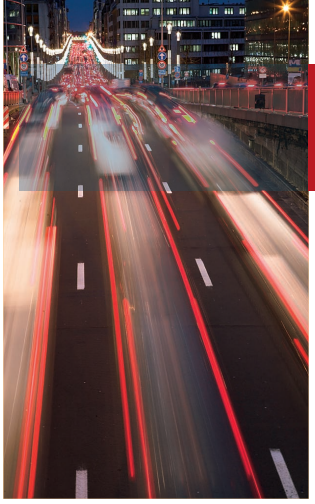

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Parallel Traffic Management for the 2010 Asian Games

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The 16th Asian Games will be held in Guangzhou, China, from 11 to 27 November 2010. Guangzhou, the capital of Guangdong Province, will be the second city in China to host the Asian Games after Beijing in 1990. With 42 sports scheduled, more than 100 thousand people directly involved, and a scale similar to Beijing's 2008 Olympic Games, it will be the largest Asian Games event. In addition to regular games, the First Asian Para Games, the parallel sport event for disabled Asian athletes, will start two weeks after the conclusion of the 16th Asian Games.

One of the major challenges facing the 2010 Asian Games is the transportation problem. Because the games will use 58 existing game facilities and 12 new sports stadiums, which are located across the Guangzhou metropolitan areas (see Figure 1), safe and effective traffic control and transportation management will be essential to their success (see http://www.gz2010.cn/en/). The city already has a big issue with road congestion, caused mainly by the inadequate supply of transportation infrastructures. For example, between 2001 and 2008, the number of private passenger vehicles in Guangzhou increased 529 percent to 783 thousand, an annual increase of 26.9 percent. However, only 193.1 km are scheduled to be added to the total length of metropolitan road networks between 2007 and 2010, which is an increase of 5,528 km, a mere 3.6 percent. By 2010, the number of private passenger vehicles will increase to an estimated 1.261 million, but the space for new roads and transportation infrastructures is limited.[1] Under such time and infrastructure constraints, Guangzhou has chosen intelligent transportation systems (ITS) to enhance and improve its traffic safety and efficiency for a better 2010 Asian Games.

ITS Measures Scheduled

Based on the valuable experience learned from the 2008 Olympic Games in Beijing, as well as the current traffic conditions, existing transportation infrastructures, and expected mobility demands for the 2010 Asian Games, the Guangzhou Metropolitan Transportation Administration will be implementing several major ITS measures to ensure coordinated and effective traffic networks during the games:[2]

- demand management through the establishment of smart parking facilities and bus rapid transit (BRT) lines in suburban areas;
- better and enhanced capability, quality, and environmental sustainability in bus services, taxi systems, and traffic control and management through the use of information technology and intelligent systems;
- dynamic traffic route assignment and the introduction of designated routes and high priority vehicles for the Asian Games;
- a GPS-based real-time information system for scheduling and dispatching more than 3,000 vehicles registered to serve the Asian Games, which will be critical to safely move people and equipment around in a timely manner;
- an intelligent urban traffic management system based on the existing Guangzhou-Intelligent Traffic Management System (GZ-ITMS) facility,

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Published by the IEEE Computer Society

