White Paper

Intelligent Transportation Systems (ITS) Office – Florida Department of Transportation

Strategy for Legacy Field Device Integration into new FDOT TMC System using NTCIP Controllers

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1. Introduction

This *white paper* is presented to the Florida Department of Transportation (FDOT) Intelligent Transportation Systems (ITS) Office to assist in the selection of a suitable strategy to integrate the existing ITS devices that are deployed in Florida into the new Integrated Traffic Management System currently under procurement.

It is common to the various strategies that all new devices procured in Florida, and integrated with the Traffic Management System, will conform to the National Transportation Communication for ITS Protocol (NTCIP) standards. The question for discussion in the white paper concerns the existing infrastructure of signs, cameras, detectors, and other devices that are already installed and in service.

It has been proposed that a possible strategy for integration of these legacy devices is to design, code and test a number of device driver software modules that will control these various legacy devices using the original manufactures' vendor specific protocol. A figure illustrating this approach is attached as Appendix 1.

This white paper proposes an alternative architecture, where all field devices are brought up to the required functional condition, including the ability to communicate using NTCIP, with a small field controller deployed at the field end of the communication link. A figure illustrating this approach is attached as Appendix 2.

2. Summary of the Central "Device Driver" Approach

The device drivers are software modules that reside on the communications server located in each TMC, where physical connection to the field is made. These device drivers offer an internal interface to the rest of the Central System software, through a software interface called an Application Programming Interface (API). This carefully designed interface would be the same for all drivers, and would accommodate the functional requirements for all the different device types, and would probably reflect a "NTCIP – Like" character, as this will be the protocol for all future procurements.

Inherent in providing a Central system is the requirement for the system to support the NTCIP communications standards. This is required for all future field devices, which will be procured with the requirement that they support NTCIP. This will be required in any event, and so is a common cost in both this as well as the alternate approach. However, the key feature of this approach is that a custom software driver, residing in the TMC that controls field devices, needs to be written and tested for each type of legacy device that is currently installed in Florida. This is significantly complex and costly.

Internally, each of the device type drivers would need to translate each and every function required to be carried out by the device into the native Vendor Specific Protocol. The actual protocol packets then transmitted on the wire will be potentially incompatible vendor specific packets, and different for each manufacturer of sign, camera, and so on.

This approach is illustrated in the attached figure 1.

3. Summary of the Distributed “NTCIP Controller/ Translator” Approach

This approach only requires that a NTCIP device driver be implemented in the Central System. Each and every device, irrespective of its original manufacturer, will expose the same NTCIP interface for Center-to-Field communications. This device driver offers an internal interface to the rest of the Central System software, through a software interface.(API). This interface would accommodate the functional requirements for all the different device types, and would probably reflect a “NTCIP – Like” character, as this will be the protocol for all future procurements.

Internally, the NTCIP device driver would need to encapsulate each data transaction in the NTCIP format. The actual protocol packets then transmitted on the wire will be in accordance with NTCIP, and will be identical for each manufacturer of sign, camera, and so on. This NTCIP device driver in the Central is an inherent part of the new Central system in any event, and is not a cost associated with this approach.

In the field, a small NTCIP controller/translator is added to each device. This controller would execute all the NTCIP communications requirements, as well as some of the functionality of the field device. It means that the Central system, and all field communications, are executed with NTCIP communications only, with resulting decrease in complexity of Central System and Communications.

This approach is illustrated in the attached figure 2.

4. Advantages of the Distributed “NTCIP Controller/ Translator” Approach

The advantages to this approach are further examined in four main categories:

a. Functional issues.
b. Maintenance issues.
c. Timing and availability issues.
d. Commissioning and contractual issues.

4.1 Functional Issues.

4.1.1 Augmenting functional requirements

Florida DOT has established a baseline of functionality for the various field device systems deployed in Florida. Most recently, a functional specification for Dynamic Message Signs (DMS) has been established based on the NTCIP standards for DMS, and expanded with Florida specific requirements (the Florida MIB). These requirements are important to Florida, and are not implemented in a number of the legacy sign systems installed. With the Central Device Driver approach this means that these features simply cannot be achieved, and must be abandoned in some of the legacy parts of the system.

Typically, legacy systems do not deal well with the issue of message priority, message integrity (CRC), communication failure performance, message duration performance, short and long power failure performance, schedule, event logging and reporting, variable brightness curve, and so on. In the distributed NTCIP controller approach, all these issues are dealt with in the NTCIP controller, and there is no need to even consider how they may or may not be implemented in the legacy field device. Up to an estimated 70% of the functionality of the field device will be executed by the NTCIP controller in a manner natively consistent with the requirements of the NTCIP standards, which will make a deployed system conform in all respects to the Florida baseline of functionality.

