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Application of Context awareness in Crude Oil pipeline Monitoring and Encroachment Detection – A Review.

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ABSTRACT

Context Awareness has found application in various domain. This ranges from domestic application, personal assistant, health, education, social, political, and industrial sector. The oil and gas industry has also benefited from the emergence of context aware computing. Context aware computing is a domain of Computer Science that develops and implements the theories and fundamentals for practical implementation of systems and devices with the ability to sense, react and adapt to changes in the physical or virtual world. It is worthy of note that the crude oil distribution network has suffered a lot of set back because of damages to the distribution network. This damage arises due to vandalism of equipment failure. Context aware computing is a practical solution to monitoring and detection of potentials for leak occurrence. In this paper, a review of some of the areas where context awareness has been successfully deployed shall be looked into. This will draw the attention to the application of this concept of context awareness to the monitoring of crude oil pipeline and encroachment detection.

Keywords: Context Awareness, virtual world, crude oil, vandalism, equipment failure, monitoring, encroachment detection, leak occurrence.

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1. INTRODUCTION

Context aware systems are systems with the capability to sense, detect, act and react to information and changes to those information within its environment. In the works of [3], context was defined as any information that can be used to characterise the situation of an entity. An entity is a person, place or object that is considered relevant to the interaction between a user and an application, including the user and application themselves.

Context aware systems adapt according to the environment of use, the collection of nearby people, hosts and accessible devices as well as changes to such things over time [2]. A system with these capabilities can examine the computing environment and react to changes to the environment. In the works of [2], three important aspects of context were enumerated. These are: where you are, who you are with, and what resources are nearby. Context encompasses more than just the user's location, because other things of interest are also mobile and changing. Context includes lighting, noise level, network connectivity, communication costs, communication bandwidth, and even the social situation; e.g., whether you are with your manager or with a co-worker. The ultimate goal of a context-aware system is for the system to arrive at a representation of the surrounding world that is close to the perception of the user [1]. Several applications have been designed in the area of context awareness. These applications aid users in interacting with the domain of application. It is worthy of note to state that one of the challenges of ubiquitous systems is to exploit the changing environment. This is more so because of the changing environment where the application is deployed. It is expected that context aware systems should be aware of the environment in within they run.

2. CONTEXT AWARENESS IN OIL AND GAS

Oil and Gas sector is one of the vital areas of a country's economic prosperity. Critical assets for the extraction, production, refining and distribution of oil and gas are constantly under attack due to sabotage or occasionally operational failure. This has called for a conceited efforts of protecting this critical infrastructure. Several approaches for the protection exist but there are imminent drawbacks from these approaches. Context awareness is an area that can be explored extensively in the protection of oil and gas facilities. Several works have been done by researchers in bringing to limelight the importance of application of context awareness in crude oil pipeline value chain. Some of these are reviewed below:

A. An Ontology-based Model for Typical-Context Awareness in the Oil Products Distribution System.

In the works of [7], Disruption Management on oil product distribution was looked at. They stated that the typical context in the oil distribution is decided by the characteristics of an unexpected event and the current distribution state. In their work, they captured the context of unexpected event and the current distribution state in real time and then judged whether the original distribution plan is disrupted by the event under the current context. They developed an ontology based model in management of disruptions. In course of oil product distribution, disruptions are diverse and can occur at different distribution routes. These disruptions could be as a result of gas stations changing their demands, disabled roads induced by traffic accidents or traffic jams, vehicle breakdown etc. Responding to these disruptions in real time necessitate the works of [7], in designing an ontology based model in handling the distribution timely and guarantees smooth process delivery.

