RESEARCH NOTES

January 2007

PATH Task Order 5313

1. Why was this research undertaken?

Multi-jurisdictional incident management is common problem in urban traffic management that continues to present challenges to system managers. Prior research funded as part of the ATMS Testbed at UC Irvine proposed as a solution to this problem: the Coordinated Adaptive Real-Time Expert System for Incident management in Urban Systems (CARTESIUS). The CARTESIUS approach is to view multi-jurisdictional traffic management from a Distributed Problem Solving (DPS) perspective whereby the global traffic management problem is decomposed into a collection of subproblems in which each agency optimizes its local subnetwork while trying to satisfy constraints from neighboring jurisdictions deriving from potential response strategies under consideration.

Research using the original CARTESIUS prototype demonstrated the promise of both the DPS philosophy and its particular implementation. Development of the original prototype, however, was heavily oriented toward research and did not produce a deployment-ready product. PATH Task Order 5313 was funded to test the existing implementation of CARTESIUS as a precursor to developing a deployable version for general use in California.

2. What was done as part of this research?

The research plan originally identified three broad issues to be resolved in a limited Field Operational Test (FOT) including: related architectural issues making the existing prototype software deployment ready, verification and validation of embedded knowledge, and protocols for testing developing technology in the field. To address these issues, the research plan called for a limited FOT of CARTESIUS involving real-world data and Traffic Management Center (TMC) personnel.

During the course of the research, however, it became clear that the original project goals were unrealistic for a variety of reasons. The core reasons involve limitations of the existing CARTESIUS prototype that stem from its history as a research tool. Because of these identified limitations, and because concurrent PATH research related to CARTESIUS added additional changes to the expectations regarding CARTESIUS, the scope of Task Order 5313 was revised to perform a technical evaluation of the existing prototype, revise the functional role of CARTESIUS to be in-line with Caltrans expectations, and to develop a set of recommendations for making a product that implements the CARTESIUS philosophy in a manner consistent with real-world deployment.

3. What can be concluded?

The core philosophy of CARTESIUS provides a promising framework for inter-jurisdictional traffic management. In particular, the power of DPS approach proposed by CARTESIUS maps nicely to the multi-jurisdictional traffic management domain. The original prototype implementation of these concepts served its role to demonstrate the efficacy of the approach, but with the focus of the project shifting toward deployment, it has now reached the end of its useful lifetime.

It is therefore premature to conduct an FOT with the existing prototype. Indeed, any conclusions drawn from such a test would suspect at best due to the simplifying assumptions made to make the prototype workable for research purposes.

4. What do researchers recommend?

The evaluation of the prototype produced a set of recommendations for moving the CARTESIUS project forward including:

- scrapping the current proprietary G2-based implementation in favor of one using general purpose languages and communications protocols,
- the use of an event-driven, service-oriented messaging architecture to provide communications between jurisdictional agents,

- a redesign of the software to better separate analytical functionality (business logic) from interface functionality,
- a revision of CARTESIUS data model to leverage data standards and relational datastores as well as available libraries for manipulating such data,
- refocusing CARTESIUS on characterizing the problem state and the implications of potential control actions rather than a focus on including CARTESIUS in a closed control loop,
- restating and focusing the set of functional requirements that define CARTESIUS role in the traffic management system

Based on these findings, we have reinterpreted how the CARTESIUS philosophy can be used as an organizing principle for real-world multi-jurisdictional systems. This interpretation focuses on the power of the DPS approach CARTESIUS uses to partition analysis and optimization functions in the system across jurisdictions. This partitioning minimizes the amount of local information that must be shared between jurisdictions and paves the way for defining a collection of TMC-to-TMC messages that support the CARTESIUS DPS perspective in a manner that respects existing deployments.

5. Implementation strategies

As part of the Implementation Strategy, it is recommended to build a new TMC software agent that provides operators with a view of the system from CARTESIUS DPS perspective by using the new TMC-to-TMC messages to construct a view of the global problem from the local perspective. This tool will initially be advisory in nature, providing operators with guidance regarding how local actions are likely to conflict with the actions of neighboring jurisdictions (or lack thereof). Where it is appropriate, and where local policy permits, the new management agent could also be connected to available control subsystems to provide operational or tactical control in response to problems in the system.

6. Project Contacts

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