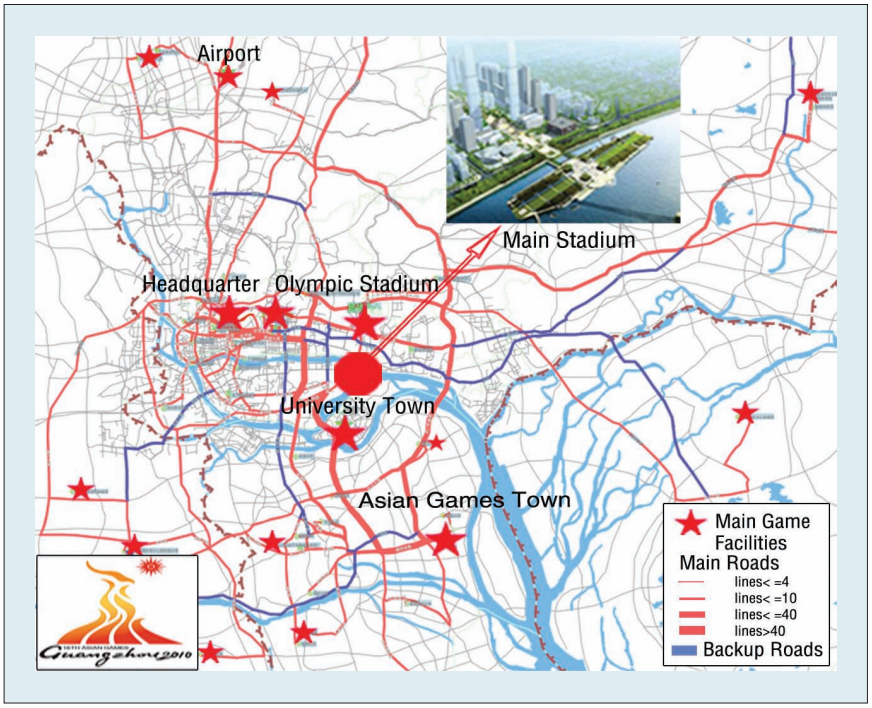

Figure 1. Distribution of game facilities and traffic networks for 2010 Asian Games. Intelligent transportation systems (ITS) will help transport people and equipment safely and efficiently.

Figure 2. Parallel traffic management system (PtMS) version 3.0. Actual (right side) versus artificial (left side) traffic systems.

which includes new traffic-flow measurement, traffic guidance, accident detection, vehicle-plate identification, and traffic-control systems; and
- a comprehensive traffic information broadcasting system that will provide detailed, real-time, and accurate traffic-related information to observers, reporters, athletes, organizers, interested citizen, and the general public.

These measures are expected to significantly reduce traffic flow to the central district.

PtMS for 2010 Asian Games

To implement the planned ITS measures for the Asian Games, the Guangzhou Municipality and the Chinese Academy of Sciences have formed a joint partnership that will construct a parallel traffic management system (PtMS) to support various ITS functionalities.[2–4] Figure 2 shows the demonstration system of PtMS version 3.0 that will be used for this purpose.

The PtMS operation is based on the ACP (which stands for artificial systems, computational experiments, and parallel execution) framework[2,4] that uses artificial transportation systems for modeling and representation, computational experiments for analysis and evaluation, and parallel execution for control and management of transportation systems. In a PtMS, both actual and artificial transportation systems are operated with identical but independent traffic operation systems (TOSs), and transportation operations are carried out under three modes:[2]

- The *learning-and-training mode* is supported by operator training systems for transportation (OTST) software for traffic operators and administrators, which incorporates actual procedures for traffic operations and emergency handling to make its functionality more realistic and effective. OTST sessions can be generated manually by human operators or automatically by agent programs.
- The *experimentation and evaluation mode* is supported by dynamic network assignment based on a complex adaptive system (DynaCAS) software system for conducting computational transportation experiments, detecting existing and emerging traffic patterns, and helping the operation of both advanced traveler-information systems (ATISs) and advanced traffic-management systems (ATMSs).

- The *control and management mode* is supported by the agent-based distributed and adaptive platform for transportation systems (Adapts) software environment for designing, constructing, managing, and maintaining autonomous-agent programs for traffic tasks and functions. Those agents are delivered to traffic control centers, roadside controllers, sensing devices, and information systems via communication networks to make correct decisions and collect the correct information at the correct times.

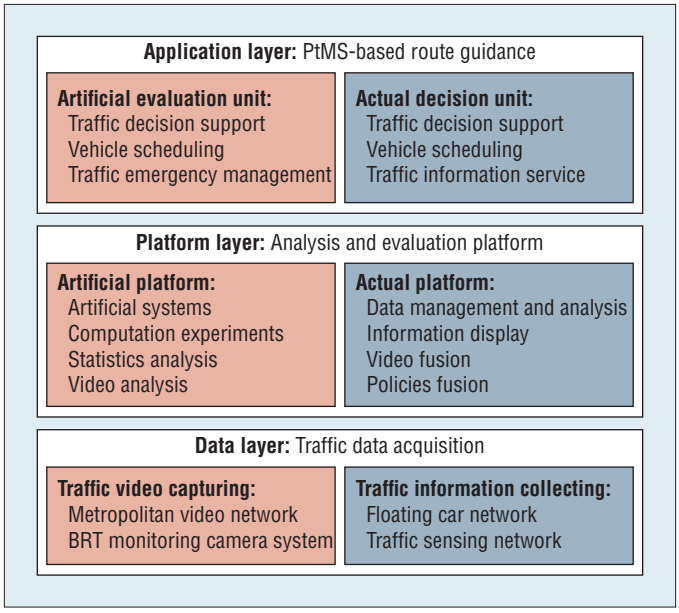

Figure 3. The parallel traffic management system (PtMS) system architecture and main functionalities for the 2010 Asian Games. The system consists of three layers: data acquisition, operational platforms, and traffic applications.

So far PtMS version 3.0 has been successfully applied in the city of Su Zhou, China, with an initial result of a 20 percent improvement in overall traffic efficiency.[5] For the 2010 Asian Games, a simplified but more reliable and effective version of PtMS will be constructed and operated with real-time video and other traffic information.

