THE TMDD STANDARD –

DATA INTEGRATOR FOR INFRASTRUCTURE INFORMATION

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ABSTRACT

The ITS industry is moving toward technologies for "big data" management as a tool to efficiently handle and integrate real-time and historical information about the surface transportation network. This paper discusses the opportunity to leverage the ITE/AASHTO Traffic Management Data Dictionary for Center-to-Center Communications (TMDD) Standard to support data integration (big data) in the ITS and Connected Vehicle environment. Current initiatives such as the USDOT's *Real-Time System Management Information Program* (RTSMIP) *Data Exchange Format Specification* (DXFS), the *Integrated Corridor Management* (ICM) program, and the *Connected Vehicle* program rely on information exchanges between transportation management centers and other centers. The TMDD Standard, which already interfaces with other domains such as road weather information, serves as the key standard to support the interfaces that collect and share the data necessary for the seamless integration of data about the transportation infrastructure.

Key Words: systems engineering, ITS standards, Reference Implementation, Integrated Corridor Management, Connected Vehicles, Real-Time System Management Information Program (RTSMIP), Data Exchange Format Specification

INTRODUCTION

A number of contributing factors have led to an exponential growth in the volume of data being collected from transportation systems. Key factors include: increased number of ITS deployments, increased numbers of centers sharing information, the increased efficiency and capacity of recent technology and mature standards, and the emergence of tools capable of managing "big data". The coupling of these factors has resulted in a new paradigm and new operational challenges in ITS: the focus of ITS programs has shifted *from* addressing gaps with new deployments *to* integration, maintenance, upgrade, and sharing of data from existing deployments. The explosive growth in the amount of data that transportation agencies handle raises new questions -- the question is no longer "where do I need to build out ITS infrastructure and where can I get data", but instead has become "how do I deal with the data I already have, and how do I integrate it with all the other data I am receiving".

ITS Standards are a key component of a transportation agency's toolbox to allow an agency to efficiently manage, integrate, and share huge volumes of transportation data. In particular, the Traffic Management Data Dictionary (TMDD) allows transportation management centers to connect and exchange data in a common format[1].

Three key USDOT programs represent the next wave of ITS:

- *Real-Time System Management Information Program (RTSMIP) Data Exchange Format Specification (DXFS):* a Federal Rule covering the sharing of real-time transportation information, including a suggested data exchange format[2];
- *The Integrated Corridor Management Program (ICM):* an initiative by USDOT to optimize the use of the existing transportation assets and leverage unused capacity along transportation corridors. This program is based on multiple agencies jointly managing a transportation corridor, rather than having each agency manage its own transportation assets as a standalone system;
- *Connected Vehicle:* the connected vehicle environment includes the collection and analysis of massive amounts of real-time transportation data from a first-person (or first-vehicle) source

Each of these programs relies heavily on center-to-center (C2C) information sharing. As the key industry standard for C2C communications, the TMDD Standard supports the system interfaces necessary to collect and share the transportation data for infrastructure data integration. TMDD is already being used in several of these programs and has proven easily adaptable to meet the challenges of "big data" C2C information sharing.

BACKGROUND

In mid-2006, work began on the development of Version 3.0 of the ITE/AASHTO Traffic Management Data Dictionary for Center-to-Center Communications (TMDD) Standard. The TMDD is an information-level standard that defines messages and data elements for information exchange between a traffic management center and other management centers. The goal of the TMDD standard is to support the development of system interfaces between

centers, primarily for real time traffic information exchange. The standard does not define nor discuss the processes that occur within each center.

Version 3.0 of the TMDD includes significant updates from the previous version, Version 2.1. The older version supported information exchanges, such as transportation network details, event information (both planned and unplanned), device inventory, device status, device control requests, and data collected from the transportation network including traffic volumes and weather conditions. Version 3.0 added data elements and message sets from the *Clarus* initiative and the Archived Data User Service (ADUS) standards effort, addressed several unresolved issues from earlier versions, and incorporated a systems engineering process (SEP), which added user needs and requirements.

