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Internet of Things (IoT)
IoT on cloud – Enabling future of oil and gas industry

Contents

Introduction

The Internet of Things puts digital information to work in the world. The concept involves connecting machines, facilities, fleets, networks, and even people to sensors and controls.

The ongoing improvement in cost and performance capabilities of computing, storage, bandwidth and software application has led to advancement in information, communication and connectivity technologies and triggered new waves of innovations.

The Internet of Things (IoT) represents one major concept within these innovations that promotes the connection of everything in manifold contexts and industries. This includes connecting machines, facilities, fleets, network and even people to sensors and controls; feeding sensor data into advanced analytics applications and predictive algorithms; automating and improving the maintenance and operations of the machine and the entire systems.

As many applications of the Internet of Things realize bring diverse benefits, companies have started seeking to build new businesses that impalement novel strategies and business model in order to create new sources of business creation and appropriation. The Internet of things provides great potential for the oil and gas industry, among many others, in terms of cost saving and operational efficiency. A number of use cases, applicable to the oil and gas industry, where IoT has been shown to add business value(s) are:

- Predictive analysis and maintenance on well productions
- Sensor enabled well monitoring and analysis
- Geological and seismic data analysis
- Sensor driven analytics to detect pipeline failures

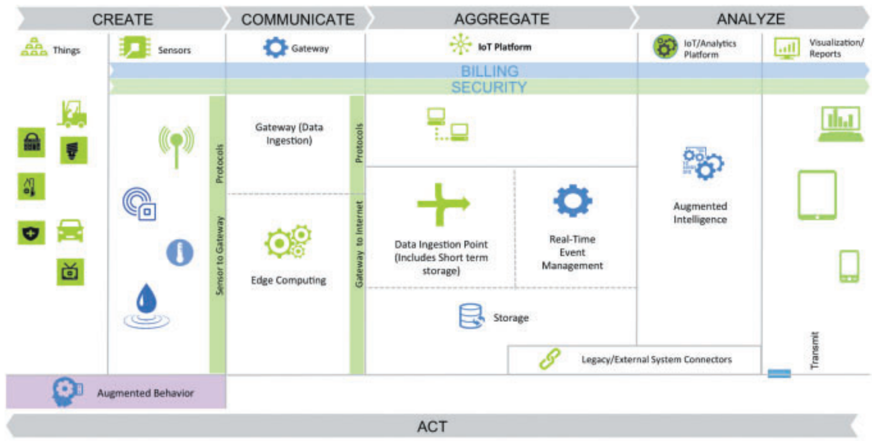
To that end, the purpose of this paper is to:

- Define IoT and its common benefits for enterprises to adopt cloud based IoT solutions, along with a recommended reference architecture and foundational principles
- Detail AWS IoT ecosystem and its solutions (Non-comprehensive)
- Detail some of the oil and gas industry issues (Use cases) that cloud-based IoT solution has addressed
- Deep dive one of the use case (Predictive maintenance) and depict its architecture within the AWS IoT ecosystem

Internet of things

Definition, Reference architecture and Foundational principles

The internet of things (IoT) is a network of physical objects (things) containing embedded technology to communicate and/or interact with their internal states or the external environment (Source- Gartner Glossary IoT). The connecting of assets, processes and personnel enables the capture of data and events from which a company can learn behavior and usage, react with preventive action, or augment or transform business processes. In most cases, IoT is considered a foundational capability for the creation of a digital business.



Though multiple definitions exist for IoT, it can be broadly defined as a network of physical objects that contain sensors or embedded technologies to interact with the internal or external environment and to take intelligent decisions. The diagram below depicts Deloitte's perspective on the high level IoT reference architecture.

