A Well Log Data Management System Utilizing PPDM

Harry E. Schultz,
President,
Oilware, Inc.

Jeffrey W. Pferd,
Sr. VP of Product Management,
Petris Technology, Inc.

David Jones
Product Manager,
Petris Technology, Inc.

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Introduction

Petris Technology and Oilware have teamed up to build a web-based well log data management system that uses the Public Petroleum Data Model (PPDM) as the storage schema. Oilware provides flexible and extensive format reading and writing capabilities, and Petris provides a web-based data management solution with seamless integration between the data storage and application usage.

This system combines capabilities that make it application independent and enable full storage of data in its raw state as delivered from the field. Application independence means that changes in petrophysical applications do not require migration of data, and data management needs can be separated from petrophysical and geoscientists application needs.

Full data storage of the raw data allows not only preservation of both the well log depth and response values, but also all of the data capture field parameters. These parameters are required for later well log analysis using state of the art processing algorithms.

Design Goals

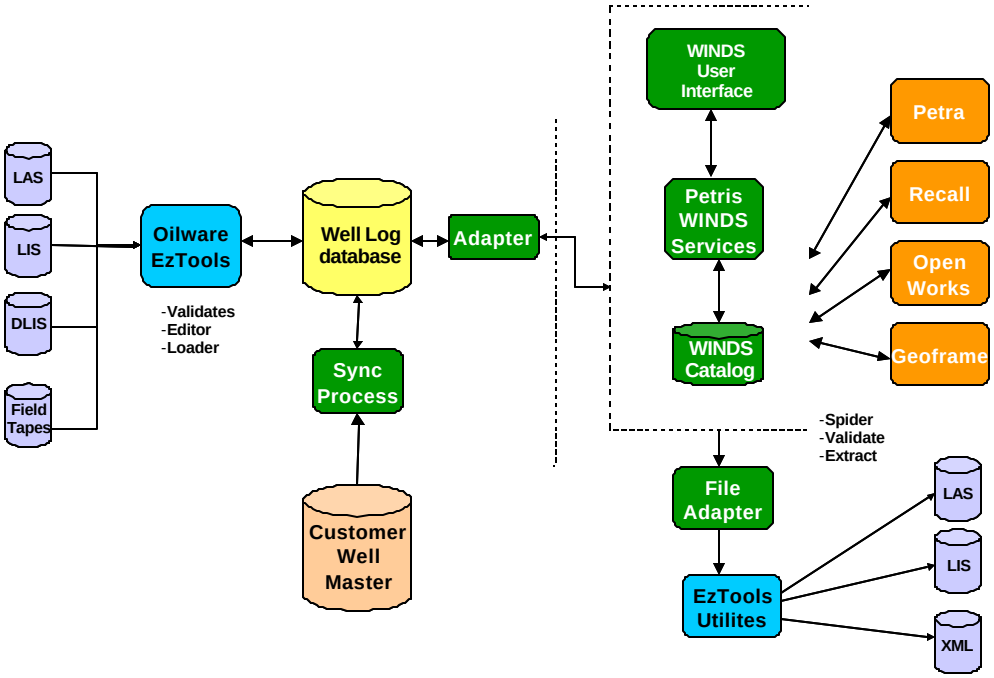
A Well Log Data Management System (WLMS) should provide the following features and functions:

1. Loading of well log data from all of the common data interchange formats.
2. User definable verification of the data as it is loaded.
3. Archival of the data in its original format. The data should be considered a corporate asset, and be archived exactly as it was received.
4. The data must be *indexed* for intuitive and comprehensive searching.
5. The data must be easily integrated with existing well information.
6. Coordination and integration with Corporate well master data stores.
7. Independence from any specific petrophysical analytical system while providing for automated transfer and loading into any geotechnical application outfitted with appropriate adapters.
8. Map and attribute based search capabilities.
9. Map and Table results display to find appropriate log header information.
10. Flexible filtering of log and curve data to select appropriate logs.
11. Seamless insertion of log data into application projects or the user s desktop in the desired format regardless of the archived format.

High Level Architecture

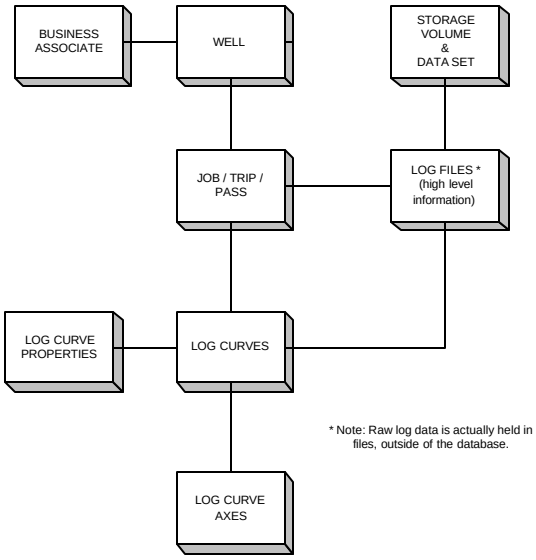
The diagram below shows the high level organization of components in the WLMS.