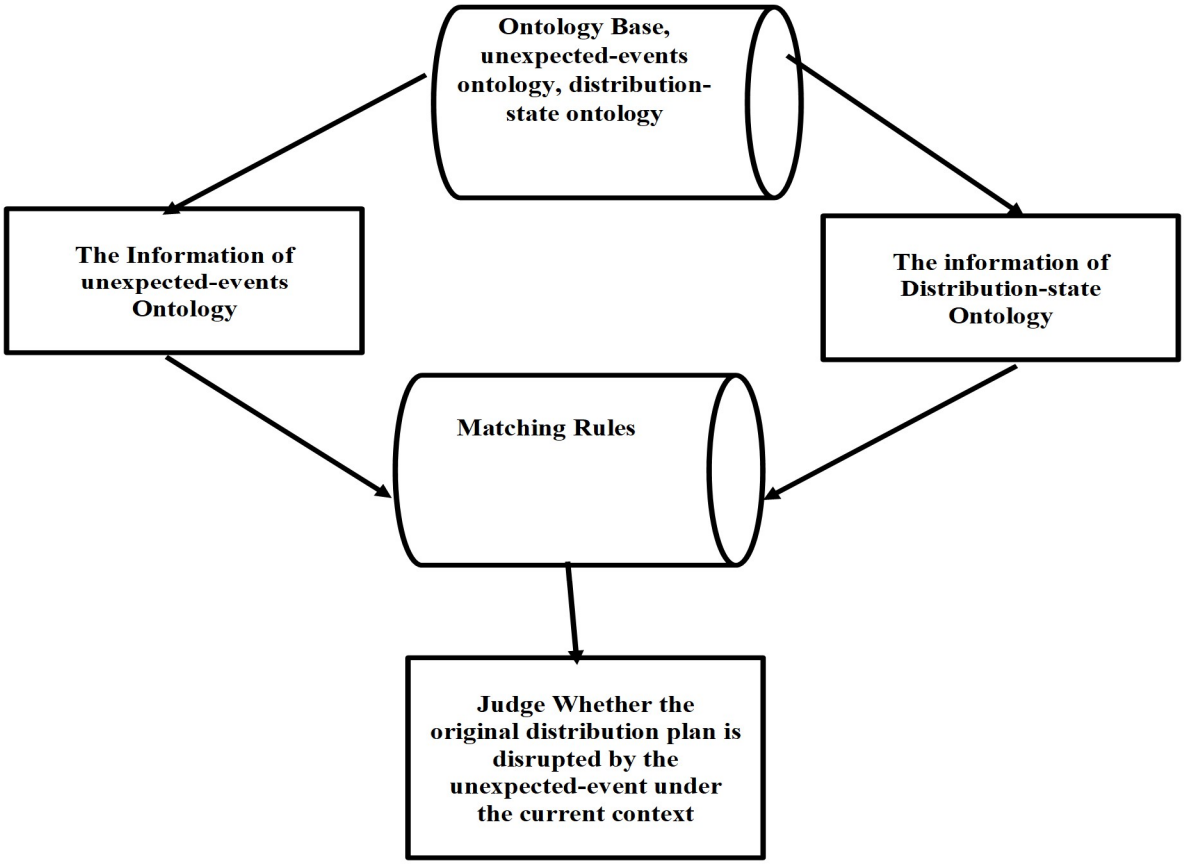

Figure 1: An ontology-based typical-context awareness framework (Adapted from Li et al., 2016)

B. Pipeline Monitoring System by Using Wireless Sensor Network

In the works of [8], systems that utilizes acoustic emanation impacts to perceive a hole or crack and to find position of the hole or crack on oil pipelines was discussed. They proposed uprooting noise before handling break signals and additionally dissected issues of underground remote sensor hubs that should be considered. Furthermore, in their work, they proposed a structure for underground sensor hubs. In view of these examinations, they proposed a checking framework that uses acoustic emanation impacts to screen underground pipeline spillages. The proposed framework utilizes remote correspondence so it can be effortlessly conveyed, arranged, and kept up.

Analyses demonstrated that the correspondence furthest reaches of the proposed framework was 10m on a level plane and 30cm vertically. Figure 2 shows Wireless Sensor Network framework architecture adapted from [8]. The figure shows the distribution of signal from the pipeline being monitored to the computer system. It consists of Sensor node for detected signals from the pipeline. The detected signal is transmitted through Wireless Sensor Network (WSN) to a Distributed Acoustic System (DAS) that process signal of sound of noise from the pipeline. This is transmitted to the computer system for user visualization.

