PRODML v2.1 Release Candidate Notes

2018-08-22

Contents

Overview of Scope of Changes Made

PRODML version 2.1 (v2.1) represents an incremental change from version 2.0. Version 2.0 was a major change to PRODML, which included the addition of new capabilities (see below) and to conform to the Energistics Common Technical Architecture, a set of design patterns to integrate all the Energistics standards (WITSML, RESQML and PRODML respectively covering drilling and completion, reservoir modelling and production data). In contrast, v2.1 makes changes only where implementation experience found deficiencies in v2.0. The exception to this statement is the addition of pressure transient analysis (PTA) capability. This is additive to the standard with the exception of a small number of changes for compatibility in PVT and in simple product volume reporting (SPVR).

Since the release of v2.0 in February 2017, the focus of the PRODML special interest group (SIG) has been on adoption of the standard as opposed to the development of further data transfer capabilities. Sub-teams of the SIG have worked on the adoption of each of the three principal elements added in v2.0:

- DAS (Distributed Acoustic Sensing)
- SPVR (Simple Product Volume Reporting)
- PVT

Of these workgroups:

- DAS has conducted trials between multiple member companies whose types span operators, service companies and software companies, all of whom have implemented or partially implemented, v2.0.

- SPVR has conducted end–to-end trials between two member companies, with other members reviewing and commenting on proposed changes.
- PVT has two companies that have implemented the standard. Neither of these is a PVT lab services provider, which has limited the ability to test. However, one such services company is implementing v2.0 during 2018, meaning that end-to-end trialing should be possible in 2019.

The work done in v2.1 reflects the degree to which the sub-team activity outlined above identified needs for improvement. Details are in sections below.

- DAS has not changed the structure of the standard but has made a number of detail-level improvements, which have been extensively reviewed.
- SPVR has a relatively small number of detail-level changes, which have had moderate review.
- PVT has no changes other than corrections to errors, except for changes needed so that PVT v2.1 can support the fluid characterization needs of pressure transient analysis. These changes have been implemented by Energistics with no member company review.

In addition, pressure transient data and analysis (PTA) capability has been added. This work was initially conceived and developed jointly by member companies Schlumberger and Kappa Engineering in 2013 and 2014. After initial testing, the two companies decided to donate the work done to Energistics. This process was completed in 2016. The initial PTA modeling was done using the patterns of PRODML v1.x. Accordingly, Energistics first task was to transform the v1.x pattern PTA model to the v2.x Common Technical Architecture patterns. This work was completed in 2017. In 2018, Energistics staff, with the agreement of the two donating companies and SIG members, drafted a new version of PTA for review and comment. This is the version released as part of PRODML v2.1.

Energistics wants to thank, on behalf of all future users of the PTA standard within the industry, Schlumberger and Kappa Engineering for their generous donation of their initial work.

New Version of Energistics common: v2.2

This PRODML release candidate includes a new version of Energistics common, v2.2. Some changes were to clarify underlying technical aspects; if you simply work with the latest schemas included in this download, the changes are implemented.

Additionally, these objects were either moved from one of the Energistics domain standards or updated:

- Cost (moved from PRODML)
- MeasuredDepthCoord (moved from WITSML)
- WellVerticalDepthCoord (moved from WITSML)
- Facet and PropertyKindFacet (moved from RESQML)
- PublicLandSurveySystem and dependents (moved from WITSML)
- NEW: for Energistics Unit of Measure standard, added new measure classes and units of measure needed for the new Pressure Transient Analysis data objects in PRODML.

Distributed Acoustic Sensing (DAS)

The DAS standard has not changed in terms of overall structure but a number of incremental changes have been made.

DasAquisition Fields – Changes to Optionality

For more detail on these fields, see the documentation in the UML model (reproduced in the PRODML Technical Reference Guide).