WLMS High Level Configuration



The following diagram provides a high level overview of the major elements of the data model that incorporates PPDM elements and those that are required to capture and store well data.

Petris / Oilware Well Log
Data Model (overview)



Specific Benefits to PPDM Users

1. The WLMS can be easily added to any existing PPDM compliant implementation. Both EzTools and WINDS have been designed to be independent of the underlying data model. Thus, they are easily adaptable to any privately or publicly defined data model, including PPDM.
2. The system allows the user to leverage existing PPDM compliant software currently in use. The user of WLMS can continue to manage all existing well information just as before, adding WLMS.
3. Well Logs are associated with previously loaded well information. Since a PPDM implementation of WLMS exploits the Well Logs portion of the PPDM data model, all well log data loaded is immediately associated with the current well information. No replication of well information is necessary.
4. **No** new data model learning curve. Support staffs already know the data model and can immediately begin using the system with confidence.

Input Data Characteristics

Digital Well Log Data s typically exchanged between companies using one of the common well log interchange formats. These include:

- **DLIS** - The Digital Log Interchange Standard, also known as API Recommended Practice 66 (RP66). This format is very flexible, and in its most general form can be modeled as an object-like network database which has been serialized for output on sequential media.
- **LIS** - The Log Information Standard, sometimes referred to as LIS-79, was developed by one of the major logging companies in the late 1970 s and early 1980 s. This format was never formally adopted by any standards body, however, it is probably the most universally used format for exchanging well log data. The format specification describes a syntax for encoding well log data for output on sequential media, however it says nothing about how each piece of data relates to any other. The semantics of the data can only be inferred by the order in which the records are read, and the proximity of one item of data to another within a file or tape.
- **ASCII** - This is a general category of files which are human readable. The most common example of an ASCII log data file is the Log ASCII Standard (LAS) created by the Canadian Well Logging Society.
- **BIT** - The Basic Information Tape format was created by Atlas Wireline in the 1970 s. It is not in general use today, however it is not uncommon to encounter this format in archives of well log data, or when reading well log data originating in China.

There are others, but these four types are most commonly encountered in the exchange of well log data.

Despite the differences in these formats, they do share several common characteristics:

- DLIS, LIS, and BIT are multi-file tape formats which can be encapsulated and created on, or copied to disk as a single physical file. Each *logical* file within this physical disk file is roughly comparable to the information contained in one LAS file.
- All of the formats are self describing in at least some ways, and their structure varies form tape to tape (or file to file).

- All identifying information and parametric information is recorded in tables as *mnemonic/value pairs*. The *value* member of the pair can be complex if the item of information is numeric. The associated units of measure may also then be present.
- The basic semantically relevant package of information is the file for ASCII formats or the *logical* file for DLIS, LIS, or BIT. In later sections, this will simply be referred to as a *file*.

Data Mapping Issues

The most important issue of mapping from the common well log formats to PPDM is reconciling the view of the data presented by the exchange format with the view of the data represented by a PPDM database. Both are essentially hierarchical in nature, however their hierarchies are significantly different.

The well log delivery formats are primarily organized by their physical elements:

- **Files** - This is the basic unit of well log data interchange, and contains all of the other items below.
- **Parameters** -Each file may contain one or more sets of mnemonic/value pairs. Regardless of how this information is semantically related, it is organized in a simple table structure. There are over 13,000 recognized mnemonics which may appear in these tables. Some are easily recognizable and are commonly used, however there are no enforced standard for these mnemonics or their meanings. It is very common to find more than one mnemonic for the same item of information. For example, if one was looking for the temperature at the surface when the well was logged, one would have to search for the mnemonics SHT, ST, STEM, SURFACE_TEMPERATURE, or TSUR. To make things worse, new mnemonics may be added at any time by anyone, and put into use without any prior authorization or warning to the industry. As if the naming issue isn t bad enough, some values are intended to be identified as one of a set of possible values. For example, the value for the permanent datum of the well (identified by the mnemonic PDAT), may be found to contain GL , G.L. , GROUND LEVEL or some other variation (generally in English), all meaning ground level. Standardization for these sets of values is even less formal than the parameter mnemonics themselves.

