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ON

"THE INTERNET OF THINGS IN THE OIL AND GAS INDUSTRY"

Submitted in partial fulfillment of the requirement for the 8th semester For the Course of

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By

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CERTIFICATE

This is to certify that the **SEMINAR** entitled **"THE INTERNET OG THINGS IN THE OIL AND GAS INDUSTRY"** has been successfully carried out by **ASLAM** bearing **USN 1ST18CS012** , bonafide student of **SAMBHRAM INSTITUTE OF TECHNOLOGY** in partial fulfilment of the requirements for the **8th semester** of **BACHELOR OF ENGINEERING** in **COMPUTER SCIENCE AND ENGINEERING** of **VISVESVARAYA TECHNOLOGICAL UNIVERSITY** during the academic year 2021-22.

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Date: **ASLAM**

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CONTENT

CHAPTER 1

INTRODUCTION

The oil and gas (O&G) industry is a highly regulated and capital-intensive industry that plays a pivotal role in meeting world energy demand. Despite worldwide initiative to implement green energy sources, the global demand for crude oil is expected to remain high for decades to come.Low oil prices for a longer period and increasing regulatory constraints challenge O&G actors (operators, service companies, and suppliers) to become more innovative to address their long term business goals. These business goals include, but are not limited to, reducing health, safety, and environmental (HSE) risks; extending the life of producing fields; minimizing capital and operational costs; increasing equipment reliability and operability to reduce maintenance costs and facility downtime; improving governance and regulatory compliances; and increasing production and revenue.

The fourth industrial revolution, also known as “industry 4.0”, introduces a range of digital technologies that potentially make a paradigm shift in the entire industrial and social status quo. Extractive industries, such as oil and gas, will be affected by this revolution . In 2016, on behalf of Accenture and Microsoft, Penn Energy Research, in partnership with the Oil & Gas Journal, surveyed upstream professionals worldwide to determine the digital transformation trends in the oil and gas industry . The survey identified that mobile devices, the internet of things (IoT), cloud computing, artificial intelligence, robotics and drones, wearable technologies, collaboration and social tools are the key technologies in which the O&G industry have invested and will continue to employ for the next few years. With the deployment of these digital technologies, the O&G industry is expecting to make faster (real-time) and better decisions to manage their assets effectively.

In terms of workforce, the deployment of digital technologies is expected to increase productivity, engagement, and job training. As reported in, the digital transformation of an industry involves ten steps, namely, mechanizing, sensorizing, transmitting, integrating, analyzing, visualizing, augmenting, robotizing, crafting, and virtualizing. These ten steps are carefully planned and executed to collect and analyze more data from assets to make faster and better decisions so that assets can be managed effectively while complying with regulatory requirements.

It is apparent that the collecting, analyzing, and visualizing data play pivotal roles in the digital transformation. Autonomous data collection followed by real-time, near real-time or post data processing and actuation are not new to the O&G industry. For example, the O&G sector has been using supervisory control and data acquisition (SCADA) systems for decades to monitor its assets. Additionally, wireless sensor network (WSN) based monitoring and data collection approaches have also been considered for a range of upstream, midstream, and downstream applications. However, deployment of SCADA systems and traditional WSNs entail a range of challenges. Concerning SCADA systems, the hardware and software of these systems are generally not interoperable; equipment and the maintenance costs are very high, and unscalable, due to low density in time and space; changing/updating of communication or operational protocols or software tools is extremely challenging and associated with high latency. WSNs are not homogeneous systems and typically lack coordinated communication and clarity within their operation areas and across.

With the recent advancements in information and communication technologies, as well as in microelectro-mechanical systems (MEMS), IoT has emerged as a solution to the limitations associated with SCADA and traditional WSNs. The term „internet of things‟ was coined by Kevin Ashton, executive director of the Auto-ID Center, in 1999, when he presented a radio frequency identification (RFID) based supply chain optimization system to Procter & Gamble (P&G) . In summary, IoT is a network of items, which are each embedded in smart devices (sensors, actuators) connected to the internet, that enables connectivity anytime, anywhere by anyone, and of anything Typical IoT system includes sensors, actuators, network infrastructure, and data analytic tools to collect and analyze data.

