Standardizing Fluid Property Reporting

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Introduction

Objective. This paper describes the efforts of ExxonMobil to design and implement an XML based solution for the exchange and communication of fluid property data associated with laboratory and analytical characterization studies. This work was undertaken to improve ExxonMobil's internal capabilities to acquire, load, and utilize fluid property characterizations and to address specific shortcomings related to the exchange of these data. The objective of this paper is to describe the viewpoint from which an internal solution has been constructed and to present the results of this effort as a possible starting point for the development of an industry standard.

Constraints. Among the constraints that applied to this effort, the primary requirement was that any solution must work within ExxonMobil's existing technical computing environment. At ExxonMobil, the technical computing environment has been globally standardized with respect to applications, databases, LANs, hardware and security. Of specific importance to this project were the proprietary databases and applications that store and analyze fluid characterization data, which were in turn used by other commercial and in-house applications. It was important to this project to limit the impact on this environment while recognizing that some changes were required.

A second constraint was that the solutions developed must also work with existing vendor processes. An explicit goal of the project was to work towards a solution in which fluid analysis laboratories could provide their results in a form and format that could be incorporated into ExxonMobil's workflow with a minimum of manual intervention. Also, it was intended that specific XML products not be required in vendor implementations.

A third constraint faced by this project was that existing data (both in-house and vendor) be retained. Much of the pre-existing data at ExxonMobil has been kept in hardcopy format, and a measurable fraction of the currently stored digital data does not have adequate meta-data to unambiguously connect it to specific laboratory reports and samples. It was essential that, where the data was so deemed by the owning business unit, this existing data would not be lost or corrupted by any changes implemented by this project.

A fourth constraint was to satisfy the goal that this effort contribute to industry standardization. A proprietary solution was not considered to be the optimal outcome of the project – but rather that ExxonMobil would work with interested operating companies, fluid analysis laboratories and standards organizations to develop a workable, international standard to facilitate the exchange of fluid property data.

Lessons Learned. In addition to a working system for fluid properties, this project resulted in several lessons learned – most of which are neither new nor unexpected.

The most important (and most obvious) learning was that changing a workflow produces the need to change the applications and databases that support the workflow. As a result of improving the fluid property workflow, changes were made to both the databases and applications that support the workflow. Therefore, it was very important to make sure that the resulting changes were both useful and usable as it was not acceptable to "do over" changes to systems that were in use worldwide. It was also necessary to coordinate the deliverables produced by this project with the existing development and implementation schedules for the impacted databases and applications.

This consideration encouraged the adoption of a "loose integration" design. Whereas "tight integration" tends to require that implementations understand the intimate workings of linked systems, a "loose integration" strategy focuses on system interaction through independent, often asynchronous, interfaces (i.e., a data format). By focusing on developing a data interface rather than a shared data object, for example, modifications made to different databases did not have to occur simultaneously and were also independent of changes made to applications. These parallel development efforts started with the completion of an initial data structure and concluded with final system testing, with only informal coupling for intermediate testing. A result of adopting a "loose integration" strategy was that methods of incorporating business rules in the interface (e.g., minimum data, consistency, structure, etc.) were required to compensate for the lack of code-based behavior.

As expected, understanding external and internal work processes was a key success factor. In addition to the physical behaviors that defined what an acceptable fluid property interface must communicate, the uses to which these data are applied provided key content and data management requirements that translate into interface facets such as identifiers, uniqueness constraints, content integrity rules, enumerations, units of measure, etc. Therefore, it was important to engage both users and support personnel in these discussions to ensure that an acceptable solution was being targeted. This step identified the need to view each collection of fluid data as a point within the data lifecycle rather than as independent information. This step also prompted the development of a prototype that was used prior to the completion of the final systems.

One disappointing learning was that the XML tools employed for various purposes in the project were not yet completely consistent. The XML tools utilized were the latest versions available, but differences in the interpretation (and therefore implementation) of W3C XML specifications were encountered, most notably with respect to internal key references. Adjustments, primarily the elimination of a desired capability or its reduction of a least common denominator of behavior, were required to obviate the need to specify a vendor specific toolset.

