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Cloud Based Processing of Vibrational Signal for Oil Pipeline Monitoring System

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Abstract—*Petroleum is the economic infrastructure in Iraq because it generates a significant portion of the country's revenue and can be considered as the primary source of financial costs each year. As a consequence, it is critical to protect the sector and continue to develop it. Therefore, it is important to track and maintain pipelines regularly to detect defects on time. In pipeline monitor and control, the advent of the Internet of Things (IoT) technology and the deployment of embedded sensing systems enable successful pipeline maintenance with the simple requirement for real-time precise measurements. In this paper, a wireless network based on an IoT system and integrated with cloud service is proposed for structure monitoring of oil pipelines, to detect the risks on the structure such as tampering and/or wear and tear effects. The method is based on collecting data from a sensor node equipped with an RF module attached to the pipeline structure. These nodes collectively form a network of IoT devices connected to the cloud server. The raw data is collected, stored, and statistically analyzed to be accessible by the user anytime and anywhere through the Internet. The performance of the system is evaluated in different cases, including the distance about the node to detect events on the pipe and to discriminate the distance of event to determine the location the event it was tested by using four different states of the transmitted data.*

Index Terms— *Oil pipeline monitoring, IoT, AWS, ESP32 cam, Lambda function*.

I. INTRODUCTION

Pipelines were introduced as a more cost-effective way of transporting oil to make transportation more autonomous and affordable [1]. Terrorism and sabotage, corruption, "Hot-Zones," lawlessness regarding saboteurs, and thieves are among the risk factors that have the greatest effect on petroleum products around the world [2]. Fault detection in oil transmission pipelines, especially leakage detection, is not only critical for project safety and environmental protection but also project economics [1]. Companies pay more attention to the oil pipeline leak. Since a blowout or oil leakage accident occurs, apart from the financial loss, the leaked fluid will pollute the atmosphere and may result in a fire [3]. Therefore, there is a need for a system that can track it efficiently in real-time to ascertain the fault and remaining life, so that repair and replacement can be done without disrupting export operations and the country's economy. Pipeline Monitoring Systems (PMS) are now built using a variety of methods, including visual inspection, ultrasonography, radiography, thermography, pressure, chemical, and magnetic sensing. Other methods used satellites, smart pigging, drones, smart robots, and dogs to implement PMS. Because of the pipelines' distance and the harsh climate, tracking them with traditional methods is became challenging and very costly.

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Wireless sensor networks now have new possibilities due to the advances in printed electronic circuits, RF circuits, and microcontrollers for remote monitoring [4]. On the other hand, the rapid technological advances of smart sensors, wireless networking systems, the Internet, and the innovations, such as the IoT and cloud computing, have emerged, opened up new horizons, where it can be used for monitoring methods and making it simpler and more powerful in real-time [5]. Because of its potential and ability to be incorporated into any complex structure, the IoT has recently gained a lot of attention [6]. The IoT has quickly become a popular subject among academics and businesses. Industries, companies, customers, the climate, individuals, and society will all benefit from its incorporation into monitoring systems like structural health monitoring systems (SHM). SHM is focused on the concept of collecting data from multiple sensors mounted on structures and processing and extracting useful information regarding the existing condition of the structure for maintenance and protection [7]**.** Because of the vast quantity of data produced via IoT, it is becoming important to combine it with other technologies like cloud computing, to meet the need for storage space and virtual resource utilization [8].

This work aims at designing and implementing a system to monitor oil pipelines in real-time based on IoT technology and cloud computing, to analyze and extract useful data that enable the user to view data concerning the structure's current state anywhere and anytime by connecting to the internet for maintenance and safety purpose.

A. Internet of things (IoT)

The work of [5] defines IoT as “internet-connected embedded systems that can be upgraded and adapted to changing needs on-demand, useful information can be immediately collected from remote geographic areas, and fault diagnosis and system restarts can be made more efficient and cost-effective by not having to send out technicians to remote places”. Authors in [9] indicate that “the IoT comprises a large number of sensor nodes with limited processing, storage, and battery abilities”. While authors in [10] mention that “IoT is in charge of the construction of a network of devices enabled for the Internet to promote a smart environment”.

IoT devices are connected through a network and can be operated remotely without the need for human interaction. Data is typically supported, collected, analyzed, and visualized in IoT applications on computers and mobile devices, which are all part of the IoT infrastructure [11].

The introduction of IoT technology in pipeline monitoring enables successful pipeline maintenance through the implementation of embedded sensing systems, the primary requirement of which is to make precise and real-time measurements [12]. Intelligent sensors and innovations like the IoT, which can take a potentially diverse array of data and create an image of the system's state, assist in the early detection of faults [13].

B. Wireless Sensor Networks (WSNs)

WSNs which can sense, compute, and communicate wirelessly, can be used for a variety of purposes, including scientific observation, detection of emergence, and detection of climate change, environment monitoring, and prevention of physical harm [14].

Using WSNs in Pipeline Monitoring Systems (PMS) has become a simple and low-cost choice with high efficiency and accuracy [4].

The installation of sensing modules along the framework is needed for the establishment of an SHM system for monitoring. The spread of these devices over a large geographical area creates a distributed communications network capable of collecting environmental data and working effectively to solve it [15] Wi-Fi, Bluetooth, Z-Wave, or ZigBee are wireless Protocols for contact that can be used to connect with the base station.

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The other sections of the paper are organized as follows: Section II describes the previous studies on monitoring pipeline methods and the studies about IoT and cloud computing. Section III provides the methodology of the proposed system and describes the design and parts of the system. Section IV includes the results and discussion, then a conclusion of the work is presented in section V.

II. LITERATURE SURVEY

This section summarizes the recent works of monitoring based on WSNs, Internet of Things (IoT) technology, and cloud computing.