Mandatory fields
AcquisitionId
OpticalPath
DasInstrumentBox
FacilityId
VendorCode
NumberOfLoci
StartLocusIndex
MeasurementStartTime
MinimumFequency
MaximumFrquency
TriggeredMeasurement
SpatialSampleInterval

Optional fields
AcquisitionDescription
PulseRate
PulseWidth
GaugeLength

Obsoleted
GaugeLengthUnit
SpatialSamplingIntervalUnit
PulseWidthUnit

Array Dimension Metadata

Change from
Dimensions[1] = "time"
Dimensions[2] = "locus"

Changed to
Dimensions = ["time", "locus"]

Mapping UML to HDF5 Format

UML maps directly to XSD schema, which makes the mapping implicit. The HDF5 format does not have the concept of a schema, so the mapping has to be made explicit. The rules for this have been made clearer and more definitive in v2.1, as follows:

1. A new HDF group should only be created for the purpose of having datasets as leaf nodes, with the exception of Custom.
2. For each of the HDF datasets, XML objects whose sub-elements should be copied as attributes:
   a. the ExternalDatasetPart (or its derived types, e.g. DasExternalDatasetPart) whose “PathInExternalFile” refers to this dataset.
   b. all the parent objects of the corresponding AbstractValueArray up to the top-level objects.
3. For all of these XML objects, copy the values of sub-elements that fulfil one of these two criteria (items a and b):
   a. Element whose XML type is a (derived) primitive XML schema datatype, i.e. one of these: xs:string, xs:boolean, xs:decimal, xs:float, xs:double, xs:duration, xs:dateTime, xs:time, xs:date etc (see XML Schema Datatypes for the full list);

   b. derived type of AbstractMeasure (e.g. FrequencyMeasure), where the value (text between tags in XML) and the “uom” attribute are both copied to HDF, the latter will be given a name “ElementName.uom” in the HDF.
   c. The only element not to copy after following these rules is “PartInExternalFile”, which is the HDF dataset path.
4. When an element’s number of occurrences is 0 or 1, the HDF attribute should be a scalar.
5. When an element’s number of occurrences may be larger than 1 (e.g. “Dimensions”), the HDF attribute should be an array, even if there is only one item.
   a. Note that this applies to inherited attributes as well (e.g., uuid and schemaVersion of DasAcquisition, attributes inherited from AbstractObject).
6. However, CalibrationInputPoint of Calibration is an anomaly to the above rules. CalibrationInputPoints are copied to all the HDF files as datasets with a compound data type.
7. Readers should not rely on a fixed order of the compound datatype, but instead, deduce the column index using the member datatype name. Each CalibrationDataPoint dataset belongs to an HDF group named “Calibration[N]”, which is corresponding to the N-th Calibration element in the FacilityCalibration within the DasAcquisition. The HDF attributes in Calibration[N] are copied from Calibration following the same criteria as listed above for the other XML objects.

Proposed Data Types in HDF

The norms in the following table are not imposable by use of HDF5 schemas (the concept does not exist) and are therefore rules which must be followed in order to ensure interoperability.

Note that the following information will be released in the documentation update of v2.0 content in *Energistics Online*. It is reproduced here for new users.

XSD Type	HDF5 Data Type
xs:string	Fixed-length string, i.e. H5T_C_S1 in C.
xs:integer and its derived types	Integer data type with the bit-ness follows that defined in the XSD type. Example: • int64 is used for “xs:long” • int32 is used for “xs:int” • int16 is used for “xs:short”
xs:float	float32
xs:double	float64
xs:boolean	One of these formats: • int8 or uint8 where 0 corresponds to False, 1 corresponds to True. • Enum type where the underlying values are 0 and 1, as above.

Dataset	HDF Data Type
RawData	Various data types may be used depending on the situation, including: uint8, int8, uint16, int16, uint32, int32, uint64, int64, float32, float64
RawDataTime, RawDataTriggerTime, FbeDataTime, SpectraDataTime	int64

FbeData	float32
SpectraData	float64

HDF5 Compression

Note that the following information will be released in the documentation update of v2.0 content in *Energistics Online*. It is reproduced here for new users.

In general, HDF5 compression is not required. However, if needed, GZIP is recommended because it is widely available. Compression often requires decisions on how the data arrays should be chunked; therefore, its use requires agreement between the providers and the users.

Changes to DAS Calibration

In v2.0, the calibration model used the following hierarchy of elements:

DAS Acquisition

Calibration

Calibration Data Points.

This has changed to:

DAS Acquisition

Facility Calibration *[one per facility for optical paths, which span multiple facilities]*

Calibration *[one per calibration version on this facility]*

Calibration Input Point *[the input test points, e.g., "tap test" and location]*

Locus Depth Point *[array of locus indices vs location – optional]*

The attributes of these elements have changed to match their roles – see the UML model.