Edge, fog, and cloud blended data processing solutions are now being considered for IoT systems to alleviate latency, increase scalability, and enhance access to information so that better and faster decisions can be made from the data captured from IoT enabled sensors . There are several other concepts (terms), such as IIoT (industrial IoT), IoE (internet of everything), WoT (web of things), CoT (cloud of things), M2M (machine to machine) systems, IoNT (internet of nano things), and IoMT (internet of mobile things), that have emerged with the IoT intention of our study is not to provide a deep analysis of IoT standards, architectures, research projects, national initiatives,

Over the last two decades, the IoT concept has been further studied, piloted, and implemented across many industrial sectors, including manufacturing retail smart cities smart homes , smart grid , transportation , healthcare , and resource industries (mining and O&G).

International Data Corporation (IDC) projects that the worldwide technology spending on the IoT will reach US$1.2 trillion in 2022. Ericcson predicts that the number of cellular IoT devices will reach 3.5 billion, wide-area IoT devices will reach 4.1 billion, and short-range IoT devices will reach 15.7 billion by 2023 . As reported in DBS Asian, the IoT installed base will expand from 6.3 million units in 2019 to 1.25 billion in 2030.

1.2 METHODOLOGY

This systematic review follows a similar approach presented in and Table I summarizes the articleselection criteria for this review.

Search index	Specific content
Database	OnePetro, Scopus, Springer, IEEE Xplore,Web of Science
Article types	Scientific articles published in jour-nals, conferences, and books
Search string	(“internet of things” OR “IoT” OR “industrial internet of things” OR “IIoT” OR “internet of everything” OR “IoE”) AND (“oil” AND “gas”)
Search period	No lower bound was set for the search period. As the paper search was done in late August, 2019, only the research articles published until August 2019 are included in this review.
Screening procedure	The relevance to the IoT application to O&G was selected based on the number of occurrences of key terms followed by the manual review of contents of abstract, introduction and conclusion.
Classification scheme	The literature was classified based on the type of the study (review, concept, case-study), application areas, enabling technologies and re-searchers‟ affiliations (academic or industrial).
Other information	Opportunities and challenges related to IoT applications were identified from the selected articles

1.3 Working of iot in oil and gas industrys

Selective_deployment: Almost all the articles followed a selective technology deployment approach, where they discussed, evaluated, or piloted IoT technology for a selected use case (or few use cases), without considering a fully integrated approach or discussing how to integrate the proposed system to the existing facility infrastructures.

Stand alone deployment: The O&G industry is considering a range of digital technologies, including IoT, cloud computing, artificial intelligence, robotics and drones, wearable technologies, extended reality technologies (virtual reality, augmented reality, mixed reality), collaboration and social tools to enhance productivity, efficiency, revenue, and safety. The existing research publications/projects did not indicate how industrial research projects were going to fit into overall digital transformation initiatives. This limitation is closely related to the first limitation, i.e., selective deployment.

Lack of collaboration: The existing research projects were mostly run independently by different universities, supply chain companies, or operators. The lack of collaboration among these three entities may introduce challenges for evaluating outcomes of a research and development (R&D) project at a real O&G facility.

Lack of operator engagement: Only five O&G operators were among the contributors to the filtered 66 articles. The active engagement from O&G operators is vital for researchers in the universities and the supply chain to accurately identify the true need of the operators so that they can plan their R&D projects to fulfill operator needs.

Understanding challenges: While existing research projects try to address the challenges faced by the O&G industry using IoT, only a few projects consider the secondary issues that could arise with the IoT adoption. These issues relate to cyber security, regulatory constraints, maintenance, and obsolescence. For some projects, there has been no consideration any of these issues, causing some of the research outcomes to impractical for real-world scenarios. To address these limitations and seamlessly integrate IoT technology into the O&G industry to solve their operational challenges, we propose a research agenda.

Before presenting this research agenda, it is important to recall that the O&G industry lags industries such as manufacturing and retail, in terms of technology adoption. The primary R&D typically occurs in the industries that act as innovators and early adopters. Industries like O&G typically leverage the technologies developed by innovators and early adopters instead of engaging in intense R&D activities. However, industries like O&G still need to spend on R&D to customize existing technologies to seamlessly integrate these technologies with the existing O&G business models and infrastructures. Thus the proposed research agenda mainly focusses on proving a step-by-step guideline to adopt IoT for the O&G industry instead of focussing on research to develop new IoT tools.