REAL-TIME SYSTEM MANAGEMENT INFORMATION PROGRAM

The TMDD Standard was recently identified as a key standard by USDOT's Real-Time Data Exchange Format Specification (DXFS)[3]. The DXFS was developed by USDOT in response to Section 1201 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), which instructed the Secretary of Transportation to "…establish a real-time system management information program (RTSMIP) to provide, in all states, the capability to monitor, in real-time, the traffic and travel conditions of the major highways of the United States and to share that information to improve the security of the surface transportation system, to address congestion problems, to support improved response to weather events and surface transportation incidents, and facilitate national and regional highway traveler information." The TMDD Standard was one of the standards specifically mentioned in the rulemaking to be assessed for the DXFS. A Final Rule was published on November 8, 2010, establishing the provisions and parameters for the RTSMIP program to be established by State DOTs, other responsible agencies, and partnerships with other commercial entities. The Program is to be established on all Interstate routes within 4 years (November 8, 2014) and on other significant roadways as identified by the States and local agencies within 6 years (November 8, 2016)[2].

The DXFS assists agencies in specifying and developing an RTSMIP implementation. The DXFS is a standards-based specification that can be used to define the information exchanges across a system-to-system interface to fulfill the requirements of the RTSMIP. Except for transit-specific information and some weather alert information, the DXFS references the TMDD Standard to fulfill all the requirements identified by the RTSMIP. The DXFS will support regional data integration by providing a common vocabulary for agencies throughout a region to either exchange traveler information related data directly, or provide that data to a regional database used to integrate the multiple sources of data into a single regional view.

INTEGRATED CORRIDOR MANAGEMENT

The Integrated Corridor Management (ICM) initiative by USDOT is an effort seeking to optimize the use of the existing transportation assets and leverage unused capacity along transportation corridors. To enable these capabilities, the program relies on multiple agencies jointly managing a transportation corridor, rather than having each agency manage its own transportation assets as a standalone system. Such a system relies on the exchange of

transportation information between the partner agencies, making communications between and among transportation management centers vital to the success of an ICM program. Standardized communication of transportation information among partner agencies is the key to a coordinated effort that results in a positive impact within the corridor. In addition, a standardized approach facilitates incorporation of new partner agencies.

Information to be shared between management centers include the definition of the transportation network, existing (and planned) conditions on the transportation network, and the strategies to be implemented. The TMDD Standard already supports many of these information exchanges.

The San Diego Integrated Corridor Management site uses TMDD v3.0 to collect current traffic conditions from the various transportation agencies. Based on the traffic data collected, the ICM system selects the operational strategies to implement. The ICM system then provides the operational strategy information, using the TMDD Standard, to the transportation agencies for implementation. Although San Diego uses the TMDD Standard, it has implemented numerous region-specific extensions to support user needs not supported by the current TMDD Standard, such as support for transit, parking facilities, High Occupancy Tolling (HOT) lanes, and simulations and network prediction models.

CONNECTED VEHICLE RESEARCH

Research on the Connected Vehicle environment has focused on two key interfaces - vehicle to vehicle (V2V) and vehicle to infrastructure (V2I). Standards have been identified and developed for the V2V and V2I interfaces, such as SAE J2735 and the IEEE 1609 family of standards, but the interfaces within the infrastructure, including the interfaces between management centers, have primarily been ignored by the research[4].

The lack of a clearly defined center-to-center (C2C) standard for connected vehicles has an impact on the deployment. Many of the dynamic mobility and real-time data capture and management applications being considered rely on interfaces between the management centers that collect the data from multiple sources and the regional databases that collect, manage and integrate the multi-modal transportation data and data sets. These regional databases are expected to support applications that assist transportation agencies with traffic performance monitoring, asset management, evaluation of transportation strategies, and transportation operations and management decisions.