In [6], the authors reviewed and implemented a system of systemic health monitoring (SHM) to intelligent and accurate monitoring using IoT technologies. The technologies involved in the establishment of IoT and SHM systems, in addition to the data in a routing plan in an IoT environment. Solutions of Big data are being implemented to act with the difficult and vast volume of data gathered by sensors mounted on the framework, as the amount of data produced utilizing sensing systems is voluminous and quicker than ever before. This work presents a mechanism for deploying WSNs using the Protocol ZigBee to expand IP networks to MAC/PHY technologies based on IEEE802.15.4. The tools for big data discussed in this paper are low-cost components that can be used in conjunction with SHM data processing and mining infrastructures also exist. They can be used to provide an SHM system with dependable, scalable, modular, and low-latency solutions, and they can be used in both a modern data center and a cloud environment.

In [15], a monitoring system for oil pipelines using WSN was proposed, along with a tool for event detection and classification. The system is based on PCA (Principal Components Analysis. Vibration signals are collected when causing damage to the oil pipeline (knocking and drilling). Based on statistical features and PCA, a WSNs in monitoring and pre-warning system for oil pipeline protection is proposed. Features of the frequency and time domains derived from vibration signals were used to construct the detection model. PCA has been added to these features to analyze the data and reduce the dimension space, allowing for pipeline damage diagnosis.

In [4] authors presented a WSNs-based monitoring device for the structural health of the pipeline. The pipeline vibration is detected by the device, which sends the information to a base station for processing. A three-node is planned and implemented. Every node is based on a 32-bit ARM core microcontroller and includes an accelerometer to detect pipeline vibrations. Each sensor's measurements are wirelessly transmitted to a base station through the ZigBee protocol and demonstrate a device for measuring and collecting vibration measurements from a pipeline wirelessly to detect any ongoing damaging events. The proposed system effectively balances the limited resources of low-cost sensor nodes with the necessary data quality for detection. A three-node network is built and implemented (two sensor nodes and one acting as a base station). A 32-bit ARM core microcontroller, 3-axis ADXL accelerometer, and ZigBee RF transceiver are included in each sensor node. The Arduino DUE board was chosen as the wireless sensor unit's main component and the pipeline sample was subjected to damaging knocking and drilling events during the test.

In [16], the authors showed the architecture of IoT and a Cloud-based medical monitoring system that can be used remotely and in real-time, and showed that Amazon's AWS (Amazon Web Services) is the most popular cloud computing service it is efficient in terms of efficiency, features, and cost in a benchmarking report. Therefore, it is appropriated as a Cloud provider service for this application. Proposing a real-time monitoring framework for delocalized patients' health parameters. This framework makes use of the most up-to-date IT technologies: IoT, MQTT (Message Queue Telemetry Transport), and Cloud Computing are all terms used to describe

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medical sensor devices. The authors proposed a completely integrated framework to allow real-time remote monitoring. Patients are monitored using sensors on the body, IoT, and Cloud Services. And include a cost-analysis of the system, which revealed significant disparities between the three cloud providers, enabling to make a firm decision AWS was used.
The design of the AWS-based health monitoring system was introduced, along with information on its various components. The system's basic functionality was successfully tested, and the next move would be to bring it to the test in real-world situations with real patients.

In [17], it was described how WSNs were used to control air quality in a workshop. The proposed device prototype includes a series of gas sensors (CO, H2, NH3, Butane, Propane, Ethanol, and NO2) that are installed on a WSNs stack and infrastructure. They are powered by a microcontroller based on the ARDUINO. There is also the main server, which is built on a Raspberry Pi 3 and contains the system's main database, which supports real-time management techniques by tracking air emissions in the form of numbers and charts through the web interface. Sensors operated by the ARDUINO platform communicate with the server through wireless technology (Wi-Fi), with MQTT protocol used for communication. When the carbon monoxide gas level exceeds the threshold, the device will send a warning email to the civil defense department.

In [18], the authors presented a healthcare system of ECG diagnostic patients using the analysis capability of the Thingspeak IoT platform. This system sends ECG signals that are received from patients to a cloud service called IoT (Thingspeak). To define the heart illness, a PCA algorithm applies in the Thingspeak–MATLAB by the obtained signal contained to the numerous ECG signals in the databases of the Thingspeak channel. Nodes are spread around the hospital and intensive care patient rooms, ECG electrodes, in addition, a Node-MCU are included in each node. The nodes have a unique identifier that corresponds to the name of the patient. The Node sends ECG data in JSON format to a central broker by using a WiFi module at any moment of the day.

In [19], an E-Sense Internet of Things-based environment monitoring system was designed and developed. Temperature, humidity, air quality index, CO concentrations, rain, and light are only a few of the significant environmental characteristics measured by E-Sense. The ESP8266 Wi-Fi module is used to send the data obtained from the sensors to ThingSpeak which assists in data analysis and presentation in graphical and tabular formats. E-Sense also produces a heat map of the monitored region. The system works without human involvement, is user-friendly, small, and cost-effective, according to a tested implementation and experimentation.

In [20], the focus was on the use of IoT technology in the field of health applications, with the main goal of developing an ECG diagnostic system for patients using the Thingspeak IoT platform capability analysis and a reliable healthcare analytic system for patients that healthcare professionals can use for patient monitoring. The monitoring system uses Principal Component Analysis to analyze and compare ECG readings (PCA). Patients' ECG signals are collected and sent to the Thingspeak IoT platform for PCA in the proposed system. The technology can classify cardiac disease and allow patients with deteriorating health to be addressed by medical specialists.

In [21], an aquaponics cloud-based Internet of Things monitoring system was presented to measure the water temperature, depth, and dissolved oxygen. In addition, three infrared distance sensors were mounted to the aquarium glass at various heights to monitor the fish's group activities. Wi-Fi is used to transfer the data to ThingSpeakTM, a cloud platform. A real-time warning system for signaling irregularities is constructed utilizing data stored in the cloud, and periodic regression analysis is performed utilizing ThingSpeak's cloud-based programming.

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Based on the related works already mentioned in this research, an IoT system with accelerometer sensor node and ESP32cam MCU (Micro Controller Unit) was proposed for monitoring the oil pipeline structures health, to track any changes in the structural elements for identifying potential accidents, degradation, or harm for purposes of maintenance, repair, retrofit, and protection. This system monitoring data is available and accessible through the internet from anywhere. The monitoring data is directly submitted to the cloud via the MQTT protocol and stored in a database, analysis, and subscribers can access it from anywhere at any time. As a consequence, it would be a cost-effective and efficient method to reduce time, effort, and failures.

