The Internet of Things for the Oil and Gas Industry: Why Quality Assurance is Critical

Operations in the Oil and Gas (O&G) industry function under extreme environmental conditions, located in remote areas, and spread across geographies. A typical O&G production shop floor requires specific skills and continuous monitoring to ensure smooth functioning. The shortage of skilled labor has driven industry experts to discover smart alternatives that can drive core business processes with automation and reduced workforce dependency. However, given the magnitude of production equipment, including sensors and digital devices, business automation software alone cannot address the industry’s automation needs. To add to this, the industry needs to comply with health and safety regulations.

With its machine to machine (M2M) communication capabilities, the Internet of Things (IoT) is evolving as a potential solution. However, in order to ensure O&G business success, it is pivotal to ensure the correct, complete, and optimal performance of these IoT enabled devices. This paper discusses how IoT can be successfully channeled to deliver a positive business impact across the O&G process lifecycle.

The Oil and Gas Life Cycle

With declining prices and exponential increase in global demand, the O&G industry is undergoing major changes. Companies need to manage demand-supply imbalance with smart operations. With remote areas and extreme environments characterizing the operational landscape, companies in the O&G industry need a skilled workforce to manually monitor and manage production data. To gain actionable business insights, this production data needs to be analyzed across upstream, midstream, and downstream processes:

- **Upstream processes** involve exploration and production of crude oil. In addition to continuous optimization, these processes mandate the highest levels of workforce safety, health, and environment standards, to ensure compliance with environment and other regulations and improve overall production efficiency. To meet these process objectives, oil companies need to continuously monitor fluid flow rate, temperature pressure and density, 3D and 4D seismic data, and well logs.

- **Midstream processes** involving movement of crude oil from production sites to refineries, necessitate continuous monitoring of supply chain mediums such as pipelines, rail, trucks, and oil tankers. Transportation plays an important role in the O&G industry’s value chain – facilitating transfer of crude oil from wells to refineries, and finished products from refineries to end customer sites. With a large network of pipelines, trucks, trains, and ships, the transportation process is complex. Combined, the midstream processes have a larger economic impact – not just on ensuring on-time delivery of crude oil to refineries, but also in contributing to economic balance by reducing the demand supply gap.

- **Finally, crude oil refinement**, part of the downstream processes, results in the production of toxic gases as by-products. Leakage of these by-products can be hazardous to human lives and environment. Cracked or corroded pipelines, aging equipment, natural disasters such as earthquakes or tsunamis, intentional and unintentional hazards need to be accounted for – through regular inspection, repairs and maintenance, or by retiring pipelines damaged beyond repair. Data on by-products needs to be continuously monitored to mitigate risks and prevent hazards.

Given the challenges, the three-step process chain requires smart solutions that extend beyond automation and drive not just core business processes, but also ensure regulatory compliance and business results.
Channeling IoT in the O&G Life Cycle

Gartner, Inc. forecasts that 4.9 billion connected things will be in use in 2015, up 30 percent from 2014, and will reach 25 billion by 2020. The Internet of Things (IoT) has become a powerful force for business transformation, and its disruptive impact will be felt across all industries and all areas of society. The Internet of Things (IoT) is growing at an exponential rate. It offers great potential for organizations worldwide, enabling them to unlock the value and benefits from devices, systems and services communicating with each other, using the internet as a backbone.

Here’s how IoT enabled sensors can drive production efficiencies for O&G companies:

- **Sensors on drilling machines** can capture data on pressure, temperature, density, flow-rate, geological and seismic aspects. Analysis of this data facilitates understanding of the earth’s sub-surface, and helps drive accurate equipment performance analysis for lifetime prediction and scheduled maintenance. This enables **early detection of errors, reduced failure rate, efficient equipment performance and reduced downtime**.

- **Interconnected devices** and data from multiple sensors help in selecting the **right drilling equipment** for different environments, ultimately resulting in **efficient drilling operations**.

- **Sensor data, linked with Enterprise Resource Planning (ERP) systems**, drives efficient supply chain management, resulting in right-time raw material and spare parts ordering. This operational efficiency, in turn, leads to **efficient inventory and working capital management**.

- **IoT enabled sensors not only facilitate an efficient supply chain, but also accelerate go to market.** These sensors enable **auto-monitoring of midstream processes**, thereby reducing the complexity of a large transportation network comprising pipelines, trucks, trains, and ships, and ensuring **on-time transfer of crude oil from wells to refineries, and finished products from refineries to end customers.**

- **Safety data from sensors** helps monitor release of toxic gases, and enables prompt response to and analysis of incidents, thereby preventing unwanted accidents, ensuring **compliance** with safety regulations and standards, and of course, ensuring workforce **health and safety**.

