MEASUREMENT-CENTRIC DATA MODEL FOR INSTRUMENTATION CONFIGURATION

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ABSTRACT

CTEIP has launched the integrated Network Enhanced Telemetry (iNET) project to foster advances in networking and telemetry technology to meet emerging needs of major test programs. In the past these programs have been constrained by vendor proprietary equipment configuration utilities that force a significant learning curve on the part of instrumentation personnel to understand hardware idiosyncrasies and require significant human interaction and manipulation of data to be exchanged between different components of the end-to-end test system.

This paper describes an ongoing effort to develop a measurement-centric data model of airborne data acquisition systems.

The motivation for developing such a model is to facilitate hardware and software interoperability and to alleviate the need for vendor-specific knowledge on the part of the instrumentation engineer. This goal is driven by requirements derived from scenarios collected by the iNET program.

This approach also holds the promise of decreased human interaction with and manipulation of data to be exchanged between system components.

KEY WORDS

Model Driven Architecture, Metadata, Telemetry, XML, Instrumentation Configuration, Plug-and-play, Use-case-driven development, TENA

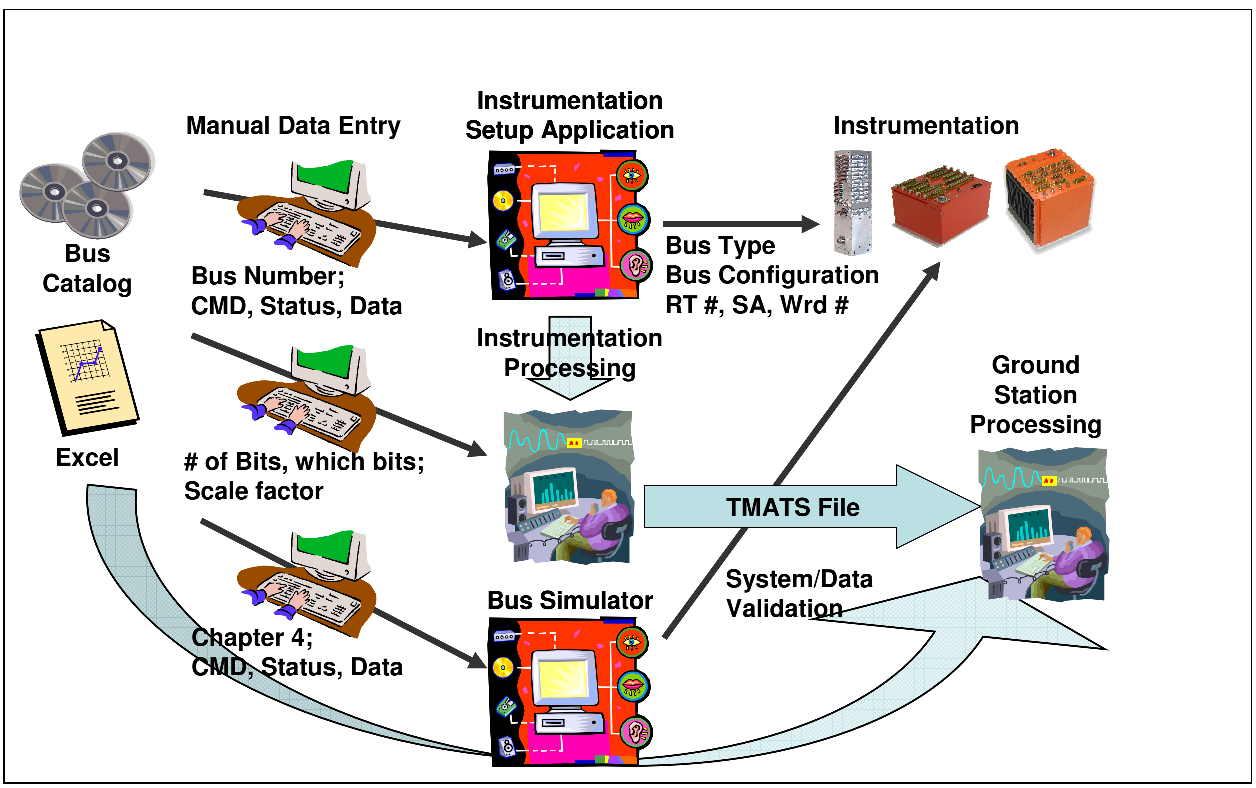
MOTIVATION

The impetus for this effort is twofold. First are the scenarios collected by the iNET program that require test article instrumentation to be remotely configurable via a network connection, to be interoperable between ranges, and to support significant new functionality such as packetized measurement flows and spectrum control.