III. METHODOLOGY AND PROPOSED SYSTEM DESIGN

In this section, the design and implementation of the proposed Health monitoring system for oil pipelines are explained as follows. The system uses device-to-cloud communication as an IoT connective model, and it aims to collect data from IoT sensor node that installation on the oil pipeline and send it via the internet using wireless communication to cloud computing to store and analyses the data. The user can reach and view data via the web anywhere and anytime if connected to the internet. This helps to expose the harm that takes place on the pipeline of oil in real-time.

The proposed system, as shown in *Fig.* 1, consists of hardware and software parts that measure vibration signal by ADXL345 accelerometer sensor where these signal's data are collected and sent to the AWS (cloud computing provider) by Microcontroller unit node (ESP32 cam) using MQTT protocol, to analyze the data and extract useful information. The proposed system store analyzes all data in AWS and shows such data in API gateway by HTTP (Hypertext Transfer Protocol) link which can be viewed in any web explorer software.

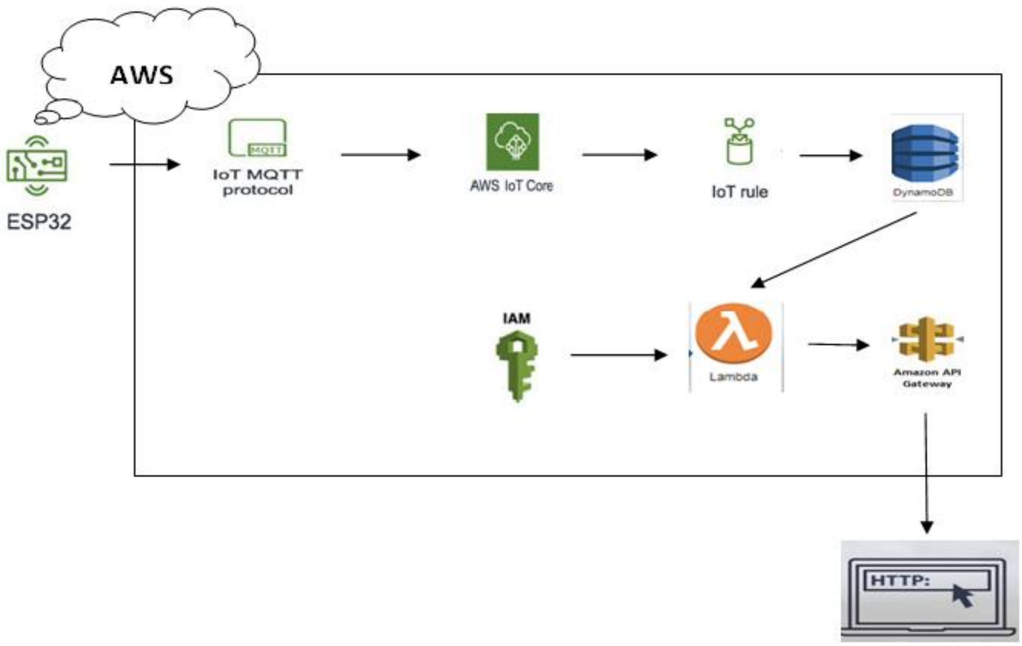

FIG. 1. PROPOSED SYSTEM DESIGN

A. Hardware System implementation

The hardware of the system consists of an ADXL345 accelerometer to sense any vibration signal and an ESP32 cam as an MCU node. The hardware components of the proposed monitoring system are described as follows;

i. ESP32-CAM

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The ESP32-CAM is a lightweight, low-power camera module based on the ESP32 microcontroller. It features an OV2640 camera and a TF card slot onboard. Intelligent IoT applications such as wireless video tracking, Wi-Fi picture upload, QR recognition, and others can all benefit from the ESP32-CAM which is a full-featured microcontroller. It's inexpensive and easy to use and is perfect for IoT devices. The ESP32-CAM board has no USB port, it needed to add an FTDI adapter [22] for programming. The microcontroller board is shown in *Fig.* 2.

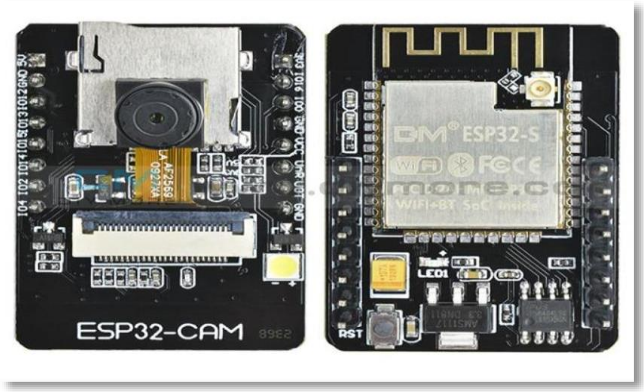

FIG. 2 ESP32CAM [22].

ii. **ADXL345 accelerometer**

The ADXL345 is a small, thin integrated IC, Analog Devices produced it. It has a very low power consumption of just 23 µA in measurement mode and 0.1µAin standby mode. The ADXL345 is a 3-axis accelerometer with resolution (10 bit) measurements at ranges of 2, 4, and 8 G (G is the acceleration due to earth gravity, which is approximately 9.807m/s2), and with a resolution of 13-bit measurements at ranges up to 16 G. The sensor digital output is compressed into two bytes in 2's complement format. The sensor's digital interface is either SPI or I2C. The output data rate can range from 0.1 to 3200 Hz [23], which is ideal for the sampling rate needed for the proposed system application.

B. **Software system implementation**

The software part of the proposed system consists of AWS, which includes services such as IoT core, DynamoDB, Lambda function, API gateway, and MQTT protocol which are described as follows;

i. AWS (Amazon Web Service):

Amazon Web Services (AWS) is a cloud computing platform that enables enterprises, governments, and individuals to store data and provides APIs (Artificial Programming Interface). Thousands of consumers in over 190 countries use Amazon Web Services [24]. With its smooth interface, AWS allows users to make their applications better and easier to use, and it offers a smooth framework for any industry [25].

a. IoT core

AWS IoT Core supports MQTT-enabled devices and clients for publishing and subscribing to messages, collecting data from ESP32 CAM, and sending it to the DynamoDB database.