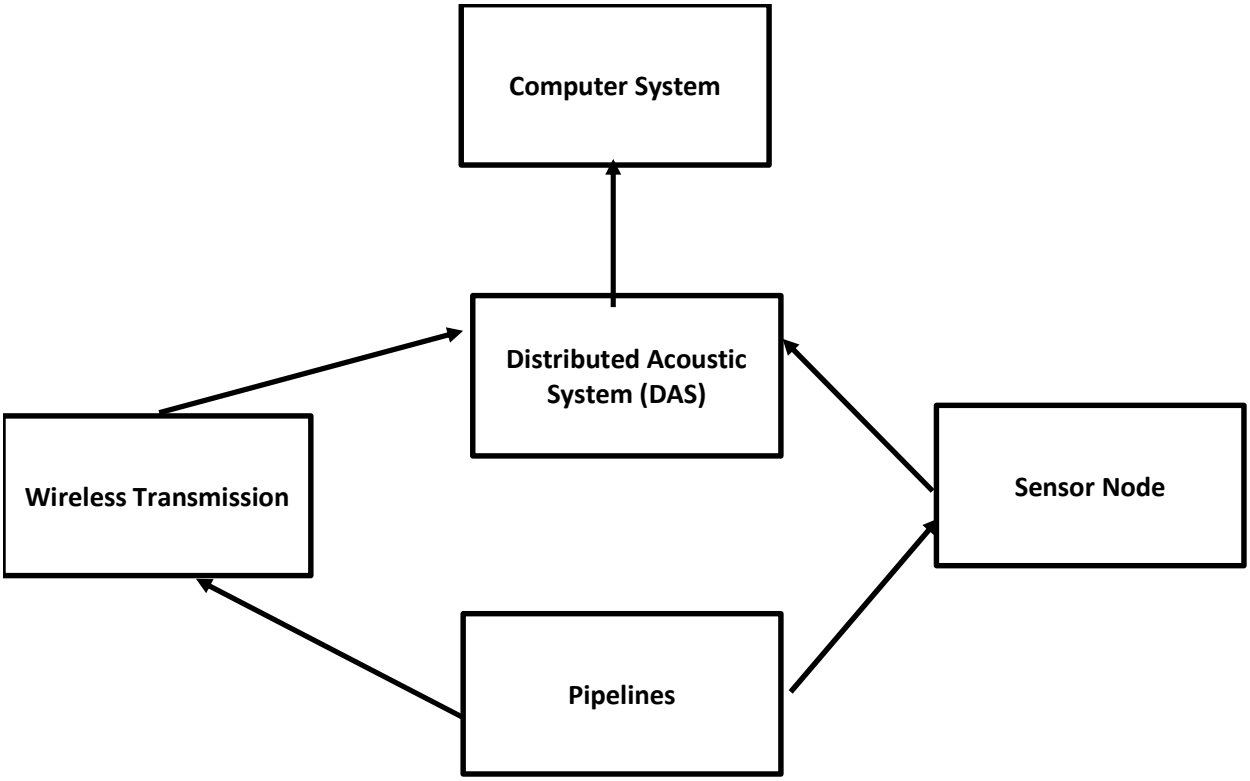

Figure 2: WSN checking framework for checking underground pipeline leak (Adapted from Milad et al, 2016).

[8] stated that previous approach to pipeline monitoring used cross-correlation method. This method worked well in metal pipes; however, the effectiveness of this case is doubtful with metallic and plastic pipes. They further stated that the problems of using the present conventional correlation techniques with plastic pipes results in high fluctuation. They noted that the distances between the sensors and the type and quality of sensor are of great importance. Moreover, low frequency content; the frequency content of the leak noise is very low (<50 Hz) and therefore very hard to distinguish as a leak. Furthermore, the propagation of low frequency sound/vibration will be limited by the impedance of fittings. [8]. A method to detect pipeline features and leaks using signal processing of reflected pressure wave measurements is described. In addition, the increasing of distance led to acoustic emission signal attenuation increases too.