Even though early adopters face the risk of immature technologies and unpredictable technological advances, innovation leaders should start their IoT projects now in order to ensure a competitive advantage. Innovation leaders in any organization should ensure that their IoT solution is:

- **Secure** – To ensure that stakeholder data are protected and security breaches are noticed early on
- **Scalable** – To be future proof and ready to support millions of things and users
- **Adoptable** – To ensure that the technology innovations- which are expected in the near and mid-term future- can be integrated into the existing architecture without major re-designs, shutdown and product recalls.
- **Cost efficient** – By using commodity hardware and easy to maintain software solutions, in order to keep costs down while scaling up the usage of the solution.
- **Performant and reliable** – To ensure that the data generated actually provides the business benefits

Organizations intending to start on an IoT journey need to have the some foundational principles that makes the respective IoT platform work for them, delivering the business benefits. Following are the key tenets (Source- AWS, Core Tenets of IoT) that makes a good business case for running IoT services on the cloud:

- **Agility** – The freedom to quickly analyze, execute, and build business and technical initiatives in an unfettered fashion
- **Scale** – Seamlessly expand infrastructure regionally or globally to meet operational demands
- **Cost** – Understand and control the cost of operating an IoT platform
- **Security** – Secure communication from device through the cloud while maintaining compliance and iterating rapidly

Internet of things on the AWS cloud

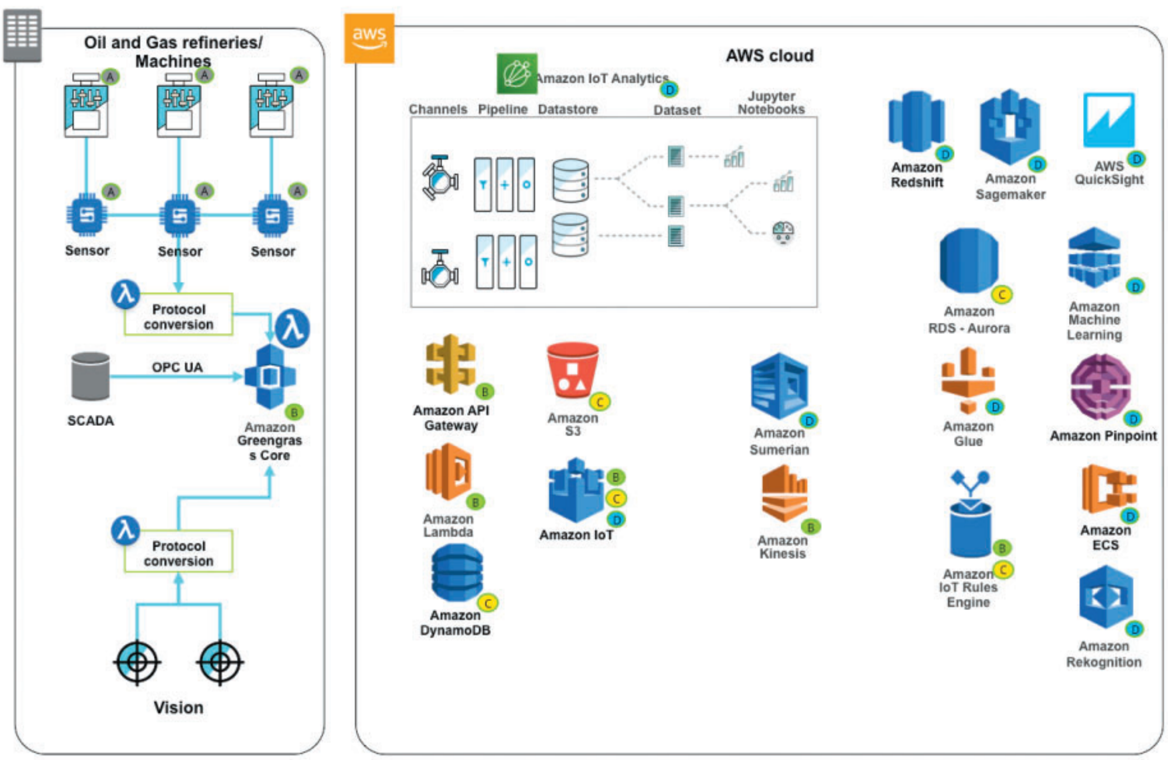
AWS IoT provides secure, bi-directional communication among Internet-connected devices such as sensors, actuators, embedded micro-controllers, or smart appliances and the AWS cloud (Source- AWS IoT Developer Guide). This enables organization to collect telemetry data from multiple devices, and store and analyze the data. Applications can also be created over the cloud platform that enable the end users to control these devices from their phones or tablets.

