Standardization Barriers in the Petroleum Industry

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1 Introduction

The petroleum industry is a multi-billion-dollar worldwide enterprise whose goal is to discover natural resources such as oil and natural gas, extract these resources from the ground and oceans, and eventually produce chemical products that are most commonly used as energy for the world's consumers. The industry is split into three main components: upstream, midstream, and downstream. It is the upstream component, also known as the exploration and production (or E&P) sector, which is responsible for finding these deposits and bringing them to the surface through the drilling of wells and the subsequent operation of an oilfield. In the last ten years, broad innovations have taken place in the processes of drilling into the planet's crust and maintaining the flow of oil and gas from the resulting fields. The well's harsh environment of 7,000 pounds per square inch of pressure and 250 degree temperature had prevented thorough instrumentation in the past but advances in insulation and shock absorption now permit electronics to survive the down-hole environment [1]. With the increase in well instrumentation has come an explosion of data which must be handled and exchanged by a number of devices and applications. This data is vital for petroleum engineers to make decisions on how to maintain these wells and keep the products flowing. Traditional solutions provided by SCADA system providers use proprietary protocols and data formats to gather and process well data. This has led to systems with incompatible formats and protocols and has impeded the exchange of data between different vendors' systems and applications throughout the oil recovery process.

In the wake of the 2010 Macondo well blowout in the Gulf of Mexico that killed 11 workers, governments require more reporting from sites to assure safety and general regulatory compliance. It is likely this increased attention will bring further pressure on the petroleum industry to standardize data communications protocols, because even though governments won't likely want real-time data, they could mandate a standard report format (as we will discuss below for Norway) and time may be saved on approvals to begin and continue drilling operations if interoperability is achieved.

1.1 Definitions

Energistics: A standards body initiated by a number of oil and gas companies in 1990 under the name Petrotechnical Open Software Corporation (POSC). They became Energistics in November 2006. Energistics actively manages the WITSML, PRODML, and RESQML standards.

PRODML: PRODuction Markup Language is a set of oil and gas production data standards, initiated by 13 upstream oil and gas service companies along with the industry standards body Energistics.
SCADA: Supervisory Control And Data Acquisition systems monitor sensor data and send control signals into the field.
WITSML: Wellsite Information Transfer Standard Markup Language is an Energistics standard used to transmit information between the specialty contractors and the operator on an oil or gas well site.

2 Objective

Our research into the petroleum industry identifies the barriers that exist to adopting data communications standards. We used a case study from an actual project in Colorado to identify a sample of specific cost savings derived by using standardized data communications protocols versus vendor proprietary protocols. We also looked at a pilot project in the High North region of Norway and research about latecomer industries to digitization to show the progress in the industry toward data and format standardization and the position that the petroleum industry is in to benefit from standardization.

This paper seeks to answer the following questions:

1) Can significant cost savings be derived from using open data and communication standards in place of current proprietary standards?
2) Can the petroleum industry benefit from their latecomer status in adopting data communications standards?
3) Do the environmental conditions affect the adoption of data communication standards?

This paper concludes with industry recommendations.

3 Scope and Assumptions

The intended audience of this paper is the oil and gas production companies, companies that service the oil and gas industry with SCADA solutions, oil and gas production software providers, and anyone with an active interest in the development of open standards.

The scope of the research is the data formats and communication protocols currently in use in the upstream petroleum industry and does not include any data in any other areas of the industry. We have made an assumption that if a data communications standard were already in place, the software used to operate the fields would not be vendor specific and could be changed out for the marginal cost of the software.

4 Relevance to Prior Work

Although a few papers have been written on the broad benefits of moving to data communication standards for oil and gas production data exchange [2] – [9], no specific cost savings have been presented. Since the standards are still very young, only the larger oil companies appear to have the resources available to test the waters. The authors contacted engineers in a smaller natural gas production company and found they were completely ignorant of the Energistics standards or the existence of the standards body.

By connecting the broader research of previous papers with the specific cost savings of our case study, we will show concrete benefits to migrating to data communication standards.

5 Analysis

Our research began with the traditional behavior of the E&P sector of the petroleum industry and sought evidence of the barriers to standardization of data formats and communications protocols. A significant problem has grown from the reluctance of the petroleum industry to recognize the value in information technology. Our research shows that the investment level in IT for the petroleum industry has been far less than comparable-sized industries [10]. This has made these companies more dependent on vendors and their equipment and data formats. In turn, those vendors have protected their turf by customizing the communication and data formats to suit their equipment which makes it difficult for petroleum companies to switch vendors without significant cost. As shown in the case study, costs were incurred when project management was forced to change from one vendor's equipment to another's, indicating that standardization could save the industry significant cost. In a world of highly volatile energy prices (which ironically has been found to be a major barrier to IT spending), this could be the key to survive.