Work Process Improvement

Internal Work Processes. The dominant work process for handling fluid property data at ExxonMobil has been a mostly manual process. The initial request for fluid sample collection and laboratory analysis was initiated by a user in a business unit, and the results of the analysis were delivered to the user as a report in hardcopy and/or electric form. The report data may have been checked for consistency, completeness or correctness by the user (typically using spreadsheets), or the data may have been forwarded to an expert for checking (typically using a proprietary application). Occasionally requests for additional vendor services or clarifications were generated.

These fluid property reports were often forwarded to central storage but a copy was usually retained by the user, kept in a desk drawer or filing cabinet. Later users seeking to use fluid property reports often requested the assistance of the original users and experts to identify and locate the correct reports. When located, the data in the fluid property report was manually entered (including "cut-n-paste") into the desired application. Within ExxonMobil, the typical workflow has been to first characterize the fluid data and then export a "fit-for-purpose" dataset for the intended engineering application. This process resulted in additional fluid characterization datasets available to later users. However, whenever users were uncertain of the pedigree of existing characterization results, the data identification and location process was often repeated and the original report data was again manually entered into an application.

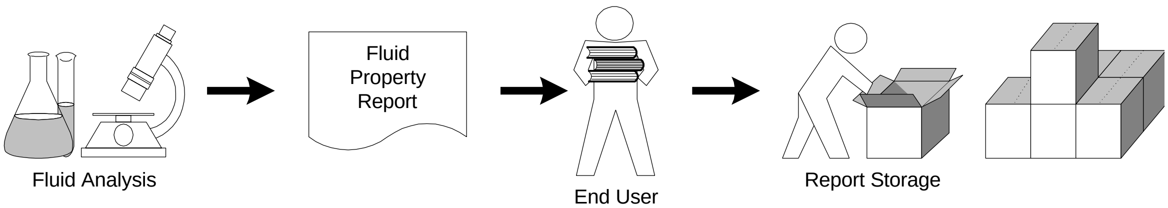

Figure 1. Current Workflow

Vendor Work Processes. The work processes of fluid analysis laboratories have become better aligned with their core business practices, requiring them to more consistently maintain descriptive data about samples collected and studies performed. This improvement has not been translated into consistent reporting formats, however. Differences in report content, layout and naming conventions are obvious when comparing different vendors, but differences are also apparent between reports produced by different offices of the same vendor. Occasionally differences are noticed among reports produced by different personnel within the same office or by one person at different times. For all these situations, it has been very important that the procedural information accompanying the report be detailed and accurate.

Variations in vendor reporting have necessitated the manual assimilation of data delivered to ExxonMobil and for the routine review of these reports by fluid characterization experts. We have noticed that procedural or reporting variations can lead to mistakes in manual data entry by non-expert users. Further, the lack of comprehensive procedural information makes the task of identifying such mistakes difficult. The fault for this situation is rooted in the lack of consistent, verifiable customer requirements.

Process Improvements. The analysis of these internal and vendor workflows indicated that several coordinated actions were needed to improve the entire process. The opportunities for improving the workflows for fluid property data included:

- a consistent and verifiable data structure for data delivery from vendors;
- automated data loading of received data into a usable database;
- easier data exchange between the databases and fluid characterization applications;
- a richer description of the pedigree and lifecycle state of fluid property data.

The actions taken to capture these opportunities included:

- "FluidReportML", an XML schema, was developed to define the content and structure of fluid property reports;
- the database tables used to store fluid property information were redesigned to better reflect the state and extent of data;
- ExxonMobil's proprietary fluid characterization application was modified to read and write XML files using FluidReportML;
- an existing data movement utility was adopted to batch read and write FluidReportML XML files to and from the modified database;

- ❖ an existing data capture application was customized to allow for the manual (online or offline) entry of legacy data and to manage the importing and exporting of XML files from the modified database.

Other ongoing actions contributing to improvements to the fluid property workflow include a separate project to standardize the LAN structure so that fluid property reports and fluid characterization files are consistently located, and efforts by local business units to search out and load "data in desks on disks."

ExxonMobil is working with its vendors of fluid property reports to implement the digital delivery of data in FluidReportML-based XML files and textual reports as PDF files. However, we are not requesting that existing reports and formats be replaced at this time so as to minimize the disruption to both vendors and our worldwide business units.