AWS IoT consists of the following components:

- **Device gateway:** enables devices to securely and efficiently communicate with AWS IoT.
- **Message broker:** provides a secure mechanism for devices and AWS IoT applications to publish and receive messages from each other.
- **Rules engine:** provides message processing and integration with other AWS services.
- **Security and Identity service:** provides shared responsibility for security in the AWS Cloud.
- **Registry:** organizes the resources associated with each device in the AWS Cloud.
- **Group registry:** allows you to manage several devices at once by categorizing them into groups.
- **Device shadow:** a JSON document used to store and retrieve current state information for a device.
- **Device Shadow service:** provides persistent representations of your devices in the AWS Cloud.
- **Device provisioning service:** allows you to provision devices using a template that describes the resources required for your device: a thing, a certificate, and one or more policies.
- **Custom Authentication service:** defines custom authorizers that allow you to manage your own authentication and authorization strategy using a custom authentication service and a Lambda function.
- **Jobs service:** allows to define a set of remote operations that are sent to and executed on one or more devices connected to AWS IoT.

The AWS IoT architecture schema presents the various products that exists (non-comprehensive) within the AWS IoT ecosystem that can be utilized for developing and implementing the use case, to achieve the intended business benefits. The products are also mapped to the stages depicted in the IOT reference architecture.

AWS IoT products ecosystem



IoT reference architecture mapping legend

- A Create
- B Communicate
- C Aggregate
- D Analyze

Challenges faced by the oil and gas industry and corresponding IoT solutions

With the increased volatility in oil prices, global oil and gas industry players are facing immense pressure to be profitable and growth oriented. IoT provides them with unique opportunities to bring not only operational efficiency and effectiveness, but also the means to increase their revenues. Listed below are some sample use cases where IoT solutions have helped an organization to address business problems:

Domain	Issue/Problem	IoT solution	Benefits/Outcomes
Geological and seismic data analysis in the cloud	• With global operations, the company had massive amounts of geological and seismic sensor data • Storing all of this data in-house takes a massive amount of storage and it is costly • The company was unable to do the analytics and computation it wanted without advanced computing space • Company wanted to explore how the cloud could enhance its computational and analytical abilities. In addition, it wanted to explore additional ways to leverage the data it was already obtaining from sensors	• The company is using cloud services to help it manage and analyze the massive amounts of geological data produced by the super-sensitive seismic sensors that it installed recently. • These sensors enable the company to detect and extract oil from wells that were formerly believed to have run dry, or in locations where previous investigations suggested that no oil was present • The company is provisioning the computing capacity themselves then running analytical models on a pay-per-use basis • The company is piloting a cloud-based Hadoop for big data analytics and focusing on sophisticated authentication for data security. It also enables authorized third parties to access its Amazon Virtual Private Cloud-based platform	• The company can now manage and conduct detailed visualization and analysis on geological and seismic data • Because of the pay-per-use model, the company can ramp up or down the amount of cloud computing power (and therefore the associated cost) as it needs
Sensor enabled well monitoring and analysis	• Company wanted to improve operations in their oil wells • A growth in well quantity makes it difficult for the company to cost-effectively scale their operations while simultaneously maintaining optimal production and minimizing downtime • The company needs a way to predict well issues and take corrective action before any issue occurred	• The company equipped wells with sensors to have the ability to send and receive data real-time • The company then developed analytical models which will take in the real-time sensor data from the wells and look for signals in the data to predict when the wells are falling outside the optimum production ranges • Team ingested data into a model built to prove ability to provide early warnings on the wells • Industrialize the solution and scale it to the entire well population	• This increased data availability provides vital information about well production, maintenance, and recommended actions • These models not only provided "early warnings" as to when a well will become sub-optimal, but they also recommended operational actions based on that analysis, focused on optimizing production • Improved engineer productivity.