Understand: As discussed in the previous section, IoT technology has numerous use cases related to the O&G industry. The value added by a given opportunity or the level of intensity of a given challenge varies from one phase to another of the O&G life cycle, process to process or location to location. For example, geographical surveys are less vulnerable to cyber attack and the severity of the cyber attack at this phase is very low Fi. In contrast, developing drilling and production phases of the upstream O&G life cycle are highly vulnerable for cyble attacks and severity of these attacks are significantly high Additionally, when considering the personnel and equipment location tracking systems, at the preliminary explorations stage (before the exploration drilling is commenced), it does not require hazard Zone 0 or Zone 1 certification.

However, at the production or drilling phases, hazard Zone 0 or Zone 1 certification is required. Moreover, consider a remote monitoring, operation, and asset optimization use case. The opportunities and challenges associated with pipeline corrosion monitoring or with sucker-pump working condition monitoring using IoT enabled system will be different. Therefore, O&G operators must work collaboratively with supply chain companies and academic experts to understand the possible applications of IoT for their field activities along with the respective benefits, infrastructure requirements, and challenges.

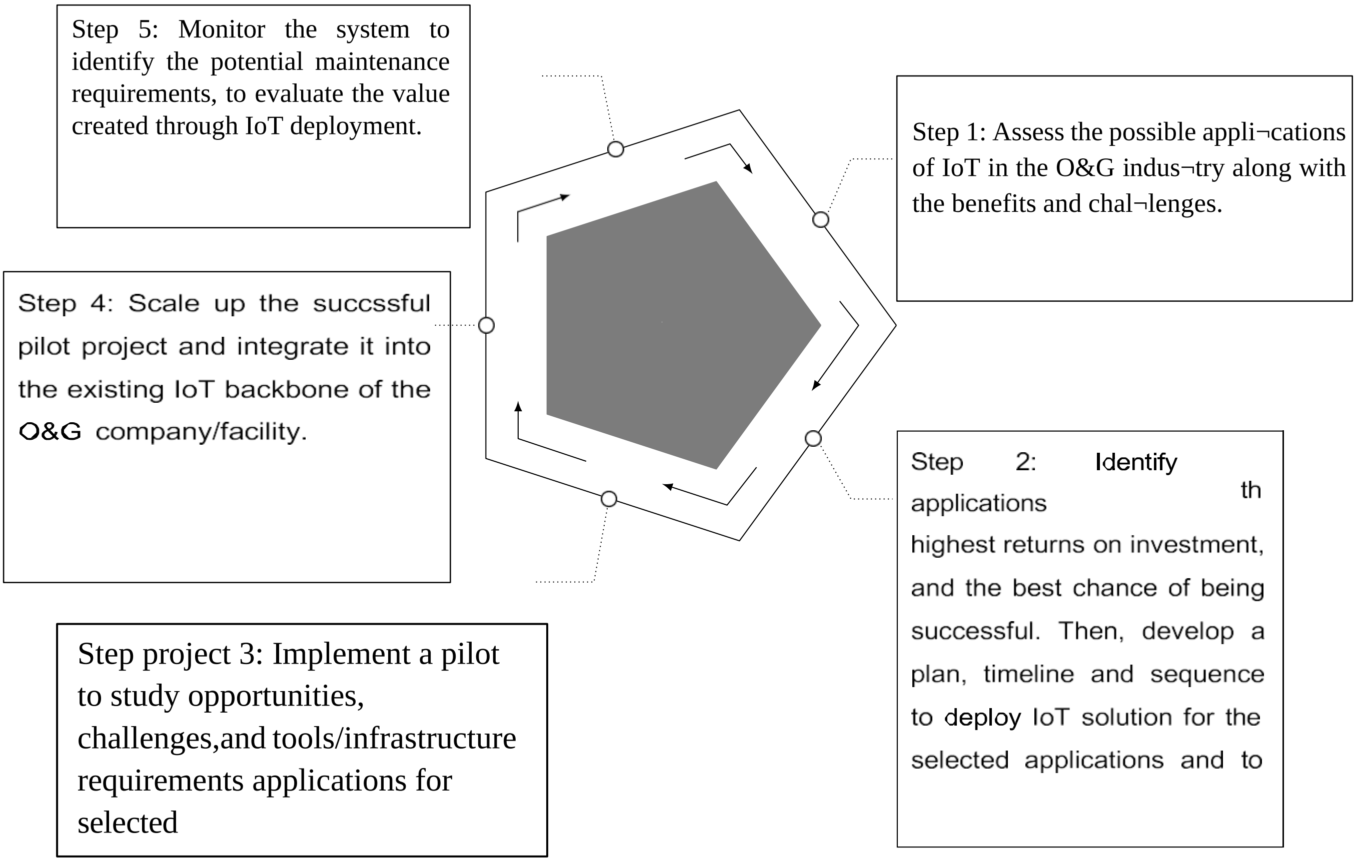

Fig 3.3: Proposed Research Agenda

Define: The possible applications and their respective bene¬fits, infrastructure requirements, and challenges analyzed at this stage to identify the applications which offer the highest returns on investment, and the best chance of being successful. Feasible applications must use existing hazard Zone-0 and Zone certified IoT devices. Once the first application has been selected, subject matter experts from the operators, supply chain companies, and universities can develop a plan to integrate with other applications identified at the first stage. This initial plan includes the list of applications, a timeline, and sequence for integrating into existing infrastructure and HCPS.

There may be applications which have more economic, health, or safety benefits, but cannot be implemented immediately due to the unavailability of safe Zone-0 and Zone-1 IoT devices. An R&D project can be planned in collaboration with the supply chain companies and universities to design, implement, validate, and certify the required IoT devices for Zone-0 and Zone-1 operation. The operator and supply chain companies, the primary beneficiaries of the technology, involved in R&D projects could share the financial responsibilities for the project while all three parties (operators, universities, and supply chain companies) share the technological responsibilities for the project. When the financial responsibilities are shared with the operators, small and medium enterprises also have more capacity to engage in R&D activities as they have an early customer for the resulting products.