5.1 Case Study

This case involves a SCADA system migration that took place in the gas fields of the Piceance Basin on the Western Slope of Colorado near Parachute and is based upon personal interviews with the engineer and project manager [10] [11]. The field in the study is made up of over 3,700 natural gas wells that are scattered across thousands of acres. Many of the wells are located in remote, mountainous regions which are out of range of traditional telephony circuits or cellular coverage. The SCADA information is captured at the wellhead and transmitted to a central well database via 900 MHz radios that are scattered throughout the basin. The radio network provides 90 miles of communication coverage using 30 ft. to 300 ft. towers and high-gain antennas.

At each well, there is a host of field equipment which both monitors and provides automatic and manual control of the well operation including: wellhead pressures, gas flow measurement, liquid flow measurement, liquid level/tank level measurement, well sales control, automatic production optimization, and smart local emergency shutdown. All of these sensors provide over thirty-one million data points which are automatically retrieved, recorded, and displayed daily.

The sensors and controllers at the wellhead are wired into a central remote terminal unit (RTU). The RTU is responsible for capturing and archiving the well sensor information locally and transmitting the information back to the well database. The RTU also maintains local programming for the controllers at the wellhead. The sensors and controllers communicate with the RTU using the MODBUS protocol. The RTU communicates with the central well database using a vendor-proprietary data communications format. While it is technically possible for the wellhead database to communicate with the sensors and controllers directly using MODBUS, because the field has grown to such a large size, the polling interval to retrieve all of the data from all of the wells cannot take place fast enough to keep the data relevant. Therefore, the primary job of the RTU is to function as the well data manager, historian, and liaison. The sensors, controllers, and the RTUs at the well sites are primarily manufactured by a single vendor, Ferguson Beauregard, who also developed the original SCADA host system which contains the well database and is responsible for communicating with the well sites.

The technicians whose responsibility it is to take care of the wells are referred to as "pumpers." Every morning, the pumpers come into the central operations center with their laptops and download the information that has been reported by their wells for the last 24 hours. The pumpers then analyze the data for each well and determine what their service route will be for the day. This procedure is referred to as "going mobile". Each pumper is responsible for 100 or so wells. The original operations center out of which the pumpers worked was located in the same building and on the same LAN as the datacenter that housed the well database. As a result, the pumpers were accustomed to having sub-millisecond latency between their laptops and the well database when retrieving their daily well information. However, the number of pumpers needed to maintain the field increased to a level that the operations center could no longer handle all of the pumpers. A new operations center was built two miles down the road from the datacenter that houses the well database server, which could not be moved with the pumpers because its radio network was homed to the datacenter's building. This meant that the radio network would have had to be rehomed to the new operations center in order to move the database, which was not cost-effective. The network connection between the new operations center and the datacenter is via a multi-hop radio network. The new network introduced a 10 millisecond, round-trip delay between the pumpers' laptops and the well database. This seemingly small increase in delay increased the time it took for a single pumper to "go mobile" from 45 minutes to over two hours, which was unacceptable.

The network traffic between the pumpers and the database was captured and analyzed to determine the source of the delay. It was discovered that the method used by the Ferguson Beauregard system to request and receive data was extremely inefficient and this inefficiency was the cause for the delay. The inefficiency had always been present but was exacerbated by the increased network latency to a level that made the application no longer usable.

Ferguson Beauregard software engineers were contacted to relay the findings from the traffic analysis and discuss how to move forward with a solution. Ferguson Beauregard took the position that the SCADA host system was based upon a Microsoft Access database structure and had never been designed to scale to such a large size. Ferguson Beauregard decided it would not be in their interest to acquire the software programming talent needed to further develop the SCADA host product and declared that they had no intention of changing it. Because there were 3,700+ units already deployed in the field, it was not economically viable for the field operator to replace all of the Ferguson Beauregard field equipment simply to replace the SCADA host system software. At this point, an alternate vendor, Cygnet, was brought in to provide a new SCADA host system solution but because the Ferguson Beauregard RTUs in the field used a proprietary data format, Cygnet was required to write a new driver from scratch for their SCADA host system to communicate with the Ferguson Beauregard RTUs. As a result, the operator of the field was forced to pay Cygnet $180,000 for this driver [11], adding significant cost to their operations. Although, $180,000 is a small amount of money relative to the income of the operation, this cost represents one piece of software, at one site. There are multiple software packages at multiple sites across the nation each of which could incur such a replacement cost.