Second is the current need for instrumentation users to be intimately familiar with the internal mechanization and configuration of a vendor's acquisition devices. This is often a distraction from achieving prescribed measurement characteristics which is their primary task.

In order to achieve the common goals of these requirements a flexible standard that allows for the description of a wide range of transport formats is essential.

The tasks involved in the configuration of aeronautical test articles are highly unconstrained as shown in the figure below. The data acquisition hardware used is from multiple vendors, each providing their own setup software and each supporting proprietary formats for hardware configuration. A variety of analog sensors are used that require in-depth knowledge of acquisition hardware idiosyncrasies to properly instrument. For bus catalogs there exists no common machine readable format for describing the measurements available on buses. All of this leads to inefficient, case-by-case solutions for pulling together the data required to instrument a test article. Error prone workflows with little reuse of laboriously hand entered data are common. A metadata standard for describing measurements, sensors and data streams would go along way in alleviating these problems.



A SOLUTION

We propose to create a metadata standard that will address the problems described above.

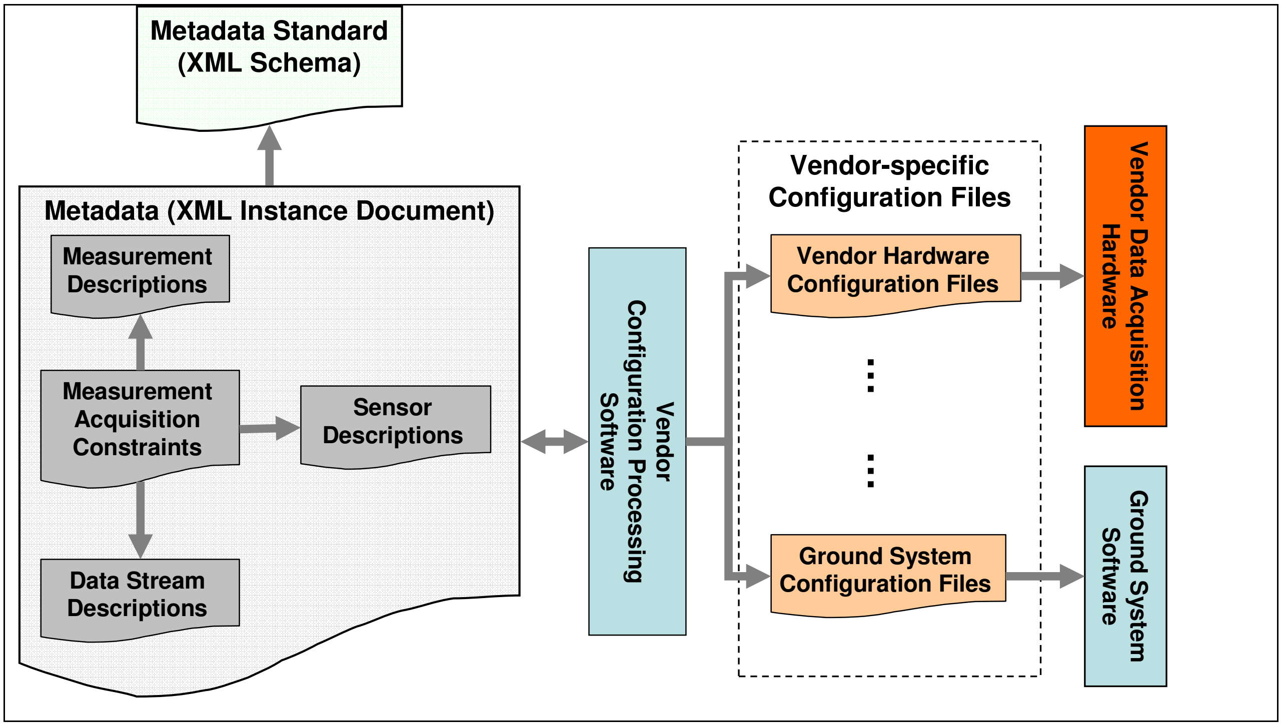
Two guiding principles are essential to this effort. The first is the segmentation of domains within the model. That is to say that an instrumentation engineer will only need to describe elements about which they have direct knowledge such as the measurement to be taken. They will not have to describe the internal configuration of acquisition hardware, but rather that task will be levied on the hardware vendor who naturally is expert at all of the subtleties of configuration of each their components.