Design and Implementation

Technology Selection. The business needs that drove the design of an improved workflow have been mentioned earlier. A "tight integration" solution was understood to provide better performance, more control and better flexibility for business rule implementation but at a cost of longer development times and higher ongoing maintenance and support. In contrast, "loose integration" allows the decoupling of related development efforts and the construction of interfaces that can more easily accommodate structural inconsistencies and adapt to changes that occur at different times, but with some sacrifice of control and performance. As performance was not a primary requirement for this workflow, a "loose integration" strategy was adopted.

The basic requirements for the "loose integration" strategy included that any intermediate products (i.e., data exchange files) should be:

- ❖ self-describing – each product should be self-documented so that the intent of the content is unambiguously communicated and that version changes, local customizations, user additions, etc. do not create misunderstandings or misreadings;
- ❖ computer parsable – each product should be constructed so that commercially available tools can correctly read, write and navigate the structure of the product without customization;

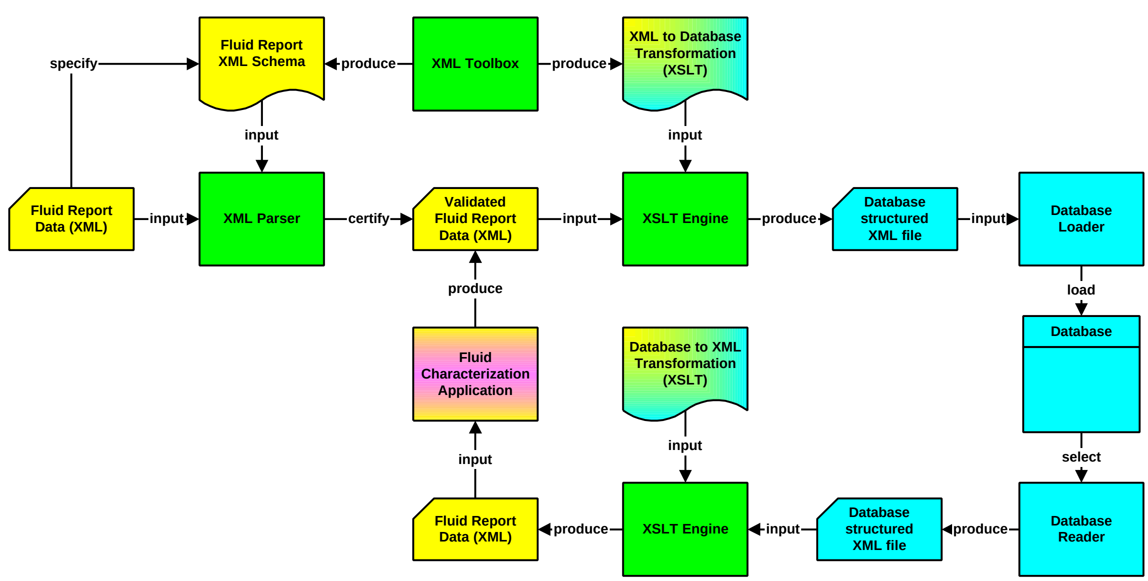

Figure 2. Loose Integration using XML

- human readable – each product must be able to be displayed using commonly available tools in a readable form so that a human reader would be able to determine from the product what information it contains;
- commonly verifiable – each product must be consistently verifiable using commonly available tools against a specification that is commonly available;
- incorporate existing standards – to the greatest extent possible, each product should be built upon and utilize existing standards.

Interface Tool. A "for purpose" tool was constructed to both manage the flow of XML-based fluid property data and the capture of data from legacy hardcopy documents. This tool was built upon existing, internally developed tools capable of producing a user interface based upon data structures and related metadata. This tool was adapted to process XML schema based files, both from a local (offline) database or the official (online) repository. The offline capability was incorporated to facilitate capturing legacy data from both hardcopy reports (typing) and digital sources (cut and paste) by allowing the suspension of business rules until incremental data capture activities were completed.

The interface tool was also responsible for maintaining the consistency and integrity of the offline and online databases, therefore it also initiated each user's access to the online database while enabling ExxonMobil's security protocols to be fully enforced. This consistency was important for newly arrived data as FluidReportML-based files were not able to express internal (i.e., foreign key) database relationships. This tool allowed for data to be loaded into an environment whereby these relationships could be instantiated and verified prior to loading the data into an online database. Another capability of the interface tool was to manage and convert the various units of measure used in fluid property hardcopy reports, XML files and the online database.