- **Sensors mounted on equipment** provide analysis data for well monitoring, fire and gas safety, emergency shutdown, and other processes, resulting in **efficient production operations**.

Further, machine to machine (M2M) communication, driven by IoT, is also gaining popularity across O&G companies. It enables machines and systems to communicate with other devices. When working in unison, M2M and IoT can help companies reduce costs, improve performance, enhance safety, and drive operational efficiencies.

IoT enabled devices and systems can facilitate efficient O&G operations, with minimum human intervention, providing higher value than traditional technology and automation. Correctly implemented IoT solutions hold the potential to introduce efficiencies in upstream, midstream, and downstream operations. IoT sensors deployed across the value chain – from exploration and production, to transportation of crude and refined oil – can bring in the much needed visibility and workplace safety, with better control and maintenance of assets. IoT enabled tools, systems, devices, sensors, and other equipment, when inter-connected with monitoring systems, can extract meaningful process information for quick analysis – analysis that can enable efficient utilization of resources, and improve production efficiency, safety standards, transportation, and other aspects. Many organizations are using IoT enabled sensors and devices to remotely monitor operations, and improve end-to-end processes. While such IoT initiatives hold potential to drive business bottom-line, the industry’s high risk production operations cannot be left dependent on untested and immature technologies. It is pivotal to assure these IoT initiatives – so that they meet their intended purpose. It is here that assurance plays a critical role in validating IoT performance and verifying its correct deployment in production.

**Assurance of Devices for the IoT**

By eliminating the need for human-to-human or human-to-machine interaction, the IoT puts operations in auto-pilot mode. While this in itself is innovative, it also demands adequate, ongoing assurance of the connected devices, as well as the systems, software, platforms and processes that drive them. Mainstream O&G processes such as well planning, drilling, oil exploration, pipeline monitoring, and crude refining are risk intensive, requiring continuous monitoring and analysis of temperature, pressure, oil outflow, water outflow, and other process data that requires validation, before being used as an input for subsequent processes.

IoT enabled devices and sensors generate astronomical volumes of data, which is used to analyze and improve operations. These devices, sensors, and associated applications and underlying data need to be tested for accuracy and correctness. The testing process requires large

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volumes of production-like data. However, using existing production data can compromise data privacy norms. Generating synthetic data too, is a difficult option, as it requires near perfect knowledge of data semantics, which is not always readily available. Further, generating testing data of such a large magnitude is difficult and time consuming. In such a situation an automated data generator tool should be considered to ensure the effective functionality and performance of these devices. Some important features that should be considered when selecting an effective test data management tool are:

- **Quality:** It should generate realistic test data that not only maintains referential integrity and business rules, but also seamlessly preserves intricate data patterns. Given the large volume of data being dealt with, the ability to drill down, roll-up and auto-incorporate schema changes and refresh data on demand is a must-have.

- **Usability:** The tool should automatically read database constraints and include user friendly interfaces for specifying transformations. This will reduce testing time, cost and effort, shorten the learning curve, and improve overall productivity.

- **Data on demand:** Data should be readily generated on demand and as per requirements, thereby reducing storage requirements.

- **Data integration:** The tools should be equipped to handle large volumes of data from varied geographies, applications and devices, including sensors, handheld equipment, web sources, and social media feeds. This will ensure correct integration and completeness of the system.

- **Data security:** Security measures should be available to prevent unauthorized access, fix vulnerabilities, and mitigate risks and threats from all devices and systems, towards ensuring overall compliance.

- **Data validation:** Data should be validated for its correctness as per business validation rules.

**Conclusion**

Fascinated by its ability to enable putting operations in auto-pilot mode, O&G companies are adopting and investing in the IoT to drive operational efficiencies. But mere device installation cannot yield results. In fact, it could pose challenges and risks. An assurance deficit could wipe out potential benefits, and may also result in catastrophic failures. For O&G companies to mitigate risks and create stakeholder value at all levels, it is both critical and essential to continuously assure IoT technologies.

**About the Author**

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Padam Nigam is a Consultant with Tata Consultancy Services’ (TCS’) Assurance Services Unit (ASU). He contributes to pre-sales, solution design and testing, and has experience in the Energy & Resources and Banking domains. Padam has worked with technologies such as Java and Mainframes, and executed functional, technical and testing assignments for clients across the globe. He holds a Bachelor’s degree in Electronics and Communication, and an MBA in Information Technology and Marketing Management.
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