The second is that a meta-structure will be created to allow for future extensibility. An example of this concept can be illustrated using recorder commands. The metadata model will identify the abstract concept of a command and then allow a standard set of commands to be agreed upon by recorder vendors and included in the model. Then, in the future, a vendor can instantly accommodate new commands as they become available by placing them under the command hierarchy. Commands which they receive using these new commands can be acted upon by their devices and simply rejected by other vendors as unknown. These new commands can either be supported as proprietary and identified as such with versioning or can be proposed to the standards maintenance committee as universally supported additions if there is broad enough interest in them by other vendors.

XML Schema will be used to implement the metadata standard. An XML schema defines a specific document structure and XML documents written to conform to that structure can be validated against the schema to check for conformance. This insures that metadata documents can be easily checked for validity. XML provides a lot of advantages for the development of the standard and the maintenance of metadata; XML documents are easily transformed into other formats using the XSLT standard; XML documents can include other XML documents to facilitate data reuse; and there are many open-source and commercial solutions for processing, validating and authoring XML documents. Based on all these features, XML is an obvious choice for the implementation of the standard.

The metadata standard will decouple the descriptions of measurements from the descriptions of the data stream formats associated with different transport technologies. This will allow measurement descriptions to be accessed independently of how they are telemetered or recorded. This goes toward addressing the iNET scenario regarding the real-time reconfiguring of telemetry streams; measurement descriptions are not directly associated with a particular data stream format so any data stream format defined for the test article can be used for telemetering or recording the measurement. This decoupling also allows flexibility in the description of data stream formats; new formats for networked or serial streaming telemetry can be defined independently of the measurement definitions. It will also facilitate the reuse of data stream format descriptions from test to test.

The metadata standard will separate the responsibilities for authoring metadata. Test engineers can define the measurements to be telemetered and recorded during a test; prime contractors can describe bus data (or range personnel can convert the bus catalogs into a common reusable representation); sensor manufacturers can describe sensor characteristics; and instrumentation engineers can describe measurement sampling attributes, data stream formats and instrumentation constraints. This separation of roles encourages the reuse of metadata from test to test, within a single test and from the test article setup to ground system setup. It also eliminates many of the error-prone tasks involving hand entered data and allows each participant to concentrate on their area of personal expertise.



One of the major challenges in developing this standard is how to define the interface between the standard and the instrumentation and ground processing hardware used in the aeronautical test environment. There are a number of vendors involved in this community and each have their own setup software and data representations for setting up their hardware and software. Our approach treats the configuration of instrumentation and ground processing hardware as a "black box". The metadata is just a way to describe the data acquisition requirements (i.e. "acquire these measurements in this way and telemeter them using this format") in a generalized, vendor-neutral format. The vendors will develop processing software that will process these requirements and generate the necessary proprietary representation for configuring the instrumentation and ground processing hardware. In the case of configuring instrumentation hardware on a test article, conflicts between what is requested in the metadata and what the hardware can support may occur. In such cases the vendor software will be able to modify the metadata to meet their hardware's limits or report back to the instrumentation engineer what requirements cannot be met. The end result is a complete, coherent description of the end-to-end flow of the measurement which can be represented by whatever artifact is appropriate to the task such as the TENA LROM with the measurements available as subscribable objects.