Fixes

Various fixes to the model around details in the way the Energistics Packaging Conventions (EPC) work for DAS have been made.

Documentation

The DAS content has been updated to clarify some of the concepts and the rules that implement. For access to documentation, see below.

Simple Product Volume Reporting (SPVR)

Changes are as follows. See the documentation in the Technical Reference Guide for the guidance as to exactly what any added elements represent.

1. Disposition: "buyback – fuel" added as a possible value in the enum list.
2. Reporting Entity. To enable a better identification of a Facility associated with a Reporting Entity, the following changes were made:
   a. A new Top-level Object (TLO) called Facility has been added.
   b. Facility has a single element Kind: ReportingFacilityExt (extensible form of Reporting Facility, which is a list of facility kinds already in PRODML)
   c. In Reporting Entity, Target Facility Reference is renamed to Associated Facility, and is an optional Data Object Reference (DOR) to a Facility TLO. Until specific facility type data objects are added, this is to be used to reference a Facility TLO, which can contain the type and identity of the facility associated with this reporting entity.

   d. In Reporting Entity, a new element Associated Object has been added. This is an optional DOR to various types of existing Energistics subsurface objects available now, for example, well, wellbore, wellbore completion etc.

3. To better support use of "legacy units of measure" (e.g., psig, scf, stb) the following changes were made:
   a. In Energistics common, made:
      i. DensityValue.Density use MassPerVolumeMeasure instead of MassPerVolumeMeasureExt so it can use Legacy units.
      ii. FlowRateValue.FlowRate use VolumePerTimeMeasure instead of VolumePerTimeMeasureExt so it can use Legacy units.
      iii. VolumeValue.Volume use VolumeMeasure instead of VolumeMeasureExt so it can use Legacy units.
      iv. link between DensityValue and AbstractTemperaturePressure optional.
      v. link between FlowRateValue and AbstractTemperaturePressure optional.
      vi. link between VolumeValue and AbstractTemperaturePressure optional.
   b. In PRODML made SimpleProductVolume::ProductRate.VolumeFlowRate use FlowRateValue instead of VolumePerTimeMeasure.
4. In Production Well Test and Well Performance Parameters, made Reporting Entity mandatory (there must be a well we are reporting against).
5. In Production Well Test:
   a. added Effective Date – the date after which this test is effective in production allocation calculations.
   b. in Test Condition, removed association to Service Fluid. This was an error.
6. In the places where fluid quantity or flow rates are reported, made a consistent pattern whereby Product Fluid Kind (or, for a Service Fluid, Service Fluid Kind) is mandatory, and Product Fluid Reference (or, for a Service Fluid, Service Fluid Reference) is optional.
   a. Product Fluid Kind (or, for a Service Fluid, Service Fluid Kind) are enums, e.g., "crude - stabilized"
   b. Product Fluid Reference (or, for a Service Fluid, Service Fluid Reference) are references (using the uid) to components contained in the Fluid Component Catalog, where not only the kind but the physical properties of the fluid can be transferred.
7. In Deferred Production Event:
   a. added planned|unplanned enum
   b. added Remark
8. In Deferred Production, made Abstract Product Quantity mandatory (1..1).
9. The way a Deferred Production Event now works is, Deferred Production Event has:
   a. planned|unplanned kind
   b. duration and event times
   c. downtime code
   d. remark
   e. 0..* Deferred Production elements. The purpose of these is to be able to report the deferred quantities related to the parent Event. Each Deferred Production has an Estimation Method, and a mandatory Abstract Product Quantity, which either is a

Product Fluid or a Service Fluid element, as used elsewhere in SPVR for fluid kind and quantity data.