PRODML is designed to provide an open standard based approach to data handling and a common data exchange format based upon XML. The potential benefits of the PRODML standard include: improved operations performance, improved collaboration and sharing of data, integration with partners, inter-organization communication and analysis, rapid deployment of internal tools, and increased capabilities of applications available in the marketplace [2]. If the Ferguson Beauregard RTUs had used the PRODML data standard to present their data instead of their own proprietary data format, a new vendor's PRODML compliant SCADA host software could have been migrated into place without the additional time and money needed to create the custom driver.

5.2 Latecomer Industry

The oil and gas industry can aptly be labeled a latecomer industry, meaning that it has been slow to adopt digital technologies and standards. The oil and gas industry is not completely devoid of digitization or standards, but rather it has been more local and segmented than many other industries.

A common trait of latecomer industries is that firms have specialized, complex industrial machinery involving large capital investments. The large capital costs lead to cyclical product demand as well as a barrier to entry for other firms. This has the effect of making it difficult for standards to gain momentum, especially when profits are high. [12]

A changing business environment, such as technological advances that significantly lower the costs of capital investments, can have the impact of creating optimal opportunities to introduce broader standards; also, if firms can clearly see instances--such as those seen in our case study—where standards could clearly reduce capital expenditure uncertainty. Though latecomer industries face obstacles in creating standards, there is the advantage of learning from other industries and the obstacles they faced in creating IT standards. [12]

The benefits of standards in the E&P industry can easily be seen from the outside looking in, leading some to wonder why standards have been slow to catch on. Part of this problem involves companies deciding when and where it is best to seek standards. With standards there is often a move to outsource, which has the potential to reduce staffing needs and lower costs. At the same time, there is a possibility of losing control of certain decisions and, of more consequence, a loss of expertise. This leads many companies to wonder whether it is prudent to take a step backwards in order to get to a point that is only fractionally better. [13]

According to the American Petroleum Institute, an Ernst & Young study showed that the five major oil companies had $765 billion of new investment between 1992 and 2006, compared to net income of $662 billion during the same period. The industry overall, consisting of the 57 the largest U.S. oil and natural gas companies, had new investments of $1.25 trillion over the same period, net income of $900 billion and cash flows of $1.77 trillion[14]. To compare to revenues, Exxon Mobil, the world's largest publicly traded oil company, reported net income of $9.4 billion for the quarter of 2011, up from $9.25 billion the year before. It posted revenue of $121.6 billion, up 16 percent. Also in the fourth quarter of 2011, ConocoPhillips had revenues of $62.4 billion. [15]

An IT standard should provide the benefits of: economic competitiveness, compressing time to market, reducing infrastructure vulnerability, expanding market for companies, decreasing supply chain for communication costs, providing global access for software vendors and reducing duplication effort. Obviously, these are all goals worth striving for, but often prove difficult in a latecomer industry. [16]

Industry standards will be necessary to provide the interoperability among third party IT components to achieve integrated operations. As the need for standards interoperability grows it will require more coordination of the standards organizations with a more cross-functional focus. A crucial step needed for more coordination of standards include developing a common understanding of the processes and methodologies of the standards. This is an important step and useful in finding areas of potential synergy as well as areas that overlap. [16]

For many industries, standards have been a key to expanding and opening new business opportunities. An important aspect of setting standards is ensuring that the standards development mirrors the way production processes are developed and improved. This essentially means that standards are seen as an industry-wide sharing of best practices that can add value to the chain in that particular industry. Standards can also be seen as closely related to quality management, in that they allow for greater predictability when deploying or changing sites. [17]

5.3 Industry Progress

The petroleum industry is driving towards standardization, in spite of some of the barriers mentioned before. However, the early adopted standards have had their own difficulties in implementation. One of the key issues which inhibited the implementation of data standards in the petroleum industry was the piecemeal and inconsistent implementation of the various standards in the industry, which, at times, would overlap and be redundant. Even within a particular standard, implementation would be uneven, with various versions of a given standard being used at any given time. This particular problem was discussed at an Energistics conference in London in 2011. During the conference, Jon Curtis (Petrolink) discussed the inconsistency of various forms of the WITSML standard (and others) being used within the industry [18]. Some reports from the well were coming in the older WITS format, which has been used since the 1980's in a non-networked environment, and some reports were coming in the various versions of the WITSML format, requiring significant data treatment to make the data uniform. By unifying standards creation and implementation, overall vendor acceptance of data standards acceptance would be greatly facilitated and more uniform standards implementation can be accomplished.

Recently, the oil industry data standardization bodies, including Energistics, formed the Standards Leadership Council (SLC). The additional standards organizations included the Public Petroleum Data Model (PPDM) Association[23], which is an organization designed to help manage exploration and production data, the PIDX, an organization designed to facilitate electronic commerce in the industry[24], the Open Geospatial Consortium[25], a standards group enabling the exchange of geospatial data across several industries, including the petroleum industry, the OPC (Open Productivity & Connectivity) Foundation[26], which manages the standards for industrial automation, the Pipeline Open Data Standard (PODS)[27], which conducts standards activities for pipeline activities, the POSC Caesar Association[28], another organization which has advocated the development of open specifications and maintains the ISO 15926 standard for oil and gas production facilities and MIMOSA[29], an organization that encourages open standards in operations and maintenance in manufacturing for various industries, including the petroleum industry.

