IoT in Oil & Gas: Don't Get Left Behind

The digitalization of oil and gas production facilities has been gaining momentum but requires a somewhat different approach than other industries in order to cost effectively achieve critical business objectives. This is the result of two unique characteristics associated with these environments—first, the extraordinarily large volume of data that can potentially be generated at upstream production sites and, second, the relatively high cost of network transport to remote and widely distributed sites. These challenges can be addressed but rely heavily on edge analytics that are shaped and informed by broader cloud-based analytics covering massive data sets. While oil and gas producers are making strides digitalizing—that is, adding Internet of Things (IoT) to—upstream production facilities, failure to adopt the correct architecture could result in producers being left behind in the race for greater efficiency and lower production costs.

This paper describes a hybrid IoT architecture that addresses the unique challenges faced by upstream oil and gas operators and delivers important and meaningful business benefits:

- *Near-zero unplanned production downtime*
- *Lower overall support and maintenance costs*
- *Improved production efficiency*

Taken together, these benefits can contribute to efforts to drive down overall production costs and further lower the breakeven point for profitable oil and gas extraction operations.

The Data-to-bandwidth Mismatch

Fully digitalized production sites, with a multitude of equipment and associated systems, can have hundreds to thousands of sensors capable of generating data messages (i.e., discrete sensor readings) at intervals as low as twenty milliseconds, or fifty times per second. This results in a massive quantity of data that must be quickly acted upon or discarded. If all of this raw data were captured and forwarded to cloud databases for processing and analysis, the bandwidth requirements would render the overall IoT system financially impractical. Consequently, most companies are forced to limit the amount of data that is forwarded to the cloud, often to as little as one or two percent of total available data.

However, this strategy hinders the accuracy of the analytics being employed to deliver desired business outcomes. A cardinal rule of data analytics is that, all else being equal, less data equals less accuracy. This might mean, for example, that instead of being able to predict equipment failure with 80-90 percent accuracy, predictions can only be made with 40-50 percent accuracy. This obviously makes the overall system considerably less valuable and, in fact might drop ROI to the point where the system is not financially viable.

Another approach is to apply analytics at the edge (sometimes called "fog computing"). Fundamentally, edge analytics calls for processing (e.g., data analytics, machine learning, rule processing, event orchestration, etc.) to be moved to where the data is rather than the other way around. The benefit here is that all data from all sensors at individual sites can be used without incurring network transport costs. However, this approach can also suffer from the fact that the analytics are only being applied to data generated at that site. One of the benefits of IoT is that data from vast populations of devices at disparate sites can be collected and sifted through in order to develop deeper (and therefore more valuable) insights. With the edge analytics approach this benefit is lost.

The bottom line with both of these traditional approaches is that they sacrifice different pools of available data in order to keep costs down but they do this at the expense of accuracy. And, again, lower accuracy adversely impacts the value of predictions, diagnostic routines, and maintenance cycles in addition to failing to improve site efficiency to the fullest extent.

A Hybrid Solution

A better approach for oil and gas operators is a hybrid IoT architecture in which both edge and cloud processing are employed in order to optimize cost and accuracy.

Figure 1 illustrates a hybrid IoT architecture. As can be seen, data generated by on-board sensors is processed by a "collect" function. In addition to data filtering and normalization, the collect function determines whether generated data should be processed locally or forwarded to cloud database(s). In normal operating conditions, the vast majority of data can be handled locally by on-board "reason" (data analytics and rule processing) and "orchestrate" (automated actions) functions.