Domain	Issue/Problem	IoT solution	Benefits/ Outcomes
Integrated workflow to optimize field performance	• The operator had substantial number of oil well, majority of which have intelligent completions, generating ample amount of data every day. Company engineers spent more time managing the data than interpreting it • Beyond delivering, processing, and managing this flood of new data, the operators needed to set up workflows to incorporate real-time data within its existing engineering processes, applications, and databases • Intelligent completions cost more than traditional completions, yet there was no benchmark for determining the payback on this type of investment.	• Production software enabled data from multiple sources to be visualized in a single, integrated environment. As a result, the team monitored well performance via a management-by-exception process allowing them to quickly take action • The company worked closely with the operator to develop new automated workflows specific to technology and engineering challenges at this field • Because the system immediately alerts the right people when well data indicated potential problems, the operator could act quickly to avoid lost production.	• The operator expected the facility to considerably increase uptime at production startup. • The operator avoided lost production. • Maximum daily production was achieved ahead of schedule • Using intelligent completions, the team re-optimized choke positions without intervention. Production from the affected zone doubled. By averting intervention, the team avoided loss in production.
Predictive analytics on well production	• Company struggled with lengthy maintenance issues causing wells to be out of production for extended periods of time • To achieve increased production, the company wanted to: • Increase operational lifetime of low-volume, steam-injected wells • Maximize production output by improving equipment reliability • Reduce operational costs and optimize maintenance schedules • Develop an overall culture of analytics for more informed decisions	• Implemented Asset Performance Analytics, which allows for accurate prediction of events that could cause outages or degrade well performance. From batch data loads to real-time, streaming IoT data, the solution analyzes sensor data to boost uptime, performance and productivity while lowering maintenance costs and reducing risk of production revenue loss • Related to this, company leveraged Visual Analytics for descriptive analysis, real-time surveillance and predictive analytics. Solution combines in-memory processing and advanced data visualization	• Lower costs through more efficient product and maintenance processes. • Extra production helping on an incremental revenue • Longer production life of mature, resource-intensive wells • Share insights from real-time surveillance and predictive analytics on mobile devices • Company will monitor and optimize all assets 24 hours a day, seven days a week, 365 days a year

Domain	Issue/Problem	IoT solution	Benefits/ Outcomes
Predictive analytics to detect pipeline failures	• Rising business complexity, aging pipeline networks, and legacy manual monitoring and control devices led to considerable losses due to fuel leaks and thefts • Company sought a way to predict these fuel leaks / breaches in order to minimize loss.	• Installed advanced sensors inside or outside the pipeline to predict breaches • Tested technologies that essentially see, feel, smell, and hear various aspects of their oil pipelines • Leveraged vapor-sensing tubes that "see" bitumen spilled by shooting air down a tube • Used fiber-optic distributed temperature sensing system that "feels" fluctuations in temperature caused by bitumen leaking into ambient soil • Installed hydrocarbon sensing cables that send electric signals to "smell" hydrocarbons and fiber optic distributed acoustic sensing system that "hears" sound variations that indicate a pipeline leak	• Decreased overall fuel leaks, thefts, and pipeline breaches • Drastically decrease the amount of time to both detect an incident and deploy a solution
Sensor-driven analytics to detect ESP failures & field potential	• Faced poor performance of its electrical submersible pumps (ESPs), including expensive pump failures, and lacked ability to predict a field's production capacity • Company wanted to better predict when these failures would happen, in order to take corrective actions before the incident occurred and/or save on maintenance costs	• Implemented analytics solution and used a 3-step process: • Used hybrid and multi-disciplinary data about pumps production, completion, and subsurface characteristics to predict submersible-pump failure with prescriptions to avoid future failures • Enabled the company to use the additional data generated in the first stage to prescribe the optimal pump configuration for the next well • Used these additional ESP performance data to evaluate fields' potential production capacity before acquiring them	• Improved performance of ESPs and decreased failures • Developed the ability to predict a field's production capacity using a "compounding effect" in which one level of data analytics provides insights that can then lead to additional analytics