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b. DynamoDB

Amazon DynamoDB is a completely managed non-relational database service that offers fast and consistent performance as well as smooth scalability. It is used to store IoT data and allow users to access it.

c. lambda function

AWS Lambda is a serverless service of computing that offers:

- Run code without having to provision or handle servers.
- Run code for virtually every form of application or backend service with no setup required to create, evaluate, and deploy it.
- Write functions in a language (Node.js, Python, Go, Java, and others).

For the proposed system lambda function is used to access to IoT data store in the DynamoDB database table and analysis it (Python 3.7 was chosen for write code) and trigger with API gateway to create HTTP link.

d. API Gateway

The Amazon API Gateway (application programming interface) is a completely managed service that enables developers to easily build, publish, maintain, track, and secure APIs that support real-time two-way communication applications at any scale. In this method, an API gateway was used to create an HTTP connection so that the data could be accessed on the site

ii. Message Queue Telemetry Transport MQTT Protocol

It is a lightweight protocol appropriate for devices with bounded processing and memory capabilities, to send data over low bandwidth networks.

Multiple clients should establish a link with the broker so that they can:

a) Subscribe to particular topics and receive written messages about those topics.
b) Send messages to specific topics [26].

Because of its lightweight characteristics and ability to operate efficiently in low-power, limited memory devices, MQTT is the best candidate for M2M communication [27]. MQTT is a publish/subscribe protocol that has a low network overhead and can be implemented on low-power devices including microcontrollers, which could be used in remote IoT sensors [28]. MQTT is ideal for devices with limited resources that depend on insecure or low-bandwidth connections. The MQTT protocol is based on the TCP protocol [29]. *Fig.* 3 below shows the flow chart of the system.

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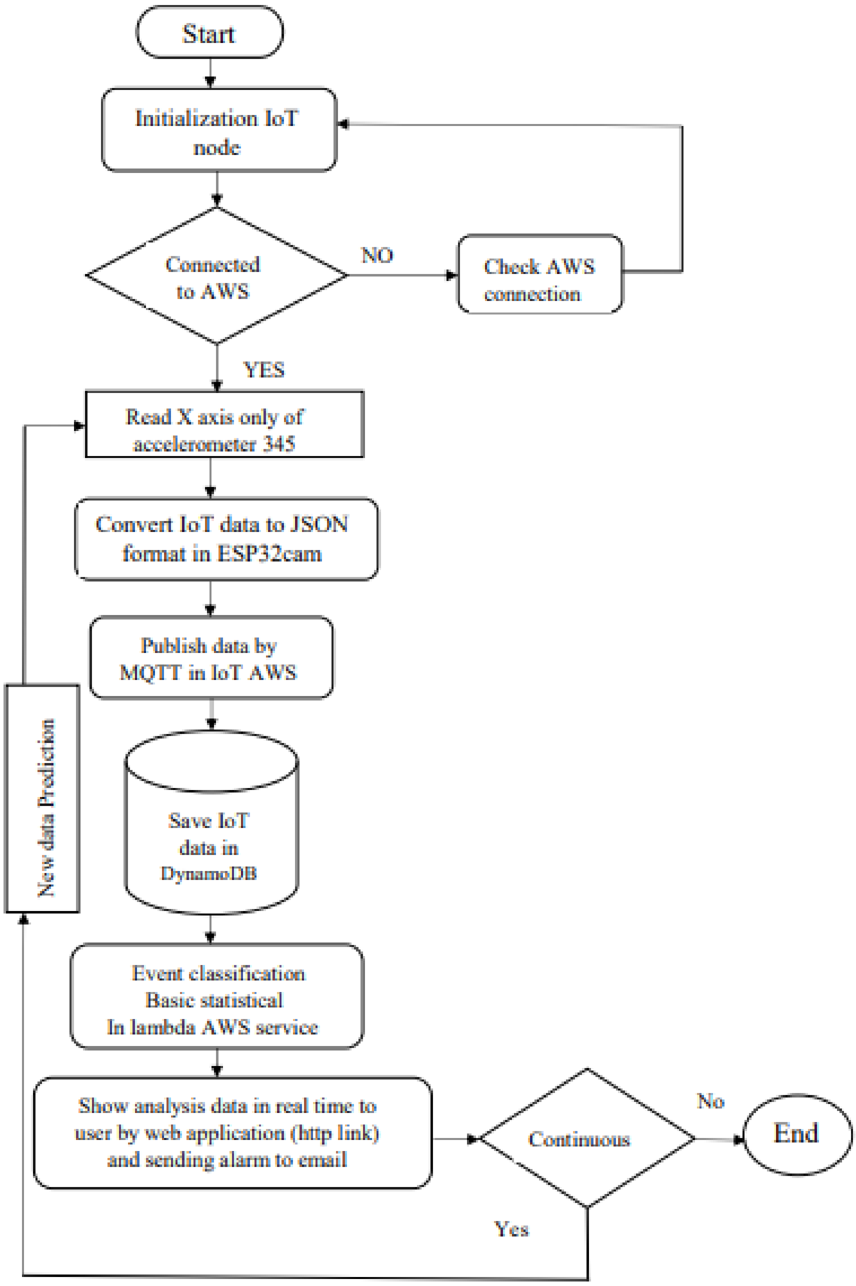

FIG. 3 THE FLOW CHART OF THE PROPOSED SYSTEM DESIGN

IV. RESULTS AND DISCUSSION

The implemented pipeline monitoring system uses one IoT sensor node to send the vibration signals from the accelerometer to AWS by ESP32-CAM via WiFi using MQTT protocol.

In AWS, many services are used to collect, store, and show statistical analysis results of the data to the user in any web explorer. Based on these services the results of the proposed system are obtained and described as follows;

A. Data collection

The accelerometer's data is collected in digital format. For each measurement, the acceleration on the three axes is represented by three values: X, Y, and Z in a 2'complment format, and these values are stored in two bytes for each value ranging between ±512.