Figure 3 shows the PtMS's main functionalities for the 2010 Asian Games. Roughly speaking, our system consists of three layers focusing on data acquisition, operational platforms, and traffic applications.

Traffic Data Acquisition

In addition to the existing traffic sensing networks, including conduct loops, monitoring cameras, probe vehicles, and so on, we will also install a new video-based traffic-flow measurement system. Specifically, based on the current metropolitan video network and BRT monitoring camera system, a new system called RoadScope will be introduced to build an automated system that collects real-time vehicular and pedestrian traffic-flow information from all major routes and stations involved in the Asian Games.

Web 2.0 type interactive systems, based on the current taxi management system, bus-dispatching system, and BRT operating system, will also be constructed to acquire, analyze, and distribute traffic information to support dynamic route guidance and traffic effectiveness evaluation for both public and governmental uses.

Analysis and Evaluation Platform

To provide accurate, reliable, and timely traffic information, we will develop an estimation and verification platform according to DynaCAS[3] that uses artificial transportation systems and computational experiments to analyze and evaluate the states of traffic networks and effectiveness of traffic strategies.

New software and hardware will be introduced to the current metropolitan traffic information to enhance its computing capacity and storage space so that the required DynaCAS functions can be implemented. Particularly, this platform will include different artificial transportation systems and experiment toolboxes for optimization, emergence handling, testing and evaluation, and operation support.

DynaCAS represents transportation networks at four abstraction levels—microscopic, mesoscopic, macroscopic, and logic—and provides two types of functions:

- *Conventional functions* include estimation and prediction of traffic conditions, evaluation and optimization of traffic control and management decisions, and generation of route guidance for travelers and other information for traffic operators and service providers.
- Special functions include fast estimation and prediction of traffic states using neural networks, design of traffic control algorithms through adaptive/approximate dynamic programming (ADP); generation of traffic guidance and management information using the state classification method; and computational experiments for road construction, special events, rare demands, severe weather, traffic incidents, and emergency management.

PtMS-Based Route Guidance

Figure 4 illustrates the main components and decision flow for PtMS-based route guidance. It consists of the actual transportation operation system (TOS) for traffic information distribution and guidance generation