The acoustic leak technique depend on external measurements is normally faced by some serious problems, which include greater signal attenuation in plastic pipes, greater attenuation in large diameter pipes, attenuation caused by soft soils; e.g. clay or grass, pipes buried under the water table level, and pipes with pressure less than 10 meters. Attempts to characterize leaks in pipelines by utilizing internal measurements of the acoustic signal generated by the leak were conducted using either a hydrophone. The drawback of this method is the noise gathered with wave and probably some optimization for signal (measurement) or filtering the measurement may be required In their work, they talked about systems utilizing acoustic emanation impacts to perceive a hole or crack and find its position.

They proposed uprooting noise before handling break signals. Additionally, they dissected issues of underground remote sensor hubs that should be considered and proposed a structure for underground sensor hubs. In view of these examinations, a checking framework that uses acoustic emanation impacts to screen underground pipeline spillages was proposed. The framework utilizes remote correspondence so it can be effortlessly conveyed, arranged, and kept up. Analyses demonstrated that the correspondence furthest reaches of their proposed framework was 10m on a level plane and 30 cm vertically.

C. System Response Function–Based Leak Detection in Viscoelastic Pipelines

In their paper, [5] investigated leak detection in a viscoelastic pipe system using Frequency Response Function Method (FRFM). The analytical expression for the FRFM originally developed for elastic pipeline was extended and applied to viscoelastic pipelines in their study. The extended FRFM was validated by numerical experimental results for one-dimensional viscoelastic models. Results demonstrate the successful applications of the extended FRFM in viscoelastic pipelines, and analysis shows that the pipeline wall viscoelasticity effect has significant impact on amplitude damping and phase shift of the pressure wave trace, but with little influence on leak-induced patterns of pressure head peaks in transient system frequency responses. Leak location can be accurately predicted if the pressure head peaks are appropriately represented and retrieved in the numerical simulations, even though the locations of these peaks are modified or distorted by the viscoelastic effect. Furthermore, the impacts of viscoelastic parameters and incident wave bandwidth on the applicability of the extended FRFM were also investigated with extensive tested in their paper, and the results indicated that this method is generally applicable to leak detection in viscoelastic pipelines. The results of their study also suggested that the “fast and sharp” transient input signal is preferable for accurate location of leaks in viscoelastic pipelines using the extended FRFM and other transient-based methods [5].

D. Wireless Sensor Networks in Oil Pipeline Systems Using Electromagnetic Waves

In the works of [9], it was stated that hostile pipeline system transfer environments prevents the direct use of most, if not all, existing wireless communication and networking solutions, due to the extremely high path loss, small communication range, and high dynamics of electromagnetic (EM) waves when penetrating the oil in the pipelines. They stated that pipeline operators also face many threats to the integrity of pipelines. Their paper focused on addressing the subject of Electro Magnetic-based Wireless Underground Sensor Network (EM-based WUSN) communication techniques on oil pipelines. Their work addressed the unique and important challenges for the realization of wireless sensor networks in challenging oil pipeline systems. According to their work, a suitable transmission range in of 100 to 500 MHz band which is optimal in terms of the absorption losses of complex underground oil pipeline environment was proposed. Research has shown that efficient communication between sensor nodes operating in the 315 MHz frequency range (MICA2 and MICA2DOT motes) is theoretically possible for distances up to 7m in underwater environment [9].

E. A Context-Aware System Architecture for Leak Point Detection in the Large-Scale Petrochemical Industry

In the works of [6], it was stated that in order to realize the accurate detection of leak points in large-scale petrochemical industries, a Context-aware System Architecture for Leak point Detection in large-scale petrochemical industries (CSALD) was proposed. In their paper, the CSALD is able to take more information (including external factors and internal factors) into consideration to improve the accuracy of the leak points location. Various functions implemented in different layers of this system are introduced. In context-aware data storing layer, Distributed Database Based on Data Categorization (DDB-DC) is designed to provide different solutions for different data types. In order to improve the processing efficiency of context-aware data stream in large-scale petrochemical industries,

Real-time Template Matching algorithm for Context-aware Systems (RTM-CS) is presented at context-aware data computing layer. Simulation results show that RTM-CS can effectively improve the matching speed. In the future, our research will focus on optimizing the feedback mechanism and improve the task scheduling algorithm in this context-aware system architecture.