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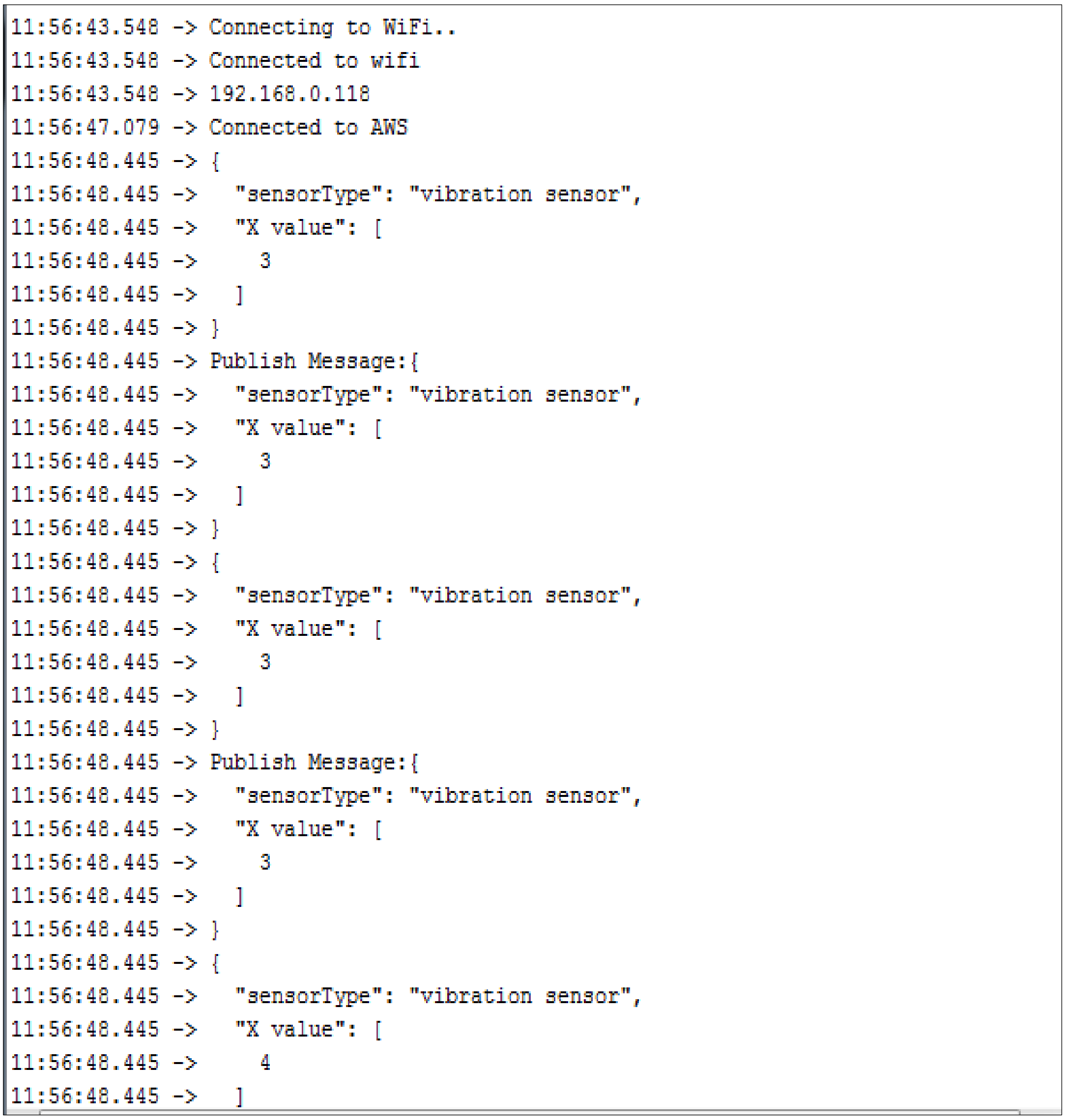
The six bytes vibration data are read in a single burst via the I2C protocol and saved in ESP23cam (MCU node) in the form of a JSON array containing 3 values (x,y,z). These data are sent every 10 ms to the IoT core of AWS as shown in *Fig.* 4.



```
11:56:43.548 -> Connecting to WiFi..
11:56:43.548 -> Connected to wifi
11:56:43.548 -> 192.168.0.118
11:56:47.079 -> Connected to AWS
11:56:48.445 -> {
11:56:48.445 ->   "sensorType": "vibration sensor",
11:56:48.445 ->   "X value": [
11:56:48.445 ->     3
11:56:48.445 ->   ]
11:56:48.445 -> }
11:56:48.445 -> Publish Message:{
11:56:48.445 ->   "sensorType": "vibration sensor",
11:56:48.445 ->   "X value": [
11:56:48.445 ->     3
11:56:48.445 ->   ]
11:56:48.445 -> }
11:56:48.445 -> {
11:56:48.445 ->   "sensorType": "vibration sensor",
11:56:48.445 ->   "X value": [
11:56:48.445 ->     3
11:56:48.445 ->   ]
11:56:48.445 -> }
11:56:48.445 -> Publish Message:{
11:56:48.445 ->   "sensorType": "vibration sensor",
11:56:48.445 ->   "X value": [
11:56:48.445 ->     3
11:56:48.445 ->   ]
11:56:48.445 -> }
11:56:48.445 -> {
11:56:48.445 ->   "sensorType": "vibration sensor",
11:56:48.445 ->   "X value": [
11:56:48.445 ->     4
11:56:48.445 ->   ]
```

FIG. 4 MEASUREMENT DATA BY THE ACCELEROMETER WITH TIMESTAMPS IN THE SERIAL MONITOR OF ESP32-CAM

B. Transfer data to AWS (Amazon Web Service)

The data is transferred to AWS cloud via WiFi of ESP32cam through MQTT protocol and collected in the cloud by using IoT core service and then stored all data in DynamoDB table (NSQL database) as shown in *Fig*.s 5 and 6.