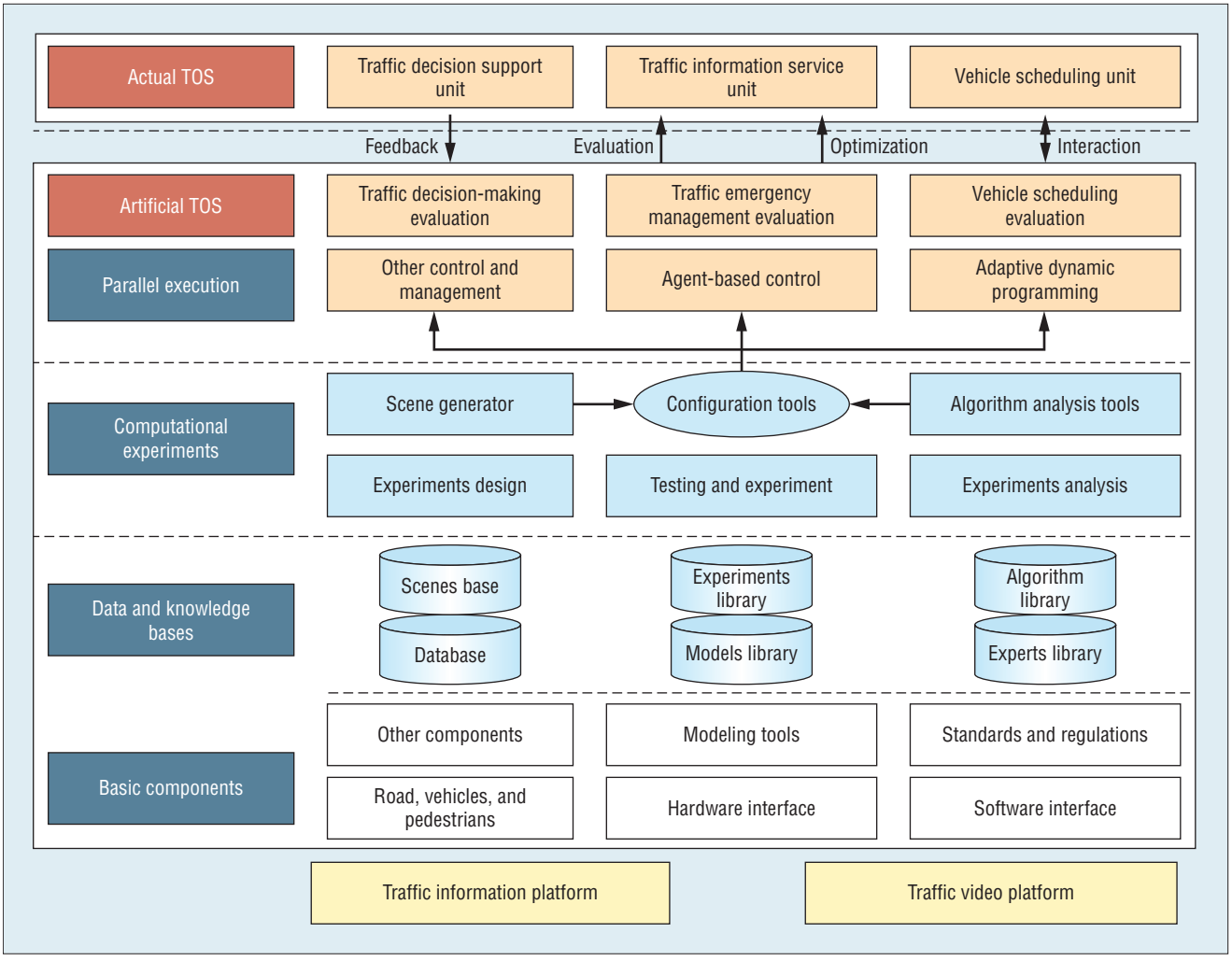

Figure 4. System architecture of parallel traffic management system (PtMS) based route guidance. The actual transportation operation system (TOS) supplies traffic information distribution and guidance generation, and the artificial TOS helps with traffic scenario generation, decision testing, and effectiveness evaluation.

and the artificial TOS for traffic scenario generation, decision testing, and effectiveness evaluation. Its major tasks are to achieve the effective vehicle scheduling, dispatching, and route guidance for the 2010 Asian Games opening and closing ceremonies and to assist with traffic flow in event of unexpected events, unplanned demands, and various emergencies.

The actual TOS consists of a traffic decision support unit, a vehicle scheduling and dispatching unit, and a traffic information service unit that provide real-time information for traffic operators, Asian Games organizers, and the general public. In particular, this system provides demand forecasting for game vehicles as well as dynamic estimation of traffic flow and vehicle capacity near or at sport stadiums. (We treat the traffic control system as a separate system, so it is outside this article's scope.)

The artificial TOS also consists of three units for evaluating traffic decisions, vehicle scheduling and dispatching strategies, and information effectiveness and emergency management policies. This system is linked directly with the analysis and evaluation platform and supported by a hierarchical architecture with four layers: basic components, data and knowledge bases, toolboxes and algorithms for implementing computational experiments, and parallel execution. We have specifically designed and constructed all these layers for the 2010 Asian Games.

We built a testing and evaluation system for the opening and closing ceremonies based a special artificial transportation system so that various experiments can be conducted systematically to analyze and verify various traffic control and management strategies, different vehicle scheduling and dispatching algorithms, as well as accidents and emergence management polices and rules designed for the two important special events.

Parallel traffic control and management for the 2010 Asian Games represents another milestone in combining and applying AI techniques and methods in complex systems in real-world complex problems. We hope that the successful implementation of PtMS in Guangzhou will provide further valuable first-hand experiences in testing and evaluating the effectiveness of the ACP-based control mechanism for both engineering and social systems and will bring a real revolution in the operation of future complex systems in a connected world.

Acknowledgments

This work is supported in part by NSFC 70890084, 60921061, 90920305; MOST 2006CB705506, 2006AA010106; and CAS 2F09N05, 2F09N06. We thank Fei-Yue Wang for his guidance and encouragement, as well as the Hi-Tech Bureau of CAS, and Guangzhou Municipality for their support in the implementation of this project.

References

1. "Execution Plan of City Transportation Organization Strategy of Guangzhou Asian Games," HuiJiaoHan no. 1799, Comm. Commission of Guangzhou Municipality, 2009.
2. F.-Y. Wang, "Toward a Revolution in Transportation Operations: AI for Complex Systems," *IEEE Intelligent Systems*, vol. 23, no. 6, 2008, pp. 8–13.
3. N. Zhang et al., "DynaCAS: Computational Experiments and Decision Support for ITS," *IEEE Intelligent Systems*, vol. 23, no. 6, 2008, pp. 19–23.
4. F.-Y. Wang and S. Tang, "Artificial Societies for Integrated and Sustainable Development of Metropolitan Systems," *IEEE Intelligent Systems*, vol. 19, no. 4, 2004, pp. 82–87.
5. S. Tang et al., "Applications of Intelligent Control Systems for Main Traffic Arterials," *J. Highways*, no. 11, 2009, pp. 226–233 (in Chinese).

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