4.1.2 Complexity

The field NTCIP controller approach makes for much simpler interfaces to the field devices compared with the central device driver approach. In the central device driver approach, each and every function of the sign must be translated, including message priority, message integrity (CRC), communication failure performance, message duration performance, short and long power failure performance, schedule, event logging and reporting, variable brightness curve, and so on, to the extent that each of these features is supported. This is in addition to the sign display functionality required to display a message, and whatever diagnostic messages are supported by the legacy sign. In the NTCIP controller scheme, only the message display and some diagnostic routines are translated, as the balance of the functionality is supported natively by the NTCIP controller. This makes a very much simpler driver to write using the NTCIP controller approach. Similar examples exist for Cameras and Traffic Sensors.

4.1.3 Uniformity of Operations.

Since all the legacy devices converted with the NTCIP controller approach, and any new procured devices, will conform to the Florida NTCIP baseline of functionality, the User Interface and system design will be much simpler to achieve than with the central Device Driver approach. Take for example features called out in new Florida DMS specifications, such as Log Full, or Error Generation Toggle. Somewhere on the user interface will be dialog boxes that enable a suitably authorized user to operate these features. In the first instance, if the Central Device Driver approach is adopted the user interface will have to be sophisticated enough to turn the availability of these features on and off, depending on which type of legacy sign it is, and whether this feature is available in that sign or not. This kind of linkage between the lowest level communication device driver, and the highest level user interface, makes for very complex system design, and makes any kind of uniformity of operation very difficult to achieve. It also requires a more sophisticated operator who has an understanding for the lack of uniformity of features and functions, and hence also requires additional training in this area. Just the identification and documentation of differences in operation of the field performance of different brands of device (which cannot be translated) will be extensive and expensive.

The NTCIP controller approach will result in devices with a much more uniform set of features and functions that conform to the Florida baseline of functionality, with resultant uniform user interfaces and a reduced training requirement.

4.2 Maintenance Issues.

4.2.1 Identifiable, accessible and testable interfaces.

A key issue in a maintainable system is the ease with which the maintenance personnel can access testable interfaces. In the Central device driver approach, a key interface is the interface between the Central System and the Device Driver, at the Device Driver API. This interface is buried deep within the computer code, and is not available to the maintenance technician to help in fault finding. In the NTCIP controller approach, this API interface is far less important, as it will be the same for all signs, cameras, sensors, and so on. Fault finding will be limited to conventional field module replacement under the NTCIP controller scheme, as the testing interfaces are at conventional “wire” connections and interfaces, and not at a complex internal computer interface as with the Central device driver approach.

4.2.2 Approach to fault-finding and test tools.

In the event of a fault occurring in a device, as reported by the Central System, the first step is to identify the location of the fault either in the field device, or in the communications, or in the central system.

With the Central Device Driver approach, this is a complex undertaking due to the number of device types deployed. There are several kinds of signs, several kinds of cameras, and a number of different types of sensors. The repair technician, on the diagnostic laptop computer, will have a number of Vendor supplied diagnostic tools, as the communications are still vendor specific. The technician will have to be schooled in the use of all of these testing tool types, in addition to the new NTCIP testing tools. This involves additional training and engineering support. Few tools are available to support testing of the communications back to Central using the legacy vendor protocol. This makes verification of the data stream at the field device difficult.

In contrast, in the NTCIP Controller approach the maintenance technician plugs in the NTCIP diagnostic utility on the maintenance laptop into the local NTCIP diagnostic port. Operating the device through this port will immediately indicate if the device is functioning correctly. If the device is functioning correctly, the repair technician will be able to attach the NTCIP device simulator on the maintenance laptop to the communication channels, and verify that a correct data stream is being received from the central. As **ALL** the communication channels are NTCIP for **ALL** devices (old and new, cameras, signs, sensors and any other device type) this approach will work with a single piece of maintenance software that is simpler to maintain, and requires less training than the requirements should a central device driver approach be adopted.

4.2.3 Migration to new NTCIP devices.

As the existing legacy devices approach the end of their life, the intention is to replace the devices with new NTCIP conformant devices. For the Central Device Driver approach, this means that an additional test and integration project will need to be undertaken as each of these replacement projects occur, as the change of field protocol will occur only when this project happens. Until that time, the vendor specific legacy protocol will continue to be used in the field. This will involve reconfiguring the central system to use the NTCIP device driver in place of the legacy device driver, complete with any changes in functionality that have been caused by the inability of the legacy field device to support the full Florida baseline of functionality. It also means that spare parts are not interchangeable, as vendor protocol is still being used in the filed.