10. For the class Well Flowing Condition, the following changes were made:
    a. Changed to an XSDGroup rather than a XSDComplexType. This enables better re-use (to be used in PTA).
    b. Included the re-typed XSDGroup in Production Well Test: Test Condition (previously, association to Well Flowing Condition as a separate class).
    c. Included the re-typed XSDGroup in Well Production Parameters: Production Well Period (previously, association to Well Flowing Condition as a separate class).
    d. Removed Flowing Pressure (ambiguous).
    e. Removed Bottom Hole Static Pressure (a different flow condition, e.g., a shut-in period, now is reported as a separate Test Period, see below.)
    f. Removed Bottom Hole Shut In Pressure (see previous).
    g. Removed Tubing Head Shut In Pressure (see previous).
    h. Added Casing Head Stabilized Temperature.
    i. Renamed Bottom Hole Gauge Depth MD to Bottom Hole Pressure Datum MD.
    j. Renamed the four elements for bottom-hole and tubing-head pressure and temperature to use the word "stabilized" in attribute names, replacing "flowing". (See the comment above concerning use of separate Test Periods for shut ins; hence, "stabilized" is the better description.)
11. In Test Condition, to re-use this content in PTA and thereby share flow test software development more easily, these changes were made:
    a. Renamed Test Condition to Test Period.
    b. Added an enum Test Period Kind to Test Period. This includes transient test types as well as, for the purposes of SPVR, the expected value of “production well test”.
    c. Deleted Test Duration.
    d. Added End Time: (so start and end are now of type dateTime).
    e. Added XSDattribute uid: String64 (because there can be multiple Test Periods included).
12. In Production Well Test, because the Flowing Conditions group no longer has “flowing” and “shut in”, and instead, a Test Period should be used for each condition, e.g., one for flowing and one for shut in:
    a. Changed multiplicity of Test Period from 1 to 1..*
13. In Well Production Parameters (see remarks for preceding change):
    a. Changed multiplicity of Well Production Period from 0..* to 1..*

PVT

In Fluid Characterization:

1. Made Fluid System Characterization Type optional.
2. AbstractCorrelationFluidViscosityBubblePointModel – for Solution GOR, corrected typo and wrong type.
3. Removed Fluid Characterization Table Format Set as container for multiple table formats. Each Fluid Characterization Table Format now sits under Fluid Characterization.

For PTA purposes, in Fluid Characterization:

1. Added Pseudo pressure and Normalized pseudo pressure to Output Fluid Property.

2. To have a single condition set of fluid parameters (rather than needing a table which spans multiple conditions), made these changes:
   a. Renamed FluidCharacterizationTableConstant to Fluid Characterization Parameter.
   b. In Fluid CharacterizationTable, the element TableConstant is now of type Fluid Characterization Parameter, otherwise it is the same as v2.0.
   c. Added Fluid Characterization Parameter Set to Fluid Characterization Model. It contains 1..* Fluid Characterization Parameter. This gives the 3rd means of defining a model (after a Table or a Model).

Pressure Transient Analysis (PTA)

Background

A draft PTA model is included in v2.1. This is intended to be the basis for a comprehensive capability for data transfer of flow tests.

As indicated above, the model is developed from an earlier model donated by two member companies with a great deal of expertise in PTA. However, because that model was developed using v1.x PRODML as its basis, it has changed considerably to fit with the unified CTA and patterns of Energistics v2.x standards. As part of this, the scope was expanded to include both wireline formation tester flow tests, and steady state (non-transient) "production" well tests. In addition, since the initial development of the donated PTA model, the whole PRODML v2.x PVT and SPVR capabilities have been added, resulting in the possibility of sharing fluid models, fluid characterization models and flowrate models. Additionally, because fluid sampling is often associated with flow tests of various kinds, the aim is to integrate the fluid sample acquisition job capability of PVT with the PTA model.

Because of the considerable amount of change included in the v2.1 model compared to the donated PTA model, and the lack of expert company peer review of the new model up to the time of this release candidate, this new PTA model must be regarded as a draft for review rather than a proposed final version for commercial implementation.

It is intended that a review sub-team possibly comprising WITSML and PRODML experts will be convened to assess the model as released with v2.1

Intended Use Cases

The PTA model in v2.1 is intended to cover these use cases:

1. Description of a Flow Test Job (example, a drill stem test operation). Maturity in v2.1: there is no detail.
2. Data for a Flow Test Activity (example, the data measured during a drill stem test). Maturity in v2.1: high.
3. Analysis of a pressure transient test (example, a pressure transient model with the resulting parameters and the analysis methods representation). Maturity in v2.1: high.