Pilot: Before moving to full-scale industrial deployment, it is critical to implement a lab-scale pilot project. Typically, universities and research institutes that collaborate with the O&G industry have laboratory-scale O&G facility models and equipment, allowing these institutions to run lab-scale pilot projects (e.g., Hibernia Enhanced Oil Recovery Laboratory, Memorial University of Newfoundland, Canada. Pilot projects act as learning platforms to critically evaluate the opportunities, challenges, and tools/infrastructure requirements for selected applications. For example, the research team can evaluate a wide variety of cybersecurity approaches, IoT tools from multiple vendors, a range of data storage mechanisms (local vs. cloud), and data analytic tools to explore options for the selected application.

Industrialize: A successful pilot program is followed by a full scale (industrial scale) implementation. IoT tools and infrastructure for this implementation should be purchased from a vendor that provides maintenance and end-of-life planning for their products. This reduces the maintenance and obsolescence issues associated with the large scale IoT deployments.

Monitor: After implementing a large scale IoT system, the O&G company can assign a group of experts to continuously monitor the system to identify the potential maintenance requirements, to evaluate the values created through the IoT deployment, and to determine the required modifications to obtain the maximum benefit from the system. Additionally, an in-house R&D team must continuously evaluate the installed IoT system against the newer systems available in the market to identify IoT systems that are approaching obsolescence.

Once the first application is successfully deployed, the O&G operator can revisit the original research plan to identify modifications. If no modification is required, a pilot program for the second application can be initiated, followed by the industrialization of the second application. This industrialization integrates the first and second applications into a single system. If modifications are required, the operator can implement these modifications before carrying out the pilot program for the second application. This iterative process continues until all of the applications have been implemented and integrated.

CHAPTER 2

APPLICATIONS

This section presents the findings related to the second research question (RQ2), i.e., “what are the key use cases (applications) of IoT adoption in the O&G industry?”. As reported in the selected articles, end-to-end IoT solutions have a wide range of use cases for the O&G industry. lists the key use-cases of the IoT deployment in the O&G industry.

1. Remote Monitoring, Operation and Asset Optimization

The O&G industry involves a high level of capital expenditure (CapEx), operational expenditure (OpEx), and HSE risk. Therefore, it is essential to operate assets optimally while ensuring safety. To achieve this objective, the O&G industry is now deploying end-to-end IoT solutions to remotely monitor field equipment, analyze field data, make data-driven decisions collaboratively and apply control commands to optimize asset performance while mitigating HSE hazards. Tele-operated robots can be deployed to perform maintenance and equipment verification in harsh, hazardous, or remote environments. Therefore, with an IoT-enabled cyber-physical system, it is possible to eliminate the need for field personnel to visit an asset for data collection, equipment maintenance, or actuation. This minimizes the risk associated with being on-site and the cost associated with traveling to remote/offshore location. Examples of IoT-based remote operation and monitoring for the O&G industry include.
pressure relief valve monitoring.