With the NTCIP controller approach, the installation of new NTCIP conformant equipment will be seamless. Both the old legacy equipment and the new equipment will have been tested to comply with the Florida baseline of functionality at the NTCIP interface, and so will appear to the operator to be identical. Additional training, documentation and configuration management will not be required under this approach.

4.2.4 Common hardware platform.

The NTCIP controllers are all based on the same hardware platform family. It is envisaged that only two different hardware platforms will be required in Florida, from the same family of controllers. There are several advantages to standardizing on one controller platform all devices, even at a small additional cost. This means that there will only be one spare part for all of Florida's legacy devices to make these legacy devices conform to Florida's NTCIP baseline of functionality. The small increased initial cost of using the more powerful hardware some locations can be assessed against the advantages of a single type of hardware, during the detailed design phase.

4.3 Timing, availability and risk issues.

4.3.1 Timing

The Central Device Driver approach will take many months, and substantial effort and resources, to develop the number of device drivers requires for initial deployment. The level of integrated testing will be significant, in that the device drivers are difficult or impossible to test on their own, as they need the deployment of the Central system to operate.

The NTCIP Controller approach is available for immediate test and deployment. Sample devices can be made available to Southwest Research to allow the development of the NTCIP driver to be completed in their software labs (this is required with either approach). The simpler device drivers for the NTCIP controllers for various manufacturers are under continual development, and so the risks involved are small, as a number have already been completed.

This approach will significantly reduce the risk of project delays and overruns due to unforeseen problems with the Central device driver approach.

4.3.2 Availability

The NTCIP Controllers are based on the proven and available IDI 1xxx family of NTCIP controllers. No hardware development is required for this project, and all the required controllers are available immediately, with normal manufacturing lead times.

4.3.3 Upgrade risk

The central device driver approach requires the use of sophisticated configuration management techniques to test the upgrade of any device driver. Let's consider the trial deployment of a device driver upgrade for 60 days. This means either the Central system will manage the simultaneous deployment of multiple versions of each of the device drivers, or the risk of deploying a new version could bring down all the cameras, or signs, of that type.

In contrast, the deployment of upgraded NTCIP controller software is a much simpler task. The new software is loaded into the flash memory of the NTCIP controller, and power is cycled. Trial software can easily be deployed on a limited number of devices (or only in the test lab) until released for general distribution. There is no risk of a general system crash during this process.

4.3.4 Custom feature support ("Tunneling")

With the Central Device Driver approach, each and every feature of each and every device type need to be contemplated, and included in the Device Driver. This leads to a great deal of complexity, and makes it difficult to integrate custom features of devices that are beyond the Florida baseline of functionality.

The NTCIP Controller approach includes a novel solution for this problem. A manufacturer (IDI or Florida or Southwest Research) specific NTCIP object is established for this feature. Activating this object causes the payload to be transmitted to the field device, using NTCIP as a "wrapper". The reply from the field device is "wrapped" in this NTCIP object, an sent back to Central.

This feature is **NOT** a substitute for regular NTCIP implementation, but is useful for providing a method of allowing Vendor diagnostic software still to be used, after the implementation of a NTCIP solution. The advantage of this could be assessed during the detailed design phase.

4.3 Commissioning and Contractual issues.

4.3.1 Commissioning and "Loop Through"

For the Central Device Driver approach, it is expected that the device drivers will become available over an extended period of time. The commissioning and deployment of the Central system will have to be carefully coordinated with the availability and test status of the device drivers. As each TMC goes live, there will have to be simultaneous deployment of the device drivers required for that district's devices.

The NTCIP controllers are provided with a "Loop Though" function. A switch on the controller card enables this function. After the NTCIP Controller card is installed, it is tested both locally and at the TMC to ensure that the field device conforms to the FDOT baseline of functionality. The switch is then turned on, and this enables “Loop Though” mode. Any communications from the central are then transferred to the field device, and any communications from the field device are transferred to Central. This test mode makes it possible to completely upgrade the field devices to NTCIP with coordinating with the Central upgrade. When the Central is available and tested, the field devices can be brought on line by moving the switch to the off position.

4.3.2 Contractual simplification.

With the NTCIP Controller approach, the field and central systems can be upgrade independently. This approach makes for much simpler project management. The contracts involved are much simpler, with reduced commercial risk.

5. Advantages of the Central "Device Driver" Approach

The main advantage of the Central Device Driver approach is that there is no additional hardware installed in the field.