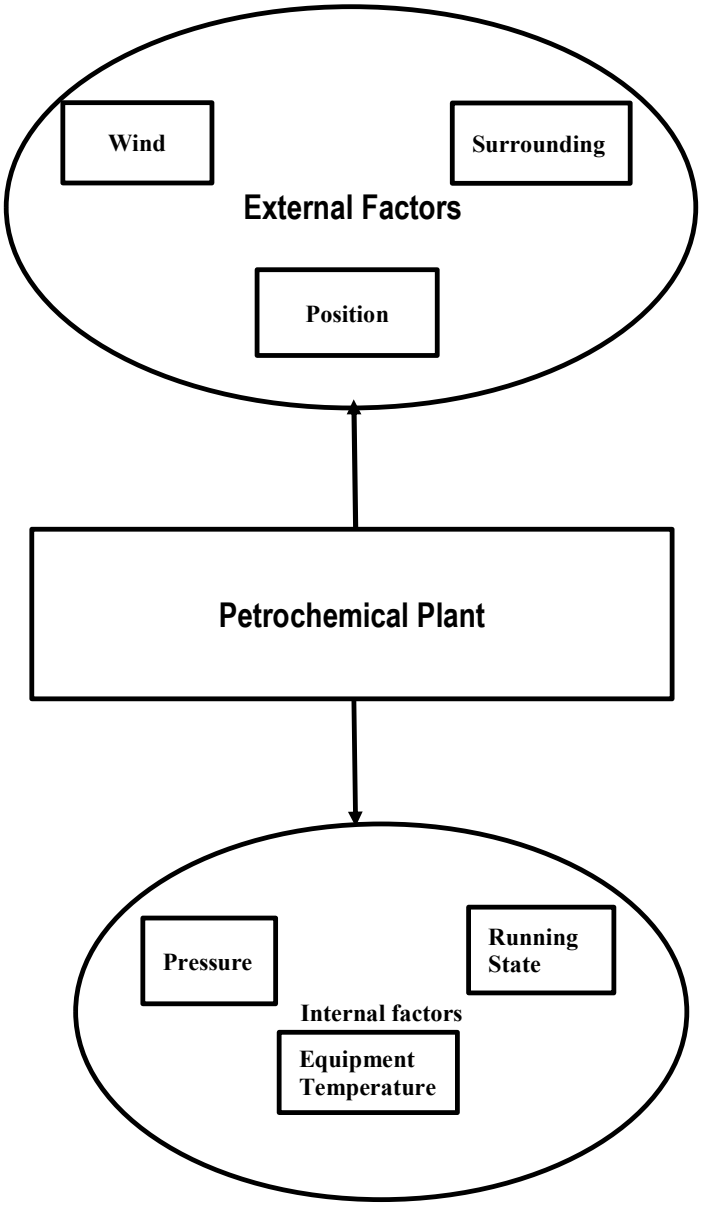

Figure 3: Context-aware Information in Large-scale Petrochemical Industries (Adapted from Kun et al., 2014)