Referencing the Standards Leadership Council, Fred Kunzinger, Senior Manager, E&P Global Data Management for Hess stated, "Hess is delighted to see these Industry Standards organizations working together. As an operating company, it's difficult to comply with standards when there are so many separate organizations creating and driving those standards. We hope that the collaboration brought on by the new SLC will improve our ability to design strategies that use industry standards to their maximum potential." [19]

Before the standards bodies joined their efforts, the larger petroleum companies were pushing for more uniform standards. Energistics and other standards bodies were started by leading petroleum companies and other service providers and also IT titans Oracle and Microsoft. Due to these standardization efforts, more economies of scale in information technologies could be brought into networking not only the field, but all layers of production in the petroleum industry, avoiding the scenario described in the initial case study.

Another significant driver in the move towards more data standards lies in the fact that government regulators will want the information standardized and the exploration for oil and gas more frequently takes the industry to harsher and more remote locations, which makes it more dangerous and costly to put people at the drill site. Norway has been a leader in recognizing these trends by requiring that reports such as the Daily Drilling Report are in a standardized format and also by participating in a project involving exploration in the Arctic North region. The Integrated Operations in the High North Joint Industry Project (IOHN) began in 2008 and is due to run through 2012 and could be the prototype of oilfields of the future. In this project, an information communications technology (ICT) architecture has been built using open standards from the POSC Caesar Association, specifically ISO 15926 (Integration of life-cycle data for process plants including oil and gas production facilities). The stated goal of this project is "to design, implement and demonstrate a reliable and robust architecture for Integrated Operations Generation 2 (IO G2). Existing open standards are used and extended when required and new standards are incubated to ensure interoperability, to facilitate integration and to transfer data. To make data-to-information-to-decisions work processes more efficient, information and knowledge models based on open standards are also developed and used." [20] and attempts to integrate several functions as shown in the diagram below:

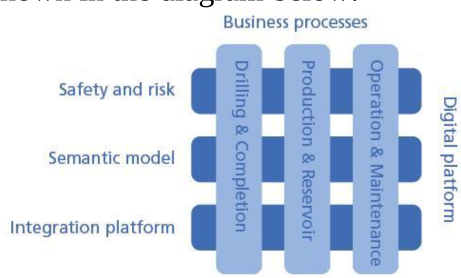

Figure 1: IOHN Function Integration [21]

Also, the research shows the petroleum industry workforce becoming sharply older, as fewer engineering students have opted to join the field for quite some time as many of the people in the field are retiring. [22] This will leave the industry inexperienced at well sites and presents a problem in analyzing the data that is streaming from oilfields, making remote operation much more important.

6 Conclusions

1) Our research shows that the industry's aging workforce and the increased exploration and production of oil and gas in harsh environmental conditions will raise the sense of urgency in standards adoption. Because of the reduction in experienced engineers at the actual well sites and also the rising costs of getting personnel to those sites, petroleum companies will be more reliant on remote data centers that will process the information coming out of the wells, which requires the data from all these remote locations to be in standard formats and use standard protocols to be cost-efficient.

2) Our research also shows that being a latecomer to digitization is a driver in the petroleum industry to adopt standards. The industry can benefit from the experience of other industries and move straight to a standardized environment.

Latecomer industries are able to exploit their position by adopting advanced technologies immediately rather than replicating previous technological arcs. Therefore, strategies need to be built around the petroleum industry's latecomer status in an effort to use it as an advantage. This will require that the petroleum industry understand the character and driving forces behind the industry and also diffusion of industrial processes and technologies. An important part of standards is finding ways to coordinate with other firms and set a growth strategy for getting from current methods to improved standards. As the petroleum industry attempts to catch up, it will remain an imitator, as opposed to an innovator.

3) If the Ferguson Beauregard RTUs in the case study had used the PRODML data standard to present their data instead of their own proprietary data format, a new vendor's PRODML compliant SCADA host software could have been migrated into place without the additional time and money needed to create the custom driver. The only cost incurred would have been the marginal cost of the new SCADA host software.

4) Using the efforts of contractors, operators, and governmental entities, improvements in reporting of exploration and production activities could be achieved to react better to overall market and environmental conditions. The interoperability of the data allows for better decision-making throughout all processes, drilling and completion, reservoir and production, and finally operations and maintenance. This also allows governmental bodies to better govern environmental impact and monitor production with fewer personnel.

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