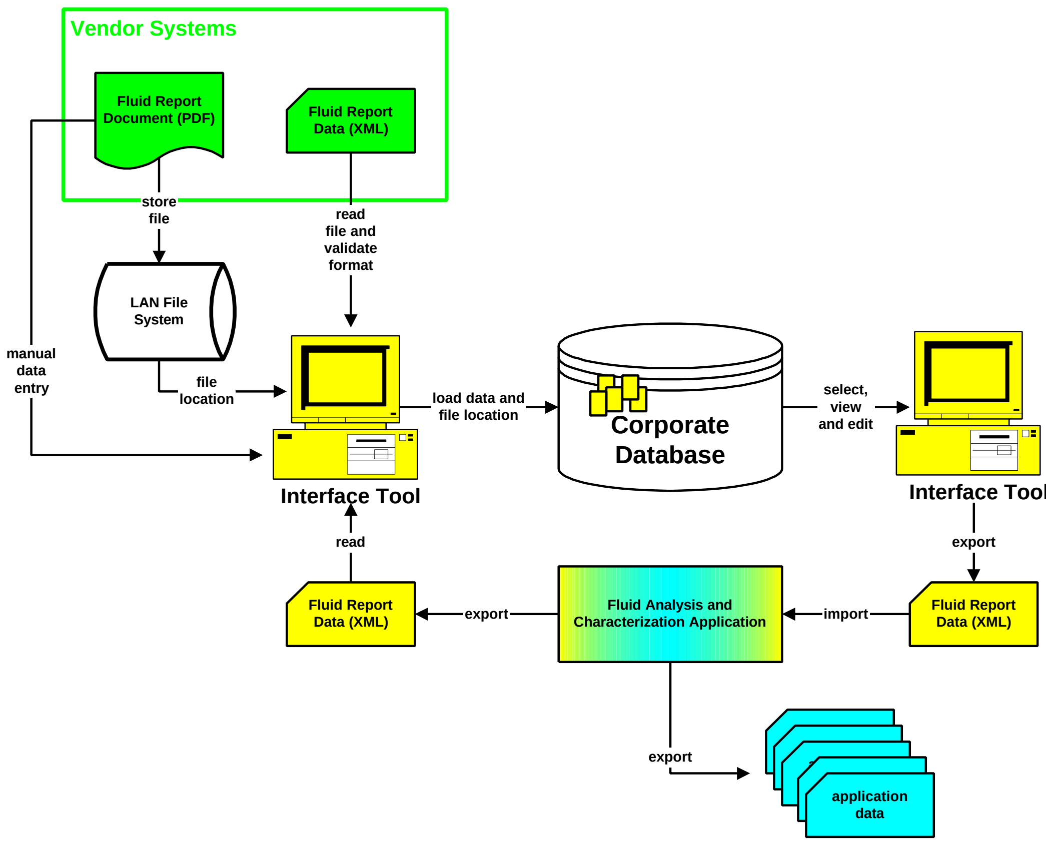

Figure 3. New Workflow

The interface tool was also used for data selection and filtering. This provided the users the ability to access and sift through large volumes of data quickly so that they could efficiently identify and work with data of interest. This capability was also employed to select data to be exported as XML files for use with other applications.

XML Schema. The content of the FluidReportML schema was determined by the information used in the specific workflows identified as candidates for improvement. For the fluid property test, the supported tests included constant composition expansion, constant volume depletion and differential liberation as well as separator tests, fluid transport properties, J-curve and saturation pressure measurements. Total and phase compositions were included along with a number of physical characteristics, such as phase densities, viscosities, volume factors, compressibilities, and standard condition ratios. For characterized fluids, a distinct set of calculated properties as well as the equation of state model parameters were included. To meet user requirements for searching and selecting data, data were added to connect fluid samples to their source wells, completions, reservoirs, or flow streams to allow for multiple analyses to be recorded for individual samples, and to record the pedigree of each analysis.