- pressure relief valve monitoring
- tank level monitoring
- infrastructure monitoring
- sucker-pump working condition monitoring
- corrosion monitoring
- production and well monitoring/optimization, including artificial lift systems
- pipeline monitoring
- pipeline monitoring
- managing the performance of rotating equipment and
- leak detection

2. Predictive Maintenance

Unplanned downtime has a significant financial impact on O&G companies. For example, it has been reported that, on average, 1% annual unplanned downtime of a production facility (3.65 days) causes O&G companies to lose US$5.037 million . Regular maintenance is required to minimize facility downtime. There are three major classes of maintenance: reactive, time-based, and predictive. For reactive maintenance, the asset runs until it fails, at which time repair and replacement takes place. Time-based maintenance follows the original manufacturer‟s datasheet and includes repair and replacement at predefined times. The predictive maintenance approach collects asset integrity and operation data at regular intervals. The collected data is analyzed using advanced data processing algorithms to assess and forecast the health of the equipment. This data-driven system allows asset owners to identify potential issues and take actions to mitigate them in a timely manner.

3. Automation and Control

End-to-end IoT solutions can be leveraged to automate some oilfield operations, including automation of drilling systems , automation of production systems, automation of well completion systems, surveillance of unmanned production platforms, automation of legacy rod-pump control, automation of tubular running services, automation of artificial lift-assisted production, and autonomous surveillance for electric submersible pumps (ESPs).

In the Bakken oil field, Equinor successfully deployed a well optimization system for 50 horizontal wells using IoT-enabled devices and advanced machine learning algorithms. Data from an IoT device which was connected to the legacy rod pump controller was compared with the traditional rod pump controller data using a machine learning algorithm to dynamically classify wells into three operating states: under-pumping, over pumping, and dialed in. This allowed Equinor to automate well optimization setpoint decisions, resulting in reduced well volatility, better pump efficiency, and increased pump fillage. With the optimized setpoint, Equinor achieved a 33% oil production gain from the wells which were under pumping. Additionally, for wells that were over-pumping, Equinor achieved a 14% increase in pump efficiency while decreasing the number of strokes by 11%.

4. Occupational Safety and Health Compliances, Situational Awareness, and Personnel Tracking

O&G drilling and production processing facilities are known to be hazardous working environments. Challenges and the risk associated with these facilities become elevated when they are located in remote and hostile locations, such as offshore Newfoundland or in the Arctic. The Worldwide Offshore Accident Databank (WOAD) reported that there were 2288 fatalities included among 6451 offshore accidents occurring between 1970 and 2012. According to the US Bureau of Labor Statistics, in 2017, the average fatality rate for US workers was 3.5 deaths per 100,000 full-time equivalent workers (FTEs). That rate increased to 12.9 deaths per 100,000 FTEs for mining, quarrying, and the oil and gas extraction industry. There is a range of occupational risks associated with working at an O&G facility, including slips, trips and falls; injuries from falling equipment; collisions with moving objects; repetitive actions of handling, lifting, and carrying; exposure to extreme environmental conditions; and exposure to toxic substances. To protect oilfield workers from such accidents, most O&G producing countries have implemented occupational safety and health (OSH) regulation frameworks for theie O&G industry. For example, SOR/87-612 is the oil and gas OSH regulation for Canada.

The regulatory body and the O&G companies (operators, service companies, companies in the supplychain) are making an unparalleled effort to establish well-defined regulatory frameworks and training programs for enhancing occupational health and safety at the oilfield. However, if the field personnel does not comply with these codes, potential OSH risk remains. IoT-enabled solutions can be implemented to monitor OSH compliance. For example, IoT enabled smart sensors can be integrated with personal protective equipment (PPE), which includes safety helmets, eye protection, highly visible clothing, protective gloves, and protective footwear. When a person enters an oilfield, the ID scanning system (RFID) can identify the person and all the safety gear that the person wears, and combine the person‟s ID and PPE IDs into a single cluster. If the person does not wear the required PPE, the IoT system can remind him/her to wear the required PPE.

If the field person does not comply with the OSH regulation even after he/she was reminded, the IoT system can send an automatic message to field supervisors, and other authorized personnel, allowing them to address OSH code violations. Once the field personnel are on site and engaged in fieldwork, the IoT system keeps monitoring the data from IoT sensor nodes to detect whether the field personnel are wearing the PPEs. If an OSH code infringement is observed, the IoT device can remind field staff to comply with the OSH code. Additionally, the

IoT device can alert field managers and other authorized personnel about OSH code violations, helping them to address issues.