The future use cases that are expected to be added include:

1. Description of a Flow Test Job.
2. Integration with Fluid Sample Acquisition Job from the PVT area of PRODML. This will entail having the correct referencing between the flow test activity and the sampling undertaken at the same time or during the same operation.
3. Data for downhole fluid analysis (example, for a wireline formation tester tool that can measure fluid properties, such as density during the flow test).
4. Analysis of formation tester results (example, fluid gradients and contacts derived from the flow tests performed at "stations" with the formation tester).

Outline of Data Model

There are three top-level objects used for the v2.1 PTA model described below.

Flow Test Job
This is a “placeholder” for additions during or after the public review period. The intention is to bring into this data object the operational reported patterns already deployed in WITSML for other wellsite operations.

Flow Test Activity
This data object has a multiple inheritance pattern, so that it takes on inherited types from the following list:

1. Drill Stem Test
2. WFT Station
3. Production Transient Test
4. Vertical Interference Test
5. Interwell Test
6. Production Flow Test

Each of these types contains Flow Test Measurement Set(s). All types other than Vertical Interference Test and Interwell Test contain one such Flow Test Measurement Set. But Vertical Interference Test and Interwell Test, which concern the observation of the effect of flow at one or more location upon pressure or flow at another location, contain multiple such Flow Test Measurement Sets.

Flow Test Measurement Set then contains the following principal elements:

1. Flow Test Location (1). This defines where the flow is happening (e.g., a flowing interval in a wellbore). Existing Energistics data objects may be used as data object references, e.g. Wellbore Completion.
2. Flow Test Period (1..*). There can be many such – e.g., drawdowns at different flowrates, build-ups, etc. This class contains the stabilized flow conditions for the period in question (pressures, flowrates, etc.).
   a. Product Rate (0..*). This defines the flow rates during the Flow Test Period.
   b. Both Flow Test Period and Product Rate are re-used from SPVR.
3. Fluid Component Catalog (0..1). This is re-used from PRODML Common (used in PVT and SPVR already) and lists the fluids with their properties (e.g., gravities) which is desired to report.
4. Time Series Data (0..*). This contains metadata about time series data and then uses the WITSML Channel and Channel Set objects to define the time series that were measured and to transfer the data as log objects.

This data object is incomplete and is expected to change during or after public review with respect to the use of WITSML Channel and Channel Set objects. It is intended to make minor additions to the log objects, in collaboration with the WITSML SIG so that *all* the metadata associated with measured time series can be transferred using log objects. This change will support easier representation of “pre-processing” of PTA measured data, e.g., re-sampled, smoothed, time shifted data, etc.

Analysis
This data object defines the methods and results of analysis of PTA data. It contains the following principal elements:

1. References to the parent Flow Test Job and Flow Test Activity.
2. Within the Flow Test Activity, reference to the Flow Test Interval(s) being analyzed. For most test types, there is only one. For interference tests, the principal and interfering Flow Test Intervals must be identified.

3. Within the Flow Test Activity, reference to the Flow Test Period(s) being analyzed. For interference tests, the Flow Test Periods for each Flow Test Interval must be identified.
4. A data object reference to a (PVT) Fluid Characterization data object containing the fluid properties, such as viscosities, which are used in the analysis. Gas pseudo pressures can also be represented using tabular models in Fluid Characterization.
5. The pressure transient analysis (PTA) or rate transient analysis (RTA) methods used. These are the log-log or specialized analysis methods and the transforms (for effects such as superposition of multiple test periods) are identified. Reference is made to further Channel data objects containing the transformed data such as log-log transforms, enabling the visualization of analysis methods. Simulated data from models is also available to be transferred in Channel data objects.
6. The transient model data. This contains a detailed set of well-known transient behavior models. The model sections are:
    a. Well model (for wellbore storage, etc.)
    b. Near wellbore model (for skin factor, formation damage, stimulation, etc.)
    c. Reservoir (for radial flow, dual porosity, etc.)
    d. Boundary (for faults, bounded reservoirs, etc.)
    e. Note that a multiple layer model capability is included. In this case, there is one common wellbore section and then near wellbore, reservoir and boundary models per layer.
    f. Note that each well-known model comes with its defined list of well-known parameters.
    g. Custom models and parameters are permitted to be added.

Documentation

The current v2.0 documentation combined with updates in these release notes should be enough to get you started with PRODML v2.1.

The v2.1 documentation and examples are currently a work in progress. These updated deliverables will be posted as soon as available.