Predictive maintenance use case deep dive

An illustration of how a cloud-based IOT solution can yield business benefits

Oil and gas industry usually has a practice of frequent and scheduled maintenance at a regular intervals, the schedule of which is determined based on general recommendations and normal operating conditions. However, many factors can impact these normal operating conditions causing unplanned deviations and failures to machines that result in unplanned downtime, reduced throughput, quality defects, and more. These impacts to downtime, throughput, and quality drive higher maintenance costs, inventory costs, production cost etc.

The predictive maintenance use-case implementation provides our clients with predictive insights for their critical assets and allow them to take action before failure occur. The use case draws on the analytical and machine learning capabilities that AWS has to offer, to proactively alert users of future maintenance and potentially automate steps within the repair process.

High level impact and outcome of the use-case implementation:

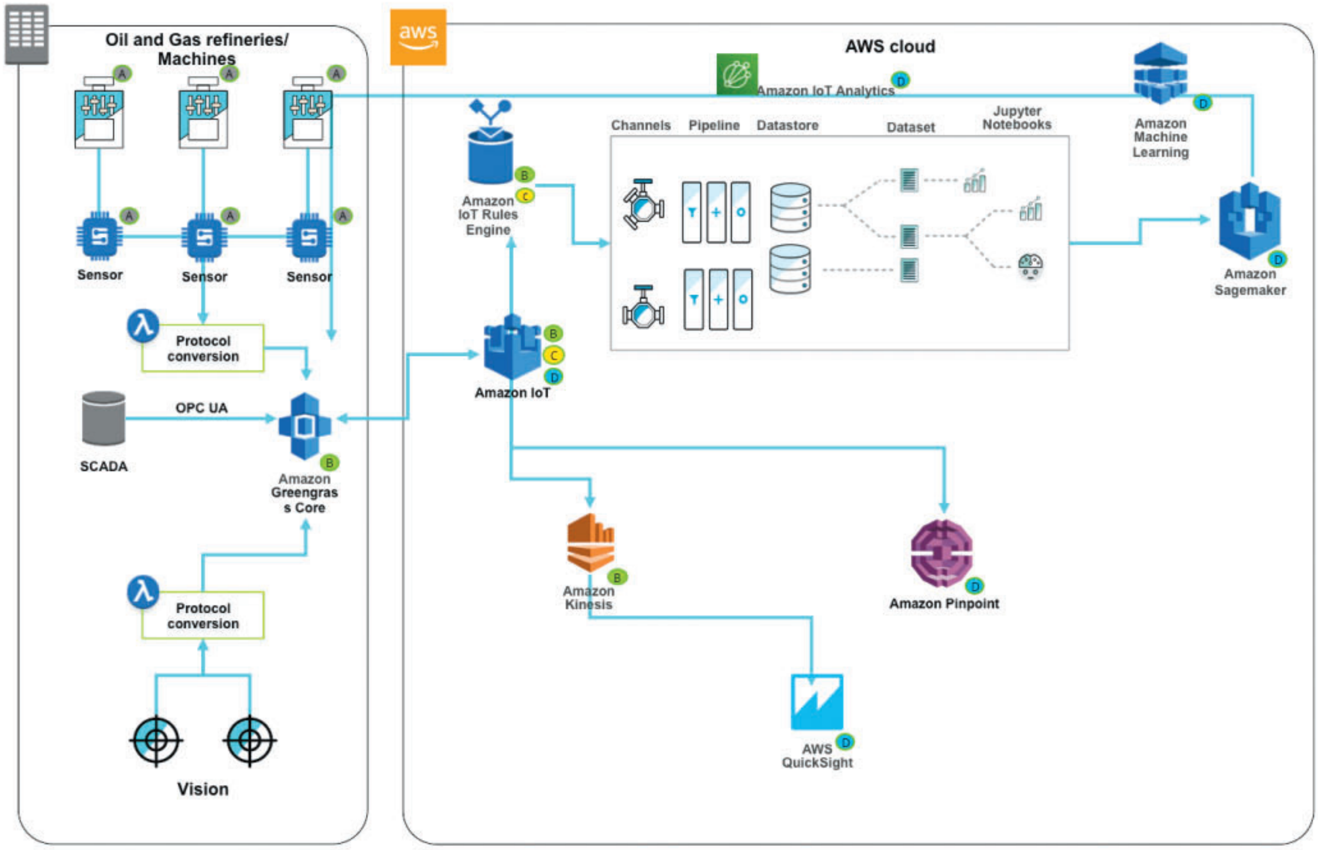
- Increased uptime, minimized unplanned downtime
- Improved quality
- Increased service levels and on-time delivery
- Increased velocity and throughput
- Reduced maintenance cost

