Cartesius and CTNET:
Integration and Field Operational Test
(PATH Task Order 5324)

1. Why was this research undertaken?

Non-recurrent congestion presents a difficult problem for existing localized automated traffic control systems. These systems operate with control parameters that are fine-tuned to meet the normal demands of recurrent congestion in the system. Incidents in the system can create disturbances that are beyond the control of such localized systems, rendering them incapable of mitigating the resulting congestion and leading to increased delays. This creates a compelling justification for interfacing such systems with a global traffic management subsystem to develop a general corridor traffic management architecture that can dynamically respond to incidents in the system.

PATH Task Order 5324 (TO-5324) is the first phase of a multi-year project to combine research in multi-jurisdictional traffic management with functioning freeway and arterial traffic control systems. The main goal of the effort is to modify the Coordinated Adaptive Real-Time Expert System for Incident management in Urban Systems (Cartesius) to work with the Caltrans Traffic Signal Management and Surveillance System (CTNET). Cartesius is a multi-agent incident management tool that provides coordinated, area-wide response strategies to incidents occurring in a multi-jurisdictional transportation network. In typical use, each participating traffic management agency maintains a Cartesius agent that is aware of the traffic control and information systems the agency can use for incident response. When an incident occurs, the collective of participating Cartesius agents uses a generic distributed algorithm to search available management responses provided by the available traffic management subsystems.

Earlier work had focused work on interfacing Cartesius with the Caltrans ATMS system to provide freeway incident mitigation, but no ability to interact with arterial traffic management subsystems was available outside of a simulation context. CTNET is such a subsystem, providing for integrated management of traffic signals to allow operators to remotely manage, view, and log real-time traffic signal field data. Interfacing these two systems will bring Cartesius a step closer to practical deployment in the state of California by finally providing Cartesius with connections to both freeway and arterial control systems that are necessary to support true multi-jurisdictional management.

2. What was done as part of this research?

As the first year of the multi-part effort, TO-5324 focused on defining the requirements for modifying the Cartesius system to meet the needs of Caltrans, in general, and to integrate the system with CTNET, in particular. This was achieved in two phases.

The discovery phase focused on understanding the challenges to deploying the existing Cartesius prototype stemming from its initial research focus and the associated assumptions that governed development of the first generation of the software. This included assessing the data and algorithmic requirements of Cartesius from a deployment rather than a research perspective. During this process, a number of technical issues with the prototype were identified including: limitations of the existing user interface, a lack of flexibility in adding agents to the system, a difficulty in updating the knowledge base, a number of overly restrictive algorithms that limit potential deployment, and a reliance on a proprietary software platform whose strengths do not match the needs of the system.
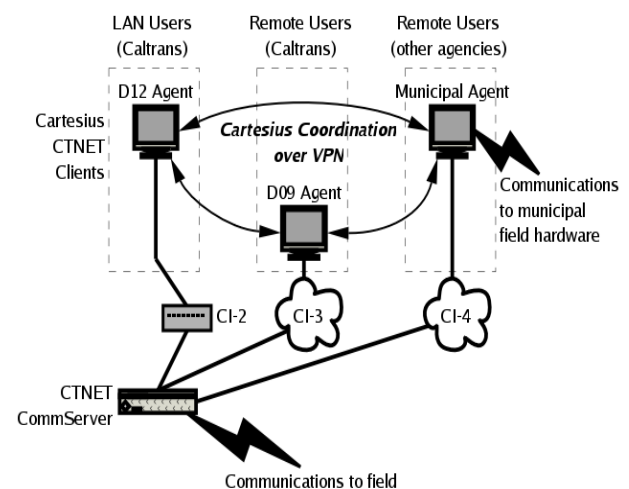

Typical Cartesius/CTNET Communications

CTNET was also studied as part of the discovery process to identify the best way to connect Cartesius and CTNET. After assessing the relative capabilities and functional roles of Cartesius and CTNET, this first year of research concluded that the best way to interface the two systems is to have Cartesius act as a client to the CTNET CommServer in order to obtain traffic data from the managed arterial subsystem and to send signal control directives in accordance with cooperatively determined response strategies. A java library was developed to implement CTNET's communications protocol and allow any java program to communicate with the CTNET server as an authenticated client.

The results of the discovery phase were then used to develop a set of requirements for modifying Cartesius to interoperate with CTNET and move closer to deployment.

3. What can be concluded?

The original Cartesius framework, focusing on cooperative information sharing and coordinated response among relatively autonomous traffic management agencies, remains a powerful option for the future of system-wide integrated traffic management. Integration with existing traffic management subsystems remains a critical step in the successful deployment of the architecture and the combination of Cartesius, CTNET, and Caltrans ATMS system offer the most viable path to this end.

The results of the first year of this project are a set of 69 specific requirements for the reimplementation of Cartesius to meet these deployment needs, including core functional requirements, user interface and API requirements, and database requirements.
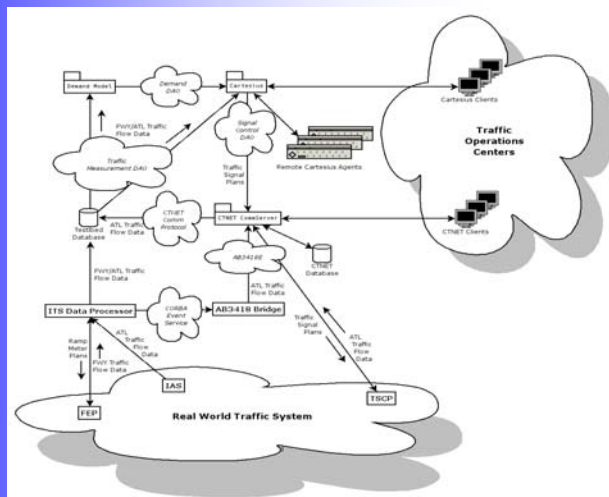
Planned Cartesius/CTNET Deployment

4. What do Researchers Recommend?

The remainder of this multi-year project should continue as planned under TO-6324, developing the Cartesius platform to satisfy the requirements determined during the TO-5324 using open source software to dramatically reduce the deployment costs of the system. TO-6324 will produce an implementation of Cartesius in the ATMS Testbed in Irvine that connects the system with the Caltrans District 12 ATMS system and a limited CTNET installation in the City of Irvine. The system will be evaluated in both simulated and on-line modes to verify its performance in the Testbed network.

5. Implementation Strategies

Cartesius and CTNET are complementary systems each serving vital roles in advanced traffic management. Coupled with the Caltrans ATMS system, this trio of tools has the potential to be a complete multi-jurisdictional traffic management system that offers cooperative incident management functions for neighboring agencies. We anticipate that the re-implementation of Cartesius with an increased focus on deployability will make Cartesius/CTNET a more viable option for future deployments in the State of California.

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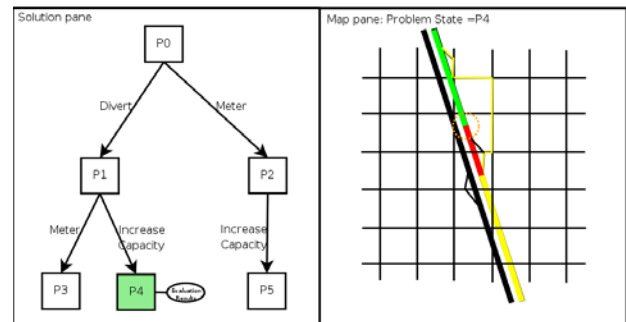
Cartesius Response Tree and Map Pane