economical, equitable and sustainable urban transport systems for Chinese cities.

To develop a suitable way to store the transport information ranging from raw data to statistical analysis, The architecture of CNUTD includes modules of users management, data exchange architecture, data warehouse and application (see Figure.2). Handling them independently in the design and development allows to focusing on technical aspects on the one hand and the fulfillment of user needs on the other hand. The CNUTD is not based on existing data and tailored for its provision, but based on the final operation. It requires that CNUTD data must have highly transfer efficiency and highly quality standard according to the objective of CNUTD. This is the major difference to other existing implementations of data platforms, where the design is purely based on a single set of data types.

Users Management

CNUTD users include data providers and decision makers. Bus companies, metro and taxies operators, different level of departments of transportation (MOT\PDOT\CDOT) are data providers whom are required to register the database and upload data regularly. All levels of DOT and their supporting research agencies are decision makers who can make use of the data analysis, evaluation and simulation results to develop transport development strategies. During the data uploading and using processes, database administrator implements data quality management to ensure good data quality for the proper work of algorithms and tools. All datasets are strictly checked according to the quality management rules, which require a minimum set of Meta-information.

Figure 2. Architecture of CNUTD.
Other potential users of CNUTD data include domestic and international academic organizations (NGOs, Universities, Specialists, etc.), and individuals. Different levels of right to the database are delivered to different groups of users. Ministry of Transport of China establishes specific network for national and international data exchange and cooperation.

Data Exchange

According to the demands analysis, there are five levels of data providers, three of them are departments of transport, they are Ministry, Provincial and City separately, the other two levels are the operation companies and passenger level separately. Because they have different demands, the data demands also different, so there need to be share and exchange data between different levels of users, which described in figure 2.

Data Warehouse

Concerning the data storage, it is necessary to design suitable framework for data warehouse, which improves the robustness of the CNUTD. It consists of three levels, geographic layer, transport layer and data modeling layer.

Geographic Layer. CNUTD catalog transport infrastructure into two types of abstracted groups, the link and the node, which defines a minimum set of Meta information to allow an efficient search for the user and fast access to the wanted information. Geographic layer provides basic map information that includes road infrastructure, all kinds of point of interests (POIs-includes banks, hospitals, shops, restaurants, oil and gas stations and etc.), bus lines and bus stop stations, metro lines and stop stations.

Transport Layer. Compared with static road and POIs information stored in geographic layer, transport layer is consist of knowledge of all moving objects such as cars, buses, metro-trains, taxies, pedestrians, passengers and etc., each moving object includes attributes and dynamics (including energy consumption, speed, ridership, flow, travel time, position and etc.) to describe its characters, such unique and general information are stored in transport layer.

Data Modeling Layer. To provide different decision support for different transport departments, based on the geographic layer and transport layer, the data modeling layer mainly including such modeling as transit performance evaluation model for cities, service evaluation model for transit operation companies, traffic congestion index evaluation model for cities, energy consumption and predication model for different transit modes and etc. Decision support could be provided through combining the data modeling and the massive urban public transport data.

Data Application

According to different users, the database need to provide different application, based on the demands analysis, we have defined four levels of application, include comprehensive monitoring, transit performance evaluation of cities, traffic performance evaluation of cities from Ministry and Provincial level, service supervised of transit companies, advanced transit information system from City level, intelligent fleet dispatching and enterprise resource management from companies level.

Summary

In this paper we have proposed the framework design of the CNUTD, and an indicator system of sustainable urban public transport system tailored for the current situation of urban development in China. The results of this study provide the evaluation basis for sustainable urban transportation in China. CNUTD will be the primary source of information and statistics on the urban transportation systems of China, serving to improve China sustainable urban transport development.

Functions of simulation and evaluation, congestion monitoring, energy efficiency, transport planning and public transport policy making has been implemented by corresponding systems. However, transport financing function is still waiting to be realized; databases still need to be
expanded and improved; communications between different systems need to be strengthened. It is also important to improve the applicability of the various indicators, the scientific and operability of the weight of each indicator, so greater adaptability would be needed for the next stage study.

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References