5. Collaboration and Digital Twin

Recent digital transformation initiatives in the O&G industry are focussed on leveraging industrial IoT solutions to bring the relevant data to the right people, allowing them to contribute and collaborate to make data-driven decisions IoT-based collaborative platforms allow subject matter experts to connect from anywhere in the world. Additionally, with a carefully implemented data sharing culture, IoT solutions enable seamless data sharing among different applications on a variety of IoT devices and across multiple vendors, contractors and oilfield service companies. In, it has been reported that the digital transformation of the O&G industry needs to follow a three-step journey: connecting asset and operation, connecting the value chain, and building a fully connected enterprise. IoT and cloud architecture assist the O&G industry to embark on this digital transformation journey by connecting assets, people, and processes. This allows O&G companies to connect their operations on a global rather than a local scale.

6. Supply-Chain and Fleet Management

Supply-chain management is one of the key use cases for IoT technology. This is also the case for the O&G industry. At the development phase, an IoT-based system can connect the supply chain, enabling unparalleled visibility along the supply chain to effectively track construction activities and raw material supply for construction. During the operation phase, an IoT-enabled system can assist in managing stores, warehouses, and transportation. Downstream players can employ IoT solutions to create new value by expanding the visibility of the complete hydrocarbon supply chain. This enables O&G companies to enhance core refining economics and target new digital consumers through new forms of connected marketing.

Similar to supply chain management, IoT technology can aid O&G companies to perform fleet management. Fleets in the oil and gas industry can be divided into three major groups, namely, the field personnel fleet, the mobile oilfield equipment and vehicles fleet, and the petroleum products (raw or processed) transportation fleet. With the aid of IoT sensor networks, the exact location of field

personnel, mobile equipment and field vehicles, and petroleum product transportation systems (trucks, trains, tankers, ships) can be monitored in real time. Fleet management software tools leverage this real time data to assess field personnel and equipment utilization and assist facility managers and supervisors to optimally deploy their fleets. Smart sensors connected to the mobile equipment and field vehicles track the performance of equipment operators and vehicle drivers.

7. Security

Maintaining a high level of security is important for the O&G industry at any stage of the oilfield lifecycle. Unauthorized access and intrusion need to be identified, and swift action must be taken to address threats to drilling, production, storage, and refinery facilities. IoT-enabled RFID tags can be used to control facility access. It is possible to define hierarchical user roles and grant a different level of facility access for individual field personnel. This minimizes unauthorized equipment access and operations. An IoT enabled smart camera system can be installed to perform smart video surveillance. Smart cameras can monitor the surroundings, detect suspicious activities (trespassing, vandalism, theft) and alert authorities.

Securing the O&G pipeline network is more challenging than securing the drilling, production, storage, or refinery facilities. These pipelines run thousands of miles and even run through remote and hostile regions.

CHAPTER 3

ADVANTAGES

3.1 Top four IIoT advantages for Oil and Gas industry

A technological enabler that can digitize industrial operations is the immediate need for the oil and gas sector.Internet of Things is one such technology that acts as a solution for the majority of the problems that the oil and gas sector faces today.

The adoption of IoT technology can make astronomical changes for this sector and help it maintain a competitive edge in the global O&G enterprise.

1) Managing emergency conditions:
2) Asset Monitoring and Predictive Maintenance:
3) Establishing workers health and safety:
4) Supply Chain Management:

1. Managing emergency conditions: Oil exploration and production companies are, in most cases, located in remote locations (sometimes even in seas), far off from any proper human habitation.

2. Asset Monitoring and Predictive Maintenance: In most of the oil refineries, there are multiple facilities for particular units (For example, the LPG production unit can have four facilities).

3. Establishing workers health and safety: With tons of moving mechanical parts and with an abundance of inflammable & toxic fluids, the oil and gas industry does not present an ideal working environment.

4. Supply Chain Management: Tth a constant rise in oil prices, O&G companies are looking for areas where they can cut costs to maintain the total expenditure. The supply chain is one such field where they can focus to reduce operational costs Internet of Things allows oil companies to manage their planning, scheduling, and procurement processes.