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FIG. 5 DATA IN IOT CORE AWS

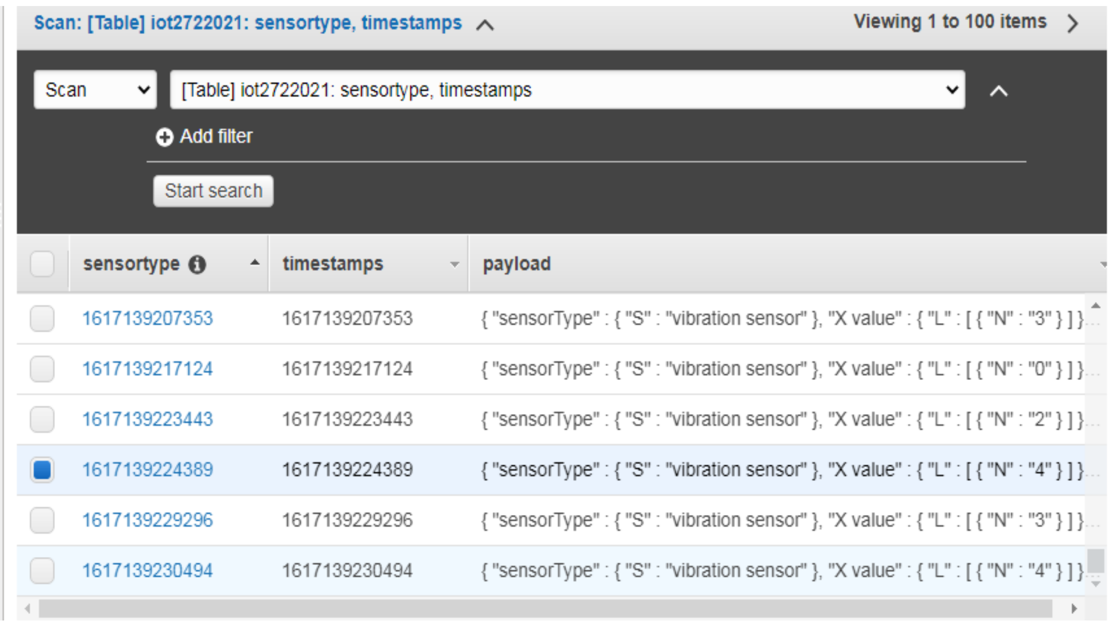

FIG .6 IOT DATA STORED IN DYNAMODB TABLE IN AWS

C. Analysis of the Data

The Analysis means the reviewing of collected data and manipulating it to produce simple easy to read and understandable data. Statistical Analysis features (Minimum, Maximum, and Mean (positive value)) are calculated for the accelerometer-collected data (IoT data).

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Data used in this system is taken from previous work data which is measured and collected in the Al-Mussaib gas turbine power plant's pipelines [15]. The data includes knocking events implemented at various distances from the nodes.

The ADXL345 accelerometer is placed horizontally on the oil pipeline. In this position the Y and Z axes are in a horizontal direction with the pipe, while the X-axis is perpendicular to it, so the X-axis is more sensitive to vibration than the rest of the axes, therefore it is considered as a measure to monitor pipe vibrations.

The system was tested in four cases scenarios as follows:

Case 1: using data collected without knocking event.
Case 2: using data collected with knocking event.
Case 3: using data collected with knocking event in one-meter distance from the node.
Case 4: using data collected with knocking event in 48-meter distance from the node.
Fig.7 below shows the structure of the system and the direction axes of the accelerometer with the pipe.

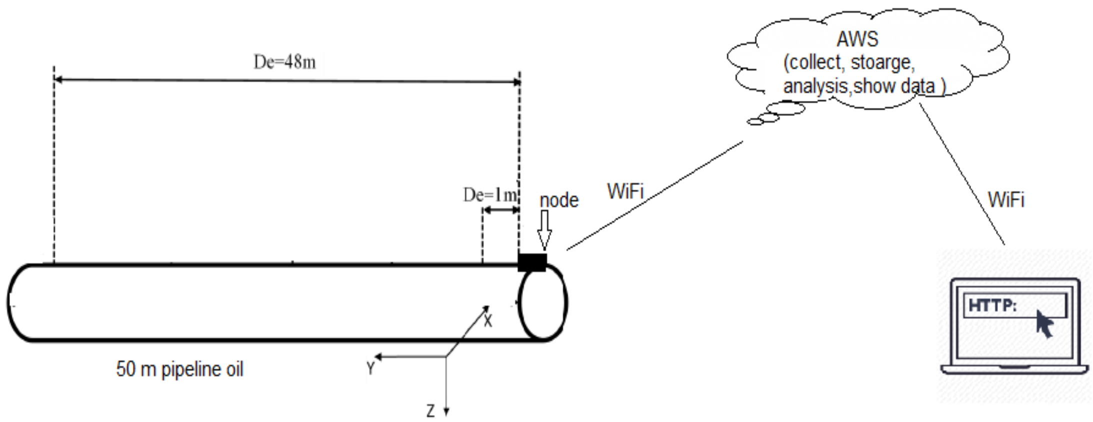

FIG .7 STRUCTURE OF THE SYSTEM WITH THE DISTANCE OF THE EVENT FROM THE NODE

The proposed system used the serverless Lambda function service in AWS to perform a statistical analysis of data based on the following functions (min, max and mean (for positive value)) for 600 value /60 seconds.

In Case 1, the vibration data measured from the pipe is shown in *Fig*. 8 below.