- **Frames** - Frames are used to organize Curves sharing a common sampling interval into a group. All of the curves in a frame of data were acquired at the same time or depth, depending on how the data in the file is indexed. LIS, BIT, LAS, and most other ASCII formats only provide for one Frame to be present in a file. DLIS however allows multiple frames to be present with various sampling intervals and index types.
- **Curves** - Each Curve, also known as a channel, may be a member of only one frame. The simplest of curves contains one value for each index value of depth or time. Curves can, however, be very complex entities, containing multi-dimensional arrays of data values in each Frame. Curves may have a number of sub elements depending on their complexity.
- **Units** - Units are not a structural element in the same sense as Parameters, Frames, and Curves, however they are pervasive within each format. There are 2 well defined unit systems used in well log exchange formats. LIS defined a set of 4 character mnemonics which also tend to be used in ASCII formats such as LAS. There is, however, no guarantee that units of measure mnemonics found in ASCII log files are in fact a member of the LIS defined set. LAS states only that units may be present, but says nothing about what a reader might expect to see. DLIS defined a new system of units in which each unit is an expression composed of numbers and fundamental mnemonics. These expressions are parsable, and provide for automated conversion. All units in BIT are implied, and are generally represented using the LIS unit mnemonic set.

PPDM and other petrophysical relational databases tend to have a project, field, or well at the top of their hierarchy. In the case of PPDM, the primary tables of interest in their hierarchical order are as follows:

- **WELL**
- **WELL_LOG_JOB** - Information associated with the set of wireline logs, run by a logging service company as part of a well site service job.
- **WELL_LOG_TRIP** - Information about the logging services and wellbore environment associated with a logging trip. A trip is defined as the events that transpire while a particular tool string enters and operates within a borehole.
- **(WELL_LOG_PASS)** - The table is implied in the PPDM model although not currently instantiated. It represents the information associated with the actual acquisition of data within a WELL_LOG_TRIP. There may be one or more WELL_LOG_PASSes per WELL_LOG_TRIP. It is roughly equivalent to the *file* in the well log delivery formats.
- **WELL_LOG_CURVE, WELL_LOG_CURVE_INTRVL, WELL_LOG_DIGIT_CURVE** - These tables are used to contain information about each individual curve acquired within a WELL_LOG_PASS.

It is ***very important*** to note that since this is a well log archival system, none of the actual curve values need to be loaded into the database. The original files are retained, and the information in the database describes them and contains everything necessary in order to retrieve the desired curves later. The architecture of the WLMS system provides for storing actual curves, but in practice, this is rarely necessary.

The determination of rows to be created in each of the above tables (and their associated supporting tables), given any specific well log interchange file, can be a challenging exercise. There is often very little information available to determine which input files belong to a WELL_LOG_TRIP, and subsequently which WELL_LOG_TRIPs belong to a given WELL_LOG_JOB. The named parameter mnemonic/value pairs may or may not provide enough information to make this determination, and even if they do, the data quality of these parameters is often suspect. This is particularly true of older data. The current set of PPDM tables do not provide for all of the information that needs to

be stored in order to later retrieve curves and parameters of interest. It was necessary to create additional tables and modify the hierarchy of WELL_LOG_CURVE related tables in order to store all of the necessary information.

A basic mapping from the well log interchange files to the PPDM database has been made, and software has been implemented to load well log interchange files into PPDM. The mapping and software will not be described in this paper since it will be changing between the time this paper is published and the time that the associated presentation is made. Updates should be available at the time of the presentation.

Data Validation

The issues of data validation are somewhat subjective and depend on usage of the data. Some users require very high data integrity that implies very strict validation as the data is loaded. As the complexity of validation increases, so too does the amount of effort required to load each new file. More information will need to be verified by the administrative user, and more information may need to be supplied at the time the well log file is loaded. It is unlikely that all of the mandatory information will be contained in the file as supplied by the service company. An alternative is to load the data with minimal validation and then resolve problems after the data has been loaded. In either case, significant human intervention may be necessary in order to achieve high data integrity. The WLMS system provides for very flexible configuration of automated validation. As a very high level example, most companies require that a WELL exist before any log data relating to that well can be loaded. This may be a good practice, but it is not absolutely necessary. The database loader could create rows in the WELL and associated tables as necessary as it loads any well log data file. Without commenting on the wisdom of either practice, the loader and validation software can easily be configured to support either method.

Data Retrieval and Management Component

After the loading and storage of the well log data has been accomplished and all data preserved in the WLMS, the geoscientifc and geotechnical staff has selection and delivery capabilities. The web technology-based WLMS has both map and attribute based search capabilities to find appropriately located well logs with those characteristics of interest.

The WLMS provides tabular and map displayed results of requested wells. Using the shopping cart model of interaction, wells of interest are selected and staged into the cart. The contents of the cart are then available for delivery into the application of choice or into a format that can be delivered to the user s desk top. The format of delivery is independent of the format in which the data was archived. The WLMS provides a very efficient and familiar model for finding and obtaining well log information from across the enterprise.

For more information, contact:

Jeffery Pferd

Sr. VP Product Management

1-877-9PETRIS

pferd@petris.com