TASK METHODOLOGY

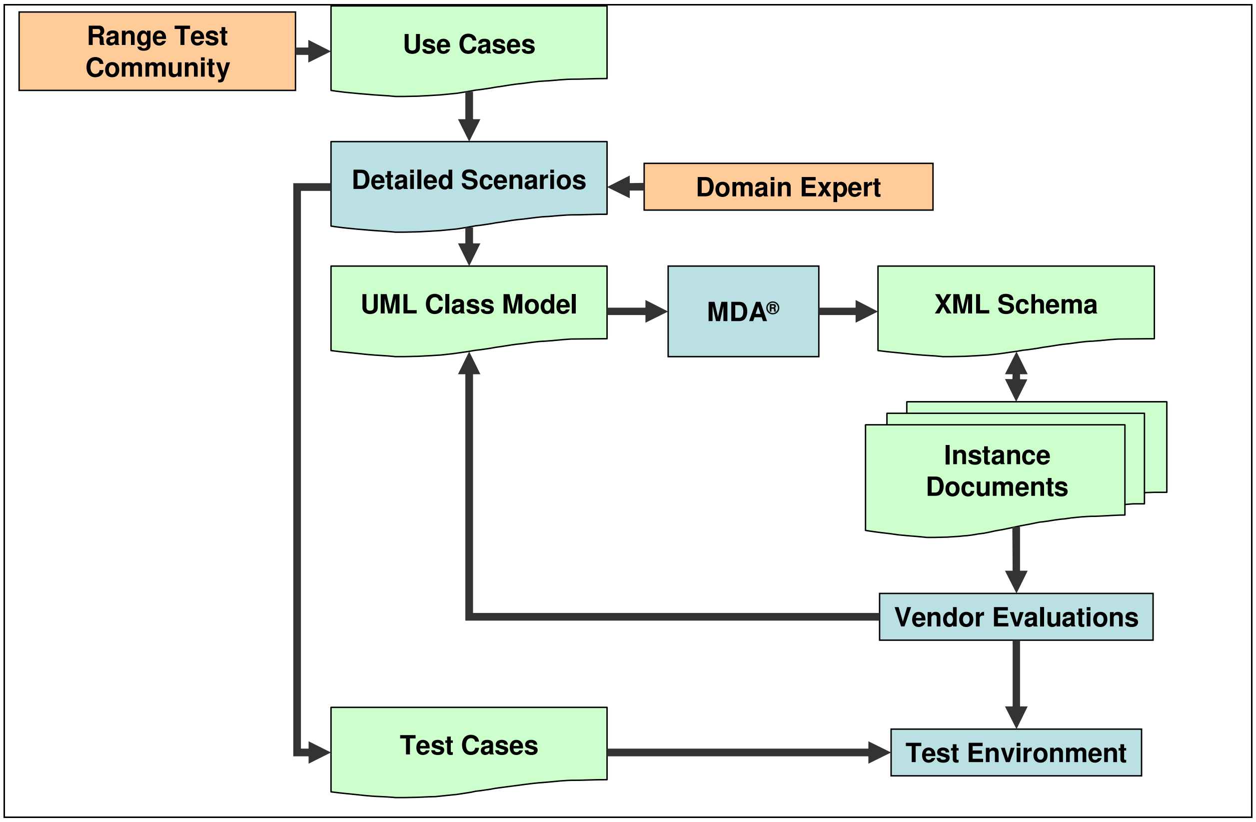
We are using a use case driven approach to developing this standard. We have collected use cases from the range test community and worked with domain experts to derive specific scenarios from these use cases. Based on the use cases and scenarios we have developed a UML class model representing the telemetry and instrumentation domain. The XML schema is forward engineered directly from the model using the Object Management Group's Model Driven Architecture® technology. This makes the model itself the primary artifact for this task. Basing the development on the model is much easier and cost effective than basing it on a particular implementation. It also gives us the flexibility to target other implementation languages beside XML Schema.

Vendor involvement is essential to the success of this task and we have been working with a representative set of companies throughout the conception and development of this standard. We have planned a set of evaluations involving these vendors to determine the completeness and usability of the metadata and to allow them to develop prototype processing software that can read the metadata and generate the proprietary representation for configuring their products. These evaluations will be based on a set of XML instance documents that represent the detailed use case scenarios. This will give us traceability back to the requirements gathering phase and will insure that the metadata provides all of the value intended. The evaluation process will be iterative and after each iteration we will evolve the model as appropriate to reflect any issues relating to the vendor's ability to process the metadata. At the end of the process we expect to have working prototype software from each vendor.

We will then begin testing the metadata standard. Test cases will be based on the original set of scenarios. The tests will be run using the same instance documents used for the evaluations, the prototype processing software provided by the vendors and hardware that has been configured using that software from the instance documents. Test measurements based on the scenarios will be used to exercise the configured data acquisition hardware. Testing will verify that the telemetered and recorded measurements acquired by the hardware are as described in the metadata.

At the end of the testing phase we will release a beta version of the standard and work with select groups of range personnel to transition it to wider use.

It is expected that preliminary test results will be available by 4Q07 and will be included in the presentation of this paper at ITC '07.



CONCLUSION

We have described a metadata based solution for some essential iNET scenarios as well as for existing test article instrumentation issues. An XML- based solution such as this one would give the range community a tool that facilitates integration with networked telemetry systems. It would also standardize some aspects of the test instrumentation work flow that currently are ad hoc and error prone. By using established software development and testing methodologies, the standard will be easy to evolve as networked telemetry technologies change over the next decade.