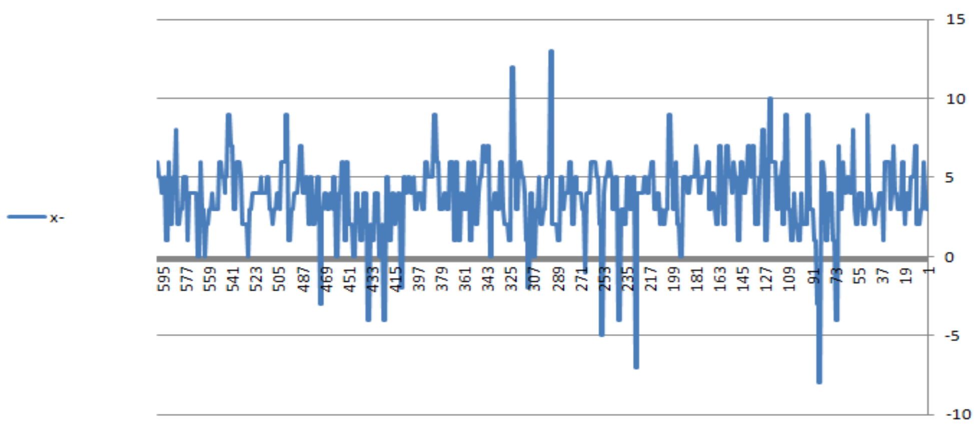

FIG .8 DATA MEASUREMENT BY ADLX345 ACCELEROMETER IN THE NORMAL CASE OF PIPE.
(X- AXIS TIME (SEC), Y- AXIS X VALUE (G))

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The statistical analysis of the data for Case 1 can be summarized as follows:

Max(x axis) = 12
Min(x axis)= -8
Mean(x axis)= 4.082

Case 2:with event
In case 2 the vibration data measured from the pipe with an event is shown in *Fig.* 9 below**.**

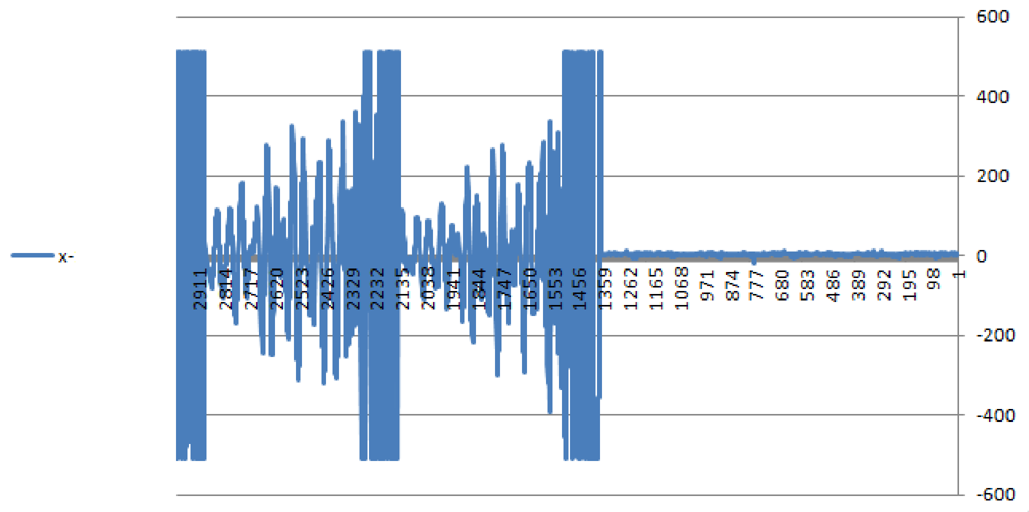

FIG .9 DATA MEASUREMENT BY ACCELEROMETER ADLX345 DURING AN EVENT ON THE PIPE.
(X- AXIS TIME (SEC), Y- AXIS X VALUE (G))

Max(x axis) = 511
Min(x axis)= -512
Mean(x axis)= 29.4142
As a result, the value of (max, min, Arithmetic mean of positive value of x-axis) increased which means the pipe exposed to the event made it under vibration.

In Case 3 and Case 4:
The system was tested with an event in different distances from node and depended on the Arithmetic mean only for the positive value of the x-axis to distinguish between cases. When vibration is created by a knock on an oil pipeline in 1m far of node and 48 m far from the node the generated signal (x-axis ADXL345 accelerometer) is shown in *Fig*s. 10 and 11.

In case 3 :1 m distance
In Case 3 the vibration data that was measured from the pipe with the event in 1m distance from the node is shown in *Fig*. 10 below:

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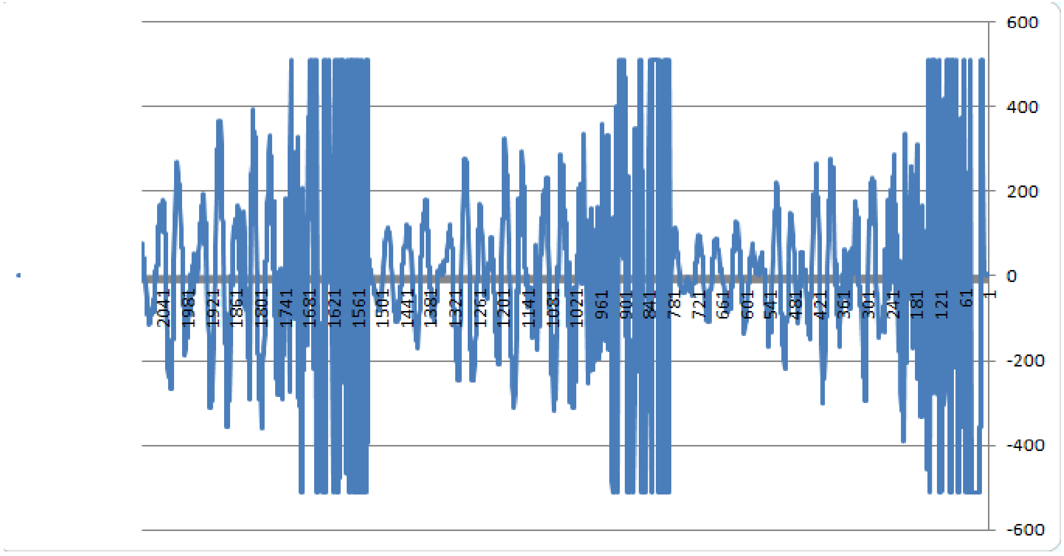

FIG .10 DATA MEASUREMENT BY ACCELEROMETER ADLX345 DURING AN EVENT ON THE PIPE IN 1M FROM THE NODE.
(X- axis time (sec), Y- axis x value (g))

Mean (positive value of x axis)= 157.690

In case 4:48 m distance.
In Case 4 the vibration data that was measured from the pipe with the event in 48m distance from the node is shown in *Fig.* 11 below.