CHAPTER 4

DISADVANTAGES

This section presents the findings related to the third research question (RQ3), i.e., “what are the key challenges for adopting IoT for the O&G industry?”. From the O&G industry perspective, and as reported in the selected articles, major challenges for IoT adoption are listed. The following subsections discuss each of these challenges.

A. Cybersecurity

IoT technology connects the physical world with the cyber world, and these connected cyber-physical systems (CPS) are highly vulnerable to cyber attacks. In 2016, the energy sector was ranked as the second largest target for cyber attacks.

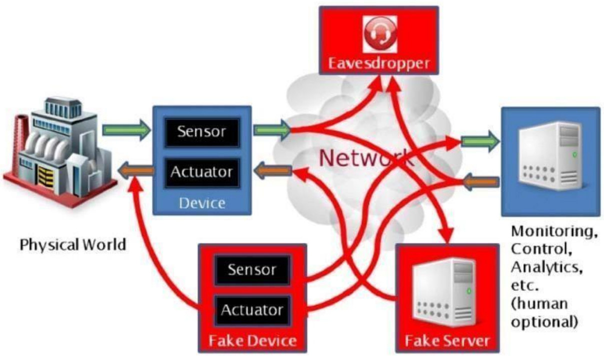

Fig. Possible intrusion for IoT system

An equipment, smart sensors/actuators, and network resources unavailable to oilfield operators temporarily or indefinitely disrupting regular operations. This type of cyber attack is referred as “denial-of-service attack (DoS attack)”. For cloud-based IoT systems, server masquerading inserts a fake server and convinces IoT devices to send data to the fake server and to execute commands coming from the fake server.

Numerous actions can be taken to detect and mitigate the cyber threat, including integration of multi-level cybersecurity systems and advanced data encryption techniques, leverage of analog side channels in IoT processors to detect intrusions, development of a user role-base hierarchical authentication system, and implementation of regular evaluation and training for employees to safeguard them and the system from cyber attacks.

B. Technological Readiness

Apart from the vulnerability to a cyber attack, the development and deployment of IoT systems for O&G facilities faces a range of technological challenges. Almost all O&G drilling, production, storage, transportation, and refinery facilities are considered as either Zone-0[3] or Zone-1[4] hazardous areas. Any hardware system (equipment, sensors, actuators) installed in these zones is subjected to a range of regulations, including ATEX[5], IECex[6], CAS[7] and UL or FM[8]. This
introduces a range of technological challenges to develop and deploy IoT-enabled systems for O&G facilities. These challenges include, but are not limited to:

- the product development cycle of intrinsically safe IoT products at O&G facilities typically take months, if not years, to deploy; including the period of required certifications,
- longer product development life cycles require IoT product manufacturers and service companies to rigorously analyze and track technological, market, and regulatory megatrends so that their product will not become obsolete before launch,
- field trials are virtually impossible as prototype testing is not a viable option at large volatile locations such as onshore or offshore O&G drilling, production, storage, transportation or refinery facilities,
- there are very few off-the-shelf battery systems that are cheap, long-lasting, intrinsically safe, lightweight, and Zone-0 and Zone-1 certified,
- cost of designing, fabricating, testing and certifying of IoT device for deploying in Zone-0 and Zone-1 hazardous environments may exceed US$250,000,
- an IoT system must be as universal as possible, allowing it to be deployed for many field applications and many other industries so that economies of scale can be achieved.

C. Interoperability, Adaptability and Standardization

IoT platforms and devices from different vendors may follow different data structures, communication protocols, security protocols, and hardware/software configurations . When implementing end-to-end IoT-based solutions for any industry, a large number of smart devices from different vendors must be unified into a single network because there is no single vendor that can cater to all the requirements set by the client. For example production monitoring IoT system may consist of smart temperature sensors, smart flow meters, smart pressure sensors, smart vibration sensors, IoT edge gateways, networking infrastructures, and cloud platforms. A single vendor is typically unable to provide all these devices. Rather, these devices generally are acquired from different vendors. Heterogeneity in the protocol, architecture and configuration may pose challenges. The biggest challenge does not arise when using newer IoT devices, but when interfacing modern IoT tools with legacy systems installed on existing O&G platforms. The communication protocols of these systems may be outdated, and the upgrading of these legacy systems may entail a high capital investment as well as increased facility downtime.