F. Improvement on Gas Leakage Detection and Location System Based on Wireless Sensor Network

In [4], it was stated that in the large petrochemical industry, one of the most concerning problem is the leakage of toxic gas. To solve this problem, it is necessary to locate the leak points and feed the possible location of leak points back to rescuers. Although some researchers have previously presented several methods to locate leak points, they ignored the impact of external factors, such as wind, and internal factors, such as the internal pressure of equipment, on the accurate detection of leak points [4]. In their work, they used gas sensor which was placed in the leak points, and senses the concentration value of toxic gases such as carbon mono-oxide. The sensor sends or imitates to the mobile device when the concentration value exceeds the normal value. The signal given to the Peripheral Interface Controller (PIC) microcontroller which intimates the mobile device through zigbee communication module. Their work proposes context-aware system architecture for leak point detection in the large scale petrochemical industry. As stated by [4], the architecture is a new scheme for accurate leak point detection, which is more consistent with practical application in the large scale petrochemical industry. In the present day existing system, gas detectors are being used which detect the gas leakage and intimate the signal to the control room. After getting the signal, workers are sent to the specific leak points to investigate the cause of the leak. The main disadvantage of existing system is, it takes more time to resolve the problem around 15 to 20 minutes. In proposed method of [4], when the gas concentration valve exceeds the normal value, the alarm signal has to be intimated to the mobile device through zigbee communication module along with numerical updates. Also, the authors used GSM to find the location of the leak points. This process can be done faster than the existing process [4].

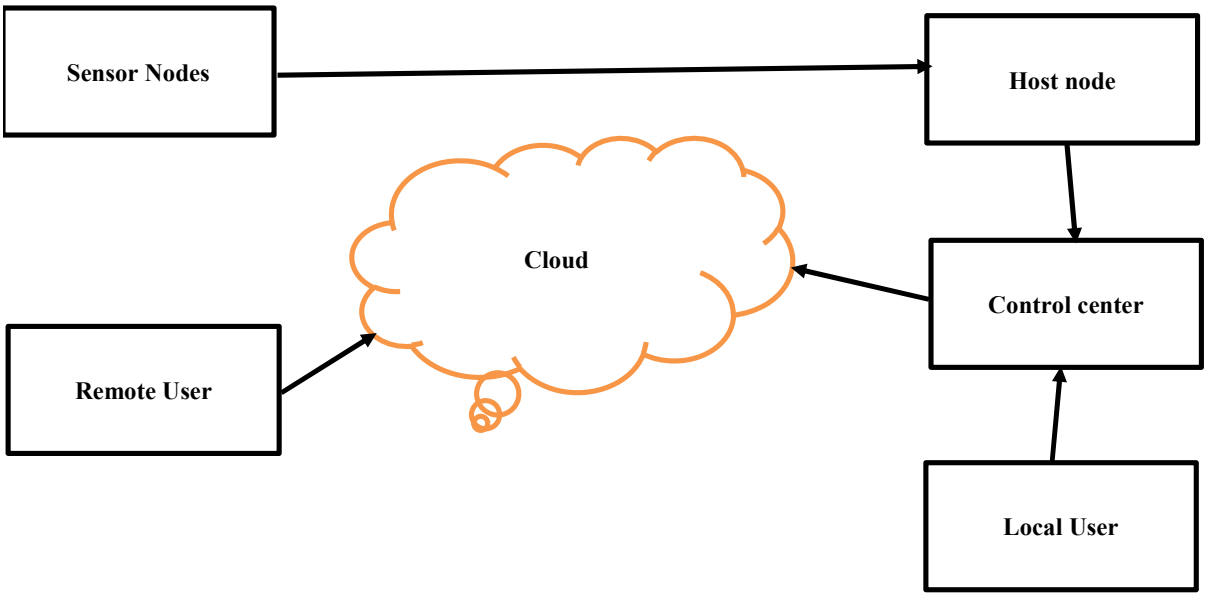

Figure 4: Wireless Sensor Network Architecture (Adapted from Ganesh et al, 2015)

3. CONCLUSION

Context awareness has been successfully applied in some domain of human endeavour. The robustness of context awareness calls for its integration into the oil and gas industry. This is particularly important in managing crude oil theft and artisanal refineries. Significant research works have been carried out in developing models and theories in the area of context awareness for crude oil pipeline monitoring and encroachment detection. These theories and models need to be expanded to develop functional systems for the detection and monitoring of crude oil pipelines and encroachment problems on crude oil pipeline Right of Ways.

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