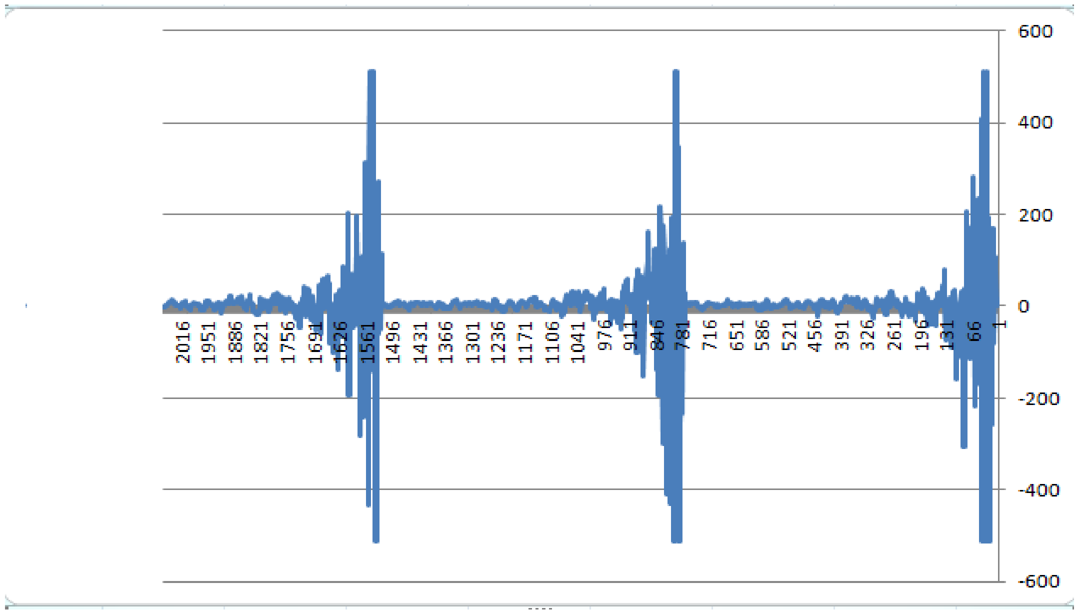

FIG .11 DATA MEASUREMENT BY ACCELEROMETER ADLX345 DURING THE EVENT ON THE PIPE IN 48M FROM THE NODE.
(X- axis time (sec), Y- axis x value (g))

Mean (positive value of x axis) = 29.142.

The difference in mean value indicates the distance of knock to which the pipeline is exposed, when the knock is near to node the value is increased, therefore, it was observed that the mean value of knock-in 1m is 157.690 and in 48 m is 29.142.

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D. Viewing the data

API gateway service is used to create HTTP weblink to show results data to users which can be viewed using any web explore. The monitor can show the analytic data results by this link as shown in *Fig*s. 12, 13, and 14 below.

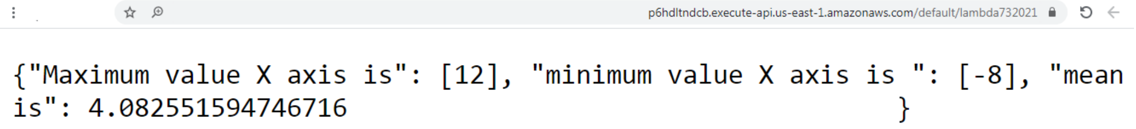

FIG .12 ANALYSIS RESULTS OF IoT DATA IN API GATEWAY(CASE 1).

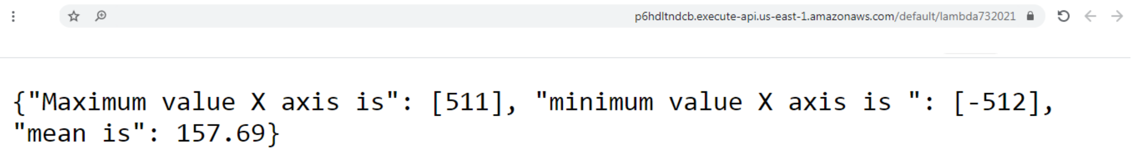

FIG .13 ANALYSIS RESULTS OF IoT DATA IN API GATEWAY (CASE2 AND 3)

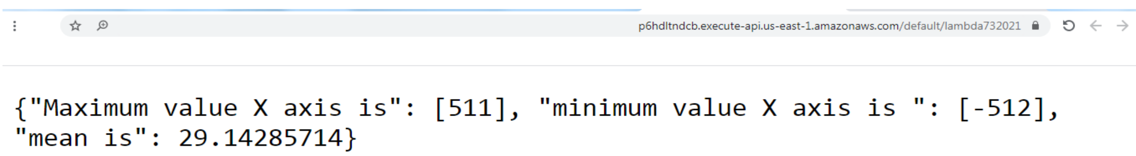

FIG .14 ANALYSIS RESULTS OF IoT DATA IN API GATEWAY (CASE4)

V. CONCLUSION

Monitoring oil pipelines in real-time plays an important role to detect the occurrence of risk immediately to reduce economic loss and environmental pollution. On the other hand, as science and technology have progressed, IoT technology began to be applied to a variety of areas, including the SHM (structural health monitoring) system. In this paper, the integration between IoT and cloud computing provides monitor system effectiveness, efficiency, ease, low cost, in real-time, and users can view the data anywhere and anytime if connected to the internet. This system can be expanded and applied along the oil pipelines due to the low cost of hardware and its application can be in any environment, no matter how harsh and inaccessible, which makes the monitoring process effective and efficient, and the result data can be accessed from anywhere, which allows discovering the

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danger on the pipeline in real-time and trying maintenance and to avoid damages. the system is tested in 4 cases, the first includes a case for normal status, the second for the pipeline of oil under knock to generate an event, the third and four created vibration on the oil pipeline in 1m far of node and 48 m far from the node. The distinction between them to determine the location of the event depends on statistical analysis using (min, max, and mean) functions, the system distinguishes between normal pipeline state and condition upon exposure to an event, depending on the values of the max and min analysis, and determine the location of the event based on the mean value of IoT vibration data obtained from the oil pipeline. The analytic results of the proposed pipeline monitoring system are visible to the observer via cloud services AWS.

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