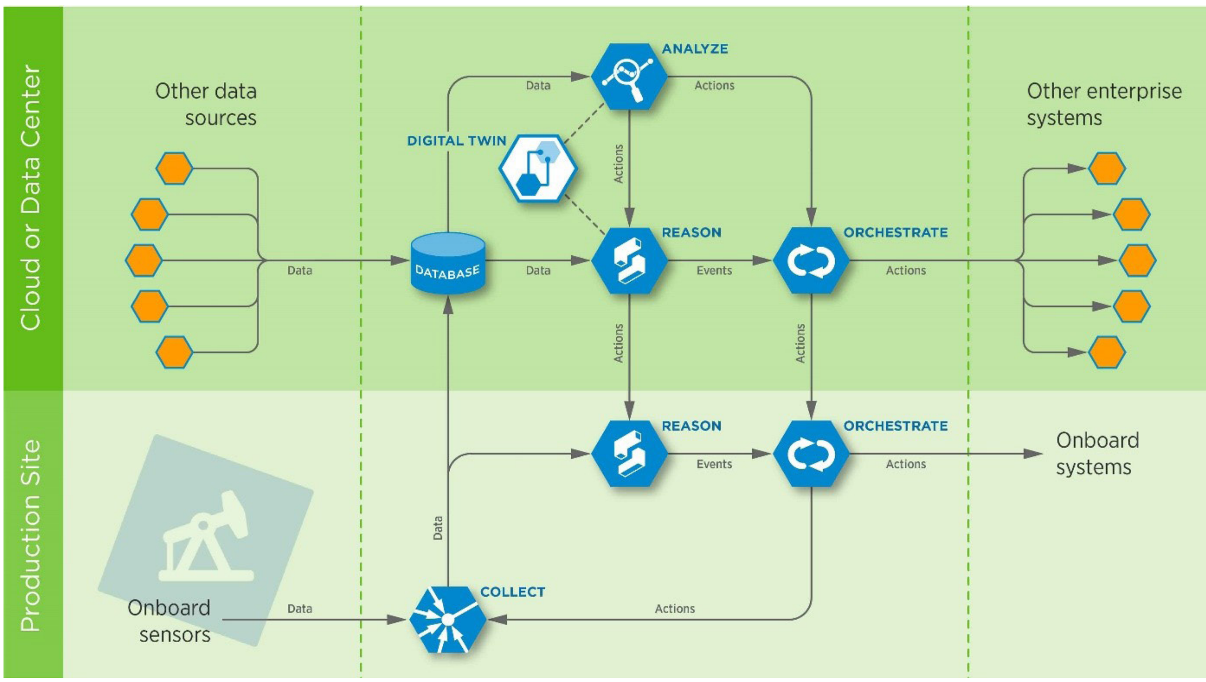

Figure 1
Elements of an IoT system

In a typical deployment, initial data sets are forwarded to cloud databases. This allows machine learning software working with extremely large data sets to develop accurate device models ("digital twins") that include not only status information but also behavioral characteristics. Using these digital twins, rules can be generated that embody business logic. Rules are exceedingly complex "if-this-then-that" statements that detect certain conditions and orchestrate required actions. These rules can be generated automatically by the IoT system or they can be authored manually by subject matter experts.

Once digital twins and business rule sets have been generated, rules can by pushed down to individual sites for local processing, thereby offloading expensive network resources without sacrificing system accuracy. From that point forward, substantially all processing is performed locally. Cloud-based analytics functions periodically sample results in order to detect "rule drift" (i.e., rules for which accuracy is declining) and take corrective steps.

IoT Use Cases Applicable to Upstream Oil & Gas Production

There are a number of IoT use cases with direct applicability to oil and gas operations. To varying extents, these use cases are designed to increase facility uptime, reduce operating costs and/or improve production yield.

Predictive Failure

Many oil and gas operators employ "run-to-fail" strategies with regard to production equipment. This is because, historically, the cost of periodically testing and maintaining equipment at widely distributed sites exceeded the cost of simply replacing the equipment when it finally failed. But with IoT, this is no longer the case.

The ability to automatically predict equipment failure with sufficient advance warning to allow smooth remediation without entailing unplanned downtime changes that cost equation considerably. Run-to-fail may have, in the past, been the most cost effective strategy but it still resulted in unplanned production downtime. With IoT, not only is the cost of monitoring and predicting equipment failure substantially reduced, unplanned downtime can be eliminated.

Adaptive Diagnostics

Even with the ability to accurately predict equipment malfunctions, failures will still occur, albeit less frequently. Another critical aspect of IoT is the ability to assist in the diagnostic process and bring equipment back online more quickly, thereby further reducing production downtime.

In a typical adaptive diagnostics scenario, equipment remediation steps have been predetermined before repair technicians are even dispatched. Predetermined diagnostic steps are based on real-time and historical operating information from large populations of similar equipment and can pinpoint likely repair steps with greater accuracy than traditional troubleshooting methods. Additionally, repair technicians can be outfitted with the right replacement equipment so as to avoid the need for multiple site visits.

Condition-based Maintenance

As described above, maintaining equipment across geographically distributed production sites can be expensive and time consuming. In almost all circumstances where maintenance schedules are followed they are based on elapsed time or hours of operation, not on actual equipment condition or other environmental factors. In addition to being expensive, this invariably leads to under- or over-servicing of equipment. This, in turn, can adversely impact equipment performance and longevity, which is why run-to-fail strategies are often employed.

With condition-based maintenance, equipment is only serviced when actual conditions warrant. As with adaptive diagnostics, the determination of whether or not equipment requires servicing is based on real-time and historical data sets gathered from entire populations of similar devices as well as contextual data. Taken together, this extends equipment life and reduces service expenses.

Asset Optimization

One of the most important operational metrics for oil and gas operators is, of course, site yield. Yield is based on a multitude of factors, many of which can be improved upon through the use of IoT.

Using data gathered from dispersed production sites, IoT machine learning and data analytics create models (again, digital twins) for various equipment types. These models can be compared in order to identify equipment that is performing more poorly than like equipment at other sites. Robust digital models can not only determine which equipment is underperforming, they can provide insight into why. With a better understanding of factors contributing to equipment underperformance, remediation steps can be automatically generated to improve overall performance and, consequently, site yield.

The Bottom Line

Upstream oil and gas production operations are complex and expensive yet vital to the national economy. Improving the efficiency of these operations has long been of paramount importance but information technology, thus far, has failed to provide operators with sufficient tools to maximize these objectives. With IoT and the digitalization of oil and gas operations, it is now possible to substantially improve production efficiency while reducing operating costs.

About Bsquare

For over two decades, Bsquare has helped its customers extract business value from a broad array of assets by making them intelligent, connecting them, and using data collected from them to improve business outcomes. Bsquare software solutions have been deployed by a wide variety of enterprises to create business-focused Internet of Things (IoT) systems that can more effectively monitor assets, analyze data, predict events, automate processes and, in general, optimize business outcomes. Bsquare couples innovative software with advanced professional services that can help organizations of all types make IoT a business reality.