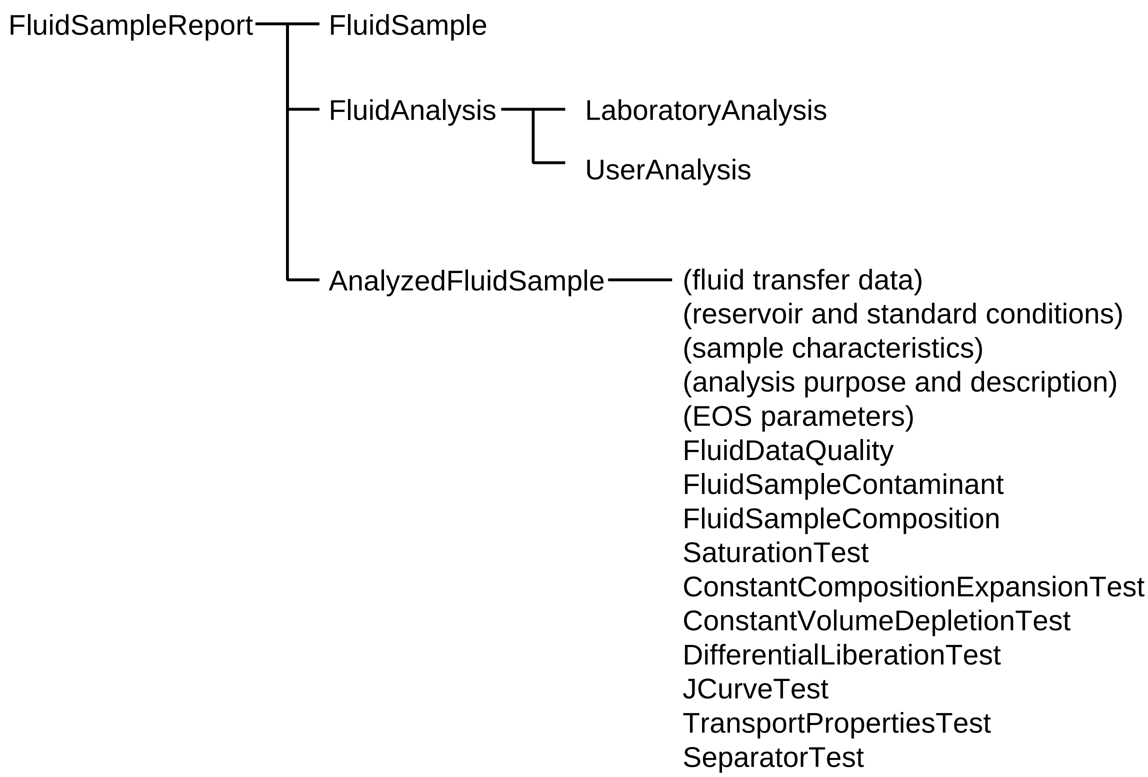

Figure 4. XML Schema Structure

An intentional limit in the scope of the FluidReportML schema was not to attempt to convey the full textual content of the report written by the laboratory. While within the capabilities of XML, it was not deemed necessary to define a single, comprehensive solution. The delivery of a textual report (PDF preferred) with all tables, charts and descriptions will be expected even after the adoption of FluidReportML, and the FluidReportML schema and ExxonMobil's database allows for the location of this file to be captured and subsequently accessed through the interface tool.

Other Modifications. As implied earlier, modifications were required to corporate databases and proprietary applications. The greatest challenge in this step was introducing the "break-in" requirements of a relatively small project within the much longer term cycles of these major development projects, and then delivering a coordinated, worldwide release. A second challenge was the identification and migration of existing data retained in non-standard systems into the new data structures.

Current Status

The system described in this paper, including FluidReportML, has been deployed in all of ExxonMobil's upstream business units. ExxonMobil has had discussions with several vendors of fluid laboratory services to present both these activities and the desire to improve the delivery of fluid report data. The goal of a standard, usable exchange format has been consistently supported.

ExxonMobil has submitted its FluidReportML to POSC as a candidate for additional work towards endorsement of an industry standard. As FluidReportML was constructed without input from other operating companies and fluid laboratories, further requirements gathering and the development are anticipated. ExxonMobil supports adoption of an industry standard format as a replacement for FluidReportML when it becomes available.