An analysis of transportation data that might be exchanged through these interfaces indicate that the TMDD Standard already supports most of the data. For example, the TMDD Standard supports the exchange of detector information (volume, occupancy speed), aggregate vehicle data (e.g., travel times, speeds), traveler information, and many of the static and dynamic information from traffic signal controllers. Though the current version of the TMDD Standard (v3.03c) does not support exchange of raw vehicle data, such as individual vehicle position, vehicle heading, vehicle acceleration, or vehicle size, that are being broadcast as part of the Connected Vehicle environment; it was recognized that the TMDD Standard can be easily expanded to support the exchange of this new data.

As the TMDD Standard is already used in many states, the use of TMDD Standard to support the interfaces with regional databases will allow a quicker deployment of this environment

and with less risk. The TMDD Standard can easily be expanded to support other applications as the Connected Vehicle infrastructure is built out ensuring that the potential of a Connected Vehicle environment may be fully realized.

DATA AGGREGATION CLEARINGHOUSE

As seen from the examples of three key USDOT initiatives, the collection and aggregation of surface transportation data, and distribution of that data is a key capability of each initiative. For the RTSMIP, transportation data is collected for traveler information; for the ICM, transportation data is collected for optimizing transportation capacity; and for Connected Vehicles, transportation data is collected for safety, mobility and environmental benefits.

Each initiative relies on the capabilities of a regional data clearinghouse to collect current transportation data from multiple sources, verify the collected data, then fuse that data to create a regional view of near real-time transportation information. This validated, verified, and processed regional transportation data can then be distributed to transportation agencies and transportation users in a variety of ways.

In addition, TMDD also serves as a key information exchange standard to other domains such as road weather data management, specifically, USDOT's *Clarus* initiative. The standard provides support to interface directly with the *Clarus* system, including the ability to retrieve *Clarus* system data, and exchange that information with others. TMDD also provides support for archived data user services, such as the ability to archive and retrieve ITS-generated data including metadata that is part of an archive.

Using the TMDD Standard to define the interfaces to and from the data clearinghouse is a logical step. The benefits of using well-defined, widely-deployed, and testable standards has been well documented. They include interoperability, lower implementation risk, and lower integration, operational and maintenance costs. Standards can also make procurements and testing easier.

REFERENCE IMPLEMENTATION

The use of TMDD is only sensible if the interface and the contents across that interface can be verified and validated. USDOT has developed a C2C Reference Implementation (RI) tool to aid in performing testing of center-to-center interfaces. The motivation for developing this tool is to standardize the development of a set of test plans, test cases and test procedures for center-to-center interfaces, which would be an enormous effort and waste of scarce resources if developedfor each implementation. For example, TMDD v3.0 consists of approximately 120 user needs and 1,160 requirements - verifying all those requirements have been fulfilled without a tool would be prohibitively expensive.

The RI tool allows an implementation to create test configurations based on the selected user needs and requirements, execute the test, and create test reports. The RI tool is not limited to testing the TMDD Standard, it can be configured to test other C2C standards, including application layer standards, but it currently provides test suites for TMDD v3.03c Standard only. User-defined test suites can be created, allowing a user to support user-defined user needs and requirements, and to support additional test cases and test procedure scripts.

SUMMARY

As seen from the examples above, the TMDD Standard is the key to successful deployment of these data collection and integration efforts because the TMDD is a widely deployed, testable standard that already supports much of the data that is expected to be exchanged across the interfaces. Successful implementations of the standard, as outlined in the first two examples above, have proven that the TMDD can be used for a variety of C2C deployments, including ICM and real-time information management.

These deployments represent a first step in big data implementations related to the transportation network. The next step will not only see increased examples of these deployments, but also exponential growth in the available data through the connected vehicle program. While much focus has been put on the ability to collect and analyze this enormous quantities of data, emphasis should also be placed on the ability of agencies to integrate and share these huge data sets. The TMDD is the key standard to support these data integration and exchange efforts.

To successfully support these key USDOT initiatives, the next iteration of the TMDD Standard should include expanded support for ICM deployments and connected vehicles. The TMDD Standard should be emphasized as a key component of successful ICM, RTSMIP and connected vehicle deployments. In addition, care should be taken to support the maintenance of TMDD so it may serve the needs of these next-generation ITS deployments.

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