D. Data Storage and Analytics

IoT sensor nodes acquire data at a high rate, generating a large volume of data daily. This high volume of data is typically referred to as “big data”. Storage and analyze of this large volume of data is the next big challenge that the O&G industry must resolve. An O&G company may store and process data using a company-hosted computing environment or a third-party IoT cloud. However, in the case of outsourcing, the O&G company must establish an explicit agreement with the third-party service provider on data ownership, security, access, and responsibility of each party. Additionally, it is important to check regional requirements associated with third-party data centers to ensure these requirements do not conflict with the O&G company‟s data policies.

As the amount of data collected from an oilfield exponentially grows, human operators are no longer able to review and analyze all of the collected data. This issue has now been addressed by deploying big data analytics tools (including artificial intelligence and machine learning algorithms) to process the data in real time to support the data-driven decision making process.

Numerous big data analytics tools and algorithms have been developed over the past few decades, making the software tool selection process more challenging than it was a few years ago.

E. Scope and Tool Selection

Exploration, appraisal, drilling, field development, production, and reclamation. It is possible to develop an IoT solution targeting operations, machines, and facilities. However, the financial or health and safety gain obtained by deploying IoT systems differ from operation to operation, machine to machine, and facility to facility. Therefore, it is vital to conduct a pre-deployment study to determine the most valuable data, the fastest and safest way to gather data, how to leverage the data, how to maximize the value of data that the company already has, and how to maximize data coverage . A wide range of IoT devices and platforms with different characteristics is available in the market, targeting the same applications. Therefore, selecting the right IoT-enabled tools and infrastructure for a given industrial application is a challenge.

F. Maintenance and Obsolescence

IoT technology is rapidly spreading across all industries, and the number of active IoT devices is expected to exceed 20 billion by 2025. Concerning the oil and gas industry, some of the asset integrity monitoring applications collect data from tens of thousands of locations. For example, the number of thickness monitoring locations (TMLs) or corrosion monitoring locations (CMLs) at some of the refineries may reach three million . Managing such a large sensor network and associated infrastructure, by delivering, in a timely manner, the required services, keeping track of failures, monitoring the performance, and executing repair and replacement of defective devices or infrastructure, is an extremely challenging task . In the event of a small number of devices failures, if the IoT system can self-reconfigure and continue to provide the service.

At an acceptable level of accuracy and quality, the frequency of human intervention for repair and replacement can be minimized. While self-reconfigurable capability does not solve maintenance issues, it does provide some flexibility for planning and scheduling of maintenance activities. Therefore, a dedicated team (in-house or out sourced) is required to manage the IoT devices and associated infrastructure.

G. Mind-set of Employees

It is important to note that for many people and organizations, continuing to do things the way they have always been done is much easier than changing. People and organizations do not like the risk that comes with change. Workforces are often resistant to change, choosing to use the approaches that have been successful in the past . This mind-set is characteristic of O&G industry and can negatively influence IoT adoption initiatives. Thus, O&G companies should have carefully evaluated strategic plans for adopting IoT technology so that employees will support the change instead of opposing it.

CHAPTER 5

CONCLUSION

The capital intensive O&G industry is attempting to digitally transform business and operations to address several long-lasting issues, including high HSE risk, low oil prices for longer periods, and large crew turnover. Deployment of IoT-based solutions to enable data-driven decisions is one of the areas in which the O&G industry is investing as a part of their digital transformation. This article attempted to provide an overview of current R&D trends, opportunities, and challenges associated with IoT deployment in the O&G industry by conducting a systematic literature review.

In terms of publication patterns, the distribution of publications across conferences, journals, and book chapters was 83.3%, 9.1%, and 7.6%, respectively. Approximately 81.8% of the content presented theoretical concepts, while 15.2% presented case studies, and 3.0% presented literature reviews. The higher number of conference publications and theoretical papers indicates that the research on IoT adoption for the O&G industry is still at an early stage. The majority (64.2%) of the articles were affiliated with companies in the supply chain, indicating that the supply chain drives IoT adoption in the O&G industry, compared to O&G operating companies or universities.

Concerning the country profiles, most of the research articles came from the US (38.4%) followed by the UK (10.2%) and Saudi Arabia (9.6%). In terms of inter-organization collaborations among operators, supplychain companies, and universities, 75.8% of the selected articles had no inter-organization collaboration. 15.2% of the publications had inter-university collaboration, while 4.5% of the publications had inter-supply chain collaboration. The remaining 4.5% includes collaboration between universities, supply-chains, and operating companies. There was no collaboration among the operating companies in the publications identified in this research.

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