Oil and Gas industry uses predictive maintenance on their own fixed assets to keep production up and running.

Predictive maintenance brings together "always on" monitoring, predictive maintenance and process automation. Below are the listed steps involved for implementing the use case:

1. Connected machines
    - Sensors are installed on the machines and connected on the IoT platform
    - The sensor streams data about the machines vital statistics in real time
2. Remote monitoring
    - Data is monitored remotely to ensure that the machines are in healthy conditions
3. Predictive maintenance
    - Machine learning module of the solution build models using historical data to predict failures
    - The module also proactively alerts the designated individuals to future maintenance needs
4. Automated maintenance orders
    - Maintenance tickets are automatically generated, production schedules alerted, maintenance tasks scheduled and technicians assigned.

Use case-predictive maintenance (IoT on AWS)



IoT reference architecture mapping legend

A Create B Communicate C Aggregate D Analyze

How can Deloitte help?

As the world's largest professional services organization, Deloitte has the technology and business strategy capabilities and deep industry insight to help you solve the most complex business challenges.

Technology and business strategy

Deloitte approaches problems by bringing an executable strategy that combines rigorous analysis, market insight, and collaborative thinking to enable confident action. Our expansive technology experience across capabilities helps organizations better manage their business and serve their customers, including analytics and information management, delivery, cyber risk services, and technical strategy and architecture, as well as the spectrum of digital strategy, design, and development services.

Oil and gas industry expertise

Our professionals guide global Oil and Gas companies and new market entrants in navigating the complexities of the global industry challenges. As market, political, and legislative changes alter the industry, we help our clients develop innovative and practical solutions. We approach the potential of IoT on this industry like any new disruptive market force: Educating our clients on the underlying technology and helping them recognize the potential opportunities to positively impact to their business by addressing existing inefficiencies and difficulties in adhering to regulatory and industry needs.

IoT and cloud capabilities

Deloitte's strength in IoT IT consulting is evident from the firm's robust capabilities that highlight educating both clients and non-clients on the potential of IoT through workshops, prototypes and research. For example, Deloitte utilizes its Greenhouse Labs to create customized and focused working sessions for clients to experience potential insight from IoT and uses of IoT and, when combined with expertise from its Studios, the firm creates functional prototypes, which support and accelerate clients' understanding of what IoT means for them.

Further, Deloitte is a member of the Amazon Partner Network providing specialization in a host of AWS and IoT solutions. Customers around the world have leveraged Deloitte's capabilities to transform their business to unlock the potential of the AWS cloud.

In order to address critical business challenges and navigate an ever-changing technology landscape, today's CXO' s cannot afford to sit idle. This is where Deloitte and AWS are able to come together to formulate a leading approach to a company's vision and overall business strategy, delivering on decades of combined experience and some of the most effective use cases in the world. By leveraging Deloitte's and AWS's experience in cloud and IoT, organizations can successfully solve problems, reduce costs, and realize exponential value.

Deloitte offers predesigned IoT solutions for predictive maintenance, asset tracking, and asset performance management as well as a dedicated IoT DevOps practice that supports solutions to monitor network connectivity between connected edge devices and machinery programmable logic controllers (PLCs).

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